SCAR 2020

Antarctic Science - Global Connections

SCAR OPEN SCIENCE CONFERENCE 2020

SESSION 7

SOUTHERN OCEAN CIRCULATION: CHANGE AND CONSEQUENCES

Marcos Tonelli
Marina Noro, Tiago Dotto

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

715

Observations of Weddell Sea Deep Water export through Orkney Passage: 2004-present

E. Povl Abrahamsen[1], Arnold L. Gordon[2], Bruce A. Huber[2], Christian E. Buckingham[3], Carl P. Spingys[4], Alberto C. Naveira Garabato[4], Eleanor Frajka-Williams[5], Andrew J. S. Meijers[1], Michael P. Meredith[1]

[1]British Antarctic Survey, Cambridge, United Kingdom, [2]Lamont-Doherty Earth Observatory, Columbia University, Palisades, USA, [3]IUEM / LOPS / Université de Bretagne Occidentale, Plouzané, France, [4]University of Southampton, Southampton, United Kingdom, [5]National Oceanography Centre, Southampton, United Kingdom

Much of the Antarctic Bottom water that reaches large parts of the World Ocean is formed in the Weddell Sea. Orkney Passage, a 3650-m deep gap in South Scotia Ridge, east of the South Orkney Islands, is a key export region of Weddell Sea Deep Water (WSDW). Since 2004, moorings have made continuous observations in this region, with the aim of shedding light on variability in deep water properties and export rates. Coincident with these moored records are full water column profiles from ship-based profiling instrumentation, and in 2017 near-bottom measurements were obtained from the Autosub Long Range autonomous underwater vehicle. These observations have been pivotal for elucidating the water mass transformation processes that take place as WSDW flows through these areas of extremely steep bathymetry. Finally, nearby repeat hydrographic sections crossing South Scotia Ridge have revealed details of links between the variability of abyssal water masses in the Weddell Sea and lighter water masses that are able to reach the Scotia Sea. In this study, we present an overview of our observations in this region, followed by a discussion of the most probable causes of the observed variability in deep water properties.

975

Transport of inorganic carbon with Dense Shelf Water from the Adélie Land coast, East Antarctica

Mar Arroyo[1], Elizabeth Shadwick[2,3], Bronte Tilbrook[2,3], Steve Rintoul[2,3], Kazuya Kusahara[4]
[1]*Virginia Institute of Marine Science, Gloucester Point, United States,* [2]*CSIRO Oceans & Atmosphere, Hobart, Australia,* [3]*Centre for Southern Hemisphere Oceans Research, Hobart, Australia,* [4]*JAMSTEC, Yokosuka, Japan*

Dense Shelf Water (DSW) supplied from Antarctic coastal polynyas is a key component of the formation of Antarctic Bottom Water, contributing to global meridional overturning circulation. In this study, the export of dissolved inorganic carbon with DSW from the Mertz and Ninnis Polynyas on the Adélie Land Coast in East Antarctica is quantified. Shipboard observations from two summer surveys in 2015 and 2017 were paired with model-derived DSW transport estimates to explore the offshore and cross-shelf fluxes of inorganic carbon. Fluxes of inorganic from the shelf were associated with DSW export through the northern boundary across the Adélie and Mertz Sills, with an additional westward transport from the Mertz through the D'Urville Trough Sill. The source of inorganic carbon to DSW is mainly derived from inflowing modified Circumpolar Deep Water in the mid-layer of the water column, with additional contributions from brine rejection during sea ice formation. This work suggests that Dense Shelf Water export serves as a conduit for the offshore transport of dissolved inorganic carbon, thereby connecting the atmosphere and the surface waters on the shallow Antarctic continental shelf with the deep ocean.

194

Rates and mechanisms of mixed layer development in the Drake Passage sector of the Southern Ocean

Alexander Brearley[1], Louise Biddle[2], Ryan Scott[1], Miguel Morales-Maqueda[3], Hugh Venables[1], Michael Meredith[1], Sebastiaan Swart[2]
[1]British Antarctic Survey, Cambridge, United Kingdom, [2]University of Gothenburg, Gothenburg, Sweden, [3]University of Newcastle, Newcastle, United Kingdom

The Southern Ocean is known to be a key region for the subduction and obduction of heat and carbon into and out of the ocean's interior. These processes are strongly governed by the deepening and shoaling of the ocean's mixed layer, which is known to respond both to surface forcing and to submesoscale fronts (scale of 1-10s km) that are present in the ocean's interior. Here, we present a unique time series of ship, surface vehicle and underwater glider measurements collected in the vicinity of the Southern Antarctic Circumpolar Current Front (SACCF) in Drake Passage for two months in 2017-2018, which tracked the development of the mixed layer during the early summer season. The autonomous vehicles were piloted so as to quantify both the background mesoscale and small-scale submesoscale gradients, and were supported with high-quality flux measurements from the ship and meteorological measurements from a WaveGlider. The results show significant high-frequency variability in mixed layer depths during the deployment, with indications suggesting this is coupled to the surface wind forcing. The wind data are analysed to assess the contribution of Ekman buoyancy fluxes in promoting submesoscale instabilities, and the accompanying glider temperature, salinity and velocity measurements are analyzed to determine the susceptibility of the flow to a variety of instability processes. We discuss the implications of these processes for heat subduction into the Southern Ocean on seasonal timescales.

134

The Southern Ocean in Global Climate: The ORCHESTRA Programme

Alexander Brearley[1], Andrew Meijers[1], Michael Meredith[1], David Munday[1], Elizabeth Kent[2], Yvonne Firing[2], Margaret Yelland[2], Tim Smyth[3], Melanie Leng[4], Helene Hewitt[5], Pat Hyder[5], George Nurser[2], Lars Boehme[6], Anna Hogg[7], Povl Abrahamsen[1], Huw Griffiths[1], Dan Jones[1]
[1]British Antarctic Survey, Cambridge, United Kingdom, [2]National Oceanography Centre, Southampton, United Kingdom, [3]Plymouth Marine Laboratory, Plymouth, United Kingdom, [4]British Geological Survey, Nottingham, United Kingdom, [5]Met Office, Exeter, United Kingdom, [6]St Andrews University, St Andrews, United Kingdom, [7]University of Leeds, Leeds, United Kingdom

The Southern Ocean accounts for around half of all oceanic uptake of carbon, and more than three-quarters of the heat uptake. Despite its profound importance, the Southern Ocean is also the least measured and arguably the least understood of the world's oceans: its remoteness and inhospitable nature have led to a dearth of sustained, strategic measurement programmes, and the small-scale and complexity of many of the key processes have precluded the desired advances in simulation. To address these issues, a £10M programme funded by the United Kingdom
NERC is underway - 'Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (ORCHESTRA)'. ORCHESTRA spans five years (2016-2021) and is using combination of novel data collection, analyses, and computer simulations to radically improve our ability to measure, understand and predict the circulation of the Southern Ocean and its role in the global climate. It is making unique and important new measurements in the Southern Ocean using a range of techniques, including basin-wide ocean/carbon/tracer sections, as well as deployments ofautonomous vehicles, meteorological aircraft, seal tagging and other innovative techniques for collecting data. It also involves the development and use of advanced ocean and climate simulations, to improve our ability to predict climatic change in coming decades. This poster will outline the
rationale and key results from the ORCHESTRA programme to date.

1319

Physical properties of the eastern Ross Sea observed during the ESTRO project

Pasquale Castagno[1], Naomi Krauzig[1], Pierpaolo Falco[1], Elena Mauri[2], Riccardo Gerin[2], Piero Zuppelli[2], Stefano Kuchler[2], Arturo De Alteris[1], Giovanni Zambardino[1], Paola Rivaro[3], Enrico Zambianchi[1]
[1]Università degli Studi di Napoli "Parthenope", Napoli, Italy, [2]Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Sgonico (TS), Italy, [3]Università Degli Studi Di Genova, Genova, Italy

During the last decades, the Ross Sea Dense Shelf Water, a precursor to AABW, experienced a steady salinity decline. Recent observations show a striking salinity increase from 2016. Besides the negative salinity trend and the recent rebound, coherent fluctuations with a time-scale of 5–10 years were observed. A quantitative estimate of the terms contributing to the Ross Sea salt budget is necessary to understand the physical mechanisms responsible for these changes. A crucial area to investigate is the eastern Ross Sea, where the inflow of freshwater from the Amundsen Sea (ASW) occurs, and where the lack of observations is still a major issue. In January 2020 the ESTRO project conducted for the first time a synoptic oceanographic survey in this area. Its main objective was to characterise the inflow of Circumpolar Deep Water and ASW, to assess the vertical mixing of these water masses, and to define their contribution to the freshwater budget. Here we present hydrographic and current observations collected during the cruise. These observations extended north-south across the shelf break from east of Cape Colbeck (155°W) to 165°W and east-west along the Ross Ice Shelf (RIS) from the Bay of Whales to Ross Island. In addition, a glider was used to complete a transect between the RIS and the shelf break. The ASW characterized by salinity of 34.12 and potential temperature of -1.86°C was identified in a 200m layer centred at 150m depth. These observations will be discussed within the context of the (few) previous ocean observations available.

1063

Pushing SOOS to its limit: what can we see with the current Southern Ocean Observing System?

Christopher Chapman[1], Didier Monselesan[1], Violaine Pellichero[2]
[1]CSIRO, Hobart, Australia, [2]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Australia

The Southern Ocean is known to be one of the most data-sparse ocean basin. Even in the era of Argo floats, the density of in-situ observations in the Southern Ocean remains substantially lower than those of other major basin, particularly in seasonally ice covered regions, and during the austral winter.

What physical processes and ocean structures can we "see" with the current Southern Ocean Observing System (SOOS) and how can the system be improved? Here, we assess the current and some hypothetical future observing systems through a series of simple Observing System Simulation Experiments (OSSEs): a realistic, high resolution ocean model is sampled using the historical distribution of ship based, Argo float and instrumented marine mammal profiles to create a database of "virtual" temperature and salinity profiles. The ocean state is then reconstructed from these "virtual" observations using a sophisticated optimal interpolation technique, which can then be compared to the "true" model state.

By selectively withholding various platforms within in-situ database, sub-sampling observations to degrade the observing network, and removing observations from selected regions, we can assess how many in-situ observations we require to effectively "see" the large, medium and small-scale ocean structure, as well as where these observations must be taken. Various hypothetical future scenarios are presented (such as a doubling of the number of Argo floats) to inform improvement of the observing system.

1571

Freshening and cooling effect of Vincennes Bay Bottom Water on the layer of Antarctic Bottom Water in the Australian-Antarctic Basin

Lingqiao Cheng[1], Yujiro Kitade[2], Keishi Shimada[2], Yu Shirayi[3]
[1]Shanghai Ocean University, Shanghai, China, [2]Tokyo University of Marine Science and Technology, Tokyo, Japan, [3]FURUNO ELECTRIC CO., LTD., Nishinomiya, Japan

Inter-annual variability of Antarctic Bottom Water (AABW) properties off the Vincennes Bay, East Antarctica, is investigated based on five-time high-quality repeat hydrographic observations carried out in Januaries 2011-2015. Spatial and temporal variability in volumetric contribution of Vincennes Bay Bottom water (VBBW), the mixture of local Dense Shelf Water (DSW) and modified Circumpolar Deep Water (mCDW), to the AABW layer have been estimated respectively. Bottom water in this region is found having a significant freshening (0.0016 /yr on average) and minute warming (0.0002 °C/yr on average) trend during these years. Evidences show that VBBW has a freshening and cooling effect on the AABW layer. The largest contribution of VBBW (> 30 %) along the ridge northwestern of Vincennes Bay (VB) is accompanied by the freshest and coldest AABW property; VB-origin DSW freshens the internal layers of AABW, resulting in plume structures tending to fresher and cooler in the potential temperature-salinity diagram. Temporal variation reflects that there is a sharp increase of contribution of VBBW from 2014 to 2015 along 110°E. This variation corresponds well to the enhanced northward wind, larger upward heat flux and more sea ice formation in the coastal polynya region of VB during freezing season in 2014. Spatial contribution of VBBW, as well as DSW, indicates that the main outflow route of DSW may be along the ridge northwestern of VB. VBBW can reach the abyssal layer deeper than 4000 m at 61°S.

80

Trends of the deep water masses properties in the Bransfield Strait, Antarctica: Austral summers from 1960 to 2019

Brendon Yuri Damini[1], Rodrigo Kerr[1], Tiago Segabinazzi Dotto[1]
[1]Universidade Federal Do Rio Grande, Rio Grande, Brazil

The Bransfield Strait (BS) is influenced by dense Weddell Sea shelf waters recently ventilated. After sinking, these waters remain restricted in the BS deep basins due to their thermohaline properties and the bathymetric configurations. Thus, this region is frequently referenced to be a proxy area to study the temporal variability of the Weddell Sea shelf waters.Here, the temporal evolution of the water masses from the deep BS is investigated for the summer periods of 1960-2019. For this, historical hydrographic data from the Word Ocean Database 2013 and from Alfred Wegener Institute spanning from the 1960s to 2010s are combined with the High Latitude Oceanography Group (GOAL) measurements from 2003 to 2019. Cooling (–0.0021 ± 0.0020 ºC/yr), freshening (–0.0005 ± 0.0005 g kg $^{-1}$ /yr) and lightening trends (–0.0011 ± 0.0010 kgm $^{-3}$ /yr) are observed in the BS central basin for that period. In turn, the eastern basin shows warming (+0.0022 ± 0.0034 ºC/yr), freshening (–0.0007±0.0005 g Kg $^{-1}$ /yr) and lightening (–0.0017 ± 0.0012 Kg m $^{-3}$ /yr) for the same period. The results indicate a strong interannual variability of BS water masses thermohaline properties, which are related to changes in the wind patterns associated to the climate modes El Niño-Southern Oscillation and Southern Annular Mode. Periods of higher salinity are associated with increased intrusions of High Salinity Shelf Water from the Weddell Sea.

1001

Offshore Transport of Particulate Organic Carbon off the Antarctic Peninsula by Nonlinear Mesoscale Eddies

Renato Castelao[1], Michael Dinniman[2], Patricia Medeiros[1], Caitlin Amos[1], John Klinck[2]
[1]University of Georgia, Athens, United States, [2]Old Dominion University, Norfolk, United States

The Southern Ocean plays a disproportionally large role in the global carbon cycle, accounting for a large fraction of the global ocean CO2 uptake. The Southern Ocean is also unique because it encircles the globe, providing a pathway for inter-basin exchange. Previous studies have shown that particulate organic carbon (POC) accumulates seasonally around Antarctica. Here, we examine the offshore export of POC off the Antarctic Peninsula, from areas of high accumulation near the coast to areas offshore that provide a link for exchange of water masses and biogeochemical properties between the worlds' major ocean basins. For that, we use decade-long satellite observations of POC based on algorithms validated against in situ data, eddy kinematic and propagation characteristics based on altimeter data and results from a high resolution ocean model coupled to a sea ice model. We show that mesoscale eddies are nonlinear (geostrophic velocities around the eddies exceed their propagation speed) in the top 750 m of the water column, and that cyclones located offshore that were generated near the coast contain higher carbon concentration in their interior than cyclones of the same amplitude generated offshore. This indicates that eddies are in fact trapping and transporting coastal water offshore. The offshore transport is estimated at 1.1 Sv off the Peninsula, resulting in an offshore POC enrichment of 4.5 ± 1.3 Gg/year. Eddies may also strongly influence the offshore transport of freshwater from ice melting, nutrients, phytoplankton and zooplankton, potentially creating offshore oases for higher trophic organisms.

1245

Italian mooring observations in the western Ross Sea from 1995 to 2019

Pasquale Castagno[1], Naomi Krauzig[1], Pierpaolo Falco[1], Federico Giglio[2], Leonardo Langone[2], Arturo De Alteris[1], Giovanni Zambardino[1], Andrea Gallerani[3], Giorgio Budillon[1]
[1]University of Naples Parthenope, Naples, Italy, [2]National Research Council (CNR) - Institute of Polar Sciences, Bolonga, Italy, [3]National Research Council (CNR) - Institute of Marine Sciences, Bologna, Italy

Antarctic Bottom Water (AABW) plays an important role in the deep ocean stratification and in the transport of heat, carbon and nutrients throughout the global ocean. In the Pacific Sector of the Southern Ocean, the Ross Sea is responsible for shaping the properties of approximately 25% of the world's AABW. The Italian Marine Observatory in the Ross Sea (MORSea) project, funded by the Italian National Program of Research in Antarctica (PNRA), has a network of four active moorings in the western Ross Sea: two located in the Terra Nova Bay polynya, where the HSSW precursor of the AABW is formed, and two close to the shelf break in the Drygalski and Joides troughs where the AABW is formed from the interaction of the shelf waters and the warm circumpolar deep water and subsequently exits from the continental shelf.
CTD data and moored observations time-series collected since 1995 have shown significant changes in the thermohaline characteristics of HSSW.
MORSEa mooring, deployed from 1998 to 2019 in the central Ross Sea, are demonstrating the important role played to assess the cross-shelf exchanges processes and changes in the AABW formation in the Ross Sea and how rapidly these changes occur.

1243

Characterization of the ocean mesoscale eddies in the Antarctic Circumpolar Current from in situ, model and remotely sensed data

Yuri Cotroneo[1], Lavinia Patara[2], Milena Menna[3], Pierpaolo Falco[1], Jan Klaus Rieck[2], Giulio Notarstefano[3], Giannetta Fusco[1], GIorgio Budillon[1], Pierre Poulain[3]
[1]University of Naples Parthenope, Naples, Italy, [2]GEOMAR Helmholtz Centre for Ocean Research, , Germany, [3]Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Trieste, Italy

Mesoscale variability and associated eddy fluxes (EF) play crucial roles in the ocean dynamics. In the Southern Hemisphere, where the Antarctic Circumpolar Current (ACC) acts as a barrier to the direct heat transport toward the Antarctica, the EF across the ACC is the main mechanism that guarantees the heat budget and distributes physical and biogeochemical properties between subtropical and polar regions.
The study area is located between the South-West Indian and South Pacific ridges. In this area, the interaction between the ACC and the topography, produces large values of EKE and eddy heat fluxes and steers the ACC path.
The aim of this study is to evaluate the efficiency of mesoscale eddies to exchange heat and other properties across the different ACC fronts and to describe the vertical and horizontal properties of the eddies. To this end, we used in-situ and satellite data in conjunction with a hindcast simulation from 1958 to 2018 performed with a 1/10° ocean biogeochemistry model.
Eddies are identified and tracked in both the model output and altimetry data while their thermohaline properties and vertical extension in situ data as well, which include repeated XBT sections (i.e. New Zealand – Antarctica and Hobart – Antarctica) and Argo float profiles.
Thanks to the joint analysis of model and observational data, we are able to 1) assess the ability of the 1/10° ocean model of simulating the eddy field properties, and to 2) better interpret the spatial and temporal variability of the observed eddies

726

Antarctic Bottom Water Outflow from the western Ross Sea: preliminary results from the Ross Sea Outflow Experiment

Melissa Bowen[1], Denise Fernandez[2], Aitana Forcen-Vazquez[3], Arnold Gordon[4], Bruce Huber[4], Pasquale Castagno[5], Pierpaolo Falco[5]
[1]School of Environment, University of Auckland, Auckland, New Zealand, [2]NIWA, Wellington, New Zealand, [3]MetOcean, Wellington, New Zealand, [4]Columbia University, NY, USA, [5]Universita Parthenope, Naples, Italy

Antarctic Bottom Water (AABW) sets the water properties of 40% of the global ocean and 25% of this water mass originates in the western Ross Sea. Recent and historic hydrographic and moored observations were used to investigate what controls the changes in water properties and outflow when dense plumes exit the shelf along the slope near Cape Adare in the Ross Sea. Bottom water exiting the region at Cape Adare is comprised of approximately 40% Ross Sea High Salinity Shelf Water (HSSW), 30% Circumpolar Deep Water (CDW) and 30% low-salinity AABW from further east. The seasonal cycle in salinity and temperature at Cape Adare can be explained by the seasonal cycle in salinity of HSSW in the Drygalski Trough. Dense water pulses occur twice a year, primarily in April and October, often after minimums in tidal velocities in both the semi-annual and spring-neap tidal cycles. Investigation continues on how tides and winds can modulate delivery of HSSW from the shelf to the deep ocean.

567

Bottom water properties in the Australian-Antarctic Basin: A perspective from the Deep-Argo pilot array

Annie Foppert[1,2], Stephen R. Rintoul[1,2], Matthew H. England[3,4]
[1]CSIRO Oceans & Atmosphere , Hobart, Australia, [2]Centre for Southern Hemisphere Oceans Research, Hobart, Australia, [3]Climate Change Research Centre, UNSW, Sydney, Australia, [4]ARC Centre of Excellence for Climate Extremes, UNSW, Sydney, Australia

The production and export of Antarctic Bottom Water (AABW) regulates the global overturning circulation and ventilates the deep ocean. Roughly 40% of AABW is exported into the Australian Antarctic Basin after being formed in two distinct source regions near East Antarctica: Adelie Land and Ross Sea. Observations from the past several decades show both flavours of AABW freshening, with the highest rates of change near the bottom water sources. A pilot array of Deep-Argo floats capable of profiling to between 4000 and 6000 dbar (depending on float type) was deployed in early 2018 in the Australian Antarctic Basin that helps put the long-term changes in context with the spatial variability of properties in the basin. As of January 2020, 12 active floats in the region have recorded over 700 profiles, with almost 450 bottom-reaching profiles and almost 600 profiles reaching the top of the AABW layer (defined as $\gamma > 28.3$ kg/m3). Calibrated against quasi-contemporaneous shipboard CTD profiles, this array reveals absolute salinities and conservative temperatures spanning 0.03 and 0.3oC in the AABW layer, respectively, with larger property ranges in the bottom 100 m of the ocean. While Ross Sea sourced AABW is relatively warmer and more saline than that sourced from Adelie Land, the differences are compensated in density. This pilot array of Deep-Argo floats puts the observed changes over the past several decades into a broader spatial context and reveals pathways of AABW through the Australian Antarctic Basin.

543

Anthropogenic temperature and salinity changes in the Southern Ocean

Will Hobbs[1,2,3], Chris Roach[4], Jean-Baptiste Sallee[4], Tilla Roy[5], Nathan Bindoff[1,3]
[1]University Of Tasmania IMAS, Hobart, Australia, [2]Australian Antarctic Program Partnership, Hobart, Australia, [3]ARC Centre of Excellence for Climate Extremes (CLEX), Hobart, Australia, [4]Sorbonne University LOCEAN, Paris, France, [5]Oceana, Paris, France

The Southern Ocean is an essential part of the climate system, due to its disproportionately-important role in global heat and carbon uptake. Hence, changes in its physical properties, especially those that affect water mass transformations (temperature and salinity) have global implications. In this study, we perform a multi-model attribution of the primary forcings of historically-observed Southern Ocean temperature and salinity change, from 1966-2005. Consistent with previous research, we find a robustly-detectable anthropogenic greenhouse gas (GHG) response, characterized most clearly by a warming of Sub-Antarctic Mode Waters and a freshening of Antarctic Intermediate Waters. The warming pattern is somewhat mitigated by non-GHG anthropogenic forcings (i.e. anthropogenic aerosols or stratospheric ozone depletion). We also find evidence of a detectable GHG-forced change in denser watermasses (i.e. deeper than 2000m and south of 60oS), with a warming of Circumpolar Deep Water and warming and freshening of Antarctic Bottom Water; the latter result must be considered with caution given the poor representation of Bottom Water in climate models.

1434

Thermal responses to Antarctic ice shelf melt in an eddy rich global ocean–sea-ice model

Ruth Moorman[1], Adele Morrison[1], Andrew Hogg[1]
[1]*Australian National University, Canberra, Australia*

Water-mass exchange across the Antarctic shelf margin plays a crucial role in abyssal ocean ventilation and the transport of ocean heat to Antarctic glaciers. Coastal freshening from accelerating Antarctic land-ice melt may alter dynamics at the shelf margin, with implications for deep ocean heat storage and future ice shelf melt rates. Due to the scarcity of observations near the Antarctic coast and difficulties associated with resolving high latitude processes in ocean models, such responses are poorly constrained and confer large uncertainties to projections of future sea level.

Using a high resolution (0.1°) global ocean–sea-ice model with a realistic representation of near-Antarctic water mass properties, we investigate the response of near-Antarctic waters to increased meltwater. We conduct two freshwater perturbation experiments based on projected ice-loss rates under RCP 4.5 and RCP 8.5 emissions scenarios at 2100. Within 10 years of the puerturbation, formation of Dense Shelf Water ceases. On the shelf, increased ocean stratification in Dense Shelf Water formation regions leads to subsurface warming, suggesting a positive feedback to ice shelf melt in these regions. In other regions, coastal freshening strengthens the Antarctic Slope Front, inhibiting the transport of warm Circumpolar Deep Water onto the shelf. Thus, freshening isolates cool shelf waters from open ocean heat, indicating a negative feedback to ice melt, and homogenize shelf waters, enhancing remote feedbacks. The net effect over the continental shelf is cooling, comprised of strong positive and negative regional temperature responses with complex implications for future melt rates.

873

The neodymium isotope fingerprint of Ross Sea Bottom Water

Liam Holder[1], Myriam Lambelet[1], Yves Plancherel[1,2], Tina Van de Flierdt[1], Helen Bostock[3], Phoebe Lam[4], John Schwartz[4], Rob McKay[5], Laura De Santis[6], Denise Kulhanek[7], IODP Expedition 374 Scientists

[1]Department of Earth Science and Engineering, Imperial College London, London, United Kingdom, [2]Grantham Institute for Climate Change and the Environment, Imperial College London, London, United Kingdom, [3]School of Earth and Environmental Sciences, The University of Queensland, Brisbane, Australia, [4]Institute of Marine Sciences, University College Santa Cruz, Santa Cruz, United States , [5]Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand, [6]Geophysics Division, Instituto Nazionale di Oceanografia e di Geofisica Sperimentale , Trieste, Italy, [7]International Ocean Discovery Program, Texas A&M University, College Station, United States

Unlocking the interplay between ocean circulation and climate change remains a key target in paleoceanography and palaeoclimate research. The 143Nd/144Nd ratio of seawater, expressed as εNd, is commonly used as a tracer for reconstructing the provenance of water masses. Applications so far have mainly focussed on the North Atlantic. What is less explored is the εNd fingerprint of Antarctic Bottom Water (AABW), now and in the past.

We here present new dissolved Nd isotope and concentration results from 15 seawater samples collected at 9 stations on the 2018 GO-SHIP cruise SO4-P around the Ross Sea. This area produces ~25% of modern AABW, and exports two physically different varieties of Ross Sea Bottom Water (RSBW). Results for both varieties of RSBW display a homogenous Nd isotopic composition of εNd = -7.3 ⍰ 0.2 (2 S.D., n = 6) and Nd concentrations of 24.13 ⍰ 0.03 pmol/kg (2 S.D., n = 6).

This Nd isotope signature of RSBW is distinct from Weddell Sea Bottom Water (εNd = -9.0 ± 0.8), Adelie Land Bottom Water (εNd = -8.9 ± 1.0) and local overlying Circumpolar Deep Water (εNd = -8.3 ± 0.7). In order to explore how RSBW acquires its unique Nd isotopic composition we will compare the influence of precursor water mass mixing on the shelf, and 'bottom-up' sediment-seawater exchange processes as inferred from detrital Nd isotope signatures. Determining which process exerts the stronger influence on the Nd isotopic composition of RSBW is critical for interpreting past Nd isotope variations in paleoceanographic records.

737

Hotspot of carbon fluxes along the Polar Front

Clothilde Langlais[1], Judith Hauck[2], Jean-Baptiste sallee[3], Andreas Klocker[4], Steve Rintoul[1], Andrew Lenton[1]
[1]CSIRO Oceans and Atmosphere, Hobart, Australia, [2]AWI, Bremerhaven, Germany, [3]LOCEAN-IPSL Sorbonnes University (UPMC), Paris, FRANCE, [4]IMAS University of Tasmania, Hobart, Australia

The Southern Ocean is an important contributor to the global carbon sink and is of most importance for our global climate. The capacity of the ocean to store and sequester carbon is set by the ocean circulation which transfers carbon in and out of the deep ocean. Decadal variability in the southern ocean carbon sink has been linked with variability in the large-scale upwelling of old carbon- and nutrient-rich deep water, the Circumpolar Deep Water (CDW).
While we know that outcropping of CDW results in CO2 outgassing, especially near the Antarctic continent, lots is still to learn about the CDW pathways from the ocean interior to the surface. Here we highlight an efficient pathway for CDW surfacing. We found that at the crossing of oceanic ridges, hotspots of carbon outgassing are a signature of CDW outcropping. We use a biogeochemical eddy-resolving ocean simulations (1/10°) to investigate the physical mechanisms involved in the CDW outcropping and carbon outgassing at these hotspots. We show that upwelling induced by flow-topography interaction, fronts merging and baroclinic instabilities control local CDW pathways resulting in hotspots of CO2 outgassing.
Gaining in-depth process understanding can help reducing uncertainties in the net contribution of the southern ocean to the global carbon sink.

1610

Frontal variability of the Antarctic Circumpolar Current.

Benoit LEGRESY[1], Steve RINTOUL[1], Annie FOPPERT[1], Gauthier GACOIN[1]
[1]CSIRO, Hobart, Australia

The Antarctic Circumpolar Current (ACC) plays a major role in regulating the transport of heat between the lower latitudes and Antarctica. The ACC has multiple substructures and fronts. Over the last decades, several studies have investigated the variability and shifts of these fronts with variable answers. Here we use 26 years of Satellite altimetry and 15 years of Argo sampling to monitor the changes in the ACC and interpret them at the same time as investigating the effect of methods used to monitor these fronts. One main finding is that the global sea level rise can significantly impact the results. Some studies reported large southward shifts of the fronts by using reference dynamic topographic levels as proxy to frontal position. Here we show that this is not as simple and that the large scale sea level rise needs to be taken into account. We propose a method to account for the large scale sea level rise in frontal position monitoring.

788

Separating roles of individual air-sea fluxes in the Southern Ocean warming under anthropogenic climate 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. It remains unclear how changes in the heat and freshwater fluxes and the poleward intensification of the westerly winds play different roles in driving the Southern Ocean warming patterns and magnitudes. In this study the contributions from individual air-sea fluxes are separated using global ocean model perturbation experiments, forced by the wind stress, heat flux, and freshwater flux anomalies under the doubled CO2 concentration provided by the Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP). Several key findings include: (1) The surface heat flux changes account for most of the ocean warming by adding heat into the ocean which is in turn redistributed by the background ocean circulation; (2) the wind-driven heat convergence is the key to enhance the deep-reaching warming at middle latitudes (centred at ~45ºS); (3) The poleward expansion of the subtropical gyres is primarily attributed to the wind forcing and heat accumulation near the poleward edges of the subtropical gyres. The wind forcing also drives a clockwise shift of the isopycnals in the Southern Ocean indicating a spin-up of the meridional overturning circulation (MOC) and the Antarctic Circumpolar Current (ACC); (4) The surface heat flux changes dominate the spiciness changes along density surfaces including cooling and freshening within the Subantarctic Mode Water (SAMW) and the Antarctic Intermediate Water (AAIW), whereas the surface freshwater flux changes contribute to a lesser extent.

1510

Changing water masses and their mechanisms in a standing meander in the Antarctic Circumpolar Current

J.J. Meijer[1,2], H.E. Phillips[1,2], N.L. Bindoff[1,2,3], S.R. Rintoul[3,4]
[1]Institute For Marine And Antarctic Studies, University of Tasmania, Hobart, Australia, [2]ARC Centre of Excellence for Climate Extremes, Hobart, Australia, [3]CSIRO Oceans and Atmosphere Flagship, Hobart, Australia, [4]Centre for Southern Hemisphere Ocean Research, Hobart, Australia

Most theories of the Southern Ocean and more specifically the Antarctic Circumpolar Current are based on zonally symmetric models that lack information about the complexity of the frontal structure and the presence of several significant topographic obstructions that cause the flow to meander.

We surveyed a standing meander in the Subantarctic Front downstream of the Southeast Indian Ridge with 11 cross-frontal transects, comprising 99 CTD profiles to ~1500 dbar, to examine the along stream change of watermass properties in the upper ocean. We describe the change in properties relative to gravest empirical mode reference fields of temperature and salinity.

Our results show that most of the temperature changes are on density levels rather than due to the vertical displacement of density layers. In the intermediate and upper deep waters ($\gamma n > 27.2$), temperature anomalies change from cold to warm from trough to crest. Whereas, in the mode waters ($26.8 < \gamma n < 27.2$) the temperature anomalies change from warmer into the trough to progressively colder in between trough and crest and then warmer into the crest again. The discrepancy between the upper and lower water column suggests different mechanisms at work.

Standing meanders from our results seem to be important pathways in heat transport as most of the watermass changes occurs on isopycnals. In the upper water column, the watermass changes occur due to changes in kinematics, whereas in the lower water column watermass changes are due to the turning of the velocity vector with depth inside standing meanders.

1438

Heat transport towards Antarctica driven by local dense water export in canyons

Adele Morrison[1], Andy Hogg[1], Matthew England[2], Paul Spence[2]
[1]Australian National University, Acton, Australia, [2]University of New South Wales, Sydney, Australia

Poleward transport of warm Circumpolar Deep Water (CDW) has been linked to melting of Antarctic ice shelves. However, even the steady state spatial distribution and mechanisms of CDW transport remain poorly understood. Using a global, eddying ocean model, we explore the relationship between CDW transport across the continental slope and descending Dense Shelf Water (DSW) transport. We find large spatial variability in onshore CDW heat and volume transport around Antarctica, with significantly enhanced flow where DSW descends in canyons. The CDW and DSW transports are highly spatially correlated within ~20km and temporally correlated on sub-daily timescales. Focusing on the Ross Sea, we show that the relationship is driven by pulses of overflowing DSW lowering sea surface height, leading to net onshore transport of CDW. The majority of simulated onshore CDW transport is concentrated in cold-water regions, rather than warm-water regions, with potential implications for ice-ocean interactions and global sea-level rise.

1027

Indian Scientific Expeditions to Southern Ocean an overview and future perspectives

Anilkumar Narayana Pillai[1]
[1]*National Centre For Polar And Ocean Research, VASCO DA GAMA, India*

The Southern Ocean is a very remotely accessible region due to its harsh climatic conditions, however it strongly controls the global climate. National Centre for Polar and Ocean Research has implemented eleven multi-disciplinary, multi- institutional scientific expeditions in the least investigated Indian sector of Southern Ocean since 2004 under the aegis of Ministry of Earth Sciences, Govt. of India. Comprehensive synoptic and time series observations are being made from these expeditions. The main focus is the "Role and response of Southern Ocean in the global and regional climatic variabilities". Studies are being undertaken to understand the air-sea-ice interaction, role of anthropogenic aerosols, water masses, circulation, biogeochemistry, productivity, carbon sequestration and paleoclimate. The major outcomes include- zones of sink (52°S) and ventilation (45°S) of CO_2; southward meandering of Antarctic Circumpolar Current; fast rate warming and freshening of bottom water; eddy influenced water masses movements; dominance of non sea salt aerosols; enhanced productivity in the shallow subtropical region; influence of melt water on productivity in the coastal and open ocean. Although changes are observed in the air-sea fluxes, hydrography and biophysical processes the data is not enough to predict the behaviour of the region in a rapidly changing climate scenario and it's influence on tropical climate variability. The future research in these waters will therefore largely focus on acquiring continuous data that involve long-term continuous observations using remotely operated platforms including moorings, floats, gliders etc.

Key words: Southern Ocean, hydrodynamics, biogeochemistry, water masses, eddies

1549

The Southern Ocean Observing System: Supporting the Community with Networks and Tools

Louise Newman[1], Sebastiaan Swart[2], Andrew Constable[3], Mike Williams[4], Eileen Hofmann[5], Phillippa Bricher[6]
[1]Southern Ocean Observing System, Hobart, Australia, [2]University of Gothenburg, Gothenburg, Sweden, [3]Australian Antarctic Division, Kingston, Australia, [4]National Institute of Water and Atmospheric Research, Wellington, New Zealand, [5]Old Dominion University, Norfolk, USA, [6]Southern Ocean Observing System IMAS-UTAS, Hobart, Australia

The Southern Ocean Observing System (SOOS) is an initiative of SCAR and SCOR and has the mission to enhance the collection and delivery of Southern Ocean observations to researchers and the broader community. SOOS was developed to address critical gaps in our observations of the Southern Ocean, which have led to uncertainties in estimates of the future state of Southern Ocean processes and the subsequent global consequences.

SOOS has now been operating for 9 years, and during this time has built community networks, focussed task groups, and tools to support collaboration and data discovery – towards addressing key observational gaps. This presentation will provide an overview of the achievements of SOOS over the last 5 years; highlight the ways that SOOS can support you in your research and data objectives; and outline the key priorities for SOOS over the next 5 years.

639

Surface water fCO_2 and Sea-Air CO_2 flux variability across the Weddell gyre and eastern sector of the Atlantic Southern Ocean, offshore Droning Maud Land/Hakon VII hav for Fall Season 2019

Margaret Ogundare[1], Agneta Fransson[2], Melissa Chierici[3], Thomas Ryan-Keogh[4], Warren Joubert[5], Alakendra Roychoudhury[1]

[1]Stellenbosch University, South Africa, Stellenbosch, South Africa, [2]Norwegian Polar Institute, Fram Centre, 9296 Tromso, Norway , Tromso, Norway, [3]Institute of Marine Research, Fram Centre, 9296 Tromso, Norway, Tromso, Norway, [4]Southern Ocean Carbon and Climate Observatory CSIR, South Africa, Cape town , South Africa, [5]South African Weather Service CSIR, Stellenbosch 7600, South Africa, Stellenbosch, South Africa

Unique austral autumn sea surface water CO_2 was monitored between 28th of February and 10th of April 2019 from Punta Arenas across the Weddell gyre and the eastern sector of the Atlantic Southern Ocean. The relative roles of the physical, chemical and biological drivers controlling the surface ocean CO_2 dynamics in the Antarctic circumpolar current (ACC) and Weddell gyre were elucidated by a correlation of CO_2 saturation (fCO_2_sat) to O_2 saturation. Surface property-property relationship of sea surface temperature (SST), sea surface salinity (SSS) and chlorophyll a (chl a) with fCO_2_sat suggests that the ACC is a weak CO_2 sink in autumn with -2.85 (±2) mmol/m²/d and -1.58 (±3) mmol/m²/d average CO_2 uptake across the west and eastern ACC transect respectively. The uptake observed in the ACC were influenced by hydrographic fronts in the ACC and photosynthesis. Frontal positions were identified by our hydrographic data and variation in the sea surface CO_2 distribution was observed at the frontal positions. A larger CO_2 flux (-8.85 (±10) mmol/m²/d) was computed for the Weddell gyre. Although, an intense CO_2 source was identified south of 60^oS due to combined upwelling of CO_2-rich waters and organic matter remineralization, the larger uptake is attributed to cooling and the photosynthesis occurring in the upwelling area of Maud Rise. An austral autumn mean CO_2 flux of -2.52 mmol/m²/d determined previously for the entire Weddell gyre compared with this study indicates the increasing CO_2 sink capacity of the Weddell gyre in autumn.

1118

Role of Southern Ocean eddies in cross-frontal transport of physical and biogeochemical properties

Ramkrushnbhai Patel[1,2], Helen Phillips[1,3], Andrew Lenton[4,5], Peter Strutton[1,3], Joan Llort[1,2,6], Sebastien Moreau[1,5], Paula Pardo[4]

[1]University of Tasmania, Hobart, Australia, [2]Australian Research Council Centre of Excellence for Climate System Science, University of Tasmania, Hobart, Australia, [3]Australian Research Council Centre of Excellence for Climate Extremes, University of Tasmania, Hobart, Australia, [4]Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere, Hobart, Australia, [5]Centre for Southern Hemisphere Oceans Research, CSIRO, Hobart, Australia, [6]Barcelona Supercomputing Centre, Barcelona, Spain, [7]Fram Centre, Norwegian Polar Institute, Tromsø, Norway

Mesoscale eddies are rotating bodies of water with diameters between 10 and 100 km that live from weeks to months. They are known to carry heat, salt and nutrients across Antarctic Circumpolar Current fronts, thereby playing a key role in the global meridional overturning circulation. Limited direct observations make it difficult to quantify the actual amount of heat, salt and nutrients carried by discrete eddies. Here, we present new observations of a cold-core eddy, collected during a voyage in the Subantarctic Zone south of Tasmania. Our analysis indicated that the amount of heat and salt carried into the Subantarctic Zone by cold-core eddies is much larger (~ 3 times) than previously reported. We also provide the first estimate of the nutrient content of the eddy and demonstrate that it carries a surplus of nitrate and a deficit of silicate relative to Subantarctic Zone waters.

Based on our ship-based observations in conjunction with satellite measurements of sea surface height and an eddy-tracking software, we propose that about 20% of the heat carried across the Subantarctic Front south of Tasmania is achieved by long-lived cold-core eddies entering the Subantarctic Zone. The annual volume of freshwater carried into the Subantarctic Zone is of the same order of magnitude as that delivered by equatorward Ekman transport. In terms of nutrients and carbon, we hypothesise that long-lived cold-core eddies can increases subantarctic mode water nutrient contents by up to 27%, which in turn has implications for global productivity and ocean carbon uptake.

1440

Flood gates for heat to Antarctica: observations in an Antarctic Circumpolar Current standing meander

Helen Phillips[1]
[1]*University of Tasmania, Hobart, Australia*

The interaction of the Antarctic Circumpolar Current with steep topography generates standing meanders in the flow. Such meanders are hot spots for eddy generation and poleward transfer of heat and other properties. Model studies and theoretical work suggest these meanders also play a significant role in dissipating the momentum imparted by strengthening westerly winds, preventing an acceleration of the ACC.

Observations in a standing meander of the Polar Front southeast of Tasmania were gathered to examine the evolution of watermass and velocity structure along the meander, and cross-stream fluxes, over the full water column. The suite of observations included full depth hydrographic transects with microstructure and biogeochemistry, high-resolution towed body measurements to 300 m, surface drifters and EM-APEX profiling floats. A heavily-instrumented tall mooring recorded an 18-month time series of water property variations and cross-stream fluxes at the crest of the meander.

The focus of this talk are the EM-APEX data which recorded watermass and velocity changes through a transition from parallel shear flow upstream of the Polar Front meander, to chaotic pathways through an intense eddy field within the meander trough. They were eventually ejected from the trough and followed a smooth pathway eastward and northward along the western side of the Macquarie Ridge to pass through a narrow gap in the ridge. We describe the along-stream variability and discuss the implications for cross-frontal exchange.

427

Antarctic shelf water changes in CMIP6 models

Ariaan Purich[1,2], Matthew England[1,2]
[1]ARC Centre of Excellence for Climate Extremes, Sydney, Australia, [2]Climate Change Research Centre, UNSW, Sydney, Australia

Antarctic shelf water plays a crucial role in driving global climate. Shelf water influences Antarctic ice sheet mass loss by ice shelf basal melt, and the formation of dense water in shelf regions modulates the global Meridional Overturning Circulation. Observational analyses have identified a shelf water warming in the Amundsen and Bellingshausen Seas, linked to a shoaling of Circumpolar Deep Water over the continental slope (Schmidtko et al. 2014). Here, we analyse temperature and salinity from the Coupled Model Intercomparison Project phase 6 (CMIP6). We assess the historical mean state and recent decadal changes in Antarctic Continental Shelf Bottom Water, Circumpolar Deep Water and Winter Water, and compare them to observed changes. We also assess projected changes under the high radiative forcing scenario (SSP5-8.5). Regions of the strongest simulated trends are compared with observed, and we identify regions of projected ice shelf melt sensitivity around Antarctica.

1272

There goes the neighbourhood: how enhanced ice shelf melting is impacting downstream polynyas in East Antarctica?

Natalia Ribeiro[1], Guy Williams[1], Laura Herraiz-Borreguero[2], Stephen Rintoul[2], Mark Hindell[1], Clive McMahon[1]
[1]Institute For Marine and Antarctic Studies, University Of Tasmania, Hobart, Australia, [2]Commonwealth Scientic and Industrial Research Organization Oceans and Atmosphere, Hobart, Australia

Antarctic Bottom Water (AABW) production, critical to the global overturning circulation, will be negatively impacted by a freshening of dense shelf waters by enhanced ice shelf melting. Using elephant seal data, we have investigated the relationship of glacier melt and downstream polynyas in East Antarctica that have been found to produce dense shelf water: Cape Darnley/Prydz Bay and, most recently, Vincennes Bay. The dense Cape Darnley source is currently on balance, protected by the recirculation of melting water within the Prydz Bay Gyre. The Vincennes Bay source is considered the weakest, producing a lower density shelf water that ultimately only contributes to the upper later of offshore Bottom Water. However this increases its significance, as a potential example of an AABW source region that could shutdown in response to ongoing and future change. Providing the first detailed oceanography description of the region, we found extraordinary intrusions of bottom-intensified modified Circumpolar Deep Water during late summer/early fall that is bottom-intensified by the influence of fresh meltwater-laden Winter Water from the upstream Totten Glacier. Local ice-shelf melting is likely to be occurring, as Vincennes Bay is fresher than surrounding waters. There is a complex interaction of mCDW with dense shelf water formation beneath two polynya regions, as the heat flux reduces local sea ice growth but the mCDW provides a positive salinity flux. Into the future, Vincennes Bay will be an important site to monitor the influence of enhanced ice sheet melting on East AABW.

1142

Recovery of Ross Sea Bottom Water formation driven by anomalous climate forcing

Alessandro Silvano[1,2,5], Annie Foppert[1,2], Stephen Rintoul[1,2,3,4], Paul Holland[6], Takeshi Tamura[7], Noriaki Kamura[8], Pasquale Castagno[9], Pierpaolo Falco[9], Giorgio Budillon[9], Alexander Haumann[6,10], Alberto Naveira Garabato[5], Alison Macdonald[11]

[1]CSIRO Oceans and Atmosphere, Hobart, Australia, [2]Centre for Southern Hemisphere Oceans Research, Hobart, Australia, [3]Australian Antarctic Program Parnership, Hobart, Australia, [4]NESP Earth Systems and Climate Change Hub, Hobart, Australia, [5]University of Southampton, Southampton, UK, [6]British Antarctic Survey, Cambridge, UK, [7]National Institute of Polar Research, Tokyo, Japan, [8]University of Tokyo, Tokyo, Japan, [9]Parthenope University, Napoli, Italy, [10]Princeton University, Princeton, USA, [11]Woods Hole Oceanographic Institution, Woods Hole, USA

Antarctic Bottom Water (AABW) supplies the lower limb of the global overturning circulation, ventilates the abyssal ocean, and sequesters heat and carbon on multidecadal to millennial timescales. AABW is supplied by dense water formed on the Antarctic continental shelf by strong winter cooling and brine released during sea ice formation. Over the past 50 years, the salinity, density and volume of AABW has decreased, with the most dramatic changes observed in the Ross Sea Bottom Water (RSBW). These changes have been attributed to increased melting of the Antarctic Ice Sheet. Here we use new observations to document a recovery in the salinity, density and thickness of RSBW, with properties in 2018-2019 similar to those observed in the 1990s. The recovery is the result of increased sea ice formation on the continental shelf. The increase in sea ice formation was triggered by anomalous wind forcing associated with the unusual combination of positive Southern Annular Mode and extreme El Niño conditions between 2015 and 2018. Our study highlights the sensitivity of bottom water formation to remote forcing and shows that episodic increases in sea ice formation driven by climate anomalies can counter the tendency for increased ice sheet melt to reduce AABW formation.

1280

Decadal trend of the carbonate system properties of shelf waters and of Antarctic Bottom Waters in the Ross Sea (Antarctica)

Paola Rivaro[1], Carmela Ianni[1], Davide Vivado[1], Pasquale Castagno[2], Yuri Cotroneo[2], Pierpaolo Falco[2]
[1]Department of Chemistry and Industrial Chemistry, University of Genoa, Genova, Italy, [2]Department of Sciences and Technology, Parthenope University of Naples, Napoli, Italy

Ross Sea Bottom Water (RSBW), the second largest source of Antarctic Bottom Water (AABW), is formed by the mixing of the Dense Shelf Water (DSW) and Circumpolar Deep Water (CDW) along the continental slope. Changes in the thermohaline properties or in the volume of the sinking dense waters can result in changes in chemical properties, such as the amount of anthropogenic CO_2 (Cant) injected in the deep layers. Total alkalinity (AT) and pH samples collected during 5 Italian Antarctic Research Program (PNRA) expeditions between 2006 and 2017 were analyzed to evaluate the variability of the carbonate system associated with different water masses in the Ross Sea. The water masses on the Ross Sea continental shelf were identified trough their physical and chemical data. The results allow to evaluate the carbonate system variability on a ten-year scale, which is considered representative for this area, considering the increase of global atmospheric CO_2 from 382 to 405 ppm and the interannual variability of the basin. The Cant values obtained from the application of TrOCA method to the dataset vary over the years between 9 and 61 µmol/Kg on average, emphasizing that the deep layers of the water column are invaded by anthropogenic carbon. The highest concentrations are found associated with the presence of High Salinity Shelf Water (HSSW) in the Terra Nova Bay polynya area, where this water mass is formed during winter. The observed variability suggests that future climatic changes may significantly affect carbon cycling in this dynamic environment.

63

Control of the oceanic heat content of the Dotson Trough, Antarctica, by the Amundsen Sea Low

Tiago Segabinazzi Dotto[1,2], Alberto Naveira Garabato[2], Anna Wåhlin[3], Sheldon Bacon[4], Paul Holland[5], Satoshi Kimura[6], Michel Tsamados[7], Laura Herraiz Borreguero[8], Ola Kalén[3,9], Adrian Jenkins[5]
[1]Universidade Federal Do Rio Grande, Rio Grande, Brazil, [2]University of Southampton, Southampton, UK, [3]University of Gothenburg, Gothenburg, Sweden, [4]National Oceanography Centre, Southampton, UK, [5]British Antarctic Survey, Cambridge, UK, [6]Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan, [7]Centre for Polar Observation and Modelling, Department of Earth Sciences, University College London, London, UK, [8]Commonwealth Scientific and Industrial Research Organisation Oceans and Atmosphere, and Centre for Southern Hemisphere Oceans Research, Hobart, Australia, [9]Swedish Meteorological and Hydrological Institute, Gothenburg, Sweden

The supply of warm Circumpolar Deep Water (CDW) to the West Antarctic continental shelf is responsible for the basal melting and thinning of the West Antarctic ice shelves that has occurred in recent decades. Here, we assess the variability in CDW supply, and its drivers, from a multi-year mooring deployed in, and a regional ocean model spanning, the Dotson Trough, Amundsen Sea. Between 2010 to 2015, the CDW within the trough underwent a pronounced cooling and freshening, associated with changes in thermohaline properties on isopycnals. Variability in the rate of CDW inflow is tightly controlled by local wind forcing of a shelf-break undercurrent, which determines the hydrographic properties of inflowing CDW via tilting of density surfaces above the continental slope. Local wind forcing is coupled to the Amundsen Sea Low (ASL) low-pressure system, which is modulated by large-scale climatic modes via atmospheric teleconnections. For the period analysed, a deeper ASL was associated with westward wind anomaly at the shelf-break. Changes in the sea surface slope decelerated the shelf-break undercurrent, resulting in less heat accessing the continental shelf and, consequently, a cooling of the Dotson Trough. As well as regulating the delivery of CDW toward the Amundsen Sea, the ASL influences the westward export of meltwater from the region via changes in the intensity of a coastal current, with possible consequences for the freshening of the Ross Sea.

64

A hydrographic gridded data set for the Northern Antarctic Peninsula

Tiago Segabinazzi Dotto[1], Mauricio Mata[1], Rodrigo Kerr[1], Mariele Paiva[1], Carlos Garcia[1,2]
[1]Universidade Federal do Rio Grande, Rio Grande, Brazil, [2]Universidade Federal de Santa Catarina, Florianópolis, Brazil

The Northern Antarctic Peninsula (NAP), is characterized as a transitional oceanic regime composed by warmer and saltier waters originated from the Bellingshausen Sea and colder and relatively fresher shelf waters from the Weddell Sea. This dichotomy provides an intense oceanographic variability on interannual time-scales. On longer time-scales, its deep waters, which are fed mainly by Weddell Sea shelf waters, have shown freshening and lightening trends. Due to its relatively easy access, the NAP can be considered an in situ laboratory to study changes associated with the Weddell Sea shelf waters. The Brazilian High Latitude Oceanographic Group (GOAL) has been surveying the region quasi-annually since 2003, measuring high-resolution hydrographic profiles. Here, we make use of this rich database from 2003 to 2019 to create a high-resolution gridded product for the NAP. Profiles of temperature, salinity and dissolved oxygen were linearly interpolated into 114 vertical levels between 5-4500 m. Then, the profiles were optimally interpolated into a grid of ~10 km resolution in space. The gridded product successfully captures the main water masses present in the region, the regional fronts (e.g. Peninsula Front and the Bransfield Front) on the surface and on deeper depths, as well as the intrusion paths of the water from Bellingshausen and Weddell Seas. As an example of its potential use, we highlight the validation of regional models, and to provide direct estimates of transport into and out of the NAP and its straits. Once ready, the NAP high-resolution gridded product will be freely available.

267

Bi-stability of the Filchner-Ronne Ice Shelf Cavity Circulation and Basal Melt Rates

Julia Hazel[1], Andrew Stewart[1]
[1]*University of California, Los Angeles, Los Angeles, United States*

Circulation and water mass transformation within the Filchner-Ronne Ice Shelf (FRIS) cavity create precursors to Antarctic bottom water, which closes the global overturning circulation. This water mass transformation is contingent upon a relative low rate of FRIS basal melt, currently around 100-200 Gt/yr. Previous studies have indicated that Antarctic climate changes may induce intrusions of warm modified Warm Deep Water (mWDW) and an order-of-magnitude increase in basal melt, and signatures of mWDW have recently been observed along the face of the FRIS. However, it remains unclear how changes in near-Antarctic climate translate mechanistically to changes in mWDW access to the FRIS cavity.

In this study a regional model is developed to investigate FRIS circulation dependence on local atmospheric state. Experiments with modified initial cavity conditions but identical atmospheric states yield bi-stable ``warm'' and ``cold'' FRIS cavity states, with an order-of-magnitude difference in basal melt rates. Idealized atmospheric perturbation experiments reveal that relatively modest perturbations to the katabatic winds shift the FRIS cavity between ``warm'' and ``cold'' states, which occur when the FRIS cavity is filled by mWDW or High Salinity Shelf Water (HSSW), respectively. The authors present a conceptual model in which the FRIS cavity state is determined by whether mWDW or HSSW is denser, and thus floods the cavity; these states are bi-stable because the basal melt rate feeds back on the salinity of HSSW. These findings highlight a key role for the katabatic winds in mediating the melt of the FRIS and other Antarctic ice shelves.

89

Effect of resolution on heat and carbon dynamics in a regional ocean circulation model for the Argentine Basin

Stan Swierczek[1], Matthew Mazloff[2], Matthias Morzfeld[2], Joellen Russell[1]
[1]University Of Arizona, Tucson, United States, [2]Scripps Institution of Oceanography, La Jolla, United States

The Argentine Basin is a region of strong currents and turbulent mixing of subpolar and subtropical waters, with large uncertainties surrounding integrated quantities such as air-sea exchanges of heat and carbon. We construct a regional ocean model with biogeochemistry at 1/3, 1/6, and 1/12 degree resolutions for the year 2017 and use initial conditions and boundary forcing from BSOSE (the Biogeochemical Southern Ocean State Estimate) and atmospheric forcing from ERA5. Model output is compared against Argo and SOCCOM float profiles, sea surface height maps, and other observation-based products. We quantify the effect of resolution both on misfit to these products, on model upper ocean heat and carbon content and the associated air-sea exchanges, and vertical transport in the upper ocean.

81

Lagrangian pathways and residence time of warm Circumpolar Deep Water on the Antarctic continental shelf

Veronica Tamsitt[1,2], Matthew England[1], Steve Rintoul[2,3]
[1]*University Of New South Wales, Hobart, Australia,* [2]*Centre for Southern Hemisphere Oceans Research, Hobart, Australia,* [3]*CSIRO Oceans and Atmosphere, Hobart, Australia*

The inflow of relatively warm modified Circumpolar Deep Water (CDW) onto the Antarctic Continental Shelf and into ice shelf cavities is a key driver of Antarctic ice shelf mass loss. While there have been recent advances in understanding the processes that control the rate of CDW transport onto the continental shelf in different regions around Antarctic, there is a gap in understanding the fate and residence time of the CDW on the shelf. Here we use Lagrangian particle tracking experiments in a high resolution circum-Antarctic ocean-ice model to map both the pathways and residence times of CDW on the Antarctic continental shelf. We investigate how residence times and transformation of CDW vary by region along the continental shelf. Results show complex spatial heterogeneity in residence times of CDW in the shelf, with generally shorter residence times in regions of rapid water mass transformation on the shelf and much longer residence times elsewhere. These results emphasize that it is the residual of the heat transport of CDW onto the shelf and the transformation into denser waters on the shelf, rather than the heat transport of CDW onto the shelf alone, that is relevant for the reservoir of warm waters on the shelf available to for ice shelf melt.

1572

Combined glider and float observations of Southern Ocean ventilation at submesoscales

Andrew Thompson[1], Lilian Dove[1], Giuliana Viglione[1]
[1]*California Institute Of Technology, Pasadena, United States*

Characterized by weak stratification, energetic frontal currents, and strong surface forcing, the Southern Ocean is susceptible to submesoscale instabilities that influence vertical tracer transport, air-sea exchange, and mixed layer depths. Here we present observations from two separate ocean glider deployments focused on transitions in ventilation and water mass transformation across the Polar Front.

In the ChinStrAP2 project, two ocean gliders were piloted across the Polar Front (PF) in Drake Passage. Despite strong surface wind and buoyancy forcing, a meltwater lens south of the PF suppresses small-scale variability and subduction in the upper ocean. Surface-interior exchange is instead localized to the PF. The intensity of upper ocean ventilation and lateral mixing at the PF increases in response to a deepening of the surface mixed layer and a weakening of the front during mid-winter, which enables along-isopycnal subduction of surface waters into the interior. During the SOGOS project, two ocean gliders were deployed alongside a SOCCOM semi-Lagrangian biogeochemical float near the PF in a large standing meander in the Indian sector of the Southern Ocean. Comparisons of physical properties and tracer variance between the high-strain/EKE region and the low-strain/EKE downstream region underscore the importance of vigorous eddies in the production of deep-reaching lateral buoyancy gradients which can lead to vertical transport via cross-frontal secondary ageostrophic circulation. Optical backscatter measurements suggest links between particular export and small-scale circulation features. We conclude that submesoscale have a strong impact on exchange between the surface boundary layer and the interior in the Southern Ocean.

118

21st century projected sea surface temperature in the Southern Ocean and the potential impacts on microbial diversity

Marcos Tonelli[1], Camila Signori[1], Bruno Ferrero[1], Amanda Bendia[1], Juliana Neiva[1], Vivian Pellizari[1], Ilana Wainer[1]
[1]*University of Sao Paulo, Sao Paulo, Brazil*

Anthropogenic global warming can have devastating impacts on marine ecosystems, especially on climate-sensitive regions such as the Southern Ocean (SO). It is, therefore, critical to understanding how Sea Surface Temperature (SST) may change in the future since it is one of the most pressing aspects of climate change with blunt consequences for Antarctic pelagic microbiomes. As key drivers of biogeochemical cycles, estimating microbial diversity and community structure across temperature will allow us to predict ecosystem functioning and help delineate potential interactions and niche characteristics. By using a suite of numerical tools derived from physical oceanography, machine learning, and microbial ecology, we investigate the long-term changes in the SO's SST throughout the 21st century, as projected by CMIP6 Earth System Models simulations, as well as the microbial diversity and interactions responding to temperature in the northwestern Antarctic Peninsula, which is rapidly warming. Four Shared Socioeconomic Pathways (SSPs) ranging from the mitigation and adaptation to the high emissions scenarios (i.e., SSP126, SSP245, SSP370, and SSP585) are considered to assess the SO's surface sensitivity to a warming climate. We discuss the potential impacts of these projections on Antarctica's marine diversity of bacteria and archaea, which are expected to be significant and persistent by the late 21st century, especially within the higher end of the range of future forcing pathways.

906

A Three-Dimensional Analysis of the Southern Ocean Residual Circulation

Madeleine Youngs[1], Glenn Flierl[1]
[1]*Massachusetts Institute of Technology, Cambridge, United States*

The Southern Ocean has a major role in the global air-sea carbon fluxes, with some estimates suggesting it takes up 40% of anthropogenic carbon dioxide. Understanding the Southern Ocean residual overturning is particularly important because it fluxes tracers between the depth and the surface. The Southern Ocean is faced with a changing climate and changing winds, but there is little theory to describe how the residual overturning in a Southern Ocean-like channel will respond to changes in wind when there is a blocking ridge, or how the existence of the ridge changes the circulation. This study uses a re-entrant MITgcm channel to examine how residual overturning, generated by appropriate relaxation boundary conditions, varies with the wind. An analysis of the three-dimensional residual circulation highlights the localized nature of this transport and the non-linear response of the circulation to changes in wind. The localization of the vertical flow shows the necessity of highly focused observations in the Southern Ocean to understand the transport.

A

Abrahamsen, E. Povl 715
Abrahamsen, Povl 134
Amos, Caitlin 1001
Arroyo, Mar 975

B

Bacon, Sheldon 63
Bendia, Amanda 118
Biddle, Louise 194
Bindoff, N.L. 1510
Bindoff, Nathan 543
Boehme, Lars 134
Bostock, Helen 873
Bowen, Melissa 726
Brearley, Alexander 194, 134
Bricher, Phillippa 1549
Buckingham, Christian E. 715
Budillon, Giorgio 1245, 1142
Budillon, GIorgio 1243

C

Castagno, Pasquale 1319, 726, 1142, 1280
Castagno, Pasquale 1245
Castelao, Renato 1001
Chapman, Christopher 1063
Cheng, Lingqiao 1571
Chierici, Melissa 639
Church, John 788
Constable, Andrew 1549
Cotroneo, Yuri 1243
Cotroneo, Yuri 1280

D

Damini, Brendon Yuri 80
De Alteris, Arturo 1319, 1245
De Santis, Laura 873
Dinniman, Michael 1001
Dove, Lilian 1572

E

England, Matthew 1438, 427
England, Matthew 81
England, Matthew H. 567

F

Falco, Pierpaolo 1319, 1245, 1243, 726, 1142, 1280
Fernandez, Denise 726
Ferrero, Bruno 118
Firing, Yvonne 134
Flierl, Glenn 906
Foppert, Annie 567, 1142
FOPPERT, Annie 1610
Forcen-Vazquez, Aitana 726
Frajka-Williams, Eleanor 715
Fransson, Agneta 639
Fusco, Giannetta 1243

G

GACOIN, Gauthier 1610
Gallerani, Andrea 1245
Garcia, Carlos 64
Gerin, Riccardo 1319
Giglio, Federico 1245
Gordon, Arnold L. 715
Gordon , Arnold 726
Griffiths, Huw 134

H

Hauck, Judith 737
Haumann, Alexander 1142
Hazel, Julia 267
Herraiz Borreguero, Laura 63
Herraiz-Borreguero, Laura 1272
Hewitt, Helene 134
Hindell, Mark 1272
Hobbs, Will 543
Hofmann, Eileen 1549
Hogg, Andrew 1434
Hogg, Andy 1438
Hogg, Anna 134
Holder, Liam 873
Holland, Paul 1142, 63
Huber, Bruce 726
Huber, Bruce A. 715
Hyder, Pat 134

I

Ianni, Carmela 1280
IODP Expedition 374 Scientists, 873

J
Jenkins, Adrian 63
Jones, Dan 134
Joubert, Warren 639

K
Kalén, Ola 63
Kamura, Noriaki 1142
Kent, Elizabeth 134
Kerr, Rodrigo 64
Kerr , Rodrigo 80
Kimura, Satoshi 63
Kitade, Yujiro 1571
Klinck, John 1001
Klocker, Andreas 737
Krauzig, Naomi 1319, 1245
Kuchler, Stefano 1319
Kulhanek, Denise 873
Kusahara, Kazuya 975

L
Lam, Phoebe 873
Lambelet, Myriam 873
Langlais, Clothilde 737
Langone, Leonardo 1245
LEGRESY, Benoit 1610
Leng, Melanie 134
Lenton, Andrew 737
Lenton, Andrew 1118
Llort, Joan 1118
Lyu, Kewei 788

M
Macdonald, Alison 1142
Mata, Mauricio 64
Mauri, Elena 1319
Mazloff, Matthew 89
McKay, Rob 873
McMahon, Clive 1272
Medeiros, Patricia 1001
Meijer, J.J. 1510
Meijers, Andrew 134
Meijers, Andrew J. S. 715
Menna, Milena 1243
Meredith, Michael 194, 134
Meredith, Michael P. 715
Monselesan, Didier 1063
Moorman, Ruth 1434
Morales-Maqueda, Miguel 194
Moreau, Sebastien 1118
Morrison, Adele 1434, 1438
Morzfeld, Matthias 89
Munday, David 134

N
Narayana Pillai, Anilkumar 1027
Naveira Garabato, Alberto 1142, 63
Naveira Garabato, Alberto C. 715
Neiva, Juliana 118
Newman, Louise 1549
Notarstefano, Giulio 1243
Nurser, George 134

O
Ogundare, Margaret 639

P
Paiva, Mariele 64
Pardo, Paula 1118
Patara, Lavinia 1243
Patel, Ramkrushnbhai 1118
Pellichero, Violaine 1063
Pellizari, Vivian 118
Phillips, H.E. 1510
Phillips, Helen 1118, 1440
Plancherel, Yves 873
Poulain, Pierre 1243
Purich, Ariaan 427

R
Ribeiro, Natalia 1272
Rieck, Jan Klaus 1243
Rintoul, S.R. 1510
Rintoul, Stephen 1142
RINTOUL, Steve 1610
Rivaro, Paola 1319, 1280
Roach, Chris 543
Roy, Tilla 543

Rintoul, Stephen 1272
Rintoul, Stephen R. 567
Rintoul, Steve 975, 737, 81
Roychoudhury, Alakendra 639
Russell, Joellen 89
Ryan-Keogh, Thomas 639

s
sallee, Jean-Baptiste 737

S
Sallee, Jean-Baptiste 543
Schwartz, John 873
Scott, Ryan 194
Segabinazzi Dotto, Tiago 80, 63, 64
Shadwick, Elizabeth 975
Shimada, Keishi 1571
Shirayi, Yu 1571
Signori, Camila 118
Silvano, Alessandro 1142
Smyth, Tim 134
Spence, Paul 1438
Spingys, Carl P. 715
Stewart, Andrew 267
Strutton, Peter 1118
Swart, Sebastiaan 194
Swart, Sebastiaan 1549
Swierczek, Stan 89

T
Tamsitt, Veronica 81
Tamura, Takeshi 1142
Thompson, Andrew 1572
Tilbrook, Bronte 975
Tonelli, Marcos 118
Tsamados, Michel 63

V
Van de Flierdt, Tina 873
Venables, Hugh 194
Viglione, Giuliana 1572
Vivado, Davide 1280

W
Wåhlin, Anna 63
Wainer, Ilana 118
Williams, Guy 1272
Williams, Mike 1549

Y
Yelland, Margaret 134
Youngs, Madeleine 906

Z
Zambardino, Giovanni 1319
Zambardino, Giovanni 1245
Zambianchi, Enrico 1319
Zhang, Xuebin 788
Zuppelli, Piero 1319

ISBN: 978-0-948277-59-7

www.scar2020.org