Scientific report

1.1 Summary

During the Pliocene-Pleistocene (c.a the last ~5.0 Ma), the Earth's climate transitioned from a warm and relative stable state towards cold conditions marked by amplified glacial/interglacial cycles and widespread ice-sheets in the Northern Hemisphere, and in less extent over Antarctica. The warm Pliocene epoch is often cited as an analog for future climate prediction because of its striking resemblance with near future predictions (e.g., high sea level and atmospheric CO_2, and reduced ice-sheets). However, the causes and consequences of this global climate switch, driving warm periods to "icehouse" conditions marked by "Quaternary-style" glacial/interglacial cycles, are still uncertain. Yet, they may include the interaction of several mechanisms tied to oceanic and atmospheric circulations, tectonic, greenhouse gases, biological activity, and Earth's orbit changes.

The workshop on Pliocene climate organized in Bordeaux, 23-25th October 2009, was the first opportunity, after more than 10 years after the last meeting focusing on this topic, to bring together the main experts working on Pliocene climate, and to discuss the different theories explaining this major climate shift of the Earth's history. During 3 days, 63 participants from 11 countries (EU and non-EU) attended the meeting and animated 7 group discussions to make the state-of-the-art of Pliocene climate, to debate on the main causes/consequences of the major Pliocene climate switch, and to draw the new directions to follow for improving our knowledge about Plio-Pleistocene climate changes. The workshop was also an opportunity to present most new data that were presented/discussed during 33 talks, 2 keynote lectures, and 17 posters.

At the end of the meeting, all participants agreed that mechanisms controlling Plio-Pleistocene climate transition are still not well understood and need to be largely improved especially by increasing the existing dataset from (new) key areas (e.g., Indian Ocean, Western Pacific warm pool, Southern Ocean, North Pacific), by improving the resolution of all paleoceanographic records, and improving models and model resolution. Such crucial step will be of primary importance to better understand the factors that triggered the global climate cooling as well as to reconstruct more precisely the global conditions under a warmer-than-today state.

1.2 Description of the scientific content, discussions and perspectives

This workshop has been divided in two major parts: Three sessions dedicated to talks and posters, and three sessions for group discussions (see below and abstract book). In addition, two speakers, Ralf Tiedemann from AWI-Bremerhaven (Germany) and Alan Haywood from the University of Leeds (UK), were choosen by the workshop organizers for their excellent expertise and experience on Pliocene climate studies (data and model) to present 2 keynote lectures summarizing their current work.

• The 33 talks presented during the workshop were classified in different categories as follow (see also abstract book, *http://www.plioclimworkshop.com/*):

- Oceanic Gateways (the closure of Panama and the restriction of Indonesia)
- Changes in Plio-Pleistocene atmospheric CO_2
- Changes in North Atlantic circulation and Impact of Mediterranean Outflow Water
- High latitude oceans (North Pacific and Southern Ocean)
- Tropical/subtropical Pacific conditions
- Modeling the Pliocene climate

• 17 posters mainly presented by early carreer scientists covered all topics related to Pliocene climate (data and model) and the Plio-Pleistocene transition (see abstract book at: *http://www.plioclimworkshop.com/*).

• 7 group discussions were also organized during the workshop and managed by chairs having an excellent expertise on the related topic.

Summary of the group discussions:

Group #1: The narrowing of the Indonesian Gateway

Chairs: Cyrus Karas, Dirk Nürnberg, and Martin Medina-Elizalde

This group mainly discussed the evolution of the Indonesian Seaway across the Plio-Pleistocene and its impact on the global thermohaline circulation. The group especially focused on the causes/consequences of the subsurface cooling occurring in the Indonesian Througflow (ITF) between 3.5 and 3.0 Ma ago, as recently revealed by new studies. Was the steady subsurface cooling of the ITF from 3.5 to 3.0 Ma a response to changing in the mode water that may have affected the thermocline structure, and consequently the subsurface waters? Or does it come from the closure of the Indonesian gateway itself?

According to recent results, subsurface cooling was also detected in the Western Equatorial Pacific warm pool (WEPWP). Was there a change in the properties of the source waters? Preliminary results based on model simulation (Uta Krebs-Kanzow, poster) suggest that subsurface waters cool when the Indonesian Seaway is closed. This also corresponded to a distinct precipitation signal with drier (than today) conditions in the eastern Indian Ocean, India, Australia after the closing. However reconstruction of the water masses and their properties are still unknown. We still do not know whether North Pacific Intermediate Waters or Subantarctic Mode Waters changed (temperature, salinity, oxygen concentration, ...), or if the source water itself changed across the Plio-Pleistocene (Antarctic Intermediate Waters instead of Subantarctic Mode Waters?). Could another tracer be used to complete existing records? Usefull proxies to trace the origin of water masses flowing through the Indonesia Seaway during the Pliocene-Pleistocene are absolutely needed to confirm whether North Pacific waters may have progressively replaced the Subantarctic ones as the dominant water masses crossing Indonesia. And if yes, how varied such water masses across the time.

To answer these questions, more sites at key locations are needed, especially records from the west Pacific and mode water formation sites in the northern and southern oceans by using tracer of water masses (e.g., Nd in planktonic foraminifera). Also, higher resolution data to resolve climatic cycles would be usefull. Within future work, the extent of the WEPWP should be further investigated, only one IODP Site being currently available (Site 806), as well as the properties of the source waters from the north and south Pacific.

Group #2: The closure of the Panama Seaway

Chairs: Jeroen Groeneveld and Petra Dekens

As for the Indonesian Gateway, the closure of Panama and its major role on the global reorganization of the oceanic circulation during the Plio-Pleistocene is still unclear despite recent works suggesting that this tectonic event only had a minor impact on Pliocene climate and the global cooling. The reasons of such uncertainties mainly lie on the fact that we still do not know if opening and closing of seaways was only tectonically driven and/or also controlled by sea level changes. Besides, it is still questionable in what extent these changes can be important enough to affect the thermohaline circulation and how big (in term of current intensity) does the throughflow have to be for affecting it.

These questions also rose because of a lack of data connecting terrestrial records, outcroups and marine archives to reconstruct the detailed tectonic history of the closing as well as changes of the geometry of the gateway. According to models and data, temperatures in the North Atlantic warmed when Panama closed which should lead to strenghtened the thermohaline circulation. Should that lead to cool Northern Hemisphere enough and participated to ice-sheets increase? Are there good proxies for recording changes in the strength of meridional overturning circulation due, or not, to the closure of Panama? Do density reconstructions have enough precision for doing this? Probably not. Moreover, the response of hydrological changes to the closure of Panama was unlikely linear since Panama did not close in once but instead steplike. Another question discussed in this group was to unravel how to isolate the different tectonic events occurring during the Pliocene and their respective impacts. Did changes in Panama and Indonesia Seaways contributed together to shift global climate?

To answer these questions, models that include (new) proxies (e.g. Nd on plankotnic foraminifera) would be helpful. Besides, there is a lot of data available already that should be further explored, especially by modelers. Several intervals of high resolution data within a longer term record would also be needed such as the 4.1-4.8 Ma interval, including Cochiti magnetic event, the PRISM interval and between isotopic stages G10-17. Future perspectives also lie on improvement of modeling work and the comparison of results from different regional and global models.

Group #3: Changes in atmospheric CO_2 during the Plio-Pleistocene

Chairs: Mark Pagani and Gretta Bartoli

The aim of this group was mainly to focus on atmospheric CO_2 changes over the last 5.0 Ma, which remain a crucial point to address for better understanding Pliocene climate conditions. How high the CO_2 could have been during the warmest time? There is a number of uncertainties in the three current existing methods (boron isotopes, alkenones epsilon-p, and stomatal indices) but they all point out to 400 +/- 50 ppm for the Early Pliocene and the Mid-Pliocene warm period and then a decrease across the Plio-Pleistocene climate transition. The mechanism lowering the CO_2 from the Pliocene to the Pleistocene can be inferred from the shape of the CO_2 curve: gradual versus step-like. If the record shows a gradual decrease, changes in the carbon cycle, weathering intensity, …, could be invoked. If the curve shows a step-like pattern, threshold in tectonic events, in ocean circulation changes, could be invoked. Also the “alkalinity hypothesis” has to be fully considered where the CO_2 is changing along with changes in the sea level, changing the alkalinity of the ocean by transferring carbon from the coastal shelf to the ocean. However, we do not have realistic sea-level records of the Pliocene Epoch. For instance, if the sea level is lowered by 25 m, where is the water going?

CO_2 records based on different methods also show some large differences as for the Miocene Epoch for instance. This may be explained by the lack of good marine records or problems due calibrations (e.g. stomatal indices). To be able to answer the question of Glacial-Interglacial variability over time and to be able to have a high-resolution CO_2 records over time, boron isotopes would be the best solution at this time. However, a discrepancy still exists between the method developed in Bristol and the method developed in Lamont, that has to be solved at some point. From a time perspective, the MC-ICP-MS method seems to be much faster. We also need to look at low-latitude SST records (from the equatorial Pacific, for instance) and constrain by reverse modeling what the level of CO_2 might have been. In this context, there is a need for more temperature records over the globe to be compared with CO_2 levels.

Group #4: Biogeochemical cycles

Chairs: Ros Rickaby & Samuel Jaccard

The group was tasked with discussing the possible changes in biogeochemical cycles during the transition from the Pliocene and Pleistocene time.

First, the group tried to outline the documented changes in the distribution or productivity by different phytoplankton groups. There appears to be concensus that the dominant locus of diatom deposition moved sharply from the high subarctic Pacific to the lower latitudes and upwelling zones approximately coincident with the onset of northern hemisphere glaciation, based on opal accumulation rates. From a coccolithophore perspective, we heard Clara Bolton’s talk on changing coccolithophore productivity during obliquity cycles of the Pliocene, but for longer term changes there emerged a view that there was a considerable increase in whole ocean productivity of bloom producers between 2.95-2.1 Myrs. Since export production of carbon is believed to be more efficient when phytoplankton blooms occur, this long period could be associated with enhanced efficiency in the export of organic carbon (i.e., the biological pump) from the surface to be sequestered in the deep ocean (as would be evidenced by lower deep ocean O_2, and lighter $\delta^{13}C$), or buried in deep sediments, and could play a role in the longer term evolution of CO_2 to lower levels.

Such a change in export productivity and bloom producers could be caused by a whole ocean change in the budget of a limiting nutrient (N, P or Fe) or in the supply of those nutrients to the surface ocean. Certainly a change in the phosphate budget might arise with a lowered sealevel giving rise to exposed shelf matter which could provide a ready additional supply of phosphate via weathering to the ocean. But for the larger part, P is not thought to be the major limiting nutrient for diatoms. P. Martinez showed a compilation of $\delta^{15}N$ records for the Plio-Pleistocene transition, all of which were characterised by a trend towards more positive values indicative of greater availability of nitrate in the past but it was necessary to consider whether the Redfield ratio of the ocean can vary on these million year timescales. Higher $\delta^{15}N$ values generally indicate higher denitrification/nitrogen fixation ratio. It was generally thought that iron limitation would have been more pervasive during the Pliocene. The continents are largely wetter and the weaker winds of the Hadley circulation and trade winds would have transported less iron to the surface waters as dust.

Reorganisation of nutrients within the ocean could have also played a role in driving productivity changes. Associated with the weaker trade winds of the ocean, upwelling is deemed to have been much weaker during Pliocene times with the modern upwelling zones being established sometime after the major growth of the northern hemisphere ice sheets. However, A.C. Ravelo presented intriguing data from a thermocline dwelling species that as the low latitude thermocline cooled, it also moved to a lower nutrient regime. The Pliocene thermocline was therefore ventilated by a source of nutrient rich waters. It is hard to predict how greater nutrient concentrations at depth but slower rates of supply of those waters to the surface would have influenced the net Pliocene export productivity. Nonetheless, it is interesting to suggest that perhaps the expansion of the low latitude warm pools and subtropics would require the source of mode waters which ventilate the thermocline to migrate to higher nutrient rich latitudes than the modern ocean. This would be consistent with the larger changes in temperatures recorded by the deeper dwelling forams than those at the surface and with the greater nutrient content. So perhaps the enhanced productivity between ~3-2Myrs could have been fuelled by these higher latitude mode waters providing a conduit of nutrient rich waters to the lower latitudes, and when upwelling intensifies, there is the added bonus of a rich supply of nutrients to the low latitude surface. As CO_2 diminishes (in line with enhanced sequestration of organic matter at depth or in sediments) and global cooling takes place, amplified at the high latitudes, then the source of the mode waters migrates to lower latitudes and more nutrient depleted sites.

In the future, it was agreed that it would be helpful to obtain better constraints on the nutrient budgets of the Pliocene ocean. More work on $\delta^{15}N$ records from key denitrification sites such as the Arabian Sea would be a major step forward. And the P/Ca of a Pliocene deep sea coral would provide a good constraint on deep ocean P. The use of Cd/Ca in deeper dwelling planktonic foraminifera could be interesting to constrain thermocline nutrients, and we explored whether benthic Cd/Ca could be useful within the uncertainty of the Cd budget of the Pliocene ocean. Furthermore, investigating predicted changes in the sediments from the hypothesis of increased deep ocean sequestration of carbon would be useful and how well are C isotopes constrained for this period in terms of whole ocean changes versus ventilation changes. A highly resolved record of the CCD in different ocean basins coupled with B/Ca or similar constraints of deep ocean CO_3^{2-} would provide an important constraint on the partitioning of carbon between the atmosphere and the ocean across the critical climatic transition.

Group #5: Sea surface temperature changes and atmospheric circulation reorganization over the last 4.0 Ma

Chairs: Erin McClymont & Jonathan LaRiviere

The group made first an inventory of our knowledge about sea surface temperatures (SST) gradients, commonly used for understanding transfer of heat between high- and low-latitudes and reconstructing atmospheric patterns.

Over the last 4.0 Ma, changes in meridional gradients are gradual and heterogenous, probably reflecting regional signatures. While the meridional gradient between the California margin and the Eastern Equatorial Pacific and across the Benguela changed around 2.1-2.2 Ma ago, West Central North Pacific is reduced until 2.7 Ma. Along the California margin, the gradient is greatly enhanced during the warm Pliocene. Overall, the gradients gradually changed between 4.0 and 2.0 Ma but the timing of these changes remains unclear. Between 3.0 and 2.0 Ma ago, there are two outliers from global cooling trend that can reflect a signature of global change but also a regional signal. However, modeling simulations targeting critical areas are still missing. Besides, both zonal and meridional gradients are related to not clearly understood events. For instance, we do not know the timing of the Panama closure and its impact on global heat transfer. Also, what is the definition of the warm Pliocene and can we define a warm early Pliocene time slice? PRISM time slice (ca 3.3-3.0 Ma) is not the warmest part of the Pliocene. Perhaps, the warm Pliocene is not an especially unique time. Therefore, we could wonder if the warm period started earlier, and when? Is it a misconception to refer to the warm Pliocene instead of the Early Pliocene?

Another point discussed in this group was related to the use of proxies for reconstructing SSTs. Alkenones, TEX86 and Mg/Ca are usually applied for reconstructing Plio-Pleistocene SSTs. However, there are still uncertainties related to calibration proxies and other non-temperature effects (e.g light limitation, nutrient stress, element contents variations (Mg and Ca)). Therefore, there is a need to present an “enveloppe of acceptability” with proxy data. Also, inter-laboratory standards could be widely used.

To answer these questions, there is a need to increase the number of records using as much as possible different proxies for reconstructing SSTs in every oceanic areas. There is also a need to develop new proxies and to better understand the relationship between high and low latitude forcing as well as deep water circulation, especially in the Pacific, by reconstructing deep sea temperature.

Group #6: Near future drilling targets

Chairs: Ralf Tiedemann & Christina Ravelo

The group was in charge to collect propositions from participants for defining near future drilling targets that are needed for improving our knowledge about Pliocene climate. This session has been organized to strongly encourage participants to submit drilling proposals in the near future.

After discussions, it is clear that data spanning Pliocene are missing almost everywhere. This is not only due to a lack of laboratory work, but also and mainly because of the absence of well situated marine records covering the last 5.0 Ma in critical oceanic areas. The best example is probably the WEPWP. Only one IODP site, Site 806, exists for monitoring Pliocene changes of the largest ocean warm pool despite its importance for understanding tropical/subtropical conditions and climate changes. We all agreed that this has to be largely improved and future expeditions should be led within and around the warm pool to reconstruct variations and structure of the latter, but it can also be used to scrutinize the impact of the Indonesian Gateways by comparing with future records from Eastern Equatorial Indian Ocean. Overall, changes in precipitation and wind strength related to ITCZ and monsoon system in the tropics and subtropics remains poorly known. In addition to WEPWP and Indian Ocean drillings, we considered that South Asian and African margins has to be further explored, especially in key areas where seasonnal monsoon is the most influential:

Bengal fan sediments, South China Sea, Congo and Nigeria basins, Western tropical African coasts, and from Somali to Mozambic margins (e.g., off Zambezi River). Marine archive from East Africa could moreover allow us to better understand the links between hominid evolution and African climate.

Not only low-latitudes records are missing but high resolution records from high-latitudes too, especially in the polar oceans. During the warm Pliocene, ice-sheets were absent or strongly reduced in the Northern high latitudes. However, we still do not know in what extent. Future drilling targets should therefore focus on the Central Arctic Ocean, Beaufort and Laptev Seas, closer to the continent, in order to monitor variations of ice-sheets and sea ice changes during the Plio-Pleistocene cooling. Besides, given the importance of oceanic gateways in thermohaline circulation, expeditions north of Bering Strait (e.g. Chukchi Sea) and northeast of Greenland are also needed. To face Arctic Ocean records and to better understand the role played by both polar oceans in Pliocene cooling, future expeditions, completing the existing ones in the Atlantic Southern Ocean and soon in Wilkes Land, should be led in the Pacific and Indian parts of the Southern Ocean, particularly around and within the polar front system. Indeed, it has been hypothesized that the frontal system in the Southern Ocean, where deep waters form, was radically different than today, however well preserved marine archives from this region are still too rare and future expeditions in the Southern Ocean should be fully considered in this context.

Group #7: Pliocene modelling outlook

Chair: Daniel Lunt, Alan Haywood, & Bette Otto-Bliesner

The group discussed 5 main issues as avenues for future work in the field of Pliocene modelling: The ‘PRISM interval’, or ‘mid-Pliocene warm period’, ~3-3.3 Ma, has been the almost exclusive focus of Pliocene modelling efforts in the last decade. It is also the time period we know the most about in terms of data, thanks largely to the efforts of the USGS. However, there is nothing particularly ‘special’ about this time interval, and it was felt we could learn a lot about the system by broadening this focus to include a more general coverage of the Pliocene, both in terms of modelling and data synthesis. To be of greatest use to the modelling community, databases of key variables such as SST, would be produced for several key time intervals, and made available online for general use. These could be ‘living’, in that various groups could contribute data as it was produced. This would require some level of organisation/coordination in the data community.

Until recently, much Pliocene modelling was carried out with models which were truly ‘state-of-the-art’, and were essentially the same models used in the IPCC to predict future climate change. However, the models are moving on, and in particular many models used in the IPCC have significantly higher resolution than the models typically used in palaeoclimate research. In order to ensure that our Pliocene modelling is as realistic as possible, and to maintain relevance to the future climate debate, it is important that the modellers aim to use the most up-to-date models. The problem with this is that these recent models are more computationally expensive, and so only a limited number (or no) sensitivity studies can be carried out.

There is a move in climate modelling towards ensembles of simulations in which a number of internal model parameters are perturbed. Carrying out many simulations in this way allows the sensitivity of the model to be investigated, and can lead to formal statistical measurements of uncertainty in model predictions. These measures of uncertainty can also be used to assess the ability of the model to predict future climate change.

Paleoclimate proxies do not in general directly measure meterological variables such as temperature and precipitation, but variables that are not routinely predicted by climate models such as $\delta^{18}O$, $\delta^{13}C$, or pollen assemblages. As such, the proxies are calibrated using methods which usually involve assumptions that certain correlations are stationary in time and space. This is not always the case. Recently, there has been a push to include a direct representation of key tracers and proxies into climate models. These models should be applied to the Pliocene, to allow a more robust model-data comparison, and interpretation of proxy records.

At present, the inability of models to reproduce the very warm Atlantic-sector Arctic temperatures as recorded in the PRISM SST dataset are probably the single greatest Pliocene model-data mismatch. The lack of agreement in this region casts doubt on the relevance of models for the Pliocene, and as such needs to be addressed urgently. Possible lines of inquiry are: depth of Atlantic sills (did lower Pliocene sills lead to greater northward heat transport?), role of orbital forcing (are the warm temperatures only associated with maximum orbital forcing?), role of West Antarctica in determining thermohaline circulation (did the reduced ice sheet shift deep convection sites?), role of Greenland ice sheet (did the reduced ice sheet lead to further North Atlantic warming?), role of CCN (did the pristine atmosphere of the Pliocene lead to cloud modifications compared to the modern, a process not yet included in most models?)

Almost all Pliocene modelling to date has been ‘snapshots’, in that only a single time slice is simulated. Of course, many key processes in the Earth System are dependent on the time-varying nature of the forcings/feedbacks (e.g. orbitak response, ice sheet evolution). As such, it is important that models begin to address the transient behaviour of the system. This is likely to be in the framework of ‘Intermediate Complexity’ models. An ultimate goal would be a model simulation of the last 5 million years, with comparison with records such as the Lisiecki and Raymo stack.

Recent reconstructions of Pliocene pCO_2 are beginning to show fascinating structure which is a huge challenge to interpret and understand. This understanding can be aided with the incorporation of carbon cycle components into models. The changes in pCO_2 through the Pliocene are ultimately driven by tectonic and/or orbital forcing. The ‘Pliocene Grand Challenge’ is the development of an Earth system model which is driven only by these processes. Given that we do not even understand Quaternary CO_2 changes, this grand challenge is currently a way off being achieved, but provides the ultimate test of our understanding of the Earth system.

1.3 Supplementary results and impact of the event on the future directions of the field

After fruitfull discussions, all participants agreed that a workshop on Pliocene climate should start to be a regular event (every 3 years). This will improve interactions between the different groups from data and model expertise working on that topic. Following the Bordeaux meeting, two short articles related to the workshop will be published in two different journals: ***Scientific Drilling Journal*** (IODP) and ***EOS Transactions, American Geophysical Union***. Besides, a special issue on Pliocene climate that will be edited by A. Haywood, A.C. Ravelo and H. Dowsett, is currently proposed in a top-level journal with the collaboration of most of the participants at this workshop. At this day, around 17 articles have been proposed. The workshop has also strongly stimulated some participants to prepare/submit proposals for futur IODP expeditions.

1.4 Finale programme of the meeting

Friday 23.10.09

Morning

8:50-9:00	**Opening Words – J. Etourneau**
9:00-9:20	**M. Sarnthein**: The "Panama Hypothesis" on the Onset of Quaternary-Style Climates — a Resumé
9:20-9:40	**J. Groeneveld:** Marine Isotope Stages (MIS) 96-101: The glacial induced closure of the Panamanian Gateway
9:40-10:00	**C. Karas:** Simulated climate response to the tectonic displacement of New Guinea during the Mid-Pliocene
10:00-10:20	**A. Csank:** Tales from ancient forests: multi-proxy reconstructions of Pliocene Arctic climate using tree-rings, tree-ring isotopes, moss and molluscs
10:20-10:40	**Coffee Break**
10:40-11:00	**M. Medina-Elizalde:** Tropical Pacific thermal evolution, the 100 ky cycles, and the role of greenhouse gases during the late Pliocene glaciations
11:00-11:20	**W. Kürschner:** Pliocene palaeo-atmospheric CO_2 proxy records, a comparison of marine and terrestrial proxies
11:20-11:40	**G. Bartoli**: Pliocene atmospheric CO_2 changes
11:40-12:00	**M. Pagani:** High climate sensitivity to atmospheric CO_2 for the past 5 million years
12:00-13:00	**Posters**

Lunch

Afternoon

14:00-14:20	**N. Khélifi:** Potential links between changes in Mediterranean Outflow Water and North Atlantic Deep Water formation, 3.6 – 2.6 Ma ago
14:20-14:40	**B. Risebrobakken**: Latitudinal temperature gradients during the Pliocene warm phase
14:40-15:00	**S. De Schepper:** North Atlantic Current variability through Marine Isotope Stage MIS M2 (ca. 3.3 Ma)
15:00-15:20	**D. Naafs:** Pliocene climate and Northern Hemisphere Glaciation as seen from the North Atlantic
15:20-15:40	**P. Sexton:** A persistent "glacial-like" Atlantic overturning circulation regime during the intensification of Northern Hemisphere Glaciation
15:40-16:00	**Coffee Break**
16:00-17:30	**Panel discussions: The Narrowing of the Indonesian Gateway/ The Closure of the Panama Seaway/ Changes in Atmospheric CO_2 during the Plio-Pleistocene**
17:30-18:00	**Reporting of panels**
18:30-19:00	**Keynote Lecture – R. Tiedemann:** Tropical Pacific climate change during the Pliocene – causes and consequences
19:00	**End**

Saturday 24.10.09

Morning

9:00-9:20	**J. LaRivière**: Pliocene Sea Surface Temperature Records from the mid-Latitude North Pacific
9:20-9:40	**S. Jaccard:** Subarctic Pacific evidence for enhanced abyssal sequestration of respired carbon at the onset of Northern Hemisphere Glaciation, 2.7 Ma.
9:40-10:00	**A. Martinez-Garcia:** Plio-Pleistocene evolution of Subantarctic Atlantic temperatures: Implications for the dynamics of the Antarctic ice-sheet
10:00-10:20	**M. Williams:** A high fidelity molluscan climate record of the Weddell Sea for a warm interval of the Early Pliocene
10:20-10:40	**Coffee Break**
10:40-11:00	**M. Robinson:** Global ocean thermal structure during the mid-Pliocene: Data indicate increased northern component deepwater production
11:00-11:20	**N. Scroxton**: Characterising the Pliocene Equatorial Warm Pool from Individual Foraminifera
11:20-11:40	**J. Sliko:** Pliocene corals, rainfall, and El Niño teleconnections
11:40-12:00	**K. Sniderman:** The nature and evolution of Pliocene vegetation and climates in southern Australia
12:20-13:00	**Posters**

Lunch

Afternoon

14:00-14:20	**Z. Liu:** Plio-Pleistocene SST Changes in Warm Pool Regions
14:20-14:40	**C. Bolton:** Evolution of nutricline dynamics in the equatorial Pacific during the late Pliocene
14:40-15:00	**J. Etourneau**: Reconstruction of both Walker and Hadley circulations during the Plio-Pleistocene climate transition
15:00-15:20	**C. Ravelo:** El Padre in the Pliocene: What lies beneath?
15:20-15:40	**A. Fedorov:** Expansion of the Tropical Warm Pool, Permanent El Niño conditions, and Climate Feedbacks in the Early Pliocene
15:40-16:00	**Coffee Break**
16:00-17:30	**Panel discussions: Sea Surface Temperature Changes and Atmospheric Circulation Reorganization/ Biogeochemical Cycles**
17:30-18:00	**Reporting of panels**
18:30-19:00	**Keynote Lecture – A. Haywood:** Progress, Uncertainties and Opportunities in Reconstructing & Modelling Mid-Pliocene Climate/Environments
19:00	**End**

Sunday 25.10.09

Morning

9:00-9:20	**A. Jost:** High resolution climate and vegetation simulations of the mid-Pliocene, a model-data comparison over western Europe and the Mediterranean region
9:20-9:40	**U. Salzmann:** A New BIOME4-based Data/Model Hybrid Vegetation Reconstruction for the Middle Pliocene (Piacenzian Stage)
9:40-10:00	**S. Bonham:** HadCM3 Simulations of ENSO behaviour during the Mid-Pliocene Warm Period
10:00-10:20	**D. Hill:** Modelling Pliocene East Antarctica: reconciling ice sheet retreat and evidence for stability
10:20-10:40	**D. Lunt:** An estimate of Earth System Sensitivity from the Pliocene
10:40-11:00	**Coffee Break**
11:00-12:30	**Panel discussions: Pliocene Modelling Outlook / Near Future Drilling Targets**
12:30-13:00	**Reporting of panels**
13:00-13:10	**Ending Words – N. Khélifi**

Lunch

Afternoon

14:30-18:30	**Excursion: “Wine and Terroir”**
19:00	**End**