L – IPSL LABEX

MID AND LONG-TERM ACTION PLAN OCTOBER 2014

This document describes the mid and long-term strategy and objectives of the LABEX program, summarizes past projects and results in current projects. It also describes research, innovation and expertise transfer and education propositions for the mid-term and current achievements. It is an update of the 2013 action plan.

This document follows the same structure as the 2013 Action Plan, in a simplified form as concerns previous actions. It contains a number of new elements and modifications, summarized below:

Research:

- The general presentation is simplified,
- The starter actions are not anymore in the PA, but can be found in the PA2013 document
- A new table (p. 12) is given for summarizing post-doc projects status
- The research budget is updated (new Section 2.3, p. 41-42) and contains new funded actions
- Intermediate results of the projects in the mid-term program are now given in Appendix A
- Appendix B contains a note in French explaining the Research committee actions (sent to all in July 2014)
- Appendix C contains the text of the internal call for climate change impacts

Innovation and transfer:
An update of innovation and transfer plan is provided. Page 43
Appendix C contains the text of the internal call for IPSL-SMEs projects

Education:
An update of education plans is provided. Page 53

1. Elements of context, objectives

1.1 Elements of context

The L-IPSL LABEX is a climate change program hosted by the IPSL federation.

The project, as it was approved by the "Investissements d'avenir", has 3 interlinked dimensions:

(a) A project to accelerate research in a few directions which are key to improve our assessment of future climate change (but reversely do not encompass the totality of the IPSL research).
(b) A project to enhance educational actions on climate change.
(c) A project to favor transfer innovative activities from the IPSL to external partners, including emerging companies.

Although their aims differ, there is of course a necessity to maintain a strong consistency between those actions. This document describes mostly the projected research agenda of the LABEX. The interactions between this research agenda and the educational and innovation activities are also underlined.

The program started in September 2011. The initial proposal described a general long-term vision of the LABEX but no implementation plan. Along the first few months a methodology to design that plan was discussed. The agenda of the LABEX was then structured into 3 phases as illustrated below (see Figure 1 below):

- **an initial phase (2011 – mid 2012) where three programs were proposed in order to (i) invite foreign scientists to start working on key issues (ii) initiate or develop collaborations between IPSL and the two new laboratories , and (iii) strengthen IPSL infrastructures (modeling and data bases) which are required for the future LABEX work,**
- **a mid-term phase (mid 2012 –2014) where research projects will be developed; this accounts for all projects started in this period, but projects can continue 1 or 2 years after**
- **a long-term phase (2015 – 2020) where the initial vision will be further developed.**

The long-term phase will in practice be initiated after an open workshop to be held in December 2014, in order to establish the long-term work axes. This workplan (PA2014) is the last of the mid-term phase.

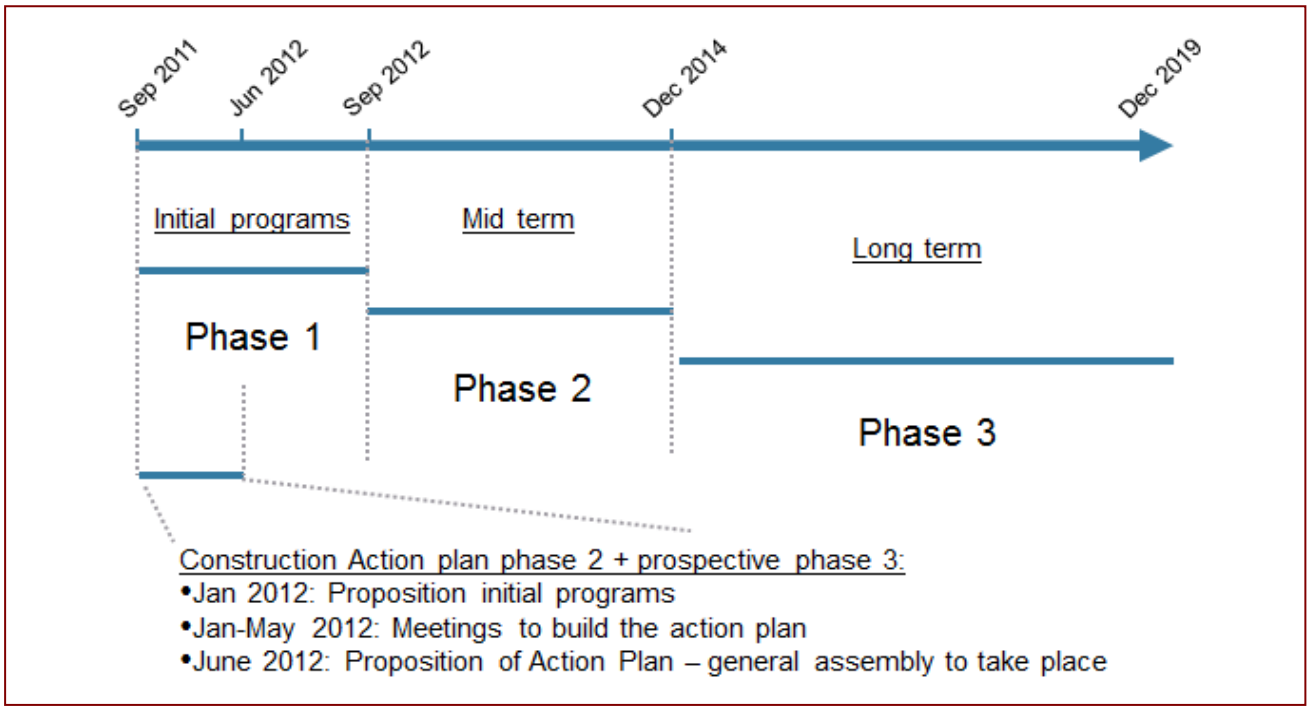


Figure 1: Schematic phases of the LABEX program

1.2 Objectives of this document

The objectives are:

- **to recall the main long-term issues, objectives of the LABEX program,**
- **to summarize the actions decided in the initial phase**
- **to summarize the complete research work that is intended in the mid-term perspective to fulfill the LABEX main objectives,**
- **to report progress made in the ongoing mid-term projects**
- **to propose longer-term issues that should be addressed by the LABEX program, which will be discussed in an open workshop in December 2014**
- **to propose targeted training, innovation and transfer of expertise actions and report current results**

1.3 General objectives of the LABEX as described in the proposal

Mitigation of and adaptation to climate change are among the largest collective challenges that our societies need to face during the next decades and beyond. The last IPCC report stated that global warming is unequivocal and will amplify in the coming decades due to the increase in atmospheric concentrations of long-lived greenhouse gases. The design of adaptation policies and strategies for energy use and production, as well as the management of limited environmental and energy resources require all a rapid increase in our understanding of the climate system and our capacity to predict its evolution with the largest possible accuracy on relevant space and time scales. The LABEX program is designed to provide improved climate understanding and tools, as well as education actions and a strategy for transfer of expertise and innovation based on the skill and tools of the laboratories partners of the LABEX.

For the research program, the LABEX project aims at addressing the following key (broad) questions

(1) How far can we robustly anticipate the future evolution of the atmospheric composition, which depends on a very large number of factors including socio-economic drivers?

(2) How can we determine what is actually predictable in terms of future climate evolution, in a system that combines anthropogenically and other externally induced changes and natural fluctuations?

(3) What are the relations between the global evolution of the climate and its regional consequences?

(4) How much do these local or regional climate evolutions impact environmental resources such as freshwater availability, air quality, and oceanic and terrestrial ecosystem services including the maintenance of biodiversity?

(5) How can we assess the potential impact of unpredictable “climate surprises” that may result from the rapid non-linear behaviour of Earth System components?

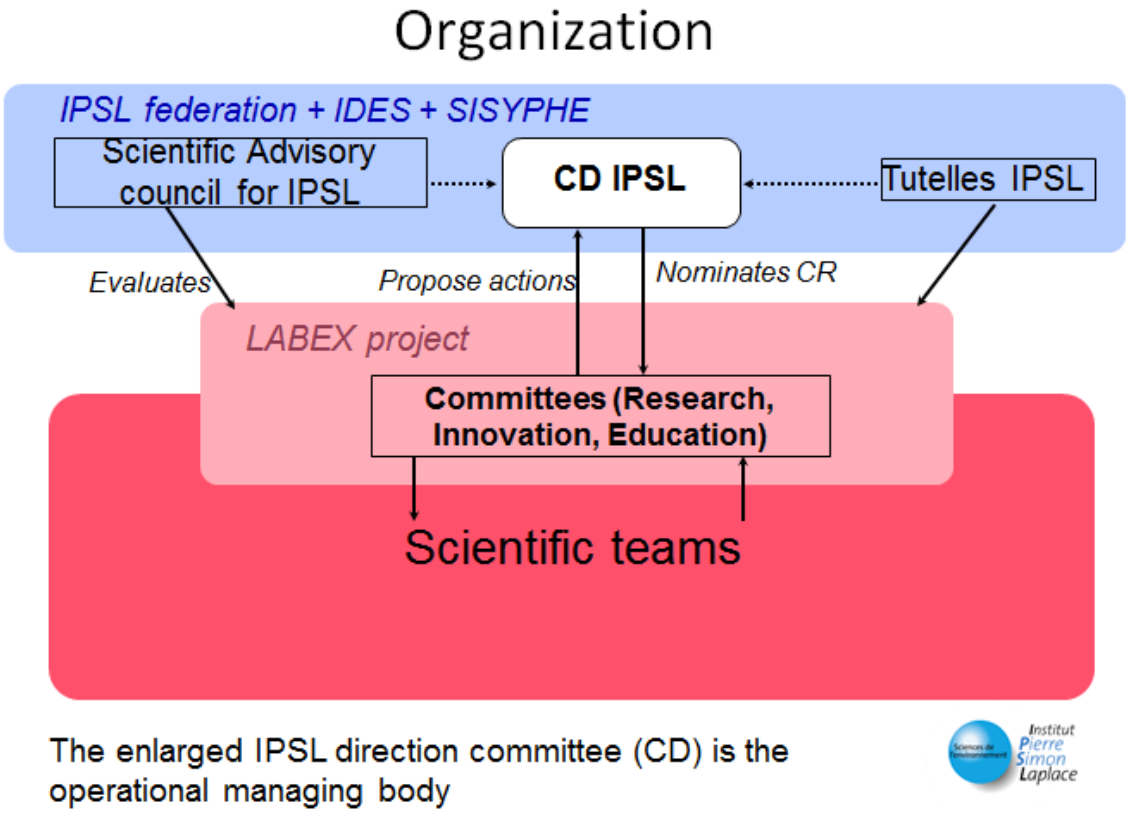
Research is structures in thematic and methodological work packages that address these questions, and rely on existing IPSL infrastructures (modeling, observing strategies) and will benefit from methodological developments for uncertainty estimation.

The LABEX will also develop an important innovation and expertise transfer program, especially in the domains of innovative instrumentation, modeling and toward the development of climate services.

The LABEX will also bridge training and education with the rapidly developing climate science.

1.4 Governance, in a nutshell

The LABEX program is steered by an institutional steering committee (the “tutelles”), advised by an advisory committee which evaluates the program and the strategy. The Direction Committee (CD IPSL) gathers the direction of IPSL, and the managing directors of the partner laboratories. It nominates the members of the internal committees (research, innovation and education), proposing the action plans and are responsible of the LABEX evolution operational management.



Schematic picture of the LABEX organization

1.5 Long-term aims of the L-IPSL

The LABEX project has an important specificity compared to classical projects: it runs over 10 years, which enables to define long-term goals. After the first phase, a number of goals have been identified, which must be progressively updated and specified along the first years. In summary these goals are:

- to strengthen and further develop the research community in the Ile-de-France working on climate change **area by developing coordinated actions and further sharing and mutualizing research tools and data; this will be achieved by fostering coordinated actions on observation and simulation data bases and portals and ways for a better synergetic use of such data; this will also be achieved by developing large-scale research projects using these data**

- to develop a modeling capacity to simulate and predict climate at a spatial scale and with processes allowing impact assessments and adaptation strategies: **this will be achieved by developing new model versions of the IPSL model adapted to the high-performance computing power (new grids such as finite volume on "cube spheres" or "icosahedral grids", new dynamical cores, new tools for i/o), as well as further developing integration of improved physical and biogeochemical processes (C, N and other cycles, aerosols, clouds and convection);**

- to develop an "indicator factory" downstream of model projections, to be used for impact studies and more generally for climate services: **A systematic methodology will be set up by examining impact needs (from existing and new projects), producing the indicators starting**

from global climate projections and downscaling these projections, evaluating these indicators and their uncertainties, and applying impact models in a few selected sectors where LABEX teams have projects using such models;

- to ease the development of new instruments and observation strategies for climate monitoring of essential climate variables: **this includes for instance the development of new lidars measuring both the content of water vapor and aerosols in the atmosphere, or a coordinated strategy on stable water isotopes monitoring; other new observing strategies will also be designed;**

- **to further improve the model / observations integration by improving the capacity of comparing observations and simulations:** on the observation side, this will be achieved by formatting data bases and defining new products better adapted for model comparison, and by studying new processes during field studies. New products in models and simulation data, for instance the development and integration of the stable water isotope evolution modules in all compartments will be included in the coupled model;

- to build education bridges between the continuously evolving research proposed by the labex**, the multi-actor higher-education system, and the increasing demand of knowledge from various sectors of the society about the climate issues.**

2. Research activities

2.1 Long term research aims

Climate change science has long-identified challenges, but the tremendous amount of syntheses and assessments made in the WGI 5th IPCC report brings new ones. Less uncertain projections of climate change crucially rely on more accurate estimations of the climate sensitivity to external forcings. However climate sensitivity results from the complex interplay of direct forcing effect, feedbacks and energy exchanges among all compartments of the earth system. Less uncertain projections also rely on an improved understanding and quantification of climate variability, especially at decadal to multi-decadal scales. Changes at these time scales, such as the recent slowdown in surface warming, hinder accurate estimation of climate sensitivity and attribution of long-term changes. The simulation of regional climate, with phenomena ranging from the meso-scale interacting with the circulation at global scale remains a challenge because of the wide spectrum of scales and processes to be accounted for. For instance the African monsoon region undergoes such poorly understood interactions. A better prediction of regional phenomena such as rainfall regimes is necessary to better estimate climate change impacts that remain highly uncertain in such vulnerable regions.

Given the expertise of LABEX research teams, the major long-term overarching research goals are threefold:

- Provide improved estimates of the climate sensitivity to natural and human driven forcings: **L-IPSL teams have leading expertise in earth system physics, biogeochemical cycles, their interactions and feedbacks. This expertise should allow to better quantify least documented interactions such as interactions between carbon cycle, aerosols, chemistry, the atmospheric circulation, and carbon exchange between several components where uncertainty is large (soil, rivers, …); The expertise in paleo-climate reconstruction and modeling should help quantifying robust feedbacks both in the current and past climates; L-IPSL teams also have sufficient expertise to better document the sensitivity of climate to solar and volcanic forcing, with climate experiments simulating the effects of major volcanic eruptions and solar forcing variations;**
- Provide an improved attribution of recent decadal to multi-decadal changes of the climate to forcings and natural variability: **the expertise in paleoclimate, as well as ocean-atmosphere coupled modeling, the emerging expertise in initialized climate simulations, as well as the online simulation of more interactions with biogeochemical cycles should help characterizing changes at the scale of a few decades, which is particularly relevant to adaptation; the expertise in statistical analysis of climate data should also help to develop detection and attribution studies in combination with modeling experiments. In particular, these combined studies should lead to understanding the mechanisms involved in the recent slowdown of surface temperatures;**
- Provide better and more reliable projections of climate and related impacts in a few key sectors at both global and regional scale: **the expertise in climate modeling and impacts of climate change is present or emerging in several L-IPSL teams. For instance, the impacts of climate on ecosystems, water resource, agriculture and energy is an expertise that has grown through several projects over the past decade. The large participation to CORDEX exercise has demonstrated the growing involvement of L-IPSL teams in regional climate modeling. This should enable major advances in the framework of the LABEX, as concerns the implications of climate change in several regions of the world, including the national level. At a more fundamental level, a deeper understanding of the interactions among regional processes and between regional and global circulations is necessary, and the best way to model these interactions should be identified. The development and a larger use of zoomed, coupled versions, with nudging possibilities, of the IPSL-CM model, used in combination with other regional models (WRF, MAR) should help this.**

2.2 Summary of research post-doctoral project status for mid-term phase

(orange=PA2012; blue=PA2013; grey=PA2014; pink=extensions asked in PA2014; darker grey=reported from previous PA)

Project number and short title	P.I. + date decision	Contact CR & WP	Dates & Status	Short description
1 Carbon in rivers	P Ciais 2012	A Ducharne WP1-WP4	Jul 2013 – Jun 2015 ongoing	2-Year post-doc Modeling the C cycles in rivers with ORCHIDEE
2 Volcanism	M Khodri 2012	E Guilyardi WP2	Sep 2013 – Aug 2015 ongoing	2-Year post-doc Climate impacts of volcanism in the last millennium and modeling
3 Impact indicators	B Sultan 2012	P Braconnot A Ducharne WP4-WP3-TWP3	May 2013 – Apr 2015 ongoing	2-Year post-doc Construction and evaluation of climate impact indicators
4 Chronology	A Landais 2012	F Bassinot WP5	Oct 2013 – Sep 2014 ongoing	1-Year post-doc (+6 month) construction multi-archive chronologies
5 Arctic portal	K Law 2012	K Law TWP2-WP3	Sep 2013 – Aug 2014 completed	1-Year engineer arctic data portal gathering data & information
6 Isotope database	V Masson-Demmotte 2012	C Colin TWP2-WP5	May 2013 – Apr 2014 extension 5+6 months	1-Year post-doc Web portal on data paleo archives +5 month + 6 month
7 CMIP5 data	S Denvil 2012	JL Dufresne TWP1	Oct 2013 – Sep 2014 Completed	1-Year post-doc Facilitation of access to CMIP5 data
8 W Africa Climate change	S Bastin 2013	F Hourdin WP3	Oct 2014 – Sep 2016	2-Year post doc How climate models simulate W African climate
9 Climate sensitivity and clouds	S Bony 2013	JL Dufresne WP2	Sep 2014 – Aug 2015 ongoing	1-Year post-doc on cloud feedback processes in the LGM
10 Migrations of Zooplancton	L Bopp 2013	M Gehlen WP1-TWP1	Sep 2014 – Apr 2015 ongoing	8-month post-doc on carbon cycle and migration of zooplankton
11 IPSL-CM6	O Boucher & JL Dufresne 2013	JL Dufresne TWP1	Mar 2014 – Feb 2015 ongoing	1 year Post-doc on radiative transfer modeling, 0.5 year on air-sea coupling
12 Stretched model version	JL Dufresne & F Hourdin 2012	JL Dufresne TWP1	Oct 2014 – March 2014	6 month post-doc to develop and customize the use of a stretched version of IPSL-ESM
13 SIRTA data reconstruction	M Chiriaco 2013	M Haeffelin TWP2	Nov 2014 – Oct 2015	1-Year engineer on reconstructing all data from archived SIRTA observations
14 Impact of dust on IR radiation	P Formenti 2014	B Marticorena WP1	Oct 2014 – Sep 2016	2-Year post-doc on determining the IR radiative impact of dust aerosols
15 Impact of CC on river nutriments	V Thieu	TBD		1.5-year post-doc on impacts of CC on river nutriments
16 Ocean acidification	D Dissard	TBD		1.5-year post-doc on impact of CC on acidification

2.3 Contribution of Work Packages to the LABEX objectives

- ***Work Package 1: Factors controlling the atmospheric composition***

Main objectives and strategy

The future evolution of the Earth's radiative forcing will depend upon anthropogenic activities, reflecting economic development pathways and the structure of energy production systems, as well as the response of natural biogeochemical cycles.

Over the past two decades, 80% of the increased radiative forcing of long lived greenhouse gases is caused by the emissions of CO2 from fossil fuel burning and land use change. This illustrates how crucial is the **carbon cycle in controlling the future rate of climate change**. Roughly half of the current anthropogenic CO2 emissions are absorbed by natural sinks in the ocean and in terrestrial ecosystems. But models of the coupled climate-carbon system consistently predict that future climate change will reduce the ability of natural sinks to continue to absorb anthropogenic CO2.

Like the carbon cycle, **other long lived greenhouse gases** with a global warming effect, CH4 and N2O, also have an anthropogenic and a natural component linked to land and ocean biogeochemistry and to atmospheric chemistry. The evolution of these two components in response to climate and atmospheric composition changes is important to quantify and understand, including the underlying processes.

Short-lived aerosols and reactive gases are produced by a variety of processes and transported away from emission regions. Unlike long lived greenhouse gases, these species exert a regional climate forcing, which can be either positive or negative in the case of aerosols. Locally, the climate forcing of aerosols and reactive gases can be larger in magnitude than that of greenhouse gases. Measures to improve air quality worldwide may release the 'aerosol brake', and foster the warming induced by greenhouse gases. Some aerosols like nitrates, ammonium, and mineral dust containing iron and phosphorus also exert a "fertilizing" effect over ocean and terrestrial ecosystems where they are deposited, generally increasing productivity. Increased productivity can result into more efficient CO2 sink, but can also yield to higher CH4 emissions by wetlands. In some instances, however, excess deposition of nitrogen will lead to decline of productivity in polluted regions, and sulfate deposition may inhibit CH4 emissions in wetlands.

The goal of WP1 is to coordinate and develop research on the evolution of atmospheric long-lived greenhouse gases, CO2, CH4, N2O and aerosols and reactive gases at IPSL, both for observations and for modelling. Specific focus will be given to interactions between aerosols and greenhouse gases, and the attribution of changes in biogeochemistry induced by aerosols, and in a second phase, by reactive gases as well.

Mid-term actions

Over the next 2 years, WP1 will focus on four main actions:

Action 1: Improved budgets of greenhouse gases and aerosols to reduce uncertainties on sources of radiative forcing over the globe, with emphasis on selected regions

We will use atmospheric inversion models, forward atmospheric chemistry transport models and observations to reduce uncertainties on key sources of radiative forcing for selected regions of interest, and underlying processes. As a contribution to mid-term issues 2, 3 and 4, Focus will be given to CH4 emissions in the Arctic from fires, permafrost, wetlands and anthropogenic activities, in linkage with the 'Chantier Arctique' national activities, the phase-A of the CNES-DLR MERLIN satellite mission, and using available in-situ (ICOS), campaigns (YAK, CLIMSLIP), and satellite observation (IASI, GOSAT). The second process investigated will be organic aerosol emissions and transport in the Mediterranean region (CHARMEX). The third proposed activity will analyze radiative forcing trends over Asia caused by multiple anthropogenic actions including emissions of greenhouse gases, land use change, reactive gases (NOx, Ozone) and aerosols emissions, and indirect effects of aerosols such as black carbon deposition on snow.

Results

This action is taking place in the three selected regions (Arctic, Mediterranean region, and east-Asia), but mostly taking stocks of other projects. Action 1 has thus been recently re-oriented and re-focused (decision of the Comité Recherche June 2014) towards a more precise estimation of the direct radiative effect of mineral dust aerosols. Mineral dust is indeed one of the most abundant aerosol species in the atmosphere and strongly contributes to the total aerosols content. At the present time, large uncertainties still exist in the estimation of the dust radiative effect and its atmospheric and climatic impacts.

To improve the accuracy on our estimate of dust aerosol radiative forcing, a 2-step project has been designed and will be funded by L-IPSL through a 2-yr postdoctoral contract (starting end 2014, and working in –between LISA and LSCE). In the first step, experiments performed in the CESAM simulation chamber at LISA will help develop new parameterizations of the dust infrared optical properties as a function of mineralogical composition and size. In a second step, these new parameterizations will be integrated in LMDzOR-INCA coupled to the new RRTM radiative module and simulations will be performed to analyze climate sensitivity to the dust radiative effect.

Resource needed: *2-Year post doctoral position (starting end 2014)*

Action2: Attribution of the radiative forcing of long-lived GHG, aerosols and short lived gases to underlying mechanisms.

We will use models to attribute observed global and regional radiative forcing changes to emissions and sink processes. This activity will first focus on the **interactions** between the biogeochemical cycles of climate forcing agents, in particular the climatic and biogeochemical (fertilizing) effects of aerosols and reactive gases on the carbon cycle and on natural ocean and terrestrial fluxes of CO2, CH4 and N2O (e.g. climate cooling induced by sulfate aerosols effect on land / marine productivities, the carbon cycle and atm. CO2). Specific focus will be given to the effect of climate,CO2 and aerosols on variability and trends of the productivity of marine and terrestrial ecosystems.

Results

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Results

This action has started in 2013-2014 with the visit of N. Mahowald (Cornell University) for 12 months at IPSL (LISA, LATMOS, LSCE). N. Mahowald is a world-leading expert in earth system modelling and has been one of the first to show the potential effect of aerosols on the global carbon cycle through their cooling effect on climate and their fertilizing effects on both the land and the ocean biosphere (Mahowald et al. Science 2011).

Her visit has triggered fruitful discussions between L-IPSL teams. Recent work on this action includes the PhD work of T. Gasser (CIRED & IPSL-LSCE) and the development of OSCAR, a simplified but comprehensive model of the carbon cycle (Ciais et al. Nature Climate Change 2013). Several simulations using OSCAR, and presented in T. Gasser's thesis, have demonstrated the potential role and associated uncertainties of these key feedbacks linking aerosols and the global carbon cycle.

Finally, a recent Marie-Curie Fellowship has been obtained by R. Wang at IPSL-LSCE, targeting the question of the fertilizing effect of aerosols (ammonium aerosols and iron-dust) on the terrestrial and oceanic biomass. To do so, R. Wang plans to combine key components of the IPSL earth system model (the INCA model for the aerosols modelling, the ORCHIDEE and PISCES models for the land and ocean biosphere respectively). The project has started in July 2014 and will last 2 years to July 2016.

Action 3: Incorporation of the aquatic loop of the carbon and nitrogen cycle in the IPSL Earth System Models

The transport of C (DIC, DOC, POC) from soils to river headstreams up to the coastal ocean is a large global lateral flux of carbon, commensurate with the land and ocean sinks of atmospheric CO2. An increasing number of measurements are being collected for diverse river basins. We propose to incorporate a simple version of C (and in a second step N) transport by rivers into the routing scheme of the ORCHIDEE land surface model and to calibrate the global model with emission factors from soils estimated from data mining and synthesis of literature data (in particular regarding the age of exported C). The process of CO2 outgassing by freshwater systems and burial of C in lake sediments will be included in a simplified manner. Effects of land use and climate changes in the export of C and N from land to oceans will be studied for different scenarios, and used to force the ocean biogeochemistry model PISCES. The development of a higher resolution version of the NEMO-PISCES model, in the context of a collaboration of L-IPSL with the Labex-Mer, will greatly benefit to this action.

Results

This action has started in 2012 with the visits of Peter Raymond (from Yale University) and with the hiring of a post-doc researcher (Rony Lauerwald) who is working with L-IPSL teams since July 2013.
The main outcome of P. Raymond visits is a Nature article published in 2013, led by Raymond himself and including co-authors from IPSL-LSCE and SISYPHE (now IPSL-METIS), in which they estimate the contribution of inland waters to the global carbon cycle. In this study, Raymond et al. have combined a new data set of CO2 partial pressure from lakes, streams and rivers, as well as new methods to estimate the global stream surface area and gas transfer velocities. They obtain global CO_2 evasion rates of 1.8 PgC per year from streams and rivers and 0.32 PgC per year from lakes and réservoirs. The resulting global evasion rate of 2.1PgCyr^{-1} is higher than previous estimates owing to a larger stream and river evasion rate. This new analysis also identifies global hotspots in stream and river evasion, with about 70% of the CO_2 flux occurring over just 20% of the land surface.
The second step of this action, incorporating carbon into the routing scheme of the land surface model ORCHIDEE, is now taking place thanks to the work of R. Lauerwald and the L-IPSL teams. The work is conducted in between IPSL-LSCE, IPSL-METIS and a research team of the Université Libre de Bruxelles (ULB) in Belgium. The work is progressing well and the first results have been presented to the Comité Recherche Labex in June 2014.

Finally, the initial funding from the L-IPSL, as well as the close collaboration between IPSL teams and ULB on this topic, has led to the preparation of a proposal on the transfer of carbon between land and ocean at planetary scales, which has been submitted to the 2014 Initial Training Network call from the EU commission (April 2014). The proposal has been accepted; 2 PhD students and 1 post-doc researcher will be funded at IPSL through this proposal on (1) C-cycle modelling in rivers and streams, (2) CO2 measurements in rivers and streams, (3) C-cycle modelling in the Arctic Ocean influenced by riverine carbon discharge.

Action 4: On the role of diurnal vertical migration of zooplankton on the marine carbon cycle: incorporation in the IPSL earth system Model

The diurnal vertical migration (DVM) of zooplankton is a widespread phenomenon in the marine environment. Conventionally, zooplankton is at the surface during the night and goes down to several hundred meters at dawn. These migrations may have an impact on the biogeochemical fluxes of nutrients, carbon and oxygen. Migrant organisms will generally feed on the surface, but they excrete, respire, produce fecal pellets and die at depth, inducing a vertical transport of nutrients and carbon from the surface to the subsurface. This could increase the efficiency of the carbon pump. Numerous studies have shown the importance of this active transport, that could contribute up to 10-30% of the global carbon export.

The opportunity to co-design a ocean-focused project with the Labex Mer "A changing Ocean" (at the Université Bretagne Occidentale) has led the Comité Recherche to propose to work on the incoporation of zooplankton diurnal migration in the PISCES model (marine biogeochemical component of the IPSL earth System Model).

Resource needed : To do so, a 8-month post-doctoral researcher (incl. 4-month funded by L-IPSL) has been hired to work on the role of these diurnal migrations in a changing climate. The project just started in September 2014 and wiil be detailed in the next Plan d'Action.

▪ *Work Package 2: The predictable part of climate for the next decades*

Main objectives and strategy

A large component of the recent global warming is now attributed to human activities. Global warming will continue during the next decades at a rate depending primarily on the anthropogenic emissions discussed in the previous section. However, the mechanisms and the respective role of internal variability, of natural or anthropogenic forcings on most aspects of recent climate changes (such as sea-ice decrease in the Arctic or precipitation changes in the Sahel) are currently not established. This lack of understanding limits our ability to predict climate evolution over the next few decades.

For the future, the predictability of regional climate for the next decades to century will primarily depend on: (1) the response to changes in long-lived greenhouse gases; (2) the response to regional changes in aerosols and other short-lived species; (3) the low-frequency modes of natural variability. The goal of WP2 is to coordinate and develop related research at IPSL, both for observations and for modelling, with a focus on three related key objectives:

- Quantify and understand the internal and natural variability of climate**. Understand climate fluctuations (e.g. AMOC, ENSO, …), their dependencies on the mean climate state and their response to external forcings (GHG, sun, aerosols,…). A specific effort will be devoted to the study of the last millennium, a period for which decadal to sub-decadal climate variations may**

be reconstructed from various natural archives, and for which some estimates of forcings associated with solar variations and volcanic eruptions are available.

- Quantify and understand climate changes due to anthropogenic forcing. **The primary mechanisms involved in the spread of climate feedbacks, in particular those due to radiative feedbacks will be explored in order to improve our estimate of the amplitude of climate change in response to external forcings. We will also investigate how climate parameters and phenomena (e.g. tropical precipitation change, AMOC, ice sheets dynamics, storms, heat waves,…) will change with temperature and forcings..**

- Predict and assess climate changes at decadal time scales. **Unravelling the respective contributions of external forcing and internal variability in the recent and future decadal change requires to (i) to identify and assess mechanisms that drive climate variability and trend and (ii) to increase our confidence in climate change projections. A joint development and use of global earth system models and observations will help both the detection and attribution of these decadal signals. The possibility to forecast the predictable part of the next decades will be explored using a combination of historical and initialised simulations. For such timescales, the slow components of climate models (ocean, sea-ice,…) need to be initialized near observations and the L-IPSL will seek to develop new methodologies and select appropriate observations. New approaches will include perfect model studies to better understand the mechanism at work in the models (beyond the issues related to model errors, lack of data, and the combination of different sources of external forcing over the last 50 years).**

Mid-term actions

Over the next 2 years, WP2 will focus on four main actions:

Action 1: The role of volcanic and solar forcing

Volcanic forcing has been shown to be a major driver of decadal variability and predictability both in recent decades and during the last millennium, in particular in the North Atlantic and for the AMOC (eg Booth et al. Nature 2012). Before this action, the physical and chemical representation of volcanoes in the IPSL model was too simplified to 1) explore the mechanisms by which volcanoes can provide a source of climate variability and 2) compare to the many related observations available at IPSL. The goal of this funded action is, first, to adapt an existing 2D model of the microphysics of stratospheric volcanic aerosols (LATMOS) to the 3D IPSL GCM (LMD) and, second, analyse the resulting simulations for the last decades and last millennium (LOCEAN, LSCE), with a focus on North Atlantic THC variability and predictability. Below is a summary of the work undertaken and future plans. This action is also a contribution to TWP1.

Results

The first 12 months (Sept-13-Sept14) of the project were dedicated to improving and re-evaluating the microphysical model (Bekki et al, 1994) against observations (CCMI, satellite observations; balloons, etc) and implement the computed aerosols radiative properties in the IPSL model solar spectral bands and atmospheric model grid (M. Khodri, O. Boucher). An ensemble simulation was performed first for the Mt Pinatubo eruption to evaluate the model skills. The results being in good agreement with observations, several additional ensemble simulations were performed for Samalas and Tambora. An important re-assessment of ice-core data was performed to define realistic scenarios of SO2 injection into the stratosphere. This approach allowed exploring the range of uncertainties arising from analyses of sulphate deposition in multiple ice cores. We also explored the uncertainties related to the season of eruption and the altitude of the volcanic plumes deduced from plumice fall deposits. To help evaluate our results we've initiated collaborations with Swiss (U. of

Geneva) dendro-climatologist and historians working on historical documents and improved temperature reconstructions for the last 1500 years based on an unprecedented network of tree-ring series. For the first time, tree-ring proxies and climate simulations yield similar magnitudes for northern hemisphere summer cooling over land induced by these eruptions, estimated between –0.8 and –1.3°C. Our results indicate the importance of a correct representation of climate sensitivity in models, and challenge both earlier temperature reconstructions and climate simulations performed with simplified reconstructions of large volcanic eruption forcing. This study was submitted to Nature (Stoffel M et al. 2014).

We also developed idealized experiments aiming at exploring the range of climate sensitivity to the magnitude (amount of SO2 and altitude of the volcanic plume), latitude and season of eruptions. We performed several ensemble simulations by injecting 1, 3, 10 and 30 times the SO2 amount of the Mt Pinatubo eruption. The SO2 buoyancy, transport, conversion into aerosols, coagulation, gravitational settling etc., were systematically evaluated. Climate simulations reveal that there is no universal linear relationship between the global cooling and the magnitude of the eruptions due to self-limiting microphysical processes and stratospheric dynamics. These processes explain the relatively weak cooling on global average that never exceeds 2°C for the very large eruptions and the strong spatial heterogeneity of temperature anomalies (Poulain V, M. Khodri, M. Marchand & S. Bekki, Stratospheric dynamics and micro-physical processes confines climate responses to volcanic mega-eruptions, to be submitted). We aim now at providing thorough forcing reconstructions for major volcanic eruptions (13th and 19th century) and contribute to the on-going effort to reduce the large uncertainties regarding the climatic responses to volcanic forcing identified in CMIP5 simulations.
Within this context with recently sent to V. Eyring (Chair CMIP/WCRP) an application for a Model Intercomparison Project on the climatic response to Volcanic forcing (VolMIP) as CMIP6-Endorsed MIP (Co-chairs: D. Zanchettin C. Timmreck and M. Khodri. Scientific Steering Committee: G. Hegerl, A. Robock, A. Schmidt, M. Toohey and E. Gerber). Our actions for 2015 will consist in evaluating aerosols interactions with both solar and terrestrial spectral bands (involving O. Boucher) and ozone chemistry (LMDz-Reprobus).

Action 2: The use of observations of past decadal variability to validate models

The use of observations of past decadal variability to validate models, in particular the use of deep corals in the North Atlantic will be investigated. This will require synchronisation both in time and across variables in climate archives. The L-IPSL is uniquely placed to make significant progress in this area, initially involving experts from IDES, LOCEAN and LSCE. This action requires more meetings in the next year to mature into specific integrating action (cf HAMOC ANR, MISTRALS/PALEOMEX).
The second aspect of the project will concern the detection and attribution of decadal changes. This requires (1) the development of statistical methods expertise to detect changes in decadal variability both in observations and in models and (2) to distinguish two time horizons: 30-40 years for which the external forcing dominates and 10-20 year which requires initialised deterministic simulations.

The ANR HAMOC was successful and will contribute to this topic. A postdoctoral position is starting in Dec 2014 on the acquisition of geochemical recordings of North Atlantic deep corals (measuring the variability of hydrology in the NE Atlantic). A new set of SSTs and sea ice data from the LEFE/NAIV project and from the IGBP/PAGES international working group Ocean2k LR will be used for new data / model cross-analysis.

Action 3: Climate sensitivity, climate forcing and climate change amplitude

This action will seek to understand what are the mechanisms that primary explain the spread of climate feedbacks. The following mechanism will be explored: clouds, cryosphere, climate-carbon, etc. and how to estimate and access them. The sensitivity of climate change to different forcing agents and mitigation policies (GHG emissions, aerosols emissions, land-use,...) will also be explored (LMD, LSCE,…).

Specific integrating actions have included (1) the invitation of international experts such Isaac Held from GFDL (Princeton USA) who gave a series of well attended lectures and seminars at IPSL, and Aiko Voigt (Columbia University) to start a collaboration on the role of clouds and aerosols in the atmosphere circulation, with one study already published (Voigt et al. 2014), (2) the support of IPSL leadership in WCRP Grand Challenge on "clouds, circulations and climate sensitivity" and namely the invitation of experts and the travel of IPSL experts to the related WCRP workshops, and the upcoming organization of a paleo-cloud workshop, and (3) the study of cloud-circulation feedbacks, especially in tropical regions, and using both recent past, future, paleo or idealized simulations (CMIP5, PMIP3, CFMIP) within a postdoctoral project. Two one-year post-docs are associated to this action. A first one has been hired and is starting in Oct 2014 (in conjunction with a one year WP3 postdoc grant), working on the local and remote factors that influence the variability and sensitivity of the African monsoon (LATMOS/LMD collaboration). The second postdoc (who started in Sept. 2014) is working on the role of cloud processes on ITCZ shifts in past climates, notably during the mid-Holocene and the last glacial maximum.

Action 4: Large-scale patterns of climate change and impact on climate phenomena

The large-scale patterns of climate change (global circulation changes, precipitation, weather regimes, storm tracks, drought, heat waves, etc.) will be analysed to infer what element of predictability they provide for the next decades, considering again two time horizons. The impact of climate change on climate phenomena (Monsoons, ENSO, etc.) will be specifically addressed (LMD, LOCEAN, LSCE,…). Specific integrating actions will be decided on the basis of several meetings.

Reporting on this action will be done in the next action plan update.

Action 5: Initialization methods for coupled climate models

The development and validation of initialisation methods for coupled climate models using both the historical set up and associated observation and a perfect model set up to understand mechanisms will be further developed for the IPSL model.

Results

Results obtained show the key impact of sea surface salinity nudging used in conjunction to SST nudging to reconstruct the sub-surface ocean decadal variability in a perfect model framework (Servonnat et al. Clim. Dyn. 2014). The extension of this work to the historical context has confirmed the results obtained in perfect model and has shown the limits of evaluating the reconstructed tri-dimensional ocean of the last decades due to the paucity of data and a lack of agreement between ocean re-analysis (Ray et al. Clim. Dyn, revised). Current work within the SPECS project seeks to study the impact of wind nudging (both via surface wind stress and 3D wind nudging) in addition to that of SST and SSS. Beyond ocean initialisation, we will explore sea-ice and land surface initialisation. This action will be done via projects (GICC, ANR, EU) meetings and workshops.

Links to other projects

The following projects will provide effort towards the WP2 actions in the next two years:
National: MISSTERRE (LEFE/IMAGO, CNRS/INSU), NAIV (LEFE/IMAGO, CNRS/INSU), EPIDOM (GICC, end in 2013), ANR (Green Greenland, 2011-1014, HAMOC, MORDICUS)
EU: SPECS (FP7, 2013-2017), EUCLIPSE (FP7, 2010-2013), COMBINE (FP7, 2009-2013), EMBRACE (FP7, 2011-2014).

- ***Work Package 3: Regional implication of global warming***

Main objectives and strategy

The overarching objective of WP3 concerns the characterization of the implications of global warming in terms of regional climate changes as experienced by the human societies is needed to make appropriate adaptation decisions. WP3 will focus on the existing strengths of L-IPSL in terms of expertise (the water cycle, the biogeochemical cycles, and their interactions) and tools (observatories, space-borne observations as well as global and regional modeling – CMIP5 & CORDEX). Enhanced knowledge on how regional climate can also impact global climate will be achieved by assessing the role of mesoscale and regional processes in climate projections.

Disciplinary advances regarding the comprehension of the processes responsible for the changes for key climatic variables currently observed, and their evolution as inferred from climate projections will be developed. The role of regional changes driven by local feedbacks (hydrological coupling, clouds, aerosols, land cover and land use, regional water bodies) must be addressed and weighted against the large scale processes (interactions with the ocean, greenhouse gases, tele-connections, …).

WP3 will benefit from the momentum created at IPSL by the international CORDEX exercise and participate to international inter-comparisons, studies using model ensembles, with four regions of focus, where IPSL participates to CORDEX: Europe, the Mediterranean region, Africa and South America. From the corresponding simulations, a synthesis of issues raised within the exercises will be carried out and more general regional modeling bottlenecks will be identified.

WP3 will also provide capacity building for L-IPSL laboratories on climate change implications at the regional scale, as for instance advice on the use of projections on at regional scales and guidance for selecting model simulations and also improving models.

Mid-term actions

Action 1: Intermediate scales issue

WP3 will assess the relevance of high resolution modeling for the investigation of the regional implication of global warming at intermediate scales (i.e. scales covered by both global and regional models, 30-50 km). This issue is particularly critical for precipitation regimes over the Sahel region but also on other regions such as Europe, for which neither GCMs nor limited-area models are currently able to cover all concerned spatial scales. Regional models are designed to represent mesoscale processes and surface conditions more realistically than GCMs. However, since they are area limited they lack the climatic feedbacks at teleconnections present in global models. ***The overarching question is which type of model should be given more credit when applied at intermediate scales?*** Existing CORDEX runs will be used to assess the impact of dynamical downscaling on key climatic variables (with TWP1 and TWP3) and impact indicators (with WP4) by comparison with CMIPS5 runs. Advanced knowledge will be gained through this exercise for instance on the necessity to guide or nudge regional models using global models.

This action will contribute to the long-term goal aiming “to strengthen and further develop the research community in the Ile-de-France working on climate change by developing coordinated actions and further sharing and mutualizing research tools and data”.

Results

The work will be based in part on the multi-model analysis of CMIP5 simulations (in order to identify robust mechanisms and features), benefiting from the fact that the same model has been used for past climate, historical simulations and climate change projections. A particular focus will be put on the analysis of the radiative forcing (CO2 and aerosols) and feedback (water vapor) over the Saharan heat low. To test physical hypotheses about the role of these forcings and feedbacks on climate change over West Africa, the analysis of existing simulations will be complemented by dedicated simulations with the LMDZ atmospheric general circulation model, which is the atmospheric component of the IPSL Coupled Model (involved in CMIP5). The model can be run either in global mode or zoomed over a particular region of the globe. It can be run either in climatic mode or "nudged" toward the large scale dynamics of the reanalysis or the results of another simulation. The LMDZ physical package has also been coupled to the dynamics of the WRF regional model, which will allow testing the use of limited area model without modifying the physics. This suite of configuration will be used 1) to separate local feedbacks from large scale couplings (using nudging or not at the boundary of the domain, or imposing idealized diabatic heating like albedo patches over a region, or more or less interactions with surface), and 2) to perform big-brother experiments to compare and assess the strengths and limitations of different downscaling approaches: a reference simulation run with a fine global regular grid is used as a reference (or model truth) for various approaches (zoom with or without nudging, limited area versions). This work will be starting on October 1st with the hiring of Marco Gaetani as a Labex post-doctoral fellow.

This action will further benefit from the organization of a workshop on "Understanding climate change in West Africa" by Serge Janicot in 2015, possibly as a parallel session of the International Conference "Our Common Future Under Climate Change" which will be held in Paris (France) on 7-10 July 2015.

Action 2: Climate variables and indices for impact-oriented indicators

The aim is to build the bridge between the output of climate and regional models, on the one hand, and environmental variables that are relevant for impact assessment, on the other hand, whether they relate to the mean state of the environment (e.g. ecosystem productivity, water resources) or extreme events (e.g. frequency, intensity, persistence of floods, droughts, heat waves, blocking, cyclones). This will be achieved via brainstorming workshops with WP4. An attempt will be made to define the best indicators for a variety of impact studies covering a wide spectrum of applications, namely agriculture, water resources, renewable energies, pollution, health, food security, etc…

Once defined, CMIP5 downscaled by CORDEX regional runs with possible further statistical downscaling will be used to construct the above-defined indicators and analyze their trends. The analysis on impact indicators will be conducted is some key regions, namely West Africa, South America, the Mediterranean region and Europe, which are the regions for which CORDEX experiments were made at IPSL. This action will contribute to the long-term goal aiming "to develop an "indicator factory" downstream of model projections, to be used for impact studies and more generally for climate services".

This action is currently taken by WP4

Action 3: Development of a theory for land-ocean-atmosphere coupling on decadal time scales

Dust emitted from the Sahara and Sahel regions of Africa vary on time scales ranging from hourly to decadal, and influence the climate of the tropical and subtropical Atlantic via changes to the radiative budget at the surface through the top of the atmosphere. It is also known that the physical state of the Atlantic Ocean influences the regional atmospheric circulation, and thus the hydrological cycle over Africa. In theory these changes in the circulation and the hydrological cycle should affect dust

emission, thereby establishing a regional coupling of ocean-atmosphere-land surface processes, but to-date no such coupled theory has been developed or tested.

We propose to identify the two-way relationship between regional climate variability and mesoscale processes over the Sahara-Sahel region of Africa via a combination of observational analysis and modeling studies. This action will contribute to the long-term goal aiming "to further improve the model / observations integration by improving the capacity of comparing observations and simulations".

Results

This action has been fostered by the visit of Amato Evan (during initial LABEX phase, see above). We first evaluated African dust in 23 state-of-the-art global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (including the IPSL model). We found that all models fail to reproduce basic aspects of dust emission and transport over the second half of the twentieth century (Evan et al., 2014). The models systematically underestimate dust emission, transport, and optical depth, and year-to-year changes in these properties bear little resemblance to observations. These findings cast doubt on the ability of these models to simulate the regional climate and the response of African dust to future climate change. The tools developed for this work will be used in a collaborative framework to assess whether the new developments in the IPSL model linking deep convection and wind bursts (in-turn leading to enhanced dust emissions) can overcome this deficiency and lead to more realistic year-to-year dust load variability over the Africa and the adjacent water bodies.

Another major research result stemming from Amato Evan's visit was to demonstrate that, via the greenhouse effect, small changes in water vapor in the atmosphere over the Sahara Desert alter the thermodynamic structure of the Saharan Heat Low, thereby modifying the monsoon circulation and precipitation across the Sahel (Evan et al., 2014, accepted in J Clim). We have shown that when forced by SST alone, most state-of-the-art climate models do not reproduce a statistically significant upward trend in Sahelian precipitation over the last 30-years, and that those models with a significant upward trend in rainfall seem to achieve this result for disparate reasons. We examined the role of the Saharan Heat Low (SHL) in the recovery from the Sahelian drought of the 1980s. Using observations and reanalysis we demonstrated that there has been an upward trend in SHL temperature that is coincident with the drought recovery. A heat and moisture budget analysis of the SHL suggested that the rise in temperature is due to greenhouse warming by water vapor, but that changes in water vapor are strongly dependent upon the temperature of the SHL; a process we termed the Saharan WAter vapour-Temperature (SWAT) feedback. We have shown that the structure of the drought recovery is consistent with a warming SHL, and is evidence of a fundamental, but not exclusive, role for the SHL in the recent increase in Sahelian monsoon rainfall. Efforts on this action will continue with a focus on the concomitant and maybe competing impact of mineral dusts on the structure of the SHL. Accompanying the drought in Sahel there was an increase in dust advected off West Africa and presumably an increase in dust over the continent (Evan et al. 2014). However, it is not clear how dust within the SHL may have changed over this period, particularly as the SHL is a persistently dusty region, nor is it clear if dust here has a net cooling or warming effect; the SW scattering may be completely balanced by the LW warming, and the LW warming is very sensitive to the microphysical properties of the over-land dust.

Action 4: Process level feedbacks and interactions in the Arctic region

Clear evidence for climate change is being observed at northern high latitudes in the form of diminishing summer sea-ice extent, thawing permafrost and changes in the Greenland ice sheet etc. Anthropogenic forcing, both local and remote, is clearly playing a role but complex interactions with

natural physical and biogeochemical cycles in the atmosphere, ocean and cryosphere make changes in this region difficult to predict with current climate models. Here a key aim will be to better understand the contribution of anthropogenic activities to Arctic climate change and the feedbacks between atmospheric composition/dynamics, and ocean, cryosphere processes. This will be tackled using a combination of high resolution modeling coupled to data analysis and make use of the Arctic data portal developed in TWP2. One aim is to better use existing datasets to evaluate regional/global climate model performance at IPSL in the Arctic region, a topic of importance discussed in the modelling section of the Chantier Arctique prospective. Specific processes such as the impacts of aerosols will also be examined. A workshop will also be held to identify and develop cross-cutting research topics at the level of IPSL and in coordination with developments as part of the Chantier Arctique. This action will contribute to the long-term goal aiming "to further improve the model / observations integration by improving the capacity of comparing observations and simulations" as well as "to strengthen and further develop the research community in the Ile-de-France working on climate change" in the Arctic.

For example, a first step towards enhanced knowledge of the processes impacting global warming at high latitudes will be undertaken through a synergetic approach involving observations and models, both in the laboratory (at L-IPSL) and in the field (e.g. Siberia).

This task has benefited from the visit of Steve Clifford in the initial LABEX phase, as well as that of Jerome Fast (PNNL) who visited LATMOS to foster collaborations in the field of regional chemical/aerosol modeling and aerosol-cloud interactions. This action further benefitted from the visit of Steven Reising (Colorado State University) who visited LATMOS for 6 months to work on atmospheric water vapor related process in the Arctic.

Results

This action will continue with:

- *a second visit of Amato Evan, scheduled June-July 2015, one month of which will be dedicated to the analysis of the cycle of mineral aerosols in the Arctic from observations and modeling tools available at IPSL (among others),*
- *the organization of an Arctic workshop by K. Law and J.-C. Raut (and others) representing the IPSL Pôle "Climats et Environnements Regionaux" during the first semester of 2015. The aim of the workshop will discuss common research interests, links to other national/international efforts and will examine ideas for potential research projects addressing cross-disciplinary topics identified in the Chantier Arctique prospective. The Labex Arctic data portal will also be presented.*

Links to other projects

On-going FP7, ANR, INSU, IRD projects in West Africa (non exhaustive): AMMA, AMMA-2, FENNEC, RIEPCSA, DRUMS, CAVIAR, contribution to "Chantier Arctique", possible IPSL lead for national projects, link with Labex BASC regarding the productivity of terrestrial ecosystems and agrosystems, and the feedbacks with the water cycle (irrigation, water quality). Other funded projects such as EU-ACCESS, EU-ECLIPSE and CLIMSLIP-ANR will also help structure of the work in WP3.

▪ *Work Package 4: Impacts*

Main objectives and strategy

We focus here on the impacts of climate change on the natural resources and the ecosystem services, the human activities they support and evolve with, and the resulting environmental changes. Regarding the future, an important issue is to characterize impacts in terms of vulnerability/benefit for resources and ecosystems services in order to propose sound adaptation strategies. The retrospective direction is also important regarding the detection and attribution of observed changes, and the necessary validation of models. An improvement in knowledge of processes in the natural environment including new process studies is needed in order to build forecast capacities for future impacts.

Such studies cover a very wide range of topics and require integrated approaches combining various data and models, with important issues regarding up/downscaling methods and uncertainty analyses, which will be addressed in tight collaboration with WP3 and TWP3. Based on the existing strengths of L-IPSL, we initially identified four sectors on which to focus our efforts: water resources (including ground water and hydrological extremes), biogeochemical fluxes and ecosystems along the land-ocean continuum (including terrestrial and marine productivity, water quality); energy resources and infrastructures; sources of regional and global air pollution.

A first WP4 meeting held on March 16th, 2012, helped to refine our scientific strategy. WP4 can rely on about 30 dedicated scientists from all L-IPSL laboratories, with different levels of experience regarding impacts studies, thus different kinds of actions depending on scientific expertise:

- **water resources, vegetation production: reinforce and integrate existing activities**
- **cold-processes/Arctic, terrestrial water quality and related fluxes, land-sea interface, marine ecosystems, air pollution: move from process studies to impact studies**
- **energy : develop the working force to continue preliminary results**

The L-IPSL budget cannot support all specific impact studies, and we rather aim at developing the potential of L-IPSL teams to attract their own funding, by promoting scientific structuration and methodological advances:

- ***Capacity building at IPSL on climate change impacts:*** **share experience on inherent difficulties; develop/adapt *ad-hoc* modeling capabilities to be responsive to research projects solicitations; promote supporting data-mining, observational & experimental work.**
- ***Cutting-edge methodological research:*** **disciplinary advances regarding overlooked aspects of the global cycles (*e.g.* land/sea fluxes, transfers and transformation in hydro-systems, marine ecosystems, ground water); interdisciplinary integration, including solicitations to climate modelers (WP3); adaptation strategies, in tight collaboration with TWP3 (Uncertainties) and the L-IPSL innovation activities.**

Mid-term actions

Action 1 and 2: Propose impact-oriented indicators and create a catalog of impact-oriented indicators

The aim of these actions was to build the bridge between the output of climate models (often biased multivariate 3D fields with a wide variability spectrum over centuries) and environmental variables that are relevant for impact assessment, whether they relate to the mean state of the environment or extreme events.

Results

This "indicator factory" has been launched with a dedicated workshop organized on June 27, 2013, targeted towards L-IPSL members, and selected representatives of stake-holders. The aim was to

define the impact-oriented indicators to be effectively characterized. This relies on the recruitment of a two-year post-doc (Yan Zhao) shared with WP3 and TWP3, who started in May 2013. The choice was made to focus on health-related heat stress indicators, which account for the combined effects of temperature and humidity on comfort and health. She and the L-IPSL group used three widely-used heat stress indicators, and showed that their main differences come from the importance of humidity when computed from the observed climate. Using an ensemble of 21 CMIP5 simulations (historical + RCP8.5), we found that climate models tend to underestimate heat stress over the Tropics, because of dry and cold biases, while warm and dry biases balance each other at higher latitudes. All climate models project increased heat stress; global mean changes are comparable to the one of surface air temperature, but the patterns are less contrasted because of the buffering effect of humidity. In particular, heat stress indicators increase more than temperature in warm and humid areas of the Tropics, where the number of days subjected to severe heat stress increases consistently amongst the climate models. The dispersion between climate models is smaller than the climate change signal, but the choice of heat stress index carries as much uncertainty

Action 3: Define the extrapolation power of impact models

Impact assessment relies on either conceptual or numerical models, which are both developed based on observations of recent climate. The transferability of such models under unprecedented climate condition is a crucial issue[1]. Our goal is to document, for a variety of L-IPSL models, climate ranges in which the models are supposed to hold, the larger ranges in which they might hold, and the thresholds over which uncertainty dominates, via workshops or questionnaires. Process studies will also be encouraged for documenting poorly-known relationships between hydrology/ecosystems and climate change.

Results

Action 3 has not started yet and will be rediscussed in 2015. Note that it will be partially addressed in Action 5, where corals grown in low pH and higher temperature typical of the end of the XXIst century will be analyzed and compared to corals grown in present-day conditions, enabling the test of the extrapolation power of the growth models for these vulnerable ecosystems.

Meeting the long term research aims: strategy for 2015-2016

In order to develop new projects related to the long term research aims of the Labex-IPSL, the strategy for the period going from 2015 to 2016 was to launch a "call for projects regarding the impacts of climate change". The link to the long term research aims articulates with the aim 3 which is the need to "**Provide better and more reliable projections of climate and related impacts in a few key sectors at both global and regional scale**". The answer to the call was large (7 projects) among which 2 projects were selected which are related to the impact of climate change on ecosystem functioning. These are related to vulnerable ecosystems, namely the land-sea continuum aquatic ecosystem which have been exposed to anthropogenic contamination and perturbation for decades before the change of climate and coral reefs which are endangered by anthropic activity, climate change and acidification. Both projects examine, with different approaches, the regional impact of climate change: North-western Europe for the first, and Equatorial Pacific Ocean for the second.

Action 4: Climate change impacts on riverine nutrient transfer and delivery to coastal sea

Ecological functioning of aquatic ecosystems is directly impacted by increasing human activities and climate changes. Altering these functions sometimes results in environmental damages affecting the

[1] E. M. Wolkovich, B. I. Cook, J. M. Allen, T. M. Crimmins, J. L. Betancourt et al. (2012). Warming experiments underpredict plant phenological responses to climate change, Nature, 485: 494-497, doi:10.1038/nature11014

whole aquatic continuum from headwaters to coastal sea (such as eutrophication, green tides, anoxia, fish mortality …) and the viability of human society. Most often, human and climate impact act in synergy to deteriorate the productivity of the ecosystem and its services to the environment (e.g. Hypoxia in the Baltic Sea).

Most regional prospective analysis rely on statistical approaches, but the changing climate and environmental conditions rises up the challenge of a mechanistic representation of microscopic processes operating in the aquatic continuum, scalable and compatible with regional (and up to continental) domains. The newly developed biogeochemical model pyNuts (which include the biogeochemical RIVE model) is now operational for all the north-east Atlantic rivers (more than 350 000 km of drainage network) for assessing present nutrient transfer. It has been tested and validated against datasets extending over the past two decades, but the challenge is to add functionalities that will allow to use it in climate change impact studies: (i) implementation of a hydrological module, (ii) regionalization of several model's parameters under changing climatic conditions, (iii) selection of relevant ecological indicators to assess the impacts of climate change on estuary and costal area biogeochemical functioning, (iv) the implementation of an estuarine model to evaluate the link with the coastal ocean.

Two case studies will be performed: the Seine-Normandy river basins flowing into the Bay of Seine, and the Adour-Garonne systems associated with small Cantabrian rivers flowing into the Bay of Biscay.

Resource needed: *A collaborative effort is undertaken between METIS and LSCE to meet the goals of the above project. An 18-month post-doc will be hired in early 2015.*

Action 5: impact of climate change and acidification on vulnerable ecosystems: the case of coral reefs

Temperature and carbonate chemistry (pH and [CO_3^{2-}]) of the oceans are critical parameters that not only control key chemical and physical processes, but also a wide range of biogeochemical processes that are important triggers for marine organisms' development and survival. The biological impacts of ongoing changes are intensively studied; however, the lack of long-term high-resolution observations (decadal to centennial scale) hampers a full understanding of anthropogenically driven climatic changes and their feedbacks on Earth's climate. To overcome the lack of long-term instrumental records of T and pH, geochemical proxies preserved in the carbonate skeleton of marine calcifying organisms such as corals, provide a unique tool to reconstruct changes in seawater environmental parameters. High-resolution decadal time-series from the pre-industrial period are critical to reconstruct changes in seawater environmental parameters over time and evaluate the validity of climate change scenarios (naturally and anthropogenically driven).

It has been shown that changes in vital effect can bias geochemical signatures in corals and therewith paleo-reconstructions. At the same time, environmental stressors and alteration by boring micro-organisms (i.e., euendolithic micro-algae, fungi, cyanobacteria) endanger the ecosystem viability. It is thus critical to identify the biogeochemical processes involved in the environmental stressors and their relation to climatic parameters such as temperature. At the same time, the understanding of the incorporation of trace elements and isotopic signatures in the aragonitic coral skeleton and its relation to the climatic and environmental signal is necessary. For this purpose, interactions between the coral organisms and their environment need to be better assessed to fully constrain the reliability of coral skeletons as natural archives for climatic signals.

Different tracers will be measured using ICP-MS (see below): Li/Mg, Sr/Ca and $\delta^{11}B$ - from different paleo-environmentally pertinent species (e.g. the massive coral of the genus *Porites*) at different stages of their life cycles (i.e., post-larvae, juveniles and adults), in stressed and impaired corals (e.g., coral grown under ambient *vs* pCO_2 predicted for 2100, skeletal tumors and corals bio-eroded by

microborers). Two oceanic regions of the equatorial Pacific Ocean (New Caledonia and French Polynesia) can be targeted, where corals are known to be particularly vulnerable to climate change (IPCC, AR5 2014).

Resource needed: *This project will gather scientists from LOCEAN, LSCE and GEOPS, and will promote collaboration around the development of the laser ablation coupled to the ICP-MS technique shared by these three laboratories (LA-MC-ICP-MS at LSCE, ICP-QMS at LOCEAN and ICP-MS-HR at GEOPS). A post-doc will be hired for 18 months*

Links to other projects

WP4 benefits from many on-going or planned projects (FP7, ANR, GICC, GIS-Climat, FIRE, PIREN-Seine, MISTRALS (http://www.mistrals-home.org), etc.), and interesting links can be developed with LABEX BASC regarding the productivity of terrestrial ecosystems and agrosystems. The recent ISI-MIP project (Inter-Sectorial Impact Model Intercomparison Project, coordinated by the PIK) is a pioneer for international coordination of impact studies, and L-IPSL models have participated to this effort, using the ORCHIDEE land surface model.

▪ *Work Package 5: The risk of abrupt unpredictable climate evolutions*

Main objectives and strategy

Past climate archives have documented abrupt or non-linear changes, occurring sometimes in less than a few decades. These abrupt climate changes occur when the climate system is forced to cross some threshold, triggering a transition to a new state at a rate determined by the climate system itself and faster than the cause. Chaotic processes in the climate system may allow the cause of such an abrupt climate change to be undetectably small.

In order to properly address the risk of future abrupt climatic changes, the WP5 will conduct concerted efforts for the analysis and interpretation of high-resolution past climate archives, both on the continents (i.e. speleothems, lacustrine sediments, ice cores) and in the ocean (shallow and deep-sea corals, marine sediments), and will compare these data with models outputs (especially, proxy forward models) in order to better understand the causes, mechanisms and impacts of abrupt climatic changes, and take full advantage of paleo-archives to unravel potential climate crisis ahead (e.g. meta-program MISTRALS).

Key efforts will be devoted (i) to understand the importance of mean, initial climate conditions on natural climate variability and abrupt climatic shifts, (ii) to identify and quantify thresholds, and (iii) to highlight potential precursors that could help us to predict the occurrence of future tipping points. (These *early warning signals* likely include changes of climate variability, whose study is therefore included in WP5 long-term goals).

Mid-term actions

During February and March 2012, a prospective discussion was launched within WP5 in order to identify top priority topics that should be addressed over the first 2 to 3 years of the L-IPSL labex. In this prospective exercise, we identified the **variability and abrupt changes in the North Atlantic and surrounding continents** as a key issue for the WP5 (Issue 1). The importance of the North Atlantic area in terms of climate variability and predictability is readily explained by (i) its direct, regional importance for the climate over Europe, (ii) its potential sensitivity to climate warming through perturbations of the hydrologic cycle and the melting of the Greenland ice caps, (iii) its impact on

global climate through perturbations of the thermo-haline circulation. WP5 will therefore contribute to addressing Issue 1 as stated above.

Within the upcoming couple of months, the WP5 will assess results obtained over the last two years and define objectives for the new prospective exercise. This will be done through two brainstorming workshops; one being organized in October and the other one after the third conference on "Climate and Impacts" (November 17 and 18), co-organized by GEOPS and LSCE and co-supported by L-IPSL together with LSCE, GEOPS and UP11. Conference sessions will be dedicated to the state-of-the-art of rapid climate changes during glacial time (including the last deglaciation), Holocene climate variability, calibrations of time scales and improvement of geochemical trac*ers for quantitative paleoclimatic reconstructions.*

In the initial prospective exercise, four main actions were identified around North Atlantic variability:

Action 1: reconstruct climate variability over the last millennia in the North Atlantic

by using very high-resolution natural archives (i.e. ice records, speleothems, deep-sea corals, tree rings and marine and lake sediments from high accumulation rates) that make it possible to extend our understanding of natural climate variability beyond the instrumented period. This research topic lies at the interface with WP2. In order to discuss key issues and set up specific targets for this action, further discussion is needed. For instance, such an effort was undertaken within MISTRALS /PaleoMex for the Atlantic/Mediterranean domain and of the LMI Paleotraces (PRIMO project) for the Tropical Atlantic/south America region.

In connection with this first action, Marie-Josée Gaillard, palynologist, professor at the University of Kalmar in Sweden will be invited for 2 months in 2015 (supported by the L-IPSL) to work at LOCEAN (PI AM Lézine) with the support of the African Pollen Data Base. Meetings will be scheduled with the LSCE teams involved in climate and carbon modeling (interface with the WP1). M-J Gaillard has developed a biological model making it possible to infer a realistic description of past vegetation, based on pollen paleo-data. This is of primary importance in particular for estimating (i) anthropogenic impact on landscape, (ii) changes in carbon stocks and (iii) for addressing feedback effects of vegetation changes and land cover on climate. This method, first applied in Europe, is now being developed for tropical Africa, where the impact of climate change together with the growth and spread of Bantu people in the Congo Basin have significantly impacted the forest cover. MJ Gaillard will apply this biological model using the high resolution, pollen series obtained through the C3A ANR project in Cameroon and through a collaboration with the University of Cologne in Chad and with the ISEM Laboratory in Senegal. This will allow us to quantify the impact of the last environmental crisis, which marked the end of the Holocene humid period in tropical Atlantic Africa.

Action 2: better understand the risk of future abrupt changes in warm climates by analyzing and comparing high-amplitude climatic shifts under interglacial conditions.

This topic covers the study of the Holocene, 8.2 ka cold event (timing, chain of events and quantification of water fluxes involved) and the comparison of Holocene and MIS5 variability in order to determine if abrupt or non-linear changes took place during past interglacials, under different conditions.

Discussion within L-IPSL WP2 and WP5 made it possible to setup ANR project HAMOC (integrating GEOPS, LSCE and LOCEAN). This project is devoted to improve present knowledge of AMOC variability and links with the Mediterranean outflow and input of fresh water from the high latitude during key events, abrupt or not, of the Holocene (e.g. Medieval Warm Anomaly, Little Ice Age, 8,200 yrs cold event…). HAMOC will use state-of-the-art tools (geochemical tracers, chronometers...)

and accurately dated cold-water corals and deep-sea sediments to reconstruct NE Atlantic and Mediterranean Sea circulation changes at unprecedented temporal resolution (<decadal to centennial). Paleoclimate reconstructions will be derived from rarely combined proxies of surface and mid-depth North Atlantic gyre and deep-water circulation. Data-model comparisons will be performed to explore the mechanistic links (forcing factors) between past climates and large-scale ocean circulation changes. In association to this "action 2", a PhD thesis has been launched and a Post-doc will be funded by the ANR HAMOC in 2015 to study the variability of North Atlantic mid-depth hydrology through the use of new tracers (εNd, Li/Mg, …) analyzed in deep-sea corals and foraminifera. These research works will make it possible to reconstruct past changes in water mass fluxes.

This action will benefit from the already active MISTRALS/PaleoMex program focusing on climate and hydroclimate changes in the Mediterranean Sea over the Holocene using a multi-proxy and multi-archive (tree-rings, speleothems, sediments, corals) approach.

Action 3: unravel the mechanisms explaining the abrupt glacial variability across MIS3.

The study of specific events and the comparison with proxy oriented model outputs are necessary to characterize past thresholds, test model responses, reconstruct the succession of events and identify the feedback mechanisms, which make it possible to bring back the system to its initial state.

This on-going issue is associated to an ERC project accepted in 2013 (PI: Claire Walbroeck, LSCE). In association to this action 3, a PhD thesis has been launched to study the variability of MIS3 through the use of a new tracer (Pa/Th) that allows the reconstruction of past changes in water mass fluxes. This action (as well as Action 1) requires the improvement of synchronization between various paleoclimate archives (ice cores, speleothems, marine and continental sediments). This chronology issue was discussed during a dedicated session of the "Climate and Impacts" workshop in November 2012. The first step of a specific action on chronology, supported by L-IPSL, deals with improvement of the DATICE tool, which allows improving age models and the synchronization of climatic records based on advanced bayesian methods.

Results

*This was achieved through a one-year contract with Bénédicte Lemieux-Dudon (half time – auto-enterprise), supported by L-IPSL. Ms Lemieux-Dudond, who developed DATICE tool for ice cores, has adapted this software to sedimentary archives. The main part of this seminal work has been dedicated to code implementation and adaptation, and the L-IPSL community was invited to join two training sessions (February and June 2014). A dedicated web page shows how to use the software and how to visualize the data (*http://blemieux.wordpress-hebergement.fr/datice_multiarchives/*). At the end of this first step, all the implementations requested to run DATICE with sedimentary archives have been achieved. The DATICE tool has been successfully tested and can now be used for developing integrated, multi-archive chronologies. This action will be extended by 6 months of post-doc to help scientists from WP5 to put within a common timeframe, ice cores and key marine records from the North Atlantic, the Mediterranean Sea and the Austral Ocean. Scientific questions behind these applications are (i) the links between high and mid latitudes over the millennial scale variability of the last climatic cycle and (ii) the links between variations of temperature (over continent), ice sheet size, vegetation, greenhouse gases concentrations. Based on the interest of researchers from the WP5, we will include, in addition to ice cores, several marine cores.*

In addition to the work on multi-archive chronologies, L-IPSL was a contributor of the First Open Science Conference of IPICS (Presqu'île de Giens, October 1-5 2012). The objective of this conference was to present, discuss and put into perspective the most recent results coming from past and current ice core drilling projects (deep drillings such as EPICA, WAIS, NEEM, TALDICE,… but also shallow drillings) in Antarctica and Greenland.

Action 4: explore the risk of future massive destabilization of the Greenland and Antarctica ice caps.

Precious information on the maximum rates of ice-sheet melting is contained in the records of past sea level changes. In order to extract all the climatic information and explore the risk of future massive destabilization, realistic models of ice cap dynamics will be coupled to regional models or zoomed global models.

The implementation of models of ice cap dynamics (i.e. grizzly) is under progress. A workshop took place in March 2014 to discuss the state-of-the-art of action 4 and define the pending mid-term actions.

Miscellaneous, other actions

There is a consensus within the WP5 community about the key interest – for all WP5 main actions – of:

(i) improving past hydrological cycle reconstruction and water fluxes (molecular isotopes in biomarkers, …)
(ii) developing precise, integrated chronologies,
(iii) improving new geochemical proxies measured on bio-carbonates (i.e. pH from B/Ca and $\delta^{11}B$; temperature from Li/Mg and Mg/Ca…) and their use for quantitative reconstructions, climate dynamics studies and data/model comparisons.

These items are three main actions supported by L-IPSL WP5 (see also TWP2 for (i) and WP4 for (iii)). For the action (iii), Jonathan Erez, professor in geology at the Hebrew University in Jerusalem (Earth Science institute), will be invited 1 month (supported by the L-IPSL) to exchange his own expertise with colleagues of the LSCE, GEOPS and LOCEAN on several topics about biomineralization of foraminifera and corals, development of new tools for paleoceanography and paleolimnology using stable isotopes and trace elements, carbon and nutrient cycling in coral reefs in view of global change, etc… He will give an invited talk during the conference on ''climate and impacts'' and several seminars in the laboratories of the L-IPSL.

Links to other projects

ANR-HAMOC (Holocene North Atlantic Gyres and Mediterranean Overturning dynamic through Climate Changes), MISTRALS/PaleoMex (interactions between Climate/Environment/Human societies during the Holocene in the Mediterranean Sea); ANR-MONOPOL (Indian Monsoon Paleovariability); ANR-ELPASO (ENSO/ELNiño and their impacts on low latitude hydrology and monsoon); LMI Paleotraces and the PRIMO project; On-going data-oriented or modeling projects at the European level or national level (NEEM, EMBRACE, COMBINE,…); FATES (FAst climate changes, new Tools, to understand and simulate the evolution of the Earth System) and LIA-MONOCL (East Asian Monsoon variability).

▪ *Transverse Work Package 1: Numerical modeling of the climate system*

Main objectives and strategy

The ability to better understand and to anticipate the climate change over decadal timescales and beyond depends for a large part on major developments and improvements of the predictive capabilities of climate models. In the absence of established analogues of greenhouse gas-driven climate change, numerical modelling based on a physically-based representation of the key processes and components that govern the dynamics of the climate system is increasingly recognized as the most valuable approach to anticipate future climate change, at both the global and regional

scales, and to improve the predictive capabilities of climate models. IPSL has progressively developed a comprehensive Earth System Models (ESM), with a leading position in many of the relevant aspects (such as ocean modelling, carbon-climate coupling, cloud feedback studies, paleo-climate simulations...). The three main objectives of this transverse work package are (i) to provide simulation results and to carry out specific simulations to "feed" in the other work packages, (ii) to undertake specific developments that help the other work packages, and (iii) to continue to develop the IPSL climate model to maintain the IPSL Earth System Models (ESM) as world-leading.

In view of these major scientific and societal concerns, L-IPSL will focus on three related key objectives:

- Improving the representation of physical processes and their couplings: **The inclusion of new interconnected components (carbon cycle, chemistry and aerosols) into climate models and the need of more reliable regional climate-change projections require improved representations of the basic physical processes. Special efforts will be made to improve the representation of cloud-convection-turbulent processes, the hydrological cycle over land, coastal upwelling and ocean vertical mixing at high latitudes, coupling between atmosphere-ocean and cyrosphere, aerosol-cloud interactions, fast coupling between atmosphere and ocean, and to increase the resolution of the models.**

- Improving the representation of aerosols and biogeochemistry processes and their coupling with physical processes**: To better represent the ability of natural sinks to absorb anthropogenic CO_2, key processes will be included and improved (land-vegetation phenology, phytoplankton physiology, carbon-nitrogen cycle interactions) in the terrestrial and oceanic carbon cycle models. Beyond CO_2, other climate forcing agents (aerosols, methane, ozone, N_2O…) will have to be more explicitly represented, which requires both interactive atmospheric chemistry and representation of biospheric fluxes (e.g., oceanic DMS or VOC production as well as methane production by anaerobic soil respiration).**

- Developing new algorithms and models to take advantage of new computer performance: **Increased computer power in the coming years is expected to come from new architectures and an increased number of CPUs. A major effort will be made in rewriting the "dynamical cores" of the atmospheric and oceanic models, using new approaches (e.g. finite volume on "cube spheres" or "icosahedral grids"), in developing new tools for the Inputs-Outputs and model infrastructures. The increased power will enable increased model complexity, resolution, and the number or length of the simulations.**

Mid-term actions

TWP1 will develop tools and provide support that will contribute to the five issues. The following specific actions are proposed for the next 2 years:

Action 1: Working towards high resolution versions of the IPSL Earth system model.

This goal will be achieved through work in three main areas: (i) increasing resolution of current version of the atmospheric model and adapting the parameterizations accordingly, (ii) developing new tools for high performance input-output and testing them with the oceanic model and (iii) rewriting the "dynamical cores" of the atmospheric model using finite volume approaches on "icosahedral grids".

Reporting on this action will be done in future Action Plan versions (no LABEX funding yet)

Action 2: Development and better integration of the various cycles.

All model components have a representation of the water isotopes, but the full integration in the global coupled model has to be done. The current aerosol model is comprehensive but the effect of aerosol deposition on the carbon cycle, vegetation and cryosphere needs to be included. The nitrogen cycle also needs to be integrated across the different model components (chemistry, ocean and terrestrial carbon cycle).

Reporting on this action will be done in future Action Plan versions (no LABEX funding yet). However WP1 partly covers this action.

Action 3: Development, adjustment and evaluation of the versions of the IPSL Earth system model.

New developments have been made respective to the IPSL-CM5 model used for CMIP5 that should significantly improve the characteristics of the simulated climate: update of the atmospheric convections, new land hydrology, increase of horizontal and vertical resolution for both the atmosphere and the ocean, etc… In addition, the adjustment of key coefficients of the parameterizations is now recognized as a key phase of the development process of climate models. A new version of the IPSL ESM will be developed, tuned and evaluate. It will constitute a "beta" version of the model version that will be used in the next phase of CMIP.

Results

Two post-doc have been hired in 2014 to help the development and the tuning of the new version of the IPSL-CM model. The main objective of their work is to improve the energy flow within the climate system, with a focus on the latent heat flux over ocean for one of them, on the clear sky radiative flux for the other. For the latent heat flux, the link between its bias in AMIP runs and the SST bias in couple runs has been established, and work to improve the latent heat formulation is in progress. For the clear sky radiative flux, the two first steps are ongoing and are the following (i) to test and optimize a new radiative code of the atmosphere and (ii) to include for the ocean an albedo model that depends on meteorological (wind speed) and biogeochemical (plankton) variables in addition to the solar zenith angle. Then the development and the adjustment of the relevant parameterizations will be done in all the model components (atmosphere, ocean, land surface...) using mainly forced simulations. Both works will be summarized in publications.

Action 4: Development of a stretched version of the IPSL Earth system model.

LMDZ, the atmospheric component of the IPSL model, has a stretchable longitude-latitude grid that allows grid refinement. To transpose this capability to IPSL-ESM, it is necessary to develop general tools to interpolate gas and dust emissions on the atmospheric grid and to interpolate any data on very fine grids.

Results

This action, already decided and funded in 2012 was delayed. An engineer has been hired in 2014 to work on both actions 5 (below) and 4. He started to work on action 5 and the development of the stretch version of the IPSL model will start October 2014.

Action 5: Facilitating the distribution and analysis of CMIP5 and related projects

The CMIP5 model outputs constitute an exceptional database used by climate centers to investigate the climate, climate change and the impact of climate change. Many related projects have now adopt the same data-base system and convention as CMIP5.To fully benefit from this database, an infrastructure has been implemented by IPSL that includes a very large storage capacity and computing resources relevant for the analysis of large datasets. New tools will developed in order to facilitate the analysis of this very reach data-

base that is expected to feed many research questions during the next years.

Results

An engineer has been hired in late 2012. He already has published and documented new CMIP5 results for the IPSL models, has corrected around 50% of the detected errors, documented the various errata and written a FAQ web page. He is part of the ESGF Publisher Working Team to improve file versioning thought CMIP5 archive. He also developed tools to facilitate CMIP5 analysis and documented them. In particular, he developed tools to (i) find and list the available CMIP5 aggregations at IPSL according to the user requirements and (ii) to check the time axis of all the files and to automatically correct them when possible. This later task is very important as many CMIP5 files can't be used or, even worse, produced erroneous results, due to problems in the time axis description. To facilitate the analysis of the CMIP5 data, additional disk space has been bought to increase the storage space (currently 450 To). Data and tools are available through the icmc web site http://icmc.ipsl.fr in the CMIP5 section.

Links to other projects

National:

- MissTerre (LEFE/IMAGO, CNRS/INSU)
- Dephy (LEFE/IMAGO, CNRS/INSU)
- EPINES (Mastodons/CNRS)

European

- COMBINE (2009-2013)
- EMBRACE (2011-2014)
- IS-ENES 2 (2013-2016)
- SPECS (2012-2015)

ANR

- CONVERGENCE (2013-2016)

▪ *Transverse Work Package 2: Data management*

▪

Main objectives and strategy

Observations for monitoring climate changes require long data sets including instrumental measurements and paleoclimate proxies. Available series of observations and proxies are strongly inhomogeneous in nature, length, observed parameters, location, sampling, resolution, requiring adjustments, corrections … and always correspond to a partial view of the climate systems. One strategy for taking advantage of these measurements consists in comparing them with numerical simulation outputs that give a more global context. Another strategy consists of simultaneously collecting observations of many essential climate variables to better understand processes. Finally, innovative instruments and methods are required to access new measurements that help to characterize climate changes and constrain models. Preliminary tasks consist of identifying, collecting, qualifying, correcting, coupling, and formatting these time series to insure a better use of these data with models. The attribution to climate changes on long-term series of measurements as well as numerical simulations requires both sophisticated statistical analyses. The L-IPSL LABEX proposes to complement and insure a better coordination with the thematic national data centers like ETHER or ICARE, for atmospheric and aerosol composition respectively. IPSL teams are collecting a large array of observational data (satellite, airborne, ground-based). The use of such data to

evaluate models requires specific analyses to ensure the consistency of observed and simulated parameters (parameter definition, spatial representativeness, long-term homogeneity of measurements). IPSL has setup the ESPRI structure for coordinating data handling for both observations and model outputs (Prodiguer-CMIP5 project). The expertise on innovative techniques can be further increased with a better coordination across the LABEX partners.

One of the main goals will be to provide accurate reference observations available for direct observations with numerical models and associated statistical analyses. For such purpose, new innovative measurements and data series analyses will be developed. One example is the use of water isotopes to compare model outputs with field measurements and/or paleo-proxies through proxy-forward models.

Mid-term actions

Action 1: Water stable isotopes database and working groupe

Water isotope ratios in rainfall and paleo-proxies (ice, carbonates, organic molecules) provide information about the history and circumstances of water precipitation (transfer, phase change, temperature, convection, precipitation, evaporation). This is complex but useful information for understanding atmospheric, continental and oceanic cycling of water for both actual measurements and paleo-climate archives. While isotopes are already include in the IPSL Earth model, this LABEX action is a good opportunity to compare model and observations. Two tasks are proposed:

The first one consists in collecting existing 180, 170 and D data series in a database to allow direct comparisons with model outputs in the framework of CMIP5/PMIP3. This action may concern the instrumental series, the most recent (last centuries) proxy-data (tree rings, speleothems,Š), the best continuous older records and those centered on CMIP5 periods 6k and 21k. This database will be developed in coordination with the IPSL data management team (ESPRI).

The second task consists of forming a specific working group, on water isotopes in a first stage, then other isotopes might be included, with the objective to start the building of the database, to promote and improve methodologies (reports, courses), the model/observations comparisons, to promote the data base use in L-IPSL WP actions and to design campaigns using Picarro spectrometers and other measurements dedicated to water cycle investigation, in different domains.

Results

Fifteen months of the post-doc have permitted to compile all the available d18O and d13C records stored in the NOAA and PANGAEA websites and the internal database of the LSCE. Raw data from published datasets were isolated, homogeneously formatted (fixed data disposition and samples age unit) and stored on individual files, while age model information were extracted and stored separately. The evaluation of the quality of the available age models was performed on dated datasets, and age control quality flags were integrated in a single metafile also providing essential information on all compiled datasets (~1500 dated records and 1700 not dated for d18O, and 800 d13C dated records).

An open-access online platform, http://webportals.ipsl.jussieu.fr/ClimateProxiesFinder/latest/, has been built, providing dynamic and interactive browsing, visualization and downloading facilities for compiled data, and a manuscript in being written for future publication. This action should be extended by 6 months of post-doc to finalize the database and manuscripts as well as to integrate the database in the PMIP program.

Additional resources needed: *6 months of post-doc to finalize the database and manuscripts*

Action 2: Climate data availability and statistical analyses for climate attribution

Time series of both numerical experiments and direct observations include a large inter-annual variability. For future projections based on past data, and for the attribution, it is important to be able to analyze the variability and identify their causes. Available data need to be identified and shared. This can be done through a "climate portal" indexing the contact people and the archived database. A metadata management tool has been developed to organize all data portals that are developed within the TWP2 (valid for the Arctic data portal and for the Climate data portal). In addition, sophisticated and robust statistic methods need to be developed. The relative reduction of the ground temperature increase observed during the last decade or the solar signature could be good candidate for such investigations. Such a group already exists within IPSL: SAMA. Within the LABEX, it is proposed to organize dedicated workshops to share the expertise and present some of the challenges corresponding to specific LABEX issues. This action will be coordinated with WP2.

IPSL developed a comprehensive multi-parameter observatory of atmospheric processes and surface-atmosphere interactions in the Paris area covering over a decade (2003-2014). In this action, we propose to finalize the development a harmonized level-3 dataset that include over 40 essential climate parameters observed over the Paris area, provided with a regular time step (hourly over 10 years), ensure homogeneity of data processing, and data quality control. Data sources are: SIRTA observatory, Météo-France surface stations and radiosondes, Meteosat geostationary satellite. The project will allow new key parameters to be included in the level-3 dataset (Lidar profiles, H2O isotopes, MSG data, large-scale regime, …). The initial version of this level-3 dataset has proven to be very useful for both GCM model evaluations (Cheruy et al., 2012) and for climate variability understanding (Chiriaco et al., 2014).

Resources needed: 12-month engineer contract to finalize level-3 dataset development.

Action 3: Arctic data portal (see also WP3)

TWP2-Action3 is linked with WP3-Action4. A data portal linking existing observational datasets at high northern latitudes leading has been created with the aim to add value in terms of new data analyses and model developments particularly in the IPSL global modeling community. The LABEX Arctic data portal is complementary to and builds on/ contributes to other national efforts. In particular, this initiative uses existing data infrastructure, ESPRI (climate portal). Many sources of data have been identified, building on the Chantier Arctique prospective and direct links provided in the portal. Links to other international efforts are also part of the portal.

Results

The portal will be presented first to the Labex committee and then to the wider community, as part of the Arctic workshop planned for the first semester in 2015 (WP3). The aim will be to present the many datasets which are available and discuss how they can be used in new ways, to improve IPSL modeling capabilities in the Arctic.

Action 4: Lidar strategy

IPSL has developed a strong expertise in lidar technology. Many applications for ground network, onboard planes, and from space, are envisioned. All these proposed instruments are different but use similar expertise. To conduct an optimal development of the future innovative instruments, dedicated workshops have been held and will continue. A strategic document has been written. A powerful 3-wavelengths lidar to measure the aerosol size distribution from ground to the tropopause was designed and is under development (deployment spring 2015). The next project will concern the water vapor airborne lidar. This action will be coordinated with WP3. Within the LABEX, attention will be paid to GES observations. This action will be coordinated with WP1.

Resources needed: invited senior researcher expert in lidar and other waper vapor techniques

Action 5: development and shared use of analytic platforms

Climate change research will benefit from the coordinated use of the existing platforms.

- Most of the IPSL laboratories benefit from their location in or around Paris to develop observations related to air composition. The large spread of their implantation at different locations provides a valuable network that needs to be coordinated. This will enable the study of local emissions in the Paris megapole on regional air quality and global atmospheric composition.

- Another area concerns analytical laboratory instrumentation within L-IPSL laboratories for geochemistry and geochronology. The build-up of such coordination in an analytical platform at LSCE and IDES has started and was supported within the initial phase of LABEX for the funding of a clean preparation room. The LABEX is actively promoting the shared use of this platform within LABEX laboratories: a new project mostly funded in WP4 concerning the impact of climate change and acidification on coral reefs will start in 2015. The project will promote new geochemical tracers and their understanding and calibration and will rely on the shared use of ICP-MS coupled to Laser Ablation at the LSCE-GEOPS platform and the ALYZEE platform at LOCEAN who will coordinate the project. The project will also benefit from the new acquisition of an LA-ICPMS-HR at GEOPS, funded by the Ile de France Region and University Paris Sud (Orsay).

Resources needed: invited senior researcher expert in air quality

Links to other projects

The isotope working group will benefit from the ongoing experience of Wsibiso project (combination of satellite measurements, FTIR, Picarro and GCM outputs for Siberian region – J. Jouzel). The introduction of water isotopes in the Oceanic Model is being realised through the Past 4 Future project (J.C. Dutay). The group is also involved in the ISOTROPIC ANR project, designed to better understand water cycle and related coupled modeling uncertainties through water vapor isotope measurements. The Arctic data portal work at L-IPSL will be linked to national efforts related to the Chantier Arctique and to international data catalogs.

A Pôle for Earth Observations at IPSL has been established with the objective to strengthen our activities dedicated to a better understanding of the climate system based on observations. The goals are (1) to better coordinate our contributions to Earth observation programs (satellite missions, ground-based observatories, field campaigns, analytical platforms) and (2) to develop more advanced tools to support the scientific exploitation of observational data.

TWP2 of L-IPSL is strongly linked to the second goal of the IPSL Earth Observation Pôle, since it proposes several actions that develop new tools to improve data harmonizing and access for IPSL users. Hence TWP2 will help the development of the Earth Observation Pôle.

- ***Transverse Work Package 3: Assessment of uncertainty in climate diagnostics and projections***

Main objectives and strategy

The objective of this transverse work package it to strengthen strategies and methodologies across the different WP for assessing the uncertainties associated to climate diagnostics and projections. The work is divided into two major tasks. The first one will make use of scientific expertise developed in the different WP to improve the characterisation of the cascade of uncertainties from the climate forcings to the regional climate response focussing on model skill and the understanding of model uncertainties. The second will provide the scientific ground, climate indicators and methods that are needed to characterise the uncertainties in the different model outputs and to evaluate climate indicators that are used in impact or adaptation studies. New scientific developments are needed to achieves these goals and the outcome of this TWP will be of direct use to define the innovation and expertise transfer strategy related to the dissemination of key results on climate change and variability.

This requires to:

1) gather the key analyses and methods used to characterise the uncertainties in the different WPs;

2) develop a common expertise to qualify and quantify the uncertainties considering the different sources of errors inherent to model structure, experimental protocols used to run climate simulations, downscaling strategies or statistical analyses;

3) offer a forum to discuss model evaluation considering both large scale and regional scale simulations, including specific targets on user oriented questions.

In the long term this will provide:

- **A quality assessment of the IPSL climate projections considering large scale and regional simulations (linl with WP2 and WP3, TW1 and TW2)**
- **A suite of key diagnostics and examples to qualify, quantify and understand model uncertainties, including a focus on variables of interest for impact studies and adaptation (all WP and TW1)**
- **A documented catalog of methods to assess model results depending of the scientific objectives (WP2, WP4)**
- **An analyses of the sources of uncertainties of the suite of climate indicators computed from climate simulations or from impact models (link with WP4) that will be distributed and used to characterize the impact of climate change on the environment of society**

Mid-term actions

For the next two years the focus will be on the characterization of model performances and uncertainties in the different analyses performed along the 5 major issues identified to be the major mid-term focus of the LABEX.

Action 1: Development of new methodologies using multi-model ensembles

Several gaps have already been identified in the IPSL community concerning the use of different types of model ensembles. A first action will be to share the different practices across the work packages. This also includes the specific analyses of model ensembles needed for decadal prediction as part of WP2. There is thus a need to organize specific seminars and internal workshops for large scale diffusion and common development of new methodologies.

Results

A specific day will be organized (organizer: M. Vrac) in November 2014 around a seminar by James Annan who will visit IPSL. The objective will be to review the ensemble methods used in the different labex WP, considering large scale multi-model analyses and multi-model forcing for regional studies.

Action 2: Gather key diagnostics for model evaluation

Model evaluation is a key component of the estimation of uncertainties. An objective is to gather the key diagnostics that are used in the different work packages so as to build a suite of evaluation tools that can be used to assess different aspects of the climate system. This task is common with similar activities in TW1. TW3 will in addition, contribute to the transfer of expertise that needed to be provided with the model results as part of the IPSL model results distribution strategy.

Results

Jerome Servonat visited PCMDI in spring. The objective was to discuss the new metric software developed at PCMDI and to test how it can be interfaced with the "jardin of metrics" under development between IPSL and CNRM for systematic benchmarking of new Earth System Model versions. The new tool will be presented on September 30 2014 at IPSL. The objective for next step is to create a network of diagnostic developers to

1. *incorporate a suite of basic diagnoses in the model running environment*
2. *share more sophisticated diagnoses in a common library.*
3. *Systematically apply these new tools to test and improve IPSL-CM6 climatology.*

A specific meeting will be organized together with LEFE-MISSTERRE and ANR-CONVERGENCE project in early 2013, so as to best use these new evaluation capacities to evaluate the IPSL and CNRM model versions that will be use to run the CMIP6 ensemble simulations.

Action 3: Identify and diffuse best practices and statistics

Statistical methods play a key role in climate analyses to isolate modes of variability or extreme events, or in downscaling and corrections of model output to be used in impact studies. This activity is spread in different projects and an objective of TW3 will be to organize the return of expertise and the diffusion of the best practices across the WP. This will be done in collaboration with all the WPs. Key topics to be discussed across the work packages will be defined with the help of the research committee. A first priority will be given to downscaling methods and on methods used to isolate and correct model biases.

Results

The starting point for this activity will be a short workshop during the labex AG to identify what are the different statistical methods used in the different work packages to analyse climate variability or extremes, downscale model results, or assess uncertainties.. We plan to isolate one or two transverse subjects and to propose a synthesis papers. We envision that on of them would be on downscaling and bias corrections and the other one on model evaluation at different spatio-temporal scales.

Action 4: Estimate and understand uncertainties in key climate indicators

The growing use of model simulations for impact studies or the development of adaptation strategies requires new developments in the way model results are provided to the other communities and in the presentation and scientific discussion of the different uncertainties. The production of climate

indicators in WP4 will serve as examples on which specific assessment of uncertainties will be performed. Cross meeting will be organized between WP2, WP3 and WP4 to discuss uncertainties at the regional level and to specifically assess how model reproduce the key indicators that will be developed in WP4. This will be achieved through a post-doc position open, coordinated with WP3 and WP4.

Results

This action is conducted jointly with WP4. A 2-year post-doc was hired in Spring 2013.

A first analyses was done on heat stress for health indicators, jointly with WP4 (post-doc : Yan Zhao). The choice of this indicator was motivated by the fact that different indicators exist and that they require to consider temperature and humidity. Since humidity is in general not well reproduce in climate models it is important to know if climate model outputs are reasonable and can be used to tackle these health questions. A manuscript is under preparation.

Several CEPS ANR project are nearly finished. In 2015 a TW3 meeting will be dedicated to the use of key indicators in these project and prepare a synthesis of the results with specific emphasize on the treatment of their uncertainties.

Action 5: Assess the different sources of uncertainties

Clear assessments of the results that are provided to other communities are needed. However it is difficult to find its way in the numerous sources of uncertainties, their characterization and their impact on the final result. In a first step TW3 will foster the synthesis of ongoing work and prepare a work plan concerning the different scientific action needed to tackle these new subjects. This will be done through the participation of IPSL members to different international and national projects and meeting and the organization of small IPSL workshops. The first year will be used to establish the catalogue of key emerging scientific questions on these topics and the level of implication of IPSL LABEX.

Results

Several actions started in connexion with the ANR-SECIF, the EU-CLIC and IS-ENES2 projects. A particular focus was put on cold waves, so as to quantify the sources of uncertainty arising from the definition of cold wave and the choice of a socio-economic scenario in one hand, and model biases, structural uncertainty and internal climate noise on the other hand. The results are part of Aglaé Jézéquel OACOS M2 report.

As part of SECIF, and with the co-funding of GIS-CLIMAT environment, IPSL-labex, and IDDRI a colloquium "(In) certitudes) will be organized (Alexandre Magnan, IDDRI and Pascale Braconnot, IPSL) on 17-18 November 2014. This meeting is organized around 3 sessions covering respectively 1. Certainties and Uncertainties; 2. Different opinions on uncertainties. 3. Dealing with uncertainties. For each of these topics a plenary session will introduce the subject and round tables will allow in depth discussions. A group of student will be engage to prepare the conclusions of the meeting and propose new directions for future work.

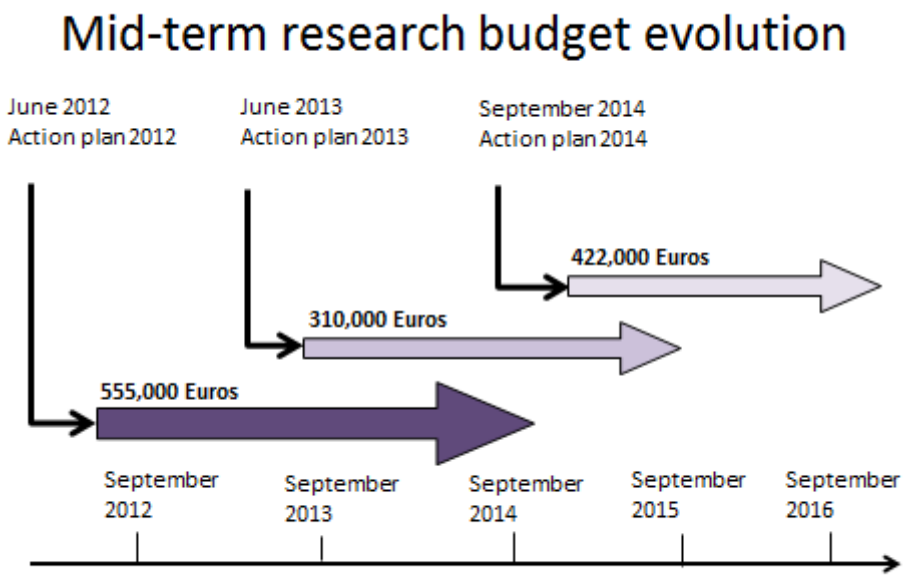
Links to other projects

IPSL members are already involved in European or national projects in which some of the points listed above are developed. The value added of TW3 would be to organize the return of expertise of these projects and to propose more perennial activity. It will also help to identify questions and results that will further benefits from a transfer of expertise as part as the labex valorization strategy.

Interactions with IS-ENE EU e-infrastructure and DRIAS project for the understanding of user needs and the identification of gaps in research activities.

2.4 Research: Provisional Budget for the mid-term

The LABEX budget is proposed on a yearly basis with a 2-year perspective (projects decided on Year n can last 2 years). This is illustrated in the figure below.



Each year the budget includes

- **30,000 euros for animation, internal workshops etc… for a 1-Year period, to be decided by WP/TWP leaders**
- **A budget for projects (post-doc or engineers salaries), in 2014 360,000 euros**
- **A budget for invitations of foreign scientists, in 2014 32,000 euros**

The table below summarizes the proposed funding for mature actions for the mid-term research action plan. Actions proposed for funding (orange lines when decided in 2012 and blue when proposed in 2013) are distinguished.

Proposed funding and laboratories involved	Dates / schedule	WPs	Proposed budget in 2012	Proposed budget in 2013	Proposed budget in 2014
1 Year post-doc for the development of a data base on Water Isotopes IDES/LMD/LOCEAN/LSCE	Jan --> Dec 2013	**TWP2/WP5**	**45**		
1 Year post-doc for the development of multi-archive, integrated age models. IDES/LOCEAN/LSCE	Mid 2013 --> Mid 2014	**WP5**	**45**		
2 Year post-doc to study the role of volcanism in the last millenium LATMOS/LMD/LOCEAN/LSCE	2013 and 2014	**WP2-WP5**	**90**		
2 Year post-doc to study the changes in the C transfer between land and ocean in the Arctic region LOCEAN/LSCE/SISYPHE	2013	**WP1-WP3-WP4**	**90**		
1 Year Engineer to develop the Arctic data portal ALL	2013	**TWP2-WP3**	**45**		
Iinvitation of expert for the development of time of emergence indicators LMD/LOCEAN	2013	**WP2**	**15**		
2 Years post-doc development and evaluation of indicators ALL	2013 and 2014	**WP4+WP3-TWP3**	**90**		
2 years engineer model to facilitate model results analysis and to set up new IPSL-model configurations	2013 and 2014	**TWP1**	**90**		
Invitation of an expert on cycles interactions	2013	**WP1**	**15**		
Workshops and animation 2012-2013		**All**	**30**		
1 Year post-doc on Grand Challenge issues on LGM and future climate sensitivity, and paleo-cloud workshop	2013 and 2014	**WP2**		**50+10=60**	
Invitation of Scientists in the framework of the WCRP Grand Challenge	2013 and 2014	**WP2**		**20**	
2 Year post-doc regional modeling of the intermediate scales in West Africa, and cloud–circulation feedbacks WCRP GC on climate sensitivity	2014 – 2015	**WP2-WP3**		**100**	
Visit of scientists on water vapor observation over the Arctic region and on PBL (SIRTA)	2014	**WP3**		**15+5=20**	
1 year post-doc (co-funded LABEX MER)	2014	**WP1**		**25**	
1 year post-doc support to IPSL model development and tuning	End 2013 - End 2014	**TWP1**		**55**	
Workshops, animation for 2013-2014				**30**	

6 month continuation for the development of a data base on Water Isotopes	End in 2015	**TWP2/WP5**			**25**
6 month continuation for the development of multi-archive, integrated age models.	End in 2015	**WP5**			**25**
2 year post-doc on IR impacts of dust aerosols		**WP1**			**110**
1 year engineer on SIRTA data reconstruction		**TWP2**			**40**
1.5 year on impacts of CC on fluvial exports		**WP4**			**75**
1.5 year on acidification		**WP4/WP5**			**85**
Invitation scientifiques V Balaji (6 mois), J Erez (1 month) A Evan (3 months), M.-J. Gaillard (2 months)		**WP3-WP5-TWP1**			**32**
Workshops		**WP5**			**30**
Total			**555**	**310**	**422**

3. Innovation and expertise transfer

Climate research teams – and in particular IPSL – have built scientific knowledge and technical tools that is transferable beyond the sole realm of research. A stronger and more integrated link between climate science and society is therefore required to build this transfer. This will steer employment for students, further use of IPSL science in many domains, and new scientific questions, sometimes fundamental from downstream applications. The L-IPSL needs to design an adequate strategy to spread climate knowledge and the associated tools and services, so that (1) it makes sure that its evolving expertise and the associated uncertainties and limitations, are fully taken into account, but also that (2) dedicated new structures are set up to provide the necessary help to confront a huge demand which is well beyond the capacity of L-IPSL alone. This strategy requires involvement of the scientists.

The capacity of L-IPSL to transfer knowledge and innovation concerns several domains:

- **Innovative instrumentation for environment observation and monitoring;**
- **Innovative modeling for environment prediction;**
- **Distribution of climate information and associated uncertainties;**
- **Advanced mathematical (for example statistical) methods to combine observations and model results for monitoring, forecasting; downscaling or uncertainty assessment.**

In each case, a specific strategy for innovation and the creation a value is needed. The strategy of the L-IPSL will be twofold:

- **to develop autonomous initiatives, relying on its strengths, or those of its sponsors to develop training programs with the universities or communication actions toward the public ;**
- **to develop a stronger partnership with industries and SMEs and use them as vectors of Knowledge transfer, in particular through non-academic partners.**

The L-IPSL LABEX has developed innovation and transfer in two strategic areas which are reported here:

- **Innovative instrumentation**
- **Climate services (grouping all activities such as modeling, climate information and methods)**

3.1 Innovative Instrumentation

L-IPSL scientific priorities concerning the monitoring of climate require the development of instrumentation for all possible platforms: ground based, airborne, within the ocean, from balloons or ships, from space missions. The observational strategy implies to monitor key parameters on the long term, with multiple parameters being observed and analyzed at collocated instrumental sites. The continuous development of innovative instruments and analyses is absolutely necessary to calibrate the measurement networks, increase their reliability. This part will be addressed by TWP2. It naturally leads to a transfer toward SMEs or larger companies. This transfer is necessary for long-term climate monitoring, which require development and operations of series of identical instruments, with operator institutions that are not necessarily within research teams.

The figures present a few of major instrumental L-IPSL facilities, lidars, mass spectrometers, as an example of past IPSL instrumental use or development:


Erreur ! Source du renvoi introuvable.

Based on developments of prototypes by research laboratories, transfer of knowledge is necessary to ensure this long-term observing strategy. The objectives of L-IPSL will be to transfer a few instruments or part of instruments or innovative algorithms or methods.

An innovative instrumentation ad hoc group has been implemented. A meeting has allowed to have an panorama of IPSL activities. The type of activities could be splinted in instrumentation, codes and algorithms. For the three last years, only activities related to lidar have been implemented. At IPSL level (compared to laboratories activities), no other instrumental projets have been identified with strong links with the labex. **Therefore, L-IPSL support has and will help the lidar strategy to be implemented. L-IPSL will help the development of new generation for aerosols and vater vapor lidars. This is a common action with TW2.**

The strategy will be from one side to start a new innovative lidar system development for the atmospheric water vapor measurement with several objectives: research objectifs activities and possible to industry to answer to the requirement of continuous observations both for operational network and research climate observatories. On the other hand, within two years, high performances multispectral lidar observations will be performed continuously as long term observations.

In 2012 2013, L-IPSL activities have been the following:

- **IPSL High-Performance multi-wavelength Raman Lidar**

Gordien Strato and Raymetrics conducted a pre-design study conducted from January to June 2013 to explore several possible optical and mechanical design options. The pre-design study yielded a 75 page document presenting technological challenges and solutions regarding (1) Laser emission, (2) Lidar telescope design for near and far field, (3) wavelength separation optical box (including wavelength filtering, depolarization, optical alignment), (4) system control and automation capabilities (including safety, optical alignment, optimized operation), (5) sensors and electronics, and (6) design of the enclosure. Three 1-day meetings were conducted with Gordien Strato, Raymetrics and IPSL to discuss the pros and cons of the various technological solutions. The predesign study allows us to adjust design vs cost (telescope, optics and automation) and to write a more precise Purchase Technical Document.

Therefore, the instrumental specification was written. The contract was obtained by Gordian Strato and Raymetric. The kick-off the IPRAL development was held on 3 April 2014. Manufacturing of the instrument will take place over a 10-month period, followed by a 2-month implementation and test period on site.The funding includes the contributions of the Ile-de-

France region, Ecole Polytechnique, CNRS / INSU, CNES and labex L-IPSL. ***The support from L-IPSL will allow IPRAL to include specific features on system control and automation to help operate the instrument remotely with limited operator intervention***. These features will include: (1) outdoor controls to make sure operating conditions are safe (this includes an aircraft detection radar that stops the Lidar in the presence of overflying aircraft at low altitude); (2) optical alignment system using boresight detector to verify the alignment frequently and improve data quality; (3) depolarization calibration through robotized polarizer to allow frequent verification of the calibration and hence improve the data quality; (4) filter wheels to adjust the received power according to atmospheric conditions to avoid detection saturation. These features are innovative in high performance Lidars, and corresponding developments done by the manufacturers will be able to be applied other Lidars developed in the future. Moreover, a project is underway between Ecole Polytechnique and Kaust University to develop a second IPRAL Lidar to be deployed at Kaust University (Saudi Arabia).

- **Pre-study on DIAL lidar development for tropospheric water vapor measurement**

In 2011, the LABEX financed the purchase of a lambdameter for future dial lidar (Leandre2 follow on).

One of the major constraints is that the system is to facilitate eye-safe operations under ground and airborne operations. At the time of the definition of the IPSL strategy (early 2012), we decided to move towards the area 1.5 microns, including an R & D expected to focus on the 'release' of the system (laser source based OPO - Optical Parametric Oscillator- and lambdameter). The L-IPSL allows to buy a the lambdameter is built by the German company High Finesse and marketed in France by OPTON LASER INTERNATIONAL) and the only available for the spectral resolution (30MHz) in impusionnel in the spectral range (800-1750nm). In autumn 2013, the lambdametre was mounted in the ATR-42 for a series of test to check its performance during flight, including his behavior when changing altitude (and therefore pressure).

In parallel, the financing of a dial lidar follow on "Leandre 2" has continued. Note that the targets were enriched by discussions and work within the L-IPSL around the measurement of water vapor isotopes. Therefore, it has been chosen to refocus our development lidar DIAL to domain 2 microns to allow measurement of the mixing ratio of water vapor and one of its isotopes, ie HDO. Following this decision, we decided to test the performance of lambdameter to 2 microns. However, tests carried out LMD showed that the detector did not respond and cut net in the IR beyond 1750 nm and can not operate at the wavelength selected to make measurements H2O / HDO (1980 nm). These tests cause to use a model operating continuously.The lambdameter remains at the disposal of the lidar community IPSL for any future development in the spectral range between 800 and 1750nm.

In 2015 Pre-study for a commercial lidar system :

This study is related to the need to have an automated instrument for meteorological needs. As the financing of a dial lidar struggling to be found, it is proposed to advance the industrialization component.

The observations of meteorological parameters are more and more scattered from the surface, especially in France where the number of observation stations has fallen sharply over the past decade. Although it is a priority to keep the radiosonde stations still operational in France, it is nevertheless necessary to develop stations equipped with automatic instrumentation for simultaneously measuring multiple parameters of interest for weather forecasting, climate, and monitoring crisis situations.The lidar could be part of this set of automated instrument and provide access to temperature and specific humidity, two basic parameters for meteorology, and

a temporal resolution schedule. An automated lidar would measure the state of the atmosphere at a much better than radiosonde frequency, although the vertical extent depend on instrumental characteristics and time of day (noise induced by the solar flux).

LSCE has developed a Raman vapor water system that has been implemented successfully in the framework of the Mediterranean and Hymex Charmex programs (Chazette et al. AMT 2014 and ACP 2014). This system could be a prototype for industrial development. The instrumental characteristics to measure the specific humidity profile up to an altitude of about 7 km at night (you can reach the tropopause clear sky). The details available are worse by day than night, but they are sufficient to estimate the water content in the boundary layer all day long (day or night). It also provides access to the contents aerosol to the tropopause day and night. LATMOS has developed the lidar DIAL water vapor LEANDRE-2 airborne successfully used in numerous national and international research programs. As already mentionned, the lidar system is now out of service and needs to be replaced.

A Raman lidar allow significant progress, but the feasibility of such a system as airborne instrument remains to be demonstrated. Another approach would be to develop a lidar DIAL operating in the near infrared. Such a DIAL system is also a promising technological solution for meteorological observation networks. ***The work proposed is to carry out studies to assess the advantages and disadvantages, and complementarities of Raman lidar and DIAL systems for the return of the vertical profile of specific humidity.*** *The study will be conducted for ground based systems (used in networks) and for airborne systems. At first, we will analyze the Raman Meteoorological lidar that would carry out measurements of water vapor, temperature and aerosol / cloud. For that purpose, we have an instrument in operation whose data will validate the numerical simulator. Moreover, we will study a new technology DIAL lidar using the atmospheric situations already considered for the error budget study of the Raman Lidar. Note that the numerical simulators are available in the laboratories involved. It will remain to adpt them to the observations choosen for these studies.*

The L-IPSL will fund a CDD of 6 months. This assessment will allow to detail the design of lidar systems and an evaluation of their cost.

Budget for instrumentation activities

Actions	2011- 2013	PA 2014
Project 1. Pre-study IPRAL	35121€	
Project 2. Pré-study dial lidar	62577€	
Participation IPRAL	125000€	
Pre-study comparison of Raman and Dial lidars		30000€ (2015)
Participation prototype of lidar To be decided after the pre-study		80000€ (2016)
	222698€	**2015 : 30000€** **2016 : 80000€**

3.2 Climate services

In 2013 the L-IPSL LABEX elaborated a strategy in the field of climate information transfer for adaptation, the so-called “climate services”, and which proposes a few actions that could take place in a time frame of 2 years by the LABEX teams, building upon existing activities.

The goal for IPSL is to develop an interface between the research and the many applications that could be developed in climate services by activity and the intended targetted communities. It must therefore develop active links with its network of companies, and have a capacity to:

- Provide projection and processed data (eg, general indicators on all climate projection data, CMIP5, all CORDEX areas), consistent with the work done within the framework of IS-ENES and CLIP-C Copernicus projects
- provide software prototypes developed in IPSL laboratories (eg statistical analysis of series, bias correction of datasets from the current climate and downscaling)
- develop “pilot studies " with industry and SMEs, but with an innovative character, ie non-repetitive, and that would have a return on scientific research (new original questions, etc ...)

Several actions have been proposed, and a number of actions are underway, also funded through external calls (Climate KiC FP7/H2020 projects, MEDDE, Copernicus). The dynamism of the area of climate services has also led to start new unforeseen actions. So far funding of activities has been primarily external to LABEX, but LABEX has funded several key actions:

- a call for proposals for transfer actions IPSL - SMEs was launched, and two projects were selected
- travel to several important meetings (CSP, preparation of Copernicus Climate Change Service)

Eight action types were defined, we report here the progress in each, and the proposition for 2015:

1. ***Forming a « climate service committee » to collect and exchange information and discuss actions***

A small group of researchers and engineers has indeed been formed to promote the dissemination of climate information, via contact with the non-academic world (policy makers, industry, SMEs, consultancies). It proposed a set of projects, made a call for proposals for projects between SMEs and IPSL teams, and selected two proposals. It is also working to participate to the national strategy on climate services as part of AllEnvi, and at European scale to the services Copernicus Climate Change Service (C3S).

2. ***The development of the PRODIGUER service***

The PRODIGUER team first core mission is to develop a facility providing climate projections at global or regional scale relying on major international exercises such as CMIP or CORDEX, as a node of the international distribution network (ESGF). Apart from the IPSL CMIP5 simulation outputs and together with several results contributing to various MIPs (PMIP3, TAMIP, EUCLIPSE, GeoMIP, LUCID, Obs4MIPS), the PRODIGUER service integrated IPSL simulation outputs from EURO-CORDEX (IPSL-chain CM5A-MR-WRF331) at low (50 km) and high (12 km) resolution. Within this scope PRODIGUER coordinates the national activity by gathering CNRM, CERFACS and the 3 GENCI's computing centre in the ESGF-France group. The PRODIGUER team continues on a regular basis to help projects making their way to ESGF. The current one being CCMI (Chemistry-Climate Model Initiative).

The second core mission of the PRODIGUER team is to lower the barrier towards the accessibility of the ESGF resources. Together with a High Performance Data Analysis cluster PRODIGUER maintains up to date users specified subsets of several high value datasets (CMIP5, Obs4MIPS, EUCLIPSE, ISIMIP, CORDEX, ...). Set of new features are continuously developed to help users to that end. The next step towards that goal will be to homogenize time axis of all the CMIP5 subsets hosted by PRODIGUER.

The development of this service has benefited from several external sources of funding (GIS CLIMAT, INSU, ANR CONVERGENCE, IS-ENES). The PRODIGUER team is currently composed by 2 permanent positions, 1 contractual research engineer and two subcontractors.

To strengthen the service it is proposed to extend by 6 month the research engineer work. The errata module and the associated strategy that has been developed by the research engineer at the beginning of his contract will be implemented within the new ESGF end user interface in collaboration with DKRZ. The aim being to have this centralized errata service ready and endorsed for CMIP6.

3. New processed reference climate data sets

Given climate simulations and projections from CMIP5 and CORDEX, several sets of "processed" reference data have been proposed to allow both for research projects on impacts and for adaptation studies to develop, both for research and application studies. These products are based on ongoing scientific projects. They must be made more generic and documented to be eligible for wide distribution. The proposed products are:

- **Product (s) 1**: A set of historical bias-corrected climate projections put on a common grid through statistical downscaling methods developed at IPSL (CDFT in particular). The aim was to have such products for a few key variables (T, P, V, radiation, etc.) for the global scale (CMIP5, ENSEMBLES, CORDEX [parts of Africa, Europe, Mediterranean, South America]. This action has received external funding, in particular from the climate KiC E3P for a few variables for EURO-CORDEX, to start the work, but must be continued to expand to the ambitions.

The proposition is to extend the E3P work by the funding of a research engineer for one year, to achieve most of the proposed data sets

- **Product 2**: A set of global multi-model corrected for bias (compared to the current climate) in 4 dimensions from CMIP5 on a common grid for the main variables used to force the models of regional climate simulations limits (U , V, T, some surface variables). For these data collaboration with INERIS took place, but no specific funding has been identified. At present, the methodology is still being validated (Colette et al., 2013), and the work should continue for climate projections.

The proposition is to mature the methodology in collaboration with INERIS. Funding is to be identified

- **Product 3:** A generic set of indicators from the impact models used in IPSL projects. The production of indicator data of heat stress has not yet started because the validation phase is still underway (WP4, research component of the LABEX). Other projects have nevertheless allowed the calculation of indicators for energy, as E3P (number of frost days), IMPACT2C, ISI-MIP (wind/solar power output, carbon cycle indicators), as examples.

4. A multi-model data set for national-scale DRIAS service

The goal is to provide Météo-France, which leads the DRIAS service, processed data (downscaled, bias-corrected based on SAFRAN dataset), resulting from the EURO-CORDEX projects and MED-CORDEX new high-resolution regional simulations (about 10 km resolution). This task is now complete. IPSL delivered to Météo-France all projections from EURO-CORDEX from European partners, projected on the SAFRAN grid and corrected for bias. This realization is gradually inserted into the DRIAS service and allowed the writing of the "Jouzel 2" report on climate change in France (see http://www.drias-climat.fr). This project has received funding from an external MEDDE (project "scenarios for France").

5. Collection and description of projects « towards climate services »

A web server is currently under construction for the description of identified projects. Its opening is planned for the end of 2014.

This action will be continued in 2015

6. An ensemble of climate change impacts projections

On the basis of the work of LABEX research WP4, the goal is to provide the outputs of several climate change impact models and adaptation projects. Following developments that will be made in the research component dedicated he is to provide term (2-4 years) products from regional or global impacts in a few key sectors where IPSL developed expertise through ongoing/previous projects:

- agriculture and forestry (thanks to developments around the ORCHIDEE model)
- water
- energy (several projects developed in IPSL teams)
- air pollution and health

This action has no identified external funding, and the strategy is to wait for maturation of data sets from research projects.

7. Climate analysis software

A set of analysis and data processing softwares is currently being developed. For example, this includes CDFT which is currently the subject of a code in R, but remains poorly suited for large data sets or as CMIP5 CORDEX. A specific development for these large sets is underway to optimize the code for these sets.

This action will continue in 2015, and will benefit from several external projects (CDF2). Part of the 1-year funding proposed in Action #1 could be devoted to this action.

8. New prototype projects with SMEs

These studies, to be conducted in connection with users outside academia, are to be identified through investigation of ideas from IPSL teams. The strategy is both to propose calls for projects with consultancies and possibly users (see below), and to develop strategic partnerships with SMEs to foster expertise transfer. Two types of actions are underway:

(1) A call for proposals was launched in 2013 by the climate service committee, for transfer to SMEs, funding "IPSL - SME" teams for the development of a demonstrator (see Appendix C): two projects are selected and started :

A project of transfer of the LMDz model to a SME (Aria Technologies) for different climate applications (lead Frederic Hourdin), summary:

The team that develops the atmospheric compenent of the IPSL climate model, LMDZ, did propose to work together with Aria-Technologies, a private company with strong experience in modeling in environmental sciences, to prove the capability of zoomed versions of LMDZ to answer demands on impacts of climate change. A one-year project was partially supported by the Labex. For Aria, it corresponds to an investment in a new tool and new focal area, and, thanks to this initial funding from L-IPSL, a permanent position was created and offered to a scientist issued from IPSL laboratories. One of the advantages seen by Aria in using LMDZ, is to compete at international level with a tool for which they can show a strong direct link with developers, as US companies can show with the WRF model which has reach a dominant position on such questions.

In practice, the one year project supported by the Labex consists in: 1) a transfer of expertise of the LMDZ model (the model itself being available on the LMDZ web site); 2) a demonstration study which consits in reruning a case study of climate down scaling for an impact study performd recently with the WRF model in the frame of the Cecif ANR project 3) finalize and promote a Grid-Cascade approach developed by Laurent Li for climate change simulations at regional scales. In this LMDZ-GC approach, global simulation with regular grid is ran together with the zoomed version to avoid inconsistency between the simulated global and regional simulation. This year will also be used to establish the modalities of collaboration with Aria-Technology and to perform a market study.

A « proof of concept » innovation project on statistical subseasonal forecasting (lead Pascal Yiou), summary:

The statistical method of atmospheric circulation analogues was devised in the 1960s as a means for weather prediction. Its performances as such were soon superseded by numerical weather prediction. It has mostly been used as a statistical downscaling tool (e.g. Vautard and Yiou, 2009). Recently, this method found innovative applications: the reconstruction of atmospheric fields that are compatible with surface atmospheric structures (Yiou et al., 2013, 2014), and the detection of extreme events (Yiou and Cattiaux, 2012, 2013, 2014). Within the Climate KIC project "Extreme Events for Energy Producers" (E3P: https://e3p.lsce.ipsl.fr/), LSCE developed a stochastic weather generator (AnaWEGE) that simulates time series of climate variables (temperature and precipitation) that are related to the atmospheric circulation, with a daily time step (Yiou, 2014). The ingredients of this weather generator are random selections of analogues of the atmospheric circulation over the North Atlantic region. This weather generator was tested for European temperatures, with a couple of test cases (summer 2003, winter 2009/2010).

In its present version (free software protected by a depository at the French APP), AnaWEGE simulates large ensembles of sequences (for instance, seasons) that are initialised by observed conditions between 1st January 1948 and 31st december 2012. It allows to determine the probability distribution of daily climate variables (temperature, precipitation) after a known initial state. It appears that this tool can be modified to produce simulations in "prediction" mode with an appropriate choice of circulation analogues. Hence, we plan to test the performance of this tool to simulate the spread of climate trajectories at a time scale between days and seasons.

This tool is not intended to replace predictions from meteorological centres, but to generate large ensembles (at least several hundreds of members, on a desktop computer in a few minutes) of climate variables, and compute their probability distributions. The scientific added value is a focus on regions, which is not reachable by numerical weather prediction products. Its ultimate use (for ARIA) is to increase the client awareness on uncertainty of weather prediction, and hence constitute a useful pedagogical tool. ARIA also showed an interest of the AnaWEGE tool (as is) for its own needs.

The scientific tasks of the project will be to adapt the AnaWEGE programme to prediction mode (based on regularly updated reanalyses). In this project, we will test the stochastic prediction mode against observations (and available operational analyses). ARIA Technologies made several market

studies on the impact of climate change. It was found that most potential clients are interested in subseasonal climate prediction and uncertainty.

The project is intended to transfer to ARIA-Technologies knowledge, statistical methods and uncertainties at such scales, by performing a common evaluation work.

(2) A project of transfer to a new spin-off added-value data sets from PRODIGUER, partly funded by the LABEX and the Climate KiC

The project, "Climate Data Factory 2", is following a “pathfinder project” (CDF) of the Climate KiC, is gathering a consortium with IPSL, ALTERRA (University of Wageningen) and the company CLIMPACT-METNEXT, with a goal of developing start-up developing making the first data processing that would allow work from consultancies with simpler and more calibrated climate data sets than direct data from ESGF, as well as training on the data. The “pathfinder” project was designed to do a market analysis and product definition, and propose intellectual property rules. The new innovation project, if funded by Climate KiC, will have 3 years to launch the spin-off and products. A summary of the project is:

CDF2 will target its products and services to “non-climate specialist” business of the services-to-businesses sector allowing them to easily include climate projections data in their own products or services and act as Value Added Resellers of climate information. The technical challenge is to reduce the complexity of use of the raw climate projections simulations with a post-processing (data standardization, correction and synthesis) to make these data “easier to use”, combined with a service of training and coaching. The training offer will involve Climate-KIC academic partners for their delivery across Europe. The major outcomes of the project are thus innovative data products and training services as well as a new company dedicated to their commercialisation that aims to operate under the Climate-KIC and contribute to the KIC’s sustainability through value sharing.

IPSL is now involved in two projects of the Copernicus Climate Change pre-operational services (EUCLEIA and CLIP-C), and is currently defining its strategy for the future Copernicus Climate Change Services (C3S) that will start in 2015. Another national project funded by the MEDDE has started in 2014 (EXTREMOSCOPE).

EUCLEIA and EXTREMOSCOPE both aim at developing new methods and tools to better understand extreme events in the context of climate change. EUCLEIA works at the scale of European events while EXTREMOSCOPE works at the scale of France. A major aim is the attribution of events. This is a topic where demand from media, public stakeholders and the insurance sector exist. The first study of these two projects concerns the case of last winter, which is ongoing. CLIP-C is a project where IPSL will develop research and methods for projection data processing for the definition of useful climate indices and uncertainty definition.

IPSL strategy for the Copernicus Climate Change Services will be to further develop climate projections and their processing (CMIP and CORDEX) for the service. IPSL will also propose indicators in a few key sectors where past and ongoing projects helped develop expertise (energy, water, agriculture, extreme events, …).

Budget for climate services activities

The LABEX expenses (committed and foreseen) are summarized below (green=starting in 2014, yellow=starting in 2015)

Actions	Commit. 2013-2014	PA 2014
Project 1. Transfer of LMDz	60000	
Project 2. Transfer méthodologie analogues	37000	
Missions & training	4885	
Project 3. Climate Data Factory		100000 (2015) 50000 (2016) 50000 (2017)
Project 4. Bias corrected data sets at global/European scale		50000 (2015)
Project 5. PRODIGUER support		25000 (2015)
Other projects : AO IPSL-SME 2015		150000
Missions		10000 (2015)
Total	**101885**	**2015 : 335000** **2016 : 50000** **2017 : 50000**

4. Education and Training

4.1 Main objectives

During the next decade, the needs for education and training on environmental changes should increase largely, because political and economic decisions will have to take global changes into account from global to local scales. This will concern all aspects of our socio-economic system, from citizens to governments, from start-up initiatives to international companies. New opportunities of careers will appear, the skills for existing jobs will be modified by environmental policies and training all along the professional life will become a more critical issue. Teaching on climate has developed since 20 years in close relationship with research activities. It has reached a good maturity, making possible and necessary its spread beyond the research community through projects of reference textbooks, e-learning modules, and collaborative websites. At the same time, the fast expansion of the international dimension of research and education, with a constant motion of students and post-docs between the major laboratories around the world, is also an element to add in the education equation. The various master degrees existing on climate issues in *Ile de France* must improve their coordination and be more visible for French students but also for foreign students.

The objective of L-IPSL, in a very active education and training ecosystem around Paris, is to provide and improve the bridges between the continuously evolving science developed in the research part of L-IPSL, the multi-actor higher-education system (universities, *grandes écoles*, …), and the increasing demand of knowledge about climate issues from various sectors of the society.

4.2 Implementation

The implementation of the above general objectives is organized through five axes, defined and animated by the education committee of L-IPSL, formed by one professor or assistant professor per partner of the L-IPSL :

- ***Axis 1: Improvement of the organization and visibility of the graduate level education on climate sciences in Ile de France***

A label for master education on climate: In phase with the *plans quinquennaux* of the universities, the education committee propose the development of a Climate path through masters of the L-IPSL partners with a joint knowledge base and skills that all graduate students studying climate should have. A label is proposed validating (1) a minimum knowledge of climate sciences and (2) minimum skills on observing and modelling the climate system. The former will be assessed through identified teaching modules, either specially developed for L-IPSL, or existing in master degrees. The latter will be based on lab/field works organized in the different observing and modelling platform of L-IPSL. This label is an opportunity to progress towards a (necessary) harmonisation of the offer of master degrees on climate sciences in Ile de France and to launch a reflexion to make them more attractive for students in France but also for foreign French-speaking students worldwide. First joint courses part of this label will start in September 2015.

An integrated Web platform for information and orientation of students: A WEB platform has developed, to present the education offer on climate and environment in *Ile de France* : climport.ipsl.fr This platform aims at informing and guiding students towards the best pathways based on their interests and their targeted jobs and skills. It is developed in partnership with PRES UniverSud-Paris and with the support of a contractual assistant hired by L-IPSL to gather and organize information. The originality of the platform is the search engine specifically developed to sort masters depending on keywords chosen by the students and including skills, types of jobs,

themes or disciplines to study, for instance. The WEB platform has been released in June 2014 and will experience a first update by the end of 2014 to include new master programs and to update already-referenced ones..

A project of master dedicated to climate change for journalists and communicants (ACCES): Acknowledging the poor understanding of climate sciences in the general public, and in line with the L-IPSL objectives to train the trainers, we designed the content of a master dedicated to journalists and communicants. Through an e-learning platform, this master, when funded, will propose knowledge and skills about global changes and their impacts to journalists and communicants worldwide. A first action has been performed in 2013 : Several small videos explaining challenges around IPCC reports have been realised and released at the same time as the IPCC report was available in September 2013. These videos are available on: www.accesterra.org.

- ***Axis 2 : Promotion of practical training on climate sciences***

Support to lab and field works: Linked with the objectives of axis 1, labex L-IPSL will support the creation and improvement of the offer of lab and field works proposed by licence and master programs on climate and environment in *Ile de France*. This covers lab works (TPs), field work (e.g. students at sea, weeks at *observatoire de Haute Provence*, …) This practical approach to climate sciences is very attractive for students. It also allows training students on classical experimental and modelling techniques (sprectrometry, chromatography, optical methods, programming, data analysis sampling of soils waters and air, …) that can be useful for them whatever is their future professional life. An extensive database of existing lab and field work activities is under development by a contractual assistant hired by L-IPSL to gather and promote on the WEB existing activities. This axis funded a generic call for practical session for master students and will launch soon a new call (by December 2014) to fund undergraduate lab works in order to promote climate sciences before studends choose their master.

Support for student/PhDs projects: Students with collective training projects to realise during their master or PhDs can benefit of a support from L-IPSL. Projects can imply field work,, summer/winter schools, or workshops, with the condition that at least a part of the activity is dedicated to collective student training,. Several projects have been supported in 2013 and 2014 and this action will continue in 2015. Requests are examined and approved by the education committee

- ***Axis 3 : Professional insertion and training***

Development of training modules for professionals: one objective of this task is to provide training modules of 1-3 days about climate and environment dedicated to professionals needing minimum knowledge and skills about the different topics treated within L-IPSL. We act on two sides for this axis. On one side, two modules have been designed and inserted in the professional training catalogue of CNRS : one on air pollution, and one on climate change and its impacts, linked with the release of the IPCC AR5 in autumn 2013. On the other side, we also answer to requests from industrials on dedicated training sessions for their employees. A contractual person is hired by L-IPSL to find and organize professional sessions. First sessions should have been given in spring 2014 and should continue during Autumn 2014.

Improvement and diversification of professional insertion of graduated students: One aim of this axis is to create closer links between students and their potential employers including academic and non-academic ones. The promotion of our master programs will be organized for services of human resources in private companies, which could potentially hire the graduate students of L-IPSL partners. Their needs will also feed our reflexion to design the offer of formation within L-IPSL in

order to better prepare students to future jobs in the climate domain. This action has started in 2013 but paused in 2014 to concentrate on professional training. It should restart in 2015.

▪ *Axis 4 : Development of e-learning*

Development of e-learning modules: Developing e-learning content is important both as a complement to in-situ teaching and as a tool to largely diffuse training programs on climate sciences. Several projects have already been totally or partially funded by L-IPSL and are available through : http://www.ipsl.fr/fr/Formation/Formations-en-ligne :

- **An online module on climate system seen from the point of view of observations and data analysis, with a very broad targeted public (http://mmse-uved.ipsl.jussieu.fr/html/index.html)**
- **An online module e-climat (**https://proxy.reeds.uvsq.fr/galleries/broceliande7/E-Climat) **presenting a global view on climate system and on climate change, targeted public being any person with a bachelor in sciences.**
- **The Web site *"le climat en questions"* a series of questions linked to climate and climate change, answered and signed by scientists with different level of complexity depending on the targeted audience (from large public to specialist). This site is to be released during Autumn 2014.**
- **An online module on the impacts of climate change on marine and continental ecosystems, dedicated to a broad public will be available in autumn 2014.**
- **A project of international master2 on climate change and its environmental, social, political and economical implications (ACCES) has been included in the master program of the future université Paris-Saclay.**
-

Developing a local e-learning platform: L-IPSL also decided to develop an e-learning platform to host the developed e-learning content. This platform will have a public area with above modules and a private area to organize online training sessions with registered students or profesionnals with supervision from scientist. This platform should be available by the end of 2014.

▪ *Axis 5: Asserting a discipline through the diffusion of knowledge and of teaching and communication material*

After more than 20 years of development, academic teaching about climate sciences has now reached maturity, which needs to be consolidated to play its full role as part of global change education. In this axis we propose:

- to support training actions and knowledge diffusions through summer and winter schools, workshops with sessions dedicated to students, sea universities, thematic days about climate for various public, … Demands are submitted to the education committee which decide to fund them or not. This part has been very active since 2012 as many training actions needs to build thei budget with multi funding sources.
- to initiate a series of reference textbooks, online material, gathering and synthetizing the existing knowledge and skills existing among L-IPSL partners about climate sciences. An editor will be chosen and an e-learning framework chosen to perform these developments, which will be encouraged and supervised by the education committee with the support of a contractual assistant hired by L-IPSL. Thematic schools will be funded and/or proposed and/or advertised to complement existing offer at a national level. This axis has already support some summer schools and will start to develop its own activities in 2015.

4.3 Mid and long-term objectives

During the next 18 months, the education committee, with the support of education assistants hired by L-IPSL will :

- **implement the label for graduate education on climate sciences**
- **extend the CLIMPORT master website to new master programs**
- **propose e-learning content through a dedicated platform**
- **Organize and deliver actions on professional training and insertion**
- **initiate the work to produce one or two textbooks on climate sciences**
- **use the different contents developed by L-IPSL (WEB, e-learning, textbooks, professional training) to "train the trainers" that is to provide the minimum knowledge about climate sciences to society relays such as teachers, journalists or policy makers.**

The L-IPSL education label will give more opportunities to students in their professional life.

The success of these five educational objectives will be assessed through a set of visible deliverables. Within 10 years L-IPSL aims :

- **to improve the national and international visibility of L-IPSL universities and *Grandes Ecoles* with more international students in the masters, renewed and harmonized contents, completed by regular attractive international thematic schools proposed or supported by L-IPSL;**
- **to have a collection of consolidated teaching and training resources dedicated to a quantitative description of the "Earth system sciences" available in various formats : e-learning modules and full programs, textbooks, web site, training modules for influencers and trainers, … ;**
- **to have closer links and more opportunities in terms of jobs for graduate students, by improving the links with non-academic companies and local authorities.**

4.4 Budget 2013

RECETTES		DEPENSES	
NOM	**MONTANT**	**NOM**	**MONTANT**
Subvention L-IPSL	**150000**	**Personnel**	**82860**
		ingénierie auto-entrepreneur (Axe 1)	15984
		CDD ingénieure pédagogique (Axe 1)	5552
		CDD ingénieure pédagogique (Axe 2)	16544
		Conseil auto-entrepreneur (Axe 3)	12480
		CDD e-learning (Axe 4)	32300
		Fonctionnement / Actions	**48363**
		Vidéos IPCC ACCES (Axe 1)	9205
		Site Web le climat en questions (Axe 1)	28376
		Soutien formation DOWEX2013 (Axe 5)	1192
		Soutien écoles thématiques (Axe 5)	5617
		Soutien diffusion des connaissances (Axe 5)	3973
		Report 2012	**14073**
TOTAL	**150000**	**TOTAL**	**144303**
Différentiel	**+5697**		

Appendix A : Mid-term projects

This section includes reporting on all 11 post-doctoral projects decided in 2012 and 2013. In each case, the position offer is presented. For 2012 projects, intermediate reporting is presented, as most projects are not achieved yet. For 2013 projects, only the position offer is presented.
Publications from the projects are reported

Project 1 (WP1-WP3-WP4): Modeling inland water greenhouse gas fluxes

Project lead: Philippe Ciais
Post-doctoral researcher: Ronny Lauerwald
Project start/end: July 2013 – June 2015

Position offer:

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a post-doctoral position of 2 years to integrate into the IPSL Earth System Model some of the key previously neglected inland aquatic processes than form the so called "boundless carbon cycle". The proposed post-doctoral position project is a reaction to the growing awareness that inland waters contribute significantly to global greenhouse gas (GHG) fluxes, and to the realization that their sensitivity to projected climate change and eco-hydrological disturbance is poorly constrained.

Context : The conventional wisdom is that inland waters simply transport terrigenous organic carbon to the oceans. This view is perpetuated by current models of the global carbon cycle that largely ignore inland waters as represented in, for instance, the Intergovernmental Panel for Climate Change (IPCC) – Fourth Assessment Report (FAR), or the Integrated Global Observing Strategy report (GEO-Carbon). In the five years since the publication of IPCC's FAR in 2007, it has become apparent that the global flux of GHGs from inland aquatic sources to the atmosphere is much larger than previously suspected (Battin et al., 2008; 2009; Butman and Raymond, 2011; Bastviken et al., 2011; Barros et al., 2011). Thus, recently published estimates indicate that inland waters degas from 0.8 Pg (1Pg= 109 metric tons) of carbon per year (excluding wetlands, Cole et al. 2007), up to 3.3 Pg C y-1 (including wetlands, Tranvik et al., 2009; Battin et al., 2008; 2009; Aufdenkampe et al., 2011; Butman and Raymond, 2011), the latter estimate of similar magnitude to the terrestrial carbon sink of 2.8 Pg C y-1 (Canadell et al. 2008). Only recently have regional scale carbon balances begun to consider these fluxes (e.g. Luyssaert et al., 2012), but large knowledge gaps remain concerning their magnitude and their ultimate significance for global carbon cycle models. Current estimates based on global surveys and 'bottom up' extrapolations from streams and rivers in the United States for example indicate that this GHG flux is significant relative to the total anthropogenic flux of carbon to the atmosphere, with emissions from the northern hemisphere temperate zone (25oN-50oN) rivers alone estimated to be c. 0.5 Pg annually (Butman and Raymond, 2011). Additionally, a recent survey of CH4 emissions from inland aquatic systems (lakes, reservoirs and rivers) indicated annual CO2-equivalent methane emissions of a similar magnitude (0.65 Pg of C as CO2 equivalent; Bastviken et al., 2011). These recent estimates necessitate a paradigm shift from the traditional depiction of streams, rivers and other inland freshwater bodies as inert conduits and reservoirs, to one in which the kinetics of climate-sensitive GHG production by aquatic biogeochemical transformation reactions, hydrologically driven soil gas flushing from riparian zones and the dynamics of gas transfer processes at water/air interfaces are incorporated into realistic 'boundless carbon cycle' models.

Despite the potential importance of these GHG emissions, their inclusion, even under a simplified form, in current Earth System Models is still missing, although several research teams began to work in that direction. The sensitivity of lateral C fluxes in aquatic systems to global change and eco-hydrological disturbances is largely unknown, and their overall significance for Earth's global carbon budget remains to be established as well. Much previous work on regional scale carbon balances has focused on terrestrial sinks and sources, but it is increasingly appreciated that flux measurement techniques that are applied widely to terrestrial systems (e.g. Eddy covariance methods) are inappropriate or require re-evaluation for aquatic systems.

Description of work: The postdoctoral fellow will interact with researchers at LSCE and SISYPHE laboratories, part of L-IPSL, and incorporate a set of simplified parameterizations on the land surface scheme ORCHIDEE of the IPSL Earth System model the following processes : C emissions from soils to

rivers headstreams for DIC and DOC, with a highly parametric inclusion of chemical alteration fluxes of C from atmospheric origin, CO2 evasion data from rivers and floodplains, C burial in lakes and freshwater sediments and CO2 emissions from estuaries (the later using the global upscaling model developped by Pierre Regnier at University of Utrecht). The ORCHIDEE model enabled for carbon transport from soil to rivers and lakes will be tested and calibrated against a new pCO2 global database and river fluxes of DOC, DIC (COSCAT database of 150 catchments; http://www.agu.org/pubs/crossref/2006/2005GB002540.shtml). The model will be applied in the second year for characterising the presently unknown atmospheric feedbacks (positive and negative) between inland aquatic carbon evasion fluxes and drivers such as climate change and anthropogenic eco-hydrological disturbance.

Supervision team: The researcher with a PhD in earth system science, will be hired by CNRS and will be hosted at LSCE in Saclay while working in close collaboration with SISYPHE in Paris. The work will be in a project team led by Philippe Ciais, including also Laurent Bopp, Josette Garnier, Sebastiaan Luyssaert and Christophe Rabouille.

Duration and salary: The post-doctorate will be recruited for 24 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a vita, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to Philippe Ciais (philippe.ciais@lsce.ipsl.fr).

Preliminary results:

(1) Step 1: A better estimate of CO2 evasion from inland waters (Lauerwald et al. sub)

R. Lauerwald and co-workers have established a new and more robust estimate of CO2 fluxes between inland waters and the atmosphere at planetary scales. To do so, they have used data of riverine CO_2 partial pressures (pCO_2) from ~1200 sampling locations as well as empirical prediction function for river pCO_2. They have applied this prediction equation to calculate a highly resolved (0.5°) global river pCO_2 map. Combining this pCO_2 map with spatially explicit estimates on stream surface area and gas exchange velocity, they have calculated a map of CO_2 evasion (Figure 1).

At the global scale, as representative for the time after 1990, they estimate an average river pCO_2 of 2400 µatm and a total FCO_2 of 456 Tg C yr^{-1}. About half of the global FCO_2 is contributed from the latitudinal band between 10°N and 10°S. Streams and small rivers with annual average discharges below 100 m^3s^{-1} contribute about half of the effective stream surface area, but even 69% to FCO_2.

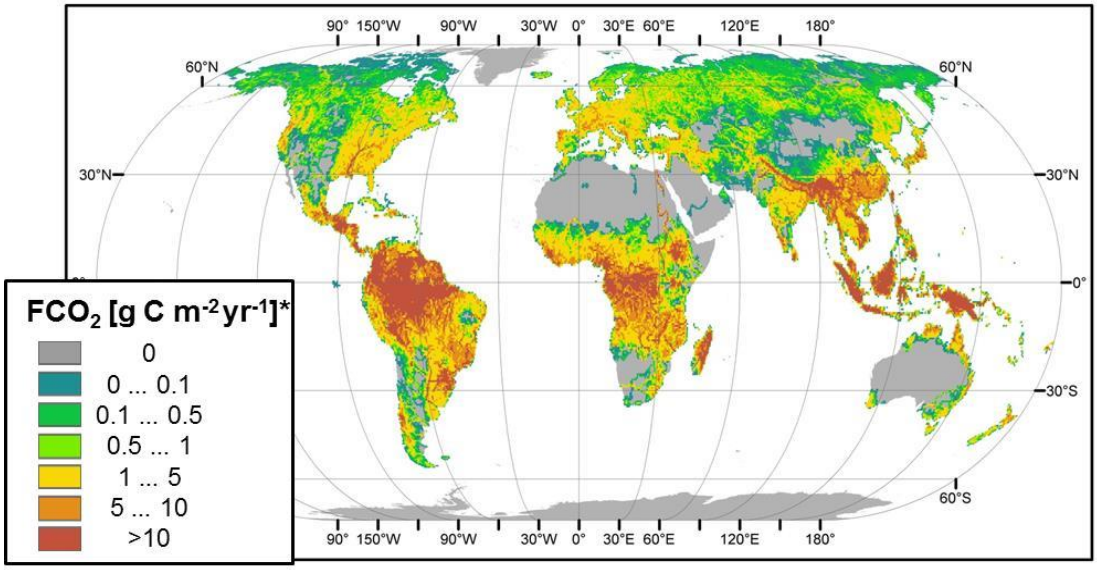


Figure 1 : Estimated CO_2 evasion (FCO_2, gC m-2 y-1) per half degree grid cell. FCO_2 refers to total cell area.

This estimate of global FCO_2 is substantially lower than the 1800 Tg C yr^{-1} recently estimated by *Raymond et al.* [2013], mainly due to a lower estimate of the effective global stream surface area and a more conservative estimate of average river pCO_2 in tropical rivers. Analyzing and discussing different sources of uncertainty in their methodology and that of previous studies, Lauerwald et al. argue that their estimate is more robust and less prone to biases than earlier estimates. As a further supportive evidence, their estimate of FCO_2 fits well into recent, integrated C budgets of the global in-land water system.

Step (2): Incorporation of carbon in the routine scheme of ORCHIDEE (in progress)

At the present stage, Rony Lauerwald has enabled the routing code to transport two different species of dissolved carbon (C): dissolved organic carbon (DOC) and dissolved CO2. He also introduced the decomposition of DOC which, at each time-step, decreases the DOC pool and increases the CO2 pool in each reservoir.

The evasion of CO2 from the water surface to the atmosphere is not yet included, but will be the next step. So far, the input fluxes with runoff and drainage are merely hypothetical based on fixed concentrations, which makes it easier to verify whether the routing works and is conservative where it should be conservative.

References:

R. Lauerwald, G.G. Laruelle, J. Hartmann, P. Ciais, P.A.G. Regnier, Spatial patterns in CO_2 evasion from the global river network, submitted to Global Biogeochemical Cycles.

Project 2 (WP2): Volcanism during the last millenium

Project lead: Myriam Khodri
Post-doctoral researcher: Virginie Poulain
Project start/end: September 2013 – August 2015

Position offer:

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a post-doctoral position of 2 years to address impacts of volcanism on climate in the last millenium.

Context: It is now generally recognised that volcanic eruptions have an important effect on climate variability from inter-annual to decadal timescales. Using comprehensive Earth system models, much progress in understanding volcanic climate effects have been achieved in recent years, including the impacts on atmospheric chemistry and dynamics, on ocean dynamics, marine and terrestrial biochemistry and on the hydrological cycle. These results are however hampered by many assumptions on the reconstructed past volcanic activity, but also on the choice on sulphate aerosol size distribution and their implementation in the radiation scheme of models themselves. Several outstanding questions remain and concern the behaviour of huge SO_2 cloud injected into the stratosphere after super eruptions such as those that did occur during the last centuries.

Description of work: All in all, these results call for more process-oriented sensitivity experiments. The challenging task for the hired post-doctoral fellow would be to improve the actual volcanic forcing reconstructions and its implementation in the IPSL models. As a first step, the focus will be on the calculation of the temporal evolution of volcanic aerosol size distribution, global fields, and optical characteristics, for the two biggest volcanic eruptions of the last millennium, i.e. the 1258 AD and the Tambora (1815). Such calculations will be done with a global 2-D stratospheric climate model including detailed microphysical and chemical processes for stratospheric volcanic aerosols. This model has been developed at the LATMOS laboratory (IPSL). New estimates of SO_2 release are now available for these two eruptions and will be used to constrain the SO_2 loading in the 2-D model. This will allow the calculation of (1) consistent evolution of the global distribution and size of stratospheric sulphate aerosols after each eruption and (2) deduce the related optical properties (AOD, single scattering albedo and parameters of asymmetry) for both v*isible* and *infrared* spectral bands.

In a second step and in collaboration with LMD laboratory (IPSL), the deduced new size distribution and optical parameters will be implemented into the LMDz radiation scheme for both spectral bands (visible and infrared). Sensitivity experiments with chemistry-climate models (CCM), LMDz-REPROBUS and/or LMDz-INCA, coupled to NEMO, including the new stratospheric aerosol radiation schemes will then be used to run sensitivity experiments and evaluate the impact of competing non-linear radiative and chemical processes on the simulated climates for volcanic eruptions. We will start by a test case, simulating the Mont Pinatubo eruption in the CCM model. The results will be validated against the large datasets of observations (satellite, balloon, reanalysis,…) and serve as a reference control run. Then we will tackle the two biggest volcanic eruptions for the last millennium (i.e. 1815, 1258 AD).

In the last step, cross validations of the sensitivity experiments for the mega eruptions with proxy data will be essential to better evaluate the realism of the new volcanic forcing parameterisation for the largest eruptions. More proxy reconstructions are now available at IPSL (LSCE, LOCEAN, etc.) and in other national and international laboratories. They will help constrain the climate sensitivity. In interaction with the LOCEAN laboratory (IPSL), further tests will be required on the influence of the initial state (including the ocean) on the simulated climatic response following these volcanic eruptions before extending our approach to the whole millennium.

Supervision team : The work will be conducted under the main supervision of M. Khodri (LOCEAN), in close connection with other researchers : M. Marchand (LATMOS), S. Bekki (LATMOS), O. Boucher (LMD), J. Mignot (LOCEAN), D. Swingedouw (LSCE). The work will be mainly conducted at LOCEAN, but in other IPSL sites also.

Duration and salary: The post-doctorate will be recruited for 24 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a vita, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to Myriam Khodri (Myriam.Khodri@ird.fr).

Preliminary results :

Modèle 2D

La première année du projet (Sept-13-Sept14) a été dédiée la prise en main du modèle 2D (*Bekki et al, 1994*), son amélioration et réévaluation pour être cohérent avec les observations actuelles (mesures ballons, satellitaires). Nous avons ajouté des équations sur la chimie du souffre, des équations de chimie hétérogène et nous avons modifié la formation des noyaux de nucléation. La comparaison des résultats avec les différents jeux de données (*Gao et al 2008 ; Sato et al, 1998* ; CCMI et SAGE) pour l'éruption du Mont Pinatubo a révélé une bonne cohérence et a permis la validation du code. Nous avons également implémenté ces forçages dans le modèle couplé de l'IPSL (bandes spectrales solaires), dans sa version CM5A-LR et évalué les résultats pour un run d'ensemble (5 membres) pour l'éruption du Mt Pinatubo.

Les résultats de ces simulations étant très satisfaisants nous avons ensuite réalisé plusieurs simulations pour les deux méga-éruptions du dernier millénaire (Tambora 1815 et Salmas 1258) en injectant dans le modèle 2D les quantités de SO_2 mesurées dans les carottes de glace. Un important travail de ré-analyse des carottes de glace Groenlandaises et Antarctiques a été entrepris par V. Poulain afin d'estimer au mieux la quantité de souffre dégazé dans l'atmosphère pour 4 éruptions majeurs dont celle du Samalas (1258) et Tambora (1815). Nous avons aussi exploité les estimations des hauteurs des colonnes éruptives réalisées à partir des dépôts (isopleth et isopach) autour des deux volcans. Enfin, une collaboration a été nouée avec des dendro-climatologues et historiens suisses qui disposent d'archives historiques (pour le 13^{e} et 19^{e} siècle) et d'un réseau de cernes d'arbre sans précédent couvrant l'Hémisphère Nord pour les 1500 dernières années (résolution annuelle).

Nous avons pu ainsi, tester et évaluer les effets de l'altitude d'injection (test sur les incertitudes associées aux méthodes empiriques isopleth/isopach), la quantité de SO_2 injectée (test sur les incertitudes des mesures dans les glaces), la saison de l'éruption (éruption en janvier, mai, ou juillet) et l'atmosphère dans laquelle évolue l'éruption (atmosphère actuelle et préindustrielle). Nous avons également confronté nos résultats avec ceux de *Gao et al. (2008),* et *Crowley et al (2008)* qui correspondent aux reconstitutions recommandées par PMIP3 (*Schmidt et al., 2011*) et utilisées dans le cadre de l'exercice CMIP5. Les résultats de cette étude révèlent pour la première fois, une convergence entre les reconstructions des cernes d'arbres et des simulations

climatiques avec un refroidissement moyen de l'Hémisphère Nord induit par ces éruptions, de l'ordre de -1,2 ° C (contre -2.5 à –5.7 pour les modèles PMIP3). Nos résultats indiquent l'importance de la représentation des processus microphysiques des aérosols stratosphériques dans les modèles de climats. Ils remettent également en cause les reconstructions antérieures des températures pour l'Hémisphère Nord (i.e. d'Arrigo et al 2006), et les résultats des simulations climatiques réalisées avec des forçages simplifiés. Les résultats de cette étude ont été soumis à la revue Nature.

En parallèle nous avons réalisé un jeu d'expériences idéalisées afin d'explorer l'espace de phase de la réponse climatique en fonction de l'intensité de l'éruption (1, 3, 10, 30 fois la quantité de SO_2 du Mt Pinatubo), la saison de déclanchement (été/hiver) et l'altitude de la colonne éruptive (basse/moyenne stratosphère). La distribution en tailles des aérosols ainsi formés, leur transport dans la stratosphère et leurs paramètres optiques ont été systématiquement évalués. L'impact climatique (température globale, tropicale ou hémisphérique) a été étudié grâce à la réalisation pour chaque scénario, de runs d'ensemble (5 membres) de 10 ans avec le modèle couplé de l'IPSL-CM5A-LR (64 simulations au total). Les résultats révèlent la réponse non-linéaire du refroidissement de surface en fonction de l'intensité de l'éruption. Dans le cas des éruptions les plus puissantes (= éruption du Toba, 600 Tg de SO_2 contre 20 Tg pour le Mt Pinatubo) le refroidissement n'excède jamais -2°C en moyenne globale.

En revanche une asymétrie inter-hémisphérique du refroidissement apparaît dans le cas où la colonne éruptive atteint 35 km (i.e. Samalas). Les aérosols volcaniques formés à partir de l'oxydation de SO_2 ont tendance à être entrainé en altitude par la circulation grande échelle (upwelling, circulation de BD) où ils sont alors détruits par vaporisation. Ces gazes soufrés d'altitude (sans épaisseur optique et donc sans forçage radiatif) sont ensuite transportés par la circulation stratosphérique vers l'hémisphère d'hiver. Aux latitudes extratropicales la subsidence leur permet de condenser à nouveau sous forme d'aérosols avant de sédimenter vers la surface. Ces processus expliquent le faible refroidissement en moyenne globale au regard de l'intensité de l'éruption et la forte hétérogénéité spatiale du refroidissement (jusqu'à -6°C dans certaines régions extra tropicales). Les méga éruptions génèrent néanmoins par phénomène de coalescence de plus grosses particules qui sont donc moins réfléchissant (par unité de masse) vis à vis du rayonnement solaire.

Cette étude est en cours de rédaction avec une soumission prévue avant la fin de l'année (Poulain et al., 2014, in prep).

Notre objectif à court terme est de pouvoir proposer un nouveau jeu de forçage pour le volcanisme du dernier millénaire et contribuer à l'effort international en cours visant à réduire les incertitudes sur les forçages naturels et leur représentation dans les modèles. Dans ce cadre nous avons récemment envoyé (12/09/2014) à Veronika Eyring (Chair CMIP/WCRP), la proposition d'un VOLMIP dans le cadre de CMIP6 (« *Model Intercomparison Project on the climatic response to Volcanic forcing*"**.** Co-chairs: Davide Zanchettin , Claudia Timmreck and Myriam Khodri**.** Scientific Steering Committee: Gabi Hegerl, Alan Robock, Anja Schmidt, Matt Toohey and Edwin Gerber.)

Prospective Année 2015

Modèle 3D LMDz-Reprobus-NEMO et prise en compte en plus du rayonnement solaire, de l'effet des aérosols sur le LW terrestre (en collaboration avec O. Boucher).

Le premier semestre sera consacré à l'évaluation de la prise en compte du couplage des effets radiatifs à la chimie hétérogène induite par la présence d'un nuage d'aérosols. La prise en compte des effets chimiques (Ozone) et/ou radiatifs des aérosols volcaniques nous permettra de mieux évaluer l'impact relatif de chacun sur le climat (e.g. Thompson and Salomon 2009 ; Timmereck et al, 2012).

Le protocole expérimental reste à préciser mais nous envisageons un protocole équivalent à celui réalisé avec la version IPSL-CM5A en 2013.

References:

Poulain V, M. Khodri, M. Marchand & S. Bekki, *Stratospheric dynamics and micro-physical processes confines climate responses to volcanic mega eruptions*, in prep.

Stoffel M., Corona C, Guillet S., Khodri M., Poulain V, Guiot J., Luckman B.H., Oppenheimer C., Bekki S., Beniston M. & Masson-Delmotte V., *Reconciling dendroclimatic reconstructions and simulations of volcanic cooling*. Submitted.

Project 3 (WP4-WP3-TWP3): Assessing the robustness of multi-region and multi-sectoral indicators of climate change impacts

Project lead: Benjamin Sultan
Post-doctoral researcher: Yan Zhao
Project start/end: May 2013 – April 2015

Position offer:

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a post-doctoral position of 2 years to assess impacts of climate change in various sectors and regions of the world.

Context: The Fourth Assessment Report of the Intergovernmental Panel on Climate Change has, with greater confidence than previous reports, warned the international community that the increase in anthropogenic greenhouse gases emissions will result in global climate change with potential impacts on natural resources, ecosystems and human's activities. Thus, there is a growing literature on the impacts of climate change, mostly using global climate models (GCM) projections to drive process-based or statistical impact models. However, very large uncertainties remain between impact studies, reflecting the diversity of such studies, which often focus on different locations, and rely on different climate projections (models, scenarios), type of impacts and impacts models, downscaling techniques, time horizons, etc.

Description of work: We therefore propose a coherent multi-region and multi-sectoral approach to examine the robustness of projected impacts driven by IPSL-CMIP5 climate change scenarios. Various downscaling methods (delta method, CDFt, homogenous climatic zones, CORDEX dynamical downscaling, and use of raw GCM outputs) will be used in order to assess knowledge and uncertainty in impacts projections among sectors and regions of the globe. This work is part of the Labex L-IPSL project which aims at improving our knowledge on climate change and to anticipate its impacts on nature and society.

The recruited post-doctorate fellow will participate to the selection of a set of indicators of impacts of climate change on prone sectors and regions. This part of the task implies a very close collaboration with all L-IPSL partners. He/she will be in charge of downscaling IPSL-CMIP5 climate change scenarios with various existing methods (most of them have already been implemented at IPSL). He/she will then use several impacts models developed or used by the l-IPSL teams, including the land surface model ORCHIDEE, to produce maps of relevant indicators of climate change impacts and to analyze the robustness of such impacts projections in regards to the used downscaling method. Experience in biosphere modelling, statistical analysis and linux environment will be greatly appreciated.

Supervision team: The work will be conducted at LOCEAN/IPSL located at University Pierre and Marie Curie (4 place Jussieu, Paris 05), under the main supervision of B. Sultan (LOCEAN) and in close connection with other researchers of LSCE (P. Braconnot, M. Vrac, N. De Noblet, O. Bopp), SISYPHE (A. Ducharne), LATMOS (C. Flamant) and in the L-IPSL project.

Duration and salary: The post-doctorate will be recruited for 24 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.
Contact for applications: Applications should include a vita, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers.

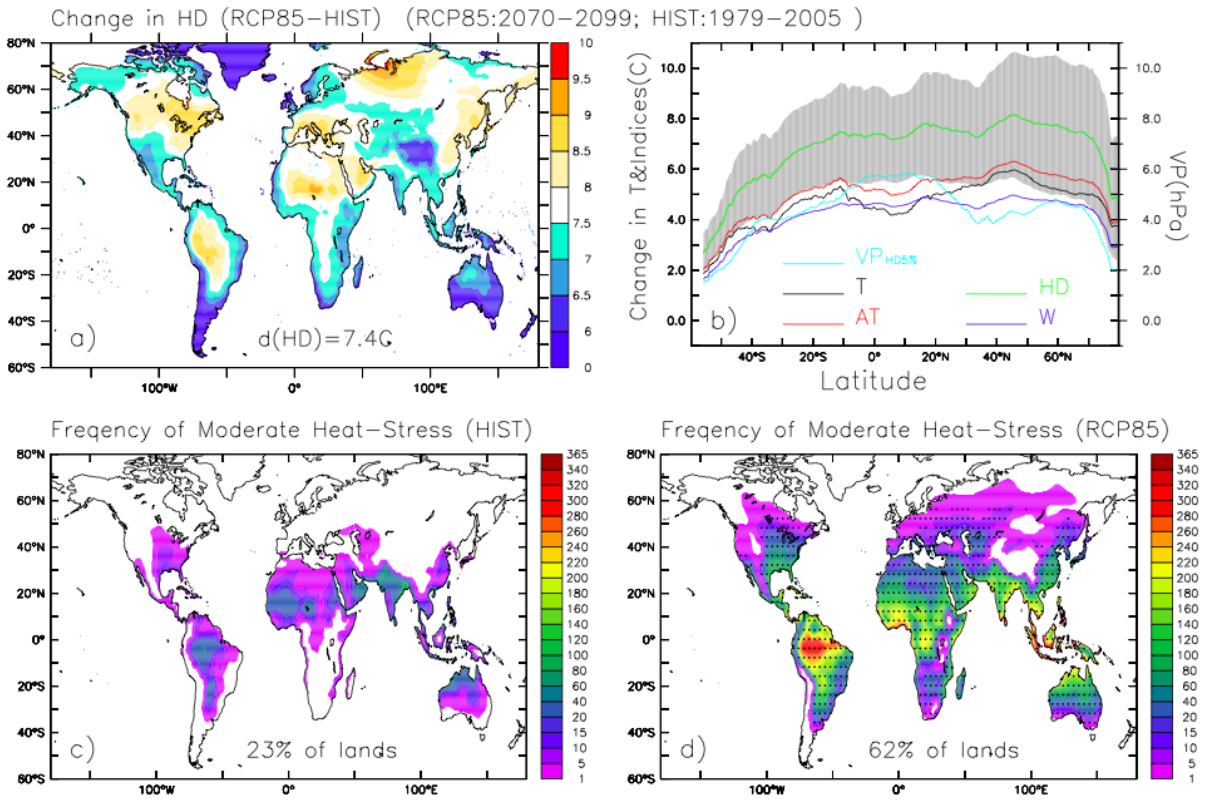
Applications should be submitted by e-mail to Benjamin Sultan (Benjamin.sultan@locean-ipsl.upmc.fr).

Preliminary results:

Heat is an environmental and occupational hazard. It can have disastrous consequences, as was illustrated by the hot summer of 2003 in Europe. The risk of heat stress posed by climate change is likely to enhance thus needs to be urgently assessed in order to take corresponding adaption action. We use three health-related temperature-humidity thermal indicators (Steadman, 1979, 1984; Masterton and Richardson, 1979; ABM), and 21 climate simulations from CMIP5 (historical + RCP8.5) to examine how well climate models simulate present-day heat-stress distribution on global scale, and how the latter may evolve in the future. We also investigate the uncertainty of simulated temperature and humidity attributed to heat-stress estimation. Making use of a bias-corrected database (Hempel et al., 2013) provided by the international project ISI-MIP, the effect of bias-correction technique on heat-stress estimation is explored.

Our results show that humid tropical areas tend to experience frequent heat stress than other regions that is, 250-300 day/year under at least slight stress; the most severe heat stress is found in Sahel and south India during the dry-wet transient period. Generally the severity of heat-stress increases by one category under RCP8.5 by the end of the century (Fig c, d). Heat stress is projected to be significantly enhanced over tropical and subtropical humid areas, although temperature is not projected to increase as much as in mid-latitude (Figure panels a, b). Regions at mid to high latitudes experience rare heat stress today but are vulnerable under climate change. In Western Europe, for instance, the projected frequency of heat-stress increases by about 400% by the end of 21th century. At present-day GCMs tend to underestimate heat stress over tropics due to dry and cold biases. Over mid to high latitudes, heat stress is only slightly overestimated due to a compensation effect between biases in humidity and temperature (Fischer and Knutti, 2013). As a result there is a risk to underestimate heat stress in tropics while slightly overestimate in mid- and high latitude.

In terms of long-term summertime mean, the bias-correction applied in this study showed little add-value for the climate change signals. For heat-stress estimation which relies on exceedance thresholds, the effect of bias-correction varies geographically. It reduces ca 50% of the biases of simulated heat-stress frequency in tropical humid areas but does not show much advantage, if not worse, in mid to high latitudes. The reason is that the compensation effect between the biases of temperature and humidity does not hold when the current ISI-MIP bias-correction method is applied. Finally, when estimating the impact of climate change on human health and work productivity, the uncertainty caused by climate models should be taken into account. Here, the spread (STD) of modeled heat-stress frequency is about 2 times larger than the ensemble mean biases, 1-3 times larger than the uncertainty caused by the choice of heat indicators except in extreme severity category. Thus, it is not trivial to disentangle the uncertainty contribution from GCMs and from the imperfection of thermal indicators, as already noticed by d'Ambrosio Alfano et al. (2011).



Change in ensemble mean of extreme mean variables (mean of 5% highest values) and heat-stress frequency. (a) Extreme mean Humidex $HD_{5\%}$; (b) Zonal mean extreme mean Humidex (HD), surface air temperature, (T) aparent temperature (AT), simplified WBGT (W) and vapour pressure (VP) corresponding to $HD_{5\%}$. One stand deviation of changes in $HD_{5\%}$ are in shade; (c) Ensemble mean of simulated Moderate heat-stress at present-day (1979-2005); (d) Ensemble mean of projected Moderate heat-stress (2070-2099). The dots in (d) indicate robust change (at least 18 out of 21 models agree in the increasing trend).

References:

ABM: Australian Bureau of Meteorology (http://www.bom.gov.au/info/thermal_stress/)

d' Ambrosio Alfano FR, Palella BI and Riccio G. (2011) : Thermal environment assessment reliability using temperature--humidity indices. Ind Health.;49(1):95-106.

Fischer EM and Knutti R. (2013) : Robust projections of combined humidity and temperature extremes. Nat Clim Change. 3(2):126-130.

Hempel S, Frieler K, Warszawski L, Schewe J, Piontek F (2013). A trend-preserving bias correction – the ISI-MIP approach. Earth Syst Dynam. 4(2):219-36.

Masterton, J.M., and F.A. Richardson. Humidex: A method of quantifying human discomfort due to excessive heat and humidity. (1979) ; Atmospheric Environment Service, Environment Canada, pp45

Steadman RG. (1979) : The Assessment of Sultriness. Part II: Effects of Wind, Extra Radiation and Barometric Pressure on Apparent Temperature. J Appl Meteorol.;18(7):874-885.

Steadman RG. (1984) : A Universal Scale of Apparent Temperature. J Clim Appl Meteorol.; 23(12):1674-1687.

Project 4 (WP5): Development of integrated, multi-archive chronologies

Title: Developing and testing integrated, multi-archive chronologies to improve our understanding of past, rapid climate changes and bifurcations.
Project lead: Amaëlle Landais
Post-doctoral researcher: Bénédicte Lemieux & Lucie Bazin
Project start/end: October 2013 – September 2014 extended for 6 months until March 2015

Position offer:

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a post-doctoral position of 2 years to join a collaborative effort involving specialists of ice, continent and marine climatic records and aimed at putting key archives into a common chronological framework in order to improve our understanding of past, rapid climate changes.

Context: Understanding the mechanisms at the heart of rapid climate changes and major bifurcations recorded in paleoclimatic archives requires that we are able to resolve accurately minute leads/lags in order to fully understand signal propagation and identify feedbacks across the various compartments of the earth climatic system. This requires to put ice, marine and continent paleo-records into a common chronological framework, with an unprecedented accuracy and with a clear understanding of uncertainties associated to the various approaches used to define tie-points (e.g. ^{14}C, ash layers, ^{10}Be, magnetic field paleo-intensity,..). Such an effort is mandatory if one wants to test the robustness of climate scenarios. The synchronization of ice records over the last 800 kyr (AICC2012 chronology, special issue of *Climate of the Past*) has been recently achieved through an inverse *Bayesian* assimilation approach. The DATICE tool (http://datice.gforge.inria.fr/) formulates a variational inverse problem, which aims at correcting the main parameters associated with the ice core timescales (e.g. accumulation, thinning) through integration of absolute and stratigraphic tie-points. The next step is to adapt this powerful tool to different archives and use it to develop and test chronologies for key continental and marine archives, and insure their optimal synchronization, in connection with ice records.

Description of work: To reach these goals, we propose to adapt the DATICE tool to continental and marine records (e.g. dealing with potential hiatuses, integrating archive-specific accumulation rate scenarios, …). Then, the DATICE tool will be used on key, high-resolution, multi-proxy paleo-climate records (1) to develop and test possible chronologies, (2) to carefully analyze uncertainties and limitations, and (3) to conduct inter-archive comparisons and address climatic implications once an optimal synchronization has been achieved. In accordance with the main goals identified for L-IPSL mid-term objectives, a special effort will be devoted to study mid- and high-latitude records around the North Atlantic (including the Mediterranean Sea) and the Nordic Seas, but other areas will also be explored as part of several on-going research projects of L-IPSL groups (i.e. monsoon variability).
The post-doctorate fellow will participate to the selection of key, high-resolution archives. He/she will be in charge of modifying the DATICE tool in order to take into account the specificity of the different continental and marine archives used. He/she will be at the heart of the chronological development with DATICE in close collaboration with the specialists. He/she will train those interested in using DATICE. He/she will be involved in the maturation and publication of paleo-climatic interpretations based upon the improved chronologies.

A solid experience in programing and data assimilation (i.e. Bayesian statistic) is mandatory, as well as good general knowledge of climatic archives.

Supervision team: The work will be conducted at LSCE/IPSL under the main supervision of A. Landais and C. Waelbroeck, and in close connection with other researchers of LSCE (F. Bassinot, D. Blamart, D. Genty, H. Guillou, C. Hatté, C. Kissel, V. Mason, E. Michel, M.A. Sicre,..), LOCEAN (AM Lézine, B.

Turcq, D. Wirrman..), IDES (C. Colin, S. Sepulcre, G. Siani, S. Duchamp-Alphonse,...) and in the L-IPSL project.

Duration and salary: The post-doctorate will be recruited for 24 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a vita, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to A. Landais (Amaelle.Landais@lsce.ipsl.fr) and C. Waelbroeck (Claire.Waelbroeck@lsce.ipsl.fr).

Preliminary results:

1- Code implementation

Bénédicte Lemieux-Dudon launched her self-employed company (*auto-entreprise*) in 2013 and she has been under contract with L-IPSL to develop and modify the DATICE tool.

Two important modifications have been implemented: (i) First, the possibility of correlating the errors (or introducing a systematic bias) for the dating constraints given as inputs of DATICE. This is useful for dating constraints obtained with the same dating method (ie. layer counting, ^{14}C or U/Th on a certain instrument). (ii) Second, the code is now able to deal with constraints on age difference between two depth levels. This is especially useful when dating constraints are obtained from layer counting or orbital tuning. These developments and examples of applications have been published [*Bazin, Lemieux-Dudon et al., 2014*].

The modified DATICE code is now adapted for marine cores and speleothems. An interface has been developed (in python language) to enable the visualization of DATICE results (*see Figure, below*).

2- Users training

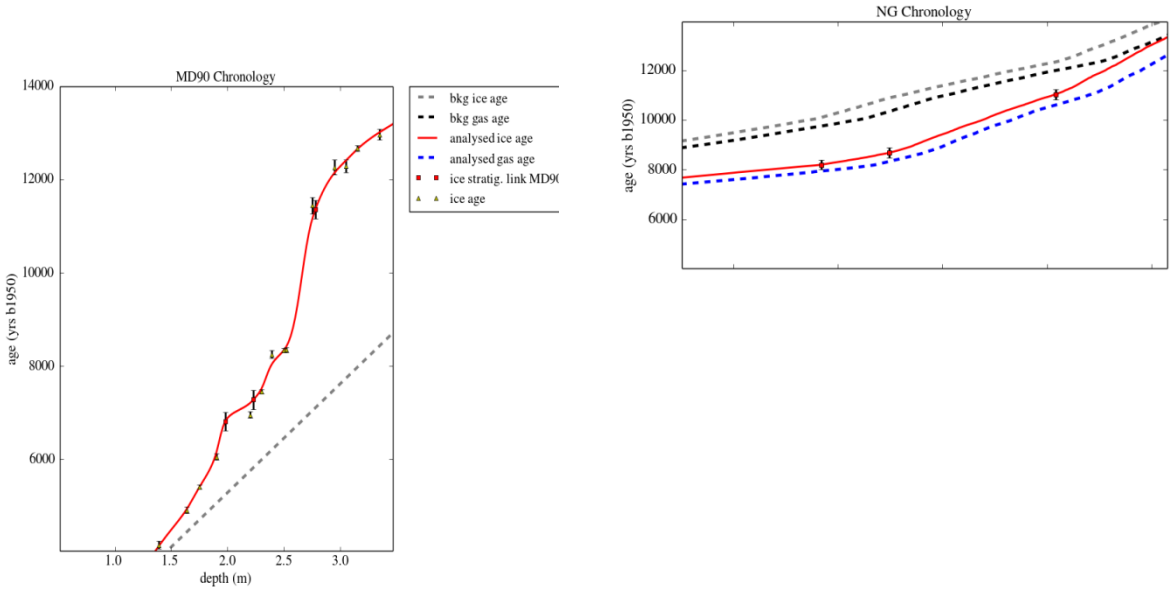
Two training sessions have been organized (February 2014; June 2014). Twelve scientists from LSCE, IDES and LOCEAN attended these sessions.

The modified DATICE tool has been installed on LSCE computer (obelix) and the code should be made open in a few months. An utilization guide is available at : http://blemieux.wordpress-hebergement.fr/datice_multiarchives/. An help forum has been launched at : http://blemieux.wordpress-hebergement.fr/inriaforge/

Next step of the project

All the implementations requested to run DATICE with sedimentary archives have been achieved. The DATICE tool has been successfully tested and can now be used for developing integrated, multi-archive chronologies.

L-IPSL will hire **Lucie Bazin for 6 months** (post-doc position). Lucie has intensively used the DATICE tool during her PhD and the WP5 will benefit from her expertise to develop common chronology in order to address several key questions, such as: (i) the links between high and mid latitudes over the millennial scale variability and (ii) the links between variations of temperature (over land, over continent), ice sheet size, vegetation, greenhouse gas concentrations. For this step, several key sedimentary archives have already been identified in the Mediterranean Sea, the Austral Ocean and the Northern Atlantic.



<u>Figure</u> : Test chronologies obtained for the marine core MD 90-017 (left) and NGRIP (right) using the developed code for DATICE adapted for multi-archives. The black dashed lines stand for the background chronology. The red curves show the produced chronology using the absolute and stratigraphic dating constraints (black points with error bars)

References:

Bazin, L., B. Lemieux-Dudon, A. Landais, M. Guillevic, P. Kindler, F. Parrenin, and P. Martinerie, Optimisation of glaciological parameters for ice core chronology by implementing counted layers between identified depth levels, *Clim. Past Discuss*., 10, 3585-3616, 2014.

Project 5 (TWP2-WP3): Arctic data portal

Project lead: Kathy Law
Post-doctoral researcher: Laura Cordero LLana
Project Start/End: September 2013 – August 2014

Position offer:

The laboratory of excellence L-IPSL of the Institut Pierre-Simon Laplace offers a post-doctoral position of 1 year to develop an L-IPSL Arctic data portal.

Context: The Arctic is undergoing unprecedented changes as a result of global warming such as the rapid decline in summer sea-ice. However, the reasons for such changes and their impacts on the environment and society are not well understood thereby limiting our ability to predict what might happen in the future. In particular, the performance of global climate models needs improving including treatments of many processes and their interactions within the atmosphere-ocean-ice-biosphere system. Process-based studies based on a combination of analysis of available data and models of varying complexity/scales will lead to improvements in climate models. The Arctic has been highlighted as a research priority within L-IPSL and nationally with the creation of the French Chantier Arctique.

Description of work: Many different datasets exist at L-IPSL collected as part of different projects examining a wide range of scientific issues in the Arctic. These include projects studying atmospheric, ocean, biogeochemical processes as well as pollution, permafrost, glaciers, sea-ice etc. In order to promote new avenues in Arctic research within IPSL and to improve Arctic modelling capabilities, L-IPSL is creating an Arctic data portal. In the first instance, the aim is that this data portal will provide links to existing datasets including information about each dataset using a user-friendly web-based environment. It will contain information about different regions and types of data (ground-based, marine, aircraft, satellite). In a second phase, a data policy will be developed to facilitate the use of datasets for the evaluation of models at IPSL, including the global IPSL climate model and regional models. Modelling results may also be incorporated into the data portal.

Supervision team: The work will be conducted under the main supervision of P. Keckhut (IPSL) and K. Law (LATMOS) and carried out in close collaboration with the IPSL data management team as part of the ESPRI project (in particular, at LMD/Palaiseau). The work will be carried out at LATMOS in Guyancourt, west of Paris where the Observatoire Versailles and Saint Quentin (OVSQ) Arctic network is also based.

Expertise: Persons with expertise in geophysical data management who are motivated to work on scientific issues in the Arctic are invited to apply. Good written and spoken English is required together a willingness to interact and discuss with different groups. Applications from people with research experience in the Arctic are also welcome. Experience in computing is also useful.

Duration and salary: The researcher (master level upwards) will be recruited for 12 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a CV, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to Philippe.Keckhut@latmos.ipsl.fr and Kathy.Law@latmos.ipsl.fr.
Final results :

As part of the LABEX-IPSL many types of datasets exist obtained by different projects focussed on the wide range of scientific issues in the Arctic. These include projects studying atmospheric, ocean, biogeochemical processes as well as pollution, permafrost, glaciers, sea-ice etc. The motivation for the creation of an L-IPSL Arctic Data portal is to promote new avenues in Arctic research within IPSL, and to improve Arctic modelling capabilities. A first aim is to provide links to existing datasets including information about each dataset using a user-friendly web-based environment. The portal will contain information about different regions and types of data (ground-based, marine, aircraft, satellite). In a second phase, a data policy could be developed to facilitate the use of datasets for the evaluation of models at IPSL, including the global IPSL climate model and regional models. The development of the Arctic Data portal started in September 2013 and was planned to last one year. Due to technical problems with the creation of the portal interface, the launch of the portal is still in progress. Fig. 1 shows the preliminary presentation page as it will appear in the LABEX-IPSL website (http://climserv.ipsl.polytechnique.fr/arcticportal/).

Fig. 1: LABEX-IPSL Arctic Data Portal preliminary presentation page

The first objective of the project was to make a list of all the contacts within the IPSL who have been involved making observations in the Arctic and hence who could provide metadata information about their datasets. They were contacted via email or meetings with the contacts from the different laboratories in IPSL or linked to it. At the same time, another list was compiled including existing Arctic data portals and databases at an international level. These portals, databases and project websites are included in the portal as external links. The portal contains standardized information about each dataset as part of the metadata, together with links to relevant publications and to the data distribution sources. Examples are shown in Fig. 2. Fig. 3 shows how the metadata information is classified for each dataset. Finally, all the datasets that will be in the final version of the portal are listed in Table 2 (see Annex B).

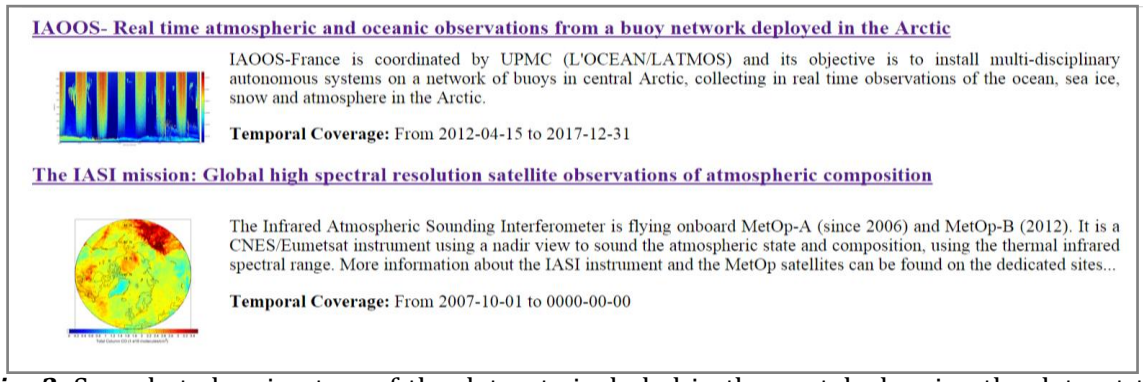


Fig. 2. Snapshot showing two of the datasets included in the portal, showing the dataset title, plot related to the measurements, summary of the dataset and temporal coverage (http://climserv.ipsl.polytechnique.fr/arcticdatadb/Datasets/).

Dataset | Projects | Contacts | Parameters | Datacenter | References | Multimedia Sample | Distribution | Data Resolution | Instrument | Spatial Coverage | Paleo Coverage

Dataset Title	IAOOS- Real time atmospheric and oceanic observations from a buoy network deploied in the Arctic
Dataset Purpose	
Dataset Abstract	IAOOS-France is coordinated by UPMC (L'OCEAN/LATMOS) and its objective is to install multi-disciplinary autonomous systems on a network of buoys in central Arctic, collecting in real time observations of the ocean, sea ice, snow and atmosphere in the Arctic.
Acquisition Methodology	The platform is equipped with CTD vertical profilers, ice mass balance, temperature and pressure sensors, micro-lidars and optical depth sensors. Vertical cloud profilers are produced several times per day by the micro-lidars. 6 platforms to be deployed every year following the first deployment of 15 platforms, making a total of 40. All the systems on each buoys should operate during 2 years with satellite transfer data. The deployment will start in spring 2014 with two buoys totally overseen by public organisms (DT INSU, LATMOS, LOCEAN). Then all the others buoys will be developed under contract with two first units for autumn 2014.
Quality	
Dataset DOI	
Access Constraints	Restricted access to the data through ICARE data centre.
Use Constraints	
Keywords	
Status	In work
Temporal Coverage	
Start Date	2012-04-15
Stop Date	2017-12-31

Fig. 3. Snapshot showing how the different information for each dataset is classified in different categories (http://climserv.ipsl.polytechnique.fr/arcticdatadb/Datasets/view/1).

The final step of the portal, once all the datasets are included in the web interface, will be to publically launch it after all the contacts involved revise the datasets information (planned for October 2014). A small article to be sent to Dataset Papers in Science (http://www.hindawi.com/journals/dpis/) is being prepared.

Project 6 (TWP2-WP5): Water isotope database: present and past archives

Project lead: Valérie Masson-Delmotte
Post-doctoral researcher: Timothé Bolliet
Project Start/End: May 2013 – April 2014 extended 5+6 months end March 2015

Position offer:

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a post-doctoral position of 2 years to build a database on ^{18}O and D isotopes combining observations and simulations at various time-scales.

Context : Water stable isotopes are a powerful tool to decipher the hydrological cycle at global and local scales. The objectives of this project are:

- to obtain a global vision of isotopic changes for well documented past periods (6kyrs, LGM, Eemian, DO events,…) and to better interpret isotopic proxies in terms of climate change.
-
- to better understand the differences between data and models: are they related to the representation of processes? to different spatial (horizontal and/or vertical) scales between the data point and the model grid?
-
- to better understand the factors controlling past isotopic evolutions in ice, carbonate and sediment archives. A forward proxy modeling will be developed for better quantify the relative influence of different climate parameters.
-

Description of work : This work is part of the Labex L-IPSL project which aims at improving our knowledge on climate change and to anticipate its impacts on nature and society The main tool to be developed is a database on ð18O and ðD grouping data (instrumental and paleoclimate archives) and model simulations at different time scales. The activities include:

- synthesis of precipitation and sea water observational data for the instrumental period prolonged for the period of historical simulations (1800-2010) by tree-rings, ice cores, speleothems and coral data;

- synthesis of paleo-data, beginning with continental data, for key periods of the past (6k, Eemian, ..) or transition period where simulations are (will be) available (6 – 2k, D/O, Late Glacial,…). A link with two other IPSL projects concerning LGM and water vapor must also be developed.

- making available simulated equivalents for each data point, at least for IPSL models.

The recruited post-doctorate fellow will have to gather the data and discuss their validity/uncertainty for isotope value and chronology. A close collaboration with IPSL researchers will be necessary for this task that, certainly, will lead to the production of scientific publications. An experience in isotope geochemistry is required for this project.

Supervision team: The work will be conducted at LSCE/IPSL, under the main supervision of V. Masson-Delmotte and in close connection with other researchers: Françoise Vimeux (Water Vapor), Laurence Gourcy (Precipitations), Camille Risi (Atmosphere Modeling), Jean Claude Dutay (Ocean Modeling); Catherine Pierre (Ocean Data), Valerie Daux (Tree Rings), Dominique Genty (Speleothems), Claire Waelbroeck (Ocean Cores), Didier Roche (Glacial Periods), Laurent Bergonzini (Lakes), Bruno Turcq (Paleo-monsoon), Bruno Malaize (Lake Sediment).

Duration and salary: The post-doctorate will be recruited at least for 12 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

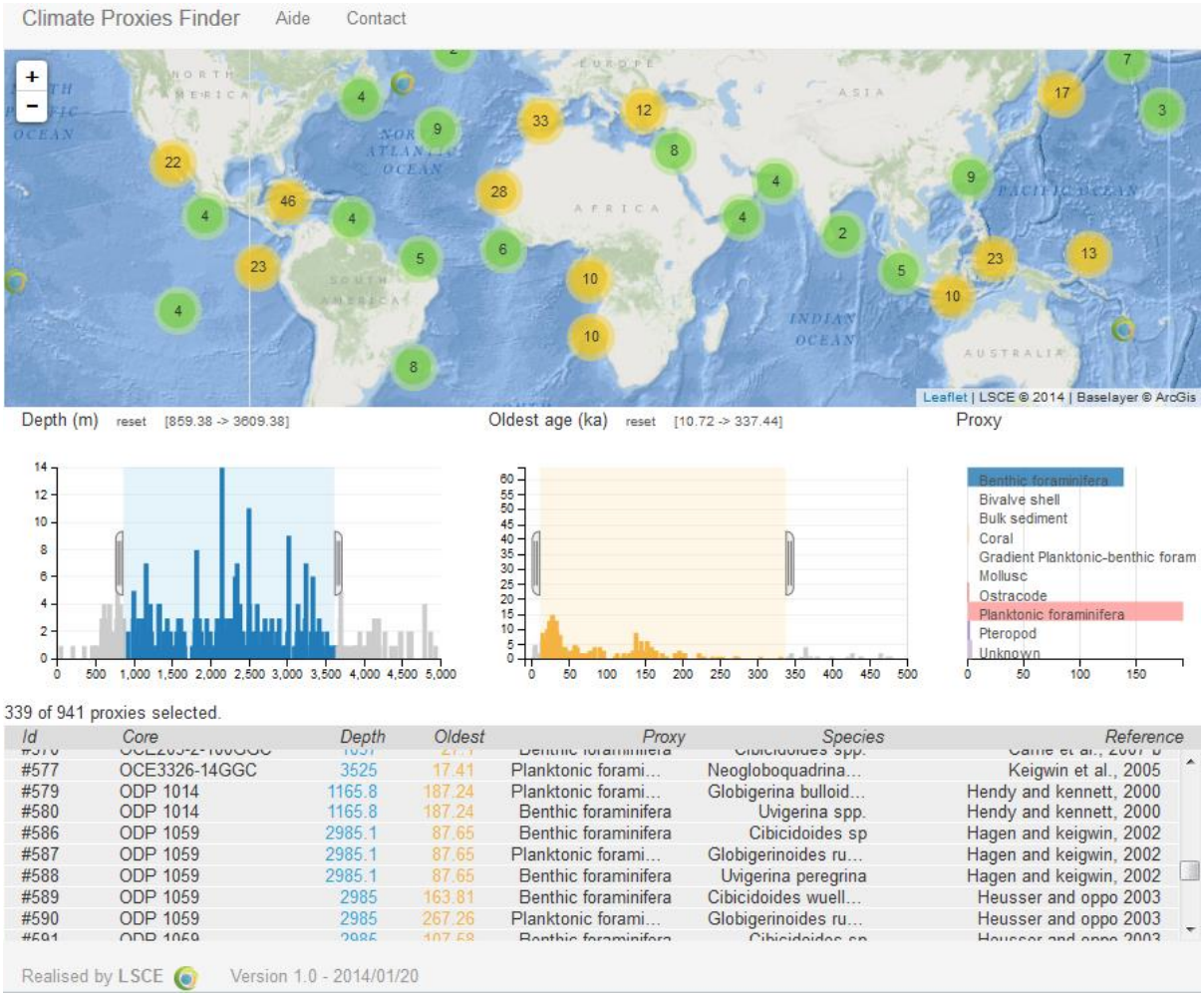
Contact for applications: Applications should include a CV, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to Valérie Masson-Delmotte (Valerie.Masson@lsce.ipsl.fr).

Preliminary results :

The LABEX-IPSL post-doc aimed to establish the state of the art of existing data sources for oxygen and carbon stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) for different types of archives (lacustrine and marine sediment cores, speleothems, ice cores and tree rings cellulose) for the last two glacial/interglacial cycles. Afterwards, a database of the available datasets was built, with a particular focus on the PMIP key periods (last 200 years, Mid-Holocene, Last Glacial Maximum and the Eemian).

The first 15 months of this work (beginning in May 2013) consisted in compiling all the available $\delta^{18}O$ and $\delta^{13}C$ records stored in the NOAA and PANGAEA websites, as well as in the internal database of the LSCE and by communication with authors. Raw data from published datasets were isolated, homogeneously formatted (fixed data disposition and samples age unit) and stored on individual files, while age model information were extracted and stored separately. After that, the evaluation of the quality of the available age models was performed on dated datasets, and age control quality flags were integrated in a single metafile also providing essential information on all compiled datasets (~1500 dated records and 1700 not dated for $\delta^{18}O$, and 800 $\delta^{13}C$ dated records).

In association with Patrick Brockmann (data analyst at LSCE), an open-access online platform is being built, providing dynamic and interactive browsing, visualization and downloading facilities for compiled data, and a manuscript in being written for future publication. It is possible to access to a preliminary version of this open-access online platform on the following web site: http://webportals.ipsl.jussieu.fr/ScientificApps/dev/forge_patrick/proxies/v1.0/.



Prototype of the data browsing feature of the online platform based on compiled marine $\delta^{18}O$ records. Numbers on the map correspond to clusters of records, with density-based colours. Note that the density of records displayed on the map is dynamically linked to parameters chosen by the user (water depth of the core site, time interval spanned by the record, group and/or species of foraminifera used for analysis).

Next step of the project

The extension of this contract (6 months of post-doc) will allow: (i) the finalization of the database; (ii) the finalization of manuscript as well as the optimization and promotion of the interactive online platform; (iii) the establishment of connection with other complementary project of other foreigner laboratories; (iv) the integration of the database in PMIP program.

Presentation and publications associated to this project:

This work was presented at two international meetings:

- PMIP workshop on oceans, December 2013, Corvalis, OR, USA. *Water Isotope Database: Present and past archives in a new online open-access library*.
- EGU general assembly 2014, Vienna, Austria. EGU2014-7396, *Stable Isotope Database: present and past archives*. Session IG7/CL6.14/SSP1.3, with companion Poster.

Ongoing work was additionally presented to the L-IPSL scientific committee (February 2014), and to the WP5 working group every three months, for review and feedbacks.

References:

T. Bolliet et al., in prep. *An interactive tool for navigation within a database of water and carbon stable isotope records from natural archives.*

Project 7 (TWP1): Facilitating the distribution and analysis of CMIP5 and related projects

Project lead: Sebastien Denvil
Post-doctoral researcher: Guillaume Levavasseur
Project Start/End: October 2013 – September 2014

Position offer:

Intitulé du poste : Soutien à la diffusion et à l'utilisation des résultats des simulations climatiques du projet CMIP5

CDD, 12 mois, Ingénieur d'étude ou Ingénieur de recherche

Lieu de travail : IPSL, Paris, Université Pierre et Marie Curie (Jussieu)

Rémunération brute: 2000 à 2600 € (selon diplôme et expérience)

Contexte : Le projet CMIP5 coordonne au niveau international la réalisation de simulations climatiques et la distribution de leurs résultats. Ces simulations servent de supports à de très nombreux travaux d'analyses scientifiques et alimenteront notamment le prochain rapport du GIEC.

Le Pôle de Modélisation de l'Institut Pierre Simon Laplace (IPSL) contribue au projet CMIP5 en réalisant des simulations climatiques avec trois versions du modèle climatique qu'il développe. Ces données, ainsi que celles de la trentaine de modèles participants à ce jour au projet CMIP5, sont stockées sur un important espace disque (450 To) accolé à un cluster de calcul afin de faciliter leur analyses par les personnels de l'IPSL. Ce travail est réalisé en liaison avec les autres activités de l'IPSL concernant l'analyse, l'archivage, et la distribution de données scientifiques (projet ESPRI, Ensemble de Services Pour la Recherche à l'IPSL) et est supporté par le labex L-IPSL.

La précédente phase du projet CMIP (CMIP3) a connu un très grand succès: les données ont été et sont toujours très utilisées, par des acteurs très variés (des scientifiques aux bureaux d'études) et ont alimenté un nombre considérable d'articles scientifiques (supérieur au millier). On anticipe un succès encore plus important pour le projet CMIP5, pour lequel le nombre de variables et de simulations est beaucoup plus élevé, avec des fréquences de sorties et des résolution spatiales également plus élevées. Au sein de l'IPSL, plusieurs dizaines de personnes analysent déjà les données CMIP5.

Mission :

- contribuer à la mise en forme des données CMIP5, à leur transfert sur l'espace de stockage, à leur publication sur le système ESGF (Earth System Grid Federation) et à leur documentation

- recenser les erreurs identifiées dans ces données, contribuer à leur corrections, tenir le journal d'évolution des versions des fichiers au fur et à mesure de ces corrections

- aider les utilisateurs pour l'utilisation des données CMIP5, notamment via les outils et les moyens mis à disposition par l'IPSL

- compléter le site icmc.ipsl.fr avec les informations sur les simulations, sur les variables, sur leur accès et leur utilisation
- constituer une FAQ à partir des questions-réponses déjà existantes

- faire évoluer cette FAQ avec les nouvelles questions et les réponses obtenues auprès des experts de l'IPSL

- orienter les utilisateurs dans l'utilisation des résultats de simulations en fonction de leurs besoins

Profils et Compétences:

- Unix/Linux ; scripts (bash/python)

- format de fichier netcdf et utilitaires associés (nco, cdo...),

- visualisation et analyses statistiques simples

- excellent relationnel, capacités organisationnelles et autonomie

- bonne pratique de l'anglais indispensable

- connaissances de base en climatologie appréciées

- le site icmc est sous joomla : apprentissage prévu si besoin

Contact:
Sébastien Denvil: tel: 01 44 27 21 10 - courriel: sebastien.denvil@ipsl.jussieu.fr

Preliminary results

IPSL researchers have different knowledge of existing databases (e.g. CMIP5) or computer languages. Consequently, data analysis quickly becomes complex and time-consuming, especially for beginners or doctoral students. It appears necessary to clarify the data access and to facilitate analysis without resorting to more training. Task 5 of the TWP1 of Labex-IPSL aims to improve support for CMIP5 analysis at IPSL.

I - Clarify and facilitate data access

Initially CMIP5 IPSL files were divided into 3 storage areas: DMF and STORE at TGCC-CCRT and CICLAD filesystems leading to an arduous search files. This was due to the tape archive system replacement at TGCC. In order to make easier data access, we first merged CMIP5 IPSL files into the local work disk at TGCC-CCRT. This migration process has been performed for all IPSL results. This procedure involves several steps like matching files between the 3 filesystems, copying datasets if necessary, cleaning, updating and assigning version to each CMIP5 datasets and finally deleting orphaned files.

To make our merged CMIP5 data available on ESGF from TGCC, we installed and configured an ESGF data node at TGCC accessible through any ESGF front-end and in particular from the IPSL ESGF front-end. Consequently, CICLAD cluster will thus partly be dedicated to the use and the development of CMIP5 analysis. CMIP5 data distribution of IPSL results per se becoming the role of the TGCC ESGF data node.

II - Improving support through errata and documentation

In order to clearly identify the produced data and their access, a huge documentation work was conducted to list all known errors in IPSL CMIP5 data. Today, 20 of 40 identified issues have been

corrected. These files modifications concern about 17% of the IPSL results (about 27 000 files among 140 000) and leads to 25 version number. Each file version has been assign to a possible problem to built a fully documented errata. This errata is stored in an SQL database that can be queried through a web interface on the ICMC website. Users can now easily find information about (i) all issues as short and complete descriptions, the affected files, the corresponding version numbers, graphics and/or maps and the issue status (corrected, in progress or to do) ; or (ii) send a request about downloaded data to know if they have the latest file version, if modifications occurs and their history and the links to the corresponding description (cf. schema below).

This web-module is included in a fully redesign and documented page called «IPSL contribution to CMIP5». The user can find in the same place of the errata, a lot of useful information for their analysis as: details about IPSL-CM5 model versions, all related documentation and references, the forcing files, details and graphics about CMIP5 requirements, vocabulary and tree, links to European ESGF data node and IPSL services, and answers to the most frequently asked question.

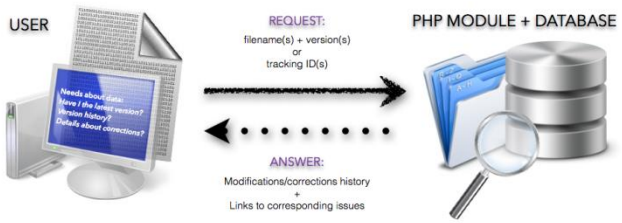
Also, we use the IPSL-CM5 errata as a proof of concept to promote such a tool into the ESGF platform and to design a more controlled versioning system during the publication process. A large portion of requests from CMIP5 users deal with files errors. To establish a controlled errata mechanism inside the ESGF platform clearly appears as a major support tool. To that end we wanted to strengthen our investment in the ESGF development. In relation to that goal we are now part of the ESGF Publication Working Team where we represent the French ESGF users community, especially located on computing center and partner institutes (TGCC, IDRIS, CINES, CERFACS, CNRM). We are the key French point of contact for publication on ESGF and we provide an essential support to those French actors.

III - A CMIP5 analysis software stack for IPSL community

Another goal specifically covered by this task was to help IPSL researchers with different computer languages skills to easily perform a reliable analysis and save time. We decided to develop an ecosystem of CMIP5 analysis software stack that will be easily usable by IPSL community:

1. The CMIP5 files are fictitiously concatenated along time dimension through OpenDAP URL. These aggregations avoid dealing with the files splitting depending on model and frequency over a time period. We developed a Python command-line tool allowing the users to find and list the available CMIP5 aggregations at IPSL in a fast and researcher-friendly way. The user just has to fill a template with the required variables, experiments and ensembles. The script directly returns available models that match ALL requirements with the corresponding aggregations list.

2. Aggregations can exist without a correct time axis. Nevertheless, time axis often is mistaken in CMIP5 files and leads to flawed studies or unused data. We developed a Python program to check and rebuild a proper time axis if necessary. About 107 000 files (i.e. 23% of the total files, see statistics below) more aggregations will be thus available. This script will be included in synchro-data downloading workflow to deliver proper data to users.



There tools are currently test following a study on Pattern Scaling. Our goal is to identify the respective role of forcings and models in the characteristics of the climate changes patterns. Pattern

Statistics about

Institute	Nb files in latest	Nb of mistaken time axis	% of mistaken
BCC	8194	5416	66,10 %
BNU	837	0	0,12 %
CCCma	6478	0	0,06 %
CMCC	28345	27072	95,51 %
CNRM-CERFACS	36185	3891	18,75 %
CSIRO-BOM	4967	25	0,52 %
CSIRO-QCCCE	4966	150	3,02 %
DOE-COLA-CNMAP-GMU	179	0	0,00 %
FIO	2380	1634	68,66 %
ICHEC	2130	949	44,55 %
INM	3905	0	0,00 %
INPE	302	0	0,00 %
IPSL	106345	34	0,28 %
LASG-CESS	32199	2	5,60 %
LASG-IAP	10351	9058	87,51 %
MIROC	49535	0	0,00 %
MOHC	34216	16	7,40 %
MPI-M	65854	5822	8,85 %
MRI	21905	0	0,00 %
NASA-GISS	53180	47846	89,97 %
NASA-GMAO	2	0	100,00 %
NCAR	9862	2106	40,29 %
NCC	12267	480	3,91 %
NICAM	39	0	0,00 %
NIMR-KMA	521	212	41,46 %
NOAA-GFDL	291206	195	0,58 %
NSF-DOE-NCAR	6762	1706	25,23 %

scaling allows to describe, at first order, the general pattern of temperature and precipitation changes. Previous tools will be part of standard analysis stack for CMIP5 file allowing to easily compare simulations of different scenarios. In just one month we bring the following conclusion : (i) pattern differences between models are much larger than pattern differences between scenarios ; (ii) for scenarios with small radiative forcings (e.g. RCP2.6), the internal variability has a significant contribution to the spread of the pattern scaling for temperature (mostly at high latitudes) and precipitation (mostly in the tropics) and (iii) stabilization of temperature, and therefore of forcings,

References:

http://icmc.ipsl.fr/

Project 8 (WP3): Modeling climate change in Western Africa

Project lead: Sophie Bastin
Post-doctoral researcher: Marco Gaetani
Supervision team:
Project period: October 2014 – September 2016

Position offer:

The laboratory of excellence L-IPSL of the Institut Pierre-Simon Laplace offers a 2-year post-doctoral position to work on climate change modeling over West Africa.

Context: The Sahel has undergone a severe (large scale and long-lasting) drought in the 1970s-1980s. West Africa has also undergone a strong paleo variability, with evidence for a "green Sahara" about 6000-7000 years ago. The recent Sahelian drought was probably in large part driven by the decadal variations of the sea surface temperature. For people of that region who crucially rely on the monsoon rainfall, anticipating the possible future variations of the African monsoon system is of great importance. However, coupled ocean-atmosphere climate model still show a rather poor skill in simulating the African monsoon, and there is still a large spread of climate projections on that region. The downscaling experiments performed under the Cordex program (which did prioritize the African continent), are at least as dispersed and biased as those from the global models. Despite the important dispersion, CMIP5 models suggest a general tendency to a reinforcement of rainfall in central Sahel, with a slight drying on the Senegal/Guinea coast. This signal may be related to some robust features found in idealized simulation that show that CO2 increase produce a rapid reinforcement of ascending motions in the tropics. This effect could be reinforced by a regional water vapor positive feedback: increased convergence over the Saharan heat low brings more water which in turns strengthens regionally the greenhouse effect. This mechanism share similarities with the response of monsoon to enhanced Northern hemisphere seasonal insulation that prevail during the "green Sahara" period. The general purpose of the work would be twofold: 1) identify the elements of robustness in climate simulations (paleo, historical reconstructions and climate change projections), analyzing the contribution of for instance change in large scale circulation and SSTs, direct CO2 forcing or regional water feedback, and 2) question the strategies for downscaling experiments over West Africa as to their ability to account for the identified critical mechanisms.

Description of work: The work will be based in part on the multi-model analysis of CMIP5 simulations (in order to identify robust mechanisms and features), benefiting from the fact that the same model has been used for past climate, historical simulations and climate change projections. A particular focus will be put on the analysis of the radiative forcing (CO2 and aerosols) and feedback (water vapor) over the Saharan heat low. To test physical hypotheses about the role of these forcings and feedbacks on climate change over West Africa, the analysis of existing simulations will be complemented by dedicated simulations with the LMDZ atmospheric general circulation model, which is the atmospheric component of the IPSL Coupled Model (involved in CMIP5). The model can be run either in global mode or zoomed over a particular region of the globe. It can be run either in climatic mode or "nudged" toward the large scale dynamics of the reanalysis or the results of another simulation. The LMDZ physical package has also been coupled to the dynamics of the WRF regional model, which will allow to test the use of limited area model without modifying the

physics. This suite of configuration will be used 1) to separate local feedbacks from large scale couplings (using nudging or not at the boundary of the domain, or imposing idealized diabatic heating like albedo patches over a region, or more or less interactions with surface), and 2) to perform big-brother experiments to compare and assess the strengths and limitations of different downscaling approaches: a reference simulation run with a fine global regular grid is used as a reference (or model truth) for various approaches (zoom with or without nudging, limited area versions).

Supervision team: The work will be conducted under the main supervision of Frédéric Hourdin from LMD and Sophie Bastin from LATMOS together with colleagues from the two teams (Cyrille Flamant, Sandrine Bony, Jean-Louis Dufresne....). The work will be performed in alternance between the two labs with a schedule to be discussed, and followed jointly by a larger Labex team who will also involve P. Braconnot (LSCE).

Experience: The applicant will have experience with numerical modeling of the Earth system based on global or regional model. He/she also have experience with handling large datasets. The applicant publication record should show a majority of papers published in English in top ranking journals.

Duration and salary: The post-doctorate will be recruited for 24 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a CV, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to Cyrille Flamant (cyrille.flamant@latmos.ipsl.fr) before 15 March 2014.

Project 9 (WP2): Grand Challenge on clouds and climate sensitivity

Project lead: Sandrine Bony
Post-doctoral researcher: Kenji Izumi
Project Start/End: September 2014 – August 2015

Position offer:

Climate system's response to past vs future conditions: comparing the strengths of radiative forcings and feedbacks for the last glacial maximum and future climates

In the framework of the « Clouds, Circulation and Climate Sensitivity » WCRP "Grand Challenge", The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a one-year post-doctoral position to analyse the radiative feedbacks operating in the PMIP3/CMIP5 LGM and future climate simulations.

Context

Man is currently disturbing the climate system by modifying the atmospheric composition (e.g. in greenhouse gases and aerosols) and the characteristics of the continental surface. These *forcings* translate into perturbations of the energetic and hydrological cycles in the atmosphere, which are then amplified or dampened through multiple *feedbacks*. Quantifying these feedbacks requires both climate models and observations of climatic changes. One of the largest uncertainties in future climate prediction arises from the difficulties to quantify the feedbacks from clouds, which are crucial in both the energy and hydrological cycles.

Compared to the recent climate changes which have been closely monitored e.g. with satellite observations, climates for periods before the satellite era are not as precisely described, but some past periods are challenging for climate modellers because they are characterised by climate changes much larger than the ones which have been recently observed. The perturbations to the climate system in these cases results from modification of the Earth's orbital parameters, but also consist, like in the scenarios for future climate change, in modifications of the atmospheric composition and of the Earth Surface, e.g. via natural changes in vegetation and changes in ice-sheet extent and height. In the last decades, much effort has been devoted to deciphering new climate archives and compiling them into databases for key periods of the past, as well as attempting to the understanding of these reconstructed climate changes using climate models of different complexities. One such effort is the Palaeoclimate Modelling Intercomparison Project (PMIP), which is currently in its third phase (http://pmip3.lsce.ipsl.fr). The Mid-Holocene (~6000 years ago) and the Last Glacial Maximum (LGM, ~21000 years ago) have been the focus of PMIP since its start. The main forcings needed to model the LGM climate is the presence of huge ice-sheets at mid- to high latitudes over the northern North America and Fennoscandinavia and the decreased concentration in greenhouse gases. The LGM surface climate and oceanic conditions are particularly well documented from multiple climatic archives which have been assembled in data sets such as the MARGO (2009) data set of reconstructions of sea surface temperature or the Bartlein et al (2011) data set of continental climate reconstructions. Finally, for the first time, the LGM climate has been modelled in the CMIP5 exercise with the exact same models as those used to compute future climate changes. There are currently 11 models for which data from the LGM, pre-industrial and future simulations are available in the CMIP5 data base. We therefore have the unique opportunity to analyse, with multiple model output and in a common framework, past and future climate forcings and feedbacks. This is one of the goals set up in the « Clouds, Circulation and Climate Sensitivity » WCRP "Grand Challenge", to which this post-doc will contribute.

Description of work

The successful candidate is expected to analyse the radiative forcings/feedbacks in the LGM vs. future climate simulations available from the CMIP5 archive. A particular focus will be on the cloud radiative forcing, for which analyses tools have been long developed at Laboratoire de Météorologie Dynamique. The candidate will also have the possibility to analyse additional sensitivity simulations run to better understand the impact of each forcing on the LGM climate: land-surface changes vs. atmospheric composition changes. The proposed research has two goals:
- to improve our understanding of the feedbacks (in particular from the clouds) operating in the climate system in LGM simulations, with the same methods as developed to quantify climate feedbacks in present and future climate scenarios;
- to examine whether the available LGM climatic reconstructions such as the MARGO or Bartlein et al, or any upcoming data synthesis, can help discriminate between different values or characteristics of these feedbacks, among the variety of results from the available CMIP5 climate models.

Supervision team: The position is funded by LABEX L-IPSL and IPSL will be the employer.

The successful candidate will work with experts in palaeoclimate modelling at LSCE, in close collaboration with experts in the quantification of radiative forcing and cloud feedbacks at LMD. The main supervisors will be Sandrine Bony at LMD and Masa Kageyama at LSCE.

Duration and salary: The post-doctorate will be recruited for 12 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a vita, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to Masa Kageyama, LSCE (Masa.Kageyama@lsce.ipsl.fr) and Sandrine Bony, LMD (Sandrine.Bony@lmd.jussieu.fr).

Project 10 (WP1, collaboration with LABEX MER): Role of daily vertical migrations of zooplankton on carbon cycle

Project lead: Laurent Bopp
Post-doctoral researcher: Stelly Lefort
Project Start/End: September 2014 – April 2015

Position offer:

Context: The diurnal vertical migration (DVM) of zooplankton is a widespread phenomenon in the marine environment. Conventionally, zooplankton is at the surface during the night and goes down to several hundred meters at dawn before rising to the surface at dusk. Many observations (essentially acoustic) have demonstrated the existence of this type of migration in numerous biogeochemical provinces. Various explanations have been advanced to explain these DVMs. One of the most explored explanation is related to predator avoidance: preys leave the illuminated layers during the day to reduce the predation pressure. Because of the strong vertical gradients of temperature and of food, DVMs could have a significant impact on the growth and reproduction of many marine organisms, and hence could inlfuence the ecology of the ocean. In addition, these migrations will also have an impact on the biogeochemical fluxes of nutrients, carbon and oxygen . Migrant organisms will generally feed on the surface, but they excrete, respire, produce fecal pellets and die at depth, inducing a vertical transport of nutrients and carbon from the surface to the subsurface. This could increase the efficiency of the carbon pump. Numerous studies have shown the importance of this active transport. They suggest a contribution of up to 10-30% to carbon export.
In the 90s, pioneering modelling work has focused on the representation of the distribution of migrant organisms in response to stimuli such as light, predation and food [Andersen and Nival , 1991; Richards et al, 1996]. However , these studies were more focused on the characteristics of migration in idealized configurations, rather than on the potential feedbacks on biogeochemistry in time and space. To study the effects of DVM on the biogeochemical cycles of carbon and nutrients, it is necessary to integrate a model of migration in a biogeochemical model. To our knowledge, there is to date only one study in which the impact of diurnal vertical migrations on marine biogeochemistry was explicitly analyzed at three contrasting stations in the Pacific [Bianchi et al. , 2013] .

Description of work: During the ANR - CEPS project MACROES (2010-2013), the ocean biogeochemical model NEMO-PISCES was coupled to an ecosystem model, APECOSM, in global-scale configurations to study the impact of climate change on marine upper trophic levels. This coupling is complete and represents the trophic and biogeochemical interactions in both directions (low to high trophic levels trophic levels and vice versa). In APECOSM, the marine ecosystem is represented by three generic communities, one of which corresponding to the organisms performing daily vertical migrations. This modeling system is therefore a perfect tool to study the impact of DVM on the marine biogeochemistry at the global level.

In this project, the succesfull candidate will use this modeling platform to meet the following two objectives:

1 . analysis and evaluation of spatial and seasonal patterns of migrations predicted by the NEMO-PISCES – APECOSM platform
2 . determination of the impact of DVM on the biogeochemical cycles of carbon , nutrients and oxygen .
3 . determination of the role of DVM in the context of a changing climate (potential retro-actions on the marine carbon sink)

This study will be conducted on the global scale in a low-resolution model forced by climate conditions (average seasonal cycle without interannual and decadal variability) for the current period, but also for a future state, representing the end of the 21st century.

In a first step, the succesfull candidate will use simulations carried out in the frame of the MACROES project. The distribution of migrant organisms will be analyzed and compared with available observations. The vertical distribution produced by the model will be assessed by acoustic observations. Once this step evaluation / validation will be completed, the impact of DVM will be analyzed. Additional sensitivity simulations may be performed to estimate the impact induced by vertical migrations on biogeochemical fluxes. Finally, the impact of DVM changes under a climate change scenario (RCP8.5) will be analysed using climate change simulations performed with the IPSL-CM5 model.

Supervision Team: This project is a joint project bewteen the 2 LABEX : Labex -Mer and Labex - IPSL. It is part of the objectives of both Labex and is based on a close collaboration between researchers from the LPO and LSCE / LOCEAN. For the Labex-Mer, this issue has been identified in the roadmap drafted during the implementation of the first phase (Action 3 Objective 2). Regarding Labex - IPSL , this action falls within the objectives of WP1 (Composition of the atmosphere - Coupling Cycles / Climate). It also addresses some of the objectives of WP4 on the development of indicators of climate change.

The succesfull candidate will work in bewteen experts at IPSL (LSCE, Saclay and LOCEAN, Paris), as well as with experts at LPO (Brest). Main supervisors will be O. Aumont (LPO) and L. Bopp (LSCE).
In addition, this project will depend on several external collaborations, with UMR EME (O. Maury) in which the APECOSM model was developed, and with McGill University (E. Galbraith, D. Bianchi) in Canada for the use of acoustic data bases and expertise on diurnal vertical migration.

Experience: The applicant will have experience with numerical modeling of the Earth system based on global or regional model, if possible already with the NEMO-PISCES tool. He/she also have experience with handling large datasets. The applicant publication record should show a majority of papers published in English in top ranking journals.

Duration and salary: The post-doctorate will be recruited for 8 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a CV, a statement of research interests and the names of at least two references including e-mail addresses and telephone numbers.
Applications should be submitted by e-mail to Laurent Bopp (laurent.bopp@lsce.ipsl.fr) before 15 March 2014.

Project 11 (TWP1): Development of the new IPSL-CM6 model to improve the energy flow within the climate system

Project lead: Olivier Boucher and Jean-Louis Dufresne
Post-doctoral researcher : Sunghye Baek and Adriana Sima
Supervision team: L. Fairhead, F. Hourdin, L. Bopp, P. Braconnot
Project Start/End: March 2014 – February 2015

Position offer: Improving the radiative energy flow in the new version of the IPSL-CM6 climate model

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers a post-doc position of 1 or 2 years to join a collaborative effort to develop the new version of the IPSL-CM climate model. The approach is to improve first the energy flow within the climate system, in particular through better parametrization of surface albedo over ocean and continent. This work can be extended in a second year with multi-parameters adjustments and tuning of the whole climate system.

Context: IPSL has developed an Earth System Model (IPSL-CM5) that includes a representation of the physical and the biogeochemical (carbon cycle, aerosols, chemistry...) processes at the global scale, for the atmosphere, land surface, ocean and sea-ice. The climate models include many parameterizations, which are approximate descriptions of sub-grid processes. These parameterizations are formulated via a series of parameters that are usually not directly observable and must be tuned so that the parametrizations fit as well as possible the statistical behaviour of the physical processes.

We are now developing a new version of the model, IPSL-CM6, and one of our objective is to improve the characteristics of the simulated climate. The energy budget within the climate system (i.e. within the atmosphere, the ocean and at the surface) has a very strong impact on how the model simulate many climate phenomena (circulation, precipitation, MJO...). Until recently, only the net, SW and LW) fluxes at the TOA were estimated with enough accuracy to be used as strong and useful constrains during the final phase of the adjustment of climate models. Recent estimates of the fluxes as the surface and within the atmosphere have been largely improved, and the main objective of the proposed post-doc is to take advantage of such new estimates to improve the energy flow simulated by the IPSL model.

Description of work: The main objective of the proposed post-doc is to improve the energy flow within the climate system, with a focus on the radiative flux. The development and the adjustment of the relevant parameterizations will be done using a suite of tests going from individual parameterizations in individual model components (atmosphere, ocean, land surface,...) to the full coupled climate model.

The work will be first focussed on clear sky flux. We propose to include an ocean surface albedo model that depends on meteorological (wind speed) and biogeochemical (plankton) variables in addition to the solar zenith angle. In the current continental surface model, ORCHIDEE, the albedo depend on the soil type, soil moisture and vegetation, the later being either prescribed or computed, and a validation, tuning and possible improvement are required. In the atmosphere, the development, the evaluation and the tuning will be done starting from clear sky conditions, then considering aerosols, and finally including clouds.

During the first year, the development and the adjustment of the relevant parameterizations will be done in each model components (atmosphere, ocean, land surface,...) using mainly forced simulations. In the second year, fluxes will be considered within the full coupled model and the work

will contribute to the final phase of the adjustment and the evaluation of the fully coupled climate model.

The candidate should have a good knowledge in climate sciences, a solid experience in climate modelling, and a good general knowledge in FORTRAN and shell programming.

Supervision team: The work will be conducted at IPSL under the main supervision of J-L Dufresne, O. Boucher, F. Hourdin, L. Bopp, P. Peylin and in close connection with other researchers and engineer of the IPSL Climate Modelling Centre (J. Ghattas, P. Cadule, C. Etthé...).

Duration and salary: The engineer will be recruited for 12 months with a net monthly salary around 2000 Euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a curriculum vitae, a statement of interest and the names of at least two references including their e-mail addresses and telephone numbers. Applications should be submitted by e-mail to J.-L. Dufresne (Jean-Louis.Dufresne@lmd.jussieu.fr).

Preliminary results :

IPSL-CM6 adopts new radiative transfer scheme RRTM, the rapid radiative transfer model (Clough et al. 2005). Sunghye Baek worked on the parallelization of RRTM in order that the results of different parallelization levels (sequential/MPI/OpenMPI) are consistent. The test has been done several machines and compilers either in local PC or those on IDRIS national computational center. She also worked on transport and optimization of LMDZ on Turing machine (Blue Gene/Q, IBM) at IDRIS with Laurent Fairhead. Turing is the last generation of super computers at IDRIS which is designed to serve to massively parallelized code with MPI and OpenMP.

Oceans cover 70% of the total surface of the Earth. A precise estimation of the ocean surface albedo (OSA) is therefore important for the Earth's radiation budget and climate modelling. Current parameterizations of ocean surface albedo in climate models are often treated in a simple way which only depends on latitude or solar zenith angle. We have developed a new parameterization of OSA in collaboration with Roland Seferian (CNRM), which allows us to include dependencies on wavelength, surface wind speed, chlorophyll content as well as the distribution of solar zenith angle. With the new scheme of radiative transfer (RRTM - Rapid radiative transfer model) recently implemented in LMDZ, we can treat spectral albedo (in up to six wavebands in the visible) instead of just a broadband albedo.

We can decompose the albedo according to the direct or diffuse character of the incoming solar radiation (into a direct albedo and a diffuse albedo term). Then each category can be divided again by according to the reflection process, i.e. a Fresnel surface albedo and an ocean volume albedo, depending on the place where the reflection occurred. We choose to adapt the parameterization of Jin et al. (2004), which shows good agreement with previous work as compared as shown in Li et al. (2006). R. Seferian adapted the fitting of Jin et al. (2004) for the wavelength range 200 to 800 nm. We added a whitecap effect following Whitlock (1982) and Koepke (1984) as per Fig. 1 and extended the wavelength range from 800 to 4000 nm to adjust it with RRTM shortwave range.

The surface direct albedo is the most important component in comparison to the other terms. Fig. 2 shows our new scheme of surface albedo which depends not only on solar zenith angle but also wavelength and wind speed. The overall value is consistent with previous works such as Preisedorfer and Mobley (1986) or Taylor et al. (2002) which has been used in some climate models.

In addition to this work on radiation, a second post-doc has been recenty hired in 2014 to help the development with a focus on the latent heat flux over ocean. The link between its bias in AMIP runs

and the SST bias in couple runs has already been established, and work to improve the latent heat formulation is in progress. Both works will be summarized in publications.A publication will summarized this work.

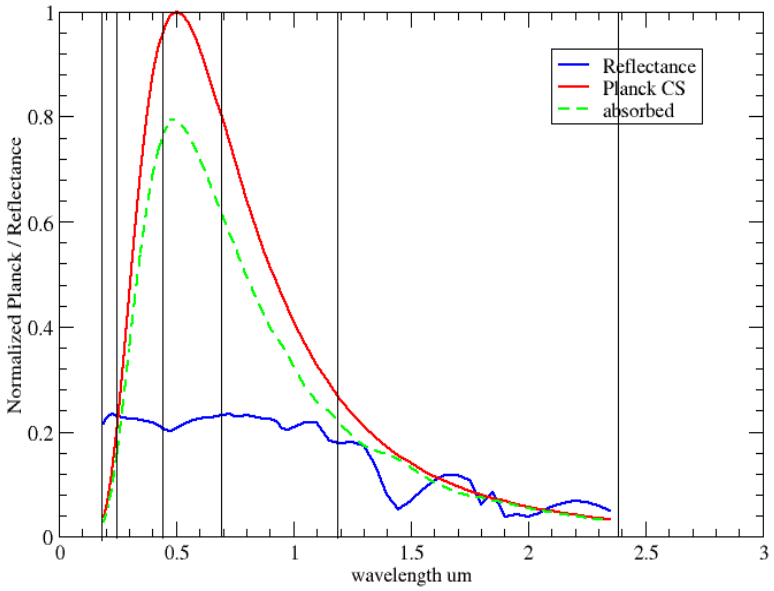


Fig. 1. Blue curve shows the reflectance due to whitecap of the ocean surface as a function of wavelength. The red and green curves shows weighting functions to calculate the whitecap albedo in the RRTM wavebands.

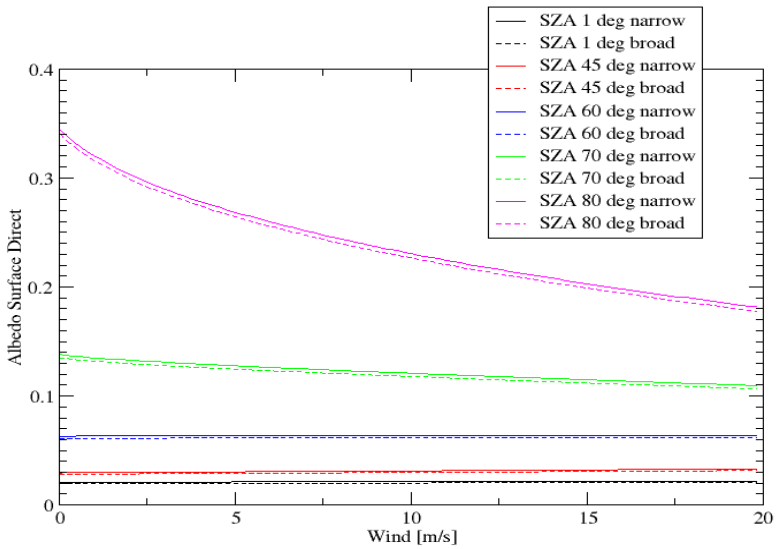


Fig. 2. Different surface direct albedo as a function of wind speed for fixed solar zenith angles (SZA) following the fitting of Jin et al. (2004). Solid curves are averaged over broad range of wavelengths from 200 to 4000 nm, dotted curves are averaged over a narrow range from 200 to 800 nm.

Project 12 (TWP1): Developing and testing a stretched version of the IPSL Earth system model

Project lead: Jean-Louis Dufresne and Férdéric Hourdin
Post-doctoral researcher : Guillaume Levavasseur
Project Start/End : October 2014 – March 2015

Position offer:

The excellence laboratory L-IPSL of the Institut Pierre-Simon Laplace offers an engineer position of 1 year to join a collaborative effort involving the IPSL climate model development team in order to develop and customize the use of a stretched version of the IPSL-ESM. The scientific goal behind this development is to simulate the climate at the regional scale for past, present and future climate conditions, and to allow the analysis the interactions between global and regional climate and between climate and biogeochemistry cycles.

Context: Simulating the climate at regional scale at higher horizontal resolution than that of usual global climate models is of high interest. This allows to better represent the orthographic effects and facilitates the comparison between model and local observations. This higher resolution can be obtained by using global models at very high resolution or by limited-area models. Each of these methods has its strengths and weaknesses. An attractive and alternative method is to use global models with stretched grid.

The IPSL-CM5 model is and Earth System Model that includes a representation of the physical and the biogeochemistry (carbon cycle, aerosols, chemistry...) processes at the global scale, for both the atmosphere, land surface, ocean and sea-ice. The atmospheric component, LMDZ, has a stretchable longitude-latitude grid that allows refinement of the horizontal grid over any specific region. The objective of the proposed work is to develop tools that allow an easy use of this refinement capability over any continental regions and for the various configurations of this ESM.

Description of work: In order to make effective an customize the use of the LMDZ “zoom” capability in the IPSL-ESM system, it is necessary to develop an ensemble of generic tools. This should include in particular interpolation procedures on the zoomed grid, as well as the development and upgrade of scripts that automatically downwoad the required input datasets, interpolate the data on the model grid, and run the simulations. The work will be done in three main steps: (1) creation of the zoom, the initial states and interpolation of all the variables necessary to drive the physical part of the model with prescribed SST (2) interpolation of all the variables necessary to drive the biogeochemistry part of the model over continents with prescribed SST and (3) same but with a coupling with the ocean and sea-ice. Two regions will be used for benchmarking in link with project that involve the IPSL-ESM team: Europe and West Africa.

The candidate should have a solid experience in FORTRAN and shell programing and a good general knowledge in climate modeling.

Supervision team: The work will be conducted at IPSL under the main supervision of J-L Dufresne, M-A Foujols and A. Caubel, and in close connection with other researchers and engineer of the IPSL Climate Modeling Center, from IPSL (J. Ghatas, S. Denvil, P. Cadule), LMD (F. Hourdin, L. Fairhead, F. Cheruy), LSCE (A. Cozic, P. Peylin).

Duration and salary: The engineer will be recruited for 12 months with a net monthly salary around 2000 euros, commensurate with experience. This includes social services and health insurance.

Contact for applications: Applications should include a vita, a statement of interests and the names of at least two references including e-mail addresses and telephone numbers. Applications should be submitted by e-mail to J-L Dufresne (Jean-Louis.Dufresne@lmd.jussieu.fr).

Preliminary results:

An engineer has been hired in 2014 to work on both projects 7 and 12. He started to work on project 7 and the development of the stretch version of the IPSL model will start October 2014.

Appendix B: List of articles with scientific work benefitting from the L-IPSL program

Published or accepted

Bazin, L., B. Lemieux-Dudon, A. Landais, M. Guillevic, P. Kindler, F. Parrenin, and P. Martinerie, Optimisation of glaciological parameters for ice core chronology by implementing counted layers between identified depth levels, *Clim. Past Discuss*., 10, 3585-3616, 2014.

Evan, A. T., C. Flamant, C. Lavaysse, C. Kocha, A. Saci (2014) Water vapour forced greenhouse warming over the Sahara Desert and the recent recovery from the Sahelian drought. J. Climate, accepted.

Evan, A. T., C. Flamant, S. Fiedler, O. Doherty (2014) An analysis of aeolian dust in climate models. Geophys. Res. Lett., published online, doi : 10.1002/2014GL060545

Raymond, P.A., Hartmann, J., Lauerwald, R., Sobek, S., McDonald, C., Hoover, M., Butman, D., Striegl,R., Mayorga, E., Humborg, C., Kortelainen, P., Dürr, H., Meybeck, M., Ciais, P., and Guth, P. Global carbon dioxide emissions from inland waters, *Nature* 503 (7476), 355-359, 2013.

Servonnat J., J. Mignot, E. Guilyardi, D. Swingedouw, R. Séférian, S. Labetoulle (2014). Reconstructing the subsurface ocean decadal variability using surface nudging in a perfect model framework. Clim. Dyn., published online, doi: 10.1007/s00382-014-2184-7

Voigt, A., S. Bony, J.-L. Dufresne, and B. Stevens, 2014 : The radiative impact of clouds on the shift of the Intertropical Convergence Zone, Geophys. Res. Lett., 41, 4308–4315

Submitted and in preparation

Bolliet et al., in prep. *An interactive tool for navigation within a database of water and carbon stable isotope records from natural archives.*Evan A., C. Flamant, L. Menut (2014) 21st century changes in dust and the effect on regional climate change, in preparation for Science.

Evan, A. T., S. Fiedler, C. Zhao, L. Menut, K. Schepanski, C. Flamant, O. Doherty (2014) A statistical analysis of Western African dust emission. Submitted to Aeolian Research.

Lauerwald, R., G.G. Laruelle, J. Hartmann, P. Ciais, P.A.G. Regnier, Spatial patterns in CO_2 evasion from the global river network, submitted to Global Biogeochemical Cycles.

Ray S., D. Swingedouw, J. Mignot, E. Guilyardi (2014). Effect of surface restoring on subsurface variability in a climate model during 1949-2005. Clim. Dyn., revised

Stoffel, M., Corona C, Guillet S., Khodri M., Poulain V, Guiot J., Luckman B.H., Oppenheimer C., Bekki S., Beniston M. & Masson-Delmotte V., 2014. Reconciling dendroclimatic reconstructions and simulations of volcanic cooling. Submitted to Nature.

Appendix B (in French)

Note de fonctionnement du Comité Recherche – Juillet 2014

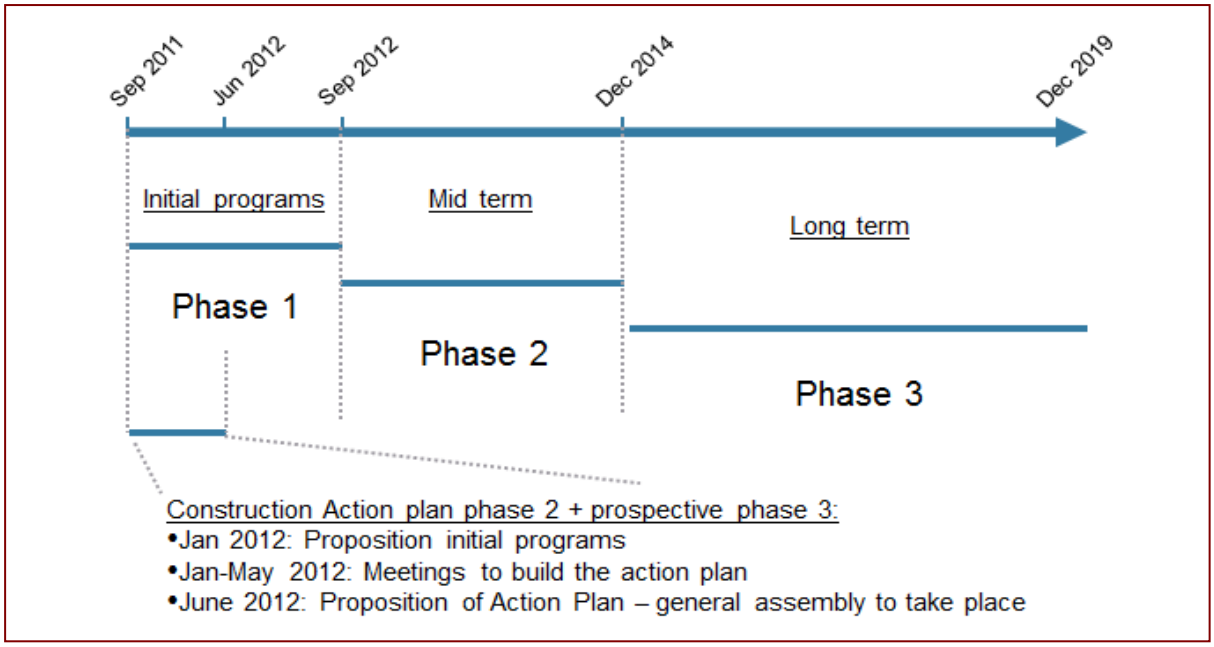
Note sur le fonctionnement du comité recherche (CR) du LABEX L-IPSL

Le volet recherche du LABEX L-IPSL

Le LABEX L-IPSL a pour objectif de développer les connaissances au meilleur niveau international sur le changement climatique et ses conséquences par un renforcement de la coordination des travaux entre les laboratoires du LABEX. Etant doté d'un financement de long terme, le LABEX L-IPSL établit donc une stratégie de recherche de long terme, et l'implémente par une série de projets stratégiques. Le volet recherche dispose d'un financement d'environ 400,000 euros par an à partir de 2014. Les actions financées par le LABEX-recherche peuvent être de différente nature :

- financement de chercheurs post-doc ou ingénieurs,
- invitation de scientifiques étrangers,
- ateliers d'animation

Ces projets implémentent la stratégie définie au sein des différents work packages du LABEX. La proposition du programme de financement est proposée au comité de direction du labex L-IPSL (CD) par le « comité recherche » (CR) composé de membres nommés par le CD. La stratégie a été établie en 3 phases : une phase initiale de lancement avec plusieurs projets, une phase intermédiaire (jusqu'à fin 2014) permettant d'établir un « rythme de croisière » dans laquelle les premiers résultats alimenteraient des travaux de plus long terme (voir schéma ci-dessous).



Le Comité Recherche et son fonctionnement

Le CR est composé de membres nommés pour 2 ans :

- les responsables des work packages (WPs et TWPs)
- des membres permettant d'élargir l'expertise
- des invités (au besoin pour certaines actions ciblées ou les responsables des structures de l'IPSL

Le CR renouvelé en Mai 2014 est composé de :

Responsables de WP :

- WP1 (factors controlling the atmospheric composition): **Laurent Bopp**
- WP2 (the predictable part of climate for the next decades): **Eric Guilyardi**
- WP3 (regional implications of global warming) : **Cyrille Flamant**
- WP4 (impacts) : **Christophe Rabouille**
- WP5 (the risk of abrupt unpredictable climate evolutions) : **Christophe Colin**
- TWP1 (numerical modeling of the cliate system): **Jean-Louis Dufresne**
- TWP2 (strategy for observational studies : instrumentation, analysis, dissimination): **Martial Haeffelin**
- TWP3 (assessment of uncertainties in climate diagnostics and projections) : **Pascale Braconnot**

Membres d'expertise complémentaire : Jean-François Doussin, Agnès Ducharne, Marion Gehlen, Alain Hauchecorne, Frédéric Hourdin, Amaëlle Landais, Kathy Law, Béatrice Marticorena, Catherine Prigent, Marie-Alexandrine Sicre, Benjamin Sultan, Vincent Thieu

Membres invités : Franck Bassinot, Philippe Ciais, Cathy Clerbaux, et les membres de la direction de l'IPSL et les responsables de pôles

Président : Robert Vautard

Le CR doit définir la stratégie de recherche et le programme de travail. Pour réaliser le plan de travail il disposera d'un financement à distribuer, dans la période 2014-2019, d'environ 400,000 euros par an. Quelques principes de fonctionnement pour le financement des actions ont été établis au cours des premières années du fonctionnement du LABEX, les voici :

Pour les financements de chercheurs/ingénieurs post-doctoraux ou invitations de chercheurs extérieurs:

Le financement des projets n'est pas a priori effectué par des appels à projets (mais il peut être décidé de le faire pour des cas particuliers). La stratégie et les actions sont proposées par les membres du comité, avec un certain nombre de contraintes que le CR s'impose :

- les projets proposés doivent être transversaux et concerner plusieurs équipes de plusieurs laboratoires du LABEX. ils doivent être construits avec une équipe projet impliquant l'ensemble des chercheurs et ingénieurs impliqués par les questions du projet
- le porteur, dans la mesure du possible extérieur au CR, est assisté par un contact au sein du CR
- lorsque la maturité semble satisfaisante au CR, le projet est budgetté et un profil de poste comportant les attendus, l'équipe projet, la formation, est proposé et validé par le CR, puis diffusé en externe

- le CR suit chaque projet par une revue du projet en réunion, dont l'objectif est d'aider les porteurs à la conduite, d'élargir si nécessaire
- le CR demande un rapport à la fin de chaque action

Pour les ateliers

- une enveloppe annuelle de 30Keuros est disponible pour l'animation, et le programme des ateliers est géré par les responsables de WP, avec donc un budget indicatif de 4000 euros/an. Au-delà de ce montant de dépenses, les actions se feront en fonction de la disponibilité des crédits restant

Proposition annuelle des actions et du budget et calendrier

Chaque année, **fin juin de l'année en cours (n)**, le CR propose au CD un **plan d'actions** pour la période allant de Septembre de l'année n à Août de l'année n+2. Cette proposition est faite via un document actualisé tous les ans, appelé « Plan d'Actions » (PA) comportant :

- un rappel de la stratégie générale pluri-annuelle
- un rappel des actions en cours
- un rapport des actions qui se terminent
- les nouvelles actions à lancer

Eléments de calendrier

- les nouveaux recrutements de chercheurs ou ingénieurs post-doctoraux sont à réaliser entre Septembre *n* et Décembre *n*+1, le projet devant être reproposé et ré-arbitré si cela n'a pas pu être fait
- le plan d'actions est établi en juin à la suite de plusieurs discussions en CR se déroulant typiquement de mars à mai. Pour 2014, le calendrier est retardé. Exemple, le PA 2013 : http://labex.ipsl.fr/images/labex/pdf/documents_public/LABEX_Action_Plan_2013_V6.pdf
- le CR se réunit tous les mois à tous les 2 mois

En pratique, pour les équipes du LABEX :

- **l'agenda du CR et les différents documents sont disponibles sur le site web du LABEX http://labex.ipsl.fr**
- **les propositions d'actions (sur les thèmes des WPs du LABEX L-IPSL et ayant une bonne transversalité au sein du LABEX) se situant entre Sep année n et Sep année n+2 doivent être faites directement (de façon informelle) aux responsables des WPs ou autres membres du CR, si possible avant fin mars de l'année *n*, afin qu'ils soient discutés en réunion de CR.**
- **Les propositions d'ateliers pour la période en cours peuvent être faites au fil de l'eau aux responsables de WPs mais il est préférable de planifier ces actions dès le mois de septembre pour l'année universitaire en cours**

Chaque projet a un porteur (si possible hors du CR), une équipe projet multi-labos, et un contact au sein du CR qui suit le projet. Les projets en cours de la phase « mid term », porteurs et contacts (le tableau devra être réactualisé après renouvellement du CR)

Tableau des projets « mid term » en cours (juillet 2014)

Pour voir les profils de post-doc correspondant aux projets, voir le Plan d'action 2013 (exemple pour les projets décidés en 2012, Pages 92 – 104) :
http://labex.ipsl.fr/images/labex/pdf/documents_public/LABEX_Action_Plan_2013_V6.pdf

Projet	**Portage**	**Contact CR**	**WPs (en gras portage principal)**	**Année décision**
Volcanisme dernier millénaire	Myriam Khodri	Eric Guilyardi	**WP2**-WP5	2012
Base de données Isotopes de l'eau	Valérie Masson-Delmotte	Christophe Colin	**TWP2**-WP5	2012
Portail Arctique	Kathy Law	Kathy Law	**TWP2**-WP3	2012
Indicateurs	Benjamin Sultan	P Braconnot A Ducharne	**WP4**-TWP3	2012
Configuration et distribution des simulations CMIP	S Denvil	JL Dufresne	**TWP1**	2012
Carbone rivières	P Ciais	Agnès Ducharne	**WP1**-WP4	2012
Modèle d'âges multi-archives	A Landais	Franck Bassinot	**WP5**	2012
GC challenge nuages et sensibilité climatique	S Bony	JL Dufresne	**WP2**	2013
Modélisation du changement climatique en Afrique de l'ouest	S Bastin	F Hourdin	**WP3-WP3**	2013
Modélisation du transfert radiatif	O Boucher	JL Dufresne	**TWP1**	2013
Biogéochimie marine avec LABEX MER	L Bopp	M Gehlen	**WP1-TWP1**	2013

Institut Pierre Simon Laplace

Labex L-IPSL

Appendix C (in French)

Internal calls :

Impacts research projects

IPSL-SME projects

Le Labex L-IPSL lance un appel à idées pour renforcer ses actions de recherche sur les impacts du changement climatique

Pour favoriser l'émergence de l'étude des impacts du changement climatique, le Labex L-IPSL recherche des projets scientifiques innovants sur les thématiques du Work Package « Impacts » (WP4). Celles-ci concernent l'étude des impacts du changement climatique sur la société, les écosystèmes et les cycles biogéochimiques, leur détection au cours du dernier siècle, ainsi que leur projection sur le siècle à venir, en utilisant notamment les dernières projections climatiques (CMIP5, CORDEX).

Pour plus de détails, le positionnement scientifique du Labex L-IPSL et de ses Work Packages est disponible sur le site http://labex.ipsl.fr. Consulter particulièrement le résumé du projet L-IPSL et le plan d'action 2013:

- http://labex.ipsl.fr/images/labex/pdf/documents_public/presentation_l-ipsl.pdf
- http://labex.ipsl.fr/images/labex/pdf/documents_public/LABEX_Action_Plan_2013_V6.pdf

Les projets sollicités devront s'articuler autour de post-docs de 1 à 2 ans, coordonnés par une équipe couvrant plusieurs laboratoires du L-IPSL, et ciblés sur les thématiques du WP4 « Impacts ». Les équipes intéressées sont invitées à répondre par une lettre d'intention « Post-doc » de 2 pages maximum, précisant succinctement les objectifs scientifiques visés, leur caractère novateur par rapport à l'état de l'art, leur pertinence pour renforcer le WP « Impacts », les liens avec les autres WP du Labex L-IPSL, l'équipe de coordination et les éventuelles collaborations extérieures, et la durée du post-doc demandée.

L'appel à idées s'étend également à l'organisation d'ateliers, séminaires, invitations courtes, concernant le thème des impacts du changement climatique. Cela pourra être proposé via une lettre d'intention « Animation » de 2 pages maximum, précisant succinctement les objectifs scientifiques visés, leur pertinence pour renforcer le WP4 « Impacts », les liens avec les autres WP du Labex L-IPSL, l'équipe de coordination et les éventuelles collaborations extérieures, et le budget demandé. Ces lettres d'intentions sont à adresser **avant le 16 mai 2014** par email aux trois personnes suivantes :

Agnes.Ducharne@upmc.fr (responsable du WP « Impacts »),
Christophe.Rabouille@lsce.ispl.fr (responsable suppléant),
Robert.Vautard@lsce.ipsl.fr (président du Comité Recherche L-IPSL).

Les demandes seront évaluées sur la base des critères ci-dessus par le Comité Recherche du Labex L-IPSL, qui se réserve la possibilité de demander des regroupements de propositions ou des aménagements. A l'issue de cette étape, des projets seront présélectionnés début juillet, et devront préparer une présentation orale devant le Comité Recherche pour Septembre, puis une fiche de poste après validation définitive.
A titre indicatif, l'enveloppe budgétaire disponible est au maximum de 3 années de post-doc, et de 15 k€ pour les actions d'animation. Les frais d'environnement des post-docs ne sont pas éligibles, hormis une enveloppe de 2500 €/an pour conférences.

Calendrier prévisionnel :
Diffusion de l'appel à idées : lundi 31 mars 2014
Envoi des lettres d'intentions « post-doc » et « animation » : vendredi 16 mai 2014
Retours aux proposants : 11 juillet 2014
Deuxième phase de construction/évaluation des projets présélectionnés : septembre 2014
Date minimum pour le financement effectif : octobre 2014

Appel d'offres pour le développement de projets communs IPSL-PME pour le transfert d'expertises climatiques

L'un des objectifs du LABEX L-IPSL est de développer le transfert d'expertises climatiques vers les entreprises afin de démultiplier les forces de diffusion de l'information climatique. Pour cela le LABEX L-IPSL propose de mettre en place un programme permettant aux équipes de l'IPSL de développer des projets avec des PME. Ces projets seront réalisés en binôme IPSL – PME, et devront avoir pour objectifs :

- de contribuer à relever les défis de l'adaptation au changement climatique,
- de proposer une réalisation scientifique ou technique (démonstrateur, outil aval permettant le transfert d'informations, logiciel, …)
- de valoriser les simulations climatiques (projections pour le futur, simulations de descente d'échelle, calculs d'indicateurs d'impacts), les modèles, logiciels,
- de permettre le transfert d'expertise à la PME partenaire qui pourra par la suite valoriser le travail dans un cadre de prestations,
- de développer le réseau de liens entre l'IPSL et le tissu industriel.

Le budget total de l'appel d'offres est de 120000 Euros, et le programme pourra financer des projets se déroulant sur 1 à 2 ans, avec une mise en place au premier trimestre 2014. Les crédits du LABEX bénéficieront à la réalisation d'un projet partenarial avec la PME[2].
Les projets, dont la présentation ne devra pas dépasser 10 pages en tout, devront comporter :

- la motivation du projet et une présentation de l'existant et de l'innovation proposée,
- la description technique du projet,
- la description des rôles respectifs de l'équipe IPSL et de la PME, de l'objet du partenariat, et l'intérêt des deux parties ,
- la présentation des suites envisagées au-delà du projet,
- la justification de l'utilisation des crédits du LABEX par rapport à ceux d'autres programmes,
- la présentation du budget global de dépenses du projet, des personnes impliquées,
- la description de l'apport budgétaire de l'entreprise (en nature ou financier).

Les projets devront être envoyés par messagerie électronique, **avant le 29 Novembre**, à Nicole Papineau (nicole.papineau@ipsl.jussieu.fr) et Robert Vautard (robert.vautard@lsce.ipsl.fr). Ils seront examinés par la cellule « services climatiques » du LABEX L-IPSL.

[2] Il sera utile, avant soumission, de faire vérifier le montage budgétaire auprès de Nicole Papineau et Robert Vautard en nous le communicant suffisamment auparavant.