**AUSTRALIAN RESEARCH COUNCIL**
**Discovery Projects**
**Application for Funding Commencing in 2024**

DP

**Project ID: DP240102358**

**First Investigator: A/Prof Helen Phillips**

**Admin Org: University of Tasmania**

Total number of sheets contained in this Application: 151

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# Part A - Administrative Summary (DP240102358)

## A1. Application Title

*(Provide a short title (up to 75 characters, approximately 10 words).)*

| |
|---|
| Antarctica's leaky defence to poleward heat transport |

## A2. Person Participant Summary

*(Add all people participating in this application as a Chief Investigator or Partner Investigator. The Chief Investigator/s must: not be undertaking a Higher Degree by Research during the Project Activity Period; reside for more than 50 per cent of their time in Australia for the Project Activity Period; and be an employee for at least 0.2 FTE at an Eligible Organisation, or be a holder of an honorary academic appointment (defined in the Glossary of the grant guidelines) at an Eligible Organisation.)*

| Number | Name | Participant Type | Current Organisation(s) | Relevant Organisation |
|---|---|---|---|---|
| 1 | A/Prof Helen Phillips | Chief Investigator | University of Tasmania | University of Tasmania |
| 2 | Dr Annie Foppert | Chief Investigator | University of Tasmania | University of Tasmania |
| 3 | Prof Nathaniel Bindoff | Chief Investigator | University of Tasmania, University of Tasmania | University of Tasmania |
| 4 | A/Prof Paul Spence | Chief Investigator | University of Tasmania | University of Tasmania |
| 5 | Prof Jae-Hun Park | Partner Investigator | Inha University, Korea | Inha University, Korea |
| 6 | Prof D. Watts | Partner Investigator | University of Rhode Island, USA | University of Rhode Island, USA |
| 7 | Dr James Girton | Partner Investigator | University of Washington, Seattle | University of Washington, Seattle |

## A3. Organisation Participant Summary

*(Add all organisations participating in this application. Refer to the Instructions to Applicants for further information.)*

| Number | Name | Participant Type |
|---|---|---|
| 1 | University of Tasmania | Administering Organisation |
| 2 | University of Washington, Seattle | Other Organisation |
| 3 | University of Rhode Island, USA | Other Organisation |
| 4 | Inha University, Korea | Other Organisation |

## A4. Application Summary

*(Provide an Application Summary, focusing on the aims, significance, expected outcomes and benefits of this project. Write the Application Summary simply, clearly and in plain English. If the application is successful, the Application Summary will be used to give the general community an understanding of the research. Avoid the use of acronyms, quotation marks and upper-case characters. Refer to the Instructions to Applicants for further information (up to 750 characters, approximately 100 words).)*

| |
|---|
| Southern Ocean currents are barriers to the oceanic transport of heat toward Antarctica. This barrier breaks down at key locations along their path and the poleward heat transport is enhanced. Changing winds are expected to accelerate heat transport, threatening ice shelves that protect Antarctic glaciers from ocean-driven melt. This project aims to advance understanding of the small-scale processes that control heat transport across the Southern Ocean. By combining funded international field campaigns that harness new advances in observing systems with next-generation numerical modelling, this research will create a step-change in our ability to predict |

Southern Ocean environmental change.

**A5. National Interest Test Statement**

*(See the Instructions to Applicants for addressing the National Interest Test and further information available on the ARC website.)*

Antarctica is a frozen continent surrounded by icy waters. The reason that warmer waters to the north are kept away from Antarctica are the powerful ocean currents, called the Antarctic Circumpolar Current and Antarctic Slope Current, that encircle Antarctica. These currents create barriers to the southward movement of warm waters but in some places the barrier leaks and heat gets through. This often occurs in places where deep currents run into rough undersea mountains, causing the currents to become wavy and create eddies. These eddies allow heat to move across the barrier and closer to Antarctica. We know that the strong winds over the Southern Ocean have a big impact on the currents and stronger winds lead to more eddies. The westerly winds have been getting stronger for decades and are likely to continue to get stronger. We expect that the southward movement of heat will increase as a result, which will increase the rate that Antarctica is melting and sea levels are rising. Our project will use new observations and models of the ocean to understand how eddies are moving heat towards Antarctica. We will apply this new understanding to turn daily maps of ocean sea surface height from satellites into daily maps of the movement of heat in the Southern Ocean toward Antarctica. This information will help governments plan how to respond to rising sea levels and how fast they need to act.

## Part B - Classifications and Other Statistical Information (DP240102358)

### B1. Australian Government priority areas

*(Does this application align with an announced Australian Government policy? For reporting purposes, the ARC is capturing relevant Australian Government policies for your application. If your application does not align with an announced Australian Government policy, please select 'No'.)*

| |
|---|
| Yes |

Full name of current Australian Government Policy and, if known, year of announcement.

| |
|---|
| Australian Government Science and Research Priorities, 2015. Priority 8 - Environmental Change. |

### B2. Field of Research (FoR-2020)

*(Select up to 3 FoR classification codes that relate to the application. Note that the percentages must total 100.)*

| Code | Percentage |
|---|---|
| 370803 - Physical oceanography | 80 |
| 370201 - Climate change processes | 20 |

### B3. Socio-Economic Objective (SEO-2020)

*(Select up to 3 SEO classification codes that relate to the application. Note that the percentages must total 100.)*

| Code | Percentage |
|---|---|
| 180402 - Antarctic and Southern Ocean oceanic processes | 100 |

### B4. Interdisciplinary Research

*(This is a 'Yes' or 'No' question. If you select 'Yes' 2 additional questions will be enabled:*
*1. Specify the ways in which the research is interdisciplinary by selecting one or more of the options below and click 'Add'.*
*2. Indicate the nature of the interdisciplinary research involved (up to 375 characters, approximately 50 words).)*

Does this application involve interdisciplinary research?

| |
|---|
| No |

Specify the ways in which the research is interdisciplinary by selecting one or more of the options below.

| |
|---|
| |

Indicate the nature of the interdisciplinary research involved (up to 375 characters, approximately 50 words).

| |
|---|
| |

### B5. Does the proposed research involve international collaboration?

*(This is a 'Yes' or 'No' question. If you select 'Yes' 2 additional questions will be enabled:*
*1. What is the nature of the proposed international collaboration activities?*
*2. If the proposed research involves international collaboration, specify the country/ies involved.)*

| |
|---|
| Yes |

**B6. What is the nature of the proposed international collaboration activities?**

*(Select all options from the drop down list which apply to this application by clicking on the 'Add' button each time an option is selected.)*

| |
|---|
| Correspondence: eg email; telephone; or video-conference |
| Face to face meetings |
| Attendance at and/or hosting of workshop or conference |
| Collaborative fieldwork |
| Hosting international Partner Investigator: short-term (less than 4 weeks) |
| Travel to international collaborator: short-term (less than 4 weeks) |

**B7. If the proposed research involves international collaboration, please specify the country/ies involved.**

*(Commence typing in the search box and select from the drop-down list the name of the country/ies of collaborators who will be involved in the proposed project. Note that Australia is not to be listed and is not available to be selected from the drop-down list.)*

| |
|---|
| United States of America |
| Korea, Republic of (South) |

**B8. How many PhDs, Masters and Honours positions will be filled as a result of this project?**

*(For reporting purposes, the ARC is capturing the number of Research Students that would be involved if the application is funded. Enter the number of all student places (full-time equivalent - FTE) that will be filled as a result of this project, not just those requested in the budget for funding in the application form.)*

Number of Research Student Places (FTE) - PhD

| |
|---|
| 2 |

Number of Research Student Places (FTE) - Masters

| |
|---|
| 0 |

Number of Research Student Places (FTE) - Honours

| |
|---|
| 4 |

## Part C - Project Eligibility (DP240102358)

### C1. Medical Research

*(This is a 'Yes' or 'No' question. Does this application have content which requires a statement to demonstrate that it complies with the eligible research requirements set out in the ARC Medical Research Policy located on the ARC website?)*

No

### C2. Medical Research Statement

*(Justify why this application complies with the eligible research requirements set out in the ARC Medical Research Policy located on the ARC website. Eligibility will be based solely on the information contained in this application. This is the only chance to provide justification, the ARC will not seek further clarification (up to 750 characters, approximately 100 words).)*

### C3. Current Funding

*(Does this application request funding for similar or linked research activities, infrastructure or a project previously funded, or currently being funded, with Australian Government funding (from ARC or elsewhere)? This is a 'Yes' or 'No' question. If 'Yes', provide the Project ID(s) and explain how funding this project would not duplicate Australian Government funding or overlap with existing projects.)*

No

Funded Project ID(s)

Detail how this project is different from the previously/currently funded project(s) (up to 2000 characters, approximately 285 words).

### C4. Other application(s) for funding

*(Are you applying for funding from the Australian Government (ARC or elsewhere) for similar or linked research? This is a 'Yes' or 'No' question. If 'Yes' provide the application ID(s) and briefly explain why more than one application for similar or linked research has been submitted and, should all applications be successful, how they will be managed to avoid duplication of Australian Government funding.)*

No

If yes, provide the application ID(s)

Briefly explain why more than one application for similar or linked research has been submitted and, should all applications be successful, how they will be managed to avoid duplication of Australian Government funding (up to 2000 Characters, approximately 285 words).

# Part D - Project Description (DP240102358)

**D1. Please confirm that potential risks have been taken into consideration for the proposed project, including the impacts of COVID-19.**

*(The application form will not validate if "No" is selected. Please note that if this application is successful a risk management plan will be required to be held by the Administering Organisation before the project starts and any changes in circumstances that affect the proposed research project will be managed as a post award issue by the ARC.)*

Yes

**D2. Project Description**

*(Upload a Project Description as detailed in the Instructions to Applicants and in the required format. Ensure that the Project Description responds to the Assessment Criteria listed in the grant guidelines (up to 10 A4 pages).)*

Uploaded PDF file follows on next page.

**PROJECT TITLE: Antarctica's leaky defence to poleward ocean heat transport**

**PROJECT AIMS AND BACKGROUND**

Overview

The circumpolar currents of the Southern Ocean are barriers to the poleward movement of heat, allowing waters around Antarctica to remain close to freezing (Figure 1a). The Antarctic Circumpolar Current (ACC) is largely maintained by strong Southern Ocean westerly winds. These winds have strengthened and shifted poleward over the last few decades due to our changing climate (Meredith et al. 2019). In response, ocean eddy kinetic energy has increased at a rate of nearly 5% per decade in eddy-rich regions of the ACC (Martínez-Moreno et al. 2021). The southern boundary of the ACC, which sits just offshore of the continental shelf in the Australian Antarctic sector, has shifted >50 km closer to some major Antarctic ice shelves (Figure 1b). These ocean circulation trends are expected to persist as Southern Ocean winds continue to strengthen and further encroach on Antarctica with anthropogenic forcing (Meredith et al, 2019).

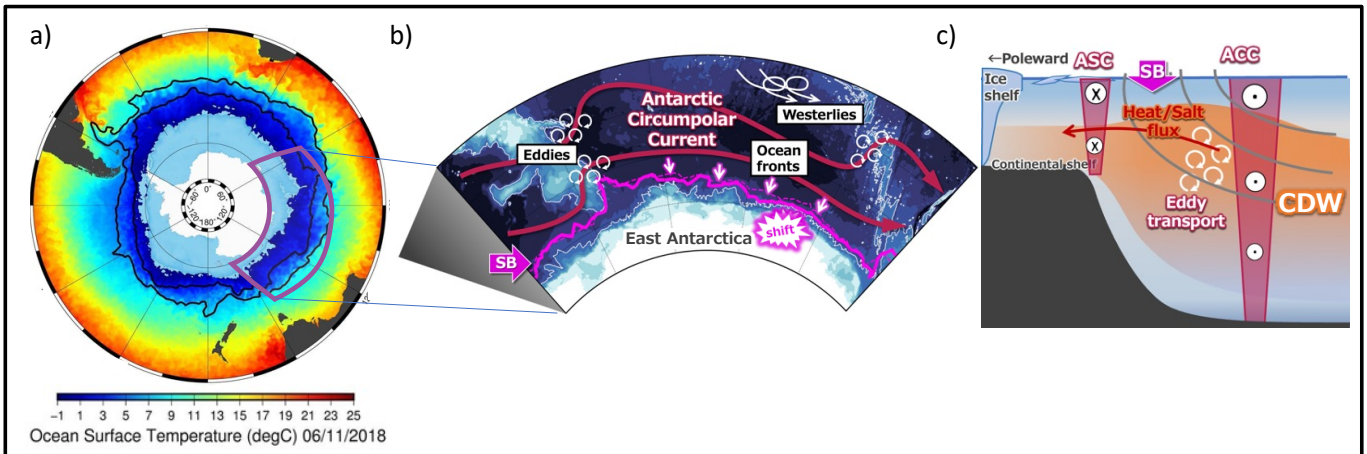


**Figure 1**. a) Observed Southern Ocean surface temperature with sea ice extent (light blue shading) and long-term position of the ACC (black lines). b) Southern Ocean of Australia's East Antarctic Territory showing eddy hotspots (white swirls), the observed position of the Southern Boundary (SB) ACC front in the 1990s (dashed magenta line near Antarctica) and its poleward shift by the 2010s (solid magenta) from Yamazaki et al. (2021). c) Ocean processes near the Antarctic continental margin. Eddies move Circumpolar Deep Water (CDW) across the sloping isopycnals (grey curves) of the Antarctic Circumpolar Current (ACC) and Antarctic Slope Current (ASC).

The impact of the observed increase in ocean eddy activity and shifting of fronts closer to Antarctica is difficult to quantify. However, it is alarmingly clear that the Southern Ocean has irrevocably warmed (Wijffels et al. 2016, Rathore et al. 2019). Glacial melt by warm and salty Circumpolar Deep Water (CDW) intruding on the underside of ice shelves (Figure 1c) has accelerated (Rignot et al. 2019, Brancato et al. 2020). Antarctic melt has already contributed 12% of total sea-level change (2006-2015) and by 2300 the IPCC could not rule out 15m of sea level rise from high-impact low confidence ice shelf collapse (Bindoff et al. 2019). While cross frontal heat fluxes are crucial to changing sea level, cross frontal salt fluxes are crucial to the global freshwater cycle and formation of Antarctic Bottom Water that monopolizes the overturning circulation (Meredith et al. 2019).

Warm and salty CDW must first cross the frontal barriers of the ACC and Antarctic Slope Current (ASC) before it can reach Antarctica's continental shelf and ice shelves. These barriers break down in key places where eddies drive fluxes through the frontal barriers (Figure 2, Naveira Garabato et al. 2011). This proposal builds on over a decade of achievements by our team in observing and modelling the Southern Ocean dynamics central to Antarctica's leaky defence to poleward ocean heat and salt transport (Frölicher et al. 2015). Our team are leaders of several funded international field campaigns that will harness new advances in observing systems and next-generation numerical modelling to target ocean heat and salt transport in key regions of Australia's Antarctic territory. The proposal will create a step-change in our ability to predict Southern Ocean environmental change and leave our society better informed about the melting of Antarctic glaciers, global sea level rise and changes in the global hydrological cycle.

Aims

1. Quantify localized cross-frontal heat and salt transports from observations collected during funded field campaigns and corroborate them with next-generation, high-resolution ocean model simulations.
2. Apply theoretical and numerical advances to fuse satellite and subsurface observations to create a new circumpolar dataset of cross-frontal heat and salt fluxes.
3. Quantify decadal trends, seasonal and interannual variability of Southern Ocean poleward heat and salt fluxes from observations and model simulations.

Background

The ocean has absorbed more than 90% of the excess heat trapped on Earth due to human influence (Rhein et al. 2013). The Southern Ocean occupies only 25% of global ocean area but accounted for as much as 43% of the global ocean heat gain above 2000 m depth 1970-2017, accelerating to as much as 62% of global heat gain 2005-2017 (Rhein et al. 2013, Meredith et al 2019). It is the unique geometry of the Southern Ocean – a circumpolar band uninterrupted by land – and the combined effect of strong winds and intense air-sea exchanges of heat and freshwater around Antarctica that make this possible (Rintoul and Naveria Garabato 2013). Steeply sloping isopycnals drive the circumpolar geostrophic flow of the ACC and ASC. At the same time, the strong meridional gradients across these sloping isopycnals limit meridional exchange throughout much of the Southern Ocean (Rintoul and Naveira Garabato 2013; Thompson et al. 2018). Instabilities of the flow extract potential energy stored in the sloping isopcynals and convert it to eddy kinetic energy (EKE) in a process known as baroclinic instability (Gill, 1982). Eddies are the product of baroclinic instability, created when the jets meander, become unstable, and pinch off eddies.

In hotspots, where standing meanders form as a result of the interaction of the deep-reaching currents and rough topography, eddy generation is enhanced and the meridional transport barrier becomes leaky (Naveira Garabato et al., 2011, Thompson et al. 2018). In these hotspots, we see enhanced EKE (Martinez-Moréno et al. 2021), poleward fluxes of heat and other properties (Thompson and Sallee 2012, Dufour et al. 2015, Foppert et al. 2017), vertical momentum transport (Thompson & Naveira Garabato, 2014), upwelling of warm Circumpolar Deep Water (CDW, Tamsitt et al. 2017) and subduction of carbon (Llort et al. 2018).

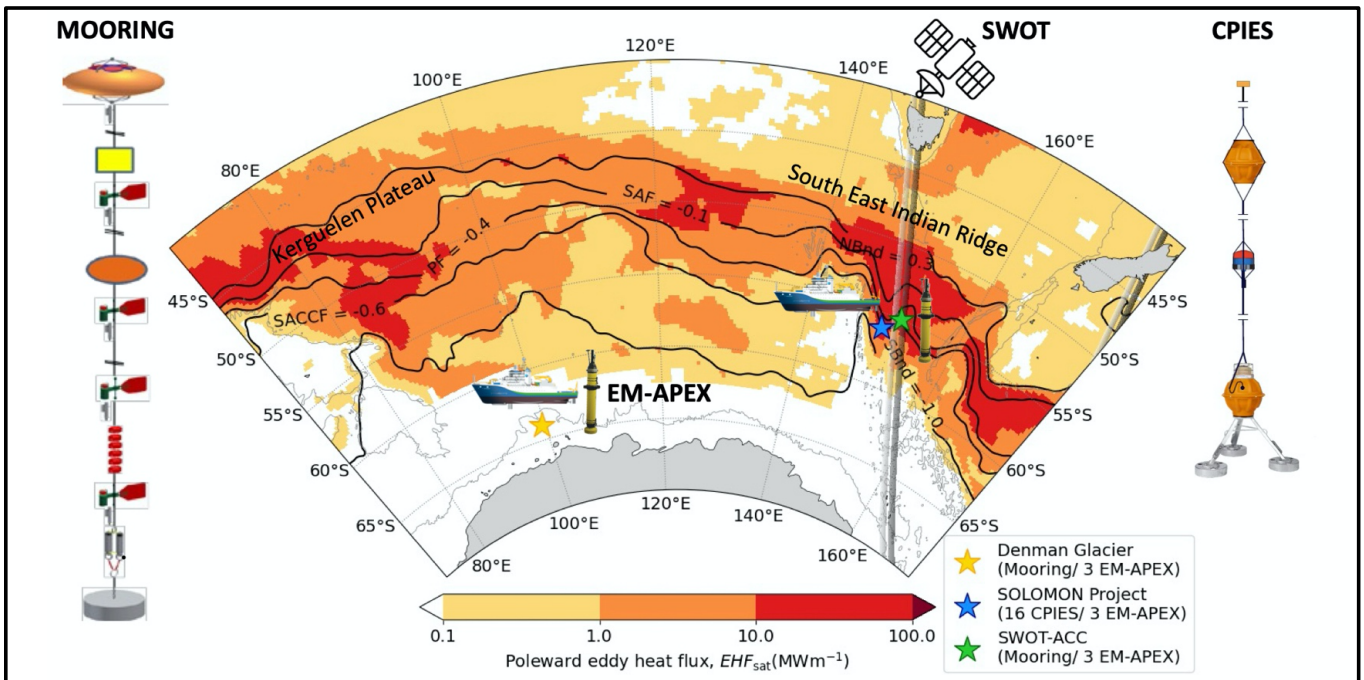


**Figure 2**. Eddy heat flux (shading, MWm$^{-1}$) derived from satellite Sea Surface Height (SSH) by Foppert et al. (2017) showing that eddy heat flux increases by two orders of magnitude in topographic hotspots. White space is under sea ice cover or an EHF below 0.1 MWm$^{-1}$. The black contours show the ACC fronts by their characteristic SSH. The thin grey lines show 2500m depth. This proposal capitalizes on approved field campaigns (coloured stars) and the overpass of the new SWOT SSH satellite launched in 2022 that coincides with the SWOT-ACC field program (grey swaths). Side panes show advanced in-situ instruments to be deployed: tall mooring, CPIES and EM-APEX.

While poleward Southern Ocean eddy heat flux is essential to the Earth's heat balance (Bryden 1979), the disequilibrium due to climate change and amplification of EKE in the Southern Ocean (Martínez-Moreno et al. 2021) is expected to accelerate heat fluxes and shift warm temperature fronts poleward (Yamazaki et al. 2021, Herraiz-Borreguero et al. 2022), delivering more warm CDW to the Antarctic margin. There have been considerable efforts to map eddy heat flux using observations from the global satellite and *in situ* observing systems (e.g. Katsumata et al. 2016, Chapman et al. 2017, Foppert et al., 2017, Sun et al. 2019, George et al. 2021). However, only Foppert et al. (2017) incorporate direct observations of subsurface velocity profiles that are the key to cross-frontal transport of heat (Figure 2). They developed a proxy for eddy heat flux from sea surface height standard deviation to map the mean poleward eddy heat flux across the ACC and investigate long term trends in key hotspots. They find significant, positive trends in 3 hotspots – Kerguelen, Southeast Indian Ridge (SEIR) and Brazil Malvinas Confluence (Figure 2 shows Kerguelen ~70°E and SEIR ~150°E). A key limitation of the Foppert et al. (2017) study is that they only have direct

observations in Drake Passage. Elsewhere around the Southern Ocean they rely on subsurface structure functions found empirically from the Southern Ocean State Estimate (Mazloff et al. 2010).

Ocean velocity defines the ocean circulation and the dynamical processes that govern the ocean's role in climate. Cross-stream fluxes occur when the horizontal velocity at depth is rotated relative to the surface velocity (Bryden 1979, Lindstrom et al. 1997). Yet direct measurements of this rotation of horizontal velocity with depth have been limited to sparse moored arrays, ships equipped with acoustic Doppler current profilers and process studies using novel profiling floats and gliders (Szuts et al. 2019). Unconstrained by observations, we risk being misdirected by models that, although highly sophisticated in their representations of the governing equations of motion, are forced with imperfect surface boundary conditions, lack information about critical ocean processes – submesoscale motions, internal waves, diapycnal and isopycnal mixing, tides, flow-topography interactions – and include parameterisations to represent subgrid-scale physics. **The need to constrain these models with direct observations is paramount.**

There is a tantalizing opportunity to harness the maturing global ocean observing system to map the time-varying ocean heat flux. The limitations of these datasets for mapping eddy heat flux are the absence of information about the subsurface velocity profile that enables the cross-front movement of heat, which our team can now provide. In this project, we will use our advances in theoretical understanding to fuse daily surface maps from satellite with the subsurface vertical structure of ocean velocity and density from more sparse observations. Thirty years of global satellite sea surface height and geostrophic currents provide extraordinary detail on the surface structure and variability of oceanic jets and mesoscale eddies. The 20-year global Argo profiling float time-series tracks the changing temperature and salinity from the sea surface to 2000m depth.

Since 2008, the UTAS team and PI Girton have been leading pioneering experiments using the novel EM-APEX profiling float to obtain high-resolution (2-3 m vertical, 1-10 km horizontal) velocity profiles, collocated with temperature and salinity, in hotspots for eddy fluxes. Our team has used these observations to investigate the vertical structure of velocity and its relationship to cross-stream fluxes along jets of the ACC (e.g. Phillips and Bindoff 2014, Meijer et al. 2022). In parallel, CI Foppert and PIs Watts and Park have conducted ambitious field programs using moored instruments to accurately measure cross-frontal heat and salt fluxes in hotspots for cross-frontal exchange south of Australia and in Drake Passage. Furthermore, our team is leading active field programs that are delivering new observations of Southern Ocean velocity and density structure that will support this project.

This project brings together our respective advances in observations and theory and major developments in high-resolution modelling of the Southern Ocean through CI Spence. We will develop a unique and innovative method to quantify rotation of horizontal velocity with depth and the associated poleward eddy heat flux across the ACC and ASC, direct from observations. We will cross-validate the observation-based fluxes with high-resolution model simulations and map the trends, seasonal and interannual variability in both observed and modelled fluxes. While this proposal is framed in terms of heat fluxes, salt fluxes will be determined in the same way (Treguier et al. 2014), providing new information on the global freshwater cycle in which the ocean plays a leading role (Bindoff et al. 2019) and salt fluxes to the Antarctic continental shelf that are crucial for maintaining Antarctic Bottom Water formation and the ocean's overturning circulation (Rintoul and Naveira Garabato 2013).

**INVESTIGATORS/CAPABILITY** (Metrics from Google Scholar/Web of Science 5/3/2023)

Our diverse team is exceptional in research productivity over a broad range of career stage from HDR (Wyatt and new HDRs), early career (Foppert and Postdoc Meijer), mid career (Phillips, Spence, Girton and Park) and senior (Bindoff and Watts). Our team comprises leaders in observational physical oceanography, specialising in Southern Ocean dynamics, and a leader in high-resolution ocean-sea ice modelling. Our strengths in expertise will translate into extraordinary outcomes in this project because of our long-term, existing collaborations in research, field programs and student supervision.

**A/Prof Phillips** (CI, 0.2 FTE) is an observational physical oceanographer with expertise in measuring, quantifying and understanding the oceanic processes that control the movement of heat and other properties across the Southern Ocean. Her PhD work provided an observational benchmark for poleward eddy heat flux across the ACC that is a fundamental reference for current observational and modelling studies and she is an international leader in investigation of ocean dynamics using EM-APEX profiling floats. She will lead the overall project and take responsibility for coordinating communications from the project. She will co-lead WP1 with Meijer and WP2 with Foppert, contribute to WP3 and WP4, lead supervision of HDR1 and co-supervise Wyatt and HDR2. Phillips has 53 high quality publications in leading discipline journals (28 in the last 5 years). Phillips's h-index is 25/22 with 1789/1168 total citations and 238/190 citations per year.

**Dr Foppert** (CI, 0.2 FTE) is an early career physical oceanographer, with a keen focus and expertise in understanding Southern Ocean dynamics and circulation. She is a sea-going, observational oceanographer and is the Deputy Chief Scientist for the SWOT voyage in year 0 of this project. Foppert is an expert in using a large suite of observational platforms to study large-scale currents and mechanisms for heat fluxes across the Southern Ocean.

Foppert and PI Watts have long-standing collaborations that have resulted in step-change in understanding of eddy heat fluxes across the Southern Ocean (Figure 2). Collaborations between Foppert, Phillips and Bindoff and Postdoc Meijer have contributed to the theoretical advances that are crucial for WP2 and WP3. Foppert will co-lead the WP2 development of eddy heat flux from EM-APEX and co-supervise HDR students, contributing to all work packages. Foppert's h-index is 7/6 with 164/113 total citations and 75/56 citations per year.

**Prof Bindoff** (CI, 0.1 FTE) is an expert in the analysis of observations (altimetry, hydrographic data, gravest empirical modes, water mass transformation and dynamics of the Southern Ocean) and their comparison to simulations. He has extensive knowledge of the Earth system models (CMIP5/6) and their application to detection and attribution to human influence. He will lead the development of WP3 (GEM climatology) and contribute comparison of observations with simulations and trends in poleward heat flux of WP4. He will participate in deployment and recovery of the instruments and their analysis (WP1 and WP2). Bindoff is highly awarded for his climate work, has h-index of 65/47 with 55,864/11,213 total citations and 5327 citations per year. Bindoff has a total of 125 peer reviewed publications, 34 in the last 5 years.

**A/Prof Spence** (CI, 0.1 FTE) is an expert in ocean dynamics and leading developer of high-resolution ocean, ice simulations. Spence is an ARC Future Fellow and CI on the 2016 and 2020 ARC Linkage grants behind the formation of the Consortium for Ocean-Sea Ice Modeling in Australia (https://cosima.org.au/). COSIMA provides world leading coupled ocean, ice model configurations, simulation data and analysis tools for the benefit of the Australian and global scientific community. Spence will contribute his experience in ocean dynamics and provide next generation ACCESS-OM3 ocean modelling tools to this team. Spence's h-index is 29/26 with 3719//2708 total citations and 521/444 citations per year.

**Prof Watts** (PI, 0.1 FTE) is an expert in deep ocean deployments to measure eddy heat fluxes and small-scale processes in energetic current systems including the ACC. Watts and Foppert developed the satellite proxy method for estimating eddy heat flux and unique instrumentation methods. He is co-leading the collaboration with Prof Park to the Southern ACC Front array south of Tasmania (Figure 2) that is one of the observational experiments central to this project. Watts will also contribute to methods used by Foppert, Phillips, Bindoff and Spence. Watts is highly awarded for his ocean circulation work in 118 peer-reviewed publications. He is a Fellow of the American Meteorological Society for his contribution to oceanography. His h-index is 44/32 with 6011/3477 total citations and 296/197 per year.

**Dr Girton** (PI, 0.1 FTE) is a physical oceanographer and expert in the measurement of finescale ocean processes. His group is the world-leader in the development and use of EM-APEX floats, including their application to Antarctica, and holds most of the data collected outside of Australia. Dr Girton and his team have been funded by the US Office of Naval Research to deploy a global array of 50 EM-APEX enhanced with temperature microstructure, three of which are included in this project. He will contribute to WP1 and WP2. Girton's h-index is 26/23 with 2911/2073 total citations and 312/198 citations per year.

**Prof Park** (PI, 0.1 FTE) is a physical oceanographer with decades of experience in observing strong current systems with CPIES and tall moorings. He will work on fluxes from the moored array and contribute to comparison of these with the EM-APEX estimates and model simulation in WP1 and WP2. Park's metrics from Scopus are h-index of 24 with 2030 total citations and more than 238 citations per year.

**Postdoctoral Fellow Jan Jaap Meijer** (1.0 FTE) is a physical oceanographer with expertise in ocean modelling, *in situ* and satellite observations, and their analysis. He has a strong background in fluid dynamics and has proposed a new mechanism for interpreting satellite altimetry to quantify vertical motion and cross-stream fluxes that are amplified in hot spots for poleward fluxes. Dr Meijer will co-lead WP1 with Phillips, contribute to the other work packages and contribute to the mentoring and supervision of PhD students.

**Mr Wyatt** (current UTAS HDR, 1.0 FTE) is cosupervised by Bindoff, Foppert and Phillips. He will work on implementing new theory and observations to update the Satellite Gravest Empirical Model climatology of Meijers et al. (2011), which will be a contribution to WP3. His PhD will be submitted in 2025.

**HDR1** (1.0FTE) will have primary supervision by Foppert and Phillips and co-supervision from Spence, Bindoff and Meijer. They will work on the development and analysis of heat fluxes from observations in WP2.

**HDR2** (1.0 FTE) will have primary supervision by Spence in the development of ACCESS-OM3 and high-resolution simulations. They will contribute to the calculation and analysis of simulated fluxes in WP4, co-supervised by all CIs and Meijer.

**PROJECT QUALITY AND INNOVATION**

This project aims to revolutionize our understanding of the processes controlling the Southern Ocean heat flux towards Australia's Antarctic territory, its variability and outlook for the future. This project is uniquely innovative and cohesive because it: 1) capitalises on the large in-kind investments in **Southern Ocean field campaigns** (Figure 2, Table 1) in the Antarctic Circumpolar Current south of Tasmania and the Antarctic Slope Current in the region of the Denman Glacier, East Antarctica; 2) applies theoretical and numerical advances to create an **advanced circumpolar dataset of**

**cross-frontal heat and salt fluxes** and examine their trends and variability; 3) utilises **next-generation high-resolution ocean modelling** to corroborate and expand upon the observations.

**1) Southern Ocean field campaigns**

RV Investigator:

We are leading a funded RV Investigator voyage to the Polar Front in the SEIR eddy hotspot south of Tasmania (*SWOT-ACC: Smaller scales of the Antarctic Circumpolar Current in a meander South of Tasmania*, Chief Scientist Legresy and Deputy Foppert, 15/11-20/12/2023). The voyage (green star, Figure 2) includes deployment of a highly equipped tall mooring in the Polar Front of the ACC to record an 18-month timeseries of heat flux; detailed shipboard and ocean glider surveys to observe the finescale processes driving cross-frontal exchange; and the deployment of the 3 University of Washington EM-APEX profiling floats equipped with turbulence sensors. SWOT-ACC is endorsed by NASA and the European Space Agency to provide in situ observations to validate the new Surface Water Ocean Topography (SWOT) satellite, which will provide at least 10-fold higher resolution in sea surface height than traditional altimeters. This voyage will significantly improve our capability to interpret the high-resolution sea surface height field provided by SWOT. The experiment aims to characterise the small-scale variability in the meander and to relate small-scale variability in sea surface height to subsurface ocean structure. CI Foppert will lead and CI Phillips and HDR Wyatt will participate in the voyage.

RV Araon:

PIs Watts and Park have a US-Korean collaborative field program underway (2021-2025) that includes a 4D current mapping array composed of 16 CPIES (Current Pressure Inverted Echo Sounders) and an additional tall mooring in the Southern ACC Front (blue star, Figure 2). PI Watts is funded by NSF and PI Park is funded through Korean government investment in the Southern Ocean Long-term Observation and MONitoring (SOLOMON) Project. These instruments will provide a 4-year timeseries of twice-daily maps of full water column ocean heat flux that are a unique and valuable resource. Tall moorings and CPIES both have well-tested best practices for accurately quantifying heat fluxes in the Southern Ocean (e.g. Phillips and Rintoul, 2000; Watts et al. 2016, respectively). The RV Araon will visit the location in January 2025 to recover the array and redeploy a smaller one that will remain in place until at least 2027, making it **the longest ocean flux time series collected in the ACC.** They will deploy three of our EM-APEX floats to profile through their array to provide the **first ever direct calibration of EM-APEX with velocity and heat flux measurements from both a tall mooring and a CPIES mapping array**.

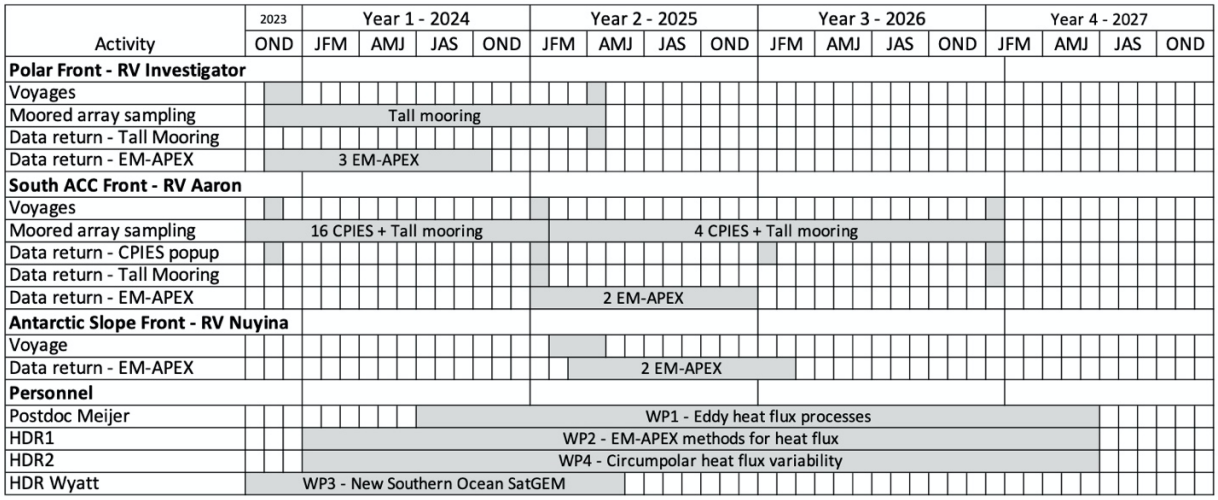


**Table 1:** Timeline of work plan for the three externally funded field campaigns, for the personnel whose funding is requested in this proposal and for HDR Wyatt who is funded by UTAS, including primary work package focus.

RSV Nuyina:

During February-April 2025, Australia's new icebreaker, RSV Nuyina, will be conducting marine science in the region of the Denman Glacier, East Antarctica (yellow star, Figure 2). This voyage is a collaboration between Australia's major Antarctic research programs, the Australian Antarctic Division, Australian Centre of Excellence in Antarctic Science (ACEAS), Australian Antarctic Program Partnership (AAPP) and Securing Antarctica's Environmental Future (SAEF). CI Phillips is the Denman voyage coordinator for ACEAS and will be participating in the voyage. The voyage will provide a transect across the southern side of the ACC and Antarctic Slope Current and as close to the glacier as is possible considering sea ice conditions at the time. The voyage plan includes shipboard and ocean glider surveys across the Antarctic Slope Current and along pathways of CDW intruding into the cavity under the glacier (Figure 1c). A tall mooring will be deployed to provide the **first ever time series of inflow and outflow between the glacier cavity and offshore**. We will deploy three EM-APEX floats next to the mooring to calibrate their estimates of heat flux. They

will follow the regional currents, providing broader spatial estimates of ocean currents, density structure, eddy heat flux and mixing over a 1-year period.

Global Array of EM-APEX:

PI Girton's ONR-funded project *A Global Distributed Observing Program for Shear, Energy Flux, and Mixing by Internal Waves* includes a global deployment of 50 EM-APEX floats. The EM-APEX float (Sanford et al. 2005) is an Argo profiling float supplemented with electromagnetic sensors to measure horizontal velocity relative to a reference level (Figure 2). Relative velocity is combined with GPS surface positions of consecutive profiles to yield absolute velocity (Phillips and Bindoff, 2014). EM-APEX operate autonomously, transmitting data to satellite and receiving mission updates. The instrument was developed in the University of Washington group that PI Girton now leads. Girton's ONR-funded floats are enhanced with temperature microstructure sensors to quantify diapycnal mixing. Three of these floats will deployed from the SWOT-ACC voyage in 2023.

In addition to the new float deployments, we will partner with Girton's team to assemble a new global collection of EM-APEX profiles, which is estimated to be approximately 60,000 collocated profiles of velocity, temperature and salinity More than half of the profiles are in the Southern Ocean. Most of these data are not available publicly because there is not yet a uniform approach to data processing and formatting by different groups. Our efforts to assemble and process the data uniformly represents an extraordinary contribution to the global ocean data collection. For comparison, a research vessel can only collect 4 deep-ocean profiles in a day, leading to a cost per profile of $30,000. Thus, **if collected by traditional shipboard methods, the 60,000 profiles would take 40 years to collect at a cost of $1.8 trillion**. This collection will underpin the research outcomes of this project and will be submitted to the publicly accessible Global Ocean Currents Database of the NOAA National Centers for Environmental Information, following recommendations of Szuts et al. (2019).

**2) Advanced circumpolar dataset of cross-frontal heat and salt fluxes**

The Argo profiling float array obtained global coverage in 2005, collecting more than 100,000 profiles per year of temperature and salinity to 2000 m depth. Using these profiles to estimate heat flux requires knowledge of the average state of the Southern Ocean and information about the structure of velocity through the water column. ACC jets are constantly moving the strong meridional gradients of density, temperature, salinity and other properties. Thus, a conventional average on a latitude, longitude grid smears the gradients and creates a mean field that misrepresents the ACC vertical and horizontal structure. An elegant solution is the Gravest Empirical Mode (GEM) approach (e.g. Watts et al. 2001, Meijers et al. 2011). The key to the GEM climatology is the strong relationship between sea surface height and the vertical structure of temperature and salinity, allowing profiles to be grouped by their position relative to moving fronts and eddies so that sharp gradients across the ACC are resolved. That is, every sea surface height value has an associated temperature and salinity profile. For every daily map of sea surface height, the GEM provides a way to reconstruct daily subsurface temperature and salinity.

In situ observations of velocity, far less numerous than temperature and salinity profiles, show clear evidence of rotation of horizontal velocity with depth in the ACC (Phillips and Bindoff 2014). This rotation is tightly linked to vertical motion and is responsible for cross-stream fluxes of heat and salt. Upwelling, anticlockwise rotation from deep to shallow and along-isopycnal advection from the warm side to the cold side of the front (downwelling, clockwise rotation, advection from cold to warm) has been demonstrated for the ACC (Phillips and Rintoul 2000; Tracey et al. 2006; Phillips and Bindoff 2014; Watts et al. 2016).

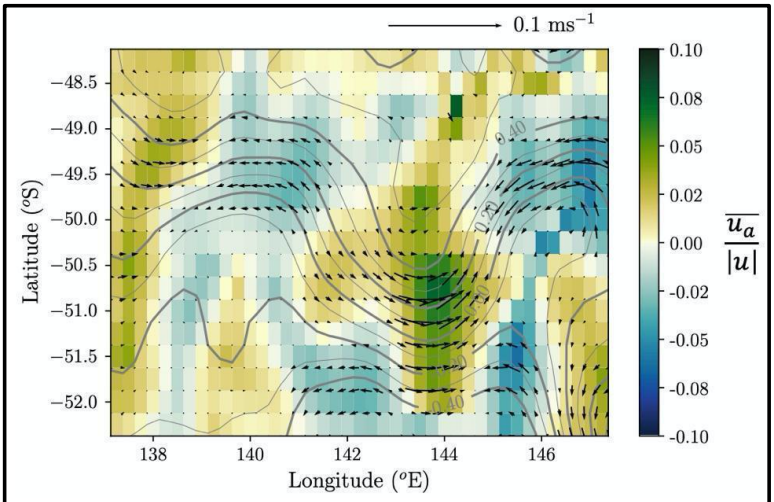


**Figure 3**. Snapshot of ageostrophic velocity from satellite sea surface height (vectors) and proportion of ageostrophic flow to the total gradient wind (shading) in an ACC meander. The ageostrophic component accelerates the flow in the crest (green shading) and retards it in the trough (blue). From Meijer et al. (2022).

The original GEM (Meijers et al. 2011) provided interior ocean velocities that assumed geostrophic balance and was therefore incapable of fluxing heat across streamlines of the flow. Similarly, sea surface geostrophic velocities estimated from satellite sea surface height (distributed as a global product by Copernicus Marine Service) also assume geostrophic balance, and are therefore non-divergent and incapable of fluxing heat. Meijer et al. (2022) applied the gradient wind balance (Holton 2004) to sea surface height to quantify the ageostrophic component of the currents that is due to strong curvature in the flow in eddy hotspots. They demonstrated that ageostrophic flow, of order 10% of

total flow in ACC meanders (Figure 3), accelerates the current in the crest (southward side) of the meander and retards in the trough (northward side). This leads to divergence between the trough and crest that drives upwelling along isopycnals and cross-stream flow of warmer water moving southward (since isopycnals slope upward to the south across the ACC and temperature on isopycnals decreases southward). Similarly, convergence between the crest and trough drives downwelling and cooler water moving northward along isopycnals. The resulting phase-locked sub- and super-geostrophic flows include the leading ageostrophic velocities in simulations of the ACC (Meijer et al 2022).

This new insight presents a powerful dynamical tool that can be also applied throughout the water column (via dynamic height surfaces that are referenced to the sea surface and calculated from available profiles of temperature and salinity). We now have a **dynamically based method to determine the full ocean depth total velocity (geostrophic + ageostrophic) that drives poleward fluxes** and will apply this to construct a new circumpolar SatGEM capable of fluxing heat. This subsurface flow field, built on physical principles applied to satellite altimetry since 1992 and Argo (and other) data, will deliver more accurate heat fluxes than the empirical approach used by Foppert et al. (2017) and will allow us to **quantify the temporal variability of poleward heat flux** (WP4).

**3) Next-generation high-resolution ocean modelling**

A suite of factors makes observing and attributing the cause or strength of changes in eddy variability and poleward fluxes in the Southern Ocean exceptionally difficult. Harsh and remote conditions focus *in situ* observations to short time scales in just a few locations. Satellites do not observe subsurface ocean or under sea ice conditions, and prior to the SWOT mission their resolution just barely captured Southern Ocean mesoscale features (Figure 4a). The innovative measurements and observational programs described above address some of the questions and aims of this project, but it is only when numerical modelling is linked to the direct experiments and satellite observations that we have capacity to explicitly test dynamical mechanisms and close heat and salt budgets.

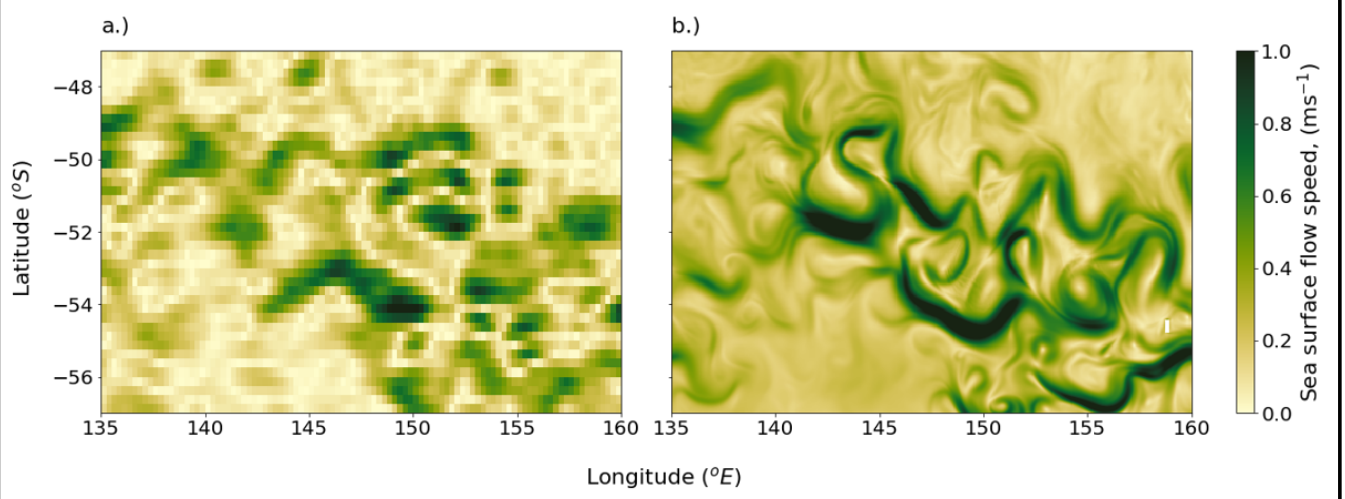


**Figure 4.** Snapshot (1-day time-mean) of surface current speed ($ms^{-1}$) in the Southeast Indian Ridge hotspot of the ACC derived from (a) satellite altimetry sea surface height and (b) the next generation, fully eddy resolving 1/20° horizontal resolution ACCESS-OM3 model simulation. This proposal will also capitalize on a 1/40° ACCESS-OM3 model currently being configured by COSIMA as well as the new SWOT satellite altimetry data.

ACCESS-OM2-01 is Australia's current work-horse global eddy resolving (1/10th degree) ocean model, but it utilizes the outdated MOM5 ocean code and its resolution does not resolve mesoscale dynamics at the southern boundary of the ACC or near the Antarctic continental shelf. This project will push new boundaries in numerical modelling by utilizing the next-generation ACCESS-OM3 configurations created by CI Spence and COSIMA. ACCESS-OM3 is a step change in ocean modelling because it adopts the transformative MOM6 ocean code, upgrades the sea-ice model (CICE6) and incorporates the Wave-watch 3 wave model. MOM6 is uniquely transformative for many reasons, particularly because it has a versatile vertical coordinate system that minimize spurious numerical mixing and includes dynamic ocean cavities under Antarctic ice shelves.

This project will use ultra high-resolution ACCESS-OM3 simulations, known as PanAnt-ACCESS-OM3, that have a circumpolar Southern Ocean domain and lateral open ocean boundary conditions on the equatorial flank. Simulations at 1/20$^{th}$ degree horizontal resolution with varying vertical coordinates have been extensively tested at Australia's National Computing Intrastructure laboratory and are ready for scientific application. See, for example, the difference between present-day satellite altimetry and this high-resolution model (Figure 4). By mid-2023, Australia's first circumpolar Southern Ocean model capable of resolving sub-mesoscale features, PanAnt-ACCESS-OM3 at 1/40$^{th}$

degree resolution, will be ready. By utilizing these cutting-edge models, in conjunction with intensive observational campaigns, this project will improve predictions of environmental change throughout the Southern Ocean.

**Work Packages**

The overarching aim of this project is to derive the **Southern Ocean poleward eddy heat and salt flux** and **quantify trends, seasonal and interannual variability**. We will accomplish this within 4 work packages:

**WP1: Regional investigation of processes that drive eddy heat flux (Lead Phillips/Postdoc Meijer)**

- Conduct field experiments at the Polar Front and Southern ACC Front in the SEIR eddy hotspot and Antarctic Slope Front in the region of the Denman Glacier (stars, Figure 2, Table 1). These field experiments will provide contemporaneous EM-APEX, shipboard, and moored time series measurements of temperature, salinity and velocity. All three field experiments include tall moorings for well-tested estimates of eddy fluxes to refine the heat flux calculation from EM-APEX floats. Deployment voyages are: 1) SWOT-ACC – RV Investigator (confirmed, Nov-Dec 2023), 2) Southern ACC Front – RV Icebreaker Araon (Korea, voyage confirmed, early 2025 dates to be decided) and 3) Denman voyage – RSV Nuyina (confirmed, Feb-Apr 2025).
- Examine processes that lead to phase-locking of 3-dimensional ocean velocity with surface meander patterns. We will quantify the relationships between surface properties - e.g. front curvature, vorticity balance terms and ageostrophic motions, building on Meijer et al. (2022) - and subsurface rotation of horizontal velocity with depth and the resultant vertical motion and poleward fluxes, building on Phillips and Bindoff (2014), using in situ and satellite observations and high-resolution ocean models.
- Expand knowledge of submesoscale processes measured by the EM-APEX floats through complementary analysis of the new SWOT sea surface height product and the 1/40° ACCESS-OM3 simulations.

**WP2: Poleward heat flux from EM-APEX data (Lead CI Foppert/Phillips, HDR1)**

- Develop the method to calculate eddy heat flux vectors from EM-APEX data. We will use the method of Watts et al. (2016) to isolate the dynamically important, divergent component of velocity, the deep barotropic velocity and use the vertical shear from SatGEM in WP3 to extend EM-APEX velocities to full-depth profiles. The resulting flux estimates will be compared rigorously with contemporaneous CPIES- and tall mooring-based heat flux estimates from our field experiments and with ACCESS-OM3 simulations.
- Apply the new best-practice methods to calculate eddy fluxes in the Southern Ocean EM-APEX collection.

**WP3: Construct a new Southern Ocean SatGEM (Lead CI Bindoff, HDR Wyatt)**

- Create a circumpolar Southern Ocean GEM climatology using all available temperature and salinity profiles in the Southern Ocean - including delayed-mode quality-controlled profiles from the Argo, SOCCOM, and seal observer arrays and shipboard data from publicly accessible, online repositories. This update will have >300,000 more profiles than the original GEM of Meijers et al. (2011).
- Update the SatGEM methodology to incorporate the influence of gradient wind balance. Gradient wind balance will be applied throughout the water column using the GEM to project the sea surface height field at the surface into dynamic height surfaces through the full ocean depth. The temperature profiles in the GEM will be adjusted based on the divergence-driven cross-frontal flows and GEM temperature fields.
- Validate the SatGEM velocities using velocity profiles from EM-APEX floats and moored instruments and test the velocity reconstruction using ACCESS-OM3 simulations.
- Implement the updated methodology to deliver a new SatGEM of time-varying, full-depth temperature, salinity and velocity fields over the 30-year satellite era.

**WP4: Circumpolar poleward heat flux – mean, trends and variability (Lead CI Spence/Foppert, HDR2)**

- Calculate the 30-year time series of eddy heat and salt flux using the updated SatGEM.
- Using standard approaches (e.g. Dufour et al. 2015), calculate eddy heat and salt flux from the ACCESS-OM3 simulations with interannual atmospheric forcing spanning 1958-present day and future climate scenarios.
- Quantify the mean, trends, seasonality and interannual variability of poleward eddy fluxes in observations and model simulations.

**BENEFIT**

Understanding the processes that regulate poleward heat and salt flux across the Southern Ocean and contributing to efforts to simulate them in climate models, will improve predictability in ocean forecasts and future climate predictions. We will expand Australia's knowledge base and research capability by advancing our understanding of an important climate-relevant process at our doorstep in the Southern Ocean. We will enhance the international collaboration and competitiveness of Australian research by partnering across world-leading teams. The Southern Ocean is of intense interest to the international community at this time and is paramount in determining the level of adaptation needed to respond to climate change. Within this environment we will train a Postdoctoral Fellow, two PhD students and four

Honours students in oceanographic skills, building Australia's capacity in oceanographic observations and modelling. The project will be active in communicating the role of ocean eddies in the climate system, and the consequences of changing trends in ocean heat fluxes for the world (e.g. through its control on sea level rise).

The Southern Ocean influences Australian climate and is an important driver of Australian weather, including rainfall (e.g. van Ommen et al. 2010). It is an area that is changing rapidly (Rhein et al. 2013) and is strongly affected by human influence (Bindoff et al. 2019, Hobbs et al. 2022). This project will contribute to the Australian government's National Science and research priority – Environmental change – by advancing understanding of the principal physical oceanographic processes in Australia's open-ocean waters and improving predictions of Australian climate variability and change by understanding the role of the oceans in the climate system. We will build Australia's capacity to respond to environmental change through improved accuracy in measurements of ocean heat flux toward Antarctica, addressing a key uncertainty in the rate of warming of the Southern Ocean, melt of Antarctic ice and consequent sea level rise.

This research will help realise the Australian government's vision of *engaging all Australians with science* by novel communication approaches (e.g. NCI data visualisation and film/digital art student internship) ; *building our scientific capability and skills* by providing training and mentoring to PhD and Honours students and a Postdoc; *producing new research, knowledge and technologies* aligned with the science goals of this project; and *improving Australian's lives by addressing a key challenge facing Australia, our region and the world* of uncertainty in the rate of advance of climate change, ocean warming and sea level rise. Our direct estimates of eddy heat fluxes and their variability provides information that society needs to understand the heating of the Southern Ocean and contributes to the critical questions around the future stability of the Antarctic Ice Sheet.

Our research aligns precisely with UTAS marine research strength in IMAS. It bolsters the core activities of IMAS and strengthens one of its areas of strategic importance, Ocean and Antarctic Physics and Chemistry. At IMAS, we benefit from strong ties with partner marine and Antarctic efforts at CSIRO, Australian Antarctic Program Partnership and the Australian Centre for Excellence in Antarctic Science. This creates a vibrant intellectual environment through shared seminars and working groups and provides excellent training and networking opportunities for HDRs and early career researchers.

We have a clear pathway for our development of knowledge of ocean process to be used directly in climate models, through the Australian ACCESS NRI (CI Spence is part of the science steering group and contributes to model development) and through CI Spence's development of the ACCESS models with the COSIMA team. The sea-going fieldwork will train the next generation of Australian oceanographers. The SWOT-ACC and Denman field campaigns will include 10-20 HDRs and ECRs.

**FEASIBILITY**

This research project capitalises on existing investment in research voyages to the Southern Ocean by Australia (RV Investigator 2023, RSV Nuyina 2025) and South Korea (RV Araon 2025) and on associated field program investments by Australia, the US National Science Foundation and Office of Naval Research and the Korean government. Through our US and Korean partners, we have access to a much larger collection of new observations and we will draw on their expertise to meet the objectives of this proposal. Our field experiment costs are small compared to the overall value of the shiptime (>$16 million) and moored instruments provided in-kind by collaborators (>$2 million).

CIs Phillips, Foppert and Bindoff and PIs Watts, Park and Girton have decades of seagoing experience between them. PI Watts is the creator of the CPIES instrument; PI Girton now leads the group that developed the EM-APEX profiling float and has pioneered the addition of dissipation sensors to EM-APEX. All have a strong record in processing and analysing new observations to deliver new insight into ocean dynamical processes that are published in highly regarded and well cited publications. Our project further benefits from the fruition of many years of development by CI Spence and the COSIMA team toward a pan-Antarctic 1/40$^{th}$ degree ocean model. This model resolves the finescale ocean processes responsible for ocean heat transport and now includes the capability to simulate the intrusion of warm ocean water into ice shelf cavities and consequent ice melt, which has been a frontier for some time. Through his involvement with COSIMA, CI Spence has existing allocations of high-performance computing time through both the National Compute Infrastructure and Tasmanian Partnership for Advanced Computing. Thus, we have the necessary facilities and expertise to complete the modelling side of the project.

**COMMUNICATION OF RESULTS**

The results from this project will be submitted to the most relevant and highest quality journals in our field, such as the *Nature* group of publications, *J. Phys. Oceanogr.* and *J. Climate*. We will present at international conferences, such as the Ocean Sciences Meetings, and at the national level at the Australian Meteorological and Oceanographic Society annual conference and COSIMA annual workshop. Invitations to give keynote lectures will provide further avenues for reporting this work. In addition to support provided by the IMAS Science Communications Officer, we will continue to engage with the NCI visualisation laboratory (e.g. https://nci.org.au/media/videos/circulation-southern-ocean) to

produce high-profile animations and with a graphic designer to create interpretations of our findings that are accessible to the general public. This will build on efforts in past projects that provided an internship to a Masters Student in film to produce a documentary (https://www.youtube.com/watch?v=YbYqdUR-xas) of our DP17 voyage. We will offer an internship to a film or digital art student to participate in one of the voyages and engage with the scientific results of our project. We will also report our science results through the scientific network letters such as CLIVAR exchanges and Southern Ocean Observing System webpage and will contribute articles to The Conversation. We will actively engage the AAPP Media Coordinator, Mark Horstman, to broadcast voyages, results, and the importance of our work to the general public through broader media and social media streams. This project is particularly newsworthy because of the novel instruments, voyage, high-resolution ocean modelling and world-leading science.

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## Part E - Project Cost (DP240102358)

**E1. What is the proposed budget for your project?**

*(There are rules around what funds can be requested from the ARC. You must adhere to the scheme specific requirements listed in the grant guidelines. Refer to the Instructions to Applicants for detailed instructions on how to fill out the budget section.)*

Total requested budget: $1,044,542

### Year 1

| Description | ARC | Admin Org | | Other Org | |
|---|---|---|---|---|---|
| | Cash | Cash | In-kind | Cash | In-kind |
| Total | 286,946 | 46,380 | 229,031 | | 2,072,739 |
| Personnel | 93,559 | 34,130 | 139,031 | | 56,497 |
| HDR (Higher Degree by Research stipend) | 28,870 | 2,630 | | | |
| A/Prof Helen Phillips Level D4 @ 0.2FTE+30% on-costs | | | 44,162 | | |
| Dr Annie Foppert Level B6 @ 0.2FTE+30% on-costs | | | 32,685 | | |
| Prof Nathaniel Bindoff Level E2 @ 0.1FTE+30% on-costs | | | 25,684 | | |
| Postdoctoral Fellow Level A7-A8 @ 1.0 FTE+30% on-costs | 64,689 | | | | |
| Dr James Girton 0.1 FTE + 30% on-costs | | | | | 16,985 |
| Prof DR Watts 0.1 FTE + 30% on-costs | | | | | 19,756 |
| HDR (Higher Degree by Research stipend) | | 31,500 | | | |
| HDR James Wyatt - current UTAS PhD candidate | | | 36,500 | | |
| Dr Jae-Hun Park Level 0.1 + 30% on-costs | | | | | 19,756 |
| Travel | 15,810 | 3,750 | | | |
| Ocean Sciences Meeting 2024 | 9,100 | 3,750 | | | |
| Visit to University of Washington | 3,500 | | | | |
| Annual COSIMA Workshop | 3,210 | | | | |
| Equipment | 156,465 | 2,500 | | | 2,005,574 |
| EM-APEX Profiling Floats | 156,066 | | | | 222,954 |
| Data storage at sea | 399 | | | | |
| CPIES Array | | | | | 1,426,080 |
| Tall Mooring | | | | | 356,540 |
| Computer for Postdoc from UTAS | | 2,500 | | | |
| Other | 21,112 | 6,000 | 90,000 | | 10,668 |
| Float communication costs | | | | | 10,668 |
| Data reception support | 2,400 | | | | |
| Publication costs | 5,000 | | | | |
| Shipping costs | 10,000 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| NCI high performance computing costs and data storage | | | 60,000 | | |
| TPAC high performance computing costs and data storage | | | 30,000 | | |
| IMAS Data Management | 3,712 | | | | |
| HDR support from UTAS | | 6,000 | | | |

## Year 2

| Description | ARC | Admin Org | | Other Org | |
|---|---|---|---|---|---|
| | Cash | Cash | In-kind | Cash | In-kind |
| Total | 371,669 | 37,130 | 232,862 | | 628,997 |
| Personnel | 160,836 | 34,130 | 142,862 | | 56,497 |
| HDR (Higher Degree by Research stipend) | 28,870 | 2,630 | | | |
| A/Prof Helen Phillips Level D4 @ 0.2FTE+30% on-costs | | | 44,162 | | |
| Dr Annie Foppert Level B6 @ 0.2FTE+30% on-costs | | | 32,685 | | |
| Prof Nathaniel Bindoff Level E2 @ 0.1FTE+30% on-costs | | | 25,684 | | |
| A/Prof Paul Spence Level - Future Fellow - D4 @ 0.1FTE+30% on-costs | | | 22,081 | | |
| Postdoctoral Fellow Level A7-A8 @ 1.0 FTE+30% on-costs | 131,966 | | | | |
| Dr James Girton 0.1 FTE + 30% on-costs | | | | | 16,985 |
| Prof DR Watts 0.1 FTE + 30% on-costs | | | | | 19,756 |
| HDR (Higher Degree by Research stipend) | | 31,500 | | | |
| HDR James Wyatt - current UTAS PhD candidate | | | 18,250 | | |
| Dr Jae-Hun Park Level 0.1 + 30% on-costs | | | | | 19,756 |
| Travel | 7,988 | | | | |
| AMOS National Conference | 4,778 | | | | |
| Annual COSIMA Workshop | 3,210 | | | | |
| Field Research | 3,000 | | | | 572,500 |
| Shiptime costs | | | | | 572,500 |
| Voyage consumables | 3,000 | | | | |
| Equipment | 160,065 | | | | |
| EM-APEX Profiling Floats | 156,066 | | | | |
| Specialist computer for data analysis | 3,999 | | | | |
| Other | 39,780 | 3,000 | 90,000 | | |
| Float communication costs | 10,668 | | | | |
| Data reception support | 2,400 | | | | |
| Publication costs | 15,000 | | | | |
| Science communication | 8,000 | | | | |
| NCI high performance computing costs and data storage | | | 60,000 | | |

| | | | | | |
|---|---|---|---|---|---|
| TPAC high performance computing costs and data storage | | | 30,000 | | |
| IMAS Data Management | 3,712 | | | | |
| HDR support from UTAS | | 3,000 | | | |

## Year 3

| Description | ARC | Admin Org | | Other Org | |
|---|---|---|---|---|---|
| | Cash | Cash | In-kind | Cash | In-kind |
| Total | 209,826 | 40,880 | 214,612 | | 56,497 |
| Personnel | 160,836 | 34,130 | 124,612 | | 56,497 |
| HDR (Higher Degree by Research stipend) | 28,870 | 2,630 | | | |
| A/Prof Helen Phillips Level D4 @ 0.2FTE+30% on-costs | | | 44,162 | | |
| Dr Annie Foppert Level B6 @ 0.2FTE+30% on-costs | | | 32,685 | | |
| Prof Nathaniel Bindoff Level E2 @ 0.1FTE+30% on-costs | | | 25,684 | | |
| A/Prof Paul Spence Level - Future Fellow - D4 @ 0.1FTE+30% on-costs | | | 22,081 | | |
| Postdoctoral Fellow Level A7-A8 @ 1.0 FTE+30% on-costs | 131,966 | | | | |
| Dr James Girton 0.1 FTE + 30% on-costs | | | | | 16,985 |
| Prof DR Watts 0.1 FTE + 30% on-costs | | | | | 19,756 |
| HDR (Higher Degree by Research stipend) | | 31,500 | | | |
| Dr Jae-Hun Park Level 0.1 + 30% on-costs | | | | | 19,756 |
| Travel | 16,610 | 3,750 | | | |
| Synthesis workshop at Ocean Sciences Meeting 2026 | 9,900 | 3,750 | | | |
| Visit to University of Rhode Island | 3,500 | | | | |
| Annual COSIMA Workshop | 3,210 | | | | |
| Other | 32,380 | 3,000 | 90,000 | | |
| Float communication costs | 10,668 | | | | |
| Publication costs | 15,000 | | | | |
| Science communication | 3,000 | | | | |
| NCI high performance computing costs and data storage | | | 60,000 | | |
| TPAC high performance computing costs and data storage | | | 30,000 | | |
| IMAS Data Management | 3,712 | | | | |
| HDR support from UTAS | | 3,000 | | | |

## Year 4

| Description | ARC | Admin Org | | Other Org | |
|---|---|---|---|---|---|
| | Cash | Cash | In-kind | Cash | In-kind |
| Total | 176,101 | 18,565 | 230,954 | | 56,497 |
| Personnel | 146,401 | 17,065 | 140,954 | | 56,497 |

| | | | | | |
|---|---|---|---|---|---|
| A/Prof Helen Phillips Level D4 @ 0.2FTE+30% on-costs | | | 44,162 | | |
| Dr Annie Foppert Level B6 @ 0.2FTE+30% on-costs | | | 49,027 | | |
| Prof Nathaniel Bindoff Level E2 @ 0.1FTE+30% on-costs | | | 25,684 | | |
| A/Prof Paul Spence Level - Future Fellow - D4 @ 0.1FTE+30% on-costs | | | 22,081 | | |
| Postdoctoral Fellow Level A7-A8 @ 1.0 FTE+30% on-costs | 131,966 | | | | |
| Dr James Girton 0.1 FTE + 30% on-costs | | | | | 16,985 |
| Prof DR Watts 0.1 FTE + 30% on-costs | | | | | 19,756 |
| HDR (Higher Degree by Research stipend) | | 15,750 | | | |
| Dr Jae-Hun Park Level 0.1 + 30% on-costs | | | | | 19,756 |
| HDR (Higher Degree by Research stipend) | 14,435 | 1,315 | | | |
| Travel | 7,988 | | | | |
| AMOS National Conference | 4,778 | | | | |
| Annual COSIMA Workshop | 3,210 | | | | |
| Other | 21,712 | 1,500 | 90,000 | | |
| Publication costs | 15,000 | | | | |
| Science communication | 3,000 | | | | |
| NCI high performance computing costs and data storage | | | 60,000 | | |
| TPAC high performance computing costs and data storage | | | 30,000 | | |
| IMAS Data Management | 3,712 | | | | |
| HDR support from UTAS | | 1,500 | | | |

**Other Organisation**

| Organisation | Year 1 | | Year 2 | | Year 3 | | Year 4 | |
|---|---|---|---|---|---|---|---|---|
| | Cash | In-kind | Cash | In-kind | Cash | In-kind | Cash | In-kind |
| University of Washington, Seattle | | 250,607 | | 16,985 | | 16,985 | | 16,985 |
| University of Rhode Island, USA | | 1,089,512 | | 19,756 | | 19,756 | | 19,756 |
| Inha University, Korea | | 732,620 | | 592,256 | | 19,756 | | 19,756 |
| Total | | 2,072,739 | | 628,997 | | 56,497 | | 56,497 |
| Committed Total | | 2,072,739 | | 628,997 | | 56,497 | | 56,497 |

**E2. Justification of funding requested from the ARC**

*(Fully justify, in terms of need and cost, each budget item requested from the ARC. Use the same headings as in the Description column in the Budget Table of this application (upload a PDF of up to 4 A4 pages and within the required format).)*

Budget Justification

Uploaded PDF file follows on next page.

## E2 Justification of funding requested from the ARC

Our project is a collaboration with two significant international field programs funded by the US Office of Naval Research, the US National Science Foundation and the Korean government. We share the goal of quantifying eddy heat fluxes across the Southern Ocean that are warming waters around Antarctica. Our collaboration will return the first coordinated experiment to both measure and model heat and salt fluxes across the Antarctic Circumpolar Current and Antarctic Slope Current. These collaborations bring large in-kind contributions of instruments and research voyages that need to be accommodated in the timeline of our project. We therefore request a four-year funding cycle because the float data collection will not be completed until the end of year 2 and the first part of the mooring time series will not be available until mid-year 2. Four years will allow detailed analysis of the data and integration with the modelling results in years 3 and 4. Note that USD to AUD conversions were made using xe.com on 3/3/2023.

### Personnel

*Postdoctoral Research Fellow (years 1-4):* Dr Jan Jaap Meijer is the postdoc on this project. His PhD and publications are foundational to this work and he has the necessary expertise to make a substantial contribution to the project. He is currently at UTAS and available to begin mid year 1. We request 3.5 years of funding for Dr Meijer because his efforts are integral to both the observational and modelling work. Dr Meijer will lead the WP1 analysis of full water column observations and model simulations of cross-frontal exchange processes and contribute to all WPs. He will lead manuscripts for publication, contribute to co-supervision of PhD students and participate in voyages. We have costed the Postdoc at full time Level A7 for 6 months in year 1 and Level A8 in years 2-4. Request to ARC is $64,689 in year1 and $131,966 in years 2-4, including 30% on-costs.

*HDR (years 1-3.5):* HDR1 will work with the EM-APEX profiling float data collected in years 1 and 2 of this project and with other Southern Ocean EM-APEX from the global collection. The HDR will work with the CIs to develop methods to estimate cross-stream heat and salt fluxes from the EM-APEX and compare them with estimates from the moored arrays and model simulations. CI Phillips will be the lead supervisor with co-supervision provided by CIs Foppert, Bindoff, Spence and Postdoc Meijer. The HDR will join a dynamic group that includes six other PhD students working on projects highly complementary to this project and who are supervised by the CI team. UTAS will supplement the ARC PhD stipend of $28,870 by $2,630 per year for 3.5 years to bring it up to the level of standard UTAS stipend. We will also seek a top-up scholarship of $5,000 per year from the UTAS-CSIRO Quantitative Marine Science (QMS) Program to help attract an excellent student. The student will become part of our Southern Ocean dynamics team and will have access to graduate training programs in QMS and the ARC Centre for Excellence in Antarctic Science and Australian Antarctic Program Partnership. The combined observational and modelling expertise of the team is recognised internationally and presents an extraordinary opportunity for this student. We have selected a Level 1 HDR starting in year 1 that provides a 3-year stipend. We have requested an additional 6 months stipend from ARC in year 4 that will be supplemented by $1,315 from UTAS. Request to ARC is $28,870 in years 1-3 and $14,435 in year 4.

### Travel

*Ocean Sciences Meeting 2024 (year 1):* The Ocean Sciences Meeting of the American Geophysical Union occurs in February every 2nd year and is the pre-eminent international meeting for Physical Oceanography. The 2024 meeting will be in New Orleans, USA. This will be an opportunity for the postdoc and CIs to meet the PIs and coordinate analysis plans. We have estimated the travel costs for the postdoc and one CI and will seek institutional funds to cover travel for the other CIs. HDRs will not have commenced in time for this meeting. The cost includes return economy airfare Hobart-New Orleans per person ($3125), 6 night's accommodation (6x$250), per-diem (6x$150), conference registration ($800) and ground transport ($100). Total cost is $6,425 per person x 2 participants, less $3,750 provided by UTAS for postdoc travel. Request to ARC, $9,100.

*Australian Meteorological and Oceanographic Society Conference (Years 2, 4):* The Australian investigators will share the responsibility for disseminating our results to the Australian scientific community, and for interacting with other Australian groups working on complementary research. The AMOS conference provides an excellent opportunity for this, and we request funding for the postdoc and one HDR to attend AMOS in years 2 and 4. We will apply for competitive travel grants within UTas to allow more of the team to attend each year. The host cities for these meetings have not yet been decided but we use Sydney to estimate the cost. The cost includes return economy airfare Hobart-Sydney per person ($365), 4 night's accommodation (4x$180) and meals (4x$100), conference registration ($800) and ground transport ($100). Total cost is $2,389 per person x 2 participants. Request to ARC, $4,778 in years 2 and 4.

*Annual COSIMA workshop (years 1-4):* The postdoc, 1 HDR and 1 CI will attend the 2-day Consortium for Ocean Sea Ice Modelling in Australia (COSIMA) annual workshop. This workshop offers a unique opportunity to engage with experts in Australia's modelling community. The cost includes return flights and transportation from Hobart

to Canberra ($410), 2 night's accommodation (2x$180) and meals (2x$100) and ground transport ($100). Note that the workshop is often held in Canberra, albeit subject to change. There is no registration fee for this workshop. Total cost is $1,070 per person x 3 participants. Request to ARC, $3,210 in years 1-4.

*Synthesis workshop at Ocean Sciences Meeting (Year 3)*: The synthesis meeting is timed to occur after the EM-APEX have finished reporting and the US-Korean moored array has been recovered. This will be an opportunity to share initial results from the observational and modeling components and plan synthesis activities. We will add a 1-day workshop to the end of the conference. The Ocean Sciences Meeting of the American Geophysical Union occurs in February every 2nd year and is the pre-eminent international meeting for Physical Oceanography. The 2026 meeting venue has not been decided but we use the 2024 destination to estimate the cost. We have estimated the travel costs for the postdoc and 1 CI and will seek institutional funds to cover travel for the rest. The cost includes return economy airfare Hobart-New Orleans per person ($3125), 7 night's accommodation (7x$250), per-diem (7x$150), conference registration ($800) and ground transport ($100). Total cost is $6,825 per person x 2 participants, less $3,750 contributed by UTAS for the Postdoc travel. Request to ARC, $9,900.

*Visit to the University of Washington (Year 1):* Postdoc Meijer and CI Phillips will visit PI Girton for 1 week to develop methods to estimate ocean heat flux from EM-APEX data and to standardise processing of the global collection of EM-APEX. We will combine this travel with the Ocean Sciences Meeting in 2024. We have estimated the cost for one person and will seek institutional funds to cover the rest. The cost includes return airfare from New Orleans to Seattle, WA ($600), 7 nights of accommodation (7x$250), per-diem (7x$150) and ground transport ($100). Request to ARC is $3,500 in year 1.

*Visit to University of Rhode Island (Year 3):* CI Foppert and Postdoc Meijer will visit PI Watts for 1 week after the Ocean Sciences Meeting 2026 to work on comparison of the flux estimates from 3 observational platforms with the model fluxes. We will combine this travel with the Ocean Sciences Meeting in 2024. We have estimated the cost for one person and will seek institutional funds to cover the rest. The cost includes return airfare from New Orleans to Providence, RI ($600), 7 nights of accommodation (7x$250), per-diem (7x$150) and ground transport ($100). Request to ARC is $3,500 in year 3.

**Field Research**

*Voyage Consumables (Year 2):* Deployment of EM-APEX during the RV Araon and RSV Nuyina voyages will involve small costs for items required at sea, including straps to secure equipment, safety boots for personnel, stationery, etc.. Cost is estimated to be $3,000.

**Equipment**

*Specialist computer for data analysis (Year 1):* The analysis of observations at sea requires computing power that doesn't rely on virtual machines (e.g NCI and TPAC). We require a high-performance laptop to manage the data volume and processing requirements at sea. This computer will be used primarily by the Postdoctoral Fellow and and should have fast processing speed and large memory. An example machine is DELL XPS 15 i9 32Gb RAM 500GB hard drive. Request to ARC is $3,999 in year 1.

*Data storage hard drive (Years 1, 3):* This is to backup all data and code during research voyages. An example drive is LaCie Rugged Portable USB-C SSD Drive (1TB). Request to ARC is $399 in year 1.

*EM-APEX profiling floats (Years 1,2):* A key component of this experiment is the EM-APEX profiling floats (Argo floats supplemented with an electromagnetic velocity measurement system). These velocity measurements are essential for quantifying the small-scale ocean processes that accomplish eddy heat fluxes. The sole supplier of EM-APEX is Teledyne-Webb Research Corporation in the USA. The cost of one EM-APEX with Lithium batteries is USD 35,000 (AUD 52,022). PI Girton will provide 3 EM-APEX in year 1 and we have requested 6 from ARC. PI Girton's EM-APEX will be deployed on the SWOT-ACC voyage Nov-Dec 2023 just before our project begins and data will be delivered throughout year 1. Three ARC EM-APEX will be deployed from the RV Araon voyage and three from RSV Nuyina, both in year 2. The data returned will be > 5000 profiles of temperature, salinity and velocity in locations of key importance to this work. Request to ARC is $156,066 in years 1 and 2.

**Other**

*Float communication costs (years 2-3)*: The EM-APEX transmit data to the Iridium satellite phone system. And will be received at the University of Washington ground receiver at no cost to the project. Costs still to be paid include line rental of $14 per SIM card (i.e. per float) per month and $7 per profile. The profile cost is based on actual cost for data return from our 2018 Southern Ocean deployment (DP170102162) using a service with NAL Research Corporation. We expect each float to return 500 profiles. The floats will profile for around 1 year in bursts of 4 profiles separated by a drift to conserve battery of 3-4 days once the floats move away from the

moored instruments. With deployments just before the start of year 1 and early year 2, we have budgeted for the communications costs to be spread across years 1-3. Total communication cost per float is $3,556. University of Washington will cover the cost of their 3 floats in year1, leaving the cost for the remaining 6 in years 2-3. Request to ARC is $10,668 in years 2 and 3.

*Data reception support (years 1-2):* The EM-APEX float data will be received at the University of Washington ground receiver. A data server at UTas will be established to copy the float data, automatically run software to convert the binary data stream to physical units and transfer the files to our data processing computer. The Tasmanian Partnership for Advanced Computing (TPAC) at UTas has worked with us to establish and maintain this data server and is ideally suited to provide this service for our project. We estimate the time involved is 30 hours each for years 1-2 at the hourly rate of $80. Request to ARC is $2,400 in years 1 and 2.

*Publication costs (all years):* Our research will be published in high quality, peer-reviewed, international journals published by, e.g. American Meteorological Society, American Geophysical Union and the Nature family. The page charge cost per paper averages at approx. $5,000 for open-access to increase visibility and accessibility within the community. Our investigator team is dynamic and productive, and the postdoc and two PhD students will each lead 2-3 papers. We have requested funds from ARC for 1 paper in the first year, 3 in subsequent years. Our Partner Investigators will pay publication charges on the manuscripts that they lead. Request to ARC is $5,000 in year 1 and $15,000 in years 2-4.

*Shipping costs (Years 1):* The six EM-APEX will be ordered and shipped together in year 1. The estimated cost of transport from Falmouth, MA, USA to Hobart from Teledyne-Webb Research Corporation is $10,000 for 6 floats. Request to ARC is $10,000 in year 1.

*Science communication (all years):* A critical step in communicating our work is distilling the science into clearly understandable stories. Graphic design to develop schematic illustrations is a powerful and cost-effective approach to achieve this. The cost for a detailed schematic is approx. $900 (10 hours @$90 per hour), and one per publication is expected, giving a total cost of $9,000. An additional approach is an internship for a film student or digital artist to participate in one of the voyages to produce short films and animations. The internship cost is approximately $5,000 (travel costs and a small per diem). We partnered with Ocean Media Institute (http://www.oceanmediainstitute.org) to produce a short film about our DP170102162 voyage (https://youtu.be/YbYqdUR-xas). This film balances information and entertainment to show scientists enjoying their work in a ship on the ocean. It has a tone that is fresh and fun and has been a wonderful resource to communicate the reason for the work and that a career in science is amazing and possible. We have allowed $5,000 in year 2 for the film internship and $3,000 per year for graphic design in years 2-4. Total request to ARC is $14,000.

*IMAS data management (all years)*: Data collected in the execution of this project will be managed in accordance with ARC requirements and the Institute for Marine and Antarctic Studies (IMAS) Data Management Policy which currently meets or exceeds the requirements of the Australian Code for Responsible Conduct of Research (http://imas.utas.edu.au/data). In accordance with this policy, data will be held in long-term and secure archival storage, described using ISO19115 compliant metadata, managed using FAIR data principles and made publicly available on completion of this project through the IMAS Data Repository, part of the Australian Ocean Data Network (AODN). This process recognises the data as a high-value asset including: the high cost involved in collecting the data; its value as an historical record; and its value in contributing to future research. The cost is 1.5% of total amount requested from ARC, spread over the project life. Request to ARC $3,712 in years 1-4.

**E3. Details of non-ARC contributions**

*(Provide an explanation of how non-ARC contributions will support the proposed project. Use the same headings as in the Description column in the Budget Table of this application (upload a PDF of up to 2 A4 pages and within the required format).)*
Details of Non-ARC Contributions

Uploaded PDF file follows on next page.

## E3 Details of non-ARC contributions (USD to AUD conversions made at xe.com 3/3/2023)

### Personnel

*HDR James Wyatt (years 1-2):* Mr Wyatt is a current PhD student whose candidature runs until mid 2025. He is working to implement new knowledge of cross-stream processes to create an updated SatGEM in Work Package 3. He is an integral part of this project's research team and is supervised by CIs Bindoff, Foppert and Phillips. He will work on the SatGEM in year 1 and will contribute to the investigation of the circumpolar variability of heat flux in the GEM for Work Package 4. He receives a UTAS PhD stipend and a $5000 per year QMS top-up scholarship. Existing in-kind support from UTAS is $36,500 in year 1 and $18,250 in year 2.

*HDR (years 1-3.5):* The University is committed to high quality HDR training and recognises the importance of attracting outstanding scholars to high calibre research programs. Therefore, the University will commit one PhD stipend to the project, matching one requested from the ARC. Every effort will be made to attract a domestic HDR candidate through recruitment networks and advertising, however, there is an opportunity to support an international student with an International Tuition Fee Scholarship if necessary. The University will ensure that stipend rates for all recruited HDR candidates are maintained in line with Department of Education recommendations, that all HDR students are funded equally (noting the University's standard rate is higher than the ARC's current base rate) with the appropriate extended parental and sick leave permitted as per the University HDR conditions. This UTAS-funded student, HDR2, will be trained in Southern Ocean dynamics and high-resolution modelling. They will focus on the 1/20th and 1/40th degree ACCESS-OM3 simulations and will contribute to the calculation and analysis of simulated fluxes in WP4. CI Spence will be the lead supervisor with co-supervision provided by CIs Phillips, Foppert, Bindoff and Postdoc Meijer. UTAS will provide a stipend of $31,500 for 3.5 years for this student. We will also seek a top-up scholarship of $5,000 per year from the UTAS-CSIRO Quantitative Marine Science (QMS) Program to help attract an excellent student. Total support from UTAS is $110,250.

*HDR student funded by ARC (years 1-4):* UTAS will supplement the ARC PhD stipend of $28,870 by $2,630 per year for 3.5 years to bring it up to $31,500, which is the standard UTAS stipend. Total support from UTAS is $9,205.

*A/Prof Helen Phillips:* UTAS will contribute 0.2 FTE of Phillips's salary per year, including 30% on-costs, to a total of $44,162 per year.

*Dr Annie Foppert:* UTAS will contribute 0.2 FTE of Foppert's salary per year, including 30% on-costs, to a total of $32,685 per year.

*Prof Nathaniel Bindoff:* UTAS will contribute 0.1 FTE of Bindoff's salary per year, including 30% on-costs, to a total of $25,684 per year.

*A/Prof Paul Spence:* UTAS will contribute 0.1 FTE of Spence's salary, including 30% on-costs, after he finishes his Future Fellowship at the end of year 1. This UTAS contribution is $22,081 per year in years 2-4.

*Dr James Girton:* University of Washington will contribute 0.1 FTE of Girton's salary per year, including 30% on-costs, to a total of $16,985 per year.

*Prof DR Watts:* University of Rhode Island will contribute 0.1 FTE of Watts's salary per year, including 30% on-costs, to a total of $19,756 per year.

*Dr Jae-Hun Park:* Inha University will contribute 0.1 FTE of Park's salary per year, including 30% on-costs, to a total of $19,756 per year.

### Travel

*Ocean Sciences Meeting 2024 (year 1):* The Ocean Sciences Meeting of the American Geophysical Union occurs in February every 2nd year and is the pre-eminent international meeting for Physical Oceanography. The 2024 meeting will be in New Orleans, USA. This will be an opportunity for the postdoc and CIs to meet the PIs and coordinate analysis plans. UTAS will provide $3,750 for Postdoc travel to supplement the request from ARC. Support from UTAS, $3,750.

*Synthesis workshop at Ocean Sciences Meeting (Year 3)*: The synthesis meeting is timed to occur after the EM-APEX have finished reporting and the US-Korean moored array has been recovered. This will be an opportunity to share initial results from the observational and modeling components and plan synthesis activities. We will add a 1-day workshop to the end of the conference. The Ocean Sciences Meeting of the American Geophysical Union occurs in February every 2nd year and is the pre-eminent international meeting for Physical Oceanography. UTAS will contribute $3,750 for the Postdoc travel to supplement the request from ARC. Support from UTAS, $3,750.

### Field Research

*Shiptime costs (year 2):* PIs Park and Watts have 10 days shiptime funded on RV Araon (USD$40,000 per day) for

the recovery and redeployment of the US-Korean CPIES and tall mooring array in January 2025. The data collected from this array will be used in this project to provide a 4-year time series of 3-dimensional maps of ocean heat flux in the Southeast Indian Ridge hotspot. The CIs, HDR Wyatt and Postdoc Meijer will work closely with PIs Park and Watts to compare the direct estimates of heat flux with the GEM and model heat fluxes. In addition, PI Park will coordinate the ship schedule so that 3 ARC EM-APEX floats can be deployed at the upstream side of the moored array and profile through the array before it is dismantled and recovered. This will allow the first ever comparison of heat flux estimates from simultaneous observations from three platforms (EM-APEX, CPIES and tall mooring). In-kind support from Inha University $572,500.

*Shiptime costs (years 1 and 2):* The SWOT-ACC voyage is 36 days on RV Investigator Nov-Dec 2023 (year 0). CIs Foppert and Phillips are investigators on this voyage and the observations collected will be used in this ARC project. Three EM-APEX provided by PI Girton to our project will be deployed from SWOT-ACC and will deliver data in year 1 of our project. The Denman Marine voyage is 60 days on RSV Nuyina in Feb-Apr 2025 (year 2). CI Phillips is the Denman Voyage Coordinator for the Australian Centre for Excellence in Antarctic Science and will participate on the voyage. This will be the first ever research voyage to the Antarctic shelf in the Denman Glacier region of Australia's East Antarctic Territory. Three ARC EM-APEX will be deployed on this voyage and our project will have access to the other oceanographic data collected during the voyage. The value of shiptime is estimated to be $130,000 per day for RV Investigator and $200,000 per day for RSV Nuyina. The value of the data collected is priceless. The in-kind contribution of these extraordinary and timely opportunities is not listed in the budget but amounts to over $16 million.

### Equipment

*EM-APEX Profiling Floats (year1)*: A key component of this experiment is the EM-APEX profiling floats (Argo floats supplemented with an electromagnetic velocity measurement system). These velocity measurements are essential for quantifying the small-scale ocean processes that cause eddy heat fluxes. PI Girton's three EM-APEX will be deployed on the SWOT voyage in December 2023 just before our project begins and data will be delivered to us throughout year 1 of the project. These EM-APEX are supplemented with additional sensors to measure temperature microstructure that allows investigation of internal waves and mixing. The UW enhanced EM-APEX cost USD$50,000 per float (AUD $74,318). In-kind support from University of Washington is $222,954.

*CPIES Array (year 1):* CPIES are Current Pressure Inverted Echo Sounders. They measure currents and pressure near the sea floor and round-trip travel time from the sea floor to sea surface. Combined with temperature and salinity profiles from a research vessel collected at the time of deployment and recovery, each CPIES delivers twice daily profiles of full water column temperature, salinity and horizontal currents over the deployment. When deployed in a mapping array 3-dimensional maps of these fields are obtained twice a day, which provides an extraordinary dataset to investigate ocean dynamics and map heat flux in the ocean. The US-Korean funded CPIES mapping array consists of 16 CPIES including Pop-up Data Shuttles worth USD$60,000 each (AUD$89,130). In-kind support from Inha University for 4 CPIES is $356,520 and for 12 CPIES from University of Rhode Island $1,069,560. Total in-kind support $1,426,080.

*Tall Mooring (year 1):* Tall moorings anchored to the sea floor and instrumented through the water column with temperature, salinity and velocity sensors are the traditional and most accurate way to measure ocean heat flux. A mooring provides a single point in space with relatively high vertical sampling resolution and super high (often hourly) temporal sampling. The Korean 3 km deep flux mooring system deployed in the US-Korean Southeast Indian Ridge experiment has a value of USD$240,000 (AUD$356,540). It will return a 4-year time series of temperature, salinity and velocity variability from which a very accurate estimate of heat flux will be determined. It serves as a calibration point for the CPIES and EM-APEX heat flux estimates. In-kind support from Inha University $356,540.

### Other

*NCI high performance computing costs and data storage:* PI Spence has an allocation of computing time and data storage with the National Compute Infrastructure. In-kind support from UTAS $60,000 per year.

*TPAC high performance computing costs and data storage:* PI Spence has an allocation of computing time and data storage from the Tasmanian Partnership for Advanced Computing. In-kind support from UTAS $30,000 per year.

*HDR support from UTAS:* All UTAS students receive $1500 towards the cost of a laptop and $1500 per year for costs associated with their candidature, which can include travel to conferences. In-kind support from UTAS for 2 HDRs is $6,000 in year 1 and $3,000 in years 2-4.

## Part F - Participant Details including ROPE (A/Prof Helen Phillips)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Chief Investigator

Title

A/Prof

First Name

Helen

Middle Name

Elizabeth

Family Name

Phillips

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 31/12/2000 | Doctoral Degree | PhD | Physical Oceanography | University of Tasmania | Australia |
| 01/12/1990 | Bachelor Honours Degree,Graduate Certificate, Graduate Diploma | BSc (Honours 1st Class) | Physical Oceanography | The Flinders University of South Austrlia | Australia |
| 01/12/1988 | Bachelor Honours Degree,Graduate Certificate, Graduate Diploma | Graduate Diploma | Computer Science | University of Tasmania | Australia |
| 01/12/1985 | Bachelor Degree | BSc | Oceanography and Meteorology | The Flinders University of South Australia | Australia |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

Uploaded PDF file follows on next page.

**F5 Research Load (non-ARC Grants and Research)**

| **Description** (All named investigators on any application or grant/fellowship in which a participant is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application/ Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Boyd, P; Swadling, K; Nicol, S; Bestley, S; Blanchard, J; Lannuzel, D; Williams G; Coleman, R; Nikurashin, M; Bowie, A; Phillips, H; King, M; Watson, C; Hurd, C; Bindoff , N. Antarctic Science Collaboration Initiative, Australian Department of Industry, Innovation and Science, 2019-2030 $50 million | N | C | n/a | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| National Environmental Science Programme Climate Systems Hub UTAS node – Marsland, S; Holbrook, NJ; Harris, R; Remenyi, TA; Phillips, HE; Kajtar, JB; McDonald, J 2021-2027 | N | C | n/a | 3,080 | 3,080 | 3,080 | 2,679 | | | |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

| |
|---|
| 0.2 |

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| University of Tasmania | Yes | Employee | 1.0 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

| |
|---|
| University of Tasmania |

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

| Identifier | Investigators | Admin Organisation | Project Title | Funding | End Date | Final Report Due Date | Final Report Status |
|---|---|---|---|---|---|---|---|
| DP170102162 | Prof Nathaniel Bindoff ; A/Prof Helen Phillips ; Dr Maxim Nikurashin ; Dr Stephen Rintoul | University of Tasmania | How topography brakes the Antarctic Circumpolar Current | $783,000 | 31/12/2022 | 31/12/2023 | Draft |
| DP210100643 | A/Prof Helen Phillips ; Dr Maxim Nikurashin ; Dr Bernadette Sloyan ; Dr Susan Wijffels | University of Tasmania | Unraveling ocean mixing and air-sea forcing along the Indo-Pacific exchange | $764,194 | 31/08/2025 | 31/08/2026 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SR200100008 | Prof Matt King ; A/Prof Delphine Lannuzel ; Prof Matthew England ; Prof Nerilie Abram ; A/Prof Alan Aitken ; Prof David Antoine ; Prof Nathaniel Bindoff ; Prof Julia Blanchard ; Prof Andrew Bowie ; Prof Philip Boyd ; Prof Zanna Chase ; Prof John Church ; Prof Richard Coleman ; Prof Michael Ellwood ; A/Prof Bishakhdatta Gayen ; Hon A/Prof Ian Goodwin ; Dr Jacqueline Halpin ; Dr Nicole Hill ; Prof Mark Hindell ; Prof Mary-Anne Lea ; A/Prof Vanessa Lucieer ; Prof Andrew McMinn ; A/Prof Laurie Menviel ; Dr Adele Morrison ; Dr Maxim Nikurashin ; A/Prof Helen Phillips ; Prof Anya Reading ; Prof Eelco Rohling ; Dr Katherine Selway ; A/Prof Alexander Sen Gupta ; A/Prof Paul Spence ; Prof Peter Strutton ; Prof Paul | University of Tasmania | The Australian Centre for Excellence in Antarctic Science | $20,000,000 | 31/12/2025 | 31/12/2026 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Tregoning ; Dr Christopher Watson ; A/Prof Duanne White ; A/Prof Joanne Whittaker ; A/Prof Guy Williams ; Dr Jan Zika ; Dr Ben Galton-Fenzi ; Dr Robert Massom ; Dr Klaus Meiners ; Dr Jason Roberts ; Dr Alexandra Post ; Dr Clive McMahon ; Dr Karsten Gohl ; Dr Hartmut Hellmer ; A/Prof David Vaughan ; Prof Andrew Thompson ; Dr Herve Claustre ; Dr Jean baptiste Sallee ; Dr Gael Durand ; Dr Amaelle Landais ; Dr Xavier Crosta ; Prof David Thompson ; Dr Pippa Whitehouse ; Prof Michael Bentley ; Dr Stewart Jamieson ; Prof Chris Stokes ; A/Prof Shigeru Aoki ; Prof Darryn Waugh ; Dr Tamsin Edwards ; Dr Won Sang Lee ; Dr Pierre Dutrieux ; Dr Stephen Griffies ; Prof Helen Fricker ; Prof Sarah | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Gille ; Prof Lynne Talley ; Prof Bernd Kulessa ; Prof Adrian Luckman ; Prof Eric Wolff ; Dr Ted Scambos ; Prof Anna Wåhlin ; Asst Prof Naomi Levine ; Prof Yusuke Yokoyama ; Prof Scott Doney ; Prof Michiel Van den Broeke ; Dr John Toole ; Adj/Prof Terence O'Kane ; Dr Xuebin Zhang | | | | | | |

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

Yes

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

No

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement**

**date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*
Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

Justification of PI status

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

No PDF file uploaded.

**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|
| Associate Professor | Institute for Marine and Antarctic Studies | Permanent | Full Time | 01/07/2019 | | University of Tasmania |
| Senior Lecturer | Institute for Marine and Antarctic Studies | Permanent | Full Time | 08/04/2019 | 30/06/2019 | University of Tasmania |
| Senior Research Fellow | Institute for Marine and Antarctic Studies | Contract | Part Time | 28/10/2016 | 07/04/2019 | University of Tasmania |

| | | | | | | |
|---|---|---|---|---|---|---|
| Senior Lecturer | Institute for Marine and Antarctic Studies | Contract | Part Time | 28/10/2016 | 07/04/2019 | University of Tasmania |
| Senior Research Fellow | Institute for Marine and Antarctic Studies | Contract | Part Time | 01/01/2016 | 28/10/2016 | University of Tasmania |
| Senior Research Fellow | Institute for Marine and Antarctic Studies | Contract | Full Time | 01/01/2015 | 31/12/2015 | University of Tasmania |
| Research Fellow | Institute for Marine and Antarctic Studies | Contract | Full Time | 27/08/2010 | 31/12/2014 | University of Tasmania |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*

Has the participant experienced a significant interruption that has impacted on research opportunity?

Yes

From when

01/08/2002

To when

31/10/2002

FTE of academic interruption

1.0

Interruption Category

Other

Details

Disruption due to international relocation.
I did not work at all for 3 months during my relocation from my Postdoctoral Scholarship at the Woods Hole Oceanographic Institution, USA to my Postdoctoral Fellowship at CSIRO, Hobart, Australia.

From when

01/01/2003

To when

31/12/2004

FTE of academic interruption

1.0

Interruption Category

Other

Details

Primary carer of a dependent child - 2 years for my first child.

From when

01/01/2005

To when

31/12/2006

FTE of academic interruption

1.0

Interruption Category

Other

Details

Primary carer of a dependent child - 2 years for my second child.

From when

01/01/2007

To when

31/12/2008

FTE of academic interruption

1.0

Interruption Category

Other

Details

Primary carer of a dependent child - 2 years for my third child.

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

Uploaded PDF file follows on next page.

**F17 Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

## AMOUNT OF TIME AS AN ACTIVE RESEARCHER

I was awarded my PhD 22 years ago in December 2000. In that period, I have experienced interruptions due to childbirth, caring responsibilities, unemployment and relocation for jobs that reduce my career age to 16 years.

## RESEARCH OPPORTUNITIES

### Research opportunities in the context of employment

My research opportunities and outputs are illustrated in Figure 1. From the award of my PhD in 2000 until 2010, I was juggling caring for my young children with multiple part-time, research-intensive contracts. During this period, I maintained connection with my field, began to supervise PhD students and published at a rate of 1 paper every 2 years with an average of 0.5 FTE for research. With colleagues, I developed a proposal building on my Southern Ocean PhD research and was successful in obtaining a Discovery Project (DP0877098) that launched my career into finescale measurement of ocean velocity and watermass change using the EM-APEX profiling float. At the same time, my Indian Ocean research, begun during my Postdoctoral Fellowship at CSIRO, was gaining momentum through a collaboration with colleagues at the University of Hawaii. I joined their NSF proposal to bring an observational approach to their theoretical and modelling study of the Leeuwin Current System. Together, we were funded for 3 years (NSF grant 0961716, Lead CI Jay McCreary) and I was paid a full-time salary for one year as a subaward to the University of Tasmania.

The period 2011-2015 was pivotal in accelerating my research output and establishing my reputation. While employed with the NSF grant (80% research:20% service), I developed a proposal to make direct observations of the Leeuwin Current and offshore connections to address outstanding questions from the modelling work. This was funded by ARC (DP130102088) and the Marine National Facility for ship time to undertake the work. I was not a CI on the proposal as I needed to be paid salary but I held the responsibility of a CI in terms of leading the voyage, recruiting PhD students and progressing the research. This 5 years of research intensive activity consolidated my direction and increased my capacity to support research students. As a result, I delivered a step change in publication rate, grant success, student supervision and received international invitations to participate in research leadership opportunities (e.g. CLIVAR Indian Ocean Region Panel). I was promoted to Senior Lecturer in 2015.

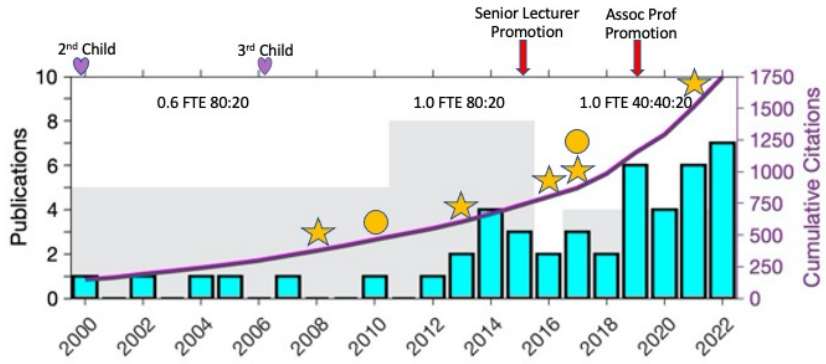


*Figure 1. Career summary. Publications per year (blue bars) and cumulative citations (purple line). Average full time equivalent (FTE) employment and time available for research indicated as research:service and research:teaching:service in 3 periods 2000-2010, 2011-2015, 2017-2022 (grey shading illustrates FTE x research proportion ÷ 10 on publications scale). Significant events marked: birth of children, promotions, ARC Discovery Project awards (gold star) and international grants (gold circle).*

My employment contract lapsed at the end of 2015 once the DP13 funding ran out. I obtained a 50% research contract in mid 2016 that was converted to a balanced academic position (40% research, 40% teaching and 20% service) at IMAS in late 2016. I have continued in a balanced role since then. While my time available for research was reduced to 0.4 FTE, my strong support of PhD students and postdocs and engagement with collaborators has allowed me to continue the upward trajectory in publications, citations, research funding and recognition. I was successful in obtaining 3 Discovery grants during this period, one as lead CI (DP210100643) and two as second CI (DP160102870, DP170102162). These grants have allowed me to continue to develop research achievements in the area of ocean circulation and dynamics in the Southern and Indian oceans. I was also invited to be a CI on a New Zealand grant in this period (Marsden Fund NIW1702, CI Stevens). I was awarded tenure in 2019 and promoted to Associate Professor soon after.

With the resources I have brought in, I have developed an internationally recognised research group with sustained supervision of 5-7 PhD students and 2 Honours students per year. The acceleration in my publication rate and citations is testament to the success of my group and the high quality research we are conducting. My involvement in the Australian Antarctic Program Partnership, Australian Centre for Excellence in Antarctic Science and National Environmental Science Programme (NESP) Climate Systems Hub combine to provide an environment that is highly conducive to continued consolidation and acceleration of my research success.

**Research mentoring and facilities**

Throughout my career I have been mentored by world leaders in the field. I completed my PhD under the supervision of Dr Steve Rintoul (CSIRO) who is a Fellow of the Australian Academy of Science, Australian Meteorological and Oceanographic Society and American Geophysical Union. The primary publication we wrote has been cited 202/143 times (Google Scholar/Scopus 28/2/23) and has been a foundational contribution to the research area of this proposal. When I returned to UTAS in 2005, Dr Rintoul was a strong supporter of my research grant proposals. He was a CI on my DP08 and DP17 grants, has co-supervised students and co-authored publications with me.

At IMAS, I have been fortunate to be mentored by Prof Nathan Bindoff who is a world-renowned expert in oceanography and climate. Prof Bindoff has provided an extraordinary research environment at IMAS through provision of a culture of integrity and team building, supported by national collaborations through the ARC Centres of Excellence in Climate Systems Science and Climate Extremes. These centres delivered research training and career development for my PhD students and provided resources to enable national and international collaborative exchanges. Prof Bindoff also won funding from the NESP Earth Systems and Climate Change Hub that secured my position at a time when I had no other prospects for employment in science. My involvement in NESP was an education in delivering policy-relevant science and communicating effectively across a diverse audience. I am now a lead investigator in the UTAS node of the current NESP Climate Systems Hub. In addition to providing exceptional facilities, Prof Bindoff has supported my career development through contributions to grant proposals, publications, student supervision and helping to solve research questions.

Support from international colleagues has contributed enormously to my career. Dr Susan Wijffels provided an early opportunity to work with Argo profiling floats during my Postdoctoral Fellowship at CSIRO and this has been fundamental to my advances in finescale observations of the ocean. Prof Alberto Naviera Garabato (National Oceanography Centre, UK) welcomed my team on his SOFINE research voyage that launched our EM-APEX floats and my career. With Dr Kurt Polzin (Woods Hole Oceanographic Institution), he has contributed to new understanding from these observations, joint publications, grant proposals and PhD supervision. My recognition in research on Indian Ocean circulation has grown exponentially since the award of my NSF grant with Prof Jay McCreary. This has been supported enormously by mentoring and sponsorship from key figures in this research community (Prof Raleigh Hood, Dr Mike McPhaden and Dr Caroline Ummenhofer) and has resulted in invitations to join international steering panels, lead review articles and contribute to a new book on the Indian Ocean. In research on the dynamics of the ACC, Prof Randy Watts has been a scientific advisor since I first met him during my PhD. His deep knowledge of the dynamics of strong current systems, his generosity and exuberance for science are inspirational. Prof Watts and now his colleague Prof Kathy Donohue are key collaborators on the research of this project. I base my own mentoring approach on these outstanding examples.

This project will be undertaken within the Institute for Marine and Antarctic Studies (IMAS) at UTAS. IMAS is an internationally recognised centre of excellence for marine and Antarctic research. It houses the largest concentration of scientists working in the marine and Antarctic science discipline in Australia and is a dynamic, supportive research environment, with access to high performance computing facilities and marine datasets that are essential for this project. The research area of this project is highly complementary with existing expertise in oceanography and climate science at IMAS.

**RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS**

**Research supervision, mentoring and advice**

I have provided mentoring to 7 Postdocs, 19 PhD students (11 as primary, 6 current, 13 graduated), 16 Honours and Masters students (9 graduated Hons 1st Class), and 9 summer fellows. In my Honours Coordinator role for the Ocean University of China-UTAS 2+2 program in Physical Oceanography, I provided mentoring and pastoral care to around 20 Honours students each year 2017-2021. I have been involved in organising early career researcher events and scientific writing workshops and have led an initiative to provide training in oceanographic observations at sea on Australia's Marine National Facility (30 ECRs 2012-2019). I established the Southern Ocean dynamics research group at IMAS that includes Postdocs from CSIRO and UTAS and PhD students. Their confidence in leading and participating in discussions has increased over the four years we have been together. I am frequently asked to provide advice and letters of support for their career development opportunities. Increased engagement of more senior staff has

also been a rewarding outcome of this group. My research group's recognition enables our students to work with experts from around the world. My graduates are winning positions at leading oceanography institutions.

**Research Income:** I have a sustained track record of successful bids on research grants totalling $4.1 million of which $2.6 million is from 5 ARC Discovery Projects. I contributed to the success of 3 large centres as Chief Investigator of the $50 million Australian Antarctic Program Partnership, $25 million Australian Centre for Excellence in Antarctic Science and the $4.3 million UTAS node of the NESP Climate Systems Hub. These funds support postdoctoral scholarships, top-up scholarships for PhD students and field programs. With colleagues, I have been awarded 208 days of ship time on Australia's Marine National Facility during 2012-19, which is an in-kind contribution to my university of $18.7 million.

**Speaker and visiting scientist invitations:** I am regularly invited to give presentations at specialist workshops, visit leading research institutes around the world and participate in high profile research expeditions. Significant invitations include

*International field projects and proposals:*

- National Science Foundation Grant 0961716 (McCreary, Furue and Potemra, US$446,000 with subaward of US$132,000 to Helen Phillips, 2010-2012) – *Dynamics of near-surface eastward flows in the South Indian Ocean.*
- Marsden Fund Standard Contract – NIW1702 (Stevens, O'Callaghan, Carter and Phillips), NZ$900,000, 2018-2022*) – Ocean Mixing at High Reynolds Number: Efficiencies in Extrema.*
- Southern Ocean Finestructure Experiment (SOFINE, UK/USA/Australia), RRS James Cook, Oct-Nov 2008, Lead CI Prof Alberto Naveira Garabato, National Oceanography Centre, UK.
- Measurement and Modelling of the Indonesian Seas (MINTIE, USA/Indonesia/China/Australia), Indonesian vessels, 2021-2024, Lead CI Dr Susan Wijffels, Woods Hole Oceanographic Institution, USA.

*Extended visits to world class oceanography institutes:*

- Woods Hole Oceanographic Institution, USA in 2004 and 2019.
- National Oceanography Centre, Southampton UK in 2009 and 2011.
- University of Hawaii, USA in 2012 and 2014.
- University of Rhode Island, USA in 2019.
- Japan Agency for Marine-Earth Science and Technology, Japan. Postponed due to Covid-19.
- National Institute of Water and Atmospheric Research, New Zealand. Postponed due to Covid-19.

*Invitations to present at specialist international meetings and workshops:*

- International Ocean Science Conference, November 2014, Barcelona, Spain
- Gordon Research Conference, Ocean Mixing, June 2018, Proctor Academy, NH, USA.
- Australian Academy of Science, Multiscale Dynamics of the Southern Ocean, December 2021, Canberra/Online.
- International Symposium on Polar Ocean and Global Change, May 2023, Qingdao, China.

**Community leadership and professional activities:**

*Member/Chair of National and International Committees*

- Member, International Steering Committee for the Second International Indian Ocean Expedition (IIOE-2), 2019-present.
- Co-Chair, International Committee for IIOE-2 Theme 4: Ocean Circulation, Variability and Change, 2015-present.
- Member, Australian Steering Committee for the IIOE-2, 2015-present.
- Member, International CLIVAR/IOC-GOOS Indian Ocean Region Panel, 2014-2016.
- Chair, Tasmanian Regional Centre of Australian Meteorological and Oceanographic Society, 2017-2018. Member 2014-present.

*Editorial positions*

- Review Editor for the Physical Oceanography section of Frontiers in Marine Science, a rapid publication and open-access journal with a rapidly-growing readership and impact factor, 2018-2020.
- Editor, for the international journal Ocean Dynamics published by Springer, 2020-2022.

Expert reviewer for international journals, including the Nature group, Journal of Physical Oceanography, Journal of Geophysical Research, Deep-Sea Research, Geophysical Research Letters, Journal of Climate.

Expert assessor for ARC and the National Environmental Research Council, UK.

**Contributions to the advance of knowledge in my field**

The observations I have gathered with EM-APEX instruments are a world-first, measuring the large-scale flows and eddy circulations in the Indian and Southern Oceans with autonomous instruments, and improving our understanding of the Southern Ocean's role in the climate system. My early uptake of these floats, working with the manufacturer, has led to substantial improvements in the reliability and capability of EM-APEX. The EM-APEX profiling float was intended to provide information on internal waves through the measurement of small-scale variations in profiles of horizontal velocity shear. I developed the application of these floats to large-scale ocean circulation and mesoscale eddy field. With colleagues and students, I have dramatically increased the range of information these floats can deliver to include absolute horizontal and vertical velocity (Phillips and Bindoff 2014), diapycnal mixing and internal wave characteristics (Meyer et al. 2014, 2015; Cyriac et al. 2021, 2022) and Ekman layer dynamics (Roach et al. 2015). We released a toolbox to calculate diapycnal mixing from EM-APEX data (Meyer et al. 2014, Mixing (MX) Oceanographic Toolbox for EM-APEX) that has been downloaded 2,800 times.

My expertise with EM-APEX has led to me being invited to participate in proposals with groups around the world. This led to a successful New Zealand Marsden Fund grant (NZ $900,000, PI-Craig Stevens, NIWA), and development of an Australian component of the multi-million dollar US effort to undertake new measurements and modelling of the Indonesian Throughflow (MINTIE). The Australian EM-APEX component of MINTIE is now funded through ARC Discovery Project DP210100643 with partners at CSIRO and Woods Hole Oceanographic Institution.

I began my research career investigating the role of eddies in carrying heat across the Antarctic Circumpolar Current, and in controlling the speed and volume transport of the ACC. This work (Phillips and Rintoul 2000, 2002), based on observations south of Tasmania, attracted international attention, is highly cited in fundamental oceanographic research on Southern Ocean dynamics and is central to this proposal. I was awarded the Australian Marine Sciences Association-Australian Antarctic Division Young Scientist Award for this work.

My postdoctoral positions at the Woods Hole Oceanographic Institution and CSIRO allowed me to develop new skills, bringing analysis of global model simulations to support observational studies (Joyce et al. 2004, Phillips and Joyce 2007) and developing expertise in the analysis of Argo profiling float data to answer questions around the impact of large-scale modes of climate variability on ocean salinity (Phillips et al. 2005).

Our mass-deployment of EM-APEX profiling floats on a long-term mission in the Antarctic Circumpolar Current was the first attempt to use these instruments to measure large-scale, 3-dimensional current structure in a dynamic regime. Conventional operations at that time involved deployments over a number of days to measure internal waves in enclosed seas. With these extraordinary observations, my team has challenged the paradigm that the ACC flows in the same direction at all depths (Phillips and Bindoff 2014), documented rare Ekman spirals in the Southern Ocean and confirmed that classical steady-state Ekman theory reliably describes observed spirals (Roach et al. 2015), estimated vertical mixing from breaking internal waves and showed that mixing is elevated where ACC jets interact with steep topography (Meyer et al. 2015, 2016) and is modulated by interaction with mesoscale eddies (Cyriac et al. 2021, 2022)

The unique view provided by these along-stream observing instruments attracted international attention, leading to my invited presentation at the inaugural Gordon Research Conference on Ocean Mixing in 2019. There I presented the first direct observational evidence that ACC jets suppress cross-frontal stirring by energetic eddies, a mechanism that allows the ACC to be a barrier to heat transfer toward Antarctica except in a few leaky places associated with steep topography. This work is in revision for Journal of Physical Oceanography (Phillips, Naveira-Garabato, Polzin, Bindoff and Waterman, "Fingerprints of eddy stirring suppression in Antarctic Circumpolar Current jets"). I was also invited to present at the Australian Academy of Science Multiscale Dynamics of the Southern Ocean workshop and to lead a section devoted to Mixing in the ensuing article to be published in Reviews of Geophysics.

In addition to my work on small-scale processes that transport heat and fresh water across the ACC, I have also investigated the contribution from discrete eddies, large and persistent enough to be sampled from a research vessel. In 2016, I led the physical oceanography component of a physical-biogeochemical survey of Southern Ocean eddies. A surprising result from this work is that cold-core eddies breaking off the northward side of the ACC are responsible for around 20% of the poleward heat transport across the ACC south of Tasmania (Patel et al. 2019). We also found that the cold-core eddy we sampled was a large source of carbon dioxide to the atmosphere in a region where the ocean is expected to be a $CO_2$ sink (Moreau et al. 2017).

In parallel to my Southern Ocean work, my Indian Ocean work developed new knowledge of meridional overturning circulation pathways from the Southern Ocean into the Indian Ocean and highlighted the critical role of Australia's boundary current system in this circulation. This work is published in 12 papers (Furue et al. 2013, 2017, Benthuysen et al. 2014, Menezes et al. 2013, 2014, 2015, 2016, Mao et al. 2018, Zhang et al. 2018, Cyriac et al. 2019, 2021 and Duran et al. 2020). Motivated by rapid warming in the Indian Ocean, our focus expanded to global analysis of ocean heat uptake (Rathore et al. 2020), which has revealed a new mechanism for internal variability that causes an asymmetry in the rate of ocean heat uptake in the northern and southern hemisphere. Over the last 15 years, the state of rapid

warming in southern hemisphere oceans with virtually no warming in the northern hemisphere appears to be reversing. This work was cited in the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report.

My current focus is on the importance of standing meanders for controlling the transport of the ACC and the movement of heat toward Antarctica. This focus has been transformational in developing a vibrant research community at IMAS that brings together experts in observations (Bindoff, Rintoul, Foppert, Cyriac) and models and theory (Nikurashin and Doddridge) and talented PhD students to advance understanding of the momentum and vorticity balances of the ACC and cross-front exchanges. Current PhD students and postdocs are making leading contributions to this international research area:

- Jan Jaap Meijer's PhD work has demonstrated the importance of curvature in meanders for driving ageostrophic circulations that lead to acceleration of flow in meander crests and deceleration in troughs and associated horizontal divergence patterns that drive vertical motions connecting surface and deep flows and cross-front exchange (Meijer et al., "Dynamics of a standing meander of the Subantarctic Front diagnosed from satellite altimetry and along-stream anomalies of temperature and salinity", in review with J. Phys. Oceanogr.).
- Felipe da Silva is quantifying variability of watermass and velocity structure along the Polar Front meander in the ACCESS-OM2-01 of the COSIMA group to test the hypothesis that standing meanders strongly modify the vertical structure of the front as they decelerate the jet through vertical momentum transport and cross-front exchange.
- Maya Jakes is working with EM-APEX float data from our 2018 deployments to diagnose the production of temperature and salinity anomalies from the interaction of eddies and jets along the ACC that are central to the movement of heat and salt across the ACC and to quantify isopycnal stirring by eddies.

**Contribution to this application**

I have world-leading expertise in the operation of EM-APEX profiling floats, and in the analysis of their data to deliver paradigm-shifting results. I am leading a talented team who are at the forefront of investigations of finescale ocean dynamics through analysis of these and other observations and high-resolution models. Our research has dramatically expanded the science questions that can be addressed with these instruments and we have made substantial contributions to quantifying small-scale variability in the ACC and its influence on the large-scale circulation. These results are published in 9 peer-reviewed articles with 3 more in review.

My role in this project is to provide intellectual leadership of the overall project and lead the delivery of science results. My particular focus will be on Work Package 1 in the early years, to lead the field programs and regional investigation of ocean processes that flux heat. This focus will shift to refine methods to quantify poleward fluxes with EM-APEX in years 2 and 3 (Work Package 2) and the circumpolar analysis of variabilitiy in year 4 (Work package 4). I will mentor the Postdoctoral Fellow in this project who will lead the effort to examine processes that lead to phase-locking of 3-dimensional ocean velocity with surface meander patterns (Work Package 1). I currently co-supervise HDR Wyatt's PhD that is contributing to SatGEM development (Work Package 3). I will be the lead supervisor for HDR1 and will co-supervise HDR2 with the other CIs and Postdoc Meijer.

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

Since receiving my PhD a full time equivalent of 16 years ago, I have published 53 peer-reviewed articles, including 6 as first author and 8 as second author, and 23 with students as first author. I have 8 more manuscripts and 2 book chapters currently in revision. My papers have been cited 1789/981 times (Google Scholar/Scopus accessed 3/12/2021) with citation rates now exceeding 200 per annum. My H-index is 25/19, my i-10 index is 37. This publication record is excellent relative to higher-level science academics in Australia's leading universities. A H-index of N for every N years post PhD (e.g. H-index=8 for 8 years post PhD) is considered exemplary. My H-Index divided by (EFT Years Post Phd) is 1.5. I have an additional 14 technical research outputs (technical reports, published datasets and outreach). Articles for The Conversation have reached >75,000 readers.
The primary publication from my PhD (Phillips and Rintoul 2000) has become a cornerstone publication in the area of eddy heat flux across the Southern Ocean. It has been cited 202/143 times and is in the 95th percentile for citations in Scopus. My publication that reported advances in this area using EM-APEX floats (Phillips and Bindoff 2014) has already been cited 40/27 times. I regularly publish in high-quality journals that specialize in my research area with most of my publications appearing in journals with IF > 4 (e.g. Geophysical Research Letters, Journal of Climate). In addition, I have one manuscript in a very high impact journal (Impact Factor, IF>11), Rathore et al. 2020, Nature Communications. All of my papers are in journals with Q1 quartile rankings (top 25% of journals in relevant subject category), and 39/53 publications discuss Southern Ocean and Antarctic dynamics, and global pathways of heat that are central to this proposal. SciVal (2018-2020) indicates 31% of my papers are in the top 10% cited worldwide and 55% are in top-decile journals. My Field-Weighted Citation Impact is 1.48, indicating that my publications have been cited 48% more than would be expected based on the world average for similar publications. I achieved this publication record within the context of multiple short-term contracts and part-time work.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] * **Phillips, HE** & Rintoul, SR 2000, 'Eddy Variability and Energetics from Direct Current Measurements in the Antarctic Circumpolar Current South of Australia', *Journal of Physical Oceanography*, vol. 30, no. 12, pp. 3050-3076, doi:10.1175/1520-0485(2000)030<3050:EVAEFD>2.0.CO;2 (Refereed Journal Article)

[2] * **Phillips, HE** & Bindoff, NL 2014, 'On the non-equivalent barotropic structure of the Antarctic Circumpolar Current: an observational perspective', *Journal of Geophysical Research: Oceans*, vol. 119, no. 8, pp. 5221-5243, doi:10.1002/2013JC009516 (Refereed Journal Article)

[3] * Meijer, JJ, **Phillips, HE**, Bindoff, NL, Rintoul, SR & Foppert, A 2022, 'Dynamics of a standing meander of the Subantarctic Front diagnosed from satellite altimetry and along-stream anomalies of temperature and salinity', *Journal of Physical Oceanography*, vol. 52, no. 6, pp. 1073-1089, doi:10.1175/JPO-D-21-0049.1 (Refereed Journal Article)

[4] * Cyriac, A, **Phillips, HE**, Bindoff, NL & Polzin, K 2022, 'Turbulent mixing variability in an energetic standing meander of the Southern Ocean', *Journal of Physical Oceanography*, vol. 52, no. 8, pp. 1-19, doi:10.1175/JPO-D-21-0180.1 (Refereed Journal Article)

[5] Furue, R, Guerreiro, K, **Phillips, HE**, McCreary Jr, JP & Bindoff, NL 2017, 'On the Leeuwin Current System and its linkage to zonal flows in the South Indian Ocean as inferred from a gridded hydrography', *Journal of Physical Oceanography*, vol. 47, pp. 583-602, doi:10.1175/JPO-D-16-0170.1 (Refereed Journal Article)

[6] **Phillips, HE**, Wijffels, SE & Feng, MK 2005, 'Interannual variability in upper ocean salt content in the southeast Indian Ocean', *Geophysical Research Letters*, vol. 32, no. 3, pp. L03603, doi:10.1029/2004GL021755 (Refereed Journal Article)

[7] Duran, ER, **Phillips, HE**, Furue, R, Spence, P & Bindoff, NL 2020, 'Southern Australia Current System based on a gridded hydrography and a high-resolution model', *Progress in Oceanography*, vol. 181, pp. 1-20, doi:10.1016/j.pocean.2019.102254 (Refereed Journal Article)

[8] Menezes, VV, **Phillips, HE**, Schiller, A, Domingues, CM & Bindoff, NL 2013, 'Salinity dominance on the Indian Ocean Eastern Gyral current', *Geophysical Research Letters*, vol. 40, no. 21, pp. 5716-5721, doi:10.1002/2013GL057887 (Refereed Journal Article)

[9] **Phillips, HE**, Tandon, A, Furue, R, Hood, R & Ummenhofer, CC et al. 2021, 'Progress in understanding of Indian Ocean circulation, variability, air-sea exchange and impacts on biogeochemistry', *Ocean Science*, vol. 17, no. 6, pp. 1677-1751, doi:10.5194/os-2021-1 (Refereed Journal Article)

[10] * Patel, PS, **Phillips, HE**, Strutton, PG, Lenton, A & Llort, J 2019, 'Meridional heat and salt transport across the Subantarctic Front by cold-core eddies', *Journal of Geophysical Research: Oceans*, vol. 124, no. 2, pp. 981-1004, doi:10.1029/2018JC014655 (Refereed Journal Article)

## Refereed Journal Articles

[1] * Yang, X, Strutton, PG, Cyriac, A, **Phillips, HE** & Pittman, NA et al. 2022, 'Physical drivers of biogeochemical variability in the Polar Front Meander', *Journal of Geophysical Research: Oceans*, vol. 127, no. 6, pp. 1-19, doi:10.1029/2021JC017863

[2] Cyriac, A, **Phillips, HE**, Bindoff, NL & Feng, M 2022, 'Characteristics of wind-generated near-inertial waves in the Southeast Indian Ocean', *Journal of Physical Oceanography*, vol. 52, no. 4, pp. 557-578, doi:10.1175/JPO-D-21-0046.1

[3] Marin, M, Feng, M, Bindoff, NL & **Phillips, HE** 2022, 'Local drivers of extreme upper ocean marine heatwaves assessed using a global ocean circulation model', *Frontiers in Climate*, vol. 4, pp. 1-16, doi:10.3389/fclim.2022.788390

[4] **Phillips, HE**, Patel, RS, Benthuysen, JA, Duran, ER & Marin, M 2022, 'Watermass characteristics and circulation near 110 E in the southeast Indian Ocean', *Deep-Sea Research. Part 2*, vol. 202, pp. 1-9, doi:10.1016/j.dsr2.2022.105149

[5] Su, J, Schallenberg, C, Rohr, T, Strutton, PG & **Phillips, HE** 2022, 'New estimates of Southern Ocean annual net community production revealed by BGC-Argo floats', *Geophysical Research Letters*, vol. 49, no. 15, pp. 1-10, doi:10.1029/2021GL097372

[6] Marin, M, Feng, M & Bindoff, N And **Phillips, HE** 2021, 'Accepted 26/10/2021. Local drivers of extreme upper ocean marine heatwave events in a global ocean circulation model', *Frontiers in Climate*

[7] Rathore, S, Bindoff, NL, Ummenhofer, CC, **Phillips, HE** & Feng, M et al. 2021, 'Improving Australian rainfall prediction using sea surface salinity', *Journal of Climate*, vol. 34, no. 7, pp. 2473-2490, doi:10.1175/JCLI-D-20-0625.1

[8] Chen, X, Schallenberg, C, Phillips, H & Chase, Z 2021, 'Biogeochemical characteristics of eddies in the East Australian Current depend on eddy type, history and location', *Journal of Marine Systems*, vol. 216, pp. 1-14, doi:10.1016/j.jmarsys.2021.103512

[9] Cyriac, A, **Phillips, HE**, Bindoff, NL, Mao, H & Feng, M 2021, 'Observational estimates of turbulent mixing in the Southeast Indian Ocean', *Journal of Physical Oceanography*, vol. 51, no. 7, pp. 2103-2128, doi:10.1175/JPO-D-20-0036.1

[10] Marin, M, Feng, M, **Phillips, HE** & Bindoff, NL 2021, 'A global, multiproduct analysis of coastal marine heatwaves: distribution, characteristics, and long-term trends', *JGR Oceans*, vol. 126, no. 2, pp. 1-17, doi:10.1029/2020JC016708

[11] Marin, M, Bindoff, NL, Feng, M & **Phillips, HE** 2021, 'Slower long-term coastal warming drives dampened trends in coastal marine heatwave exposure', *JGR Oceans*, vol. 126, no. 11, pp. 1-24, doi:10.1029/2021JC017930

[12] * Rathore, S, Bindoff, NL, **Phillips, HE** & Feng, M 2020, 'Recent hemispheric asymmetry in global ocean warming induced by climate change and internal variability', *Nature Communications*, vol. 11, no. 1, pp. 1-8, doi:10.1038/s41467-020-15754-3

[13] * Patel, RS, Llort, J, Strutton, PG, **Phillips, HE** & Moreau, S et al. 2020, 'The biogeochemical structure of Southern Ocean mesoscale eddies', *Journal of Geophysical Research: Oceans*, vol. 125, no. 8, pp. 1-24, doi:10.1029/2020JC016115

[14] Rathore, S, Bindoff, NL, Ummenhofer, CC, **Phillips, HE** & Feng, M 2020, 'Near-surface salinity reveals the oceanic sources of moisture for Australian precipitation through atmospheric moisture transport', *Journal of Climate*, vol. 33, no. 15, pp. 6707-6730, doi:10.1175/JCLI-D-19-0579.1

[15] Sprintall, J, Gordon, AL, Wijffels, SE, Feng, M & Hu, S et al. 2019, 'Detecting change in the Indonesian seas', *Frontiers in Marine Science*, vol. 6, no. June, pp. 1-24, doi:10.3389/fmars.2019.00257

[16] Cyriac, A, McPhaden, MJ, **Phillips, HE**, Bindoff, NL & Feng, M 2019, 'Seasonal evolution of the surface layer heat balance in the eastern subtropical Indian Ocean', *Journal of Geophysical Research: Oceans*, vol. 124, no. 9, pp. 6459-6477, doi:10.1029/2018JC014559

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[18] * Szuts, ZB, Bower, AS, Donohue, KA, Girton, JB & Hummon, JM et al. 2019, 'The scientific and societal uses of global measurements of subsurface velocity', *Frontiers in Marine Science*, vol. 6, pp. 1-8, doi:10.3389/fmars.2019.00358

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[20] Zhang, Y, Feng, M, Du, Y, **Phillips, HE** & Bindoff, NL et al. 2018, 'Strengthened Indonesian throughflow drives decadal warming in the Southern Indian Ocean', *Geophysical Research Letters*, vol. 45, no. 12, pp. 6167-6175, doi:10.1029/2018GL078265

[21] Mao, H, Feng, M, **Phillips, HE** & Lian, S 2018, 'Mesoscale eddy characteristics in the interior subtropical southeast Indian Ocean, tracked from the Leeuwin Current system', *Deep-Sea Research. Part 2*, vol. 161, pp. 52-62, doi:10.1016/j.dsr2.2018.07.003

[22] Inoue, M, Curran, MAJ, Moy, AD, van Ommen, TD & Fraser, AD et al. 2017, 'A glaciochemical study of 120 m ice core from Mill Island, East Antarctica', *Climate of the Past*, vol. 13, pp. 437-453, doi:10.5194/cp-2016-72

[23] * Moreau, S, Della Penna, A, Llort, J, Patel, R & Langlais, C et al. 2017, 'Eddy-induced carbon transport across the Antarctic Circumpolar Current', *Global Biogeochemical Cycles*, vol. 31, no. 9, pp. 1368-1386, doi:10.1002/2017GB005669

[24] * Meyer, A, Polzin, KL, Sloyan, BM & **Phillips, HE** 2016, 'Internal waves and mixing near the Kerguelen Plateau', *Journal of Physical Oceanography*, vol. 46, no. 2, pp. 417-437, doi:10.1175/JPO-D-15-0055.1

[25] Menezes, VV, **Phillips, HE**, Vianna, ML & Bindoff, NL 2016, 'Interannual variability of the South Indian Countercurrent', *Journal of Geophysical Research: Oceans*, vol. 121, no. 5, pp. 3465-3487, doi:10.1002/2015JC011417

[26] Strutton, PG, Coles, VJ, Hood, RR, Matear, RJ & McPhaden, MJ et al. 2015, 'Biogeochemical variability in the central equatorial Indian Ocean during the monsoon transition', *Biogeosciences*, vol. 12, no. 8, pp. 2367-2382, doi:10.5194/bg-12-2367-2015

[27] Meyer, A, Sloyan, BM, Polzin, KL, Phillips, H & Bindoff, NL 2015, 'Mixing variability in the Southern Ocean', *Journal of Physical Oceanography*, vol. 45, no. 4, pp. 966-987, doi:10.1175/JPO-D-14-0110.1

[28] * Roach, CJ, **Phillips, HE**, Bindoff, NL & Rintoul, SR 2015, 'Detecting and characterizing Ekman currents in the Southern Ocean', *Journal of Physical Oceanography*, vol. 45, no. 5, pp. 1205-1223, doi:10.1175/JPO-D-14-0115.1

[29] Inoue, M, Fraser, AD, Adams, N, Carpentier, S & **Phillips, HE** 2015, 'An assessment of numerical weather prediction-derived low-cloud-base height forecasts', *Weather and Forecasting*, vol. 30, no. 2, pp. 486-497, doi:10.1175/WAF-D-14-00052.1

[30] Benthuysen, J, Furue, R, McCreary, JP, Bindoff, NL & **Phillips, HE** 2014, 'Dynamics of the Leeuwin Current: Part 2. Impacts of mixing, friction, and advection on a buoyancy-driven eastern boundary current over a shelf', *Dynamics of Atmospheres and Oceans*, vol. 65, pp. 39-63, doi:10.1016/j.dynatmoce.2013.10.004

[31] Menezes, VV, Vianna, ML & **Phillips, HE** 2014, 'Aquarius sea surface salinity in the South Indian Ocean: revealing annual-period planetary waves', *Journal of Geophysical Research: Oceans*, vol. 119, no. 6, pp. 3883-3908, doi:10.1002/2014JC009935

[32] Menezes, V, **Phillips, HE**, Schiller, A, Bindoff, NL & Domingues, CM et al. 2014, 'South Indian countercurrent and associated fronts', *Journal of Geophysical Research: Oceans*, vol. 119, no. 10, pp. 6763-6791, doi:10.1002/2014JC010076

[33] Furue, R, McCreary, JP, Benthuysen, J, **Phillips, HE** & Bindoff, NL 2013, 'Dynamics of the Leeuwin Current: Part 1. Coastal flows in an inviscid, variable-density, layer model', *Dynamics of Atmospheres and Oceans: Planetary Fluids, Climatic and Biogeochemical Systems*, vol. 63, pp. 24-59, doi:10.1016/j.dynatmoce.2013.03.003

[34] **Phillips, HE** & Joyce, T 2007, 'Bermuda's tale of two time series: Hydrostation S and BATS', *Journal of Physical Oceanography*, vol. 37, no. 3, pp. 554-571, doi:10.1175/JPO2997.1

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[36] * **Phillips, HE** & Rintoul, SR 2002, 'A Mean Synoptic View of the Subantarctic Front south of Australia', *Journal of Physical Oceanography*, vol. 32, no. 5, pp. 1536-1553, doi:10.1175/1520-0485(2002)032<1536:AMSVOT>2.0.CO;2

[37] Hunter, JR, Craig, PD & **Phillips, HE** 1993, 'On the use of random walk models with spatially variable diffusivity', *Journal of Computational Physics*, vol. 106, no. 2, pp. 366-376, doi:10.1016/S0021-9991(83)71114-9

[38] Meyers, G, **Phillips, HE**, Smith, N & Sprintall, J 1991, 'Space and time scales for optimal interpolation of temperature - Tropical Pacific Ocean', *Progress in Oceanography*, vol. 28, no. 3, pp. 189-218, doi:10.1016/0079-6611(91)90008-A

## Fully Refereed Conference Proceedings

[1] Harris, RMB, Remenyi, T, Fox-Hughes, P, Love, P & **Phillips, HE** et al. 2017, 'An assessment of the viability of prescribed burning as a management tool under a changing climate: a Tasmanian case study', *Research Forum 2017: Proceedings from the Research Forum at the Bushfire and Natural Hazards CRC and AFAC Conference*, report 263, pp. 48-63

[2] * Roach, CJ, **Phillips, HE**, Bindoff, NL & Rintoul, SR 2012, 'Anomalous Ekman Transport Near Kerguelen Island', *Proceedings of the 18th Australasian Fluid Mechanics Conference*, pp. 1-4

[3] * Meyer, A, **Phillips, HE**, Sloyan, B & Bindoff, NL 2010, 'High Resolution Current Velocity Profiling Floats Preliminary Results from Subantarctic Waters', *Proceedings of the 'OceansObs'09: Sustained Ocean Observations and Information for Society' Conference (Vol. 1)*, pp. EJ

[4] MacKinnon, JA, Alford, M, Bouruet-Aubertot, P, Bindoff, NL & Elipot, S et al. 2010, 'Using global arrays to investigate internal-waves and mixing', *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society*, vol. 2, pp. EJ, doi:10.5270/OceanObs09.cwp.58

## Additional Research Outputs

[1] * **Phillips, HE**, Legresy, B & Bindoff, N 2018, 'Explainer: how the Antarctic Circumpolar Current helps keep Antarctica frozen', Newspaper Article

[2] Harris, RMB, Remenyi, T, Fox-Hughes, P, Love, P & **Phillips, HE** et al. 2018, 'An assessment of the viability of prescribed burning as a management tool under a changing climate. A Report for the National Bushfire Mitigation - Tasmanian Grants Program (NBMP)', pp. 94

[3] **Phillips, HE** 2017, 'I have always wondered: why is the sea salty?', Magazine Article

[4] **Phillips, HE**, Menezes, VV & Bindoff, NL 2015, 'Refining our understanding of surface currents in the southeast Indian Ocean', *CLIVAR Exchanges*, vol. 19, no. 3, pp. 7-9, ISSN 1026-0471

[5] Constable, AJ, Blain, S, Bowie, A, Boyd, PW & Chase, Z et al. 2015, 'Kerguelen Axis 2015-16: Marine science activities in support of research and observing of marine ecosystems in the vicinity of the Kerguelen Axis during 2015-16 austral summer', Internal Newsletter

[6] * Meyer, A, **Phillips, HE**, Sloyan, BM & Polzin, KL 2015, 'Mixing (MX) Oceanographic Toolbox for EM-APEX* float data applying shear-strain finescale parameterization'

[7] Phillips, H, Klekociuk, A, Marshall, A & Reid, P 2014, 'AMOS national conference 2014: southern investigations', *Bulletin of the Australian Meteorological and Oceanographic Society*, vol. 27, pp. 45-46, ISSN 1035-6576

[8] * Meyer, A, **Phillips, HE**, Sloyan, BM & Polzin, KL 2014, 'Mixing (MX) Oceanographic Toolbox for EM-APEX float data applying shear-strain finescale parameterization', pp. 76

[9] * **Phillips, HE** 2000, 'Mean flow, eddy variability and energetics of the Subantarctic Front south of Australia'

[10] **Phillips, HE** 1999, 'U.S.–Australia: Cooperation in the Southern Ocean', Magazine Article

[11] Bailey, R, Gronell, A, **Phillips, HE**, Tanner, E & Meyers, G 1994, 'Quality control cookbook for XBT data'

[12] Meyers, G & **Phillips, HE** 1992, 'TOGA XBT sampling strategy', Magazine Article

[13] Craig, PD, **Phillips, HE** & Andrewartha, JR 1992, 'Wanaea current modelling - The influence of stratification, CSIRO Division of Oceanography Report', pp. 50pp

[14] **Phillips, HE**, Bailey, RJ & Meyers, G 1990, 'Design of an ocean temperature observing network in the seas north of Australia. Part II - Tropical Indian Ocean: Statistics'

[15] Meyers, G, Sprintall, J, **Phillips, HE**, Peterson, J & Fonseca, T 1989, 'Design of an ocean temperature observing network in the seas north of Australia. Part I - Tropical Pacific Ocean: Statistics'

**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

| |
|---|
| No |

## Part F - Participant Details including ROPE (Dr Annie Foppert)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Chief Investigator

Title

Dr

First Name

Annie

Middle Name

Family Name

Foppert

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 31/08/2017 | Doctoral Degree | PhD | Oceanography | University of Rhode Island, Graduate School of Oceanography | United States of America |
| 30/04/2011 | Bachelor Honours Degree,Graduate Certificate, Graduate Diploma | Bachelor of Science | Atmospheric Science | McGill University | Canada |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

Uploaded PDF file follows on next page.

**F5 Research Load (non-ARC Grants and Research)**

| **Description** (All named investigators on any application or grant/fellowship in which a participant is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application /Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Dr Annie Foppert | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

| |
|---|
| 0.2 |

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| University of Tasmania | Yes | Employee | 1.0 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

| |
|---|
| University of Tasmania |

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

| |
|---|
| Yes |

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

| |
|---|
| No |

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant*

*guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*
Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

Justification of PI status

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

No PDF file uploaded.

**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Research Associate | Institute for Marine and Antarctic Studies, Australian Antarctic Program Partnership | Contract | Full Time | 01/07/2020 | 30/06/2025 | University of Tasmania |
| Postdoctoral Fellow | CSIRO Oceans and Atmosphere, Centre for Southern Hemisphere Oceans Research | Contract | Full Time | 29/01/2018 | 30/06/2020 | Commonwealth Scientific and Industrial Research Organisation |
| Lecturer | College of Arts and Science | Contract | Part Time | 01/09/2017 | 31/12/2017 | University of Rhode Island, USA |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*

Has the participant experienced a significant interruption that has impacted on research opportunity?

Yes

From when

01/09/2017

To when

31/12/2017

FTE of academic interruption

1.0

Interruption Category

Non-research employment

Details

Lectured part-time at the University of Rhode Island with no research component to my employment.

From when

01/01/2018

To when

28/01/2018

FTE of academic interruption

1.0

Interruption Category

Unemployment

Details

Unemployed before starting postdoc at CSIRO.

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

Uploaded PDF file follows on next page.

## AMOUNT OF TIME AS AN ACTIVE RESEARCHER

I was awarded my PhD in August 2017, and, since then, I have experienced career interruptions totalling 5 months at 1.0 FTE [Figure 1]. I experienced 4 months of non-research employment as a lecturer and ~1 month unemployment before relocating to Australia. Thus, I have been an active researcher for 5 years since earning my PhD.

## RESEARCH OPPORTUNITIES

My background and expertise in Southern Ocean processes makes me the ideal candidate for this project, as I am **uniquely positioned as an expert on mechanisms for cross-frontal exchange and poised to revolutionise our understanding of poleward heat transport towards Antarctica**. My track record as a researcher – including publications in ***Nature*** and ***Nature Geoscience*** **(second author)** and a **sole-author paper in the *Journal of Physical Oceanography*** – provides compelling evidence that I am an expert physical oceanographer. I independently design and implement successful analyses and insightful interpretations of ocean data that deliver high-impact results and publications. I have strong and on-going collaborations with numerical modellers [e.g. Foppert and Spence, in review; Spence et al, in prep], thus linking observational and modelling perspectives to enable a more comprehensive view of the processes driving poleward heat transport across the Southern Ocean.

### *Career*

I am a highly sought-after oceanographer and have held two postdoctoral research positions at internationally renowned organisations/institutes, CSIRO and UTAS. Both involved an 80% research and 20% service fraction. My research focusses on **understanding what drives the ocean's global meridional overturning circulation and its role in Earth's climate.** I am interested in (i) the dynamics of the upwelling limb of the overturning circulation that brings heat across the Southern Ocean towards Antarctica and (ii) the mechanisms for variability and change in the southern downwelling limb through the formation and export of Antarctic Bottom Water (AABW). I approach both from an observational perspective, integrating theories for ocean circulation and geophysical fluid dynamics and incorporating numerical model output. In both postdoctoral roles, I independently led innovative research, expanded the theoretical foundations of ocean dynamics, and actively mentored the next generation of researchers.

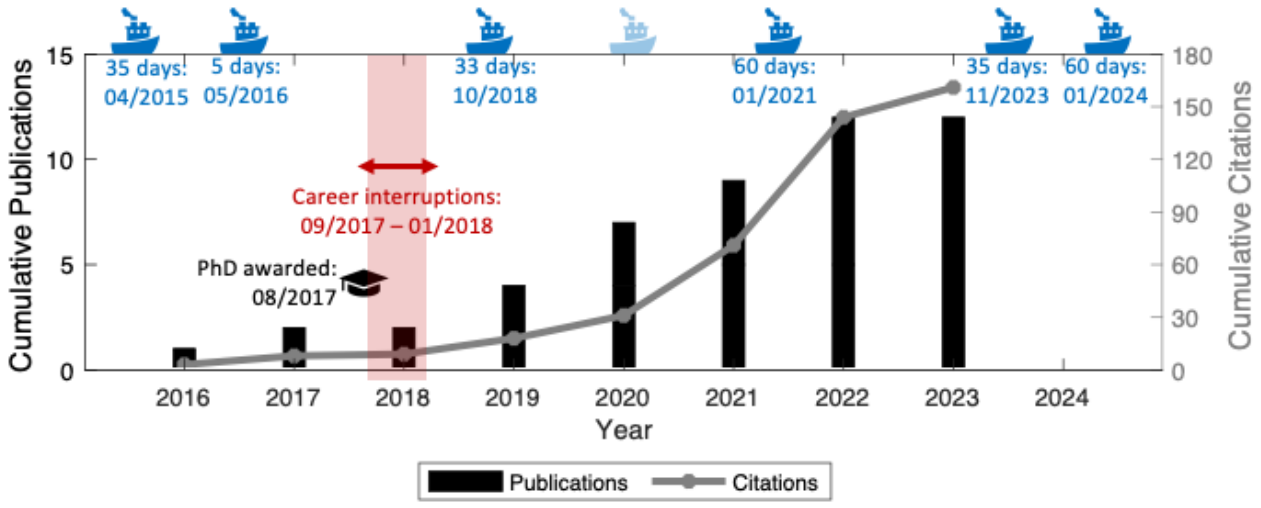


Figure 1: Publication and citation records showing rapid increase in both publications and citations since the start of my postdoctoral research in 2019 (data from Google Scholar, 28 February 2023). The date of my PhD conferral, career interruptions, and research voyages (number of days and starting month) are shown schematically. The semi-transparent ship icon represents a voyage that was cancelled do to Covid complications.

Sea-going fieldwork remains a vital aspect of my research. I have participated in voyage in roles ranging from CTD watch-stander to Chief Scientist. I have spent **~135 days at sea on research voyages** to collect a large suite of interdisciplinary data – the foundation of my research and the research of others. I am Principal Investigator or co-Investigator on three approved research voyages in the upcoming field season and two others pending approval for future seasons. While at sea, I have also trained students on techniques for oceanographic sampling and processing.

Active student supervision an demonstrates **my commitment to the transfer of knowledge to future oceanographers and climate scientists.** In this time, I have co-supervised five PhD students. One of these students has recently completed his degree and received outstanding reviews from the external examiners. I also co-supervise a Masters student with collaborators at the Australian Antarctic Division. Further, I have been the primary supervisor of three Honours students, with one student ready to submit her thesis as a manuscript to a special issue of *Frontiers in Marine Science* on physical-biological interactions in East Antarctica [Liang et al, in prep.].

**RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS**

I have published 11 peer-reviewed papers – including a five first-author publications, a single-author publications in the *Journal of Physical Oceanography* [Foppert, 2019], and a publication in both *Nature* and *Nature Geoscience* [Stokes et al. 2022 and Silvano et al. 2020, respectively] – one book chapter and have an h-index of 7. I am recognized as an emerging expert of physical process in the Southern Ocean, with **near-exponential growth to my citation count** every year since starting postdoctoral research [Figure 1]. This is considered an excellent publication record for a sea-going observational physical oceanographer.

***Dynamics of the upwelling limb of the overturning circulation***

The north-south transport of mass and heat across the Southern Ocean regulates global climate and the rate of sea level rise, yet remains poorly quantified and understood because it depends on motions on scales that are difficult to observe. My work has **delivered critical insights that have underpinned a new conceptual model of how the eddy field and the mean flow interact to drive regional and global climate**. This has motivated a growing body of theoretical and numerical work exploring the dynamics of poleward heat transport across the Southern Ocean. My reputation as an expert in this field led to my recruitment to provide the oceanographic perspective for a *Nature* review on the influence of past and future climate change on the East Antarctic Ice Sheet [Stokes et al. 2022], and my recruitment to lead a section on eddies, jets, and fronts in a *Review of Geophysics* on multiscale dynamics and interactions in the Southern Ocean [Bennetts et al. in prep.].

My PhD research exemplified the importance of the mesoscale eddy field in controlling the dynamics of the upwelling limb of global overturning circulation and heat transport toward Antarctica. Part of this work quantified of the heterogenous nature of the Southern Ocean eddy field for the first time, highlighting the importance of local dynamics in maintaining the upwelling limb of the overturning circulation [Foppert et al. 2017]. Further, my first-ever estimates of total eddy-driven heat transport **corrected long-standing uncertainties in the Southern Ocean heat budget** and revealed that prior estimates of air-sea heat exchange were significantly overestimated.

In one study, I made the first-ever observations of an instability process and revealed new ways in which the eddy field and mean flow interact in the Southern Ocean [Foppert, 2019]. To do this, I independently designed and implemented techniques from atmospheric science and oceanography to illustrate the dynamics of oceanic storm tracks. The first, and only, observations of mixed baroclinic-barotropic instability in the Southern Ocean that I discovered represent a major advancement in the community's understanding of eddy-mean flow interactions. Prior to this work, only highly idealized channel models were able to simulate this process [Chapman et al. 2015; Youngs et al. 2017]. This work highlights how my deep understanding of atmospheric and oceanic dynamics allows me to recognise dynamical analogues in the two systems that deliver high-impact insights. The **resulting sole-author paper in the *Journal of Physical Oceanography* is an outstanding achievement** for an early career researcher.

The poleward transport of warm, saline Circumpolar Deep Water has a global impact by influencing global sea level rise through ice melt and global climate through modulation of the meridional overturning circulation. Over a large swath of the East Antarctic margin, **I elegantly applied a simple theory to a complex dataset** and discovered the spatial distribution of eddy-driven transport of Circumpolar Deep Water [Foppert et al. 2019]. That is, I quantified the strength of Circumpolar Deep Water transport by eddies using oceanographic data collected by elephant seals. The resulting along-slope variability revealed hotspots of poleward transport across the continental slope for the first time. This work highlights the regionality of heat and salt transport to the shelf and **identified regions where the ice sheets may be particularly vulnerable to basal melting**.

My expertise in Southern Ocean dynamics and mechanisms for poleward heat transport along the upwelling limb of the overturning circulation is key to this Discovery Project. This project builds on my record of outstanding research achievements and contributions and utilizes collaborative networks developed as part of that work.

***Mechanisms for variability and change in the southern downwelling limb of the overturning circulation***

A global effort is underway to transform our understanding of AABW – including its formation processes, temporal changes, and contribution to the lower limb of the global meridional overturning circulation – **putting my research at the forefront of cutting-edge research of global importance**. My international leadership in AABW research began in 2019 with the deployments of the Australian Deep Argo floats in the Australian-Antarctic Basin. Subsequent works with international collaborators represent a significant increase in our understanding of AABW variability in the Australian-Antarctic Basin by mapping pathways of AABW [Foppert et al. 2021]; estimating the partitioning between Adélie Land and Ross Sea Bottom Waters in the reginal makeup of AABW [Thomas et al. 2020]; and examining how AABW formation responds to changes in wind forcing and sea ice production in the Ross Sea due to large-scale climate modes, namely El Niño and the Southern Annular Mode [Silvano et al. 2020]. My work has led to an invitation to co-author a review paper detailing progress made in observing AABW over the last several decades [Silvano et al. in prep]. I was also an **invited presenter at the pre-eminent international oceanography conference**, *Ocean Sciences Meeting,* in a session focussed on advances in observing and modelling the deep and bottom limbs of the meridional overturning circulation, where I presented both a talk and a poster.

I am the leader in Australia, and one of a handful of people in the world, in the use of the transformative Deep Argo technology to observe and track deep-ocean variability. In Foppert et al. [2021], I found variability of AABW properties on short temporal and spatial scales near the outflow of Dense Shelf Water near Adélie Land – something not previously observed. I documented the passing of a pulse of Adélie Land-sourced AABW between profiles taken a day apart and nearly co-located, that manifested as significant cooling and freshening of bottom water. A few days later the bottom water returned to its previous state. Observations like this, made possible by Deep Argo floats, can revolutionise the way we understand how AABW is exported from the shelf and into the abyss, and provide a comprehensive view of processes controlling the southern downwelling limb of the global meridional overturning circulation. This is crucial to understanding the ocean's role in climate as this limb of the overturning circulation carries heat and carbon into the abyssal ocean, where it remains for centuries.

***Leadership and training***

My strong leadership and training skills are demonstrated by **active student supervision, at-sea training, and teaching**. Together, this places me at the forefront of the crucial transfer of knowledge to the next generation of oceanographers and climate scientists.

I have maintained an active sea-going fieldwork aspect in my research, in roles ranging from CTD watch-stander to Chief Scientist. I have been on a total of four research voyages for a **total of ~135 days at sea**. I am an expert at water sampling – the bedrock of physical oceanography – and at-sea data collection that facilitates analyses by myself and others. Soon after the start of my postdoctoral research, I was recruited to join a 2018 voyage on the *R/V Investigator* to examine the dynamics of the Antarctic Circumpolar Current and its interactions with local topography. I guided students in data collection and processing and supervised research projects that contributed to the overall success of the project, including co-supervising two PhD students. Due to my at-sea expertise and promise as a leader, I was selected as **Chief Scientist for a voyage in 2020** to recover the highly equipped tall current-meter mooring that we deployed in 2018 (unfortunately, the voyage was cancelled due to covid-related complications).

Further, I am a **Principal Investigator or co-Investigator on five large international and interdisciplinary teams undertaking observational programs in the Southern Ocean**. Two voyages are approved by the Marine National Facility for this field season on the *RV Investigator*; one is approved by the Australian Antarctic Program for instrument deployments off the *RSV Nuyina* next year; and two are pending at the Australian Antarctic Program for future field seasons. The two *RV Investigator* voyages will add **95 days of sea time to my growing sea-going expertise in the next field season.** This includes the SWOT-ACC voyage that contributes directly to this Discovery Pfoject. As deputy Chief Scientist on this voyage, I will play a major role in voyage planning and execution, engage in daily logistics meetings with the captain and Chief Scientist, and be largely responsible for ensuring the success of the voyage and its research outcomes.

I also demonstrate leadership through my substantial teaching experience. During my PhD, I worked with a team to **design a new full-year coastal oceanography unit for PhD students** to make observations of tidal flow in a local river and investigate the seasonal overturning in the bay. I gained valuable active-learning techniques through this experience, proven to be a more effective way of teaching, that I have enthusiastically applied in my various leadership and training roles. My strong foundation in geophysical fluid dynamics and ocean circulation theory led to an invitation to **teach an intensive week-long winter school on geophysical fluid dynamics** for 60 PhD students and postdoctoral researchers in the ARC's Centre of Excellence for Climate Extremes in 2022. I designed and taught lectures, and developed and led an observational-based data analysis lab. Further, appreciating the importance of mental health for everyone, and especially the toll that both being at sea for longs periods and working towards a PhD can take on a person, **I undertook a 2-day course to become an accredited Mental Health First Aider** in May 2022, expanding my skills and knowledge relevant to teaching and supervision.

My deep understanding of ocean dynamics and observations has made me a sought-after collaborator and has led to my involvement in a diverse suite of research teams. I co-supervise four PhD students, with a fifth having successfully completed his PhD in 2022, and one Masters student. I have been the **primary supervisor for three successful Honours projects**, with the work resulting from one of the projects ready to be submitted to *Frontiers in Marine Science* [Liang, Foppert et al. in prep]. Through my supervisory roles, I have expanded my knowledge into biological oceanography and numerical modelling, for example, through collaboration with experts in Southern Ocean ecosystem dynamics at the Australian Antarctic Division and in ocean-sea ice modelling at the Australian National University, respectively.

***Awards and recognition***

I am recognised by the oceanographic and Earth science communities for my research achievements, presentation skills, and commitment to the oceanographic community. Awards and recognition include:

- Foppert et al. [2021] chosen by editors of *JGR: Oceans* as **one of the best accepted articles for the broad Earth and space science community**, featured as a Research Spotlight on eos.org and the journal's website
- Foppert et al. [2019] chosen to be highlighted on the Marine Mammals Exploring Pole-to-Pole website
- Young Scientist Presentation Award (2nd place), 2019, QNLM Annual Meeting. (~$1200 AUD)
- Ada L. Sawyer Award for Oceanography, 2016, URI-GSO. (~$2000 AUD)
- Robert H. and Marjorie P. Fillmore Memorial Scholarship Award, 2014, URI-GSO. (~$2000 AUD)

***Communication***

I am dedicated to communicating my research and have engaged with numerous community groups to increase awareness of my work and contributions to the field. I have attended 30 international or national conferences/workshops, listed below. I have presented at 21 of these and convened 8 sessions with a diverse range of co-conveners (indicated by the asterisks). I was invited to speak at the pre-eminent international *Ocean Sciences Meeting* (2022) and the Australian Academy of Science's *Elizabeth and Frederick White Research Conference* series. Conferences and workshops that I have attended and/or presented at include:

- International Conference on Southern Hemisphere Meteorology and Oceanography: 2022*
- Australian Meteorological and Oceanographic Society's Annual Meeting: 2022*, 2021*, 2020*, 2019, 2018
- **AAS's Research Conference Series, Multiscale Dynamics of the Southern Ocean: 2022 – invited talk**
- ARC's Australian Centre of Excellence in Antarctic Science's Research Forum: 2022
- Consortium for Ocean-Sea Ice Modelling in Australia's Annual Meeting: 2022*, 2020*, 2018
- ARC's Centre of Excellence for Climate Extremes' Ocean Extremes Workshop: 2022
- Australian Antarctic Program Partnership's Annual Symposium: 2022, 2021
- **Ocean Sciences Meeting 2022* – invited presenter (talk and poster)**, 2020*, 2018, 2016
- BGC-Argo and Deep Argo International Workshop 2021
- Argo Australia Annual Planning Meeting: 2022, 2021
- Centre for Southern Hemisphere Oceans Research's Annual Science Meeting: 2020, 2019, 2018
- Deep Argo International Workshop 2019
- ARC's Centre of Excellence for Climate Extremes' Annual Workshop: 2019
- European Geophysical Union's General Assembly: 2019

- Qingdao National Laboratory for Marine Science and Technology's Annual Meeting: 2019
- ARC's Antarctic Climate and Ecosystems Cooperative Research Centre Symposium: 2018
- Mentoring Physical Oceanography Women to Increase Retention's Pattullo Conference: 2017

***Professional service***

A strong commitment to give back and serve the scientific community in various ways is seen in my roles as:

- **AAPP Project Leader**, responsible for the scientific leadership of the Oceanography Project (2023-present)
- Peer reviewer in several scientific journals, including but not limited to *Geophysical Research Letters*, *Journal of Physical Oceanography*, and *Journal of Geophysical Research: Oceans*
- **Australian representative to the Deep Argo Mission Team** (2020-present)
- Member of professional organisations: Australian Meteorological and Oceanographic Society, European Geosciences Union, American Geophysical Union, Association for the Sciences of Limnology and Oceanography
- Member of community groups: Association of Polar Early Career Scientist and Antarctic Women's Network
- Organizer of regular informal science discussions, including a Hobart-based Physical Oceanography meeting (2019-2020) and Southern Ocean Dynamics meeting (2022-present)
- Guest lecturer for undergraduate oceanography class at UTAS (May 2022)
- Organizer of Early Career Researcher's Day Out 2019 (funding secured from UTAS and CSIRO, $4000 total)

***Public engagement and outreach***

I ensure that my research has impact beyond my scientific community by seeking outreach opportunities whenever possible. These include:

- Author of a ***Frontiers for Young Minds*** article on the Southern Ocean [Foppert and Spence, in review]
- Interview on *ABC Radio Hobart* (November 2020) to discuss my work on drivers of deep-ocean variability
- Volunteer to visit and interact with students and teachers at *STEM in Schools* 2018 and 2019
- Roving Scientist engaging with the public as part of *Beaker Street Festival* 2018, 2019, 2021
- Volunteer during public tours on *R/V Investigator* at Australian Antarctic Festival 2018

**REFERENCES**


1. Chapman et al. (2015) The dynamics of Southern Ocean storm tracks. *Journal of Physical Oceanography*. doi:10.1175/JPO-D-14-0075.1
2. **Foppert** et al. (2021). Deep Argo reveals bottom water properties and pathways in the Australian-Antarctic Basin. *Journal of Geophysical Research: Oceans*. doi:10.1029/2021JC017935
3. **Foppert** et al. (2019). Along-slope variability of cross-slope eddy transport in East Antarctica. *Geophysical Research Letters*. doi:10.1029/2019GL082999
4. **Foppert** (2019). Observed storm track dynamics in Drake Passage. *Journal of Physical Oceanography*. doi:10.1175/JPO-D-18-0150.1
5. **Foppert** et al. (2017). Eddy heat flux across the Antarctic Circumpolar Current estimated from sea surface height standard deviation. *Journal of Geophysical Research: Oceans*. doi:10.1002/2017JC012837
6. **Foppert** et al. (2016) The Polar Front in Drake Passage: A composite-mean stream-coordinate view. *Journal of Geophysical Research: Oceans*. doi:10.1002/2016JC012132
7. Meijer et al. (2022) Dynamics of a standing meander of the Subantarctic Front diagnosed from along-stream anomalies of temperature and salinity. *Journal of Physical Oceanography*. doi:10.1175/JPO-D-21-0049.1
8. Silvano, **Foppert**, et al. (2020) Recent recovery of Antarctic Bottom Water formation driven by climate anomalies. *Nature Geoscience*. doi:10.1038/s41561-020-00655-3
9. Stokes et al. (2022) Response of the East Antarctic Ice Sheet to Past and Future Climate Change. *Nature*. doi:10.1038/s41586-022-04946-0
10. Thomas et al. (2020). Spatial variability of Antarctic Bottom Water in the Australian Antarctic Basin from 2018-2020 captured by Deep Argo. *Geophysical Research Letters*. doi:10.1029/2020gl089467
11. Youngs et al. (2017) ACC meanders, energy transfer, and mixed barotropic- baroclinic instability. *Journal of Physical Oceanography*. doi:10.1175/JPO-D-16-0160.1

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

I have published 11 peer-reviewed papers in high-quality journals and one book chapter. The observational nature of my work is such that projects can take longer to complete due to extensive time at sea doing fieldwork (I have spent ~4.5 months at sea) and post-processing of novel datasets (e.g. I individually calibrated data from each Deep Argo float). My h-index of 7 is considered outstanding for an early-career observational oceanographer.

The journals in which I publish my results are all well-respected and high-impact, including the Nature [career-best output #5], Nature Geoscience [career-best output #3] and Geophysical Research Letters [career-best output #2]. A sole-author paper in the Journal of Physical Oceanography [career-best output #6; impact factor = 3.373] is a remarkable achievement for someone of my career stage. My standing as an internationally recognised expert is rapidly increasing, with more than double the number of citations each year since the start of my postdoctoral research.

Opportunistic collaborations, through early career researcher networks and sea-going fieldwork [e.g. career-best output #10], have resulted in successful projects in fields adjacent to my expertise. In the former, we assessed Australia's progress at fulfilling the IPCC's Sustainable Development Goal #14, Life Under Water. In the latter, we discovered a fascinating subsurface structure in a Gulf Stream warm-core eddy, something that had never been observed in the Atlantic Ocean.

I am committed to the transfer of knowledge. Actively supervising students, training students in at-sea data collection and processing, and teaching a geophysical fluid dynamics winter school for the ARC's Centre for Excellence in Climate Extremes are a few examples of my roles as a leader. I am currently supervising three PhD students and another PhD student has successfully completed his degree with outstanding reviews from the external examiners. I have been the primary supervisor of three successful Honours students. A manuscript – in prep. for submission to a special issue of Frontiers in Marine Science – has resulted from one of the Honours projects, an exceptional accomplishment in the field of oceanography.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] * Annie Foppert, Kathleen A. Donohue, D. Randolph Watts & Karen L. Tracey 2017, 'Eddy heat flux across the A ntarctic C ircumpolar C urrent estimated from sea surface height standard deviation', *Journal of Geophysical Research: Oceans*, vol. 122, no. 8, pp. 6947–6964, doi:10.1002/2017jc012837 (Refereed Journal Article)

[2] * Annie Foppert, Stephen R. Rintoul & Matthew H. England 2019, 'Along-Slope Variability of Cross-Slope Eddy Transport in East Antarctica', *Geophysical Research Letters*, vol. 46, no. 14, pp. 8224–8233, doi:10.1029/2019gl082999 (Refereed Journal Article)

[3] Silvano, A, Foppert, A, Rintoul, SR, Holland, PR, Tamura, T, Kimura, N, Castagno, P & Falco, P et al. 2020, 'Recent recovery of Antarctic Bottom Water formation in the Ross Sea driven by climate anomalies', *Nature Geoscience*, vol. 13, no. 12, pp. 780-786, doi:10.1038/s41561-020-00655-3 (Refereed Journal Article)

[4] Annie Foppert, Stephen R. Rintoul, Sarah G. Purkey, Nathalie Zilberman, Taiyo Kobayashi, Jean-Baptiste Sallèe, Esmee M. Wijk & Luke O. Wallace 2021, 'Deep Argo Reveals Bottom Water Properties and Pathways in the Australian-Antarctic Basin', *Journal of Geophysical Research: Oceans*, vol. 126, no. 12, doi:10.1029/2021jc017935 (Refereed Journal Article)

[5] Chris R. Stokes, Nerilie J. Abram, Michael J. Bentley, Tamsin L. Edwards, Matthew H. England, Annie Foppert, Stewart S. R. Jamieson & Richard S. Jones et al. 2022, 'Response of the East Antarctic Ice Sheet to past and future climate change', *Nature*, vol. 608, no. 7922, pp. 275–286, doi:10.1038/s41586-022-04946-0 (Refereed Journal Article)

[6] * Annie Foppert 2019, 'Observed Storm Track Dynamics in Drake Passage', *Journal of Physical Oceanography*, vol. 49, no. 3, pp. 867–884, doi:10.1175/jpo-d-18-0150.1 (Refereed Journal Article)

[7] George Thomas, Sarah G. Purkey, Dean Roemmich, Annie Foppert & Stephen R. Rintoul 2020, 'Spatial Variability of Antarctic Bottom Water in the Australian Antarctic Basin From 2018–2020 Captured by Deep Argo', *Geophysical Research Letters*, vol. 47, no. 23, doi:10.1029/2020gl089467 (Refereed Journal Article)

[8] * Foppert, Annie, Donohue, Kathleen A. & Watts, D. Randolph 2016, 'The Polar Front in Drake Passage: A composite-mean stream-coordinate view', *Journal of Geophysical Research: Oceans*, vol. 121, no. 3, pp. 1771–1788, doi:10.1002/2015JC011333 (Refereed Journal Article)

[9] * Meijer, J.J., Phillips, H.E., Bindoff, N.L., Rintoul, S.R. & Foppert, A. 2022, 'Dynamics of a Standing Meander of the Subantarctic Front Diagnosed from Satellite Altimetry and Along-Stream Anomalies of Temperature and Salinity', *Journal of Physical Oceanography*, vol. 52, no. 6, pp. 1073-1089 (Refereed Journal Article)

[10] Belkin, I, Foppert, A, Rossby, T, Fontana, S & Kincaid, C 2020, 'A double-thermostad warm-core ring of the Gulf Stream', *Journal of Physical Oceanography*, vol. 50, no. 2, pp. 489?507, doi:10.1175/JPO-D-18-0275.1 (Refereed Journal Article)

## Book Chapters

[1] Raes, Eric; Tamsitt, Veronica; McDonald, Karlie; Foppert, Annie; Baylis, Shane; Feutry, Pierre; et al. Measuring Success of SDG 14: An Australian perspective. Encyclopedia of the UN Sustainable Development Goals. Life Below Water. 2021. SDG14. https://doi.org/10.1007/978-3-319-71064-8

## Refereed Journal Articles

[1] Sharon Stammerjohn, Ted A. Scambos, Susheel Adusumilli, Sandra Barreira, Germar H. Bernhard, Deniz Bozkurt, Seth M. Bushinsky & Kyle R. Clem et al. 2021, 'Antarctica and the Southern Ocean', vol. 102, no. 8, pp. S317–S356, doi:10.1175/bams-d-21-0081.1

## Additional Research Outputs

[1] Foppert, Annie 2020, 'Pathways of warm water across the Antarctic slope', https://www.meop.net/news/pathways-of-warm-water.html

[2] Foppert, Annie 2020, 'Your Afternoon with Helen Shield', Radio interview

**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

| |
|---|
| No |

## Part F - Participant Details including ROPE (Prof Nathaniel Bindoff)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Chief Investigator

Title

Prof

First Name

Nathaniel

Middle Name

Lee

Family Name

Bindoff

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 01/01/1989 | Doctoral Degree | 1989 | Geophysics | Australian National University | Australia |
| 31/12/1984 | Bachelor Honours Degree,Graduate Certificate, Graduate Diploma | B.Sc. (Hons) | Geophysics | University of Tasmania | Australia |
| 31/12/1982 | Bachelor Degree | B.Sc. | Physics and Mathematics | University of Tasmania | Australia |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

Uploaded PDF file follows on next page.

**F5 Research Load (non-ARC Grants and Research)**

Funding from non-ARC sources

| **Description** (All named investigators on any application or grant/fellowship in which the Australian Laureate Fellowship candidate is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application /Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Prof. Bindoff NL, Domingues CM, Boyd PW, Harris R, Constable A. IPCC author funding, Department Industry Science Energy and Resources | Y | C | n/a | 13.5 | | | | | | |
| Bindoff NL, Swadling KM, Nicol S, Bestley S, Blanchard JL, Lannuzel D, Williams GD, Coleman R, Nikurashin M, Bowie AR, Phillips HE, King MA, Watson CS, Hurd R, Boyd PW. Australian Antarctic Program | Y | C | | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Partnership. Department of Industry, Innovation and Science | | | | | | | | | | |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

| |
|---|
| 0.1 |

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| University of Tasmania | Yes | Employee | 1.0 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

| |
|---|
| University of Tasmania |

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

| Identifier | Investigators | Admin Organisation | Project Title | Funding | End Date | Final Report Due Date | Final Report Status |
|---|---|---|---|---|---|---|---|
| DP170102162 | Prof Nathaniel Bindoff ; A/Prof Helen Phillips ; Dr Maxim Nikurashin ; Dr Stephen Rintoul | University of Tasmania | How topography brakes the Antarctic Circumpolar Current | $783,000 | 31/12/2022 | 31/12/2023 | Draft |
| DP210101650 | A/Prof Mark Holzer ; Prof Nathaniel Bindoff ; Dr Richard Matear ; Prof Francois Primeau | The University of New South Wales | Changes in the ocean's biological pump: innovative models and diagnostics | $426,000 | 24/10/2024 | 24/10/2025 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LE220100089 | Prof Zanna Chase ; A/Prof Delphine Lannuzel ; Prof Nathaniel Bindoff ; Prof Peter Strutton ; Prof Philip Boyd ; Prof Michael Ellwood ; Dr Julie Janssens ; Dr Stephen Rintoul ; Dr Bernadette Sloyan ; Dr Petra Heil ; Dr Klaus Meiners | University of Tasmania | HydroBox: A containerised hydrochemistry lab for Australian oceanography | $552,086 | 31/12/2022 | 31/12/2023 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SR200100008 | Prof Matt King ; A/Prof Delphine Lannuzel ; Prof Matthew England ; Prof Nerilie Abram ; A/Prof Alan Aitken ; Prof David Antoine ; Prof Nathaniel Bindoff ; Prof Julia Blanchard ; Prof Andrew Bowie ; Prof Philip Boyd ; Prof Zanna Chase ; Prof John Church ; Prof Richard Coleman ; Prof Michael Ellwood ; A/Prof Bishakhdatta Gayen ; Hon A/Prof Ian Goodwin ; Dr Jacqueline Halpin ; Dr Nicole Hill ; Prof Mark Hindell ; Prof Mary-Anne Lea ; A/Prof Vanessa Lucieer ; Prof Andrew McMinn ; A/Prof Laurie Menviel ; Dr Adele Morrison ; Dr Maxim Nikurashin ; A/Prof Helen Phillips ; Prof Anya Reading ; Prof Eelco Rohling ; Dr Katherine Selway ; A/Prof Alexander Sen Gupta ; A/Prof Paul Spence ; Prof Peter Strutton ; | University of Tasmania | The Australian Centre for Excellence in Antarctic Science | $20,000,000 | 31/12/2025 | 31/12/2026 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Prof Paul Tregoning ; Dr Christopher Watson ; A/Prof Duanne White ; A/Prof Joanne Whittaker ; A/Prof Guy Williams ; Dr Jan Zika ; Dr Ben Galton-Fenzi ; Dr Robert Massom ; Dr Klaus Meiners ; Dr Jason Roberts ; Dr Alexandra Post ; Dr Clive McMahon ; Dr Karsten Gohl ; Dr Hartmut Hellmer ; A/Prof David Vaughan ; Prof Andrew Thompson ; Dr Herve Claustre ; Dr Jean baptiste Sallee ; Dr Gael Durand ; Dr Amaelle Landais ; Dr Xavier Crosta ; Prof David Thompson ; Dr Pippa Whitehouse ; Prof Michael Bentley ; Dr Stewart Jamieson ; Prof Chris Stokes ; A/Prof Shigeru Aoki ; Prof Darryn Waugh ; Dr Tamsin Edwards ; Dr Won Sang Lee ; Dr Pierre Dutrieux ; Dr Stephen | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Griffies ; Prof Helen Fricker ; Prof Sarah Gille ; Prof Lynne Talley ; Prof Bernd Kulessa ; Prof Adrian Luckman ; Prof Eric Wolff ; Dr Ted Scambos ; Prof Anna Wåhlin ; Asst Prof Naomi Levine ; Prof Yusuke Yokoyama ; Prof Scott Doney ; Prof Michiel Van den Broeke ; Dr John Toole ; Adj/Prof Terence O'Kane ; Dr Xuebin Zhang | | | | | | |

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

Yes

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

No

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*

Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

| |
|---|
| |

Justification of PI status

| |
|---|
| |

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

| |
|---|
| |

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

| |
|---|
| No PDF file uploaded. |

**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|
| Professor, Physical Oceanography | Institute Marine and Antarctic Studies | Permanent | Full Time | 02/03/2007 | | University of Tasmania |

| | | | | | | |
|---|---|---|---|---|---|---|
| Program Leader Australian Antarctic Program Partnership and Professor, Physical Oceanography | IMAS | Contract | Part Time | 15/06/2020 | 14/06/2023 | University of Tasmania |
| Director of Tasmanian Partnership for Advanced Computing | IMAS | Contract | Part Time | 30/06/2000 | 15/06/2021 | University of Tasmania |
| Head of Centre, Oceans and Cryosphere | Institute Marine and Antarctic Studies (IMAS) | Permanent | Full Time | 24/11/2014 | 31/01/2018 | University of Tasmania |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*
Has the participant experienced a significant interruption that has impacted on research opportunity?

| |
|---|
| No |

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

Uploaded PDF file follows on next page.

**F17 Research Opportunity and Performance Evidence (ROPE) - Details of the participants' career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

**AMOUNT OF TIME AS AN ACTIVE RESEARCHER**

I received my PhD in 1989 from Australian National University, 33 years ago. I have had no significant academic interruptions since my first postdoctoral fellowship at Massachusetts Institute of Technology with Carl Wunsch in 1989 with one exception. The period between 2014 and 2018 when I was Head of School and Director of the Tasmanian Partnership for Advanced Computing (and thus had a near full time load of administration, about 3 FTE years).

**RESEARCH OPPORTUNITIES**

**Current Appointment: Program Leader (or CEO) of Australian Antarctic Program Partnership**
Professor of Physical Oceanography, IMAS, University of Tasmania.

**Brief employment history**: Director, Tasmanian Partnership for Advanced Computing, Dec 2000- Dec 2019; A/Professor, Physical Oceanography, Mar 2002 –Mar 2007; Professor, University of Tasmania, 2007-present. Head of Centre, IMAS Oceans and Cryosphere Centre, 2014-2018; AAPP Program Leader, June 2021 to present.

I am a tenured research Professor at the University of Tasmania and completed a term as Head of Centre, equivalent to head of school, in the Institute of Marine and Antarctic Studies, University of Tasmania. The head of centre role is about 60% management. Director of the TPAC is a 10-20% load and thus time for research during the period 2014 to 2018 was much reduced. I was a member of the ARC College of Experts (2016-2019 inclusive), was part of the initial ERA program including aspects of its design (eg "well above world standard …") and formerly part of the NZ Royal Society Marsden selection panels (2014 to 2016 inclusive). The role of AAPP Program Leader is 60% management. 30% research, 10% teaching.

I have had superb opportunities for research with a relatively low teaching but higher than average administration load (including role as Director of TPAC) and through inclusion in the fourth, fifth and now sixth round of the IPCC assessments of climate change. I am a CI in the ARC funded Centre of Excellence in Climate Extremes and have a leadership role in the NESP Earth Systems Science and Climate Change Hub. I have been provided with leadership training at UTAS and have an extra-ordinary network of oceanographers and climate scientists as part of the IPCC and on the CLIVAR Science Steering Group.

**RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS**

**Awards:**

- Atmospheric Science Librarians; 2007 ASLI Choice, Scientific and Technical Category for high impact comprehensive publication *Climate Change 2007: The Physical Science Basis*;
- Contribution to IPCC winning the Nobel Peace Prize with Al Gore; 2007
- NOAA 2008 OAR Outstanding Atmospheric Scientific Paper Award for *Technical Summary, Climate Change 2007: The physical science basis. Contribution of Working Group 1 to the Fourth Assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 77pp., 2007* by the NOAA Earth System Research Laboratory – Chemical Science Division;
- The National 2012 Resilient Australia Award for Education, Training and Research was awarded to the Climate Futures team.
- The Tasmanian 2012 Resilient Australia Award for Education, Training and Research was awarded to the Climate Futures team.
- The University of Tasmania Distinguished Service Medal 2016, for sustained service and is the highest medal awarded to staff.
- Fellow of Australian Meteorological and Oceanographic Society (announced 2020)

**International Committees**

- Steering Committee of Science Brief
- Deep South Challenge (New Zealand)n Independent Science Panel.

- IPCC, Coordinating Lead Author Chapter 5, Changing Ocean, Marine Ecosystems, and Dependent Communities, 2017- Dec 2019.
- CLIVAR, Science Steering Group, member, 2014- Dec 2019.
- CLIVAR, Open Science Committee, member, 2014 - 2018.
- IPCC Scholarship Panel, Chair of WG1 review committee, 2015 - present.
- World Ocean Circulation Experiment, Co-Chair of Data Products Committee (years)

**National Committees**

- NCAR (AAS)
- ARC College of Experts
- ARC ERA pilot and development rounds
- Tasmania Antarctic Gateway (2021- present)

**Research outputs and achievements other than publications**

I was a Coordinating Lead Author on IPCC AR4 Oceans Chapter, the Technical Summary and Summary for Policymakers (totalling ~20000 citations in Google Scholar) and contributed to the IPCC being awarded the Nobel Peace Prize in 2007. I have a similar role in the fifth assessment report, leading the Detection and Attribution chapter (Chapter 10) with Peter Stott and again for the Special Report on Oceans and Cryosphere in a changing climate. These world-leading roles have provided me with the international experience and international connections in climate change and oceanography. IPCC reports are the peak assessments on behalf of governments that are used in climate policy by governments. They form the basis of decisions around the world for the evidence for climate mitigation and adaptation.

My role on international committees and IPCC (I have served on 17 and co-chaired 4) provides me with a very strong understanding of the next set of challenges in climate system science and where I can make a fundamental contribution. I am a regular invited speaker at conferences and workshops (now more than 40), and one more this year. I have co-chaired 2 workshops and was guest editor on 2 special volumes of Deep Sea Research.

I have also played a major national leadership role in technological change and Australian model development, climate simulations over Australia and availability of research data for climate scientists.

I have been an active supervisor of PhD students – 36 have completed since 1995 and all have succeeded in research or industry. They have won awards and prizes for best talks. Many hold permanent positions in international University (Cambridge University, University of Washington, University of Tasmanian, Woods Hole Oceanographic Institution) and industry (Royal Dutch Shell company) or currently hold postdoctoral fellowships is USA and Europe.

The Climate Futures for Tasmania project (listed under the peer review reports) were undertaken on behalf of the state government of Tasmania (funded by Commonwealth Environment Research Facility) and the Federal Attorney General. This project resulted in 17 peer reviewed reports that assessed the impacts of climate change on Australia. It won two prizes. The reports have been downloaded thousands of times and are being used for decision making in state government (http://www.dpac.tas.gov.au/divisions/climatechange/adapting/climate_futures). This project became the basis of a similar project in New South Wales and is the highlight of the UTAS ERA multi-discipline impact projects. An independent costs benefit analysis shows a return of between $21.5 million and $86.5 million (present value terms) from total investment costs of approximately $16.4 million (present value terms). An extraordinary outcome for a research project and the team continues to work on climate change impacts.

My research is about understanding the changing state of the earth's state, including the oceans and atmospheres. In particular it is my research into the oceans changing salinity and linking these changes to the changing patterns of water of rainfall that has been pivotal in IPCC assessment of changing water cycle and the declining state of the oxygen in the world's oceans.

The greatest scientific successes of my career was the discovery of coherent pattern of warming of the key water in the Pacific, Indian and Southern Ocean and the attribution of these warming patterns to warming of surface waters (and humans). More importantly, my papers (with co-authors) were also the first to observe a pattern of change in the pattern of salinity, with freshening of polar waters and an increase in salinity of mid-latitude waters globally and also in the Indian Ocean. We have been able to show that the observations are consistent with the expected changes for the period of the observations from the Hadley Centre coupled general circulation models (eg Banks & Bindoff, 2003,

Helm et al. 2010, Rathore et al, 2020). This pattern is the acceleration of the global water cycle from human influence on the water cycle (Bindoff et al 2013).

We have extended this work to show oxygen is declining in the global ocean (Helm et al 2011) and that this decline has been attributed to rising greenhouse gases (Andrews et al 2013). The latest assessment of the oceans across the literature affirms this outcome. Collectively this work has been pivotal in establishing the changing patterns of temperature, salinity and oxygen are virtually certain to be caused by climate change. It is this body of work that has led to repeated selection for lead author roles in the fourth, fifth assessment and sixth assessment reports (Bindoff et al 2007, Bindoff et al. 2013 and Bindoff et al 2020). We are currently building a new temperature and salinity and oxygen atlas that provides a times series of the global patterns of change since the 1960's and this atlas will be used directly in the project (Roach et al, 2022 submitted)

**Granting Achievements:** Contributions to renewal of the ACE CRC in 2009 ($21 Million) and again in 2013 ($25 Million). Chief Investigator to the NESP Hub, Earth Systems Science and Climate Change Hub in 2014 ($24 Million) and in the Centre of Excellence in Climate Extremes ($30 Million). The development of the ARC Centre of Excellence in Climate Systems Science in 2011($21 Million), and the delivery of the all the milestones and success of the Climate Futures for Tasmania project ($8.5Million) and formation of the Landscape and Policy Hub ($6 Million). Total values of grants that I have participated in exceeds $220 million and now number about 85. There are many ARC grants among these 85 grants.

**Other relevant information**

Voyages on oceanographic research ships, HMAS Cook, RV Franklin, RSV Aurora Australis and RRV James Cook and CSIRO MNF Investigator. Nine of these voyages I was Chief Scientist (Physical Oceanography) and lead these projects from inception to publication. The total accumulated time is 611 days. Nine of the voyages were in the Southern Ocean or Antarctica. Role: Leading science expeditions, including funding support, organization of logistics and publication of the research outputs. Achievements: The very successful Mertz Polynya voyages and their subsequent analysis and publication, characterizing the production of Antarctic bottom waters (an important component in the climate system), and simulating the circulation and future changes and the recent (2018 MNF RV Investigator Voyage that has led to new dynamical insights into standing meanders in the Antarctic Circumpolar Current.

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

Publication context and contribution

My publication record is composed of peer reviewed journal articles, peer and government reviewed reports and book chapters on behalf of the United Nations through the Intergovernmental Panel on Climate Change (IPCC) and finally peer reviewed technical reports.

There are 188 publications, consisting of 125 peer reviewed papers, 10 peer reviewed chapters and 8 conference papers and 45 technical reports.

Nine of the peer reviewed chapters are for the IPCC and are contributions to the fourth, fifth and sixth assessment reports in 2007, 2013 and 2019. I was a Coordinating Lead Author on all three of these assessments. The IPCC AR4 Oceans Chapter, the Technical Summary and Summary for Policymakers (totalling ~20000 citations in Google Scholar). IPCC was awarded the Nobel Peace Prize in 2007. I had a similar role in the 5th and 6th assessment reports. IPCC reports are the peak assessments on behalf of governments that are used in climate policy by governments and the United Nations Framework Convention on Climate Change. They form the basis of decisions around the world for the evidence for climate mitigation and adaptation. These publications are rigorously reviewed four times, with about one to four thousand comments on each review, by teams of reviewers from both government and peer scientists.

The 125 peer reviewed journal publications are mostly in the top quartile journals and includes 7 in the nature family of publications.

There are some very important technical reports that are also highly cited (in google scholar) and have been used to inform Tasmanian and Australian policy on climate change impacts. These technical reports have led to prizes and more importantly been used as the basis of growing industry in Tasmania, particularly the wine industry (see F15).

My contributions to these publications have ranged from leading their conception, leading the writing, to providing advice and information, and have been in involved in the design of the research. My PhD students and postdoctoral fellows always lead their papers.

Number of publications (last 5 years): 34 (31 peer reviewed papers, 3 book chapters, 3 technical reports)

Number of publications (career): 188 (125 peer reviewed papers, 10 book chapters, 8 conference papers, 45 technical reports)

Citations: Web of Science 11,185 and h index = 47, Google Scholar ~53774 h index = 65 (41 last 5 years) including IPCC contributions and i10 index of 159, 112 of which come in the last 5 years.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] * Bindoff, N.L, et al 2007, 'Observations: Oceanic climate change and sea level in Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernment Panel on Climate Change' (Authored Book)

[2] * Nathaniel L. Bindoff & Trevor J. Mcdougall 1994, 'Diagnosing Climate Change and Ocean Ventilation Using Hydrographic Data', *Journal of Physical Oceanography*, vol. 24, no. 6, pp. 1137–1152, doi:10.1175/1520-0485(1994)024<1137:dccaov>2.0.co;2 (Refereed Journal Article)

[3] * Nathaniel L. Bindoff & Trevor J. McDougall 2000, 'Decadal Changes along an Indian Ocean Section at 32°S and Their Interpretation', *Journal of Physical Oceanography*, vol. 30, no. 6, pp. 1207–1222, doi:10.1175/1520-0485(2000)030<1207:dcaaio>2.0.co;2 (Refereed Journal Article)

[4] * Phillips, H.E. & Bindoff, N.L. 2014, 'On the nonequivalent barotropic structure of the antarctic circumpolar current: An observational perspective', *Journal of Geophysical Research: Oceans*, vol. 119, no. 8, pp. 5221-5243 (Refereed Journal Article)

[5] Hobbs, W.R., Bindoff, N.L. & Raphael, M.N. 2015, 'New perspectives on observed and simulated Antarctic sea ice extent trends using optimal fingerprinting techniques', *Journal of Climate*, vol. 28, no. 4, pp. 1543-1560 (Refereed Journal Article)

[6] Oliver, E.C.J., Benthuysen, J.A., Bindoff, N.L., Hobday, A.J. & Holbrook, N.J. et al. 2017, 'The unprecedented 2015/16 Tasman Sea marine heatwave', *Nature Communications*, vol. 8 (Refereed Journal Article)

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**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

| |
|---|
| No |

## Part F - Participant Details including ROPE (A/Prof Paul Spence)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Chief Investigator

Title

A/Prof

First Name

Paul

Middle Name

Family Name

Spence

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 15/05/2009 | Doctoral Degree | Doctor of Philosophy | Climatology | University of Victoria | Canada |
| 15/08/2005 | Masters Degree | Master of Science | Climatology | University of Victoria | Canada |
| 15/05/1999 | Bachelor Degree | Bachelor of Science | Physics | University of Victoria | Canada |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

Uploaded PDF file follows on next page.

**F5 Research Load (non-ARC Grants and Research)**

| **Description** (All named investigators on any application or grant/fellowship in which a participant is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application /Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| No non-ARC Grants to report | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

| |
|---|
| 0.1 |

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| University of Tasmania | Yes | Employee | 1 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

| |
|---|
| University of Tasmania |

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

| Identifier | Investigators | Admin Organisation | Project Title | Funding | End Date | Final Report Due Date | Final Report Status |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CE230100012 | Prof Christian Jakob ; Prof Nerilie Abram ; Prof Todd Lane ; A/Prof Sarah Perkins-Kirkpatrick ; Prof Neil Holbrook ; Prof Steven Sherwood ; Dr Martin Singh ; Prof Elizabeth Ritchie-Tyo ; Prof Julie Arblaster ; A/Prof Shayne McGregor ; Dr Ailie Gallant ; Dr Claire Vincent ; Dr Andrew King ; Dr Josephine Brown ; Prof Andrew Hogg ; Prof Jason Evans ; Prof Lisa Alexander ; A/Prof Andrea Taschetto ; A/Prof Paul Spence ; Dr Charmaine Franklin ; Dr Acacia Pepler ; Dr Eun-Pa Lim ; Dr Gilbert Brunet ; Dr Simon Marsland ; Dr Jaclyn Brown ; Dr James Risbey ; Dr Tilo Ziehn ; Dr Jon Petch ; Dr Benjamin Shipway ; Ms Catherine Senior ; Prof Dr Heini Wernli ; Prof Dr Sonia Seneviratne ; Dr Cathy Hohenegger ; Prof Dr Bjorn Stevens ; A/Prof Adam Sobel ; Dr Gretchen Mullendore ; Dr Gerald Meehl ; Prof Axel Timmermann ; Prof Paul O'Gorman ; Dr Robert Hallberg | Monash University | ARC Centre of Excellence for the Weather of the 21st Century | $35,000,000 | 31/12/2029 | 31/12/2030 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DP190100494 | Prof Matthew England ; Prof Andrew Hogg ; Dr Adele Morrison ; A/Prof Paul Spence ; Dr Stephen Griffies | The University of New South Wales | Risks of rapid ocean warming at the Antarctic continental margin | $582,500 | 31/12/2022 | 31/12/2023 | Draft |
| FT190100413 | A/Prof Paul Spence | University of Tasmania | The Antarctic Slope Current in a warming climate | $871,793 | 13/03/2025 | 13/03/2026 | Draft |
| LP200100406 | Prof Andrew Hogg ; Prof Matthew England ; Dr Adele Morrison ; A/Prof Paul Spence ; A/Prof Luke Bennetts ; Prof Alexander Babanin ; Dr Ryan Holmes ; Dr William Hobbs ; Dr Callum Shakespeare ; Prof Alessandro Toffoli ; Dr Benjamin Evans ; Dr Petra Heil ; Dr Gary Brassington ; Capt Robert Woodham ; Dr Richard Matear ; Dr Paul Sandery ; Dr Simon Marsland ; Dr Stephen Griffies | The Australian National University | Building Australia's next-generation ocean-sea ice model | $1,161,512 | 03/06/2025 | 03/06/2026 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SR200100008 | Prof Matt King ; A/Prof Delphine Lannuzel ; Prof Matthew England ; Prof Nerilie Abram ; A/Prof Alan Aitken ; Prof David Antoine ; Prof Nathaniel Bindoff ; Prof Julia Blanchard ; Prof Andrew Bowie ; Prof Philip Boyd ; Prof Zanna Chase ; Prof John Church ; Prof Richard Coleman ; Prof Michael Ellwood ; A/Prof Bishakhdatta Gayen ; Hon A/Prof Ian Goodwin ; Dr Jacqueline Halpin ; Dr Nicole Hill ; Prof Mark Hindell ; Prof Mary-Anne Lea ; A/Prof Vanessa Lucieer ; Prof Andrew McMinn ; A/Prof Laurie Menviel ; Dr Adele Morrison ; Dr Maxim Nikurashin ; A/Prof Helen Phillips ; Prof Anya Reading ; Prof Eelco Rohling ; Dr Katherine Selway ; A/Prof Alexander Sen Gupta ; A/Prof Paul Spence ; Prof Peter Strutton ; Prof Paul Tregoning ; Dr Christopher Watson ; A/Prof Duanne White ; A/Prof Joanne Whittaker ; A/Prof Guy Williams ; Dr Jan Zika ; Dr Ben Galton-Fenzi ; Dr Robert Massom ; Dr Klaus Meiners ; Dr Jason Roberts ; Dr Alexandra Post ; Dr Clive McMahon ; Dr Karsten Gohl ; Dr | University of Tasmania | The Australian Centre for Excellence in Antarctic Science | $20,000,000 | 31/12/2025 | 31/12/2026 | Draft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Hartmut Hellmer ; A/Prof David Vaughan ; Prof Andrew Thompson ; Dr Herve Claustre ; Dr Jean baptiste Sallee ; Dr Gael Durand ; Dr Amaelle Landais ; Dr Xavier Crosta ; Prof David Thompson ; Dr Pippa Whitehouse ; Prof Michael Bentley ; Dr Stewart Jamieson ; Prof Chris Stokes ; A/Prof Shigeru Aoki ; Prof Darryn Waugh ; Dr Tamsin Edwards ; Dr Won Sang Lee ; Dr Pierre Dutrieux ; Dr Stephen Griffies ; Prof Helen Fricker ; Prof Sarah Gille ; Prof Lynne Talley ; Prof Bernd Kulessa ; Prof Adrian Luckman ; Prof Eric Wolff ; Dr Ted Scambos ; Prof Anna Wåhlin ; Asst Prof Naomi Levine ; Prof Yusuke Yokoyama ; Prof Scott Doney ; Prof Michiel Van den Broeke ; Dr John Toole ; Adj/Prof Terence O'Kane ; Dr Xuebin Zhang | | | | | | |

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

| |
|---|
| Yes |

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they*

*will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

No

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*

Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

Justification of PI status

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

No PDF file uploaded.

**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|
| Future Fellow | Institute for Marine and Antarctic Studies | Contract | Full Time | 01/09/2021 | | University of Tasmania |
| Future Fellow | School of Geosciences | Contract | Full Time | 01/02/2021 | 31/08/2021 | The University of Sydney |
| Senior Lecturer | Climate Change Research Centre | Contract | Full Time | 01/07/2016 | 16/06/2019 | The University of New South Wales |
| ARC DECRA Fellow | Climate Change Research Centre | Contract | Full Time | 15/06/2015 | 16/06/2018 | The University of New South Wales |
| Lecturer | Cimate Change Research Centre | Contract | Full Time | 01/04/2012 | 14/06/2015 | The University of New South Wales |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*
Has the participant experienced a significant interruption that has impacted on research opportunity?

Yes

From when

14/02/2020

To when

14/02/2021

FTE of academic interruption

1.0

Interruption Category

Unemployment

Details

Time off before commencing my Future Fellowship grant.

From when

20/06/2019

To when

14/02/2020

FTE of academic interruption

0.5

Interruption Category

Caring and parental responsibilities

Details

Carer's leave for family illness.

From when

01/01/2015

To when

26/06/2015

FTE of academic interruption

1.0

Interruption Category

Other

Details

Unpaid leave.

From when

04/05/2012

To when

07/07/2012

FTE of academic interruption

1.0

Interruption Category

Other

Details

Unpaid leave.

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

Uploaded PDF file follows on next page.

**F17 Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

## AMOUNT OF TIME AS AN ACTIVE RESEARCHER

I was awarded my PhD 13.5 years ago in 2009 and in that period I have experienced a total of 2 years at 1.0 FTE of academic interruptions.

## RESEARCH OPPORTUNITIES

I joined the CCRC as a level A Postdoctoral Researcher in June 2009 and was selected for promotion three times. Amongst international candidate searches, I was awarded a Level B Research Fellow position in November 2011 and an academic faculty Lecturer appointment (25% teaching load) in February 2012. In July 2016, I was promoted to a Level C Senior Lecturer appointment through by demonstrating that my performance was within the top 25% of existing Level C faculty.

In 2015 I was awarded an ARC Discovery Early Career Researcher Award (DE150100456) at the CCRC. My DECRA finished in June 2018, and was on a fixed-term contract with UNSW that expired in January 2020. In 2019 I reduced my workload to 0.5 FTE for six months to deal with a serious family illness.

In 2019 I was awarded an ARC Future Fellowship at the University of Sydney. After taking 12 months off work (including some covid related travel complications) I began my Future Fellowship in February 2021.

In September 2021 my Future Fellowship was successfully transferred to the University of Tasmania where I am now an Associate Professor. The University of Tasmania ranked 7th in the world for oceanography (top in Australia) in the latest Centre for World University Rankings. Hobart, Tasmania more broadly hosts Australia's largest group of Southern Ocean and Antarctic scientists, including CSIRO oceanographic labs and major federally funded oceanographic research programs such as the Australian Antarctic Program Partnership, Centre for Southern Hemisphere Oceans Research, and Integrated Marine Observing System.

### *Research mentoring and facilities available to me*

Throughout my career I have been mentored by world-leaders in oceanography and climate science. I completed my MSc and PhD under the supervision of Prof. Andrew Weaver at University of Victoria, a Nobel prize winning climate scientist, American Geophysical Union (AGU) Fellow, and elected member of British Columbia parliament. At the CCRC, I have been fortunate to be mentored by Prof. Matthew England; Prof. England is a world-renowned expert in oceanography and climate, a Fellow of the Australian Academy of Science and AGU, and ARC Laureate Fellow, among a suite of other accolades. My Associate Investigator status with the ARC Centre of Excellence for Climate System Science (2011-2017) and the ARC Centre of Excellence for Climate Extremes (2017-) enable frequent collaborations with the world's foremost leaders in ocean modelling.

The University of Tasmania ranked 7th in the world for oceanography **(**top in Australia**)** in the latest Centre for World University Rankings. Southern Ocean and Antarctic research are core to the University of Tasmania strategic plan. At the University of Tasmania I am a Partner Investigator with the Australian Antarctic Program Partnership (AAPP) and Chief Investigator with both the Australian Centre of Excellence in Antarctic Science (ACEAS, 2021-2025) and the ARC Centre of Excellence for Weather of the 21$^{st}$ Century (2023-2029).

Hobart, Tasmania more broadly hosts Australia's largest group of Southern Ocean and Antarctic scientists, including CSIRO oceanographic labs and major federally funded oceanographic research programs such as the Australian Antarctic Program Partnership, Centre for Southern Hemisphere Oceans Research, and Integrated Marine Observing System. A new icebreaker (Nuyina) based in Hobart come into service in 2021, and will greatly enhance capacity for Antarctic ocean research.

## RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

### *Speaker and Visiting Scientist Invitations*

Reflecting my role in generating and communicating novel scientific ideas, I am regularly invited and funded by organizers to give oral presentations at prestigious international meetings and workshops, including:

- *Australian Academy of Science, Theo Murphy Workshop on Antarctic Science*, Sept. 2017, Hobart, Australia.

- *National Center for Atmospheric Research Southern Ocean Workshop*, April 2017, Boulder, Colorado.
- *World Climate Research Programme Ocean Model Development Planning Committee*, Jan. 2016, Yokohama, Japan.
- *CLIVAR Workshop on High Resolution Ocean Climate Modelling*, May 2014, Kiel, Germany.
- *CLIVAR Southern Ocean Panel meeting*, May 2014, Kiel, Germany.
- *Past Global Changes Young Scientists Meeting*, Feb. 2013, Goa, India.
- *The Japan-Australia Polar Ocean Circulation and Processes Workshop*, Nov. 2011, Tokyo, Japan.
- *National Science Foundation Physical Oceanography Dissertation Symposium*, a selective gathering of the most promising young ocean scientists. Oct. 2008, Hawaii.

I have been an invited visiting scientist at many international research institutions, including:

- JAMSTEC, Yokohama, Japan in 2023.
- NOAA Geophysical Fluid Dynamics Laboratory, Princeton, USA in 2012, 2013, 2015, 2017, 2018. Host: Dr. Stephen Griffies.
- National Center for Atmospheric Research, Boulder, USA in 2012 and 2017. Host: Dr. Frank Bryan
- Canadian Centre for Climate Modelling and Analysis, Victoria, Canada 2010-2017, 2022. Host: Dr. Oleg Saenko, Adam Monahan.
- University of Hokkaido, Sapporo, Japan in 2015. Host: Prof. Keichi Ohshima.
- GEOMAR, Kiel Germay in 2013. Host: Prof. Claus Boning.

I have given more than 19 invited seminars at world leading research institutes and presented at more than 22 international conferences.

***Research Income***

I have a sustained track record of successful bids on research grants and external funding in excess of $58M AUD, including:

- Chief Investigator on 2023 ARC Centre of Excellence, “Weather of the 21st Century. (CE230100012, ARC $35M)
- Chief Investigator on 2020 ARC Linkage Project, “Building Australia's next-generation ocean-sea ice model”. (LP200100406, ARC $1,161K, partners $300K + in kind contributions)
- Chief Investigator on 2020 ARC SRI, “The Australian Centre for Excellence in Antarctic Science”. (SR200100008, ARC $20M)
- Chief Investigator on 2019 ARC Future Fellowship, “The Antarctic Slope Current in a Changing Climate”. (FT190100413, ARC $871K, UTas 20K/annum + in kind contributions)
- Chief Investigator on 2019 ARC Discovery Project, “Risks of rapid ocean warming at the Antarctic continental margin”. (DP180102521, ARC $580K)
- Chief Investigator on 2016 ARC Linkage Project, “An Australian Consortium for Eddy-Resolving Global Ocean-Sea Ice Modelling”. (LP160100073, ARC $599K, partners $240K + in kind contributions)
- Chief Investigator on 2015 ARC DECRA Project, “Dynamics of Southern Ocean abyssal flows”. (DE150100223, ARC $357K, UNSW $20K + one year salary)
- Chief Investigator on 2015 ARC *Linkage Infrastructure, Equipment and Facilities* Project, “Connecting big data with high performance computing for climate science”. (LE150100089, $490K)
- Chief Investigator on 2012 ARCCSS Early Career Research Grant, “Southward wind shifts in the classic recharge oscillator theory for the termination of ENSO events” ($22K).
- Awarded 2012 Australian Academy of Science France/Australia Science International Collaboration Grant, “Development of high-resolution global ocean simulations: an assessment and optimization of French and Australian modeling efforts”. ($6K)
- Awarded a prestigious National Science and Engineering Foundation Grant, Canada for PhD ($66K).

***Research supervision, mentoring and advice***

I currently supervise four active PhD students and two postdoctoral researchers. I have supervised to completion two postdoctoral researchers, two PhD students and five undergraduate students summer internships.

***Research contributions***

My research uses theory, models and observations to understand the physical processes at play during important ocean climate events. I made a series of ground-breaking discoveries and innovations in the following key Earth science areas:

1. *Ocean climate model development*
2. *Ocean eddies and global climate change*
3. *Antarctic Coastal Ocean Dynamics and Ice Shelf Interactions*

*1. Ocean climate model development*
My ambition is to be a pioneering ocean model developer throughout my career. My professionalism and affection for model coding began while working as a scientific programmer at an ocean acoustics company for several years (2000-2003). When I began my PhD, numerical simulations of Earth's climate resolved only large-scale (~100 km) features of the ocean circulation, while most of the observed ocean energy is found in mesoscale (10-100 km) processes. During my PhD, I created the first global, coupled climate model simulations capable of resolving ocean mesoscale features. This independent model development effort led to numerous advances in our understanding of mesoscale ocean dynamics.

I have been leading research on creating Australia's next generation of ocean-sea ice models since 2011. From 2011-2017 I spent roughly 3 years of research time creating new mesoscale resolving global ocean models that are now widely used and openly shared via github repositories. In recognition of these efforts, I received the Most Outstanding Contribution to the ARC Centre of Excellence for Climate System award from the center director (Prof. Andy Pitman) in 2014. The research output from this research include 40+ peer reviewed journal publications and features in high impact ocean science videos created in collaboration with Australia's National Computing Infrastructure facility that have >70,000 views on YouTube: https://www.youtube.com/watch?v=8VMSF28J9H4 and https://www.youtube.com/watch?v=gaFjlZxM7S4).

I am a Chief Investigator behind the formation of the Consortium of Ocean and Sea Ice Modelling in Australia (www.cosima.org.au). Funded by with a 2016 and 2020 ARC Linkage Grant, COSIMA aims to consolidate high-resolution ocean modelling activities across all the major Australian agencies, and is currently supported by a number of universities (ANU, UNSW, UTas, UAdelaide) and major government research agencies (Bureau of Meteorology, Australian Antarctic Division, CSIRO, Australian Research Council). As Chief Investigator and very active participant in COSIMA, I have helped to create a new series of global ocean models with multiple horizontal resolutions (1°, 1/4° and 1/10°), multiple vertical resolutions (50-135 z-levels), multiple sea ice models (SIS and CICE), multiple atmospheric forcing data sets (JRA and CORE), different mixing parameter settings, and biogeochemistry coupling (WOMBAT). These models are being created in collaboration with government agencies and openly shared throughout the Australian community, including python analysis code (see https://github.com/COSIMA). The models and analysis code are currently being adopted by the Bureau of Meteorology, CSIRO and the Australian Antarctic Division.

*2. Ocean circulation in global climate*
The central theme of my research is geophysical fluid dynamics with a focus on mesoscale (10-100km) ocean processes in global and regional climate. I have published extensively on a wide range of ocean and climate dynamics of the Southern Ocean, North Atlantic, Tropical Pacific and Antarctic margin. My commitment to innovative ocean modeling in combination with sound dynamic and observational understanding has led to important advances in Earth science, such as:

- Identifying a greater inter-hemispheric coupling of the ocean's overturning circulation in higher resolution models, with more of the deep water formed in the North Atlantic flowing into the Southern Ocean.
- The first global, fully-coupled climate model study to demonstrate that the Antarctic Circumpolar Current transport is less sensitive to wind forcing at higher resolution, and that much of the observed Southern Ocean warming at mid-depths can be attributed to poleward shifting of small-scale ocean fronts.
- Proving that reduced friction and high-resolution bathymetry greatly improves the dynamical representation of abyssal flows, which in turn strongly impacts the modelled response to perturbations.
- Demonstrating that changes to the formation rates of Antarctic Bottom Water around Antarctica will be conveyed to all of the subtropical basins on decadal time-scales.
- The first evaluation of the Earth's climate sensitivity to freshwater perturbations at the ocean surface with global, ocean eddy-permitting climate models.

*3. Antarctic Coastal Ocean Dynamics and Ice Shelf Interactions*
Melting ice sheets around Antarctica have significantly increased global sea level in recent decades, and comprise the largest uncertainty in future projections of sea level rise. Ultimately, the melt rate of Antarctica's marine-terminating ice sheets is controlled by heat delivered from the Southern Ocean to the Antarctic continental shelf margins. I am a world leader in Antarctic coastal ocean dynamics, and have recently authored several innovative and highly cited papers revealing the mechanisms behind the warming of ocean water at the base of floating ice shelves around Antarctica, with potentially massive ramifications for global sea level rise (1,2,3,4).

As lead author in a *Geophysical Research Letters* article, I showed how local changes in Antarctic coastal winds, caused by increased greenhouse gas emissions create intense warming of subsurface coastal waters that exceeds 2°C. This study revealed the importance of a fundamental dynamic link between changes in the wind stress curl and the coastal ocean heat flux. Another study I led, published in *Nature Climate Change*, reveals a unique susceptibility of the Antarctic coastal ocean, particularly subsurface ocean temperatures on the western side of the Antarctic Peninsula, to remote wind perturbations. It demonstrates how coastal- trapped waves can communicate a distant wind disturbance around the entire Antarctic coastline, leading ocean warming at distant Antarctic locations on short time-scales. Together, these papers present novel and leading hypotheses for the mechanisms that are driving the observed ocean warming trends on the Antarctic continental shelf.

The international appreciation for these papers has led me to write two review papers on Antarctic coastal oceanography and coastal waves. I recently joined three other world leaders to write the first review of the Antarctic Slope Current in over 25 years that was accepted in Annual Reviews of Geophysics. It details the advances in our understanding of Antarctic Slope Current properties, dynamics, variability, and the growing appreciation for its crucial role in global climate. I am co-author on a second review paper that looks at the fundamental dynamics of how sea level and coastal trapped waves mediate the interaction between the between the predominantly geostrophic dynamics of the interior ocean and the ageostrophic dynamics which must occur at the coast.

***Leadership and professional activities***

Scientific Advisory Committee of the Australian Earth-System Simulator (ACCESS-NRI), a national research infrastructure created to support development and research with the Australian Community Climate and Earth System Simulator (ACCESS) modelling system.

Consortium of Ocean and Sea Ice Modelling in Australia Project Management Committee since 2016.

Denman, Antarctica 2024/25 ocean and terrestrial voyage planning committee.

High Performance Computing Representative for ACEAS and AAPP compute committee since 2021.

Expert Assessor for ARC proposals since 2015.

Session organizer for 2022 Ocean Sciences Meeting.

Organizing committee for the 2018 Australian Meteorological and Oceanographic Society Annual Meeting. Session organizer for 2013 and 2018 Australian Meteorological and Oceanographic Society Annual Meeting.

Organizing committee for the 2016-2022 Consortium of Ocean and Sea Ice Modelling in Australia annual meetings.

Lead organiser of the four day 2015 ARC Centre of Excellence for Climate System Science Oceans Node Annual Meeting.

Member of CSIRO's Scientists in Schools Program from 2013-2015, which links scientists with local community public schools. I was partnered at Mascot and Ascham Public Schools.

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

In the disciplines of climate science, atmospheric science, oceanography, and climate extremes, highly-cited publications in high-impact journals are of value. Generally, the order of authorship is indicative of the relative role each author has contributed to the research, although there are some exceptions. It is often the case to give a student or early career researcher the opportunity to lead the paper (this applies in my case) although there could be substantial contributions in framing, methods, results, writing etc from the other authors. The Nature and Science family of journals are generally held in the highest esteem with discipline specific journals like 'Journal of Climate', 'Journal of Geophysical Research - Oceans' seen as the 'next best'. Journal 'Letters' like Geophysical Research Letters and Environmental Research Letters are also highly regarded.

Overall, my collective research outputs have been very impactful. I have authored 58 peer-reviewed publications, including 10 as first author and 11 as second author. My papers have been cited 3662/2667 times (Google Scholar/Scopus) and my H-index is 29/26 (Google Scholar/Scopus). My i10 index via Google Scholar is 52 with citation rates exceeding 500 per annum since 2019, demonstrating the increasing pace of my trajectory. These metrics are particularly impressive given that my PhD was conferred in 2009 and I have had 23 months of career interruptions since then.

I have five manuscripts in high-impact journals (Impact Factor, IF >11): two in Nature Climate Change, one in Nature Communications, one in Science Advances, and one in Review of Geophysics. I also regularly publish in high-quality journals that specialize in my research area with 30 of my publications appearing in journals with IF > 4 (e.g. Geophysical Research Letters, Earth and Planetary Science Letters). All of my papers are in journals with Q1 quartile rankings (top 25% of journals in relevant subject category. SciVal (2011-2020) indicates that 30% of my publications are in the top 10% cited worldwide and 82% are in top 10% journals. My Field-Weighted Citation Impact is 3.29, indicating that my publications have been cited 324% more than would be expected based on the world average for similar publications.

The central theme of my research is geophysical fluid dynamics with a focus on high-resolution modelling of the ocean's role in global and regional climate. Physical ocean modellers typically have lower citation statistics relative to other climate science fields due to the their model development efforts and mathematical publication focus. I have published extensively on ocean climate dynamics of the Southern Ocean, North Atlantic, Tropical Pacific and Antarctic margin. My commitment to innovative ocean modelling in combination with sound dynamic and observational understanding has led to ground breaking advances in Earth science. The international appreciation for my research has led me to author three review papers on ocean dynamics and climate.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] Paul Spence, Stephen M. Griffies, Matthew H. England, Andrew McC. Hogg & Oleg A. Saenko et al. 2014, 'Rapid subsurface warming and circulation changes of Antarctic coastal waters by poleward shifting winds', *Geophysical Research Letters*, vol. 41, no. 13, pp. 4601–4610, doi:10.1002/2014gl060613 (Refereed Journal Article)

[2] Paul Spence, Ryan M. Holmes, Andrew McC. Hogg, Stephen M. Griffies & Kial D. Stewart et al. 2017, 'Localized rapid warming of West Antarctic subsurface waters by remote winds', *Nature Climate Change*, vol. 7, no. 8, pp. 595–603, doi:10.1038/nclimate3335, DE150100456 (2016-2019) (Refereed Journal Article)

[3] Matthew H. England, Shayne McGregor, Paul Spence, Gerald A. Meehl & Axel Timmermann et al. 2014, 'Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus', *Nature Climate Change*, vol. 4, no. 3, pp. 222–227, doi:10.1038/nclimate2106 (Refereed Journal Article)

[4] A. K. Morrison, A. McC. Hogg, M. H. England & P. Spence 2020, 'Warm Circumpolar Deep Water transport toward Antarctica driven by local dense water export in canyons', *Science Advances*, vol. 6, no. 18, pp. eaav2516, doi:10.1126/sciadv.aav2516 (Refereed Journal Article)

[5] Menviel, L., Spence, P., Yu, J., Chamberlain, M. A. & Matear, R. J. et al. 2018, 'Southern Hemisphere westerlies as a driver of the early deglacial atmospheric CO2 rise', *Nature Communications*, vol. 9, no. 1, doi:10.1038/s41467-018-04876-4, DE150100223 (2016-2019) (Refereed Journal Article)

[6] Thompson, Andrew F., Stewart, Andrew L., Spence, Paul & Heywood, Karen J. 2018, 'The Antarctic Slope Current in a Changing Climate', *Reviews of Geophysics*, vol. 56, no. 4, pp. 741–770, doi:10.1029/2018rg000624, DE150100223 (2016-2019) (Refereed Journal Article)

[7] Paul Spence, John C. Fyfe, Alvaro Montenegro & Andrew J. Weaver 2010, 'Southern Ocean Response to Strengthening Winds in an Eddy-Permitting Global Climate Model', *Journal of Climate*, vol. 23, no. 19, pp. 5332–5343, doi:10.1175/2010jcli3098.1 (Refereed Journal Article)

[8] K.D. Stewart, P. Spence, S. Waterman, J. Le Sommer & J.-M. Molines et al. 2015, 'Anisotropy of eddy variability in the global ocean', *Ocean Modelling*, vol. 95, pp. 53–65, doi:10.1016/j.ocemod.2015.09.005 (Refereed Journal Article)

[9] Paul Spence, Oleg A. Saenko, Michael Eby & Andrew J. Weaver 2009, 'The Southern Ocean Overturning: Parameterized versus Permitted Eddies', *Journal of Physical Oceanography*, vol. 39, no. 7, pp. 1634–1651, doi:10.1175/2009jpo4120.1 (Refereed Journal Article)

[10] Shayne McGregor, Nandini Ramesh, Paul Spence, Matthew H. England & Michael J. McPhaden et al. 2013, 'Meridional movement of wind anomalies during ENSO events and their role in event termination', *Geophysical Research Letters*, vol. 40, no. 4, pp. 749–754, doi:10.1002/grl.50136 (Refereed Journal Article)

## Refereed Journal Articles

[1] David J. Webb, Ryan M. Holmes, Paul Spence & Matthew H. England 2022, 'Propagation of barotropic Kelvin waves around Antarctica', *Ocean Dynamics*, vol. 72, no. 6, pp. 405–419, doi:10.1007/s10236-022-01506-y

[2] Sotiria Georgiou, Stefanie L. Ypma, Nils Brüggemann, Juan-Manuel Sayol & Carine G. van der Boog et al. 2021, 'Direct and Indirect Pathways of Convected Water Masses and Their impacts on the Overturning Dynamics of the Labrador Sea', *Journal of Geophysical Research: Oceans*, vol. 126, no. 1, doi:10.1029/2020jc016654, FT190100413 (2021-2025)

[3] D. J. Webb, P. Spence, R. M. Holmes & M. H. England 2021, 'Planetary-wave induced strengthening of the AMOC forced by poleward intensified Southern Hemisphere westerly winds', *Journal of Climate*, pp. 1–45, doi:10.1175/jcli-d-20-0858.1, FT190100413 (2021-2025)

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[6] Joël J.-M. Hirschi, Bernard Barnier, Claus Böning, Arne Biastoch & Adam T. Blaker et al. 2020, 'The Atlantic meridional overturning circulation in high resolution models', *Journal of Geophysical Research: Oceans*, doi:10.1029/2019jc015522

[7] L. C. Menviel, P. Spence, L. C. Skinner, K. Tachikawa & T. Friedrich et al. 2020, 'Enhanced Mid-depth Southward Transport in the Northeast Atlantic at the Last Glacial Maximum Despite a Weaker AMOC', *Paleoceanography and Paleoclimatology*, vol. 35, no. 2, doi:10.1029/2019pa003793, DE150100223 (2016-2019)

[8] Mathias Zeller, Shayne McGregor, Erik van Sebille, Antonietta Capotondi & Paul Spence 2020, 'Subtropical-tropical pathways of spiciness anomalies and their impact on equatorial Pacific temperature', *Climate Dynamics*, vol. 56, no. 3-4, pp. 1131–1144, doi:10.1007/s00382-020-05524-8, FT190100413 (2021-2025)

[9] Chris W. Hughes, Ichiro Fukumori, Stephen M. Griffies, John M. Huthnance & Shoshiro Minobe et al. 2019, 'Sea Level and the Role of Coastal Trapped Waves in Mediating the Influence of the Open Ocean on the Coast', *Surveys in Geophysics*, doi:10.1007/s10712-019-09535-x, DE150100223 (2016-2019)

[10] Andrew E. Kiss, Andrew McC. Hogg, Nicholas Hannah, Fabio Boeira Dias & Gary B. Brassington et al. 2019, 'ACCESS-OM2: A Global Ocean-Sea Ice Model at Three Resolutions', *Geoscientific Model Development Discussions*, pp. 1–58, doi:10.5194/gmd-2019-106, DE150100223 (2016-2019), LP160100073 (2016-2020)

[11] Darryn W. Waugh, Andrew McC. Hogg, Paul Spence, Matthew H. England & Thomas W. N. Haine 2019, 'Response of Southern Ocean Ventilation to Changes in Midlatitude Westerly Winds', *Journal of Climate*, vol. 32, no. 17, pp. 5345–5361, doi:10.1175/jcli-d-19-0039.1

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**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

| |
|---|
| No |

## Part F - Participant Details including ROPE (Prof Jae-Hun Park)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Partner Investigator

Title

Prof

First Name

Jae-Hun

Middle Name

Family Name

Park

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 14/06/2001 | Doctoral Degree | Doctor of Engineering | Ocean Engineering | Hiroshima University | Japan |
| 25/02/1997 | Masters Degree | Master of Science | Oceanography | Seoul National University | Korea, Republic of (South) |
| 25/02/1994 | Bachelor Degree | Bachelor of Science | Oceanography | Seoul National University | Korea, Republic of (South) |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

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**F5 Research Load (non-ARC Grants and Research)**

| **Description** (All named investigators on any application or grant/fellowship in which a participant is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application /Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Jae-Hun Park, Understanding of physical processes governing the cross-frontal heat flux in the Antarctic Circumpolar Current near Southeastern Indian Ridge. Korea Polar Research Institute. | Y | C | n/a | 56 | 56 | 56 | | | | |
| Jae-Hun Park, Ho Kyung Ha, and Taewon Kim. Development of 3-D Ocean Current Observation Technology for Efficient Response to Maritime Distress. Korea Institute of Marine Science and Technology Promotion. | Y | C | n/a | 500 | 450 | 338 | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Jae-Hun Park. Open Innovation in Polar Region / Test of long-term monitoring system installation for oceanic environmental changes caused by accelerated sea-ice melting in the Chukchi Sea. Korea Institute of Marine Science and Technology Promotion. | Y | C | n/a | 337 | | | | | | |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

0.1

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| Inha University, Korea | | Employee | 1.0 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

Inha University, Korea

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

No

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

No

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if*

*this application is successful. While the application can be submitted, project limits must be met under the grant guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*
Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

Justification of PI status

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

Yes

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

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**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| University | Department of Ocean Sciences | Permanent | Full Time | 01/09/2015 | 28/02/2036 | Inha University, Korea |
| Research Institute | Ocean Circulation and Climate Research Division | Permanent | Full Time | 01/01/2011 | 31/08/2015 | Korea Institute of Ocean Science and Technology |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*
Has the participant experienced a significant interruption that has impacted on research opportunity?

| |
|---|
| No |

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

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**F17 Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

**AMOUNT OF TIME AS AN ACTIVE RESEARCHER**

22 years

**RESEARCH OPPORTUNITIES**

I am working in the Inha University and the percentages of my current roles in teaching, research and program manager are 30%, 50%, and 20%, respectively.

**RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS**

2017-2025 Scientific Steering Committee (SSC) member of the Northwestern Pacific Ocean Circulation and Climate Experiment (NPOCE)
2018–2019 Auditor of the Korean Society of Oceanography
2018–2020 Local organizing committee member of the IAMAS-IAPSO-IACS 2021 (MOCA-21) meeting
2019–2027 Executive Committee member of the International Association for the Physical Sciences of the Oceans (IAPSO)
2020–2021 Treasurer of the Korean Society of Oceanography
2020–2023 Co-editor of Ocean Science Journal
2020-2024 Executive Committee member of the Society for East Sea
2021- Fellow of the Korean Academy of Marine Science

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

I have published 77 peer-reviewed papers including 13 first author papers and 18 student/post-doc first author papers. My papers (h-index: 26 and i10-index: 47) have been cited 2525 times (google scholar, 1/03/2023) with citations after 2018 are 1295. Thirty-four papers mostly used in-situ mooring data from current- and pressure-sensor-equipped inverted echo sounder (CPIES) that is my primary oceanic observation instrument. Most of my papers are in journals ranked top 25% in relevant subject category with 34 papers published in the Geophysical Research Letters, Journal of Geophysical Research-Ocean, and Journal of Physical Oceanography.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] * Park, J.-H. & Watts, D.R. 2006, 'Internal tides in the southwestern Japan/East Sea', *Journal of Physical Oceanography*, vol. 36, no. 1, pp. 22-34 (Refereed Journal Article)

[2] Park, J.-H. & Kaneko, A. 2000, 'Assimilation of coastal acoustic tomography data into a barotropic ocean model', *Geophysical Research Letters*, vol. 27, no. 20, pp. 3373-3376 (Refereed Journal Article)

[3] * Alford, M.H., Peacock, T., Mackinnon, J.A., Nash, J.D., Buijsman, M.C., Centuroni, L.R., Chao, S.-Y., Chang, M.-H., Farmer, D.M., Fringer, O.B., Fu, K.-H., Gallacher, P.C., Graber, H.C., Helfrich, K.R., Jachec, S.M., Jackson, C.R., Klymak, J.M., Ko, D.S., Jan, S., Johnston, T.M.S., Legg, S., Lee, I.-H., Lien, R.-C., Mercier, M.J., Moum, J.N., Musgrave, R., Park, J.-H., Pickering, A.I., Pinkel, R., Rainville, L., Ramp, S.R., Rudnick, D.L., Sarkar, S., Scotti, A., Simmons, H.L., St Laurent, L.C., Venayagamoorthy, S.K., Wang, Y.-H., Wang, J. & Yang, Y.J. et al. 2015, 'The formation and fate of internal waves in the South China Sea', *Nature*, vol. 521, no. 7550, pp. 65-69 (Refereed Journal Article)

[4] * Farmer, D., Li, Q. & Park, J.-H. 2009, 'Internal wave observations in the South China sea: The role of rotation and non-linearity', *Atmosphere - Ocean*, vol. 47, no. 4, pp. 267-280 (Refereed Journal Article)

[5] * Andres, M., Wimbush, M., Park, J.-H., Chang, K.-I., Lim, B.-H., Watts, D.R., Ichikawa, H. & Teague, W.J. 2008, 'Observations of Kuroshio flow variations in the East China Sea', *Journal of Geophysical Research: Oceans*, vol. 113, no. 5 (Refereed Journal Article)

[6] * Park, J.-H. & Farmer, D. 2013, 'Effects of Kuroshio intrusions on nonlinear internal waves in the South China Sea during winter', *Journal of Geophysical Research: Oceans*, vol. 118, no. 12, pp. 7081-7094 (Refereed Journal Article)

[7] * Park, J.-H., Watts, D.R., Donohue, K.A. & Jayne, S.R. 2008, 'A comparison of in situ bottom pressure array measurements with GRACE estimates in the Kuroshio Extension', *Geophysical Research Letters*, vol. 35, no. 17 (Refereed Journal Article)

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[9] * Park, J.-H., Watts, D.R., Tracey, K.L. & Mitchell, D.A. 2005, 'A multi-index GEM technique and its application to the southwestern Japan/East Sea', *Journal of Atmospheric and Oceanic Technology*, vol. 22, no. 8, pp. 1282-1293 (Refereed Journal Article)

[10] Chanhyung Jeon, Jae-Hun Park, Hirohiko Nakamura, Ayako Nishina, Xiao-Hua Zhu, Dong Guk Kim, Hong Sik Min, Sok Kuh Kang, Hanna Na & Naoki Hirose 2019, 'Poleward-propagating near-inertial waves enabled by the western boundary current', *Scientific Reports*, vol. 9, no. 1, doi:10.1038/s41598-019-46364-9 (Refereed Journal Article)

## Authored Books

[1] Nam, S.H., Park, J.-H. & Park, J.J. 2015, 'High-frequency variability: Basin-scale oscillations and internal waves/tides', *Oceanography of the East Sea (Japan Sea)*, pp. 127-148

## Refereed Journal Articles

[1] * Juntian Chen, Xiao-Hua Zhu, Hua Zheng, Hirohiko Nakamura, Ruixiang Zhao, Min Wang, Jae-Hun Park & Ayako Nishina 2022, 'Observation of Topographic Rossby Waves Triggered by Kuroshio Path Meander in the East China Sea', *Journal of Geophysical Research: Oceans*, vol. 127, no. 8, doi:10.1029/2022jc018667

[2] * Chanhyung Jeon, D. Randolph Watts, Hong Sik Min, Dong Guk Kim, Sok Kuh Kang, Il-Ju Moon & Jae-Hun Park 2022, 'Weakening of the Kuroshio Upstream by Cyclonic Cold Eddies Enhanced by the Consecutive Passages of Typhoons Danas, Wipha, and Francisco (2013)', *Frontiers in Marine Science*, vol. 9, doi:10.3389/fmars.2022.884768

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[4] * Kang-Nyeong Lee, Chanhyung Jeon, YoungHo Seung, Hong-Ryeol Shin, Seung-Kyu Son & Jae-Hun Park 2022, 'Observational Evidence of Generation and Propagation of Barotropic Rossby Waves Induced by Tropical Instability Waves in the Northeastern Pacific', *Geophysical Research Letters*, vol. 49, no. 15, doi:10.1029/2022gl098327

[5] Jeong-Yeob Chae, Chanhyung Jeon, Pyeongjoong Kim, Naoki Hirose, Ahyoung Ku & Jae-Hun Park 2021, 'Variation of Semidiurnal Internal Tides along the Southeastern Coast of Korea Induced by Typhoons', *Journal of Marine Science and Engineering*, vol. 9, no. 3, pp. 328, doi:10.3390/jmse9030328

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Inverted Echo Sounders (CPIES)', *Frontiers in Marine Science*, vol. 8, doi:10.3389/fmars.2021.679534

[7] Yeongbin Park, Chanhyung Jeon, Hajin Song, Youngseok Choi, Jeong-Yeob Chae, Eun-Joo Lee, Jin Sung Kim & Jae-Hun Park 2021, 'Novel Method for the Estimation of Vertical Temperature Profiles Using a Coastal Acoustic Tomography System', *Frontiers in Marine Science*, vol. 8, doi:10.3389/fmars.2021.675456

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[9] * Ahyoung Ku, Young Ho Seung, Chanhyung Jeon, Youngseok Choi, Eri Yoshizawa, Koji Shimada, Kyoung-Ho Cho & Jae-Hun Park 2020, 'Observation of Bottom-Trapped Topographic Rossby Waves on the Shelf Break of the Chukchi Sea', *Journal of Geophysical Research: Oceans*, vol. 125, no. 7, doi:10.1029/2019jc015436

[10] Se-Yong Song, Sang-Wook Yeh & Jae-Hun Park 2020, 'Dissimilar characteristics associated with the 1976/1977 and 1998/1999 climate regime shifts in the North Pacific', *Theoretical and Applied Climatology*, vol. 142, no. 3-4, pp. 1463–1470, doi:10.1007/s00704-020-03378-y

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**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

## Part F - Participant Details including ROPE (Prof D. Watts)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Partner Investigator

Title

Prof

First Name

D.

Middle Name

Randolph

Family Name

Watts

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 30/05/1973 | Doctoral Degree | Ph.D. | Physics | Cornell University | United States of America |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

Uploaded PDF file follows on next page.

**F5 Research Load (non-ARC Grants and Research)**

| **Description** (All named investigators on any application or grant/fellowship in which a participant is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application /Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| DR Watts. Improved Ocean Forecasting by Assimilation of Deep Observations. Office of Naval Research, USA | Y | C | n/a | 81 | | | | | | |
| DR Watts. Understanding Gulf Ocean Systems (UGOS). National Academy of Science, USA. | Y | C | n/a | 553 | 553 | 553 | | | | |
| DR Watts. Vertical seafloor geodesy to accurately image slow slip events in a noisy ocean environment. National Science Foundation, USA. | Y | C | n/a | 289 | 289 | 289 | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DR Watts. Eddy fluxes across the southern ACC Front near Southeast Indian Ridge. National Science Foundation, USA. | Y | C | n/a | 282 | 282 | 282 | | | | |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

| |
|---|
| 0.1 |

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| University of Rhode Island, USA | | Employee | 1.0 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

| |
|---|
| University of Rhode Island, USA |

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

| |
|---|
| No |

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

| |
|---|
| No |

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant*

*guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*
Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

Justification of PI status

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

Yes

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

No PDF file uploaded.

**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Professor | Oceanography, University of Rhode Island | Permanent | Full Time | 01/09/1974 | | University of Rhode Island, USA |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*
Has the participant experienced a significant interruption that has impacted on research opportunity?

| |
|---|
| No |

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

Uploaded PDF file follows on next page.

**F17 Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

**AMOUNT OF TIME AS AN ACTIVE RESEARCHER**

I graduated from Cornell with a PhD in physics in 1973, 50 years ago.

**RESEARCH OPPORTUNITIES**

Research opportunities have extended continuously, starting with a Postdoc in physical oceanography at Yale (1973-74), and an Assistant Professorship at the University of Rhode Island (URI) in late 1974. I remain at URI today, and there have been no periods of unemployment or part-time employment. My research efforts at URI have intrinsically included the guidance of graduate students as they perform research on my projects funded by the US National Science Foundation and US Office of Naval Research.

The research component of my work has (prior to 2012) accounted for about 75% of my university employment (including the mentorship and funding of graduate students), with classroom teaching and committee assignments accounting for about 25%. In 2012, I stopped classroom teaching to focus upon research, which still includes advising graduate students. I also direct the activities of an engineering group that designs and fabricates oceanographic instrumentation for our own field programs and for those of colleagues at >18 institutions around the world. Hence for the past three years of 100% research effort, approximately 33% involves directing those development efforts.

I have not had any career interruptions.

I have received good advice and models over the years from colleagues, during which our "Dynamics group" has built up a world-class capability for design and fabrication, as well as the scientific application and utilization of deep-sea instrumentation, as represented on our website, https://web.uri.edu/gso/research/dynamics/.

**RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS**

Professor Watts is a physical oceanographer with an established reputation for observational studies and innovative data analyses. His specialty is in dynamical and descriptive physical oceanography, with emphasis on dynamics and energetics of large scale strong current systems.

Among the regions he has studied in recent years are the Gulf Stream, the North Atlantic Current, the Antarctic Circumpolar Current in Drake Passage and Subantarctic Front south of Australia, the current systems and subpolar front in the Japan Sea, the Kuroshio Extension, the eddies and deep current variability and Loop Current in the Gulf of Mexico, cross-frontal fluxes driven by eddies in the Southern ACC Front southwest of New Zealand, and bottom pressure variability along the continental slope off Oregon and New Zealand for geodetic/ earthquake studies.

Dr. Watts has been responsible for data synthesis and interpretation of large numbers of current meter and inverted echo sounder and bottom pressure recorder oceanographic time series records from several multi-year programs, funded by the United States National Science Foundation (NSF) and Office of Naval Research (ONR) and others. In particular, he was a lead-PI and organizer on the SYNOP program, and one of the lead-PIs on the Gulf Stream Dynamics Experiment, the SubAntarctic Fluxes and Dynamics Experiment (SAFDE), the Japan-East Sea (JES) experiment, the Kuroshio Extension System Study (KESS), cDRAKE in Drake Passage, and Understanding Gulf Ocean Systems (UGOS). He has consulted for SAIC/ Leidos on MMS/BOEM-funded field studies in the Gulf Stream and Gulf of Mexico.

HONORS, AWARDS, PROFESSIONAL SOCIETIES:
University of Tasmania Visiting Fellow, 2015
Fellow of the American Meteorological Society, 2014.
Froehlich Fellowship, CSIRO Hobart, Tasmania, Australia, during sabbatical Jul 2002-Dec 2002.
Geophysical Fluid Dynamics Summer Fellowship, 6-8/1970, Woods Hole
NSF Graduate Traineeship, 4 years: 9/1966-6/1970, Cornell University

Magna cum Laude graduation, University of California Regents, 1966
University of California Regents Scholar, 1963-1965
Member of: Phi Beta Kappa, Sigma Xi, American Geophysical Union, AAAS, The Oceanography Society

SYNERGISTIC ACTIVITIES:
Professor Watts directs the instrument group at the University of Rhode Island that developed and builds the current- and pressure recording inverted echo sounders (C_PIES), which are used by >20 US, European, Asian, South American, and South African oceanography research groups.

FUNDING:
During the past five years Professor Watts has been Principal Investigator or co-PI on scientific research grants for field programs summing to $7.6M from US Federal Agencies. In addition, the funding for C_PIES oceanographic instrumentation design and fabrication that he directed summed to $3.5M during the past five years from 12 international oceanographic institutions outside the US.

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

I have published more than 130 peer-reviewed scientific journal articles, including more than 16 first-author papers. My papers (h-index 44, i10 index 119) have been cited 6008 times (google scholar 3/3/2023), with 1387 citations since 2018. My papers have made a sequence of developments in methods to understand mesoscale processes and transports and their important effects in the ocean. These studies have applied innovative techniques to a variety of moored time-series data from current meters and CPIES, plus historical observational T,S profiles. Most of my papers are in journals ranked in the top 25% in relevant subject category, such as Journal of Physical Oceanography, Journal of Geophysical Research, Geophysical Research Letters, and Journal of Atmospheric and Oceanic Technology.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] * Stuart P. Bishop, D. Randolph Watts & Kathleen A. Donohue 2013, 'Divergent Eddy Heat Fluxes in the Kuroshio Extension at 144°–148°E. Part I: Mean Structure', *Journal of Physical Oceanography*, vol. 43, no. 8, pp. 1533–1550, doi:10.1175/jpo-d-12-0221.1 (Refereed Journal Article)

[2] * T. K. Chereskin, K. A. Donohue, D. R. Watts, K. L. Tracey, Y. L. Firing & A. L. Cutting 2009, 'Strong bottom currents and cyclogenesis in Drake Passage', *Geophysical Research Letters*, vol. 36, no. 23, doi:10.1029/2009gl040940 (Refereed Journal Article)

[3] * María Paz Chidichimo, Kathleen A. Donohue, D. Randolph Watts & Karen L. Tracey 2014, 'Baroclinic Transport Time Series of the Antarctic Circumpolar Current Measured in Drake Passage', *Journal of Physical Oceanography*, vol. 44, no. 7, pp. 1829–1853, doi:10.1175/jpo-d-13-071.1 (Refereed Journal Article)

[4] * K. A. Donohue, K. L. Tracey, D. R. Watts, M. P. Chidichimo & T. K. Chereskin 2016, 'Mean Antarctic Circumpolar Current transport measured in Drake Passage', *Geophysical Research Letters*, vol. 43, no. 22, pp. 11,760–11,767, doi:10.1002/2016gl070319 (Refereed Journal Article)

[5] * Annie Foppert, Kathleen A. Donohue, D. Randolph Watts & Karen L. Tracey 2017, 'Eddy heat flux across the A ntarctic C ircumpolar C urrent estimated from sea surface height standard deviation', *Journal of Geophysical Research: Oceans*, vol. 122, no. 8, pp. 6947–6964, doi:10.1002/2017jc012837 (Refereed Journal Article)

[6] * K. L. Tracey, D. R. Watts, C. S. Meinen & D. S. Luther 2006, 'Synoptic maps of temperature and velocity within the Subantarctic Front south of Australia', *Journal of Geophysical Research*, vol. 111, no. C10, doi:10.1029/2005jc002905 (Refereed Journal Article)

[7] * D. Randolph Watts, Che Sun & Steve Rintoul 2001, 'A Two-Dimensional Gravest Empirical Mode Determined from Hydrographic Observations in the Subantarctic Front', *Journal of Physical Oceanography*, vol. 31, no. 8, pp. 2186–2209, doi:10.1175/1520-0485(2001)031<2186:atdgem>2.0.co;2 (Refereed Journal Article)

[8] * D. Randolph Watts, Karen L. Tracey, Kathleen A. Donohue & Teresa K. Chereskin 2016, 'Estimates of Eddy Heat Flux Crossing the Antarctic Circumpolar Current from Observations in Drake Passage', *Journal of Physical Oceanography*, vol. 46, no. 7, pp. 2103–2122, doi:10.1175/jpo-d-16-0029.1 (Refereed Journal Article)

[9] * D. Randolph Watts, Karen L. Tracey, John M. Bane & Thomas J. Shay 1995, 'Gulf Stream path and thermocline structure near 74°W and 68°W', *Journal of Geophysical Research*, vol. 100, no. C9, pp. 18291, doi:10.1029/95jc01850 (Refereed Journal Article)

[10] * Meghan Cronin & D. Randolph Watts 1996, 'Eddy–Mean Flow Interaction in the Gulf Stream at 68°W. Part I: Eddy Energetics', *Journal of Physical Oceanography*, vol. 26, no. 10, pp. 2107–2131, doi:10.1175/1520-0485(1996)026<2107:efiitg>2.0.co;2 (Refereed Journal Article)

## Refereed Journal Articles

[1] * D. Randolph Watts, Meng Wei, Karen L. Tracey, Kathleen A. Donohue & Bing He 2021, 'Seafloor Geodetic Pressure Measurements to Detect Shallow Slow Slip Events: Methods to Remove Contributions From Ocean Water', *Journal of Geophysical Research: Solid Earth*, vol. 126, no. 4, doi:10.1029/2020jb020065

[2] * Watts, D. R., Wei, M., Tracey, K. L., Donohue, K. A., & He, B. (2021). Seafloor geodetic pressure measurements to detect shallow slow slip events: Methods to remove contributions from ocean water. Journal of Geophysical Research: Solid Earth, 126, e2020JB020065. https://doi.org/10.1029/2020JB020065

[3] * Bing He, Meng Wei, D. Randolph Watts & Yang Shen 2020, 'Detecting Slow Slip Events From Seafloor Pressure Data Using Machine Learning', *Geophysical Research Letters*, vol. 47, no. 11, doi:10.1029/2020gl087579

[4] * K.A. Donohue, D.R. Watts, P. Hamilton, R. Leben, M. Kennelly & A. Lugo-Fernández 2016, 'Gulf of Mexico Loop Current path variability', *Dynamics of Atmospheres and Oceans*, vol. 76, pp. 174–194, doi:10.1016/j.dynatmoce.2015.12.003

[5] * K.A. Donohue, D.R. Watts, P. Hamilton, R. Leben & M. Kennelly 2016, 'Loop Current Eddy formation and baroclinic instability', *Dynamics of Atmospheres and Oceans*, vol. 76, pp. 195–216, doi:10.1016/j.dynatmoce.2016.01.004

[6] * Y. L. Firing, T. K. Chereskin, D. R. Watts, K. L. Tracey & C. Provost 2014, 'Computation of Geostrophic Streamfunc-

tion, Its Derivatives, and Error Estimates from an Array of CPIES in Drake Passage', *Journal of Atmospheric and Oceanic Technology*, vol. 31, no. 3, pp. 656–680, doi:10.1175/jtech-d-13-00142.1

[7] * Kathleen A. Donohue, D. Randolph Watts, Karen L. Tracey, Andrew D. Greene & Maureen Kennelly 2010, 'Mapping Circulation in the Kuroshio Extension with an Array of Current and Pressure Recording Inverted Echo Sounders', *Journal of Atmospheric and Oceanic Technology*, vol. 27, no. 3, pp. 507–527, doi:10.1175/2009jtecho686.1

[8] * D. Randolph Watts, Mark Wimbush, Karen Tracey, William Teague, Jae-Hun Park, Douglas Mitchell, Jong-Hwan Yoon & Moon-Sik Suk et al. 2006, 'Currents, Eddies, and a "Fish Story" in the Southwestern Japan/East Sea', *Oceanography*, vol. 19, no. 3, pp. 64–75, doi:10.5670/oceanog.2006.44

**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

## Part F - Participant Details including ROPE (Dr James Girton)

### F1. Personal Details

*(To update any Personal Details, click on the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.*
*Note: The date of birth, country of birth, material personal interests and Indigenous status section will not appear in the PDF version of the form and will not be visible to assessors.*
*Data may be shared with other Commonwealth Entities.*
*All information contained in Part F is visible to the Administering Organisation on this application.)*

Participation Type

Partner Investigator

Title

Dr

First Name

James

Middle Name

Bannister

Family Name

Girton

### F4. Qualifications

*(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure to 'Refresh' the page to capture the changes made to the participant's profile.)*

| Conferral Date | AQF Level | Degree/Award Title | Discipline/Field | Awarding Organisation | Country of Award |
|---|---|---|---|---|---|
| 01/05/2001 | Doctoral Degree | Ph.D. | Oceanography | University of Washington | United States of America |
| 01/05/1993 | Bachelor Degree | B.A. | Physics, Honors | Swarthmore College | United States of America |

### F5. Research Load (non-ARC Grants and Research)

*(Provide details of research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2023 to 2029 inclusive.)*

Uploaded PDF file follows on next page.

**F5 Research Load (non-ARC Grants and Research)**

| **Description** (All named investigators on any application or grant/fellowship in which a participant is involved, project title, source of support, scheme and round) | **Same Research Area** (Yes/No) | **Support Status** (Requested/Current/Past) | **Application/Project ID** (for NHMRC applications only) | **2023** $'000 | **2024** $'000 | **2025** $'000 | **2026** $'000 | **2027** $'000 | **2028** $'000 | **2029** $'000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Girton, J; Lien, R-C; Szuts, Z; Essink, S. A Global Distributed Observing Program for Shear, Energy Flux, and Mixing by Internal Waves. National Science Foundation (NSF) – Physical Oceanography | Y | C | n/a | 2,084 | 2,084 | 2,084 | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Girton, J Mixing in the Indonesian Throughflow : Analysis of Lagrangian observations of shear, watermass modification, and internal wave climates. National Science Foundation (NSF) – Physical Oceanography | Y | C | n/a | 715 | 715 | 417 | | | | |
| Girton, J. Passive Acoustic Measurements Using EM-APEX Profiling Floats - implementation of machine learning algorithms for acoustic environmental characterization<br><br>Office of Naval Research (ONR) | Y | P | n/a | - | - | - | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Girton, J. NISKINE: Profiling Float Measurements of Near-Inertial Waves and Turbulence<br><br>Office of Naval Research (ONR) | Y | P | n/a | - | - | - | | | | |
| Girton, J. Collaborative Research: Exploring the Kermadec Trench--- Ventilation mechanisms and interaction with the South Pacific Deep Western Boundary Current<br><br>National Science Foundation (NSF) | Y | R | n/a | - | 202 | 202 | 202 | | | |

**F6. What will your time commitment be to research activities related to this project?**

*(Enter your time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)*

| |
|---|
| 0.1 |

**F7. Eligibility - Employment Details as at grant commencement date**

*(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at 1 January 2024. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)*

| Org name | Is this an Eligible Organisation? | Please choose your appointment type for this organisation. | Please enter your FTE for this Organisation |
|---|---|---|---|
| University of Washington, Seattle | | Employee | 1.0 |

**F8. Eligibility - Relevant Organisation for this application as at grant commencement date for this project**

*(Enter the Organisation that is relevant to your participation on this application, and that you will be associated with as at 1 January 2024. The 'relevant organisation' is the primary organisation that will be supporting your involvement in this project if it is funded. Note that the Organisation must be listed in F7 for this question to validate.)*

Relevant Organisation

| |
|---|
| University of Washington, Seattle |

**F9. Eligibility - Currently held ARC Projects**

*(This information is auto-populated. If you have any concerns with the information recorded here, please contact your Administering Organisation's Research Office.)*

**F10. Eligibility - Will the participant reside in Australia for more than 50 per cent of the project activity period?**

*(This is a 'Yes' or 'No' question. Indicate whether the participant will be residing in Australia for more than 50 per cent of the project activity period. If the participant is applying as a CI and the answer to this question is 'No' they will be prompted to contact their Research Office to check their eligibility.)*

| |
|---|
| No |

**F11. Eligibility - Will the participant undertake a Higher Degree by Research during the project activity period?**

*(This is a 'Yes' or 'No' question. If the participant is applying as a CI and their answer is 'Yes' to this question they will be prompted to contact their Research Office. Eligibility will be based solely on the information contained in this application.)*

| |
|---|
| No |

**F12. Eligibility - Project Relinquishment or Application Withdrawal**

*(ARC grant guidelines specify the limits on the number of applications and projects per named participant. This question will be activated where a participant will exceed ARC project limits at the grant opportunity closing date, if this application is successful. While the application can be submitted, project limits must be met under the grant*

*guidelines before the project can start. Project limits can be met by relinquishing existing active project(s), or relinquishing role(s) on existing active projects, or withdrawing application(s) that would exceed the project limits. This does not need to occur until all applications are announced.)*

**F13. Eligibility - Further Details Regarding Partner Investigator Status - Will the participant hold either a remunerated or honorary academic appointment at an Eligible Organisation as at the grant commencement date for this project?**

*(This is a 'Yes' or 'No' question.*
*At Question A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.*
*NOTE: this question is mandatory ONLY FOR PIs WHO:*
*• at Question F10 confirmed that they will reside predominantly (greater than 50 per cent of their time) in Australia for the project activity period of the proposed project; AND*
*• at Question F11 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after 1 January 2024; AND*
*• at Question F7 indicated that at the grant commencement date they would hold either:*
*- an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
*- an honorary academic appointment at an Eligible Organisation*
*If the participant selects 'Yes', they will be further prompted to justify their participation on this application as a PI with reference to the grant guidelines. As part of your justification indicate whether the role is remunerated.*
*)*
Do you hold either a remunerated or an honorary academic appointment at an Eligible Organisation?

Justification of PI status

**F14. Is the participant providing research input on this project?**

*(This is a Yes/No question for Partner Investigators (PI) only. If the PI answers 'Yes', the ROPE questions will be activated. You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section. If the participant answers 'No', they will be asked to upload a 2 page CV to support the PI's involvement in the proposed project. The 2 page CV must be relevant to the application and can include significant career interruptions. It is up to the participant to determine the appropriate information to include in the CV. Please read the Instructions to Applicants for further detail.)*

Are you providing research Input?

Yes

Research Career - Provide a 2 page CV to support the Partner Investigator's involvement in the proposed project. (Upload a PDF of up to 2 A4 pages)

No PDF file uploaded.

**F15. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years**

*(To update any details in this table, click on the 'Manage Employment Details' link in this question. Note this will open in a new browser tab. 'Refresh' the application page when returning to the form to capture changes made to the participant's profile.)*

| Description | Department | Contract Type | Employment Type | Start Date | End Date | Organisation |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Principal Oceanographer | Applied Physics Laboratory | Permanent | Full Time | 01/07/2004 | | University of Washington, Seattle |

**F16. Research Opportunity and Performance Evidence (ROPE) - Career Interruptions**

*(You must read the ROPE Statement http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement before filling out this section.)*
Has the participant experienced a significant interruption that has impacted on research opportunity?

| |
|---|
| No |

**F17. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

*(Provide details of the participant's circumstances and opportunities. This should not include information presented in the following questions (upload a PDF of up to 5 A4 pages).)*

Uploaded PDF file follows on next page.

**F17 Research Opportunity and Performance Evidence (ROPE) - Details of the participant's career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application**

**AMOUNT OF TIME AS AN ACTIVE RESEARCHER**

I graduated from the University of Washington with a PhD in Oceanography in 2001 and I have had no career interruptions.

**RESEARCH OPPORTUNITIES**

My position is a Principal Oceanographer in the Ocean Physics Department at the Applied Physics Laboratory of the University of Washington. This is a research intensive role. However, I am currently the Chair of the Department and this has an administrative load of approximately 50%. My research is funded through competitive grants, mainly from the US National Science Foundation and US Office of Naval Research.

**Current and Past Funded Research Projects (2004–present):**

- NOPP Global Internal Waves project: SQUID (Sampling QUantitative Internal-wave Distributions) lead, along with Ren-Chieh Lien, Sebastian Essink, and Zoli Szuts (NSF, 2023–).
- Velocity profiling float contribution to MINTIE Indonesian Throughflow experiment, in collaboration with Helen Philips, Univ Tasmania (NSF, 2022–).
- Task Force Ocean project to develop an EM-APEX ambient sound recording and processing system for environmental characterization (ONR/TFO, 2019–); with Barry Ma (APL-UW).
- Southern Ocean Wave Glider (NSF, 2016–): Study of waves, air–sea fluxes, and upper-ocean currents from a wave-powered surface vehicle, including 2 field seasons in Drake Passage and the West Antarctic Peninsula continental slope and shelf. With Jim Thomson (APL-UW).
- NISKINE DRI on near-inertial internal waves (ONR, 2018–): With Ren-Chieh Lien and Caitlin Whalen (APL-UW), and Eric Kunze (NWRA).
- Robotic network for exploration under ice shelves (Paul J. Allen Foundation, 2016–2020): Autonomous vehicle study of ocean-ice shelf interactions in Antarctica. With Pierre Dutrieux (LDEO), Craig Lee and Luc Rainville (APL-UW), and Knut Christianson (UW ESS).
- SMILE (a Submesoscale MIxed-Layer Eddies experiment; NSF, 2015–): Field study using drifting autonomous arrays and ship-towed profiler surveys to characterize the upper-ocean re-stratification following atmospheric mixing events. With Eric Kunze (NorthWest Research), John Mickett (APL-UW), and Tom Farrar (WHOI).
- West Antarctic CDW Pathways (NSF, 2014–2020): Profiling float studies of ocean–shelf transport and mixing process in the Amundsen Sea seasonal ice zone.
- NASA Science Teams: OSTST and SWOT SDT and ST (2013–2019). Internal tides from satellite altimetry, with applications to future swath altimetry data. With M. Alford and Z. Zhao (APL-UW).
- Samoan Passage (NSF, 2011–2021): Moorings, ship surveys, and modeling of the flow and mixing processes in the Samoan Passage. With Matthew Alford (APL-UW).
- DIMES (NSF, 2007–2016): Fine structure profiling float shear and strain measurements in a Southern Ocean tracer release experiment. With Jim Ledwell and DIMES investigators.
- Boundary Mixing (NSF, 2007–2010): High-resolution internal wave and nepheloid layer measurements in Monterey Canyon. With Erika McPhee-Shaw and Eric Kunze.
- Archipelago Straits DRI (ONR, 2005–2008): Internal tide and throughflow dynamics studied with profiling floats and moorings in straits within the Philippines. With Matthew Alford.
- Denmark Strait Overflow (NASA, 2005–2008): Investigations of surface eddies in satellite data as a proxy for variability in the underlying gravity current.
- AESOP DRI (ONR, 2005-2009): Observations of internal tides near Monterey Bay and comparison with high-resolution regional models. With Eric Kunze and AESOP investigators.
- EDDIES (NSF, 2005-2007): Finescale measurements from an array of EM-APEX floats for comparison with tracer release mixing estimates. With Jim Ledwell.

- EM-APEX/CBLAST DRI (ONR, 2005–2006): Technical and scientific evaluation of a new profiling float incorporating electromagnetic velocity sensors, including new observations of the upper-ocean's response to Hurricane Frances. Collaboration with Tom Sanford and Jim Price.

**Post-Doctoral Projects (2002–2004):**

- Studies of overflow dynamics including hydraulics, entrainment and friction in MITgcm simulations and field observations from the Denmark Strait, Faroe Bank Channel, and Luzon Strait.
- Hawaii Ocean Mixing Experiment (HOME) Nearfield phase, R/V Wecoma, investigating the generation and dissipation of internal tides at the Hawaiian Ridge.

## RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

### Honors and Affiliations

- NOAA Climate and Global Change Postdoctoral Fellowship, 2002–2004.
- AFFILIATIONS Office of Naval Research Graduate Fellowship, 1993–1996.
- Reviewer for Journal of Physical Oceanography, Journal of Geophysical Research—Oceans, Journal of
- Marine Research, Ocean Modelling, Tellus, Deep-Sea Research, Oceanography, Continental Shelf Research,
- Geophysical Research Letters, Ocean Science, and Journal of Marine Science and Engineering.
- Associate Editor for Journal of Atmospheric and Oceanic Technology.
- Proposal reviewer and panelist for National Science Foundation (Physical Oceanography and Antarctic
- Integrated System Science) and national research councils of Norway, Australia, Netherlands, and the UK.
- Member of AGU (1996–); TOS (1996–); AMS (2005–); Sigma Xi (1993–2011); IEEE OE (1993–1995).
- Elected member of the TOS Council (Applied Technology), 2017–2019.

### Field Programs

Lead or co-lead on more than 10 seagoing research experiments using ship surveys, moorings, autonomous vehicles, and motional electromagnetic velocity sensing.

Most recent among these was an autonomous mission with profiling EM-APEX floats and Seagliders in the ocean cavity under the Dotson ice shelf (2018) in the Amundsen Sea sector of Antarctica. This project collected an incredible set of new measurements of the inflow and outflow pathways, turbulent heat flow dynamics, and rates of oceanic melting in this region of accelerating West Antarctic Ice Sheet loss. The experiment demonstrated for the first time the feasibility of using both long-range acoustic navigation and intelligent drifting with currents to study this most inaccessible region of the ocean.

### Research supervision, mentoring and advice

Supervisor for 3 completed PhDs, 3 postdocs, and 8 undergraduate researchers, as well as graduate committee member for another 4 students. Most recent Ph.D. dissertation was by Brian Chinn (2015): "On the structure of the internal wave field: the impact of the distribution of shear and strain variance in wavenumber-frequency space on mixing estimates."

- Graduate advisor for James Stadler (2020–present), Brian Chinn (Ph.D., 2015), Byron Kilbourne (Ph.D., 2015), and Samantha Terker (ne´e Brody; Ph.D., 2012).
- Postdoctoral supervisor for Aur´elie Moulin (2020–present), Sina Khani (2019–21), and Gunnar Voet (2012–2014).
- On graduate student committees for Kelly Pearson (Ph.D., 2019, University of Hawaii), Alex Sinclair (UW Electrical Engineering, 2011–13), Katie Morrice (M.S., 2011, Moss Landing Marine Labs) and Zoli Szuts (Ph.D., 2008).
- Advisor for undergraduate research students Krysta Yousoufian (Space Grant, 2007 and 2008), Emily Lemagie (2008–09), Jacob Shoudy (SG, 2012), Jesse Ashworth-Marin (SG, 2014), Zach Larson (SG, 2016),

Benjamin Post (2016–17), Drew Vagan (2017–18), Bernardo Olivas (SG, 2018), and Chandana Mudeppa (2019–20).

- Teaching Assist. for Intro. Phys. Oceanogr. (MIT–WHOI Joint Program, Joyce and Ferrari, 2003; and UW, Hautala, 1996).
- Volunteer Instructor, Ocean Inquiry Project, 2001.
- Science Advisor for pre-service K–12 teacher course, UW Bothell, C. Kubota, 1998.

**Scientific Service**

Long-term member of relevant scientific societies (AGU, TOS, AMS) and contributor to science teams and advisory bodies. Recently the Applied Technology representative on the governing Council of The Oceanography Society (TOS), assisting in the development of updated policies on institutional membership, awards, and ethics.

**Peer Review**

Reviewer of physical oceanography papers for 11 scholarly journals and research proposal referee for national science agencies in 5 countries, including National Science Foundation review panels in Physical Oceanography and Antarctic Integrated System Science.

**Public Outreach**

Presenter on oceanography and careers to students at Seattle public schools and science outreach centers, as well as in cruise blogs and broadcasts—most recently in connection with the SMILE (Submesoscale MIxed-Layer Eddies) and Southern Ocean WaveGlider experiments, highlighting the fascinating and challenging range of scales and processes under study in physical oceanography, from microscale mixing through geophysical turbulent cascades to global climate model parameterizations.

**F18. Research Opportunity and Performance Evidence (ROPE) - Research Output Context**

*(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in their field; specific indicators of recognition within their field such as first authorship/citations, or the significance of non-traditional research outputs. If preprints or comparable resources are cited, these should be explicitly identified in the reference list by including [PREPRINT OR COMPARABLE] after the reference. The reference should include a DOI, URL or equivalent, version number where available and/or date of access, as applicable. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable (up to 3,750 characters, approximately 500 words).)*

I have published 52 peer-reviewed papers, including 6 first author papers and 11 papers first-authored by my direct-advised graduate students or post-docs. My papers (h-index: 26 and i10-index: 40) have been cited 2911 times (google scholar, 3/5/2023) with 1368 citations occurring after 2018. Twenty-five papers relied on the particular observational method of velocity profiling using electromagnetic motional induction---the approach used by the EM-APEX. Most of my papers are in journals ranked in the top 25% of their subject category, with 30 papers published in Geophysical Research Letters, the Journal of Geophysical Research-Oceans, and the Journal of Physical Oceanography.

**F19. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including 10 Career-Best Research Outputs**

*(Provide a list of research outputs marking those that are most relevant to this application categorised under the following headings: 10 career-best research outputs; Authored books; Edited books; Book chapters; Refereed Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs and preprints or comparable resources). CVs and theses should not be included in this list. The participant's 10 career-best research outputs should not be repeated under subsequent headings (up to 100 research outputs).)*

Research Outputs Listing

Generated research output document follows on the next page

## Ten Career-Best Research Outputs

[1] Girton, J.B. & Sanford, T.B. 2003, 'Descent and modification of the overflow plume in the Denmark Strait', *J. Phys. Oceanogr.*, vol. 33, no. 7, pp. 1351–1364 (Refereed Journal Article)

[2] * Ledwell, J. R., St. Laurent, L. C., Girton, J. B. & Toole, J. M. 2011, 'Diapycnal Mixing in the Antarctic Circumpolar Current', *J. Phys. Oceanogr.*, vol. 41, no. 1, pp. 241–246, doi:10.1175/2010JPO4557.1 (Refereed Journal Article)

[3] Klymak, Jody M, James N Moum, Jonathan D Nash, Eric Kunze & James B Girton et al. 2006, 'An estimate of tidal energy lost to turbulence at the Hawaiian Ridge', *J. Phys. Oceanogr.*, vol. 36, no. 6, pp. 1148–1164 (Refereed Journal Article)

[4] * Voet, G, J B Girton, M H Alford, G S Carter & J M Klymak et al. 2015, 'Pathways, Volume Transport and Mixing of Abyssal Water in the Samoan Passage', *J. Phys. Oceanogr.*, vol. 45, no. 2, pp. 562-588 (Refereed Journal Article)

[5] * Voet, G., Alford, M. H., Girton, J. B., Carter, G. S. & Mickett, J. B. et al. 2016, 'Warming and weakening of the abyssal flow through Samoan Passage', *J. Phys. Oceanogr.*, vol. 46, no. 8, pp. 2389–2401 (Refereed Journal Article)

[6] * Zhao, Zhongxiang, Alford, Matthew H, Girton, James B, Rainville, Luc & Simmons, Harper L 2016, 'Global observations of open-ocean mode-1 M 2 internal tides', *Journal of Physical Oceanography*, vol. 46, no. 6, pp. 1657–1684 (Refereed Journal Article)

[7] Girton, J. B., Pratt, L. J., Sutherland, D. A. & Price, J. F. 2006, 'Is the Faroe Bank Channel Overflow Hydraulically Controlled?', *J. Phys. Oceanogr.*, vol. 36, pp. 2340–2349 (Refereed Journal Article)

[8] Thomas, Leif N, Rainville, Luc, Asselin, Olivier, Young, William R & Girton, James et al. 2020, 'Direct observations of near-inertial wave $\zeta$-refraction in a dipole vortex', *Geophysical Research Letters*, vol. 47, no. 21, pp. e2020GL090375 (Refereed Journal Article)

[9] * Thomas B Sanford, James F. Price & James B Girton 2011, 'Upper-Ocean Response to Hurricane Frances (2004) Observed by Profiling EM-APEX Floats', *J. Phys. Oceanogr.*, vol. 41, no. 6, pp. 1041–1056 (Refereed Journal Article)

[10] * Girton, James B, Christianson, Knut, Dunlap, John, Dutrieux, Pierre & Gobat, Jason et al. 2019, 'Buoyancy-adjusting profiling floats for exploration of heat transport, melt rates, and mixing in the ocean cavities under floating ice shelves', *OCEANS 2019 MTS/IEEE SEATTLE*, pp. 1–6 (Fully Refereed Conference Proceeding)

## Book Chapters

[1] J. A. MacKinnon, Matthew H. Alford, P. Bouruet-Aubertot, N. Bindoff & S. Gille et al. 2011, 'Using global arrays to investigate internal-waves and mixing' in Hall, J., D.E. Harrison & D. Stammer (eds.), *Proceedings of the "OceanObs '09: Sustained Ocean Observations and Information for Society" Conference, Venice, Italy, 21-25 September 2009*, vol. 2, doi:10.5270/OceanObs09.cwp.58

## Refereed Journal Articles

[1] * Voet, Gunnar, Alford, Matthew H, Cusack, Jesse M, Pratt, Larry J & Girton, James B et al. 2023, 'Energy and Momentum of a Density-Driven Overflow in the Samoan Passage', *Journal of Physical Oceanography*

[2] Tan, S, Pratt, LJ, Voet, G, Cusack, JM & Helfrich, KR et al. 2022, 'Hydraulic control of flow in a multi-passage system connecting two basins', *Journal of Fluid Mechanics*, vol. 940, pp. A8

[3] Kunze, Eric, Mickett, John B & Girton, James B 2021, 'Destratification and restratification of the spring surface boundary layer in a subtropical front', *Journal of Physical Oceanography*, vol. 51, no. 9, pp. 2861–2882

[4] McPhee-Shaw, Erika E, Kunze, Eric & Girton, James B 2021, 'Submarine Canyon Oxygen Anomaly Caused by Mixing and Boundary-Interior Exchange', *Geophysical Research Letters*, vol. 48, no. 10, pp. e2021GL092995

[5] Alford, Matthew H, Simmons, Harper L, Marques, Olavo B & Girton, James B 2019, 'Internal tide attenuation in the North Pacific', *Geophysical Research Letters*, vol. 46, no. 14, pp. 8205–8213

[6] Carter, Glenn S, Voet, Gunnar, Alford, Matthew H, Girton, James B & Mickett, John B et al. 2019, 'A spatial geography of abyssal turbulent mixing in the samoan passage', *Oceanography*, vol. 32, no. 4, pp. 194–203

[7] Cusack, Jesse M, Voet, Gunnar, Alford, Matthew H, Girton, James B & Carter, Glenn S et al. 2019, 'Persistent turbulence in the Samoan Passage', *Journal of Physical Oceanography*, vol. 49, no. 12, pp. 3179–3197

[8] * Girton, James B, Mickett, John B, Zhao, ZhongXiang, Alford, Matthew H & Voet, Gunnar et al. 2019, 'Flow-topography interactions in the Samoan Passage', *Oceanography*, vol. 32, no. 4, pp. 184–193

[9] Pratt, Larry J, Voet, Gunnar, Pacini, Astrid, Tan, Shuwen & Alford, Matthew H et al. 2019, 'Pacific abyssal transport and mixing: Through the Samoan Passage versus around the Manihiki Plateau', *Journal of Physical Oceanography*, vol. 49, no. 6, pp. 1577–1592

[10] * Swart, Sebastiaan, Gille, Sarah T, Delille, Bruno, Josey, Simon & Mazloff, Matthew et al. 2019, 'Constraining Southern Ocean air-sea-ice fluxes through enhanced observations', *Frontiers in Marine Science*, vol. 6, pp. 421

[11] * Szuts, Zoltan B, Bower, Amy S, Donohue, Kathleen A, Girton, James B & Hummon, Julia M et al. 2019, 'The scientific and societal uses of global measurements of subsurface velocity', *Frontiers in Marine Science*, vol. 6, pp. 358

[12] Wagner, Gregory L, Flierl, Glenn, Ferrari, Raffaele, Voet, Gunnar & Carter, Glenn S et al. 2019, 'Squeeze dispersion and the effective diapycnal diffusivity of oceanic tracers', *Geophysical Research Letters*, vol. 46, no. 10, pp. 5378–5386

[13] Carranza, Magdalena M, Gille, Sarah T, Franks, Peter JS, Johnson, Kenneth S & Pinkel, Robert et al. 2018, 'When mixed layers are not mixed. Storm-driven mixing and bio-optical vertical gradients in mixed layers of the Southern Ocean', *Journal of Geophysical Research: Oceans*, vol. 123, no. 10, pp. 7264–7289

[14] Chao, Yi, Farrara, John D, Zhang, Hongchun, Armenta, Kevin J & Centurioni, Luca et al. 2018, 'Development, implementation, and validation of a California coastal ocean modeling, data assimilation, and forecasting system', *Deep Sea Research Part II: Topical Studies in Oceanography*, vol. 151, pp. 49–63

[15] Thomson, Jim, Girton, James B, Jha, Rajesh & Trapani, Andrew 2018, 'Measurements of Directional Wave Spectra and Wind Stress from a Wave Glider Autonomous Surface Vehicle', *J. Atmos. Ocean. Technol.*, vol. 35, no. 2, pp. 347–363

[16] Thorpe, S. A., Malarkey, J., Voet, G., Alford, M. H. & Girton, J. B. et al. 2018, 'Application of a model of internal hydraulic jumps', *J. Fluid Mech.*, vol. 834, pp. 125–148, doi:10.1017/jfm.2017.646

[17] * Troesch, Martina, Chien, Steve, Chao, Yi, Farrara, John & Girton, James et al. 2018, 'Autonomous control of marine floats in the presence of dynamic, uncertain ocean currents', *Robotics and Autonomous Systems*, vol. 108, pp. 100–114

[18] * Cusack, Jesse M., Naveira Garabato, Alberto C., Smeed, David A. & Girton, James B. 2017, 'Observation of a Large Lee Wave in the Drake Passage', *J. Phys. Oceanogr.*, vol. 47, no. 4, pp. 793–810, doi:10.1175/jpo-d-16-0153.1

[19] Mastropole, Dana, Pickart, Robert S, Valdimarsson, Héðinn, Våge, Kjetil & Jochumsen, Kerstin et al. 2017, 'On the hydrography of D enmark S trait', *Journal of Geophysical Research: Oceans*, vol. 122, no. 1, pp. 306–321

[20] Thomson, Jim & Girton, James 2017, 'Sustained measurements of Southern Ocean air-sea coupling from a Wave Glider autonomous surface vehicle', *Oceanography*, vol. 30, no. 2, pp. 104–109

[21] * Von Appen, Wilken-Jon, Mastropole, Dana, Pickart, Robert S, Valdimarsson, HéÐinn & Jónsson, Steingrímur et al. 2017, 'On the nature of the mesoscale variability in Denmark Strait', *Journal of Physical Oceanography*, vol. 47, no. 3, pp. 567–582

[22] * Chinn, Brian S, Girton, James B & Alford, Matthew H 2016, 'The Impact of Observed Variations in the Shear-to-Strain Ratio of Internal Waves on Inferred Turbulent Diffusivities', *Journal of Physical Oceanography*, vol. 46, no. 11, pp. 3299–3320

[23] Kilbourne, BF & Girton, JB 2015, 'Surface boundary layer evolution and near-inertial wind power input', *Journal of Geophysical Research: Oceans*, vol. 120, no. 11, pp. 7506–7520

[24] Byron F. Kilbourne & James B. Girton 2015, 'Quantifying High-Frequency Wind Energy Flux into Near-Inertial Motions in the Southeast Pacific', *J. Phys. Oceanogr.*, vol. 45, no. 2, pp. 369-386

[25] Terker, Samantha R, Girton, James B, Kunze, Eric, Klymak, Jody M & Pinkel, Robert 2014, 'Observations of the internal tide on the California continental margin near Monterey Bay', *Continental Shelf Research*, vol. 82, pp. 60–71

[26] Von Appen, Wilken-Jon, Koszalka, Inga M, Pickart, Robert S, Haine, Thomas WN & Mastropole, Dana et al. 2014, 'The East Greenland Spill Jet as an important component of the Atlantic meridional overturning circulation', *Deep Sea Research Part I: Oceanographic Research Papers*, vol. 92, pp. 75–84

[27] Alford, Matthew H, Girton, James B, Voet, Gunnar, Carter, Glenn S & Mickett, John B et al. 2013, 'Turbulent mixing and hydraulic control of abyssal water in the Samoan Passage', *Geophysical Research Letters*, vol. 40, no. 17, pp. 4668–4674

[28] Joyce, Terrence M, Thomas, Leif N, Dewar, William K & Girton, James B 2013, 'Eighteen degree water formation within the Gulf Stream during CLIMODE', *Deep Sea Research Part II: Topical Studies in Oceanography*, vol. 91, pp. 1–10

[29] * Terker, SR, Sanford, TB, Dunlap, JH & Girton, JB 2013, 'The EM-POGO: A simple, absolute velocity profiler', *Deep Sea Research Part II: Topical Studies in Oceanography*, vol. 85, pp. 220–227

[30] Chinn, Brian, Matthew H Alford & James B Girton 2012, 'Observations of internal waves and parametric subharmonic instability in the Philippines archipelago', *J. Geophys. Res.*, vol. 117, no. C05019, pp. 1-12, doi:doi:10.1029/2011JC007392

[31] * E. Kunze, C. MacKay, E. E. McPhee-Shaw, K. Morrice & J. B. Girton et al. 2012, 'Turbulent Mixing and Exchange With Interior Waters on Sloping Boundaries', *J. Phys. Oceanogr.*, vol. 42, pp. 910–927

[32] * Zhongxiang Zhao, Matthew H Alford & James B Girton 2012, 'Mapping Low-Mode Internal Tides from Multisatellite Altimetry', *Oceanography*, vol. 25, no. 2, pp. 42–51

[33] Arango, Hernan G, Levin, Julia C, Curchitser, Enrique N, Zhang, Bin & Moore, Andrew M et al. 2011, 'Development of a hindcast/forecast model for the Philippine Archipelago', *Oceanography*, vol. 24, no. 1, pp. 58–69

[34] Girton, James B, Chinn, Brian S & Alford, Matthew H 2011, 'Internal wave climates of the Philippine seas', *Oceanography*, vol. 24, no. 1, pp. 100–111

[35] James B Girton, Brian Chinn & Matthew H Alford 2011, 'Internal Wave Climates of the Philippine Seas', *Oceanography*, vol. 24, no. 1, pp. 100-111

[36] * Zhongxiang Zhao, Matthew H Alford, James Girton, Shaun T M Johnston & Glenn S Carter 2011, 'Internal Tides around the Hawaiian Ridge estimated from Multi-Satellite Altimetry', *J. Geophys. Res.*, vol. 116, no. C12039, pp. 1-15, doi:doi:10.1029/2011JC007045

[37] * Sanford, Thomas B, Price, James F, Girton, James B & Webb, Douglas C 2007, 'Highly resolved observations and simulations of the ocean response to a hurricane', *Geophysical Research Letters*, vol. 34, no. 13

[38] * Sonya Legg, Robert W. Hallberg & James B. Girton 2006, 'Comparison of entrainment in overflows simulated by z-coordinate, isopycnal and non-hydrostatic models', *Ocean Modelling*, vol. 11, pp. 69–97

[39] * Qu, T., Girton, J B & Whitehead, J A 2006, 'Deepwater overflow through Luzon Strait', *J. Geophys. Res.*, vol. 111, no. C01002, pp. doi:10.1029/2005JC003139

[40] * Rolf H Käse, J B Girton & T B Sanford 2003, 'Structure and variability of the Denmark Strait Overflow: Model and observations', *J. Geophys. Res.*, vol. 108, no. C6, pp. doi:10.1029/2002JC001548

[41] * James B Girton, Thomas B Sanford & Rolf H Käse 2001, 'Synoptic sections of the Denmark Strait overflow', *Geophys. Res. Lett.*, vol. 28, no. 8, pp. 1619–1622

## Fully Refereed Conference Proceedings

[1] * Sanford, T.B., Dunlap, J.H., Carlson, J.a., Webb, D.C. & Girton, J.B. 2005, 'Autonomous velocity and density profiler: EM-APEX', *Proceedings of the IEEE/OES Eighth Working Conference on Current Measurement Technology, 2005.*, pp. 152–156, doi:10.1109/CCM.2005.1506361

## Additional Research Outputs

[1] Girton, J. B. 2001, 'Dynamics of Transport and Variability in the Denmark Strait Overflow'

**F20. Is the participant applying for Teaching Relief?**

*(This is a 'Yes' or 'No' question.*
*(This question must be answered if the participant is a Chief Investigator)*
*• If you select 'Yes' you will be prompted to request the percentage of Teaching Relief for each requested year (25, 50, 75 or 100 per cent).*
*• The percentage of Teaching Relief will be automatically calculated and the request will be generated in Question E1.*
*• Note: CIs may request funding for teaching relief in order to maximise the opportunity for the CI to conduct research. This question is only relevant for CIs and will not be activated for PIs.)*

# Certification

**Certification by the Deputy/Pro Vice-Chancellor (Research) or their delegate or equivalent in the Administering Organisation**

I certify that—

- I have read, understood and complied with the *Grant Guidelines for the Discovery Program (2021 edition)*, (grant guidelines) and, to the best of my knowledge all details provided in this application form and in any supporting documentation are true and complete in accordance with the grant guidelines.
- Proper enquiries have been made and I am satisfied that the participants and the organisations listed in this application meet the requirements specified in the grant guidelines.
- In certifying the National Interest Test statement, I have considered the requirements detailed in the Instructions to Applicants, including whether the National Interest Test statement is written in plain English and for the audience – the general public.
- The ARC reserves the right to audit any evidence on which an application is based.
- I will notify the ARC if there are changes to any named participant or organisation after the submission of this application.
- The listed participants are responsible for the authorship and intellectual content of this application, and has appropriately cited sources and acknowledged significant contributions to this application.
- To the best of my knowledge, all personal material interests and Conflicts of Interest relating to parties involved in or associated with this application have been disclosed to the Administering Organisation, and, if the application is successful, I agree to manage all Conflicts of Interest relating to this application in accordance with the Australian Code for the Responsible Conduct of Research (2018), the ARC Conflict of Interest and Confidentiality Policy located on the ARC website and any relevant successor documents.
- I have obtained the agreement, attested to by written evidence, of all the relevant persons and organisations necessary to allow the project to proceed. This written evidence has been retained and will be provided to the ARC if requested.
- I have obtained the certification of all organisations contributing to the project (CEO or their delegate) that they support the project, will contribute to the resources outlined in the application, have complied with the grant guidelines and will abide by the relevant Commonwealth grant agreement, including the requirement to enter arrangements for intellectual property.
- The application, including all parties involved in or associated with this application, has undergone due diligence to assess risks from foreign interference in line with the *Guidelines to Counter Foreign Interference in the Australian University Sector (2019)* developed by the University Foreign Interference Taskforce.
- This application complies with the eligible research requirements set out in the ARC Medical Research Policy, located on the ARC website.
- This application does not request funding for the same research activities, infrastructure or project previously funded or currently being funded through any other Commonwealth funding.
- If this application is successful, I am prepared to have the project carried out as set out in this application and agree to abide by the terms and conditions of the grant guidelines and the relevant Commonwealth grant agreement.
- If this application is successful, I confirm that I have appropriate administrative controls in place to manage all governance risks should a participant with an honorary academic appointment for eligibility purposes act as the Project Leader for the duration of the project.
- The project can be accommodated within the general facilities of this organisation and if applicable, within the facilities of other relevant organisations specified in this application and sufficient working and office space is available for any proposed additional staff.
- All funds for this project will only be spent for the purpose for which they are provided.
- The project will not be permitted to commence until there is an ethics plan in place to ensure that the appropriate clearances or other statutory requirements will be met before the part/s of the project that require those clearances

commence.

- I consent, on behalf of all the parties, to this application being referred to third parties, including to overseas parties, who will remain anonymous, for assessment purposes.
- I consent, on behalf of all the parties, to this application being provided to third parties for the purposes of assessment for potential other funding opportunities.
- I consent, on behalf of all the parties, to the ARC copying, modifying and otherwise dealing with information contained in this application for the purpose of conducting the funding round.
- To the best of my knowledge, the Privacy Notice appearing at the top of this form has been drawn to the attention of all the participants whose personal details have been provided in the Participant section of the application.