SCAR 2020

Antarctic Science - Global Connections

SCAR OPEN SCIENCE CONFERENCE 2020

SESSION 3

ANTCLIM21 AND BEYOND: FUTURE ANTARCTIC CLIMATE CHANGE ON DECADAL TO CENTENNIAL TIMESCALES

Nancy Bertler

Lettie Roach, Tom Bracegirdle

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

1676

Stability of soil organic matter in ornithogenic soils of the Maritime Antarctica

Ivan Alekseev[1], Evgeny Abakumov[1]
[1]*Saint Petersburg State University, Saint Petersburg, Russian Federation*

Climate change in the polar regions has been described as very dramatic in recent decades. Better understanding and modeling the Earth´s climate system requires improving our knowledge of carbon, water and energy exchange between terrestrial ecosystems and the atmosphere (IPCC, 2007). In severe climatic conditions of Antarctica birds play an important role in transportation of organic matter to the coastal landscapes. This study is aimed at studying structural and molecular composition of organic matter in soils of King George and Ardley islands (South Shetland Islands). We revealed that redistribution of guano components significantly affects the speed of soil cover spatial development and formation of new polypedons. We found that the humic acids (HAs) of the cryoturbated, buried areas had lower amounts of alkyl aromatic and protonized aromatic compounds. In contrast, the HAs from the surface layers contain less alkyl carbon components. Our data showed that the portion of aromatic compounds is little higher in soils under materials transported by birds compared to soils developed under bryophyta or lichens communities. This is probably because birds use mainly remnants of Deschampsia antarctica (with high portion of phenyl-propanoic organic precursors) for nest building. Comparison of the 13C-NMR spectra of the HAs and the bulk SOM revealed that humification occurs in the Antarctic and results in accumulation of aromatic and carboxylic compounds and reductions in alkylic ones. This indicates that humification is one of the ways of soil organic matter stabilization.

265

Understanding the response of the Amundsen Sea Embayment to century-scale ocean forcing

Alanna Alevropoulos-Borrill[1], Nicholas Golledge[1,2], Stephen Cornford[3]
[1]Antarctic Research Centre, Victoria University Of Wellington, Wellington, New Zealand, [2]GNS Science, Lower Hutt, New Zealand, [3]Department of Geography, Swansea University, Swansea, UK

Projections of the 21st century Antarctic sea level contribution are uncertain. Much of this uncertainty is associated with the mass loss from the Amundsen Sea Embayment (ASE), a catchment that has experienced considerable mass loss and grounding line retreat in recent decades. Ocean forced basal melting, controlled by wind driven transport of warm Circumpolar Deep Water (CDW) toward ice shelf cavities, is responsible for the observed thinning and speed up of ASE glaciers. The delivery of CDW toward grounding lines of ASE ice streams is projected to increase over the 21st century, driving high melting and grounding line retreat. Here we present a series of idealised experiments of 21st century basal melting applied to a regional set up of the ASE. We use the BISICLES ice sheet model which uses adaptive mesh refinement to model grounding line position at high resolution (250 m). The sensitivity experiments are forced with a series of linear increases in the applied sub-ice shelf melting which are then removed at varying intervals to show the dynamic response of the system in the absence of forcing. We repeat these experiments but with a removal of forcing, allowing the grounding line to advance. The results provide an indication of whether advance of the grounding line is plausible after substantial ocean forcing and, if so, what magnitude of ocean cooling is necessary for the ASE ice streams to recover.

722

Drivers of Antarctic Intermediate and Mode Water export in CMIP models

Lucas Almeida[1], Mauricio Mata[1], Matthew Mazloff[2]
[1]Federal University Of Rio Grande, Rio Grande, Brazil, [2]Scripps Institution of Oceanography, San Diego, United States

The subduction rates in the circumpolar region are responsible for the formation of the Subantarctic Mode Water and Intermediate Antarctic Water in the Southern Ocean, which consist as part of the upper branch of the meridional overturning circulation, highly important in the global climate system. Theoretical understanding predicts these waters masses are driven by wind stress curl and buoyancy fluxes. The objective of this work is to evaluate how much of AAIW and SAMW variability in CMIP solutions (generation 5 and 6) is correlated to Southern Ocean fluxes. We compare AAIW and SAMW volume transport at 30oS with Ekman Pumping, Freshwater and Heat Fluxes through a Multivariate Regression procedure. We found a significantly variability of mean transport of the water masses between CMIP models. Initially, was test temporal lags were tested individually for each parameter in the analysis and resulted in a better correlation with no lags for Ekman Puming, 2 months for Freshwater fluxes and 3 months for Heat fluxes. The multivariate analysis showed that AAIW and SAMW are significantly correlated to fluxes in most models, with few exceptions. Heat fluxes is the dominant forcing to explain variability of AAIW, while the export of SAMW was best explained by a combination of Ekman Pumping and buoyancy fluxes. Correlation coefficients in most models are consistent with theoretical expectations, with a positive (negative) relationship with Ekman Pumping (buoyancy fluxes).

1381

Evaluation of the representation of the Antarctic continental shelf seas in climate models

Qiang Sun[2], Christopher Little[2], Alice Barthel[1]
[1]Los Alamos National Laboratory, Los Alamos, United States, [2]Atmospheric and Environmental Research, Inc., Lexington, United States

The Antarctic Continental Shelf Seas are a critical, rapidly-changing, element of the Earth system. Evaluation of the representation of the Antarctic continental shelf seas across CMIP6 models is critical: regional water mass properties are used to drive sea level projections from the Antarctic ice sheet, and previous CMIP ensembles show substantial biases with a wide inter-model and inter-region spread. However, the Antarctic continental shelf seas remain sparsely sampled, posing challenges for model-data comparison.

This study aims to evaluate and compare climate model performance on the Antarctic continental shelf. In particular, we showcase a new cluster-based, grid-independent, methodology to identify and compare regional water masses. Applied to WOA18, this method identifies various regimes on the shelf, such as regions of high salinity shelf water formation, and regions of mixed water masses. Preliminary work with CESM demonstrates that this method can identify the location of distinct shelf regimes independently of the mean-state model bias. This method will be used in conjunction to more traditional water masses characterization to evaluate CMIP6 models.

1613

Rapid Ross Sea Deglaciation as captured in the RICE Ice Core

Nancy Bertler[1,2], Howard Conway[3], Dorthe Dahl-Jensen[4], Ed Brook[5], Jeff Severinghaus[6], James Lee[7], Nicolas Golledge[1], Dan Lowry[2], Abhijith Ulayottil Venugopal[1,2], Lukas Eling[1,2], Katelyn Johnson[1,2], Liz Keller[2], Rebecca Pyne[2], and the RICE Science Team

[1]Victoria University , Wellington, New Zealand, [2]GNS Science, Lower Hutt, New Zealand, [3]University of Washington, Seattle, USA, [4]University of Copenhagen, Copenhagen, Denmark, [5]Oregon State University, Corvallis, USA, [6]Scripps Institution, San Diego, USA, [7]Los Alamos National Laboratory, Los Alamos, USA

The Roosevelt Island Climate Evolution (RICE) project recovered a 763.4 m deep ice core to bedrock from Roosevelt Island, at the northern edge of the Ross Ice Shelf. The ice at Roosevelt Island is grounded 210m below sea level and accumulates in situ, with the Ross Ice Shelf flowing around the rise.

Comparison of the modern RICE isotope data with meteorological records from weather stations and reanalysis products suggest that the record is representative of the temperature variability in the Ross Sea Region, the Ross Ice Shelf and western West Antarctica. In addition, the analysis shows that the RICE record is particularly sensitive to changes in regional sea ice extent and low and mid latitude climate drivers, in particular to the combined effects of the El Niño Southern Oscillation, the Pacific Decadal Oscillation and the Southern Annular Mode.

Here, we show isotope and geochemical data spanning the past 68 ka. Our data suggest that the Ross Ice Shelf grounding line retreat during the last deglaciation was driven at least in part by the early onset of deglaciation in West Antarctica as recorded in the WAIS Divide ice core (WDC). The Ross Ice Shelf grounding line started to retreat rapidly with the initiation of an ice shelf cavity. Atmospheric circulation changes precede the onset of the Antarctic Cold Reversal (ACR) by about 200 years. We observe that RICE leads the WDC onset of the ACR by about 300 years.

502

Twenty first century changes in Antarctic and Southern Ocean surface climate in CMIP6

Tom Bracegirdle[1], Gerhard Krinner[2], Marcos Tonelli[3], Alexander Haumann[4], Kaitlin Naughten[1], Thomas Rackow[5], Ilana Wainer[3]

[1]British Antarctic Survey, Cambridge, United Kingdom, [2]CNRS, Grenoble, France, [3]Universidade de Sao Paulo, Sao Paulo, Brazil, [4]Princeton University, Princeton, USA, [5]AWI, Bremerhaven, Germany, [6]University of Washington, Seattle, USA

Reliable estimates of Antarctic climate system responses under a range of future climate forcing scenarios are a high priority since, for example, ecosystems and ice shelves are highly sensitive to the timing of crossing of key thresholds in regional conditions. In the presentation results from an assessment of absolute and global-relative 21st century projections will be shown for a wide range of climate forcing scenarios based on output from the latest generation of state-of-the-art climate models participating in the new Coupled Model Intercomparison Project Phase 6 (CMIP6). Firstly an overview will be given of the main broad-scale 21st century Antarctic projections provided by the CMIP6 models across four forcing scenarios: SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5. End-of-century Antarctic surface-air temperature changes across these scenarios (relative to 1995-2014) are 1.4, 2.6, 3.8 and 4.9 °C. The corresponding proportional precipitation rate changes are 8, 15, 23 and 30 %. Results will then be shown highlighting that across these scenarios projected changes over Antarctica and the Southern Ocean exhibit significant departures from a simple proportional link to global forcing. This is particularly apparent in the aggressive mitigation scenario (SSP1-2.6) which, compared to higher-forcing scenarios, exhibits stronger global-relative 21st century warming over coastal Antarctic and the Southern Ocean. Internal ocean dynamics and projected recovery of Southern Hemisphere (SH) stratospheric ozone both appear to play a role. These results highlight the importance of accurate representation of key regional processes, some of which are still not widely incorporated in contemporary climate models.

501

Improvements in Circumpolar Southern Hemisphere Extratropical Atmospheric Circulation in CMIP6 Compared to CMIP5

Tom Bracegirdle[1], Caroline Holmes[1], Scott Hosking[1], Gareth Marshall[1], Marisol Osman[2], Matthew Patterson[3], Thomas Rackow[4]

[1]British Antarctic Survey, Cambridge, United Kingdom, [2]CIMA/CONICET-UBA, Buenos Aires, Argentina, [3]University of Oxford, Oxford, UK, [4]AWI, Bremerhaven, Germany

One of the major globally relevant systematic biases in previous generations of climate models has been an equatorward bias in the latitude of the Southern Hemisphere (SH) mid-latitude tropospheric eddy driven westerly jet. The far reaching implications of this for Southern Ocean heat and carbon uptake and Antarctic land and sea ice are key reasons why addressing this bias is a high priority. It is therefore of primary importance to evaluate the representation of the SH westerly jet in the latest generation of global climate and earth-system models that comprise the Coupled Model Intercomparison Project Phase 6 (CMIP6). In this paper we assess the representation of major indices of SH extratropical atmospheric circulation in CMIP6 by comparison against both observations and the previous generation of CMIP5 models. Indices assessed are the latitude and speed of the westerly jet, variability of the Southern Annular Mode (SAM) and representation of the Amundsen Sea Low (ASL). These are calculated from the historical forcing simulations of both CMIP5 and CMIP6 for time periods matching available observational and reanalysis datasets. From the 21 CMIP6 models currently available there is an overall reduction in the equatorward bias of the annual mean westerly jet from 1.9° in CMIP5 to 0.7° in CMIP6 and from a seasonal perspective the reduction is clearest in austral spring and summer. This is accompanied by a halving of the bias of SAM decorrelation timescales compared to CMIP5. However, no such overall improvements are evident for the ASL.

1283

Future climate response to Antarctic Ice Sheet melt produced by anthropogenic warming

Shaina Rogstad[2], Alan Condron[1], Robert DeConto[2], David Pollard[3]
[1]Woods Hole Oceanographic Institution, Woods Hole, United States, [2]University of Massachusetts Amherst, Amherst, United States, [3]Pennsylvania State University, , United States

Observational evidence indicates that the Antarctic Ice Sheet (AIS) is losing mass at an accelerated rate while ice sheet models highlight the potential for a significant future ice collapse in the next few centuries. The impacts of increased freshwater runoff and ice discharge into the ocean from a retreating ice sheet are now only beginning to be explored, and remain poorly constrained. Here, we report on changes to the climate system over the next 250 years (present to 2250CE) projected by a fully coupled global climate model (CESM 1.2) run under future greenhouse gas emissions scenarios IPCC RCP4.5 and 8.5, with meltwater discharge provided by a dynamic-thermodynamic Antarctic Ice Sheet model. The multi-century length of these simulations includes the full collapse of the West Antarctic ice sheet in the ice sheet model in the RCP8.5 run at ~2125CE in. We find that accounting for Antarctica's meltwater contribution raises sub-surface ocean temperatures at the ice sheet margin by more than 1°C, with the potential to substantially increase the rate of ice melt beyond current projections. In contrast, the surface freshening leads to a dramatic expansion of sea ice that causes Southern Hemisphere surface air and ocean temperatures to be 2-10°C cooler than experiments without meltwater from the ice sheet model. This change reduces projected global mean anthropogenic warming by 2°C during peak ice sheet collapse in experiment RCP8.5. Our results demonstrate a clear need to account for meltwater input from ice sheets if we are to make confident climate predictions.

671

Mean state and future trends of Antarctic snow accumulation dominated by atmospheric synoptic-scale events

Quentin Dalaiden[1], Hugues Goosse[1], Jan Lenaerts[2], Marie Cavitte[1], Naomi Henderson[3]
[1]Université catholique de Louvain (UCLouvain), Earth and Life Institute (ELI), Louvain-la-Neuve, Belgium, [2]Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder, Boulder CO, USA, [3]Lamont-Doherty Earth Observatory, Columbia University, Palisades, USA

The Antarctic continent has gained mass at its surface over the last century through increased snowfall, with a strong spatial variability. However, the mechanisms behind the snow accumulation changes are poorly understood. This limits our ability to assess precisely future projections of the Antarctic climate. Here, by analysing the Antarctic atmospheric moisture budget using reanalysis data and climate models, we show that the year-to-year variations in snow accumulation are governed by different processes than the multi-decadal snow accumulation changes. Our results reveal that both the moisture transport by the mean circulation and by short-lived synoptic-scale events control the inter-annual variability of regional snow accumulation. Yet, when considering the entire continent at the multi-decadal scale, only the synoptic-scale events can explain the snow accumulation increase over 1985-2014 AD and for the end of the 21st century. Our analysis indicates that, in a warmer world, these atmospheric synoptic-scale events transport more humidity due to increasing temperatures, which leads to more precipitation on the Antarctic continent and can therefore mitigate sea-level rise. Many studies have underlined the dominant contribution of the Southern Annular Mode in explaining variations of snow accumulation at regional scales but we show it has a much lesser role at the continental scale and on longer timescales. The mechanisms ruling accumulation changes identified from inter-annual changes over the last few years cannot thus be simply extrapolated to predict future accumulation changes.

449

Projected Slowdown of Antarctic Bottom Water Formation in Response to Amplified Meltwater Contributions

MATTHEW ENGLAND[1], Veronique Lago[1]
[1]UNSW , Sydney, Australia

The overturning of Antarctic Bottom Water (AABW) is a major regulator of the storage of heat, carbon, and nutrients in the ocean. AABW sinking is sensitive to changes in surface buoyancy, in particular due to freshening since salinity plays a greater role in determining density at near-freezing temperatures. Acceleration in Antarctic ice-shelf and land-ice melt could thus significantly impact the ventilation of the world's oceans, yet future projections do not usually include this effect in models. Here we use an ocean–sea ice model to investigate the potential long-term impact of Antarctic meltwater on AABW overturning. The freshwater forcing is derived from present-day estimates of meltwater input from drifting icebergs and basal melt, combined with RCP2.6, RCP4.5, and RCP8.5 scenarios of projected amplification of Antarctic meltwater. We find that the additional freshwater induces a substantial slowdown in the formation rate of AABW, reducing ventilation of the abyssal ocean. Under both the RCP4.5 and RCP8.5 meltwater scenarios, there is a near-complete shutdown of AABW formation within just 50 years, something that is not captured by climate model projections. The abyssal overturning at ~30S also weakens, with a 20-yr delay relative to the onset of AABW slowdown. After 200 years, up to 50% of the original volume of AABW has disappeared as a result of abyssal warming, induced by vertical mixing in the absence of AABW ventilation. This suggests that climate change could induce the disappearance of present-day abyssal water masses, with implications for the global distribution of heat, carbon, and nutrients.

333

COSMO-CLM2 : the regional climate model used for investigating the decadal variability and predictability of the atmosphere-ocean-ice sheet system over Antarctica.

Alexandra Gossart[1,2], Sam Vanden Broucke[2], Niels Souverijns[2], Samuel Helsen[2], Sotiris Sotiriadis[2], Matthias Demuzere[2], \ Nicole PM van Lipzig[2]
[1]Victoria University Of Wellington, Wellington, New Zealand, [2]University of Leuven, Leuven, Belgium

The climate of the polar regions, changing over the last decades, may result from external forcing, but also from natural interactions between its components (atmosphere, marine and continental cryosphere, and ocean). Quantifying the contribution of each is critical to understand decadal variability in the polar regions. The PARAMOUR project aims at revealing the fundamental drivers of climate variability and assessing the predictability in the polar regions. Coupling between the atmosphere, ocean and ice sheet regional climate models will enable to study the interactions between the atmosphere, ocean, sea ice and ice shelves at scales between a few hundreds of meters and a few kilometers, and investigate how these interactions influence the variability and predictability of the system, both in the past and in the future.
We present here the model used to represent the Antarctic climate: COSMO-CLM2. COSMO-CLM is a non-hydrostatic regional climate model, coupled to the Community Land Model 4.5. First, this coupled model was adapted for Antarctic conditions by updating the snowpack, roughness length of snow and the atmospheric stability parameters. A 30 years hindcast (1987-2016) simulation was performed and evaluated against a compilation of observational records, indicating that the COSMO-CLM2 model is capable of adequately simulating the Antarctic climate. Further studies have been led using COSMO-CLM2 to better represent the cloud-aerosols interactions and their impact on the radiative balance over the Antarctic ice sheet, as well as to include include a snowdrift routine to model the darkening of the surface due to scouring by the wind.

393

Evaluation of the representation of surface mass balance in atmospheric reanalyses

Alexandra Gossart[1,2], Samuel Helsen[2], Jan TM Lenaerts[3], Sam Vanden Broucke[2], Nicole PM van Lipzig[2], Niels Souverijns[2]

[1]Victoria University Of Wellington, Wellington, New Zealand, [2]University of Leuven, Leuven, Belgium, [3]University of Colorado Boulder, Boulder, USA

Regional climate models and reanalyses are tools to mimic the atmospheric processes over the Antarctic ice sheet. However, the mechanisms affecting the surface mass balance over Antarctica are not yet fully understood, constrained/parametrised by both climate models and reanalyses, which leads to biases in the representation of the Antarctic climate. This is not trivial, since these models are used to estimate the contribution of the AIS to sea level rise.

Therefore, an adequate representation of snow accumulation over the continent by the driving reanalyses is crucial. In that context, we evaluate the performance of four reanalyses: ERA-5 and ERA-Interim, CFSR, and MERRA-2 applied over Antarctica. Model outputs of accumulation are compared against observational datasets of surface mass balance (satellite records, in-situ stake measurements and ice cores, and reconstructions).

All reanalyses are able to capture the high accumulation event signals related to atmospheric rivers visible in 2009 and 2011 in Dronning Maud Land, but ERA-5 and ERA-Interim show the smallest bias in accumulation. Reanalyses display a correct representation of the large-scale accumulation patterns over the continent, but an underestimation of the surface mass balance at the coastal sites and the Antarctic Peninsula exists for Era-Interim and ERA-5. For inland sites, a good representation is achieved, apart from some limited locations which show an overestimation of the accumulated snow amount. MERRA-2 accumulation is best resolved over the coast but displays a general tendency to overestimate surface mass balance and CFSR displays a general underestimation of accumulation compared to the snow accumulation dataset.

176

Validation of reanalysis Southern Ocean atmosphere trends using sea ice data

Will Hobbs[1,2,4], Andrew Kleicocuik[1,3], Yuhang Pan[2]
[1]Australian Antarctic Program Partnership, Hobart, Australia, [2]University of Tasmania IMAS, Hobart, Australia, [3]Australian Antarctic Division, Kingston, Australia, [4]ARC Centre of Excellence for Climate Extremes (CLEX), Hobart, Australia

Reanalysis datasets are an essential tool for characterising the state, variability, and recent changes of the atmosphere over the data-sparse Southern Ocean. They are important not just for meteorological research, but also for understanding ocean and sea ice changes, and for interpreting ice core records. However, different reanalyses show markedly different trends over the last four decades, and in ocean regions with no long-term in situ records it is difficult to validate such trends.
In this research, we use a novel analysis based one the expected coherence between surface air temperature and sea ice trends, to compare long-term changes in 8 different reanalysis products. Our analysis shows a surprising spread between the reanalyses in their sea ice-atmosphere coupling, with surface air temperature trends ERA5 and NOAA 20CRv3 products having the most consistent relationship with observed sea ice trends

1691

Ice flow velocity on Pine Island Glacier with offset-tracking technique

Filipe Idalino[1], Kátia Kellem Da Rosa[1], Cláudio Wilson Mendes Júnior[1], Fernando Hilebrand[1], Jefferson Simões[1]
[1]*CPC-UFRGS, Porto Alegre, Brazil*

This study analyzes the variability of surface flow velocity at 100 km inland of Pine Island Glacier (PIG), West Antarctica, during the 2014–2019 period. To determine the ice flow velocity variability, an offset-tracking technique was applied in sequential pairs of SAR images from Sentinel-1A (data acquired from Novembers), and a Digital Elevation Model (DEM) of TanDEM-X data. We detect a progressive acceleration of ice flow were glacier speed increased by up to 9.6% during the period. Wide fractures that propagate parallel to ice flow direction are identified in crevasses mapping. This fracture patterns identified throughout the study area contributed to identify the direction of flow. The contemporary increase in ice velocity of PIG suggest a continual thinning and ocean-driven changes of the glacier. These results corroborate with previous studies in West Antarctica and can be an indicator of environmental changes that occur in the Amundsen Sea region.

584

Recent Antarctic climate change and its possible causes

Seong-joong Kim[1], Sang-Yoon Jun[1], Joo-Hong Kim[1], Baek-Min Kim[2], Hataek Kwon[3]
[1]Korea Polar Research Institute, Incheon, South Korea, [2]Pukyong Nation University, Busan, South Korea, [3]Seoul National University, Seoul, South Korea

Since the year 1957, the Antarctic surface temperature has shown a substantial warming in the Antarctic Peninsula (AP) and west Antarctica, but there is little temperature change in east Antarctica (EA) and even a slight cooling trend. Although this asymmetric feature is well recognised, its origin remains poorly understood. By analysing observation data and multi-model results, this east and west Antarctic climate asymmetry is amplified in austral winter, originated from the ocean temperature over the Amundsen–Bellingshausen seas and the Antarctic terrain. The warmer ocean temperature over the West Antarctic sector has positive feedback, with an anomalous upper-tropospheric anti-cyclonic circulation response centred over West Antarctica, in which the strength of the feedback is controlled by the Antarctic topographic layout and the annual cycle. The cooling in east Antarctica is associated with the increase in sea ice that is caused by both changes in sea ice dynamics and thermodynamics. Since 2000s, there is a cooling trend in the Antarctic peninsula, while warming trend in east Antarctica, that seems to be caused by weakening of polar vortex in stratosphere.

741

Understanding observed trends and future projections of the Southern Ocean warming and sea level change

Kewei Lyu[1], Xuebin Zhang[1],John Church[2]
[1]Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Australia, [2]Climate Change Research Centre, University of New South Wales, Sydney, Australia

The Southern Ocean is one of the key regions absorbing the excess heat stored in the climate system due to anthropogenic warming with important implications for global and regional sea level change. Historical datasets and climate model simulations show some common features of the Southern Ocean climate change including the rapid warming along the mid-latitude band and the meridional dipole structure of sea level changes with faster (slower) sea level rise at middle (high) latitudes. Firstly, we combine observations and climate model simulations to identify climate drivers of the observed changes. While the historical changes (e.g., since 1960) could be mainly attributed to the anthropogenic forcing, the much larger changes occurred over the recent Argo period (since 2006) are largely due to the internal climate variability that is partly connected to the tropical forcing. Secondly, we explore the impacts of model mean state biases on future projections. Most of the CMIP5 models show equatorward biases in their simulated Southern Ocean westerly winds, which have been improved in CMIP6. For those models with the westerly winds biased more equatorward, the boundary between the subtropical gyres and the ACC where the projected ocean warming peaks is also located further equatorward. Larger poleward shifts of the westerly winds and the subtropical gyres are also projected, accompanied by larger magnitudes of ocean warming and sea level changes. Thirdly, we estimate the time when the future sea level change signal will exceed the range of internal variability, i.e. Time of Emergence, in the Southern Ocean.

1418

Heat and carbon pathways between the atmosphere and Southern Ocean over the 21st century under the RCP8.5 scenario

Eric Mortenson[1], Andrew Lenton[1,2,3], Tom Trull[1,2], Elizabeth Shadwick[1,2,3], Xuebin Zhang[1,3], Matt Chamberlain[1]
[1]Commonwealth Scientific And Industrial Research Organization (CSIRO), Hobart, Australia, [2]Australian Antarctic Program Partnership (AAPP), Hobart, Australia, [3]The Centre for Southern Hemisphere Oceans Research (CSHOR), Hobart, Australia

The global oceans are a major sink of anthropogenic CO_2 and heat. This oceanic uptake impacts the ocean through changes to its chemistry and temperature. This study explores when, where, and how the pathways for oceanic uptake of heat and carbon will diverge in the “Business-as-Usual” (RCP8.5) scenario of atmospheric CO_2 changes over the 21st century. To account for mesoscale processes we used the 0.1°-resolution Ocean Forecasting Australia Model.

Regionally, the southern hemisphere oceans are projected to account for about 40% (for heat) and 55% (for carbon) of the global ocean surface uptake, and more than half of the subsurface storage for both heat (~50%) and carbon (60%), over the 21st century. In terms of oceanic effects of heat and carbon south of 40°S, a decrease in the mean annual sea surface pH (from 8.05 to 7.72) and an increase in mean annual SST (from 6.1 to 7.7°C) are projected by 2100. The ocean south of 40°S will continue to be the major hotspot for both heat and carbon uptake throughout this century, whereas the largest changes in southern hemisphere heat and carbon storage occur in the subtropics (10 to 40°S). This work highlights both the importance of the Southern Ocean to atmospheric removal of carbon and heat and therefore climate change, and the regional differences in uptake and storage. Clearly understanding and quantifying these changes is essential for current and future research on the impacts of climate change on the marine environment.

494

SO-CHIC: South Ocean Carbon and Heat Impact on Climate

Joseph Nolan[1], Amélie Lecornec[2], Renuka Badhe[1], Jean-Baptiste Sallée[3]
[1]European Polar Board, The Hague, The Netherlands, [2]Sorbonne Université, Paris, France, [3]Sorbonne Université, CNRS, LOCEAN, Paris, France

SO-CHIC (2019-2023) is a project funded by the EU's Horizon 2020 programme with 15 partners from 10 countries.

The Southern Ocean (SO) regulates global climate, controlling heat and carbon atmosphere-ocean exchanges. Rates of climate change on decadal timescales depend on processes taking place in the SO, of which little is known. Limitations come from a lack of observations and the SO's sensitivity to intermittent small-scale processes poorly captured in Earth system models. To reduce climate prediction uncertainties, SO-CHIC aims to understand and quantify SO heat and carbon budget variability by investigating key processes controlling atmosphere-ocean-sea ice exchanges with observational and modelling approaches. SO-CHIC will:

Initiate sustained monitoring of SO heat and carbon budgets, quantifying fluxes at the air-sea-ice interface and estimating interannual heat and carbon storage variability.

Improve understanding of the spatial distribution and variability of heat and carbon exchanges between the atmosphere and the deep ocean, focusing on the dynamics of the ocean mixed-layer and its relation to sea ice distribution, and assessing the causes of the Weddell Polynya in 2016 and 2017, over 40 years since its previous occurrence.

Improve understanding of bottom water formation and export in the Bottom Boundary Layer and propose new strategies to represent such key processes – major shortcomings of current models.

Identify critical SO climate system sensitivities that must be correctly represented in models to reduce uncertainties in future oceanic heat and carbon projections.

Enable free and open access to all data, maximising impact on IPCC reports, climate services, and climate-model groups.

1583

The commitment to global sea level rise over the next 500 years

Steven Phipps[1], Jason Roberts[2]
[1]University Of Tasmania, Hobart, Australia, [2]Australian Antarctic Division, Kingston, Australia

Within Australia alone, more than A$226 billion of coastal infrastructure is vulnerable to the anticipated rise in sea level by the end of the century. The IPCC Fifth Assessment Report concluded that the likely increase in global-mean sea level during the 21st century ranges from 26-55 centimetres (under the low-end RCP2.6 climate scenario) to 45-82 centimetres (under the high-end RCP8.5 climate scenario). However, subsequent modelling studies have demonstrated the potential for the Antarctic Ice Sheet to undergo irreversible collapse during the coming centuries. Sea level increases of up to 2.5 metres are therefore possible by the end of the 21st century.

Here, we combine climate modelling and ice sheet modelling to explore the evolution of the Antarctic Ice Sheet over the next 500 years under a range of climate scenarios. We run the models many times to account for gaps in our understanding of ice sheet dynamics, using our knowledge of past changes in the Antarctic Ice Sheet to identify the configurations that are plausible. This allows us to generate robust projections of the Antarctic contribution to global sea level from the present to the year 2500, complete with quantified confidence intervals.

We conclude that the sea level contribution during the 21st century will be modest, consistent with the IPCC Fifth Assessment Report, but that melting of the Antarctic Ice Sheet will accelerate thereafter. We also conclude that previous studies have underestimated the range of uncertainty in projections of future global sea level rise.

1677

Contrasting responses of marine and land-terminating glaciers to recent climate variations in King George Island, Antarctica

Katia Kellem Da Rosa[1], Cleiva Perondi[1], Rosemary Vieira[2], Felipe Daros Idalino[1], \Manoela Araújo Gonçalves de Oliveira[1], Julia Lopes Julia Lorenz[1], Jeffrey D Auger[1], Jefferson Cardia Simões[1]
[1]Centro Polar e Climático, Universidade Federal do Rio Grande do Sul -UFRGS, Porto Alegre, Brazil, [2]LAPSA, Universidade Federal Fluminense, UFF, Niterói, Brazil

In this study, we aim to analyze the marine-terminating glaciers in King George Island (KGI) (Antarctica) between 1956 and 2019. Glacial fluctuations are estimated using spaceborne remote sensing data (SPOT, Landsat, PlanetScope, Sentinel-1, Sentinel-2, WorldView-2, and TanDEM-X). The KGI witnessed continuous glacier retreat during 1979–2019, but the new land-terminating glaciers showed a deceleration in 2000-2019 in comparison to previous years (1988-2000). Seven marine-terminating glaciers changed to land-terminating condition since 1979. The accumulation area ratios (AARs) exhibiting negative mass balances. The winter air temperature was cooler during the 1970s with warming trends in the 1980s and early 2000s followed by a cooling trend until the present day. However, the annual time series has shows high interannual variability in air temperature during these periods. We show that the AAR, dimensions, length, frontal elevation, maximum elevation, slope, and changes in the terminus position influence the glacier response to climate change at different timescales. Furthermore, three geomorphic activity intensity zones and a complete paraglacial sequence are identified while contrasting the proglacial systems.

1250

Evaluating Antarctic precipitation in ERA5 and CMIP6 against CloudSat observations

Marie-Laure Roussel[1], Florentin Lemonnier[1], Christophe Genthon[1], Gerhard Krinner[2]
[1]Laboratoire de Météorologie Dynamique, Paris, France, [2]Institut des Geosciences et de l'Environnement, Grenoble, France

Surface total precipitation – the main positive term in the antarctic ice sheet mass balance – as well as temperature are projected to increase in the future according to global climate models. Sparsity of observations – due to the unpropitious environment for instrumentation – limits our confidence in numerical atmospheric models in the South pole region. Therefore, satellite-based observations are valued data that make it possible to evaluate recent models outputs : the CMIP6 (Coupled Model Intercomparison Project phase 6) ones have just been provided allowing an assessment of their progress regarding the previous phase with various setups. The reference for snowfall is the first snowfall climatology map for Antarctica – based on the CloudSat satellite Cloud Profiling Radar - produced (Palerme et al. 2014) at the surface - completed recently (Lemonnier et al. 2019) on its vertical dimension. Results from the reanalyses ERA5 of the ECMWF are evaluated because they are often used as a reference in regions where there is a lack of observations.

At continental and regional scales, ERA5 and CMIP models median are biased high. However, there are less models outputs with large overestimations in CMIP6, and the seasonal cycle is well reproduced by the median of the CMIP models – but not by ERA5. From all the configurations evaluated, amip ones perform better than historical. Relative errors in areas of complex topography are higher in the higher resolution models that is unexpected. No significant improvement are shown from CMIP5 to CMIP6 despite near-surface temperature enhancement.

1639

Present and future of rainfall over Antarctica

Marie-Laure Roussel[1], Etienne Vignon[2], Christophe Genthon[1], Alexis Berne[2]
[1]Laboratoire de Météorologie Dynamique, Paris, France, [2]Ecole Polytechnique Fédérale de Lausanne, Lausanne, Suisse

Rainfall events in Antarctica are not well referenced and currently not the subject of a major attention. This is because its proportion – both in terms of occurrence and quantity with regards to the solid phase of precipitation – and mainly its impact on the surface mass balance of the ice sheet is very low.
However, rainfall events can cause serious damages on the Antarctic fauna and they can play a major rôle in snowmelt events by preconditioning the snow surface.
Making use of statistics base on in-situ observations, we show that rainfall events can occur along a large part of the Antarctic edge, and they can sometimes even protrude further inland. Thanks to those data we could evidence an under-estimation of Antarctic rainfall occurrence in the ERA5 reanalyses. We further attempted to characterize Antarctic rainfall with remote-sensing methods but the limitation of the current products preclude any robust conclusion.
To better predict the effect of climate change on Antarctic rainfall, the recent releases of simulations from the CMIP6 (Coupled Model Intercomparison Project) models are then used to study the evolution of rainfall under different climate scenarios. The overall increase in temperature and precipitation on the ice cap is in agreement with previous study using CMIP5 models but we further show a significant increase in the amount and occurrence of liquid precipitation over a large part of the ice sheet. In addition, we provide a detailed analysis on the regional pattern and on the seasonal cycle of the liquid precipitation.

ISBN: 978-0-948277-59-7

www.scar2020.org