WP23_25: Antarctic Ice Sheet Monitoring

1542,257

Basic Information

Full title of the Initiative

Antarctic Ice Sheet Monitoring

Short Title or Acronym

AIS-MONITORING

Current category in the 2020-2022 GWP

New activity

Proposed category in the 2023-2025 GWP

Pilot Initiative

Points of Contact

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Purpose

Objective

This activity aims to produce data products with high precision on Antarctic Ice Sheet (AIS) mass change and the seafloor topography beneath the Antarctic ice shelves, which will reduce uncertainties in sea-level change projection.

Please provide a short description of the Initiative

In view of the increasing number of satellite and airborne observations in Antarctica and the increasing demand for ground validation, this initiative integrates large-scale, long-term satellite observations, high-precision ice surface monitoring data, and airborne geophysical observations of Antarctica and its surroundings to build a comprehensive observation system for the AIS and surrounding oceans. The initiative will develop new algorithms to reduce the uncertainty in mass balance estimation of AIS. Moreover, the terrestrial monitoring platform integrates GNSS antennas, laser rangers, meteorological devices, and corner cube retroreflectors. It obtains real-time ablation and accumulation conditions of the AIS and enables validation of airborne and satellite observations. The key parameters and products for the mass balance estimate of AIS are still lacked. The

airborne geophysical observation facility overcomes the difficulty that traditional shipborne multibeam echo-soundings are unavailable in regions covered by ice shelves. It collaborates with international institutions for coordinated airborne surveying plans; develops advanced inversion methods and tools to infer high-accuracy, high-resolution (2–10 km) sub-ice-shelf seafloor topography from airborne geophysical observations in Antarctica; and uses the inferred seafloor topography model to simulate the future evolution of the Antarctic marine-terminating glaciers driven by ocean forcing.

Why is this Initiative needed?

Under climate change, the AIS experiences mass balance loss, but with large uncertainty.
Moreover, several key products related to AIS mass balance are lacked, such as high-accuracy elevation change data and nearshore bathymetry of the Antarctic, which is covered by ice shelves. The development of new technologies, such as GNSS, 4G transmission, laser and airborne gravity, facilitates the establishment of various platforms that provide high-precision ice sheet mass balance and the seafloor topography beneath the Antarctic ice shelves.

What evidence is there to support this need?

AIS holds an ice volume equivalent to 57.2 m sea-level rise. However, the mass loss of AIS was estimated to be -109±56 Gt/y. With an uncertainty of 51%, this estimation results in substantial disagreement in estimating its contribution to sea-level rise. The increasing number of satellite and airborne observations in Antarctica leads to an increasing demand for ground validation.

Is this Initiative open to participation by representatives of any GEO Member, Participating Organization, and GEO Associate?

Yes

Are you aware of other projects or initiatives at a global or regional scale (both in GEO and externally) that provide similar products or services?

No

Please identify the most important actual and/or intended outputs (products, services, etc.) produced by the Initiative, along with their intended and/or actual users. This list does not need to be comprehensive but should identify the outputs which are most used and are expected to have the greatest potential impact.

Output	Status	Users	Additional info
New glacier movement shown in web	Regularly updated	GEO members, IPCC, The general public	Terrestrial observation
New snow ablation and accumulation shown in web	Regularly updated	GEO members, IPCC, The general public	Terrestrial observation
New algorithms for surface elevation change of AIS	Occasionally updated	GEO members, IPCC, The general public	Derived from ICESat-2, ZY-3, and GaoFen Satellite data
New mass balance dataset of AIS	Occasionally updated	GEO members, IPCC, The general public	Derived from multi-source remote sensing or model
New gravity anomaly grids	Occasionally updated	Geophysics, Geology, Mineral exploration	Airborne observation
New sub-ice-shelf seafloor topography grids	Occasionally updated	Oceanography, Glaciology, Climate Change, Geology, Geophysics, Ship navigation	Inferred from airborne gravity

If needed, please provide additional comments or explanation to accompany the outputs table

- no answer given -

What kinds of decisions are the outputs of this Initiative primarily intended to support?

The outputs of this initiative help national and local governments assess the impacts of global sea-level rise, risks in the near term and long term, and adaptations required.

How will these decisions benefit from the outputs of this Initiative?

The outputs of this initiative help oceanographers and glaciologists more accurately project the mass balance of the AIS and its impacts on sea-level rise. Accurate sea-level rise projections help countries and governments in coastal and sea-related areas assess the risks and help the international community make informed decisions about taking adaptation actions against global environmental changes.

What kinds of impacts (for example, reduced loss of life, monetary savings, conservation of biodiversity, etc.) are anticipated as a result of the use of the outputs of this Initiative?

The outputs of this initiative help improve the accuracy of mass balance and provide key products on AIS, benefiting mitigate the natural disasters, protect the climate, environment and biodiversity around Antarctica.

Has this Initiative been asked to provide specific information (for example, reports, data, services) on an ongoing basis to an international convention, organization, or other multilateral body?

Yes

Please identify the requesting organization.

National Snow and Ice Data Center; European Space Agency; The National Aeronautics and Space Administration; National Earth System Science Data Center; International Society for Photogrammetry and Remote Sensing; Polar Research Institute of China; International Glaciological Society; Northwest Institute of

Eco-Environment and Resources, Chinese Academy of Sciences; Institute of Oceanography, Chinese Academy of Sciences.

Describe the nature of the request.

The data products of this initiative are used for a highly accurate mass balance estimate of AIS. The data products and reports that this initiative releases to the scientific community and the general public are used for comprehensive analysis of the global climate change and adaptation actions required.

Please provide supporting documentation of the request.

- no supporting documents provided -

Technical Synopsis

Please provide a brief description of the methods used by the Initiative to produce its (actual or planned) outputs.

1) Mass Balance Estimation
The mass balance is estimated using satellite altimetry and the input-output method. The altimetry method calculates the mass balance of AIS by measuring elevation changes over the entire ice sheet and converts them into mass changes through assumed density. The input-output method calculates the mass balance of AIS by comparing accumulation of snowfall over the interior basins with ice discharge by glaciers across the grounding line. The corresponding value of sea level rise change caused by the ice-mass change is estimated by the mass loss of the AIS divided by the global ocean area and the density of water, based on the assumption that the mass change of the AIS is totally transformed into the equivalent mass change of water.
2) Seafloor Topography Estimation from Airborne Gravity
The measured gravity anomalies at flight altitude integrate the gravitational effects of the density difference between the seafloor topography and the overlying water and/or ice layers, the density variations within the shallow subsurface, and the regional isostatic compensation at the Mohorovicic discontinuity. The latter two effects are not due to the seafloor topography and should be removed prior to the inversion. We assume a uniform bedrock density, remove the gravitational effect of the ice layer and the regional gravity field from the measured gravity anomalies, and use the remaining gravity anomaly to estimate the seafloor topography through the simulated annealing method by minimizing the difference between the remaining and the forward-computed gravity anomalies.
3) Real-time Monitoring of Ice Surface Elevation
The terrestrial monitoring platform consists of several sensors: laser rangers, cameras, corner cube retroreflectors, and meteorological devices. First, the coordinates of the reference GNSS antenna at Zhongshan station are precisely calculated. Then, the GNSS observations at both Zhongshan station and the ice surface are combined to derive the baseline differences. All GNSS observations are sent back to a server through Beidou/Iridium Satellite/Argo. After postprocessing, the real-time ice surface elevations and ice-flow velocities are obtained.

If you would like to provide further details on the technical methods, you may upload one or more documents here.

- 2020jb020281_final.pdf (link)
- geophysical_research_letters_2021_yang_b.pdf (link)

Are there any significant scientific or technical challenges that need to be resolved by the Initiative during the 2023-2025 period?

No

Does the Initiative expect to complete any key new outputs, improvements to existing outputs, or improvements to the methods of producing outputs, in the 2023-2025 period?

Yes

Please describe these new outputs or improvements.

We also develop new algorithms on surface elevation change of AIS to improve the accuracy of its mass balance .

Please identify the key tasks that must be implemented to ensure delivery of these changes, with target dates for completion.

Task	Task description	Expected completion (month/year)
Establish real-time monitoring platform for snow and ice changes in key regions	Real-time observation platform for ice surfaces	12/2024
Calculate the elevation and elevation changes in Antarctica and key regions	Derived from ICESat-2, ZY-3, and GaoFen satellites	12/2023
Conduct airborne geophysical observations in Antarctica	Launch new airborne geophysical surveys in Antarctica	03/2024
Estimate the seafloor topographies beneath the Antarctic ice shelves	Using the airborne geophysical data to infer the seafloor topography beneath the Antarctic ice shelves	09/2024
Estimate the mass balance and evolution of the AIS	Multi-source data Integration and model prediction	12/2025

Resources

Have all resources required to implement the Initiative's planned work in the 2023-2025 period been secured?

Please list all financial and non-financial contributions to the Initiative (other than in-kind, voluntary participation by individual contributors) having a value of more than USD 50,000.

Contributing Organization	GEO Status	Type of Resource	Value	Currency
China Aero Geophysical and Remote Sensing Center for Natural Resources, China Geological Survey/Polar Research Institute of China/Sun Yat-sen University/Tongji University/Wuhan University Polar Research Institute of China/Chinese Arctic and Antarctic Administration	China	Equipment	254,000,000	RMB
China Aero Geophysical and Remote Sensing Center for Natural Resources, China Geological Survey/Ministry of Science and Technology of the People´s Republic of China/National Natural Science Foundation of China	China	Financial	60,000,000	RMB
Polar Research Institute of China/Chinese Arctic and Antarctic Administration	China	Other	logstic	
Wuhan University/Tongji University/China Aero Geophysical and Remote Sensing Center for Natural Resources, China Geological Survey/Polar Research Institute of China/Sun Yat-sen University/Chinese Academy of Meteorological Sciences/Chinese Academy of	China	Data		

Sciences				
Technische Universität Dresden	Germany	Data		
National Snow and Ice Data Center/Scripps Institution of Oceanography, University of California, San Diego/United States Geological Survey	United States	Data		
Australian Antarctic Division	United Kingdom	Data		

Lessons from the 2020-2022 Period

Were all planned activities for the 2020-2022 period implemented as expected?

No

> **Please describe which activities were delayed or not implemented and how has this affected plans for 2023-2025.**
>
> This is a new initiative.

Were there any key challenges faced by the Initiative in the 2020-2022 period?

No

Were there any impacts or changes to operations due to COVID-19?

No

Please describe the key changes proposed for the 2023-2025 period, for example, new projects, new areas of focus, or adjustments to the activity governance.

This is a new Pilot Initiative.

Does the Initiative have outputs (products, services, etc.) available to users now, even if only on a pilot or testing basis?

Yes

> **Please provide any available information describing this usage (for example, user statistics, results of user testing) and/or feedback from users (for example, user comments, evaluations).**
>
> User statistics for the data sets our group released during the 2020-2022 period are shown in the following.
> (real-time observation platform) http://chinare.hbaa.cn/iot/yulong.php
> (1645 views, 409 downloads) Li R., Li H., Hao T., Qiao G., Cui H., He Y., Hai G., Xie H., Cheng Y., and Li B. (2021). Assessment of ICESat-2 ice surface elevations over the CHINARE route, East Antarctica, based on coordinated multi-sensor observations. The Cryosphere. https://doi.org/10.5194/tc-2020-330
> (81 views, 57 downloads) Yang, J. (2021). Bathymetry beneath the Amery ice shelf, East Antarctica, revealed by airborne gravity. Zenodo. https://doi.org/10.5281/zenodo.5651609
> (423 views, 411 downloads) Xiangbin, Cui, Jeofry, Hafeez, Greenbaum, Jamin, Ross, Neil, Morlighem,

Please provide supporting documentation if available.

- no supporting documents provided -

Do you have evidence of any impacts that have occurred in part as a result of using the outputs of the Initiative (for example, policy decisions taken, behaviour changes by users, risks mitigated)?

Yes

Please provide examples, with evidence where available.

Mass balance of AIS is one of the key focus of IPCC. Its high uncertainty and lack of key parameters limit the forecast of future sea level change

Please provide supporting documentation if available.

- no supporting documents provided -

Have there been any internal or external reviews or evaluations of the Initiative since 2019?

No

Please indicate any GEO Work Programme activities with which you have ongoing collaboration.

- CSDR - Chinese High-resolution Satellite Data Resources

Please indicate any additional GEO Work Programme activities with which you would like to establish new collaborations.

- AMERIGEO - Americas Group on Earth Observations
- CLIMATE-OBS - Climate Observation, Simulation and Impacts
- EO4SDG - Earth Observations for the Sustainable Development Goals
- EUROGEO - European Group on Earth Observations
- NEXT-EOS - Next Generation Earth Observation Services
- GEO-VALUE - Understanding the Impacts and Value of Earth Observations

Stakeholder Engagement and Capacity Building

Are there specific countries or organizations that your Initiative would like to engage?

Yes

Please list these countries, regions or organizations.

Countries: United States, Australia, Germany, Belgium, Denmark, Sweden, New Zealand, United Kingdom, Italy,France
Organizations: NSIDC, EGU, AGU, ISPRS, ASPRS, IGS, SCAR, IBCSO, PolarGAP, BedMachine Antarctica

What are your plans to engage them?

We plan to engage these organizations by participating workshops they hold, forward news latest progress to their members, and send them our outputs.

Does your Initiative engage users in the work of the Initiative (for example, consultation, testing, co-design)?

No

Does the Initiative have a user engagement strategy or similar kind of document?

No

Are there categories of users that are not represented at this time, but you would like to engage?

No

Does the Initiative have a documented capacity development strategy?

Yes

Please upload it.

- capacity_development_strategy.docx (link)

Are there any commercial sector organizations participating in this Initiative?

No

Are there opportunities for commercial sector uptake of the outputs of the Initiative?

No

Are there opportunities for further commercial sector participation in the Initiative?

No

Does the Initiative have a plan for commercial sector engagement?

No

Governance

Please describe the roles of each of the key leadership positions, as well as any team structures involved in day-to-day management.

We welcome the partners at home and abroad. Wuhan University, Tongji University, and China Aero Geophysical Survey and Remote Sensing Center for Natural Resources are the main contributors. Wuhan University and the partners from abroad are responsible for the terrestrial monitoring platform for ice surfaces. Tongji University, the University of Gothenburg and the University of Otago mainly focus on the data processing and modeling of satellite remote sensing. The China Aero Geophysical Survey and Remote Sensing Center for Natural Resources, Australian Antarctic Division, and Scripps Institution of Oceanography are responsible for the airborne observation platform. We will share the data products with the partners. Regular meetings are organized to discuss the progress. The team is composed of a co-lead team and participants. The co-lead team is from various institutions, and participants include contributors and observers.

Is there a steering committee or other governance bodies that advise the Initiative but are not involved in day-to-day management?

No

What methods does the Initiative use to communicate with its participants?

- Email / e-newsletters
- Regular conference calls
- Website
- Regular events

Please describe the key risks that could delay or obstruct the completion of the planned activities and outputs of the Initiative, along with any actions taken to mitigate these risks.

- no answer given -

What methods are used by the Initiative to monitor its effectiveness?

- Informal discussions with users / beneficiaries
- User or beneficiary surveys
- Consultations or events
- Evaluations

Would the Initiative be interested in assistance from the GEO Secretariat for developing an impact plan?

Yes

How are the results of the monitoring and evaluation activities shared with participants and the wider GEO community?

The evaluation results will be sent to every participant through the Internet. Feedback from the evaluation and its implications for future implementation will be discussed at the annual meeting.

Are any monitoring or evaluation activities required by funders/contributors?

No

Participants

Please list the active individual participants in the Initiative

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Other information

Please provide any other comments or information that was not included in the previous sections, but you would like to appear in the Implementation Plan.

The information is included in the previous sections.

- no supporting documents provided -

Co-Editor Management

List of co-editors for this initiative

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