

Unleashing the potential of Earth Observation for Antarctica InSync: A White Paper from the Antarctica InSync Earth Observation crossing-cutting group

Follow-up Webinar: Antarctica InSync Science Planning

Online 20th & 21st January 2026



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Contributing Authors

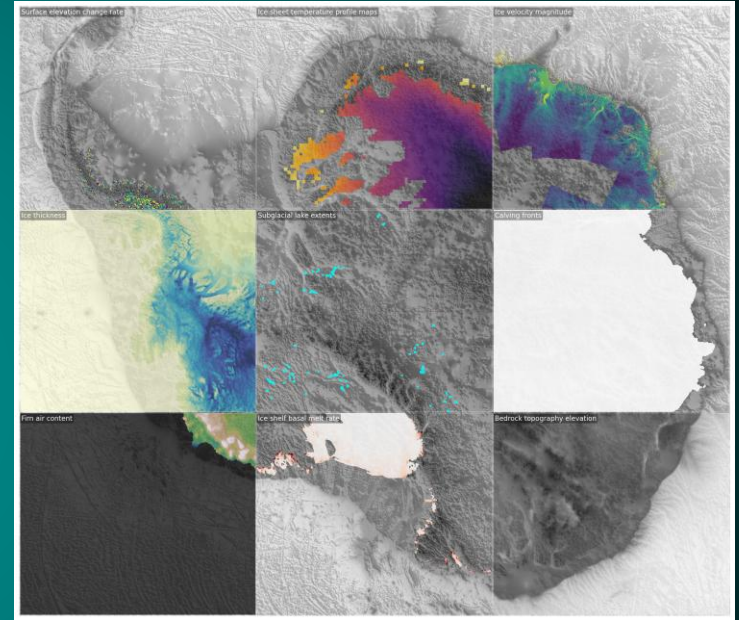
Martin Wearing, European Space Agency, martin.wearing@esa.int, Antonino Ian Ferola, European Space Agency, antoninoian.ferola@esa.int, Elisa Carli, European Space Agency, elisa.carli@esa.int, Giuseppe Aulicino, University of Naples Parthenope, giuseppe.aulicino@uniparthenope.it, Marco Vountas, University of Bremen, Germany, vountas@iup.physik.uni-bremen.de, Robert Ricker, NORCE Research, rori@norceresearch.no, Jelte van Oostveen, NORCE Research, jeoo@norceresearch.no, Signe Aaboe, MET Norway, signeaa@met.no, Thomas Nagler, ENVEO, thomas.nagler@enveo.at, Jan Wuite, ENVEO, jan.wuite@enveo.at, Alix Post, Geoscience Australia, alix.post@ga.gov.au, Kimberlee Baldry, Geoscience Australia, kimberlee.baldry@ga.gov.au, Noel Gourmelen, University of Edinburgh, noel.gourmelen@ed.ac.uk, Sebastian B. Simonsen, DTU Space, Denmark, ssim@dtu.dk Wayne de Jager, University of Cape Town, wayne.dejager@uct.ac.za, Thomas Lavergne, Norwegian Meteorological Institute, thomas.lavergne@met.no, Anna E. Hogg, University of Leeds, A.E.Hogg@leeds.ac.uk, Mal McMillan, Lancaster University, m.mcmillan@lancaster.ac.uk, Signe Aaboe, MET-Norway, signe.aaboe@met.no, Ghislain Picard, University of Grenoble, ghislain.picard@univ-grenoble-alpes.fr, Inès Otosaka, Northumbria University, ines.otosaka@northumbria.ac.uk, Wolfgang Rack, Gunnar Spreen (Uni Bremen), Sebastian Simonsen (DTU), Estrella Olmedo, David Arthurs,

Join the mailing list to follow activities and contribute to EO cross-cutting working group:

<https://www.listserv.dfn.de/sympa/subscribe/antarctica-insync-remote-sensing>

What EO brings to Antarctica InSync

- Advances in satellite Earth Observation (EO) have enabled comprehensive and continuous monitoring, and characterisation, of Antarctica and the Southern Ocean.
- EO data products provide essential information to tackle the scientific priorities of Antarctica InSync, including crucial spatial and temporal context for in-situ campaigns and modelling.
- The wealth of EO data products enables scientific research priorities to be addressed, such as understanding impacts of climate change and variability across ice sheets, ice shelves, sea ice, ocean, atmosphere and ecosystems, investigating trends, extremes and feedbacks.

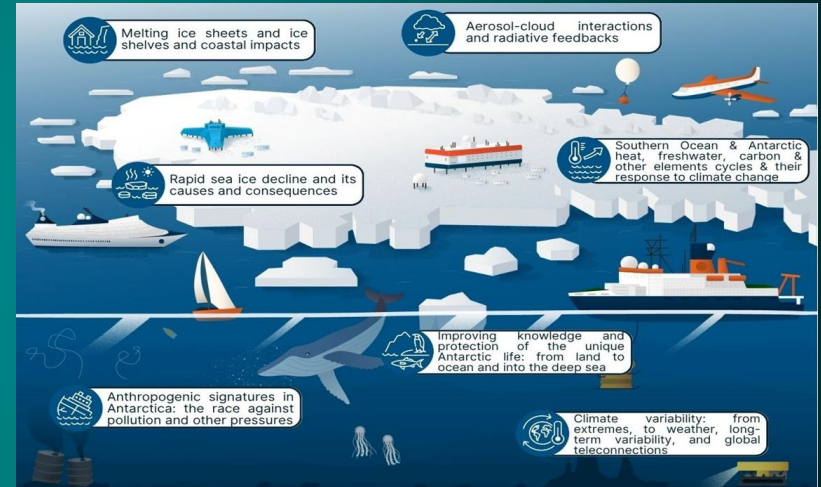


EO Priorities for Antarctica InSync

1) Continue to improve satellite EO of Antarctica and the Southern Ocean.

Efforts should target;

- extending the observational record,
- increasing range of measured variables,
- improve spatial and temporal resolution,
- quantify and reduce measurement uncertainties,
- increase data accessibility, and
- create new satellite EO capabilities.



EO Priorities for Antarctica InSync

2) Coordinate with fieldwork teams

- EO and in-situ data together should form the core observational baseline for InSync.
- EO data provides valuable information on where to target in-situ activities, such as key locations of change and regions where key physical processes are exemplified. These regions could be coordinated across Antarctic InSync science themes as **supersites**.
- In-situ cal/val is particularly important for new satellite missions, for instance, European missions such as CRISTAL, ROSE-L, CIMR, Harmony, BIOMASS.

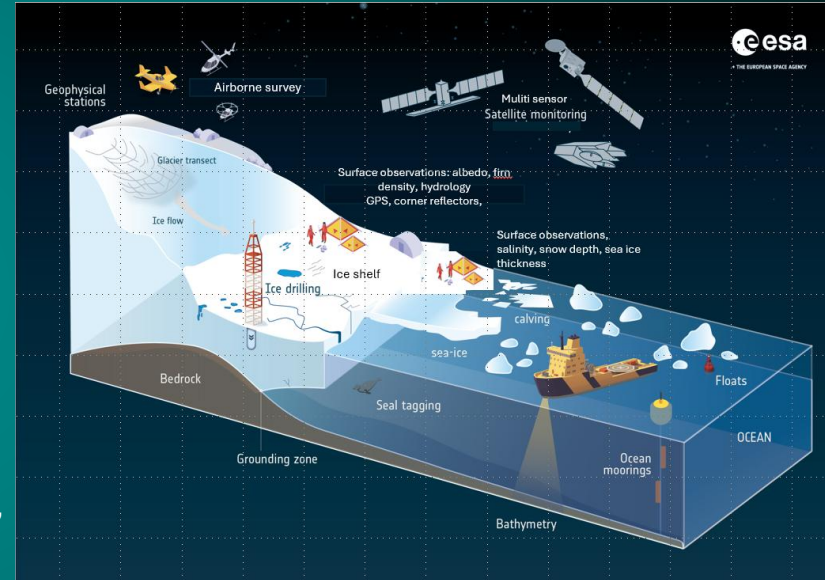


Figure: DRAFT: Schematic depicting coordination between EO and in-situ observations for calibration and validation. [New version of graphic to be produced following feedback.]

EO Priorities for Antarctica InSync

2) Coordinate with fieldwork teams

- In-situ observations are a critical resource for validation and calibration of EO data. Coordinate with fieldwork teams to maximise EO cal/val opportunities. Ideally, in-situ observations should be:
 - maintained for longer periods (i.e. years) to enable ongoing cal/val activities through multiple seasons.
 - coincident with satellite overpasses
 - sample the small-scale variability within the satellite footprint.
- Request observations for the benefit of EO from planned campaigns. For instance, relevant low-cost equipment could be provided to ongoing/planned activities:
 - corner reflectors or GNSS, ASD field spectrometers to calibrate spectral reflectance or protocol for snow sampling, on-ice drifters, shipborne snow radar(s), ApRES to calibrate and validate ice shelf basal melting.
 - Table of requests for in-situ observations →

Extract of table: In-situ datasets that are priorities for EO cal/val and product development:

Parameters to be observed	Target EO sensor	Instrument	Location	Domain (ice sheet, ocean, atmosphere, sea ice)
Sea Surface Salinity	SMOS and SMAP	CTD casts, Thermosalinographs (TSG), Argo floats, sensors mounted on marine-mammals	Everywhere, preferably close to Marginal Ice Zone and ACC frontal zones	Ocean
Sea Surface Temperature	Infrared radiometers, microwave	TSG, CTD, Argo floats, autonomous surface vehicles	Everywhere, preferably close to Marginal Ice Zone and ACC frontal zones	Ocean
Surface wind	Scatterometer, SAR	Anemometers, wavegliders		Ocean
Steric height, total ocean currents	Altimeter, SAR, scatterometer	moorings		Ocean
Ocean currents	Altimeter currents	Drifters, S-ADCP, ADCP on autonomous surface vehicles		Ocean
Ocean Colour, AOT, R _{rs}	OCI and HARP	HPLC analysis (water samples), DALEC (Dynamic Above-water Radiance (L) and	Southern Ocean	Ocean

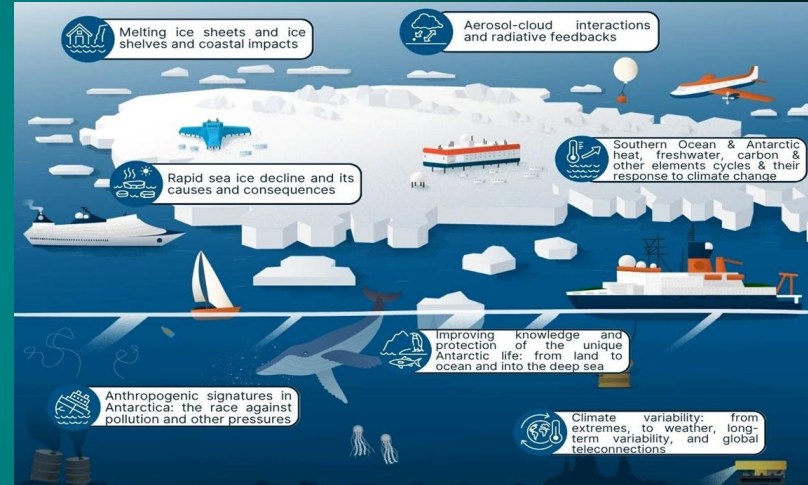
EO Priorities for Antarctica InSync

3) Coordinating activities of space agencies and commercial satellite operators:

- There is strong interest within the EO community and substantial scientific potential in high-resolution commercial data products. Access to these data could be achieved through strengthened collaboration with commercial providers and request for data for high-interest events.

4) Closer collaboration with modelling teams to ensure maximum use of EO data:

- EO data provides crucial information for model initialization, assimilation and validation.
- Improved process understanding, driven by analysis of EO data, leads to improved representation of complex processes in models and more accurate future projections.



EO Priorities for Antarctica InSync

5) EO-driven research projects

- EO datasets are now sufficiently long, detailed and varied across multiple parameters that they can address research priorities and stimulate scientific advances (Annex A).
- Annex of proposed research projects and links to working groups (Annex B).
- A major advantage of EO data is that research can start prior to the InSync observing period, link into the observing period, be deployed at pan-Antarctic scale and extend to IPY.

6) Data Management Principles and Coordinating EO data products across domains

- To enable the linkage of datasets across observation domains EO data should be easily accessible, interoperable and analysis ready.

Annex A: Satellite Earth Observation capabilities for Antarctica and Southern Ocean

Data product	Sensor (type & name)	Temporal and Spatial extent	Temporal and Spatial resolution	Primary Science Theme
Global Low Resolution Sea Ice Drift data record, release 1. OSI455	SSM/I and SSMS from CM SAF R4, AMSR-E (NSIDC) and AMSR2 (JAXA)	1991-2020; Global	24hr, 75km	Rapid sea-ice decline and its causes and consequences
Global Low Resolution Sea Ice Drift. OSI405d	GCOM-W/AMSR2 and Metop/ASCAT	2009- onwards; Global	24hrs, 62.5km	Rapid sea-ice decline and its causes and consequences
Swath-to-swath (s2s) sea-ice drift.	GCOM-W1 AMSR2 36.5 GHz	Antarctic: 15-13 July 2019. Spatial extent limited to swath overlap.	1-48hrs, 62.5km	Rapid sea-ice decline and its causes and consequences
Sea ice thickness (ESA CCI v4)	Satellite altimetry	1995-2024	Monthly, 25km	Rapid sea-ice decline and its causes and consequences

Annex B: EO-led Science Research Priorities

In the context of the Antarctica InSync initiative, there are a number of scientific research priorities that can be addressed through activities with Earth Observation at the core. These activities will be enacted through dedicated Working Groups.

Science Theme: Southern Ocean and Antarctic heat, freshwater, carbon and other elements cycles and their response to climate change.

Quantify and monitor air-sea exchanges of heat and freshwater in the Southern Ocean, and understand their role in driving climate variability and change. Adapting methodologies from the ESA projects ARCTIC-FLOW and CCI-OSHF, by combining satellite Earth Observation (sea surface salinity, temperature and currents) with in situ measurements of mixed layer depth, and applying conservation principles to estimate surface fluxes in the upper ocean. Extending this framework to the Southern Ocean will allow us to monitor flux variability and its climate impacts, while close collaboration with in situ networks and modelling teams will improve accuracy, enable robust validation, and enhance predictive skill. [Estrella Olmedo, olmedo@icm.csic.es]

Determine how the Southern Ocean's three dimensional upper-ocean circulation regulates the transfer of heat and carbon in the open ocean and close to the marginal ice zone and how these exchanges shape regional climate sensitivity. We will estimate vertical velocities, heat and carbon budgets in the Southern Ocean from satellite altimetry, including SWOT high-resolution SSH observations, and integrate these fields with targeted in-situ records from Argo and dedicated observational campaigns. These derived quantities will be combined with dynamical modeling to close heat and carbon budgets and isolate the mechanisms controlling vertical exchange [Elisa Carli, elisa.carli@esa.int]

Evaluate the impacts of the extent, seasonality and dynamics of recurring coastal and open-ocean polynvas on Southern Ocean overturning and biogeochemical cycles. We will use high-resolution satellite Earth Observation (e.g. SAR, passive microwave, optical/IR and



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We welcome further input, feedback and refinement with the Antarctica InSync community across all science themes.

