Innovation and expertise transfer

Climate research teams –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 capacity of L-IPSL to transfer knowledge and innovation has concretely focused on three aspects so far:

- Innovative instrumentation for environment observation and monitoring;
- Climate services;
- Support on data sets for climate services;

This report summarizes actions undertaken in this perspective

1 Innovative instrumentation

Our goal is to achieve a meteorological lidar system which can be described in different versions and different technologies (Raman, DIAL). One of these versions must meet market demand which can be very diverse in terms of potential customers.

As a research laboratory, we aim to make autonomous and validated lidar instruments, but also to develop the data processing algorithms associated with the complexity of these instruments. These works are not only carried out in the laboratory, but they have the advantage of also being conducted during field campaigns where instruments are subjected to various stresses associated with the meteorological environment. This brings us further in technology readiness level.

The proposed potential transfer is based on several ascertainments:

- Lidar are high-tech instruments difficult to implement and maintain, use is a matter for specialists.
- The acquisition cost is high (> 130 k €), equipment needs to be widely used to be profitable, occasional use is not of industrial profitability.
- Analysis and processing of data requires advanced expertise that is not widespread. It is nevertheless present and recognized in certain IPSL laboratories such as LSCE and LATMOS.
- The aerosol lidar market suffered a crisis following the abrupt end of the activity of operation and maintenance of aerosol lidars sold by the Leosphere Company.
- New instruments (meteorological lidar, DIAL water vapor lidar, ozone DIAL lidar) are being developed or are already deployed that might interest the industrial world.

This set of findings appeared to us as leading international markets of interest:

- Operational agencies (Météo-France, ANDRA, Met Office, NASA, …)
    - Data analysis
    - Management & maintenance of instrumental network
- Environmental / government agencies (China, USA …)
    - Expertise for pollution measurements (megacities, industrial complex)
    - Data analysis

- The industrial environment (small businesses, large industrials)
    - Foresters
    - Monitoring of pollutant emissions
- Some research laboratories
    - Data analysis
    - Maintenance and developments

Expected deliverables

There are two main deliverables that are:

- The results of market research and customer canvassing
    - List of customer requests mainly oriented data analysis for lidar systems of various types: water vapor, temperature, wind, aerosol and ozone.
    - Financial market assessment by differentiating the different types of lidar and, industrial, operational and institutional actors.

- The proposal of a business model if the return is positive.

Progress so far

The progress is along three strategic directions needed for the industrial transfer: the instruments, the algorithms and a first market study.

Water vapor channel.

A new version of the water vapor Raman channel is now developed and was involved in the framework of PARCS (Pollution in the ARCtic System) of the French Arctic Initiative. This new channel is associated with two cross-polarized channels for atmospheric aerosol studies, all constitute the lidar WALI (Water vapor and Aerosol Lidar). The laser has been upgraded and its emitted energy is now enhanced by a factor of 3. The emitting path was modified to meet the eye-safety requirements, which is preferable for a democratic use of the lidar.

The error budget of an instrument is better constrained when using the instrumental synergy which can be offered by a field experiment. The PARCS experiment held in Hammerfest (Norway) implicated ULA (Ultra Light Aircraft) flights with a payload including a meteorological probe. When comparing the vertical profile of water vapor mixing ratio derived from both the lidar and the ULA (Figure 1), the relative root mean square difference is computed to be less than 0.4 g/kg of water vapor mixing ratio. The threshold needed for meteorological purpose is thus reached.

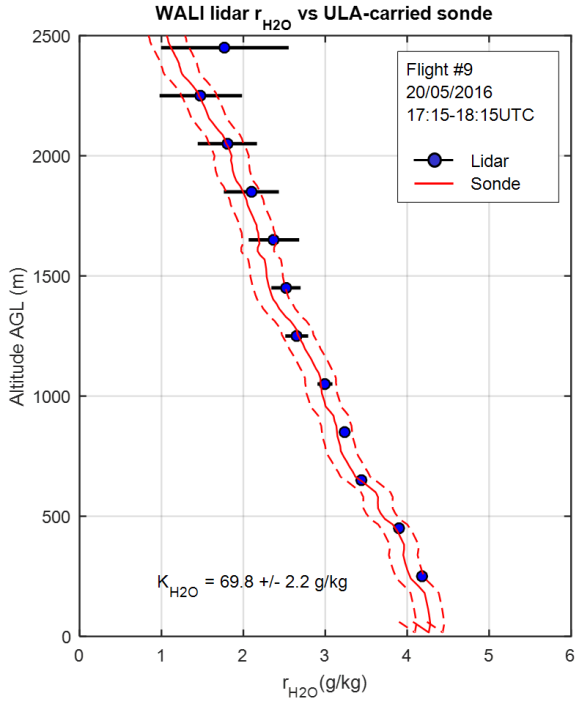

Figure 1: Atmospheric water vapor mixing ratio derived from both the WALI lidar and the meteorological probe embedded on an ULA. The standard deviations on the measurements are also shown (horizontal bars for the lidar and dash lines for the meteorological probe).

Temperature channel

In parallel to the implementation of the water vapor channel, the feasibility studies on the temperature channel were continued. A specific optical bench has been designed and both the upgrade of the laser (wavelength stabilization by injection seeding) and the optical components (high rejection filters) are ordered.

We aim absolute error on the thermodynamic temperature less than 1°K. The simulator gives the results plotted in Figure 2 for the spectral responses given in the insert. During night-time, the standard deviation of 1 K is reached for the distance from the emitter of ~8 km. During day-time this value

decrease to ~2-3 km due to the solar background. For a good optimization, the spectral responses of the interferential filter depend of the solar background level. For night, it is preferable to select rotational lines far from the Cabannes line (centred on the laser wavelength). It is the opposite for the day because the rotational line strengths are larger close to the incidence wavelength. Yet an optimum can be found between the two (insert).

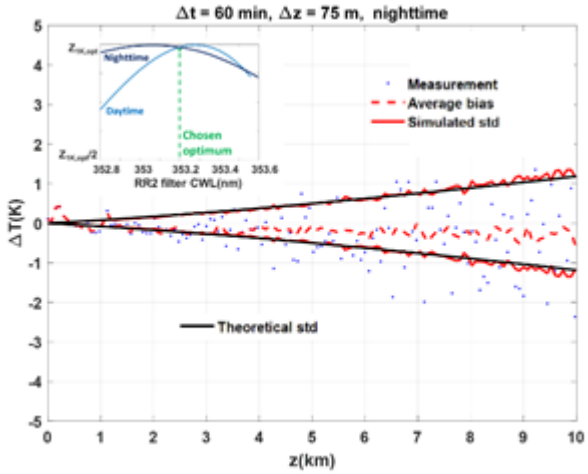

Figure 2: Theoretical assessment of the temperature error against the distance from the emitter.

Airborne Raman lidar

Both the simulations and the first test on the airborne Raman lidar conducted in 2015 led to the upgrade of the laser (30 mJ instead of 16 mJ) for improving the signal to noise ratio. The upgraded instrument flight during the Arctic campaign of May 2016.

Algorithms

One of the main goal is to improve the data analyses using automatic algorithms. This development is ongoing but needs to be adapted with the potential markets. Figure 3 gives an example of the retrievals for different aerosol layers which can be identified with the so called “lidar ratio” (LR).

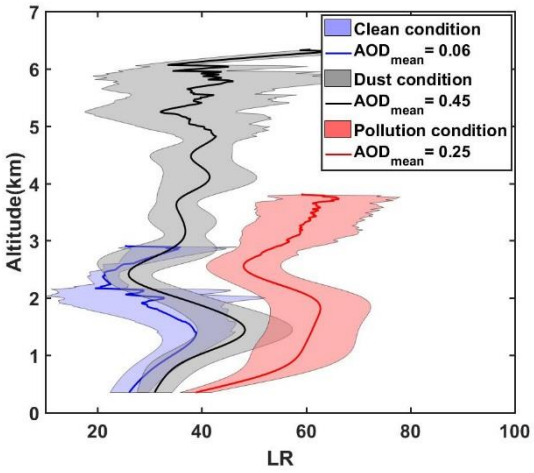

Figure 3: Vertical profile of the Lidar ratio for different aerosol types seen on the Mediterranean coast. The standard deviations are given by the filled areas.

Market research

A first market research has been performed by the SATT Paris-Saclay. The interviews were on 9 interlocutors from academic, operational and industrial activities. They were mainly oriented towards the instruments (mainly aerosol lidar) and their maintenance and did not yet cover important aspects

of the knowledge transfer. The findings are not very optimistic, but still limited to mainly French interlocutors.

The European market (French, England and Germany) on aerosol lidar is very limited, it is occupied by Sigma Space / Envicontrol and Raymetrics. It is mainly oriented towards airports and air traffic control. Prospects are expected for DIAL lidar with clients already identified but also new constraints to be respected (first lidar on the market in less than a year).

For service activities related to aerosol lidar maintenance, they are dependent on the sale of equipment and represent a very small market. For the market deserted by Leosphere, it will be very difficult to recover because of the loss of customer confidence. In the case of a recovery of confidence, only an annual maintenance is required. Sigma Space lidar are advertised as open in terms of software. There is no information to Raymetrics. In the operational world, the collection of data may not exceed 3 hours after acquisition. This is of the order of the day for AASQA. However, these various structures do not have the financial potential to acquire lidar instrumentation, even less to build a lidar network.

Envisaged activities, potential markets for a new lidar business

In the coming year, we will finalize the meteorological lidar system by including the temperature channel in which the various components have been specified following a numerical link budget study. The instrument will then be tested on the atmosphere and compared with radiosonde measurements and / or airborne measurements. We are considering the use of small drones to perform the calibration of the lidar system in the lower atmospheric layers (< 400 m amsl).
A document showing the characteristics of the lidar system will be edited quickly to be used for customer canvassing. Such a document will consider the measurement accuracy that can be achieved using both the simulator and the observations that have been acquired during the lidar tests. A similar document will be produced for the water vapor DIAL relying mainly on digital simulator available at LATMOS.

A major activity will be an enlarged market study to be conducted by a high-tech expert consulting company, using dedicated funding within the WAVIL ANR project. Overall, we insist that this study will focus primarily on service and not on the actual instrumentation. Indeed for the instrumental part, the transfer is envisaged via existing companies that have the ability for building a rugged lidar from an initially tested instrument by a research laboratory. This activity is now determined to be too risky and too costly for it to be led by a start-up company.

We remain confident that a serious need exists for an operational meteorological lidar network in Europe, from years of discussion with the French and German weather agencies. It will have major benefits for our understanding of extreme events due to precipitations as well as other cloud and aerosol physics.

2 Climate services

In 2013, the L-IPSL elaborated a strategy in the field of climate information transfer for adaptation, the so-called “climate services”. This strategy proposed a few actions that could be developed in a time frame of a few 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 and services that could be developed with targeted communities. The L-IPSL 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 FP7 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, ...)

Several actions have been undertaken, 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 and achieved several key steps, which are summarized here.

1. Climate Services and Expertise web site

A web site, http://cse.ipsl.fr has been set up in order to disseminate information and climate-service projects developed at IPSL. This was the first attempt to collect all the in-house information on climate information development. It turned out that a number of projects were developed with stakeholders, which needed to be highlighted in the context of climate service developments. The web site also includes access to news, data sets.

2. The PRODIGUER service and the development of ESGF

The PRODIGUER service is at the cornerstone of the data distribution activity, both for research and climate services. The LABEX has supported the development of the PRODIGUER data distribution service, and expanded its activities. The service core mission is to develop 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). The second core mission of the PRODIGUER team is to lower the barrier towards the accessibility of the ESGF resources.

3. In-house processed climate projections algorithm development

A new step has been achieved in production of bias corrected (or bias adjusted datasets), as a necessary step for the development of impact studies and climate services. A new algorithm for precipitation has been tested for precipitation (Vrac et al., 2016, J. Geophys. Res.). This algorithm, which is in the family of the Cumulative Distribution Function transform (CDFt) accounts for potential biases in precipitation frequency. It has been developed and applied now in several cases, including the applications below. CDFt has also been adapted to a number of situations and datasets, which required rewriting in FORTRAN to handle large data sets such as EUROCORDEX or CMIP. Typical developments have been carried out in order to handle reference observation-based data sets which have a lower resolution than the climate projection itself, which is the case in most applications of CORDEX-011.

The goal is now to generalize the use of CDFt. The new developments of CDFt have been applied:

- As a first pioneering example over Europe using E-OBS reference data, within the LABEX testing framework, and within the framework of the international bias-corrected cordex effort led by SMHI; data sets are now published on the ESGF server and on the CSE web site;

- To temperature and precipitation variables for DRIAS (the CDFt development stage was not complete at that time, which now necessitates an update);

- As an innovative application to produce a climate projection data set suited to the energy sector, within the CLIM4ENERGY Copernicus C3S demonstrator project (http://clim4energy.copernicus.climate.eu);

- As another innovative application to the ensemble of CMIP data for a few variables, within the framework of the TCDF contract (see SME projects P1 below).

4. Provision of bias-corrected data to DRIAS and the National scenarios

One of the early application of CDFt was for the DRIAS national climate service. This action was essentially funded directly through MEEM contract for the report on climate scenarios for France. For the first time, EUROCORDEX ensembles were used together with the SAFRAN reanalysis to produce a high-resolution projection data set, now available through the DRIAS server. Precipitation and temperature were bias corrected after a projection on the SAFRAN grid. The analysis of the climate projections was made and reported in the National Scenario report (rapport "Jouzel").

3. Pilot studies with SMEs

Four projects for transfer actions IPSL - SMEs were launched, and an additional one is currently being discussed and will be subject for a call for tender. These actions are still underway. Here are the summaries, but a progress report can be found in Appendix B.

P1: Generation of bias corrected CMIP5 and CORDEX essential climate variables data set. Start of the TCDF spin-off. The goal of this 18 month project is to develop a post-processing chain software to handle statistical post-processing operations on climate model data sets and generate a first data set of bias corrected climate model simulations. It is the opportunity to develop the post-processing chain expertise within the newly created TCDF spin-off, in order to harness a business-to-business service of climate projection data provision. The post-processing chain is based on the SYNDA software that is an advanced ESGF download manager developed by the IPSL PRODIGUER team. The SYNDA SDT (Synda Data Transfer) component handles the synchronisation and download of large data files between the *Earth System Grid Federation* climate model data repository on local resources. The Synda SDP (Synda Data Processing) component handles a workflow engine - it orchestrates complex distributed interdependent tasks triggered upon download completion. Principal data sets on ESGF are the CMIP5 and CORDEX projects that are a set of global (CMIP) and regional (CORDEX) reference climate simulations under several atmospheric CO2 future conditions (The so called *Representative Concentration Pathways).* During the project several computational modules are developed to perform the calculations as well as apply quality control procedures both on technical specifications (ESGF file standards) as well as a data check (outliers detection). As of December 2016, development and technical testing of the chain is almost over and the development phase will be finalized by January 2017. What remains to be done is the so-called "production" phase that is the generation of the data set. The climate data factory (TCDF) is a climate service provider of post-processed climate change model data to the climate change impact and adaptation communities of both scientist and practitioners. Indeed climate change impact studies require data that are becoming difficult to access and need correction from systematic errors in order to be used in impact models. The data management segment of the climate services market was evaluated at 850M euro in 2015.

P2: A « proof of concept » innovation project on statistical sub seasonal forecasting, using an analogue method. ARIA Technologies is participating to this project. See the Report in the Appendix B. In a nutshell,

the project aims at investigating the potential of a new *stochastic weather generator* based on atmospheric circulation analogues (AnaWEGE) for seasonal predictions. The plan is to test the performance of this tool to simulate the spread of climate trajectories at a time scale between days and seasons. This tool can 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. On the market side, ARIA Technologies made several studies on the impact of climate change. It was found that most potential clients are interested in subseasonal climate prediction and uncertainty. In the present project, ARIA Technologies gets acquainted with the modified code of AnaWEGE and will conduct the tests, with the assistance of IPSL. A Masters student (Mariette Lamige; Université de Lyon 1) was hired for 5 months for an internship at ARIA and LSCE (May 2015 to September 2015). The first step was to modify the code of the stochastic weather generator AnaWEGE code into a predictive mode. The second stage was to test the stochastic predictions against observations. Predictions are done in hindcast mode for winters between 2000 and 2010. Probabilities of temperature anomaly sign was predicted and verified against persistence and climatology. In deterministic mode, as a preliminary result, we find that the predictions of correct anomaly sign is above 60% up to Day 8 for Paris temperature. The skill appears to be lower in Toulouse. In all cases no skill was found beyond this lead time. Seasonal skill should be further investigated in the next phase of the project.

P3: A project to study the possibility of transfer of the LMDz model to a SME (Aria Technologies) for different climate applications): More and more applications connected with weather or Climate issues require high resolution 3D gridded data and use the WRF model nested in global output such as GFS or ECMWF analyses or forecast. The use of LMDz software developed by IPSL/LMD could provide a new and innovative solution including several competitive differences. In the context of the present work, we plan to carry out and evaluate several downscaling runs and to assess their possible interest in the fields of air quality and water management. The main test here is in replaying with LMDz some of the SECIF (IPSL ANR project) cases and in comparing the results obtained with those obtained previously with the WRF model. The LMDz model code was transferred and implemented on ARIA computers. A first training session was carried out. The selected SECIF case is a domain around Roman –sur –Isere (Alps Mountains) and tests on heavy rains have been done. Numerical problems on our cluster are fixed but some modelling issues remain to be solved with IPSL team assistance. The project has been delayed for several reasons and we expect more results in the next report

P4: Project to develop a platform for adaptation to climate change and phyto-sanitary risks in agriculture. The objective of this project is to offer the agricultural sector an interactive and educational platform to disseminate climate change impact scenarios on crop yields and phytosanitary risks and to be able to construct different adaptation strategies. The project started at the end of 2016 and its results are expected in the course of 2017. IPSL will work with ECOCLIMASOL for this purpose, which will develop the product platform, based on interaction with researchers. IPSL. Expected results will include: (i) a mainstream interactive web-based platform to visualize the impacts of climate change on the agricultural sector; (ii) an interactive web platform allowing practitioners to test virtually different agricultural practices to optimize their adaptation In the context of climate change, (iii) continuous improvement of the calibration of key models, methods and diagnoses for agricultural adaptation to climate change. The developed platform, here for South America, will be designed to be easily adapted to the end of the project to other parts of the globe, including France and Africa.

P5: A project on carbon budgets and their evolution in large forests. In the field of "GHG monitoring services" (GHG) at different scales, for example for cities (Paris and Recife, Brazil) and for forest areas (Landes forest), IPSL Will work to improve the modeling of carbon fluxes in large forests, based on observations of carbon fluxes and stocks on the forest basins studied. This will be done with a subcontractor which will develop his expertise in this area.

5. Support to the development of the Copernicus C3S programme

Since the start of the climate service program within L-IPSL, the new European Copernicus C3S program has developed and grown. The objective of LABEX was to ease and help the participation of IPSL to this program, by funding travel and stay to researchers to prepare projects.

IPSL is now involved in several C3S funded or submitted projects. The participation is significant in 3 funded projects:

- A sectoral application (CLIM4ENERGY) of climate projections for the energy sector (IPSL leads)
- A core activity (Climate Data Store) on global climate projection data services
- A core activity (Climate Data Store) on developing a roadmap for european climate projections (CRECP), together with the U.K. Met Office

IPSL has now also submitted 2 applications, one of which IPSL has the lead, and which are in review, in the field of core services for regional climate projections. New tenders could provide new opportunities.

It is to be noted that during 2016, IPSL has also been involved in several bids submitted to the ERA4CS programme, for the development of climate services.

For next phase, proposed LABEX support:

The Climate services strategy will pursue its initial phase, with ongoing projects. An update of the strategy will be made in 2017 [this has been delayed by the number of external projects, including the new ERA4CS program] after the end of the first projects, as it is too early currently for lessons learnt. For 2017, the LABEX will focus on a few actions:

- Further developing the IPSL-SME program, by finalizing the first four projects, and launching the last one. Funding devoted to these projects appear in previous plans, and are more concretely:
    - 123 400 euros for the IPSL-TCDF project
    - 37 000 euros for the IPSL-ARIA project on analogs prediction
    - 60 000 euros for the IPSL-ARIA project on LMDz transfer
    - 85 000 euros for the IPSL-ECOCLIMASOL project on agriculture
    - A budget of 70 000 euros is reserved for the project on forests.

The total budget for this program is therefore 375 000 euros

- Further supporting the development of C3S Copernicus projects at IPSL by hiring a climate science officer who will ease the links with stakeholders, help in writing proposals and reports, and develop innovative climate service ideas. A budget of 130 K€ 2-year salary for a scientist with experience, travel) was already approved in the 2015 plan, but applications came lately in the year and are being reviewed currently. In addition, given the load of Copernicus projects and the administration and management level required, as well as the ERA4CS activities, it is proposed that the LABEX fund a 2-year project manager (100 K€). An additional budget for travel and stay for preparing and completing C3S and ERA4CS projects is provided (20 K€).

- A new national-scale climate service development program has recently been proposed in several initiatives (MEEM program). This program follows up a number of initiatives such as DRIAS, EXTREMOSCOPE, the GICN, and a new portfolio of climate service demonstrators. This was proposed lately in January 2017 to the MEEM). This is a joint program with Meteo-France, CERFACS, in collaboration with BRGM. The ambition is to extend the program later to other ALLENVI partners. In case of success it was suggested to complement the funding by a 1-year research position in order to foster the development of the integrated modeling chain climate services at national level. The proposed funding is 60 K€.

New proposed actions starting in 2017:

Actions	PA 2016
Copernicus Climate Change & ERA4CS support Project manager	90000
C3S and ERA4CS support to travel	20000
Support to National Climate Service development	60000
TOTAL CLIMATE SERVICES	**170000**

3 Support on Data set for climate services

Leads : M. Chiriaco (LATMOS), J. Lopez (IPSL), C. Boitel (LMD)

A new action has been developed in 2016. This project of IPSL Pôle Observation to improve provision of Earth observation datasets for Climate services and other applications. In this report, we present the technical developments of ReOBS project, that are currently supported by the LABEX-IPSL (innovation) through employment of Julio Lopez. Scientific aspects are only synthetized in the annex by a list of publications.

Goals

The objective of the ReOBS project is to present a scientific approach to aggregate and harmonize about fifty geophysical variables at hourly scale on a decade, to allow multiannual and multi-variables studies combining atmospheric dynamics and thermodynamics, radiation, clouds and aerosols, from ground-based observations. Actually, there are many datasets from ground-based observations in the world, that have a significant scientific value as they contain complete and precise information on the long-term, due to their spatio-temporal collocalisation. But they are under-used, in particular the observation synergy aspects, because of their complexity and diversity (of calibration, quality control, treatment, format, temporal averaging, metadata…). This project has two main objectives: (1) developing a set of methods available for the community to process ground-based data robustly and reliably at a hourly time scale over one decade or more; (2) providing a single netCDF file based on observations carried out at a multi-instrumented supersite (e.g. SIRTA observatory), containing about fifty substantial geophysical variables hourly averaged over a decade for the oldest ones, easily usable by the scientific community. In this project, observations are “re-analyzed”. This “re” prefix applies to six main steps: calibration, quality control, treatment, hourly averaging, homogenization of the formats and associated metadata, expertise on more than ten years of observations. In contrast, previous studies (i) only take into account some of these six steps for each variable, (ii) do not aggregate together all variables in a single file, (iii) do not offer an hourly resolution for about 50 variables on a decade (for the oldest variables). The ReOBS approach can be applied to supersites other than SIRTA and to additional variables. The main implication of this work is that complex observations are made readily available for scientists that are non-experts on measurements.

Figure 1 summarizes the ReOBS approach. ReOBS is the approach proposed by ACTRIS-FR to improve the ability of users to utilize data from the French atmospheric supersites.

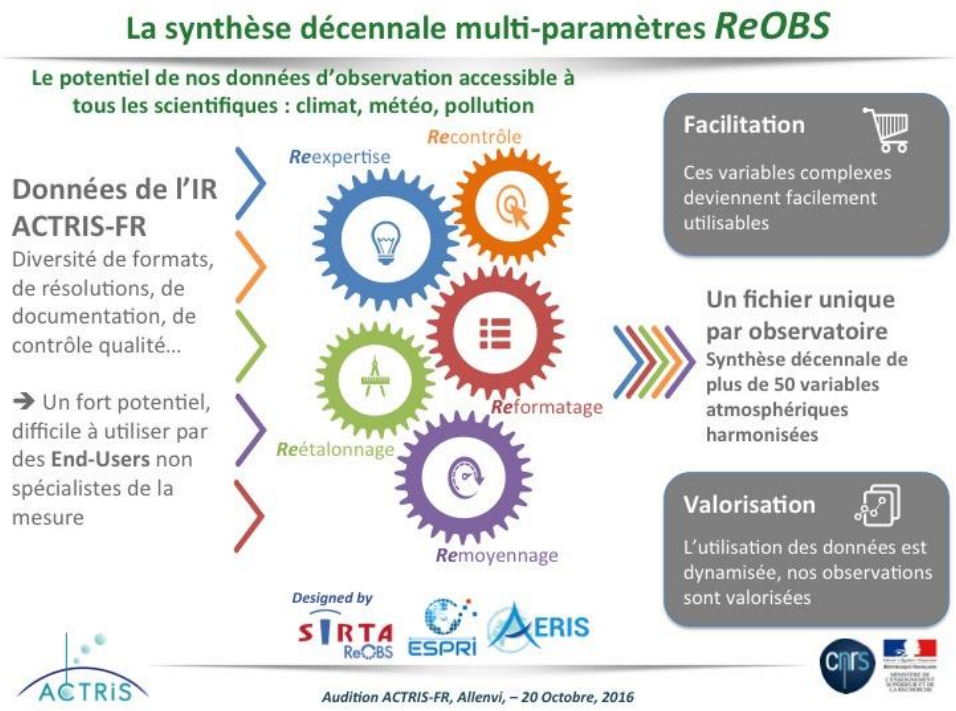

Figure 1: The ReOBS approach endorsed by ACTRIS-FR.

Expected deliverables

The goals defined for ReOBS project will result in the follow technical products:

- Production tool
- Production implementation on AERIS centers for data and services
- Production based on data from several atmospheric observatories
- Pre-requirement for input datasets to be processed
- Production of data to be included in different data communities
- Algorithm developments
- Technical documentation including user guide

Production tool. An easy to use code written in Python and bash, able to take in charge the complexities of create a multi sources file. This code is designed to ensure:

- Evolution (add/delete parametres)
- Maintenance (code partially generique, test/correction of traitements processes)
- Portability (easily implementation for production)
- Production optimisation (possibility of choice for traitement processes)
- Production monitoring
- To meet the requirements for the production of CDR to contribute to the supply of national and international projects (obs4mips, ACTRIS, …)

Production implementation on AERIS centers for data and services. Each center works with its own resources and ways of production. The simplicity in the design of the code that creates ReOBS and its modular aspect allows it to be implemented on centers specialized in data production. This implementation will allow mutualisation of expertise and production for national and international communities.

Data production from several atmospheric observatories. ReOBS file is currently created only based on SIRTA data, but the production tool is be able to create ReOBS files for observations from other sites

Pre-requirement for input datasets to be processed. A document that describes requirements that the datasets must have in order to be processed by the ReOBS production tool, this document specifies all the formats that can be handled and the necessary metadata that conforms to different standards.

Production of data to be included in different data projects. The ReOBS production tool will generate data that can be processed by other codes (ex : CMOR) in order to be able to participate in national and international observation data networks (ACTRIS, OBS4MIP).

Algorithmic development. Improvement in production of variables derived from observations and algorithms and research of innovation for optimization in quality controls.

Technical documentation. A user guide is developed and a set of documents that describes (1) the architecture of the code, (2) methods for keeping the maintenance and evolution, (3) choices of treatments and quality controls, (4) the creation of variables.

Progresses so far

The heritage of a complex and heterogeneous production system that used to create ReOBS files was the main reason for conceiving a new architecture (figure 2 and figure 3).

Some aspects in the development of the ReOBS production tool are already done:

- Conceptual framework
- Choice of code languages
- Creation of prototype processes
- Choice of variables
- Choice of filing architecture

We already started the work for production implementation on AERIS (or ACTRIS) centers for data and services by defining the metadata and the Pre-requirement for datasets to be treated. The metadata was directly modified in NetCDF on the final ReOBS file and in the new prototype processes. A document was created in order to establish the Pre-requirement of data and metadata to be treated.

The studies of actual quality controls have been done (based on both static and dynamic thresholds). Other techniques are under study such as FFT filter, rolling mean and median. These techniques are being testing by us in some variables seeking the improvement of our quality controls.

The production and evolution of ReOBS file is continuous, the ReOBS files are updated every 6 months and distributed online on a dedicated website http://sirta.ipsl.fr/reobs.html.

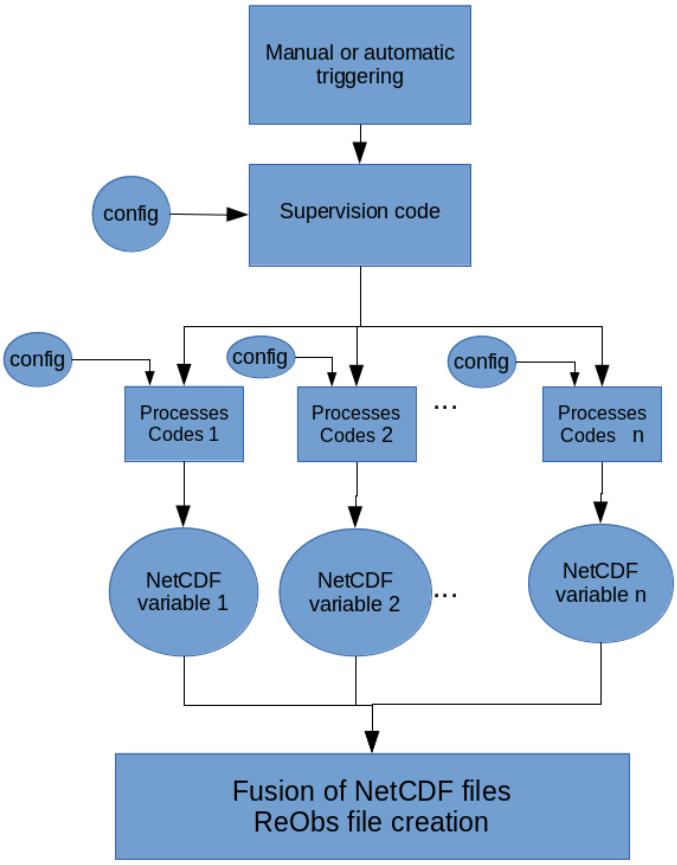

Figure 2: ReOBS processing chain

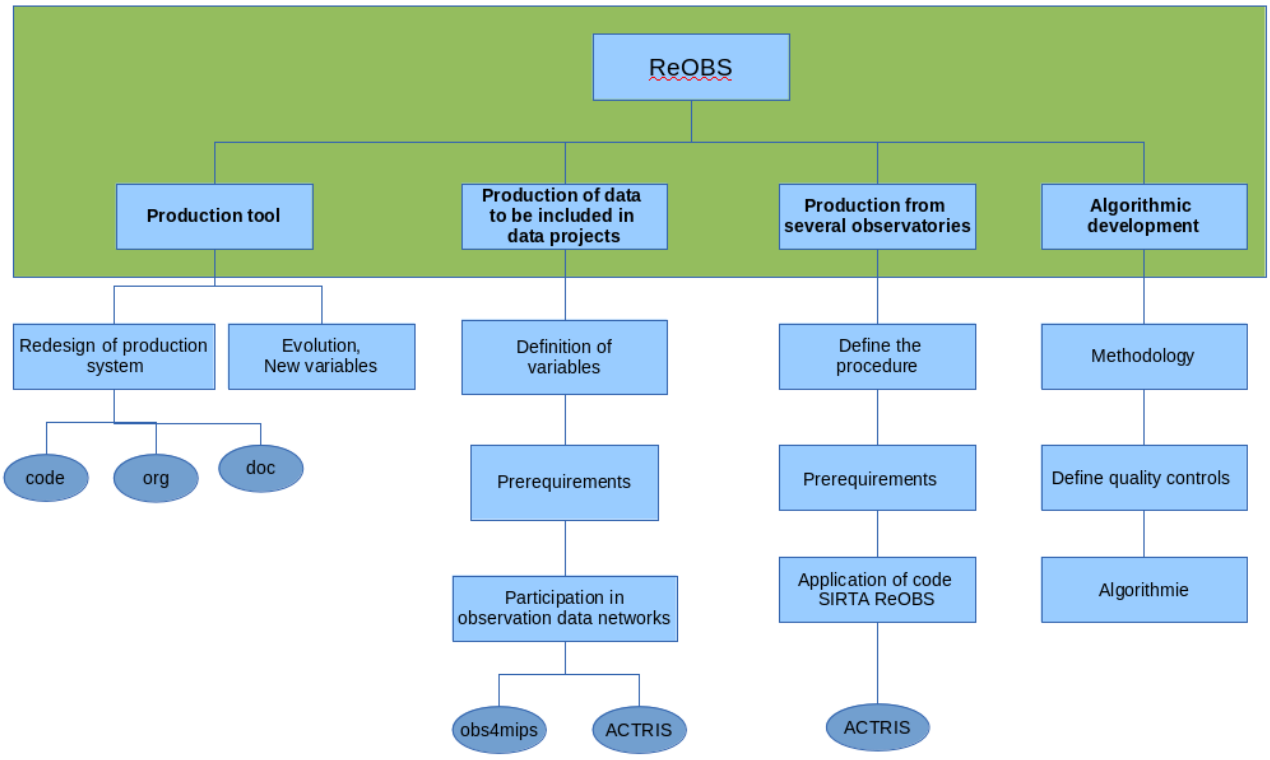

Figure 3: global view of ReOBS project

Table 1 shows the progress of the 7 sections of the work (number of months already done and future work).

	Done	Future work
Production tool	2 months	4 months
Production implementation on centers for data and services	1/2 month	2 months
Data production from several observatories	1/2 month	3 month
Pre-requirement for datasets to be treated	1 month	1 month
Production of data to be included in different data projects	1 month	3 month
Algorithmic development	1 month	2 months
Technical documentation	1 month	2 months

Table 1: progress by section: first column is what has been done, second column is for future work.

1. Envisaged activities, potential markets for companies

Next steps of the work are to continue and finalize the 7 sections, following the repartition indicated in Table 1. Emphasis will be placed on actions required for the application of the ReOBS approach to other sites than SIRTA. Implications of this work occurs at different levels:

- **ACTRIS-FR Research Infrastructure**: ACTRIS-FR RI federates the French research groups and instrumented supersites for the observation of atmospheric water, aerosols, and reactive gases. The ReOBS approach has been discussed in this group since the beginning. Currently, we work on applying ReOBS to other ACTRIS-FR sites.
- **DEPHY (LEFE) project**: ReOBS development and SIRTA-ReOBS using for model evaluation are part of one DEPHY work-package. Some model evaluations studies have been published already.
- **AERIS**: AERIS will be solicited to support the implementation of ReOBS in one of the AERIS center for the data production. Discussions with AERIS about implementation will be initiated in the first half of 2017.
- **ACTRIS**: The H2020 European project ACTRIS-2 gathers the European scientific community working on the ground-based observations of aerosols, clouds, and reactive gases. Discussions have started in ACTRIS-2 for applying ReOBS approach to European sites, taking advantage of the important amount of data with well-identified algorithms and quality approach.
- **ARM**: The ARM network is the United States equivalent of ACTRIS. Since the beginning, the ReOBS approach is inspired from the ARMBE development, and is partially the results of collaboration between Europe and United States concerning the observation of the atmosphere
- **CMIP6 and OBS4MIP**: IPSL is strongly involved in CMIP6 via IPSL model simulations, but also via contributions to observation databases developed specifically for comparisons to simulations, realized for the OBS4MIP project. Until now, OBS4MIP only contains data from

satellite measurements. One of our objectives is to add ReOBS datasets to OBS4MIP. It requires adaptations for matching OBS4MIP standards (CMOR format essentially).

Annex: Scientific publications and contribution to conferences and workshops, based on ReOBS

In preparation:

Chiriaco M., J. Bados, J.-C. Dupont, J. Lopez, M.-A. Drouin, M. Haeffelin, S. Bastin : SIRTA-ReOBS : a homogeneization work on the long-term multi-parameters of SIRTA supersite. *In prep.*

Chiriaco M., H. Chepfer, S. Bastin, M. Haeffelin : Which clouds have a cooling or a warming effect at SIRTA ? *In prep.*

Articles dans des revues de rang A à comité de lecture

Dione C., F. Lohou, M. Chiriaco, M. Lothon, S. Bastin, J.-L. Baray, P. Yiou, A. Colomb, 2016: Influence of synoptic circulations and local processes on temperature anomalies over three French observatories. *JAMC, in press.*

Bastin S., M. Chiriaco, P. Drobinski : Control of radiation and evaporation on temperature variability in a WRF/MED-CORDEX simulation, 2016: comparison with collocated long term ground based observations near Paris. *Clim. Dyn*., pp 1 – 19.

Haeffelin M., S. Crewell, A. J. Illingworth, G. Pappalardo, H. Russchenberg, M. Chiriaco, K. Ebell, R. J. Hogan, F. Madonna, 2016 : Parallel developments and formal collaborations between European atmospheric profiling observatories and US ARM research programs. *AMS Monograph*, 10.1175/AMSMONOGRAPHS-D-15-0045.1.

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Bastin S., M. Chiriaco, O. Bock, S. Somot, P. Drobinski, L. Li, 2014 : Evaluation of MED-CORDEX simulations using long-term ground-based multi-sensors observations and GPS data. *Gewex conference, La Hague.*

Chiriaco M., S. Bastin, P. Yiou, 2013 : Complementarity of CORDEX runs and ground-based observations to evaluate the contribution of large-scale circulation to temperature variability around Paris. *CORDEX Conference, Brussels, Belgium*.

Bastin S., J.-F. Rysman, M. Chiriaco, J. Delanoë, Y. Lemaître, 2013 : Evaluation of MED-CORDEX simulations using lon-term ground-based observations and A-Train satellite data. *CORDEX Conference*.

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Chiriaco M., J. C. Dupont, M. Haeffelin, L. Klenov, F. Cheruy, S. Bony : Synthèse de 10 ans d'observation de l'atmosphère au SIRTA : utilisation pour l'évaluation des modèles de climat dans le cadre d'EUCLIPSE ; *AMA 2011, session DEPHY*, Toulouse.

Workshops

M. Chiriaco, H. Chepfer, S. Bastin, M. Haeffelin, V. Noël : Quantifier et comprendre la contribution des nuages à la variabilité de la température au SIRTA. Journée SIRTA 2016, Palaiseau.

M. Chiriaco, H. Chepfer, S. Bastin, V. Noël, M. Reverdy, M. Chakroun, J.-C. Dupont, J. Badosa, J. Lopez, M. Haeffelin : Toward multi-decadal active sensor cloud observations using ground ans satellite-based measurements. ACTRIS science meeting, 2016.

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