Call	**Earth Systems Science Research Programme (ESSRP)**
Application reference	**ESS210421596426**
Applicant name	Robyn Verrinder

Applicant's Institution	University of Cape Town
Short Title of Project	A network of autonomous sea ice observation platforms in support of Southern Hemisphere climate predictions
Project Abstract	A variety of synoptic, seasonal and interannual drivers influence the forms, types and concentration of sea ice in the Marginal Ice Zone (MIZ) in the Southern Ocean (SO). The temporal and spatial distribution of the ice and its physical, mechanical and biological properties are directly related to the natural variability of the oceans and atmosphere, but also anthropogenic climate changes. Climate and Earth System Models have limited sea ice variable parameterisations due to the scarcity of spatially distributed high resolution measurements from the region, specifically during winter/spring. To better understand atmosphere-ice-ocean MIZ processes and to improve future prediction of seasonal sea ice coverage and extent, three main approaches are available: (1) in situ measurements, (2) area-wide satellite data, and (3) numerical and experimental modelling. The meaningful connection of these is essential for enhancing understanding of this region. Improved design of cost-effective autonomous devices capable of persistent in situ sampling at finer spatial resolutions over the winter/spring seasons in the Antarctic MIZ, is key to obtaining the datasets needed to improve ESMs and to validate remote-sensing products. This requires a multidisciplinary approach including engineering, oceanography and climate science. This proposal aims to: (a) improve in situ measurement capability in the SO MIZ through the development of cost-effective networked autonomous buoys; (b) examine the processes that govern the seasonal sea ice life cycle in SO MIZ through a Targeted Observational Experiment to inform Southern Hemisphere climate predictability; and (c) produce data to process-based models and climate predictions of the Southern African climate.

Alignment to National Imperatives

Please outline how this will contribute/is aligned to one or more national priorities/strategies/imperatives.

Classification in line with NRF Broad Categories

NRF broad category options
- Biological, Chemical, Earth & Marine
- Environmental, Material, Physical and Technology
- Arts, Humanities and Social Sciences
- Engineering
- Economics
- Medical and Health Disciplines
- Agriculture
- Computer and Information Sciences
- Mathematical Sciences
- Law

250 characters (including spaces)

NRF Broad Category	Justification for Selection
Biological, Chemical, Earth & Marine	This project contributes to the goal of the DSI/NRF for South Africa to become a knowledge-led economy by promoting cutting-edge scientific research in the Southern Ocean and Antarctic region as well as the training of a skilled workforce.

NRF Broad Category	Justification for Selection
Engineering	This project takes an engineering approach to addressing climate observation and modelling-related questions linked to processes and phenomena in the Antarctic Marginal Ice Zone, improving South African engineering innovation potential.

Alignment to National Priorities

National priorities options
- Poverty Alleviation
- Job Creation
- Transformation

250 characters (including spaces)

National Priorities	Justification for Selection
Job Creation	Despite South Africa's geographical strategic advance, we have limited local engineering expertise in this area. In this project we will strengthen the marine engineering capability of the country and contribute to the DSI's strategic goals.

National Priorities	Justification for Selection

Transformation	Through this project we aim to develop a highly skilled transformed cohort of South African researchers in engineering and science through strong mentorship by world experts in the fields of Southern Ocean and Antarctic research.

Alignment to National Strategy

National strategy options

- Grand Challenge – Bio Economy
- Grand Challenge – Energy Security
- Grand Challenge – Global Change
- Grand Challenge – Human and Social Dynamics
- Grand Challenge – Astronomy
- Geographic Advantage – Human Palaeontology
- Geographic Advantage – Indigenous Knowledge Systems
- Geographic Advantage – Marine and Antarctic Research
- Geographic Advantage – Biodiversity

250 characters (including spaces)

National Strategies	Justification for Selection
Geographic Advantage - Marine and Antarctic Research	The majority of observation of the Antarctic MIZ is conducted by the Global North, South Africa needs to improve its expertise in this region to exploit its geographical advantage to become a World leading Polar scientific and engineering authority.

National Strategies	Justification for Selection
Grand Challenge - Global Change	This research will improve understanding of drivers of SO states and dynamics through direct and remote monitoring of sea ice. In performing and integrating measures at various scales we seek to improve Southern African climate model predictions.

Sustainability Development Goals	Justification for Selection
Climate Action	By bringing together science and engineering, this project contributes to the Climate Action SDG, by developing tools to inform climate predictions in support of climate policies.

National Infrastructure Platforms

- This is for indicating planned equipment and/or data to be accessed outside your own institution.
- The information provided in this section is for information purposes for the NRF and will not have any impact on future decisions around grants or grantholders.

Select National Infrastructure Platform options
- Council for Geoscience
- CSIR - Biosciences
- **CSIR - Built Environment**
- CSIR - Centre for Mining Innovation
- CSIR - Materials Science and Manufacturing
- CSIR - Meraka Institute
- **CSIR - Natural Resources and the Environment**
- CSIR - National Laser Centre
- High-resolution transmission electron microscopy (HRTEM)
- Human Science Research Council (HSRC)
- South African Astronomical Observatory (SAAO)
- **South African Environmental Observation Network (SAEON)**
- South African Institute for Aquatic Biodiversity (SAIAB)
- **South African National Space Agency (SANSA)**
- South African Radio Astronomy Observatory (SARAO)

Types of Platform options:
- Data
- Data and equipment
- Equipment

National Infrastructure Platform	CSIR - Built Environment
Types of Platform	Equipment
Planned Usage	CSIR Coastal and Hydraulic Laboratory (Eugene Mabille, emabille@csir.co.za) This facility houses three large wave basins, which can produce user defined directional wave patterns, as well as two wave flumes. This facility will be used to verify single node and cluster based wave-in-ice measurement and algorithms.

National Infrastructure Platform	CSIR - Natural Resources and the Environment
Types of Platform	Data and equipment
Planned Usage	Southern Ocean Carbon & Climate Observatory (Sandy Thomalla) Knowledge and expertise regarding Southern Ocean glider deployments, data collection, processing and interpretation. Sensor development and validation. Simultaneous deployment of SOCCO glider at the same location and timeframe as the TOE to ground truth the devices developed in this project and expand the scientific scope of the programme (e.g. twinned deployments each resolving different spatial scales allows research questions to be addressed at both meso and submeso spatial scales)

National Infrastructure Platform	SAEON
Types of Platform	Data
Planned Usage	SAPRI Data Centre (hosted by the SAEON Data Centre) SAEON Data Centre will be expanded to host SAPRI data and hence will host the designated National Antarctic Data Centre (NADC) for South Africa. All verified datasets produced through this project will be uploaded to the SAPRI Data Centre.

Science Engagement

- For the purposes of this application/report, the use of the overarching term science engagement is inclusive of all aspects of public engagement with science, science communication, science literacy as well as science outreach and awareness. It includes all participation by various groups of society in a programme aimed at generating mutual (two way) understanding and responses to science, including but not limited to awareness, accumulation of knowledge, enjoyment, opinion formulation and scientific literacy.
- The approach acknowledges the importance of citizens in the research and innovation process.
- It also embraces a broad understanding of **science** and **the sciences**, encompassing systematic knowledge spanning natural and physical sciences, engineering sciences, medical sciences, agricultural sciences, mathematics, social sciences and humanities, technology, all aspects of the innovation chain and indigenous knowledge.
- Broader impact encourages engagement beyond the boundaries of academia and considers the impact of the activities/project on the various public(s) and/or the various participants in terms of knowledge and/or awareness, behavioural and/or attitudinal change, skills acquisition etc.
- For more information, click here. The attached Strategy is for the South African Context and may be used by applicants as input to their science engagement strategy. International applicants could utilise this or draw from their own national strategy if it already exists.

Category options:

- Community engagement projects (collaborative work/partnerships with communities or community groups to address jointly identified issues)
- Education and/or training interventions (including both formal and informal education-based initiatives, new curriculum content, product development, etc.)
- Policy and proactive actions (initiatives and interventions aimed at shaping various policy agendas and policy instruments)
- Science awareness (including awareness campaigns, interactive events, profile raising, etc)
- Science communication (public engagement including use of or partnerships with media, debating platforms, art, theatre, science journalists, exhibitions, etc)

Why: 750 characters (including spaces);
Engagement: 1500 characters (including spaces);
Assess impact: 1500 characters (including spaces)

Audience options:

- Civic society organisations
- Educators (school)
- Indeterminate/broader public
- Indigenous knowledge holders
- Industry professionals
- Journalists/media professionals
- Learners (school)
- Ocean and Coastal Heritage and Cultures (NMU)
- Policy makers
- Scientists and researchers
- Students (post school)
- Tourists

Category	Education and/or training interventions (including both formal and informal education-based initiatives, new curriculum content, product development, etc.)
Why is the engagement being undertaken, and what is the desired outcome of the engagement activity/project?	In this project we will raise awareness of the exciting research opportunities in Engineering and Technology for Earth Systems Science early on in the Engineering undergraduate programme by hosting a roadshow where current postgraduate students and academics in the group will be given the opportunity to present their research work to the undergraduate student cohorts at the participating universities to highlight the exciting and world leading research contributions of South Africa in the field of Earth Systems Science.

Who are the people/audiences with whom you want to engage?	Students
How do you intend to engage the various audiences you have identified?	**Engineering and Technology in Earth Systems Science Roadshow** A roadshow will be held at each of the participating academic institutions where current postgraduate students and academics in the research group will be given the opportunity to present their research work to undergraduate engineering and science students to highlight the exciting South African contributions to the Earth Systems Science field.
How do you plan to assess the broader impact(s) of science engagement initiatives?	This initiative will be used to raise the profile of ESS amongst undergraduate students to allow them to make informed decisions about their future careers. We will assess the impact of this initiative by evaluating the number of undergraduate students that chose to further their studies in our group based on their exposure to the field in the roadshow.

Category	Science communication (public engagement including use of or partnerships with media, debating platforms, art, theatre, science journalists, exhibitions, etc)
Why is the engagement being undertaken, and what is the desired outcome of the engagement activity/project?	To engage with the broader public and create attention around South African scientific endeavours in the Southern Ocean and Antarctic regions and to raise awareness of the Global Change grand challenge and the UN SDG Climate Action and Life Below Water.

Who are the people/audiences with whom you want to engage?	Indeterminate/broader public
How do you intend to engage the various audiences you have identified?	**Photography exhibition of images from the Targeted Observational Experiment** Selected photos and images taken during the Targeted Observational Experiment will be printed on A1 metal sheets and will be displayed in a photography exhibition which could be hosted by public institutions such as the Iziko museum, Cape Town Science Centre or the Two Oceans Aquarium. **Popular science and news articles on the Targeted Observational Experiment** Details of the targeted observational experiment (pre- and post cruise) will

	be written up and submitted to popular science news platforms such as the Conversation Africa as well as published through the UCT News and MARIS websites.
How do you plan to assess the broader impact(s) of science engagement initiatives?	These forms of scientific communication will be posted and displayed widely allowing many members of the broader public to view and engage with the materials.

Details of Research: Data Management and Utilisation

Provide a summary of what processes and systems will be used to compile and manage data for the project. This could include a list of data fields that will be included in the data set, the software that will be used, how data will be captured, who will be responsible for the data capture and management, and whether any data quality checking and upgrading will be carried out. If there are other plans for long term data management and dissemination, briefly discuss these.

4000 characters (including spaces)

One of the key objectives of this project is to improve measurement capability and observation of the Antarctic Marginal Ice Zone through autonomous buoy design and multi-platform deployment in the Targeted Observational Experiment. Given the general scarcity of data from this region, organisation and dissemination these data to the wider scientific community is critical. The collection and organisation of data will be done in accordance with the data management guidelines and policy, recently developed for the South African Polar Infrastructure (SAPRI) and will be made available through the SAPRI Data Centre (hosted by SAEON). In addition, all verified data (level 3) that has been included in publications will also be made available through UCT's institutional data repository ZivaHub, which runs on Figshare for Institutions SaaS (Software as a Service). These repositories enable the data to be curated, stored and disseminated. It allows for the data to be coded with identifiers (DOI) and linked directly to publications. These also allow data to be annotated with metadata enabling selective searches to be performed. In addition, ZivaHub allows for private data sharing amongst collaborators.

Genetic sequencing data (phytoplankton study) will be deposited in the NCBI Short Read Archive (https://www.ncbi.nlm.nih.gov/sra). Any patent(s) developed during the project will be registered according to the directives indicated in the NRF contract.

As this study involves a number of participants from different disciplines, data formats and standards need to be considered. All designed instruments will output raw data formats (Level 0), which will conform to standard best practice. All code and software developed in this project will adhere to coding best practices and developers will use git for collaborative version control. All code associated with published work will be made available.

The data generated by this project consist of:
1. Time-series in situ data: These data will consist of timestamped ice floe positional data (GNSS longitude, latitude, precision of dilation), environmental parameters (wind velocity, ambient temperature, humidity, and atmospheric pressure), wave motion data (ice-floe inertial response to wave excitation including acceleration and angular velocity data), solar radiation data (intensity and power), conductivity (salinity) and atmosphere-ice-ocean temperature measurements. These data will be available at three different levels of processing: From (L0) the raw data obtained directly from the low level sensors on the ice-tethered instrument (stored locally on private ZivaHub repository made available to collaborators), to (L3) the final, quality controlled and post-processed time series of the physical variables of interested used in the modelling analyses, which will be uploaded to the SAPRI Data Centre and ZivaHub.

2. Ancillary sea ice data obtained during the targeted observational experiment: These data consist of (i) ship-based measurements including meteorological data, radar data, stereo camera data, inertial ship measurements; (ii) human and automatic observations of sea ice concentration, floe size, thickness according to the ASPeCt protocol. (iii) pancake ice floe measurements (weight, 3D surface characterisation); (iv) flow cytometry data. The majority of these data are usually obtained at L3 through commercial sensors, while for image processing the full L0-L3 protocol is required. All raw data will be stored locally on a private ZivaHub repository made available to collaborators, the final, quality controlled and post-processed time series of the physical variables will be uploaded to the SAPRI Data Centre and ZivaHub.

3. Specialised digital model outputs at variable temporal and spatial resolution, will be uploaded to the SAPRI Data Centre and ZivaHub.