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SESSION 6

PAST CLIMATE VARIABILITY FROM ANTARCTICA AND THE SOUTHERN OCEAN

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ABSTRACTS SUBMITTED TO THE (CANCELLED) SCAR 2020 OSC IN HOBART

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Southern Ocean Sea Surface Temperature Response to Millennial-Scale Climate Change During Marine Isotope Stage 3: A Compilation.

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The temporal and spatial response of the Southern Ocean (SO) to rapid climate changes during Marine Isotope Stage 3 (MIS-3) is poorly constrained. Here we present a compilation of previously published high-resolution sea surface temperature (SST) records from 30°S to 60°S. We synchronise all records to the Antarctic Ice Core Chronology (AICC2012) and determine the presence and magnitude of warming corresponding to Antarctic Isotope Maximum (AIM) events. The individual SO sediment cores record warming events during 50% to 100% of all Antarctic Isotope Maxima events. The Atlantic sector of the SO has on average +0.59°C larger SST anomalies than the Pacific sector during warming events. The Atlantic sector also records more of the events in the individual core records (75% compared with 60%). Furthermore, the median amplitude of SO SST increases are positively correlated to the duration of Greenland Stadial periods ($r^2 = 0.94$, $n = 9$, $p < 0.0001$). This correlation solidifies the linkage between northern high latitude climate variability, AIM events and Southern Ocean SST variability during MIS-3. This compilation of records provides the first timescale-consistent look at the response of the SO to the rapid climate changes of MIS-3, and is consistent with the thermal see-saw theory of a heat reservoir in the South Atlantic propagating around the Southern Ocean.

1712

Understanding rapid changes in Antarctic sea ice extent using large climate model ensembles

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Antarctic sea ice extent underwent a rapid decline in the spring of 2016 and has remained below climatological averages since. Recent studies suggested that enhanced tropical convection in the Indian Ocean and Maritime Continent contributed to the highly anomalous wind patterns that led to the initial decline, with tropical-extratropical interactions also implicated in its sustained maintenance. Here we utilize the Community Earth System Model 40-member large ensemble simulations to explore the ability for rapid increases and decreases in Antarctic sea-ice extent over the historical past in various seasons. We find instances of similar multi-year decreases in the model and explore the mechanisms by which these occurred. The impact of the tropics in the determining the phase of rapid changes in sea ice is also analysed using pacemaker simulations.

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Cross-signal analysis of the Drake Passage flow and the Agulhas Leakage during the last deglaciation

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The Agulhas Leakage may apply a considerable influence on the interocean fluxes of heat and salt strength and stability of the Atlantic Meridional Overturning Circulation (AMOC). With the current geographical configuration of the Southern Ocean, the water gates of Drake Passage and Agulhas Current are critical points for the so-called “Cold and Warm Water Routes” and for the entry of intermediate water masses in the Atlantic, which contribute to the surface return flow that balances the export of deep waters from the North Atlantic. We present an analysis of the synchronicity of millennially-resolved signals from the Drake Passage and the Agulhas current during the last 25,000 years using the cross wavelet analysis, quantifying the signal strenght and time lag of these two gateways. Results show that the anti-phase signal from sea surface temperatures in the Drake Passage are well correlated with the significant increasing of the Agulhas Leakage, suggesting a wider Southern Hemisphere response signal on the salinity anomalies. Using global sea level data and orbital variability as suplemental information for the cross-wavelet analysis confirmed that Agulhas leakage increasing intensity is related to minima in precession, sinchronized with changes in the Drake Passage flow. These connections are important for the operational mode of the Atlantic Meridional Overturning Circulation (AMOC).

1211

X-Radiographic Images of Core Sediments from Grand Lagoon
at Bulgarian Antarctica Base, Livingston Island-South Shetland Islands, West Antarctica.

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This study presents to research the depositional patterns inferred from X-radiographic images of core sediments from Grand Lagoon at Bulgarian Antarctic Base “St. Kliment Ohridski” where is located in between coordinates S 62º38'28.01" and W 60º21'53.88", is also situated at South Bay of Livingston Island.

For the realization of this research will be applied to the study of sedimentological and geochemical characteristics in modern glaciogenic sediments collected from the Grand Lagoon.

So, 10 core samples with depths range from app.20 to 50 cm collected at each sites located approximately 50 m apart from the water and ice-free area along the Grand Lagoon for pioneer investigations during the 2018 Antarctic austral summer. Core sediment samples were taken with Plexiglas acrylic tubes and kept to analyze at laboratory. X-ray radiography was directly performed on core samples without any processing. The geochemical and sedimentological analyses have also already going on and then furthermore the getting results will be interpreted and figured out as soon.

Some depositional layers with laminations also were detected by X-ray radiography. These laminated layers with inferred from radiographic images of core samples will probably indicated that glaciogenic sediments deposited under different seasonal conditions at depositional site area where is dark grey to black, moist to wet, mostly sandy and mixed with small clayey aggregates observed in preliminary field studies.

As a result, the area is thought to be directly affected by under the coastal beach dynamics, fluvioglacial erosional and depositional processes during the seasonal weathering changes at surrounded area.

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Climatic information archived in ice cores: impact of intermittency and diffusion on the recorded isotopic signal in Antarctica

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The isotopic signal ($\delta^{18}O$ and δD) imprinted in ice cores from Antarctica is not solely generated by the temperature sensitivity of the isotopic composition of precipitation but also contains the signature of the intermittency of precipitation patterns as well as of post-deposition processes occurring at the surface and in the firn. This leads to a proxy signal recorded by the ice cores that may not be representative of the local climatic variations. Due to precipitation intermittency, the ice cores only record brief snapshots of the climatic conditions, resulting in aliasing of the climatic signal, and thus a large amount of noise which reduces the minimum temporal resolution at which a meaningful signal can be retrieved. The analyses are further complicated by isotopic diffusion which acts as a low pass filter that dampens any high frequency changes. Here, we use reanalysis data (ERA-Interim) combined with satellite products of accumulation to evaluate the spatial distribution of the transfer function that describes the formation of the isotopic signal across Antarctica. The minimum time scales at which the signal-to-noise ratio exceeds unity range from less than a year at the coast to a thousand years further inland. Based on solely physical processes, we were thus able to define a lower bound for the time scales at which climate variability can be reconstructed from ice core water isotopic compositions.

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Comparing the strength of the link between surface mass balance and temperature in ice cores and models in Antarctica over the last centuries

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Historical climate model simulations must be evaluated against measured records of surface mass balance (SMB) to assess the robustness of modeled future SMB. Here, we compare the strength of the link between SMB and surface air temperature (SAT) in modeled and measured data sets over the last century. We use several global climate models and the RACMO2.3 regional climate model (Van Wessem et al. 2018). Modeled results are compared to PAGES 2k ice-core compilations: Thomas et al (2017) SMB, Stenni et al (2017) d18O as a proxy for SAT, both for the last 150yrs, and the Nicolas and Bromwich (2014) SAT reconstruction, available only for the last 50yrs.
We show that the modeled SMB-SAT relationship is strong and positive at the regional scale (down to 5.5km with RACMO2.3), while the ice-core SMB-SAT or SMB-d18O relationship is weaker, over the last 150yrs. To resolve the discrepancy between measured and modeled signals, we show that averaging ice-core records in close spatial proximity increases the obtained SMB-SAT correlation slightly, but not enough to match that obtained from the models. On the model side, the RACMO2.3 simulations allow us to highlight areas where SMB and SAT are weakly correlated. We show that wind-induced processes active locally can overwhelm the large-scale positive SMB-SAT relationship in these areas. The 5.5km RACMO2.3 output along Princess Ragnhild Coast shows that wind-induced snow redistribution affects each ice promontory. However, we show that the areas with a weak SMB-SAT correlation cannot explain the whole ice-core-model discrepancy in SMB-SAT correlation strength.

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Orbital-scale, glacial evolution of the Transantarctic Mountains during the Miocene Climatic Optimum and its termination (~15.5-13.8 Ma)

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An approximately ~50m thick sequence of well-dated ice-cemented sedimentary drill cores were recovered from the Friis Hills, McMurdo Dry Valleys in 2016. The cores provide new insights into the variability and extent of glaciation through the Transantarctic Mountains (TAM) during the Early to Mid-Miocene between 15.5-13.8Ma. This interval was characterised by a period of warmth within the Miocene Climatic Optimum (MCO; ~17-15Ma), when global average temperature 3-4°C warmer than today and atmospheric CO_2 levels up to 600ppm - one of the warmest intervals since the onset of Antarctic glaciation. The MCO was terminated by major global cooling and Antarctic wide ice-sheet expansion across the Miocene Climate Transition (MCT; ~13.8Ma). We document the evolution and orbital-scale glacial variability during this long-term transition in climate state.

Sediments deposited between ~15.5 -14.4Ma consist of alternating sequences of traction tills and moraines deposited during advances of a temperate alpine glacier system, and intervening fluvio-lacustrine sediments deposited during interglacial retreat, at a likely paleo-elevation of around 1000m, indicating a much warmer and wetter environment in the TAM than today. After 14.4Ma, till facies in the Friis Hills cores become progressively thicker, less muddy, more pervasively deformed and are punctuated by thinner intervals of organic rich fluvial/lacustrine interglacial sediments, but display similar facies to the underlying organic-rich interglacials. This suggests that glaciation became progressively colder, drier and more regionally-extensive during glacial periods heading into the MCT. However, interglacials remained warm enough to sustain tundra-style vegetation including Nothofagus at high elevations where mean summer temperature was 6-7°C.

1575

Paleooceanographic reconstruciton of the Southern Ocean based on coccolith assemblages.

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Southern Ocean (SO) plays an important role in regulating global climate. The diverse species (foraminifera, Coccolithophore and diatoms) in this study area respond to the hydrographic changes along with the movement of fronts. In this study, we reconstruct SO paleoceanography from coccolithohore abundance and assemblage variation using a radiocarbon dated (up to 42 ka BP) sediment core (SK200/22a) retrieved from north of Del Cano Rise of SO. The most abundant species were Emiliania huxleyi and Calcidiscus leptoporus along with Helicosphaera carteri, Gephyrocapsa oceanica, Gephyrocapsa muellerae, Gephyrocapsa sp., Gephyrocapsa sp. small, Reticulofenestra sp., Coccolithus pelagicus, Umbilicosphera sibogae and Florisphera profunda. The coccolith assemblage exhibits higher abundance during Holocene (5.78 X 109 coccoliths g-1 sediment) while it is lesser (0.92 X 109 coccoliths g-1sediment) during glacial stage. Interestingly, during the LGM the warmer species exhibit higher values than that of glacial values suggesting a localized warming event associated with increased availability of nutrients. C pelagicus, a cold water mesotropic species records higher values during LGM as compared to the Holocene indicating higher availability of nutrients. The warmer species exhibits lowered values during the glacial stage suggesting northward shift of Antarctic Polar Front and Sub-Antarctic Front. This is the first coccolith record from the Indian sector of Southern Ocean to understand the frontal variation and the past-climate changes in this region along with other microfossil records.

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Characterising surface and sub-surface marine heatwaves in the Kerguelen Plateau region

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The Kerguelen Plateau (KP) is home to a significant Patagonian toothfish fishery as well as being home to significant populations of seals, seabirds and whales. These populations are supported by the increased primary production that is consistently observed in the eddy-field caused by the interruption of the ACC as it moves around the plateau.

Using a combination of observations provided by tagged elephant seals and model output from a data-assimilating high-resolution ocean model we characterise the frequency and intensity of marine heatwaves that have occurred in the KP region between 1994 and 2016. We show that anomalously warm water can penetrate from the surface to a depth of at least 150m and that depth penetration of warm water is likely related to downwelling favourable winds. Similarly, upwelling favourable winds appear to be related to the dissipation of marine heatwaves in the region.

We also show that the ocean temperature at both the surface and at 150m on the KP is significantly correlated with key modes of climate variability with regions of the KP displaying significant correlations with the Indian Ocean Dipole, El Nino Southern Oscillation and the Southern Annular Mode. These results suggest there may be potential predictability in ocean temperatures, and their extremes, in the KP region.

Strong MHWs, as have been seen in recent years, may be detrimental to the unique ecosystem of this region, including economically relevant species, such as the Patagonian Toothfish.

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El Niño Southern Oscillation and Southern Annular Mode signals from sea salt deposition in the Mount Brown South ice core, East Antarctica

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The mid-latitudes of the Southern Ocean are among the stormiest on Earth, yet the longer-term variability in atmospheric circulation in this region remains poorly understood. This is particularly true for the southern sector of the Indian Ocean, where reliable observations are primarily limited to the satellite era as few habitable land-masses means observational station data is sparse. Model studies and paleoclimate records (ice-cores and corals) suggest decadal variability in atmospheric circulation exists in this region, however, long annually resolved ice-core records are needed to further investigate these processes. Until recently, the Law Dome Summit South (DSS, 66.769°S, 112.806°E), remained one of few multi-century annually resolved ice-core records in East Antarctica. A new ice-core drilled at Mount Brown South (MBS, 69.111°S, 86.312°E) approximately 1000km west of DSS provides an additional high-resolution record at millennial timescale. We present a comparison between the sea salt concentrations for DSS and MBS over the satellite era. Our results suggest that annual sea salt deposition at MBS contains significant signals for the El Niño Southern Oscillation (ENSO) and the Southern Annular Mode (SAM). These signals are further demonstrated by composite maps that show (a) significantly higher (lower) sea surface temperature anomalies in the western equatorial Pacific during high (low) sea salt years that correspond with El Niño events (La Niña events), and (b) a significant contraction (expansion) of zonal wind anomalies during low (high) sea salt years that correspond with the positive (negative) SAM phase.

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A Preliminary Reconstruction of Miocene Ocean-Climate History of the Ross Sea, Antarctica based on Foraminifera from IODP Site U1521 and DSDP Site 272

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The International Ocean Discovery Program (IODP) Expedition 374 recovered deep-sea sediment cores from the continental shelf of the Ross Sea, Antarctica to evaluate the stability of the Antarctic Ice Sheet (AIS) during the warmer-than-present climates of the Miocene. Studies of AIS stability are critical to understand the modern impacts of anthropogenic warming on the Ross Sea sector, as numerical modeling indicates that this region is highly sensitive to changes in ocean and atmospheric heat flux. Located in the Pennell Basin, IODP Site U1521 recovered sediments of the Miocene Climatic Optimum (MCO; 17-14.5 Ma) and Middle Miocene Climatic Transition (MMCT; 14.2-13.8 Ma). Global proxy records indicate dynamic changes in carbon cycling, prolonged global warmth, and reduced ice cover during the MCO, followed by ice expansion during the MMCT. To reconstruct changes in the Ross Sea and the associated marine paleoenvironments during the Miocene, assemblages of fossil benthic and planktic foraminifera were analyzed from Site U1521 and assessed with foraminiferal data from DSDP Site 272.

Prior to the MCO, low diversity and a mix of in-situ and reworked foraminifera, coupled with lithology, indicate periodic ice advance and retreat. During the MCO, an increase in species diversity and predominantly in-situ microfossils suggests an interval of highly productive open water and warmer sea surface temperatures. A widespread hiatus across the shelf implies grounded ice during the late stages of the MCO. A decrease in diversity and preservation suggests a shift to a less productive paleoenvironment during the MMCT.

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Influence of climate modes and solar variability on East Antarctic ice core temperature during the past two centuries

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El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillations (PDO) and their interactions with Southern Annular Mode (SAM) largely influence Antarctic climate. Solar variability is also known to contribute Antarctic climate variability. However, the relative roles of these climate modes and solar variability are not yet well understood particularly in the backdrop of global warming scenario. In this study, we have reconstructed high resolution temperature of the past two centuries (1809 – 2013 CE) based on oxygen isotope (δ18O) record of a new ice core (IND-33/B8) from Dronning Maud Land (DML), East Antarctica together with other published records. Our δ18O record broadly agree with the simulation result from water isotope-enabled ECHAM5-wiso model except for the periods of large excursions observed in the ice record. We found that ~32% variability in δ18O records of the DML region is attributed to temperature, which is modulated by ENSO and PDO, whereas 27% variability is related to moisture source changes and transport processes. Further, moisture sources and its transport are primarily controlled by wind and the sea ice variability modulated by the Southern Annular Mode (SAM) at annual to sub-decadal time scale, whereas solar variability influences at decadal scale (9 -12 yrs band). DML temperature record shows dominant ENSO signal during the time slices 1825-1835, 1950-1960 and 1975-1995 CE with a dramatic shift from low (9-16 yrs) to high (2-8 yrs) frequency bands since 1940s. We observed significant correlation ($r=0.42$, $p<0.05$) between SAM and temperature during 1965-1993 CE when SAM started shifting to positive phase.

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Quantifying Changes in Atmospheric Oxidative Capacity since 1870 AD Using Measurements of 14CO in ice and firn from Law Dome, Antarctica

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Climate change and stratospheric ozone depletion are affected by the emissions of key trace gases as well as by their loss from the atmosphere. Hydroxyl, OH, is the main tropospheric oxidant and determines the atmospheric lifetime of many greenhouse gases and ozone depleting gases. Changes in OH concentration ([OH]) in response to large changes in reactive trace gas emissions are uncertain and constraints on future simulations by atmospheric models come from limited observations. Reconstructions of 14CO from ice cores could in principle provide such constraints but are complicated by in-situ cosmic ray production of 14CO. Recent work in Antarctica and Greenland shows that this in-situ component would be relatively small and accurately quantified at sites with very high snow accumulation rates. A joint US-Australian program in 2018-19 measured air in firn and ice at Law Dome, Antarctica (DE08-OH, 1.2 m a-1 ice). Trapped air was extracted using an on-site large-volume (~500 kg) ice melting system. Ice core air sample ages spanned from the 1870s to the early 2000s and the firn-air samples spanned from the early 2000s to present. Analyses of [CO] and halocarbons in the samples show a relatively low and stable procedural CO blank and demonstrate that the samples are unaffected by ambient air inclusion. 14CO measurements in these firn and ice core air samples will be presented. This 14CO history will be interpreted with the aid of the GEOS-Chem chemistry-transport model to place the first long term observational constraints on the variability of Southern Hemisphere [OH].

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ICEPRO: An International Collaboration Effort for improving Paleoclimate Research in the Southern Ocean

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The Southern Ocean (SO) is an active regulator of global climate through its influence on the modulation of the global ocean circulation, the phytoplankton productivity as well as nutrient cycles, the transfer of energy and gas between the ocean and the atmosphere, and sea level. Despite its importance, seasonal and sparse distribution of instrumental data across the SO prevent a robust assessment of the physical and biological response and feedback on future climate change. Paleoclimate data are therefore essential to document the natural variability of environmental conditions and identify their drivers from decadal-to-millennial timescales. However, in paleoclimate studies, several questions remain unaddressed due to the lack of robust proxy calibration. While some tools are better constrained than others, the mechanisms controlling them are not fully understood. A critical step to improve their use is to conduct a systematic multi-annual collection of samples and data throughout the SO. ICEPRO has been initiated to strengthen existing collaborations and creating new connections among several partners regularly crossing through different transects the SO and who have the opportunity to sample the water column and marine sediments spanning at least the last 2,000 years. Such collaborative work could therefore cover most of the important regions of the SO, thus allowing a better monitoring of modern environmental and hydrological conditions, and ultimately improve calibration of tools commonly used for paleoreconstructions. Here we aim to present ICEPRO, its first steps and results we obtained from the last Antarctic cruises as well as our future ambitions.

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Mid-to-Late Holocene climatic oscillations at northern Antarctic Peninsula from combined lacustrine and glacial records

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Meteorological data and climate models have pointed the Antarctic Peninsula as one of the most rapidly warming regions of the planet. However, recovering the past climate changes at that site using ice cores is still challenging since summer meltings effect ice core glacio-chemistry. In this scenario, the sediment core profiles retrieved from Holocene pro-glacial lakes arise as promising for reconstructions. The sediment cores analysis presented here comprise data from an isolated lake, covering the mid-to-late Holocene, and 9 (nine) cores surveyed from lakes located at the end of braided glaciers meltwater streams covering the modern epoch (last 150 years). From this approach, we were able to ensemble the sedimentary record and produce an integrated sedimentation history that allowed comparison with ice core records of WAIS, especially from northern Antarctic Peninsula, the James Ross ice core. Sediment core dated from the Holocene presented regular marked laminations indicating pronounced 80-to-100 yr periodicities revealing a possible signal of the Gleissberg solar cycle. Main finding from this work is an identification of a prolonged cooling phase observed during the last 2kyr. We propose here that such event is related to the combined impact of the regional volcanism concomitant to a reduced solar irradiance based on latest reconstructed time series. This work is part of UN/FAO/IAEA climate change program with support of the Brazilian and Russian Antarctic Programs.

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Southern Hemisphere Pressure Relationships during the 20th Century: Implications for Climate Reconstructions and Model Evaluation

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The relationship between Southern Hemisphere middle and high-latitude regions has made it possible to generate observationally-based Antarctic pressure reconstructions throughout the 20th century, even though routinely collected observations for this continent only began around 1957. Nearly all reconstructions inherently assume stability in these relationships through time, and in the absence of direct observations, this stationarity constraint can be fully tested in a model setting. Seasonal pressure reconstructions based on the principal component regression (PCR) method spanning 1905 – 2013 are done entirely within the framework of the Community Atmospheric version 5 (CAM5) model in this study in order to evaluate this assumption, test the robustness of the PCR procedure for Antarctic pressure reconstructions, and to evaluate the CAM5 model. Notably, the CAM5 reconstructions outperformed the observationally-based reconstruction in every season except the austral summer. Other tests indicate that relationships between Antarctic pressure and pressure across the Southern Hemisphere remain stable throughout the 20th century in CAM5. In contrast, 20th century reanalyses all display marked changes in mid-to-high latitude pressure relationships in the early 20th century. Overall, comparisons indicate both the CAM5 model and the pressure reconstructions evaluated here are reliable estimates of Antarctic pressure throughout the 20th century, with the largest differences between the two resulting from differences in the underlying reconstruction predictor networks and not from changes in the model experiments.

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Past Sea Surface Temperature and Sea Ice Extent and their role in Fragilariopsis kerguelensis size variation from the Southern Ocean”

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The present study aims in addressing the past changes in the Southern Ocean (SO) system in a quantitative and process oriented way in order to improve the understanding of future climate and environment. In this study we have reconstructed the summer sea surface temperature (SST) and winter sea ice presence (SIP) along with diatom morphometry from the sediment core located at 55˚01’ S, 45˚09’E from the Indian Sector of SO. The maximum SIP of 1-2 months/year and lowest SST of 1-3C were recorded during glacial stages, this probably resulted in reduced valve size (~250 microns) of Fragilariopsis kerguelensis. Comparison of our records with published studies demonstrates that during the glacial stages SIP was of longer duration in the Atlantic and western Pacific Sector than in the Indian Sector. This suggests additional dynamical processes in the Atlantic and Western Pacific Sector, whereby sea-ice transport by the Weddell and Ross Gyre may have allowed WSI further to the north. The relatively lower SIP in the Indian Sector resulted in the largest mean F. kerguelensis sizes which was facilitated by the efficient utilization of the nutrients by these diatoms. This study suggests that changes in the past sea ice dynamics may control the sizes more rapidly in the Atlantic and Western Sector than anywhere else in the SO if the Weddell and Ross Gyre weakens in the coming decades.

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A multi-proxy reconstruction of the SAM in the Southern Ocean Sector during the Holocene and Last Interglacial

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Of paramount interest to reconstructing Antarctic regional paleoclimate are: (i) the zonal vacillations of the Southern Hemisphere westerlies, and their encapsulation within the Southern Annular Mode (SAM) of variability; (ii) the atmospheric Planetary Waves controlled by orography and land/sea contrasts in diabatic heating; and (iii) the geographic distribution of tropical-Antarctic teleconnections.

The approach presented in this talk is based around reconstructing 'macroweather', the centennial-scale upscaling of weather patterns and climate modes. Past macroweather and climate shifts can be resolved on a deterministic manner on sub-orbital time scales due to the coupling between macroweather and the latitudinal temperature gradient. Advances in data-model assimilation using hemispheric to regional multi-proxy data are presented for the last millennium, early, middle and late Holocene and the Last Interglacial (MIS Stage 5). An alternative approach is to project far field proxy climate and sea-level data onto Antarctica to develop an 'inverse' view of climate influences by developing: (i) regional ice-sheet basin meltwater fingerprints from far field sea-level records, and, (ii) circumpolar wind fields from far field paleoclimate proxies and ice cores.

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Influence of ice-ocean interactions in the Southern Ocean on Antarctic temperatures and on the global carbon cycle over the past millennia.

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Reconstructions of Antarctic surface temperature covering the past millennia display a large centennial variability that is not synchronous with fluctuations recorded on other continents and which is generally not well simulated by models. Many processes can be at the origin of these temperature variations such as teleconnections with tropical oceans and changes in the Southern Ocean. The focus here will be on the latter, in particular on ice-ocean interactions that regionally control the stratification of the Southern Ocean and thus have a large impact on the exchanges of heat and carbon between the ocean and atmosphere. Changes in the Southern Ocean circulation and stratification also influence the carbon cycle at global scale. It is generally suggested that atmospheric CO2 variations over the past two millennia were mainly controlled by land processes but the Southern Ocean might also have played a role. We will thus test whether the joint analysis of Antarctic temperature and atmospheric CO2 concentration fluctuations can inform us on the origin of the observed changes over this period. In this purpose, we use the climate model LOVECLIM which includes a representation of the global carbon cycle. Experiments over the last two millennia will address the sensitivity to realistic perturbations of the wind stress and freshwater forcing from the ice sheet. Finally, experiments with data assimilation will allow assessing what constraints are needed for model results to better reproduce the reconstructed temperature history.

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Can we reconstruct the formation of large open ocean polynyas in the Southern Ocean using ice core records?

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Large open-ocean polynyas, defined as ice-free areas within the sea ice pack, have been observed only rarely over the past decades in the Southern Ocean. In addition to smaller recent events, an impressive sequence occurred in the Weddell Sea in 1974, 1975 and 1976 with openings of more than 300,000 km2 that lasted the full winter. Those big events have a huge impact on sea ice cover, deep-water formation and more generally on the Southern Ocean and the Antarctic climate. However, we have no estimate of the frequency of the occurrence of such large open-ocean polynyas before the 1970s. Their overall role in the natural climate variability at high southern latitudes is thus unknown. No paleoceanographic data is available in the Weddell Sea to reconstruct directly past polynya activity. Our goal here is to test if this could be done using continental records, and specifically, observations derived from ice cores. The fingerprint of big open-ocean polynyas is first described in reconstructions based on data from weather stations and ice cores for the 1970s and in climate models. It shows a clear signal, characterized by a surface air warming and increased precipitation in coastal regions adjacent to the eastern part of the Weddell Sea where several high-resolution ice cores have been collected. The potential to base reconstructions of polynya activity over past centuries on this signal using simple statistical techniques as well as data assimilation is explored.

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A constrained optimization (CONOP) biostratigraphic framework for Antarctic unconformities during the Cenozoic

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The quantitative biostratigraphic method of Constrained Optimization (CONOP) provides a common framework including geochronology for the correlation of Antarctic sediment cores to overcome discontinuous records and facies constrained biostratigraphy. CONOP has been used previously to improve age models of Antarctic shelf sites (i.e. ANDRILL-1B; Cody et al., 2012) and analyse phytoplankton turnover in response to climate cooling over the last 15 million years (Crampton et al., 2016).

The Southern Ocean biostratigraphic database now incorporates taxon ranges for diatom, radiolaria, foraminifera and nannofossils spanning the Late Cretaceous to present, with 6 radiometric ages and 342 individual paleomagnetic reversals for 50 sites south of the Polar Front. This project intends to extend beyond the Polar Front to investigate biogeographic effects at taxon and species levels. The CONOP method of computerised graphic correlation and parsimonious sequencing, allows objective assessment of assigned paleomagnetic reversals and the uncertainty of correlation to be ascribed.

This work focuses on the geographical distribution of changes in sedimentation rates in relation to widespread unconformities, and developing on seismic interpretations (e.g. DeSantis et al., 2003; Brancolini and Leitchenkov, 2010; Escutia et al., 2011; Gohl et al., 2013). Results will ultimately help inform and refine biostratigrahpic age models from the recent phase of IODP drilling around the Antarctic margin. The current development of astroCONOP (Meyers, pers. comms) will also be discussed here in the context of further chronological refinement and assistance with correlation of traditional Antarctic proxies and timeseries to those preferentially used in more temperate climates (i.e. δ18O).

1405

2000 Years of Variability in the Southern Annular Mode (SAM) from Tree Rings and Ice

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The Southern Annular Mode (SAM) is the leading mode of climate variability in the middle to high latitudes of the Southern Hemisphere, where it affects the strength and position of the westerly winds, precipitation, and temperature anomalies across oceans and continents. While several reconstructions of the SAM have been developed from existing proxies there is little agreement among them prior to the mid 1800s. Further, existing SAM reconstructions are focused on the Pacific Ocean sector, with less data from the Indian Ocean sector passing proxy screening tests. Here, we describe a project that will combine tree-ring data from Tasmania, Australia with two high-resolution East Antarctic ice cores (Law Dome and Mount Brown) to reconstruct the behavior of the SAM over the last 2000 years in the Indian Ocean sector. This new SAM record will be compared with last millennium climate model simulations in order to identify internal and external forcing of decadal to centennial variability in the SAM. As a precursor to data assimilation, we evaluated the features of the SAM in several GCMs and identified optimal sensor locations in different models to examine how they compare with available proxy sites. Initial results indicate that many GCMs exaggerate the annular shape of the Southern Annular Mode relative to reanalysis data (CSIRO, FGOALS, IPSL, MIROC, and MRI) while others more closely match (CESM, MPI and HadCM3). Data processing of the tree ring and ice core proxies is currently underway.

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Sediment accumulation rates at the edge of the Atlantic: relationships among sea ice, water current and sea floor relief.

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Sediment accumulation rates were studied at the southernmost Atlantic Ocean in the vicinities of the Filchner Trough. This is an important region for water mass formation and a marine mammal feeding spot, presumably following high primary production. The region also experiences contrasting sea ice patterns. In spring and summer there are open water conditions at the east of the trough, whereas at the west, the sea surface usually remains covered by multiyear sea ice. Earlier studies showed that sedimentary organic carbon and biogenic silica were more concentrated on the eastern flank of the trough. We attempted to study whether sediment accumulation follow this pattern and its implication for the long-term (hundreds of years) carbon storage in the sediment column. We analyzed 16, 20-cm sediment cores along the axis of the Filchner Trough and the adjacent continental shelf and slope. Sediment accumulation rates (SAR) varied from 8 to 128 cm ky-1. The highest SAR were found on the deepest parts of the axis of the trough and the shelf and slope of its eastern flank, whereas the smallest SAR were found in the shelf and slope of the western flank and at the mouth of the trough. Preliminarily, SAR values matched with the sea-ice pattern and the water current system, showing high values in areas with seasonal open water conditions and the inflow of deep water onto the shelf and low values in areas where multiyear sea ice persists and the outflow of dense cold water towards the deep Weddell Sea.

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Climatology of Antarctic ozone zonal asymmetry by MERRA-2 data

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Antarctic ozone climatology was calculated over the 1980–2018 period using monthly mean data from MERRA-2 reanalysis. The 2D (total ozone column) and 3D (ozone concentration) mean ozone values climatology for zonal band (90°S–0°S) at 42 pressure levels (1000–0.1 hPa) were retrieved. The amplitude of ozone zonal asymmetry was calculated. The monthly, latitude, and longitude morphology altitude analysis have been made. The maximal ozone zonal asymmetry is observed in spring, especially in October with dominant wave-1 zonal minimum at 0°–90°W and maximum at 120°E–180°E. The area of high ozone content is located in zonal band (40°S–80°S) with gradual shift to the pole from September to November. Latitudinal mean maximum in zonal mean ozone distribution is observed near 62°S in September, 66°S in October, and 68°S in November. Poleward shift of latitude ozone maximum continues until March with decreasing of ozone level, but in April the shift reverses into equatorward. Eastward shift of longitude ozone zonal maximum from month to month could be observed in ozone distribution from September (144°E) to October (166°E), and westward from October to November (156°E) but for ozone zonal minimum there is only eastward shift from September (29°W) to November (6°W). The highest difference in altitude ozone distribution is observed during October in the stratosphere between ozone zonal minimum (66°S, 30°W, 30hPa) and maximum (66°S, 160°E, 40hPa) points. The difference reaches approximately 4x10–12 cm–3, which is about 66% of the zonal average value at this level.

1152

The seasonal signal and variability of 17Oexcess in two contrasting ice cores from coastal Antarctica

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Stable water isotopic ratios are routinely measured in ice cores to help constrain past climate variability. In addition to measurements of the traditional water isotopic ratios,
δD and δ18O, the secondary parameters, dexcess and ^{17}Oexcess, provide insight into variability in the oceanic evaporative region. Ice core ^{17}Oexcess is thought to be primarily controlled by variations in relative humidity in the source region and has the potential to be a more reliable recorder of source conditions than dexcess, however questions still remain about how ^{17}Oexcess responds to climatic variability and fractionation along the transport pathway. We present ^{17}Oexcess data for the past 40 years from two contrasting ice core locations; James Ross Island on the Antarctic Peninsula, and Mount Brown South in East Antarctica. Both ice cores are situated in high-accumulation coastal sites, and we present ^{17}Oexcess measurements at seasonal resolution spanning the satellite observation period. The relationship between ^{17}Oexcess in the ice cores and variability in relative humidity and temperature in the source region, transport pathways, and temperature at the deposition site are investigated. This detailed analysis allows us to assess the impact of these climate variables on the preserved ^{17}Oexcess signal in the two ice cores, and the potential for developing longer ^{17}Oexcess-dervied reconstructions from these sites.

1143

Rates of dust transport to Macquarie Island during the mid to late Holocene: Implications for the position and strength of the mid-latitude westerlies and ecosystem fertilisation

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Due to its location within the core region of the Southern Hemisphere mid-latitude westerlies, Macquarie Island winds arrive almost exclusively from the west-northwest. Thus, under certain conditions, air masses arriving with enhanced or reduced dust input through time are likely associated with a reduction in the strength and/or the position of the mid-latitude westerlies, (possibly associated with more positive SAM-type conditions) and increased advection of heat to the atmosphere of the Southern Ocean. At the same time, dust is known to play an important role in ecosystem productivity, with phytoplankton production in the HNLC Southern Ocean linked to dust fertilisation. In addition, dust may also play an important role in ecosystem production on Macquarie Island itself.
In this study, we examine dust transport to Macquarie Island in the mid to late Holocene by analysing three peat cores collected from Macquarie Island in 2018. Geochronology is established for each of the cores with 210Pb and 14C dating, and they are analysed for minerogenic input (dust). Ecosystem response is quantified with diatoms, pollens, C/N ratio, and N-alkanes. Through associations between ecosystem variation and mineral input, we draw insights into biotic processes in the high-latitudes and the adaptive capabilities of the food web. Our results imply episodes of increased dust transport, possibly pointing to reduced strength of the westerly winds at these times. The results also imply increased ocean fertilisation and associated phytoplankton response at these times, which is likely to be associated with enhanced CO2 drawdown.

1133

Environmental Controls on Laminae Frequency and Biological Productivity in Adélie Land

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Wind driven currents along Antarctica's coastal margins regulate water mass exchange between the Antarctic continental shelf and Southern Ocean. As such, these currents exert control on the delivery of heat, salt, and nutrients to the coastal margins and marine based ice sheets. This exchange affects sea ice extent, primary productivity, and bottom water formation, and may be capable of change at centennial to millennial timescales. However, characterising the long-term climate variability of wind driven currents, and the effect on primary productivity, is difficult due to sparse and temporally limited observational data. Here, we present a new Holocene climate record from Integrated Ocean Drilling Program (IODP) sediment core U1357B in the Adélie Basin, East Antarctica. The sediment core consists of contrasting light and dark centimetre scale laminations through the entire 170 m of core, with light laminations reflecting changes in biological sedimentation. Using X-Ray Computed Tomography, and supported by grain size distributions, XRF data, and other physical core properties, we developed a record of near annual biogenic bloom events and link these bloom events to changing environmental conditions. As primary productivity in many parts of the Antarctica's coastal regions is strongly linked to wind-driven upwelling processes, we investigate how variations in grain size can be used to assess changes in wind-driven currents, which may influence dark and light laminae characteristics through the Holocene. The result is a centennially resolved coastal current reconstruction for the Holocene along the Adélie Land Margin.

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Seasonal Climate Variability in West Antarctica During the Holocene

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Paleoclimate proxies of the annual cycle are difficult to obtain and require a confluence of specialized technology, methodology, and modeling to interpret. This represents one of the great challenges of paleoclimate studies. In the case of ice core science, the ability to measure and interpret the annual cycle has recently become possible for water isotope records. Here, we discuss results from the West Antarctic Ice Sheet (WAIS) Divide ice core during the Holocene, including: 1) A continuous reconstruction of the annual signal throughout the Holocene, and 2) Corrections for differential diffusion due to the seasonality of accumulation. We use modeling (HadCM3) to explain changes in the summer and winter extrema, as well as the annual amplitude through time. We also discuss where modeling deficiencies exist. As additional high-resolution ice core records become available (e.g. Renland, EGRIP, Hercules Dome, possibly GISP, etc.), the ability to analyze and interpret changes in the annual cycle across space and time will improve. As a result, our understanding of climate change on timescales that humans most relate to - variability from one year to the next - will also improve.

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Reconstructing Southern Ocean sea surface temperatures from an East Antarctic ice core.

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The lack of reliable and long observational records of sea surface temperature (SST) from the Southern Ocean remains a key factor in limiting our attempts to understand climate variability on interannual to centennial scales in the Southern Hemisphere. The Law Dome DSS ice core from East Antarctica provides an annually resolved climate record, capturing atmospheric and ocean processes from the Pacific and Indian sectors of the Southern Ocean. We present a 1000 year reconstruction of sea surface temperature in the Southern Ocean using snow accumulation and sea salt records from the DSS ice core. Sea salt aerosols falling on Law Dome, carried by moisture sourced predominately from the Indian sector of the Southern Ocean, are found to be a proxy for SST through the relationship between atmospheric-ocean heat exchange and wind speed. Back trajectory analysis of ERA-Interim reanalysis data shows the origin of the moisture falling as snow on Law Dome to be predominately from the Indian Ocean sector of the Southern Ocean and reconstructs the seasonal cycle of sea salt concentrations with good agreement with the measured ice core record. Examination of the time series of the the dominant temporal modes of the SST reconstruction shows a break point in the time series at 1259CE. This shift is coincident with a series of volcanic eruptions also recorded in the same ice core archive, thus eliminating timing uncertainties between the two events, suggesting that the end of Medieval Climate Anomaly was a result of a climate response to the eruptions.

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Antarctic Surface Mass Balance: natural variability, noise and detecting new trends

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The emergence of new, statistically robust trends in Antarctic surface mass balance (SMB) requires an understanding of the underlying SMB variability (noise). We show that simple white or AR[1] noise models do not adequately represent the variability of SMB in both the RACMO2.3p2 SMB model output (1979-2017) and composite ice core records (1800-2010), under-estimating low-frequency variability. By testing a range of noise models, we find that a Generalized Gauss Markov (GGM) model better approximates the noise around a linear trend. The general preference for GGM noise applies over spatial scales from the total ice sheet down to individual drainage basins. Over the longest timescales considered, trend uncertainties are 1.3-2.3 times larger using a GGM model compared to using an AR1 model at the ice sheet scale. Overall, given our characterisation of noise, our results suggest that larger trends or longer periods are generally required before new SMB trends can be robustly separated from background noise.

721

Temperate rainforests near the South Pole during peak Cretaceous warmth

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The mid-Cretaceous was one of the warmest intervals of the past 140 million years (Myr) driven by atmospheric CO2 levels around 1000 ppmv. In the near absence of proximal geological records from south of the Antarctic Circle, it remains disputed whether polar ice could exist under such environmental conditions. Here we present results from a unique sedimentary sequence recovered from the West Antarctic shelf. This by far southernmost Cretaceous record contains an intact ~3 m-long network of in-situ fossil roots. The roots are embedded in a mudstone matrix bearing diverse pollen and spores, indicative of a temperate lowland rainforest environment at a palaeolatitude of ~82°S during the Turonian–Santonian (92–83 Myr). A climate model simulation shows that the reconstructed temperate climate at this high latitude requires a combination of both atmospheric CO2 contents of 1120–1680 ppmv and a vegetated land surface without major Antarctic glaciation, highlighting the important cooling effect exerted by ice albedo in high-CO2 climate worlds.

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Mid-to-late Holocene climate variability in the Northern Antarctic Peninsula

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The Antarctic Peninsula (AP) is one of the most sensitive areas to the recent global warming. Over the last 50 years, AP has approximately lost around 75 % of its ice shelves. The main causes of this rapid ice shelf regression are still debated given that the surface atmosphere temperatures (SAT), the subsurface ocean temperatures (SOT), or both can predominantly drive to this fast decline. However, due to the lack of observations, it remains difficult to disentangle the main physical processes primarily acting on the ice shelves. Past records can provide such information. Nevertheless, while a series of SOT records spanning the last millennia around the Northern AP have been produced, only one Holocene ice-core SAT record has been generated, in James Ross Island, Eastern AP. There is therefore no detailed information on the SAT centennial evolution elsewhere around the AP. To fill this gap, we used a recently developed method based on the application of the Glycerol Dialkyl Glycerol Tetraether (GDGT) from sediments of the Limnopolar Lake (62º37'23S, 61º06'24W), Byers Peninsula, South of Livingston Island, in order to investigate the past secular SAT changes over the last 7,500 years in the Western AP. Those data will be then compared to previous reconstructions derived from marine sediment cores and ice cores around the AP. Results and discussion of this ongoing work will be presented for the first time during the OSC SCAR-2020.

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Southern Weather Discovery - citizen science data rescue of high latitude historic weather and environmental observations

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Understanding key modes of variability and southern high latitude trends presently relies on sparse data and limited palaeo proxy evidence. This situation can be improved by augmenting meteorological data coverage for the 19th and early 20th Centuries, which would bolster Southern Hemisphere weather reconstructions derived only from surface observations (like the 20th Century Reanalysis; 20CR). 20CR is one of several tools that we can use to understand weather and climate processes, and hone interpretations about Southern Hemisphere changes.

Ship logbooks from whaling, trade, exploration and migration voyages took regimented observations across the Southern Ocean waters, covering locations where formal land-based stations do not exist. We discuss citizen science transcription of ship log meteorological data progress from our experiences with the Zooniverse-hosted Southern Weather Discovery (www.southernweatherdiscovery.org; SWD) platform. SWD was set up in 2018 as a contribution to ACRE (Atmospheric Circulation Reconstructions over the Earth. Within this platform, volunteers can transcribe typed and handwritten observations that our team has gathered from many archives located world-wide.

In the first SWD phase, thousands of volunteers transcribed >250,000 barometric pressure and temperature observations. These "new" old data are being used in Southern Annular Mode reconstructions and analysis of weather patterns that produced extreme impacts for New Zealand. We describe some preliminary results, and discuss bottlenecks for image preparation, quality control of observations, and data munging. We also introduce the "Week it Snowed Everywhere", a SWD component with aims to consolidate citizen science data transcription lessons and improve handwritten scientific data transcription using artificial intelligence.

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Foraminifera in deglacial sediments: Where can we find in situ calcareous microfossils to date Grounding Zone Wedges?

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Thanks to improved multibeam swath bathymetry, it is now possible to perform targeted coring of glacial landforms. Among them, Grounding Zone Wedges (GZWs) mark grounding line stand-stills that punctuated the progressive deglaciation. For a full understanding of deglaciation processes, it is critical to recognize and date these stand-stills. Following the NBP1502 cruises A and B to the Ross Sea, we examined post-LGM foraminiferal records from almost 30 sediment cores largely from sites near or at GZWs that were different in scale and location. We identified unusual foraminiferal taxa well-fit to survive limited food resources near paleo-grounding lines and influenced by the drainage of subglacial meltwater into the ocean. More importantly, we also recognized environments and geomorphic settings from which in situ foraminifera could be obtained and used for radiocarbon dating. Despite clear differences in post-LGM foraminiferal records between the western and the eastern Ross Sea, it appears that the high bathymetric gradient of GZWs and relative proximity to continental shelf edge were key factors promoting rich benthic foraminiferal communities. This knowledge may enable better core site selection in future studies.

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Exploring the Relationships of Sea Ice Proxies in East Antarctica

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Polar Sea ice plays an important role in the global climate system by acting as climate change indicators. Satellite observations inform us Antarctic sea ice extent has had consecutive maximum sea ice records between the years 2012 to 2014, but experienced a record low in 2016. With satellite data available from 1979, distinguishing long term trends from the noise of inter-annual variability has been challenging. This has led to reconstructions of Antarctic sea ice in the 20th century using proxies from the ice core trace chemical records extracted from the Antarctic ice sheet. Methanesulphonic acid (MSA) is closely linked to biological marine activity and its preservation in the sea ice allows it to be used as a sea ice proxy (Curran 2003, Abrams 2013). Sea salts such as chloride which are stable in the ice sheet, hold potential as proxies for sea ice extent over glacial timescales. Pre-satellite information suggests a decline in Antarctic sea ice over the 20th century although the magnitude of the decline varies regionally.

In this study we explore the relationship between sea ice proxies such as MSA and chloride with sea ice extent at three sites in East Antarctica: Mount Brown South, Aurora Basin North and Dome Summit South. We show that MSA and chloride have significant relationships with the sea ice at these regions which warrant further study. Investigating the variability of sea ice reconstructions from these regions is a vital step towards understanding the regional patterns of long term Antarctic sea ice trends.

1671

The oxygen isotopic variations in a Dome Fuji (Antarctica) ice core – Relationships of the temperature proxy with solar activity and oceanic variations

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Dome Fuji station, one of Japanese research stations in East Antarctica, is located on a summit of Dronning Maud Land at an altitude of 3,810 m a.s.l. (above sea level; 77˚19’ 01” S, 39˚42’ 12” E) and the 10 m depth mean snow temperature is −57.3˚C. The East Antarctic inland area in the vicinity of the Dome Fuji station has been recognized to be very unique: The snow and ice there contain much stratospheric information rather than tropospheric information compared with other Antarctic ice cores.

We present our quasi annually-resolved temperature reconstruction of 1750 – 1940 AD, a period of preindustrial era, based on oxygen isotope measurement on a shallow ice core drilled in 2010 at the 10 km south of the Dome Fuji station. The concerned Dome Fuji ice core called DFS10 is dated by applying volcanic signature matching to transfer the West Antarctic Ice Sheet (WAIS) Divide ice core chronology constructed by annual layer counting. Based on this quasi-annual chronology, we have examined a well-established temperature proxy, $\delta^{18}O$. We found periodicity of ~10 and ~20 years in our time series analyses. In our presentation, we will further discuss the origin of these periods by investigating their cross correlation with solar activity variations and also with Pacific Decadal Oscillation (PDO) that has been known to have ~20 years periodicity, as a representative of oceanic and atmospheric variations.

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Evidence of MIS Late Peistocene Ice Melt from Planktonic Foraminfers impacted by the Totten Glacier outflow over the Sabrina Slope, East Antarctica

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Stable isotope analyses of n. pachyderma from RV Investigator(IN2017-V01), Piston Core #1 (PC01) indicate after preliminary dating, negative delta 18O intervals during Heinrich events 4 and 5 (Epica Dome intervals AIM 8 and 12). We interpret these as indicating meltwater events from the Totten Glacier catchment. The change in delta 18O is on the order of one per mil or more during these events. The core site is located on the continental slope seaward and slightly west of the Totten Glacier in an area likely to be on the path of water moving from the front of the Totten, at a depth of 2163m. Typically, preservation of foraminifera is relatively rare in slope sediments that are close to the ice edge, however during the meltwater events foraminiferal preservation is good and the foraminifera are abundant. We suggest that the stratification established by the meltwater plumes diminishes the productivity of the diatom assemblages and reduces the flux of organic matter to the sea floor locally, which aids in the preservation of the foraminifera in the sediment underneath the plume. That significant meltwater can reach the slope region off the East Antarctic margin is a surprise given how cold and stable the East Antarctic margin is perceived to be and implies a much more dynamic East Antarctic ice sheet than previously thought.

1338

An expanded view on the Orbital Response of West Antarctic Ice Sheet Dynamics during the Mid- to Late Pliocene

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International Ocean Discovery Program Site U1524 is located on the eastern levee of the Hillary Canyon system, which acts as a major conduit for newly formed Antarctic Bottom Water (AABW) and its export into the Southern Ocean. We present an integrated sedimentological (lithofacies and grain size), inorganic geochemical (XRF), and organic geochemical (TOC and bulk carbon and nitrogen isotopes) datasets that demonstrate the significant role changes in southern hemisphere seasonal insolation had on the West Antarctica Ice Sheet (WAIS) during the mid- to Late Pliocene.

The “warm” mid-Pliocene 3.0-3.3 Ma is characterized by 100,000 year paced lithological changes and low amplitude 100,000 year variability in our iceberg rafted debris (IBRD) mass accumulation rate (MAR) record. The low amplitude variability IBRD MAR record is mostly likely a consequence of a retreated ice margin when relatively warmer than modern surface ocean conditions enhanced melt out of ice bergs close to the margin. Whereas, after 3.0 Ma the gradual increase in terrigenous mud content and large amplitude 100,000 year IBRD MAR cycles is consistent with evidence from the AND-1B record of a dynamic ice margin with large scale fluctuations in ice sheet extent and retreat superimposed on southern ocean cooling trend. The orbital pacing in our record is consistent with new far-field Pliocene sea level reconstructions and both deep ocean and surface ocean changes occurring the Pacific Ocean sector that appear to be decoupled from the globally integrated benthic d18O stack record.

1151

Million Year Ice Core: Australia's oldest ice core project

Joel Pedro[1], Tas van Ommen[1], Mark Curran[1], David Etheridge[2], Jason Roberts[1], Ben Galton-Fenzi[1], Lenneke Jong[1], Andrew Klekociuk[1], Gil Logan[1], Tim Lyons[1], Andrew Moy[1], Chris Plummer[3], Tessa Vance[3], Steven Whiteside[1], Nerilie Abram[4], Ian Goodwin[5], Andrew Smith

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The aim of Australia's Million Year Ice Core (MYIC) project is to recover a continuous Antarctic ice core reaching beyond 1.2 million years into the past. Obtaining such a record is a deliverable of the Australian Antarctic Science Strategy and a key priority of the International Partnership in Ice Core Sciences. The MYIC will extend the Antarctic continuously-dated ice core record beyond the current 800,000 years and across the Mid Pleistocene Transition, during which the pacing of glacial cycles changes from 41,000 to 100,000 years. Resolving the cause of this non-linear shift in the Earth's climate state is the major scientific motivation of the project.

The MYIC project is collaborating with the European Beyond Oldest Ice (BE-OI) project and the US Ice Drilling Program in accordance with IPICS call for two or more oldest ice cores. The target drilling sites for MYIC and BE-OI are in the 'little Dome C' region (~30km south of Dome Concordia Station) where collaborative radar surveys and modelling indicate million-year-old ice is likely present in a ~2.8 km-deep stratigraphically-continuous profile. The suite of MYIC measurements will include the primary greenhouse gases and their isotopes, temperature and climate proxies, radionuclides, volcanic markers and tracers of crustal weathering.

The project is led by the AAD, partnering with CSIRO and UTAS, with ongoing development of other national and international collaborations. The presentation will update the community on drill development, MYIC science and collaborative opportunities. We hope to stimulate discussion and engagement with the broader Antarctic science community.

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Late Holocene climate variability inferred from lake sediments in Lützow-Holm Bay, East Antarctica

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Lakes in coastal ice-free regions of Antarctica sit at the boundary of the continent and the oceans, providing an opportunity to fill a spatial gap between palaeoclimate records derived from ice cores and those from lower latitudes. High resolution records have been developed from the sediments of Lake Hamagiku and Lake Naga in Lützow-Holm Bay, East Antarctica, tracing environmental change through the last 3000 years. These reconstructions are based on sedimentary diatom species composition and bulk organic matter carbon and nitrogen isotope ratios. These records of past environmental change are supported by an investigation into the modern relationship between diatom assemblages and their habitats and lake water chemistry. Specific conductivity was found to be the primary factor explaining variations in diatom assemblage. Diatom assemblages were also found to significantly differ between the littoral region and the lake floor deeper than two metres water depth. Both lakes record a coherent and sustained shift in fossil diatom assemblage at ~1800 cal. yr BP, interpreted to reflect an increase in the duration of ice-free conditions associated with regional warming. Lake productivity, inferred from diatom valve concentrations and isotope geochemistry, appears to be stable through this time period however, which is attributed to limitations imposed by low nutrient conditions. Periodicity with a wavelength of ~250 years was identified in the records from both lakes. These periodicities are consistent with those reported from a range of Southern Hemisphere paleoclimate records and reconstructions, and have been associated with both solar activity and Southern Hemisphere westerly airflow.

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Eight centuries of hydroclimatic variability recorded in a southwest Australian speleothem with an annually resolved chronology

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Speleothems from Golgotha Cave in SW Western Australia have been investigated to extend our knowledge of past climate variability for this region during the last millennium. A challenge in their interpretation has been the disagreement between these records despite representing coeval growth from within the same cave. This presentation will focus on a record (GL-S4) that grew continuously over the past eight centuries determined by counting annual chemical laminations. The paleoclimate interpretation of GL-S4 is informed by long-term monitoring of Golgotha Cave to characterise the hydrology[1-5], hydrochemistry[5,6], rainfall water isotopes[7] and the development of proxy system forward models[1,8]. A principal components analysis demonstrates that the dominant variability in the GL-S4 geochemical record is attributable to hydroclimate (PC 1), soil connectivity (PC 2) and bedrock weathering (PC 3). These results provide eight centuries of baseline data to extend our knowledge of past hydroclimate variability for this region that is currently experiencing a prolonged decrease in rainfall.

1701

Late Pleistocene and late Pliocene records of glacial-interglacial paleotemperatures and depositional processes in the outer Amundsen Sea from diatom morphometrics and sedimentary microfabrics

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Drilling in the outer Amundsen Sea, IODP expedition 379 recovered Upper Pliocene and late Pleistocene biosiliceous records that document oceanographic changes coincident with dramatic glacial-interglacial changes in the West Antarctic Ice Sheet (WAIS) and the Southern Ocean. We are generating preliminary paleotemperature records for the last 620 kyrs (representing Marine Isotope Stages 15 (MIS-15) to MIS-4) from quantitative morphometric analysis of the dominant Pleistocene diatom Fragilariopsis kerguelensis, following techniques pioneered by Kloster and colleagues (2014; 2018; 2019). Utilizing the SHERPA image processing and analysis package, we assess two distinct morphotypes that have been shown to correlate with temperature and water mass. We have reason to believe that a significant amount of these diatoms are advected from the upwelling zone further offshore, rather than recording local production, thus the record may be useful in tracking changes in southward advection of diatoms in Circumpolar Deep Water; a primary influence on marine ice sheet instability.

Many Late Pliocene interglacials here are characterized by a strong association of enhanced ice-rafted detritus (IRD) coincident with very high diatom productivity. Using continuous light and scanning electron microscopy through key intervals we are documenting microfabrics that demonstrate a direct link between enhanced iceberg production and diatomite accumulation. This strong correlation may indicate that WAIS collapse events and iceberg melting, especially in the late Pliocene, enhanced nutrient availability to the Southern Ocean, either directly from the continent or by changing upwelling or current patterns associated with ice sheet retreat.

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A first insight into mercury atmospheric deposition in lakes from sub-Antarctic Macquarie Island

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Mercury is a potent neurotoxin with a high rate of bioaccumulation and biomagnification in food chains, causing serious health issues for wildlife and human populations. The atmospheric residence time of elemental mercury is several months to a year, and therefore it can travel long distances in the atmosphere and be deposited to remote locations such as the Antarctic region. In this study we measured mercury concentrations and fluxes in sediments of two lakes on sub-Antarctic Macquarie Island (Lake Tiobunga and an unnamed lake in the northwest, Lake 1) to examine the influence of climate and anthropogenic activities on mercury deposition. Mercury fluxes in the last 3,000 years varied from 4 to 26 (ug-1m2 yr-1), with the highest fluxes recorded between ~600 and 300 cal yr BP (1400-1700 CE). Mercury fluxes also increased in the last 100 years, suggesting the influence of anthropogenic effects such as industrial emissions and long-distance transport, as well as erosional inputs associated with the activities of introduced rabbits. Lakes from other sub-Antarctic islands need to be studied to provide a refined history of the effects of climate and wind strength on mercury deposition in the sub-Antarctic region, as well as to decouple the anthropogenic influence on mercury deposition in Macquarie Island in the last 100 years.

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Antarctic climate response to large volcanic eruptions in the historical period

Antarctic Climate Response To Large Volcanic Eruptions In The Historical Period Natalia Silva[1], Antarctic Climate Response To Large Volcanic Eruptions In The Historical Period Ilana Wainer[1], Antarctic Climate Response To Large Volcanic Eruptions In The Historical Period Myrian Khodri[2]
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Large tropical volcanic eruptions are well known to change the global climate and maybe even interfere with some natural modes of variability such as El Niño Southern Oscillation. As they inject a high amount of sulfur gas into the stratosphere, sulfate aerosol loading increases a few months after the eruption, which is then transported globally. Large tropical events may, therefore, affect extratropical climate variability. For example, temperature changes have been identified in Antarctica after the Pinatubo eruption in 1991, as warming in the peninsula. However, a causal link with the eruption and, more generally, a possible influence of large tropical volcanic eruptions on the Southern Hemisphere climate are still open questions. In this study, we aim to focus on the five biggest eruptions of the historical period (Krakatau — Aug/1883, Santa María — Oct/1902, Mt Agung — Mar/1963, El Chichón — Apr/1982 and Pinatubo — Jun/ 1991) by assessing two CMIP6 class models (IPSL-CM6A-LR Large Ensemble and BESM) and two Reanalyses (NOAA 20th Century Reanalysis and ECMWF's ERA 20th Century).

32

Diatoms in Ice Cores, a new proxy for reconstructing past wind strength in the Amundsen-Bellingshausen Seas region, Antarctica

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In the last decade, several efforts have been carried out to assess the causes of the current rapid recent warming measured on West Antarctica and Antarctic Peninsula. The increase in wind strength and shifts in atmospheric circulation patterns have shown to play a key role in driving the advection of warm air from mid-latitudes to high-latitudes. Winds are also responsible for driving surface melting in the ice shelves, enhancing the removal of surface snow, and for promoting basal melting through the upwelling of deep warm water. All these combined have shown to produce substantial effects on environmental parameters, such as sea surface temperatures, sea ice extension, air surface temperatures and precipitation.

Even though winds are fundamental components of the climatic system, there is a lack of reliable long-term observational wind records in the region. This has hindered the ability to place the recent observed changes in the context of a longer time frame.

In this work, we present records of marine diatoms preserved in a set of ice core retrieved from the southern Antarctic Peninsula, the Ellsworth Land region and sub-Antarctic Islands. The diatom abundance and species assemblages from these ice cores prove to represent the local/regional variability in wind strength and circulation patterns that influence the onshore northerly winds. We use this novel proxy to produce an annual reconstruction of westerly winds in the Amundsen - Bellingshausen seas region during the last two centuries.

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Bottom water oxygenation changes in the Southern Indian Ocean over the last glacial cycle: implications for the efficiency of the ocean biological carbon pump

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A larger remineralized carbon pool in the deep glacial ocean has been related to a more efficient sequestration of CO2, yet the interplay and dynamics of potential mechanisms responsible for this drawdown such as a slower glacial overturning circulation and/or a more efficient biological carbon pump remain elusive. Bottom water oxygenation reconstructions based on redox-sensitive trace metals can help decipher the relative contribution of these processes on the magnitude and efficiency of the partitioning of carbon between the ocean and atmosphere. We present downcore manganese (Mn) and authigenic uranium (aU) records from the last glacial-interglacial cycle based on three sediment cores retrieved in the vicinity of the Kerguelen Plateau in the Southern Indian Ocean covering a transect from the Antarctic to the Subantarctic Zones. For the Subantarctic and Polar Frontal Zones, we report higher bottom water oxygenation during interstadials and lower oxygenation during glacial periods. Compared with export production reconstruction, this suggests a dominant influence of ventilation changes compared to local export production on sedimentary redox conditions. Export production may have entailed a secondary influence on bottom water oxygenation during terminations as a result of enhanced aeolian Fe supply at our core sites, enhancing by inference the respiratory oxygen demand associated with organic matter remineralization. In the Antarctic Zone, we cannot detect a coherent glacial-interglacial bottom water oxygenation pattern. The robustness of trace-metal reconstructions may be limited due to the shallow core location exposed to temporally varying water masses and thereby affecting oxygenation patterns.

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A new dinoflagellate cyst-based transfer function for the Southern Ocean: Quantifying sea surface temperature, sea-ice and nutrient availability

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Dinoflagellate cyst assemblages are widely used to reconstruct past marine environmental conditions. Most of these reconstructions have been qualitative, limiting their potential and impeding immediate comparison to other proxies. As dinoflagellate cysts are often continuously present in past sediments, a new quantitative approach would greatly improve the reconstruction of past ocean conditions.

Here, we present a novel way to better quantify sea surface temperature, sea ice and nutrient availability for the Southern Ocean based on modern sedimentary dinocyst assemblages. We combine previously published (Marret et al., 2019) and new surface sedimentary dinoflagellate cyst assemblages from the Southern Indian Ocean and the Ross Sea, increasing the spatial coverage of ice-proximal locations, with a novel way to assess the connection of sedimentary particles to the overlying water. Lagrangian particle trace simulations in high-resolution (1/12°) ocean models allow us to account for lateral transport by ocean currents and thus lead to a more accurate identification of surface water source regions of the sedimentary dinocyst assemblages.

We now make use of several statistical means, such as a bayesian approach, to further detect, separate and improve correlations between the new database of modern dinocyst assemblages and environmental conditions. Eventually, we compare these results to existing techniques (such as the modern analogue techniques or weighted averaging–partial least squares) in order to translate dinocyst assemblages to quantitative paleoceanographic conditions.

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Climate variability in Antarctica and the Southern Hemisphere over the past 2000 years (CLIVASH2k)

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The CLIVASH2k working group is part of the PAGES 2k network. We aim to improve our understanding of large-scale modes of climate variability and the mechanisms and drivers of climate change in Antarctica, the sub-Antarctic and the wider Southern Hemisphere during the past 2000 years. We build upon previous PAGES syntheses documenting changes in Antarctica over the past 1000-2000 years to focus on the mechanisms driving climate variability. The working group is open to anyone working on climate variability in the southern hemisphere and currently consists of paleoclimateologists working on a range of archives (ice cores, marine sediments, lake sediments, and peat and moss banks), climatologists and climate modellers. Come along to the poster for more information and ways to get involved.

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The 14CO2 bomb pulse in firn air and ice at Aurora Basin North, East Antarctica.

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In modern times, the natural radiocarbon (14C) cycle has been perturbed by the large-scale combustion of fossil fuels during the industrial period and more recently by nuclear technologies. The above-ground testing of nuclear weapons during the 1950s and 1960s doubled the amount of 14C in the atmosphere and this 'bomb-pulse' of 14CO2 has been taken up in plants through photosynthesis. It has also been incorporated in air in open pores of firn before close-off in bubbles in polar ice sheets. Due to its rapid onset and known decline, the pulse provides a powerful constraint to quantify the smoothing of atmospheric CO2 signals due to firn diffusion and bubble close off. The degree of smoothing determines the time resolution with which trace gas histories can be reconstructed from ice cores. When used to tune a firn air diffusion model, the measured 14CO2 'bomb pulse' also permits accurate dating of CO2 and other gases in the air record.

Here we report on the extraction of CO2 from Aurora Basin North (ABN) firn air and ice core air bubbles. As expected, results suggest the age spread at ABN is wider than higher accumulation sites, such as Law Dome. Firn modelling has been completed and the 14C results have been incorporated to help determine (with other gas measurements) the age and age spread of air in firn and ice at ABN. Measurements at ABN will also help confirm variations measured in other cores such as at Law Dome.

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Exploring Past Connections between Productivity and Iron Supply at the Subtropical Front

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Dust can affect the global climate through several ways amongst which fertilization of the HNLC regions by iron-bearing dust is an important one. However, present-day iron-fertilization experiments have failed to reproduce a large-scale, sustained productivity increase that would result in substantial CO2 drawdown. One of the major questions is whether a significant portion of the organic carbon produced in the surface waters due to nutrient utilization is exported below the mixed layer and preserved in underlying sediments. In this scenario, the response of productivity to the past episodes of iron-bearing dust increase can provide a clue. Here we present a record of nutrient utilization (nitrogen isotope ratio of sedimentary organic matter) and consequent productivity variability and its preservation (total organic carbon and nitrogen content of bulk sediment) from the Subtropical Front of the Indian Ocean sector of the Southern Ocean (42 °S latitude and 48 °E) for the past 71 kyr. We find that the nutrient utilization and productivity preserved in the sediments are strongly coupled. We further compare our results with the EDC dust flux representing global dust concentration and ODP1090 Fe mass accumulation rate (MAR) from the Atlantic sector of the Southern Ocean representing iron-bearing dust input in the Southern Ocean. We find that nutrient utilization increases during glacial periods along with the iron-bearing dust supply, which is accompanied with high productivity. The close correspondence between these records reveals a possible connection between aeolian dust influx and global climate via natural iron ocean fertilization.

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High-Resolution Paleoceanography of the Falkland Slope and the Scotia Sea during Pleistocene based on IODP Expedition 382

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Iceberg alley and Sub-Antarctic zone of South Atlantic is a key modulator for the global climate. The sensitivity and the importance of this region to the climate change have been a significant topic of research with respect to past, present and future climate. The studies related to long term climate reconstructions and frontal movement during the glacial-interglacial cycles are lacking in the Iceberg Alley. Resolving changes in the transition of various fronts located in the region is crucial for advancing our understanding of the Southern Ocean's role in affecting ocean and climate change on a global scale. Diatom-bound □15Ndb was used to reconstruct the glacial-interglacial nutrient utilization variability of the Subantarctic Zone. Earlier down-core records from the Southern Ocean showed □15Ndb variability of 5 to 6 ‰ during the Last Glacial Maximum. The □15Ndb values decreased to values as low as 2 ‰ during the glacial terminations. Changes in nutrient utilization may have resulted from atmospheric dust influx and/or decreased mixed layer depths associated with sea ice melting. Enhanced nutrient consumption during glacial periods in Sub-Antarctic regions would have lowered the concentration of CO2 in the atmosphere. We will present here the □15Ndb and □15N-SOM of the scrape sediment and squeezed cake samples retrieved during IODP expedition 382 spanning the timespan of Pleistocene.

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Synoptic climatology of the Southern Indian Ocean and potential links to East Antarctic ice cores

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Interpretation of eastern Antarctic ice-core palaeoclimate proxies can be improved through better understanding of the synoptic-scale dynamics and variability of the Southern Indian Ocean. In the case of high-resolution (seasonal to annual) ice-cores, this is especially important, as event-scale precipitation and redistribution of surface snow can enhance or weaken links to regional climate processes. Two high resolution ice-cores in East Antarctica, Law Dome and Mt Brown South (MBS), provide an opportunity to extend and broaden our understanding of Southern Indian Ocean synoptic variability prior to the modern satellite era (post 1979). However, limited understanding of the variability of synoptic processes (daily to decadal) influencing the East Antarctic ice-cores and how these are preserved in ice cores hampers the interpretation of palaeoclimate proxies. Here we present results from a synoptic typing study for the Southern Ocean region between 40°E and 180°E – the 'atmospheric catchment' region for both Law Dome and MBS. Our results describe regional synoptic conditions, ranging from meridional, mixed and zonal patterns. The zonal and mixed patterns were strongly correlated with the Southern Annular Mode (SAM); however, the regional synoptic representation of positive SAM conditions is not zonally symmetric. Additionally, our results indicate that during austral spring and summer, the meridional patterns have stronger relationships with tropical modes of climate variability (i.e. Indian Ocean Dipole, El Nino Southern Oscillation) compared to SAM. These results are useful for East Antarctic atmospheric transport and climate variability research, in particular for improved interpretation of East Antarctic ice-core climate proxies.

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Evidence of Southern Hemisphere lead in a millennial-scale warming event of the last glacial period

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The Northern Hemisphere millennial-scale climatic oscillations of the last ice age, known as 'Dansgaard-Oeschger' (DO) events, and their Southern Hemisphere counterparts, 'Antarctic Isotope Maxima' (AIM), are characterized by their distinct phase relationship known as 'bipolar seesaw'. A recent study taking advantage of high-resolution ice core records from Antarctica and Greenland, suggests that DO-AIM events are initiated in the Northern Hemisphere. Here, we present the relative timing of these events in Roosevelt Island Climate Evolution (RICE) and Northern Greenland Ice Sheet Project (NGRIP) isotope records between 26-40 kilo years before present (ka BP 1950 AD). The well-constraint RICE age model and continuous flow methane record provide an opportunity to examine the relative phasing during AIM-DO4. We demonstrate that RICE cools 209±81 years prior to the onset of this Greenland interstadial, which could indicate the Southern Hemisphere initiation of these events, and nuances the generic Northern Hemisphere push. We propose that the influence of water column stratification resulting from sea-ice melt on areas of open-ocean convection as the major causal mechanism for the weakening of the southern limb of overturning circulation in the Ross Sea. Additional factors may have also contributed to the build-up of water column stratification in the region, such as local insolation changes and ice sheet melt. Our results show that the evolution and relative phasing of individual DO-AIM events varies, providing additional insights into the drivers of these events.

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An Interdecadal Pacific Oscillation reconstruction spanning the last two millennia

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The Interdecadal Pacific Oscillation (IPO) is a nominally 15-30 year climate mode identified through analysis of Pacific sea surface temperatures over the past 150 years. It is unclear whether the IPO is a true oscillation or simply the low frequency response of the climate system to forcing, principally ENSO. Nonetheless, the IPO has clear climate impacts, one example being hydroclimate variability in Australia. In positive phases of the IPO, drought risk is heightened due to a reduction in the likelihood of large, recharging La Nina-derived rainfall events. In negative phases, flood risk in Australia is greatly increased due to an increased likelihood of such rain events.

Previous work derived a 1000 year, reconstruction of the IPO from multiple palaeoclimate archives from the Law Dome ice core in East Antarctica. This reconstruction allowed the assessment of the true risk of drought- and flood-prone epochs in Australia. Subsequently, an entirely independent reconstruction of the IPO was developed using SE Asian tree records by Buckley et al. (2019), spanning most of the last millennium. The fidelity the two reconstructions display with respect to the instrumental IPO record and each other suggests both are representing IPO variability. Here we present an IPO reconstruction that doubles the temporal span of existing reconstructions to cover the last 2000 years using newly analysed and dated material from the Law Dome ice core. This new, longer reconstruction identifies important features of Pacific decadal variability that have significant implications for understanding hydroclimate epochs across Australasia and the Pacific region.

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High spatial and temporal variability of surface mass balance at ice rise and promontories in Dronning Maud Land (East Antarctica): precipitation vs. post-depositional processes

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The surface mass balance (SMB) is one of the largest sources of uncertainty when determining the Antarctic ice sheet total mass balance and thus Antarctica's contribution to sea level rise. Here we present a reconstruction of surface mass balance at two ice promontories located in Princess Ragnhild Coast (Dronning Maud Land). To reconstruct the SMB history, we first date our ice cores using a suite of seasonal parameters (water stable isotopes, major ions and ice conductivity). Annual layer thickness is then converted into meter water equivalent using the measured density profile and by accounting for ice deformation at depth using strain rates. The latter are obtained from ice dynamical modelling at the ice divide and differential OPTV measurements from repeated surveys in the borehole.
The resulting SMB reconstructions exhibit a large interannual variability without any trend over the last 50 years for both promontories. This is in sharp contrast with the SMB reconstruction from the Derwael Ice Rise (located at 90 km from our easternmost promontory) that showed a significant SMB increase since the 1950's, consistent with expected snowfall increase as a result of higher temperatures (Philippe et al., 2016). Different factors may contribute to these contrasting results over a relatively short distance, such as variability in precipitation regime (e.g. atmospheric rivers) and/or post-depositional processes (e.g. wind erosion). Such large discrepancies over short distances of the order of spatial resolution of global atmospheric models have major implications for understanding precipitation changes across the Antarctic ice sheet.

1105

Ice core biomarker constraints on past sea ice change in the Ross Sea

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Ice core biomarkers show great promise for reconstructing marine primary productivity and sea ice change in Antarctic waters. A novel ice core biomarker based on spectroscopy of fluorescent Organic Matter (fOM) paired with Imaging Flow Cytometry (IFC) offers new information on changes in microbiota transported in the atmosphere and deposited in Antarctic snow. Here we provide the first results of fOM from the Roosevelt Island Climate Evolution (RICE) ice core recovered from the northern margin of the Ross Sea. The 10 m firn core record of fOM captures marine variability over the past 50 years. We outline our plans to extend the fOM record to the past 2000 years providing constraints on marine primary productivity and sea ice change. Correlation of the RICE record with annually resolved marine sediments will extend the relatively short observational record of sea ice in the Ross Sea region improving our understanding of regional climate variability.

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The sensitivity of the early Cenozoic Southern Ocean to Tasman Gateway depth and wind stress

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Ocean circulation is largely modulated by the distribution of continents and seafloor topography. Tectonic motions of continents through the Cenozoic led to the opening of gateways between major ocean basins, causing the alteration of global ocean circulation. While the role of Tasman Gateway deepening has been modelled in the past, the role of wind stress in the Southern Ocean has not yet been investigated. Here, we use an eddy-permitting model (0.25°) with relatively realistic paleobathymetry to investigate the evolution of the Cenozoic Southern Ocean under the gradual deepening of the Tasman Gateway and latitudinal modifications of wind stress. We find that clockwise polar gyres exist in both Pacific and Indo-Atlantic sectors of the Southern Ocean. The latitude of the wind band affects the size and strength of the gyres. As the wind band moves southward, the gyres get shrunk, while the strength is intensified. A strong eastward current develops under the synergistic actions of gateway deepening and wind stress shifts to the south. The influence of the latitude of the wind band is particularly noticeable when the Tasman Gateway is deep at 1500 m, where a 5 degree southward shift causes a strengthening of this interbasinal current by about 20 Sv. Furthermore, we propose that it is the latitude of maximum westerly wind relative to the northern margin of the deep Tasman Gateway that controls the strength of the throughflow.

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Antarctic sea ice variability during the past 200 years

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In contrast to the Arctic, where total sea ice cover has been decreasing since systematic satellite observations began in the late 1970s, Antarctic sea ice has shown a steadily and significant increasing trend from 1979 to 2014, followed by a precipitous decline after 2014. However, the observational period is too short to evaluate the sea ice variability and its drivers over decadal to multi-decadal time scales. In this study, ice core and fast ice records are used to reconstruct the latitude of northernmost sea ice extent (NLSIE) for different sectors of the Antarctic, including the Indian and west Pacific (IndWPac), Ross Sea (RS), Amundsen Sea (AS), and Weddell Sea (WS). We analyze the linear trends of the NLSIE for the past 100~200 years (-0.03°, 0.02°, 0.07°and -0.08° per decade for the IndWPac, RS, AS, and WS respectively) and identify possible regime shifts using a sequential data processing scheme. Our results suggest that the NLSIE trend in all sectors accelerated after the mid-20th century. The rapid decreasing trend in IndWPac was associated with the positive shift of Indian Ocean Dipole (IOD) and Southern Annular Mode (SAM). The increasing trend in RS and AS, and the decreasing trend in WS was associated with the multi-decadal variability of Interdecadal Pacific Oscillation (IPO) and the positive trend of SAM.

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Identifying atmospheric processes favouring the formation of physical features in the Mount Brown South ice core.

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The features preserved in ice cores provide crucial and unique records about the past atmospheric variability, offering the possibility to increase knowledge of the climate system and better predict future climate changes. Consequently, understanding the link between features in ice cores and the atmospheric processes causing them is key to interpreting the palaeoclimate information preserved in Antarctic ice. Ice cores from Mount Brown South (MBS), East Antarctica, were drilled to help understand the past atmospheric circulation variability in the southern Indian Ocean and southwest Pacific Ocean. In addition to chemical and isotopic records, high-resolution images of the ice core were made using an Intermediate Layer Ice Core Scanner (ILCS). Upon physical inspection of these images, there are visible bubble-free layers occurring frequently multiple times a year, and the origin of these features is still unknown. This project aims to determine whether the bubble-free layers in the MBS ice core can be related to atmospheric processes. We use the newly available reanalysis products (ERA5) from the European Centre for Medium range Weather Forecasts (ECMWF) to investigate the occurrence of atmospheric processes in the Mount Brown region including temperature inversions, wind scour and accumulation hiatuses. We dated the ice cores using multiple annual chemical and isotopic horizons, and then used ERA-5 regional accumulation to estimate the season that the bubble-free layers occurred during 1979-2017. This information is used to detect the weather patterns occurring when the layers were formed in order to identify the most likely processes causing the bubble-free layers.

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Magnetostratigraphy and Environmental Magnetism Study of Hole U1524A from IODP Expedition 374

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IODP Expedition 374 aims at resolving the Ross Sea ice sheet history since the Miocene. Hole U1524A is cored ~120 km north of the Ross Sea continental shelf edge, providing important materials to reconstruct the ice sheet variability and corresponding driving forces. To determine the age of the cores of U1524A, U-channel samples were taken from the top 8 cores and discrete cube samples were taken from the rest of cores. The natural remanent magnetization (NRM) of the samples are AF-demagnetized in order to determine the characteristic remanent magnetization (ChRM) upon which the magnetostratigraphy is built. The NRM of the majority of samples are effectively demagnetized up to 80 mT. It is observed that most samples carry pronounced overprints at the low coercivity range (< 10 mT), with weak signals left for ChRM determination. Detailed rock magnetic experiments suggest that ChRM of weakly magnetized samples are often suspicious. We attempted to correct the ChRM of weak samples in order to extract the geomagnetic information from noisy data. Finally, three major normal/reversed polarity sequences are identified (down to the bottom of Core 30), which suggests the bottom of Core 30 was deposited in the Mammoth Subchrons that is about 3.3 Ma ago.

In addition, the magnetic properties of representative samples of Hole U1524A were compared with sediments from Antarctic Circumpolar Current in the Central South Pacific sector retrieved by IODP Expedition 383. The environmental connection between the Ross Sea and the far-field region are discussed based on the magnetic properties.

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