Position Description

1. General Information

Name of the position	**Millennial-to-orbital-scale climate changes over the past 2 Ma reconstructed from natural archives**
Foreseen date of enrolment	1 October 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • Université Grenoble Alpes (UGA) • University of Tasmania (UTAS)
Research Host	Université Grenoble Alpes
PhD awarding institutions	Université Grenoble Alpes & University of Tasmania
Locations	Primary: Grenoble, France Secondary: Hobart, Australia
Supervisors	Emilie Capron (UGA), Frédéric Parrenin (UGA), Joel Pedro (AAD), Taryn Noble (UTAS), Andy Menking (UTAS)
Group of discipline	Paleoclimatology, glaciology

2. Research topics (only one of these projects will be funded)

Project 1: *Climate and carbon cycle interactions across the Mid-Pleistocene Transition*

The climate across the Quaternary (the last 2.58 million years), is punctuated by warm periods known as interglacials, characterized by reduced ice cover on Northern Hemisphere continents, and they alternate with cold periods, referred to as glacial periods characterized by large ice caps in the Northern Hemisphere. The cyclicity associated with this succession of glacial-interglacial periods changed between 1.2 Ma and 800 thousand of years (ka) ago, from ~41 to 100 ka. This major change in the climate system is referred to as the Middle Pleistocene Transition (MPT) and the responsible processes are not fully understood yet. Amongst the existing hypotheses, it has been suggested that changes in the carbon cycle dynamics have played a triggering role.

The past 2 Ma are covered by natural climate archives (e.g. marine sediments, loess). Each archive has its own specific characteristics, providing a different view of past climates and information on different components of the Earth system (e.g. cryosphere, ocean, vegetation). In particular, indirect reconstructions of atmospheric CO_2 concentrations from marine sediments are available across the MPT however discrepancies between them currently exist. In addition, to interpret climate and atmospheric records and identify the sequence of changes in different parts of the world,

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precise dating of the natural archives is essential. However, it is challenging to achieve that far back in time and it results that most climatic records are attached to large dating uncertainties of several millennia. The current lack of global-scale data compilation relying on a coherent temporal framework over the past 2 Ma as well as uncertainties attached to atmospheric CO_2 reconstructions prevent a refined investigation of the regional temporal structure of the climate and environmental changes across the MPT and of their link to changes in carbon cycle dynamics.

In this context, the PhD project aims first at constructing a global-scale compilation of climate data from natural archives covering the past 2 Ma. Parameters of interest are surface and sub-surface ocean temperature, ice volume and key markers of ocean circulation, hydrological cycle, ice sheet history and ocean biogeochemistry.

In order to achieve this work, an important task will be to produce a common and robust chronology between the selected paleoclimatic and paleoenvironmental records. For that purpose, a probabilistic dating model will be used. This tool enables to date jointly numerous climate records from different types of natural archives, accounting for various types of chronological constraints and providing also quantitative estimates of the uncertainties attached to the produced age scales. The other aim of this project will be to provide a compilation and assessment of existing CO_2 reconstructions across the MPT, including data obtained from ice cores from blue ice area as well as boron-isotope based proxy-CO_2 reconstructions from marine sediment cores and CO_2 reconstructions from other proxy archives.

The new results will provide the first global-scale spatio-temporal picture of climate, ice sheet and environmental variations across the MPT and will contribute in better understanding the forcing processes for this key climatic transition, and especially the role of changes in the carbon cycle.

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Research Fields: Paleoclimatology, natural climate archives, chronologies.

Project 2: *Global and regional climate & drivers at millennial-to orbital scale during a past warm period (Marine Isotopic Stage 11)*

The warm periods (referred to as interglacials) of the last 500,000 years are relevant in the context of the current and future global climate change since they are characterized by a warming amplitude in Antarctica, comparable to that simulated for the end of the century. They represent natural laboratory to study processes within the Earth system and to understand the impact of a warm climate on its vulnerable components. In particular, the interglacial referred to as Marine Isotopic Stage 11 (hereafter noted MIS 11) that occurred about 410 thousand of years ago is one of the most prominent past interglacials during which global sea level was 9-13 m higher than today. Thus, MIS 11 is a unique period of climate to investigate the impact of climate warming on the polar ice sheets and ocean circulation. Numerous paleoclimatic records from different natural archives (e.g. polar ice cores, marine sediments and cave speleothems) cover this period. Each archive has its own specific characteristics, providing a different view of past climates and information on different components of the Earth system (e.g. cryosphere, ocean, vegetation). To interpret these climate records and identify the sequence of changes in different parts of the world, precise dating of the natural archives is essential. However, it is challenging to achieve that far back in time and it results that most climatic records are attached to large dating uncertainties of several millennia. The current lack of global-scale data compilation relying on a robust temporal framework across MIS 11 prevents a refined characterisation on the sequence of climate changes in different parts of the world. It also hinders the identification of the climate mechanisms and feedbacks during this period.

In this context, the PhD project aims at constructing a global-scale compilation of climatic data (e.g. sea and air surface temperatures, oceanic circulation intensity, sea level, hydrological cycle) from ice cores, marine sediment cores and

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speleothems covering MIS 11 to provide the spatio-temporal picture of climate variations across this past warm time interval and to progress on our understanding of the forcing processes.

In order to achieve this, an important task will be to produce a common and robust chronology between the selected paleoclimatic and paleoenvironmental records. For that purpose, a probabilistic dating model will be used. This tool enables to date jointly numerous climate records from different types of natural archives, accounting for various types of chronological constraints and providing also quantitative estimates of the uncertainties attached to the produced age scales. This dating effort will be essential to characterize eventually the amplitude of the climate warming during Marine Isotopic Stage 11, its spatial and temporal evolution, and more broadly, the sequences of events between climate, ocean circulation and polar ice sheets in a past warm world.

Also, the new results will be used to evaluate existing and up-coming Earth System Model simulations run across MIS 11 in order to identify with those physics-based tools the climate forcing and feedbacks at play during this interglacial. Overall, these results will provide (i) a better understanding of the impacts of a warm climate on the vulnerable components of the Earth system and (ii) testbeds for evaluating how well Earth System Models simulate warm climates, contributing in improving future climate projections.

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Research Fields: Paleoclimatology, natural climate archives, chronologies, earth system modeling

Project 3: *Optimal dating of Antarctic deep ice cores & millennial-scale regional climatic changes over the last glacial-interglacial cycle*

The last glacial-interglacial cycle (past 120 000 years) is one of the most studied periods in paleoclimatology due to its high coverage by natural climate archives (e.g. polar ice cores, marine sediments and cave speleothems). Also, it provides unique insights into several windows of past climate changes that are relevant to study in the context of our warming planet. For instance, multiple centennial-to-millennial scale warming events have been identified in Greenland and Antarctic ice cores during the glacial period. In addition, the last deglaciation was associated with a 4°C global warming and global sea level rise up to about 120 m that included several periods of abrupt regional temperature and global sea level change. Hence, these time periods represent great testbeds to look into the interactions between climate, the carbon cycle and the polar ice sheet evolution.

In this context, deep Antarctic ice cores provide reference records since they enclose various chemical parameters that can be linked to different parts of the Earth System and they record global atmospheric composition changes in the trapped air. To interpret these climate records and identify the sequence of changes in different parts of the world, a precise dating of both the ice phase and the gas phase is essential. Back in 2013, a common temporal framework (named AICC 2012) was built between four Antarctic ice cores and one Greenland ice cores. New dating constraints have been produced since then for these ice cores and there are also temporal divergences of up to several thousands of years that still exist with the Antarctic ice cores that were not included in this effort. However, those recent ice cores drilled mainly in coastal areas of Antarctica enclose valuable regional climatic information at a relatively high temporal resolution.

This PhD project aims at combining all the chronological information available from deep ice cores drilled both in central and coastal Antarctica to produce a new reference Antarctic ice core chronology over the last glacial-interglacial cycle. Chronological information from the well-dated cave speleothems will also be included to constrain this new timescale.

In order to produce this reference chronology, a new probabilistic dating model will be used. This tool enables to date jointly numerous climate records from different types of natural archives, accounting for various types of chronological

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constraints and providing also quantitative estimates of the uncertainties attached to the produced optimized age scales. Based on this new chronology, it will be possible to provide new insights on (1) the spatio-temporal evolution of the millennial-scale climate variability and (2) the timing and structure of the last deglaciation across Antarctica and (3) their links with Antarctic ice sheet changes.
Supervisors: Emilie Capron (UGA), Frédéric Parrenin (UGA), Joel Pedro (AAD), Taryn Noble (UTAS), Andy Menking (UTAS)
Research Fields: Paleoclimatology, glaciology, antarctic ice cores, chronologies

3. Employment Benefits and Conditions

The Université Grenoble Alpes offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). There is a probation period of 2 months and the total working hours per week is 36h40.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 28,647 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,918 EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to all the necessary facilities and laboratories at Université Grenoble Alpes and University of Tasmania, including GRICAD computational facilities.
- Tuition fees exemption at both PhD awarding institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for up to 12 months in Australia.
- 45 days paid holiday leave.
- Sick leave.
- Parental leave.

4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Applicants must hold a diploma in a relevant discipline conferring the degree of master at the end of a training programme establishing the aptitude for research. The training program must include a research component

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equivalent to 25% of a two-year Masters Coursework degree with a thesis component grade of at least Distinction grade.

Applicants must demonstrate an English language proficiency equivalent to an overall IELTS score above 7 and no band below 6.5. Note that the test needs to be completed no more than two years before enrolment. For more information about the tests accepted and scores required, visit:
https://www.utas.edu.au/research/degrees/what-is-a-research-degree

More information on Université Grenoble Alpes' requirements

Applicants holding a foreign diploma should request an exemption from the Master's degree when applying.

Visit the website: https://doctorat.univ-grenoble-alpes.fr/preparing-a-phd/doctorate-enrolment/apply-and-register-in-doctoral-school-890537.kjsp?RH=1611137559271

More information on the University of Tasmania's requirements

Visit the website: https://www.utas.edu.au/policy/procedures

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