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DML-RINGS and Enderby Land RINGS – opening extensive international collaboration to close critical data gaps for sea-level projections

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Summary

Many coastal regions in Antarctica remain inadequately surveyed or totally un-surveyed, which really hampers the development of our knowledge on how the Antarctic Ice Sheet and Southern Ocean will behave in the warming world in the coming centuries. Within SCAR, RINGS is an effort aiming to develop a coordinated framework that will facilitate and enable complementary and comprehensive airborne surveys in the coastal zone of the Antarctic Ice Sheet. On this basis an initiative has been taken to develop some early efforts in Dronning Maud Land (DML) and Enderby Land, through broad collaboration and contributions by national programs active in these regions and beyond. It is suggested that Parties lend their support to the pan-Antarctic RINGS initiative and encourage coordinated regional efforts to close data gaps, using the DML and Enderby Land effort as useful example and test case for the broader Antarctic needs.

Why there is a need/desire to know the bed topography in the coastal region

The Antarctic Ice Sheet is the largest freshwater mass on Earth, holding a volume of water equivalent to 58 meters of global sea-level rise. Accurate projections of the future evolution of the ice sheet are essential for mitigating potential risks to people and infrastructure along coastlines and on low-lying islands worldwide.

The sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC AR6) shows that the Antarctic contribution to the predicted sea-level rise is comparable to contributions from thermal expansion, the Greenland Ice Sheet, and glaciers. Nevertheless, 51–52% of the total uncertainty in sea-level rise predictions comes from the Antarctic Ice Sheet, which is far more than that from the other sources. Moreover, the uncertainty estimates only consider physical processes with medium or higher confidence. The Antarctic Ice Sheet may introduce even larger levels of uncertainty to future sea levels when processes that are less well understood are considered because these processes could lead to large, rapid, and possibly irreversible changes.

ACCE notes that Antarctic contributions to the global mean sea level over coming centuries will be net positive. ACCE underscores the importance of reducing uncertainties in the Antarctic contribution to future sea level rise and refining estimates of the rate and magnitude of that contribution. It notes as one of its key research recommendations that we should “Urgently reduce uncertainty about the current and future behaviour of the Antarctic Ice Sheet. The current observation network, especially for the hydrology and conditions at the base of the ice sheet, and the temperature and bathymetry of ice shelf cavities, coastal regions and the continental shelf, is inadequate to fully anticipate change and to understand the risks of ice shelf collapse, loss of buttressing and rapid ice sheet mass loss in the coming decades. An international effort is urgently required to address this”.

For climate predictions in the coming centuries, it is key to understand the interactions between the Antarctic Ice Sheet and Southern Ocean, and their linkages to the global climate system. Numerical models and satellite remote sensing have developed tremendously improved capacity in the past decade. However, our knowledge is still inadequate to constrain numerical models and to take the full benefits of observational capabilities of the satellites. For example, IPCC’s

Special Report on Ocean and Cryosphere pointed out that inadequate knowledge of bed topography in the coastal regions is one of root causes of large uncertainty to predict the future of the Antarctic Ice Sheet. The bed topography cannot be measured from satellites, requiring large-scale airborne geophysical surveys. In particular, many coastal regions remain surveyed inadequately or totally un-surveyed, which really hampers the development of our knowledge on how the Antarctic Ice Sheet and Southern Ocean will behave in the warming world in the coming centuries in the context of Sustainable Development Goals #13 “Climate Action”.

SCAR RINGS – facilitating pan-Antarctic action in the coastal regions

About two thirds of the Antarctic Ice Sheet coast has floating ice shelves. The transition from the grounded ice sheet to the floating ice shelf, called grounding line, has a complicated shape. Together with the coastline where ice shelves are not present, the total length of the ice-sheet margin all around Antarctica is nearly 1.5 times of Earth’s circumference. Filling the data gap all around the 62,000-kilometer-long margin of the Antarctic Ice Sheet is a big challenge. Driven by the need for an internationally collaborative approach for studying the ice-sheet margins, the Scientific Committee on Antarctic Research (SCAR) established the RINGS Action Group, in 2021. The immediate goal of this initiative is to develop a coordinated framework that will facilitate and enable complementary and comprehensive survey and mapping initiatives around the continent. The primary focus of this effort is surveying the bed topography within 50 km from the grounding line to landward, and under the ice shelves. This is critical knowledge to predict the future of the ice sheet and to measure ice-flow discharge from the ice sheet to the ocean, which defines the Antarctic contribution to the global sea level rise when it combined with snowfall over the entire ice sheet.

The RINGS Action Group organized the first International Workshop in Norway last summer and identified high science priorities in the coastal regions that can be largely addressed by airborne geophysical surveys. In addition to radar, gravimeter and magnetometer surveys for glaciology and geophysics, the community prioritizes measurements of past snow accumulation for improving climate models. It also seeks deployment of remote sensors for collecting ocean properties in regions where research vessels do not regularly visit, which remain as a large data gap. These measurements are a critical step for better predictions of the future of the Antarctic Ice Sheet and Southern Ocean.

No nation can carry out complete survey missions all around Antarctica alone. The geographical distribution of bed topography data shows that the data gaps become more significant farther from established logistics hubs. This clearly indicates that logistics feasibility is a main limitation of survey extent in the coastal regions and international coordination is needed. RINGS is working closely with COMNAP’s Science Facilitation Working Group to develop efficient and iterative collaboration between logisticians and scientists to reach beyond the historical capabilities of individual National Antarctic Programs.

DML and Enderby Land RINGS –regional initiatives paving the way

While SCAR RINGS Action Group is developing the guidelines for regional RINGS surveys, an initiative has been taken to develop some early efforts in Droning Maud Land (DML) and Enderby Land. DML have many active countries which provides a foundation for collaboration in implementing a survey to fill the data gaps in this region. Existing data are adequate enough to guide further surveys. Enderby Land is completely different from DML; it has the largest data gaps in terms of bed topography data near the grounding line, it is out of normal logistics coverage of any National Antarctic Programs, and it requires new efforts between nations that do not work regularly in this field. Therefore, DML and Enderby Land RINGS surveys are close to end-members of possible future regional RINGS surveys. These projects can also serve as

useful examples and test-cases for the wider Antarctic needs. It is a necessary step to best implement RINGS overall guidelines into active missions.

Norwegian Polar Institute and Alfred Wegener Institute are co-leading a regional RINGS mission in DML and will carry through an airborne survey in the region in the 2023/24 season. Reflecting the spirit of Antarctic Treaty System and SCAR, NPI and AWI has sought to involve the other nations active in DML to contribute to this mission. Belgium, Finland, India, Japan, South Africa and Sweden have already committed to contribute or are in the process of considering in which manner they can contribute. When Japan indicated their interest in RINGS, it provided a new opportunity to plan the next regional RINGS surveys in Enderby Land, and Australia, China and USA have joined this initiative. While DML RINGS and Enderby Land RINGS were established separately at the beginning, they are now integrated together to avoid data gaps between and to use logistics resources in the most efficient way.

Discussions pertaining to the practical aspects of the mission have been initiated, and both DML and Enderby Land RINGS are likely to be carried out in January 2024. The AWI (Germany) airplane will cover primarily cover the DML region, whereas AAD (Australia) and PRIC (China) airplanes will cover the Enderby Land. Runways at Davis, Mawson, S17, PES, and Troll will support the mission. DML RINGS will carry out about 100 flight hours to complete mapping for RINGS in this region. Missions in Enderby Land will be rather exploratory as there are no data with GPS-level positioning except for the vicinity of Mawson Station.

After the survey in 2023-24 season, the data will be analysed to estimate mass flux from this region and assess fundamental instability of these regions. It includes the use of satellite data and numerical models, and by nature it is multidisciplinary.

Proposal

Parties are encouraged to:

1. take note of the important SCAR RINGS initiative and its role in increasing the science community's ability to constrain the uncertainties relating to Antarctica's contribution to future sea-level rise;
2. make appropriate efforts to enable regional surveys and supplemental ground-based and vessel-based work in an internationally coordinated manner, looking at the DML RINGS and Enderby Land RINGS initiatives as useful examples of international cooperation enabling such survey efforts; and
3. support and contribute to the DML RINGS and Enderby Land RINGS as appropriate.