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

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).

Results:

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 with the various approaches used to define tie-points (e.g. 14C, ash layers, 10Be, 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) 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. In this project, we realised the next step of adaptation of this powerful tool to different archives to insure their optimal synchronization, in connection with ice records.

Two important modifications have been implemented in the code: (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, 14C 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 [Lemieux-Dudon et al., 2015]. 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 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 is open source. 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/.

Then, Lucie Bazin concentrated during 6 months on the following tasks for delivering a multi-archives chronology over the last deglaciation in the Mediterranean basin: (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. For this step, several key sedimentary archives have been gathered (Figure 1) with absolute and relative dating constraints obtained by ^{14}C, U/Th, tephras and Ar/Ar. The preliminary results (Figure 2) suggest a reconsideration of the chronology of the Ohrid chronology and do not support the classical hypothesis of climatic synchronization over this period. After a presentation of the results at EGU, L. Bazin is now working on a publication showing the potential of multi-archives dating tool.

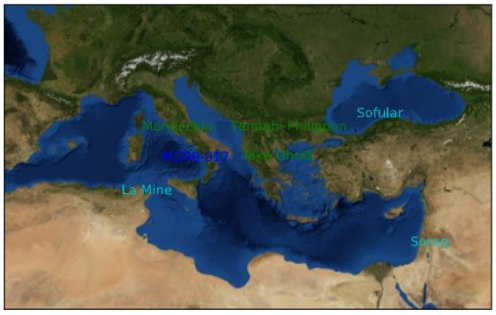

Figure 1: Location of sites

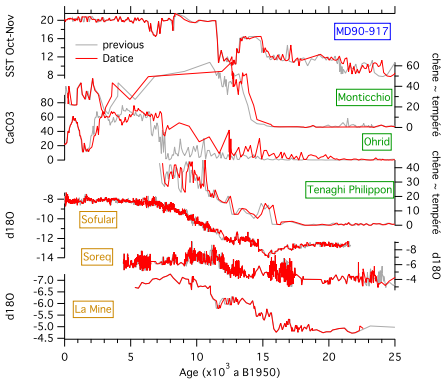

Figure 2: construction of a new chronology between archives in the Mediterranean basin using DATICE-multiarchives

References:

Lemieux-Dudon, B., Bazin, L., Landais, A., Toyé Mahamadou Kele, H., Guillevic, M., Kindler, P., Parrenin, F., and Martinerie, P.: Implementation of counted layers for coherent ice core chronology, Clim. Past, 11, 959-978, doi:10.5194/cp-11-959-2015, 2015.

Lucie Bazin, Amaelle Landais, Bénédicte Lemieux-Dudon, Giuseppe Siani, Elisabeth Michel, Nathalie Combourieu-Nebout, Dominique Blamart, and Dominique Genty, A multi-archive coherent chronology: from Greenland to the Mediterranean sea, EGU conference, Oral communication EGU2015-11850, Vienna, April 2015.

Bazin L., Lemieux-Dudon, B., Siani, G., Nebout, N., Michel, E., Landais, A., Vers une datation multi-archives : premières comparaisons entre carottes marines dans le bassin mediterranéen et carottes de glace groenlandaises, poste