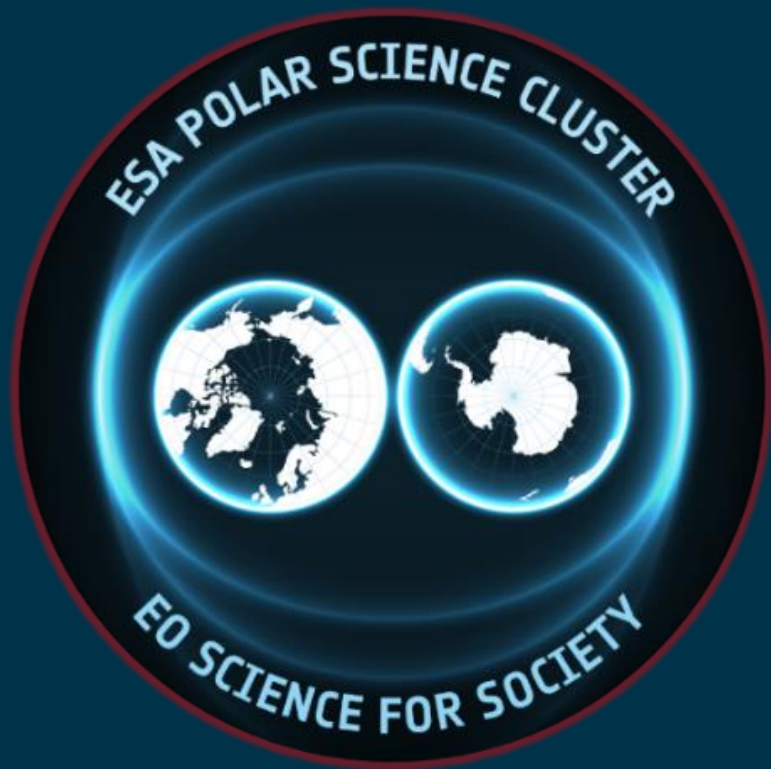


ESA Polar Science Cluster activities and contributions for Antarctica Insync

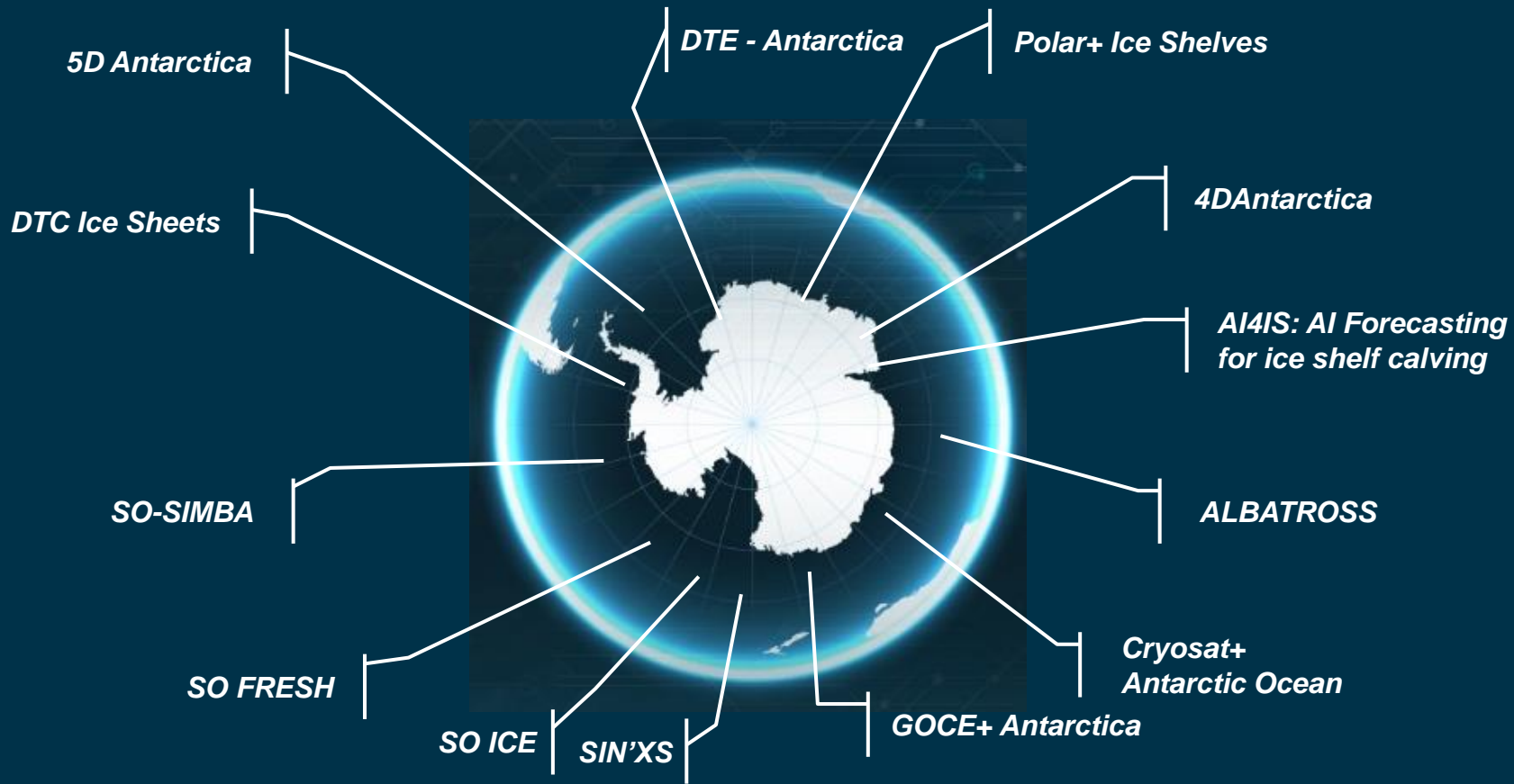
Martin Wearing
Digital Twin Earth Scientist, ESA ESRIN
Coordinator for ESA Polar Science Cluster



Core activities:

- Generating benchmarking datasets
- Developing new processing algorithms
- Innovative EO data products
- Monitor cryospheric & ocean change
- Improve process understanding

ESA Polar Science Cluster Activities: Antarctica & SO



Benefits of satellite Earth Observation for Antarctica Insync

- Spatial and temporal coverage
- Observations of multiple parameters
- Providing holistic view of Antarctica and Southern Ocean

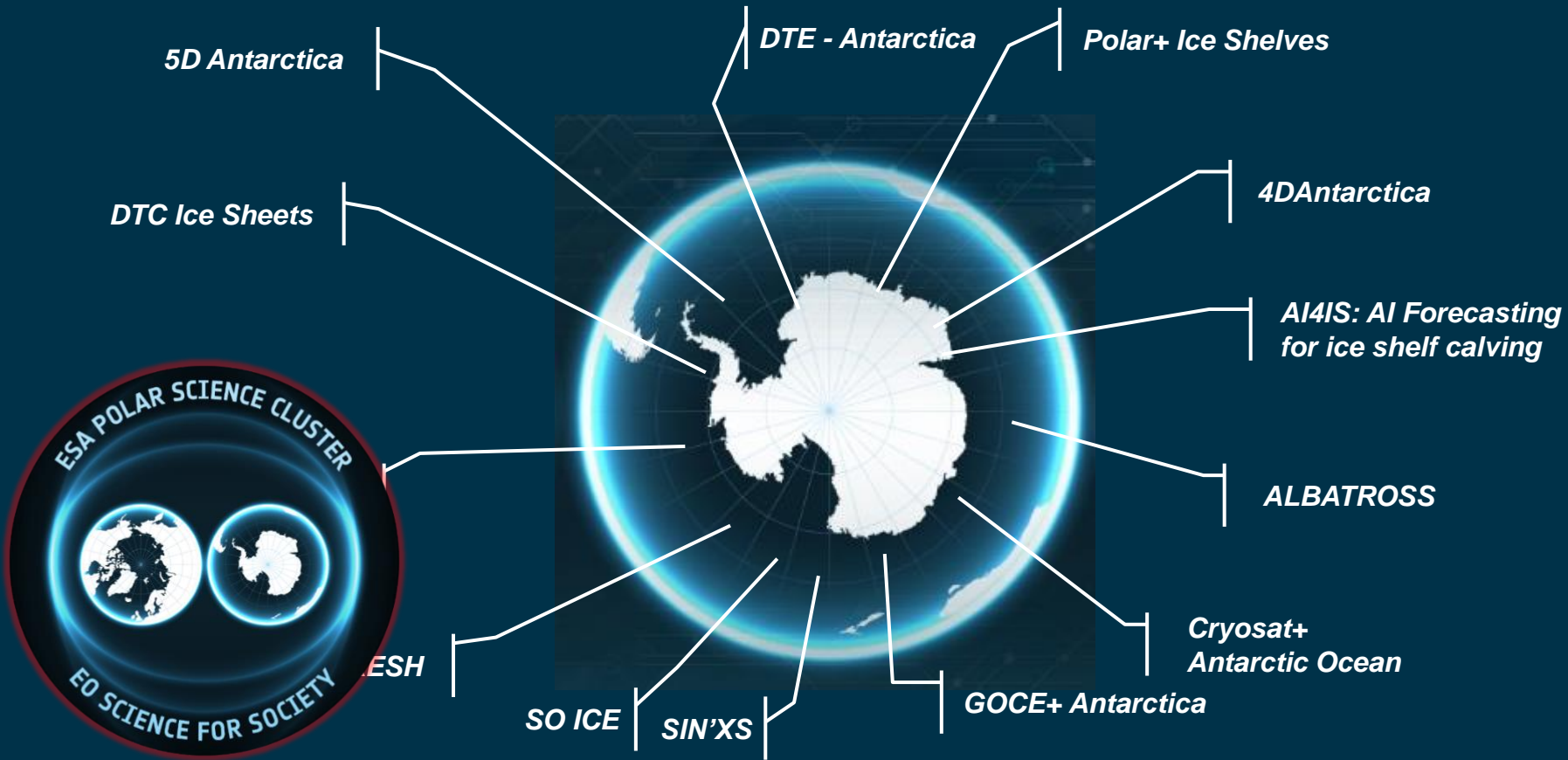


Benefits of satellite Earth Observation for Antarctica Insync

Themes and relevant EO datasets:

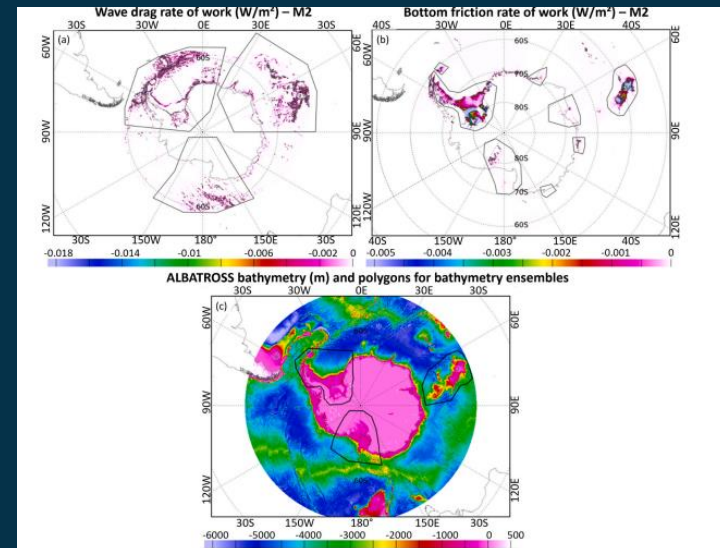
- *Southern Ocean and Antarctic heat, freshwater, carbon and other elements cycles and their response to climate change*
 - Ocean circulation, air-sea fluxes, waves, winds, chlorophyll, sea surface height, sea surface salinity, bathymetry
- *Rapid sea-ice decline and its interdisciplinary consequences*
 - Sea ice extent, concentration, thickness, volume, snow depth, freshwater budget
- *Melting ice sheets and ice shelves and coastal impacts*
 - Ice sheet mass change, thickness, velocity, englacial temperature, ice shelf melting and calving, ice damage, surface hydrology, GHF and subglacial hydrology, albedo
- *Improving knowledge and protection of the unique Antarctic life: from land to ocean and into the deep sea*
 - Species detection and monitoring, ...
- *Anthropogenic signatures in Antarctica: the race against pollution and other pressures*
 - Monitoring land, ocean, atmosphere: ship tracks, ice darkening, ...
- *Aerosol-cloud interactions and radiative feedbacks*
 - Clouds: liquid/ice water content, particle size, number and concentration, optical thickness, doppler velocity, type
Aerosols: type, extinction, optical thickness, mass content, Precipitation

ESA Polar Science Cluster Activities: Antarctica & SO

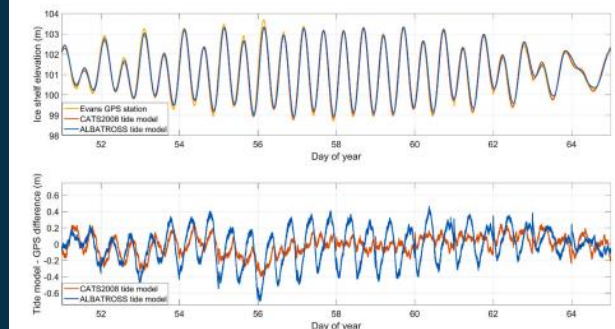


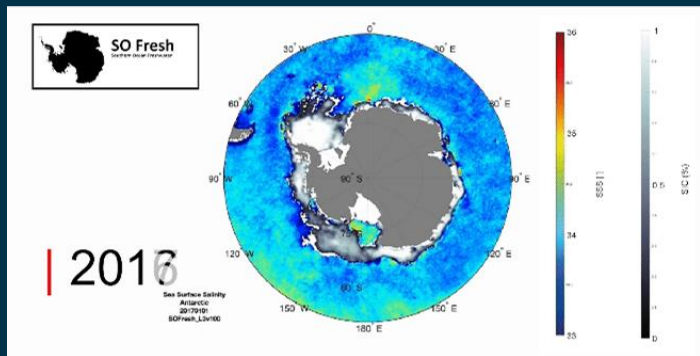
ALBATROSS: ALtimetry for BATHymetry and TideRetrievals for the Southern Ocean, Sea ice and ice Shelves

- Improved knowledge of bathymetry around Antarctica
- Improved knowledge on ocean tides in the Southern Ocean



Le Merle et al., (2024)





- Provision of a multi-year (2011-2023) record of Satellite Sea Surface Salinity (SSS)
- Related science case studies ranging from sea-ice dynamics to water masses formation

Metadata	
General	
Release date	7/21/2023, 12:00:00 AM UTC
Start date	2/1/2011, 12:00:00 AM UTC
End date	3/31/2023, 11:59:59 PM UTC
Data Version	1

Rising surface salinity and declining sea ice: a new Southern Ocean state revealed by satellites
Silvano et al. (in press)

Southern Ocean Carbon and Heat Impact on Climate

November 2019 -2023
16 partners

SO-CHIC (EU Horizon 2020)
Objectives:

- Air-sea fluxes
- Upper Ocean ventilation
- Bottom Ocean ventilation
- Abrupt shortcut events

SO-CHIC (EU Horizon 2020) is acquiring in situ high-resolution, near-surface salinity data in freshwater-stratified Southern Ocean regions

SO Fresh
Southern Ocean Freshwater

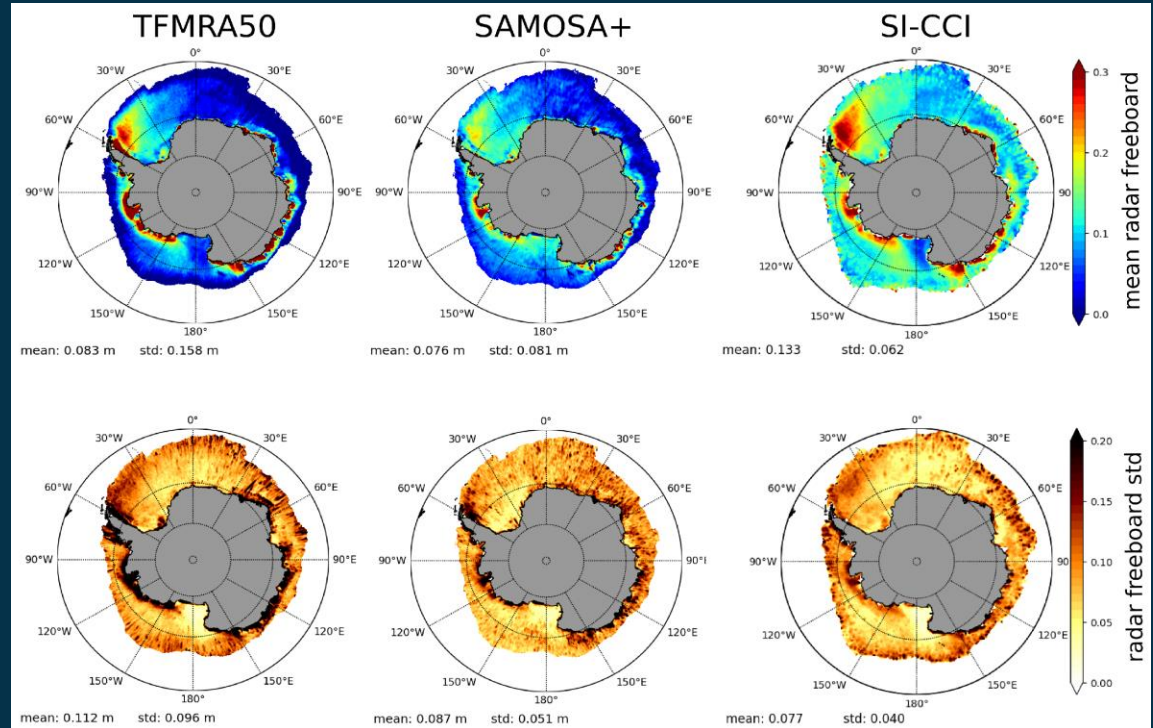
Southern Ocean Ice-Ocean Interactions SO-ICE

Sept 2021 -2023
6 partners

SO-ICE (ESA)
Objectives:

- Ice shelves links between ocean and grounded ice sheets
- Ice loss monitoring due to ice dynamics
- Improve understanding of ice-ocean interactions
- Impact of ice melt on the Southern Ocean

CryoSat+ Antarctic Ocean project, inter-compares and validates multiple approaches to sea surface height and sea ice thickness retrieval on Antarctic sea ice.

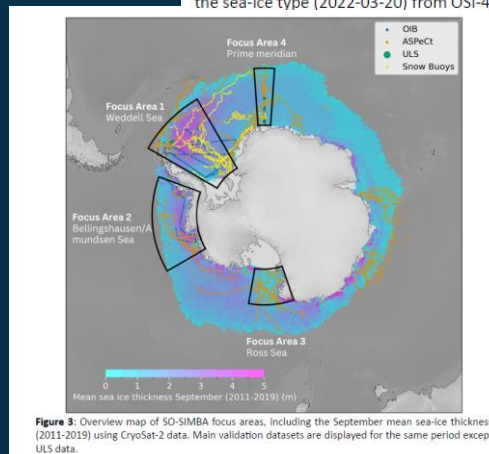
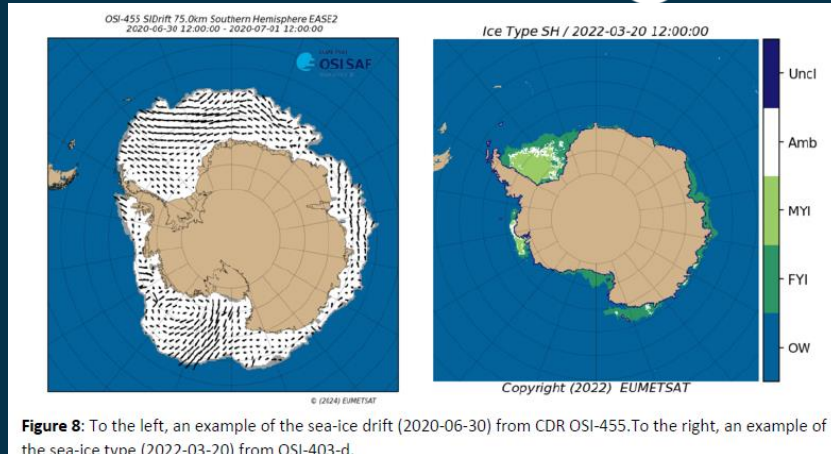


Garnier et al., (2022)

Kicked off Nov 2024

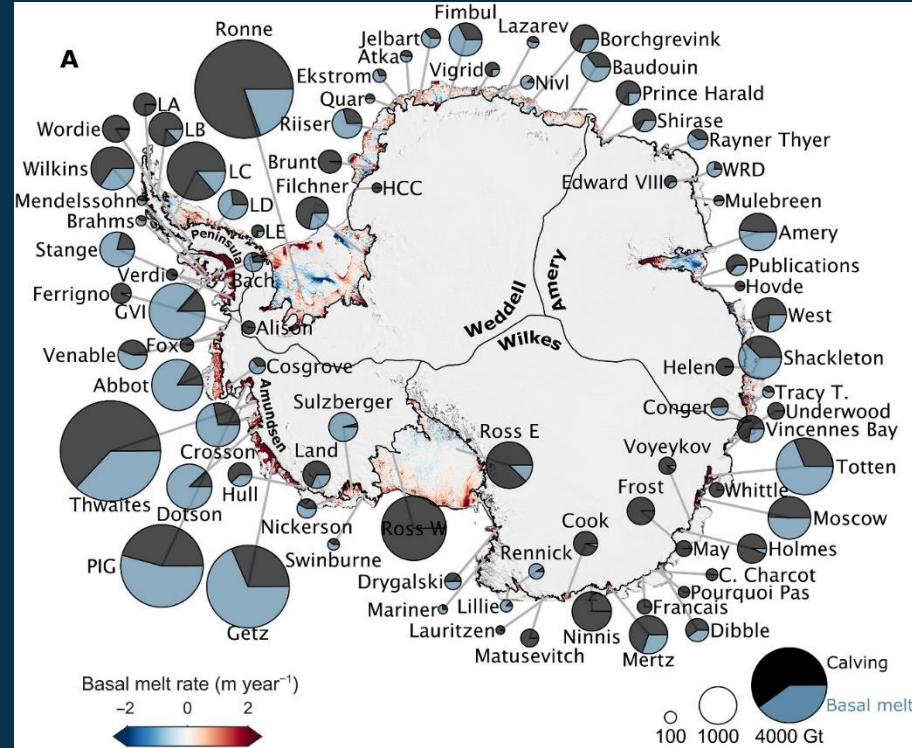
SO-SIMBA: Establishing a state-of-the-art multi-mission reference dataset for assessing the mass balance of Antarctic Sea Ice, freshwater budget and interactions with the ocean. Including: improved sea ice thickness products; radar penetration depth, snow depth, snow ice and associated uncertainties. Utilising CS-2, S-3, ICESat-2, SWOT, AMSR2, SMOS, SAR.

Prime: NORCE, Science Lead: Robert Ricker



ESA Science Cluster Projects: Polar+ IceShelves

- Generate Earth Observation datasets to characterise how ice shelves in Antarctica have changed over the last decade.
- Exploit observations from SMOS, S-1, S-2, and swath mode processed CryoSat-2.
- *Davison et al. (2023)* Annual mass budget of Antarctic ice shelves from 1997 to 2021. *Science Advances*
 - Out of 162 ice shelves, 71 lost mass, 29 gained mass, and 62 did not change mass significantly.
- Quantified meltwater input to Southern Ocean – used in European Commission project SO-CHIC via ESA SO-ICE project.



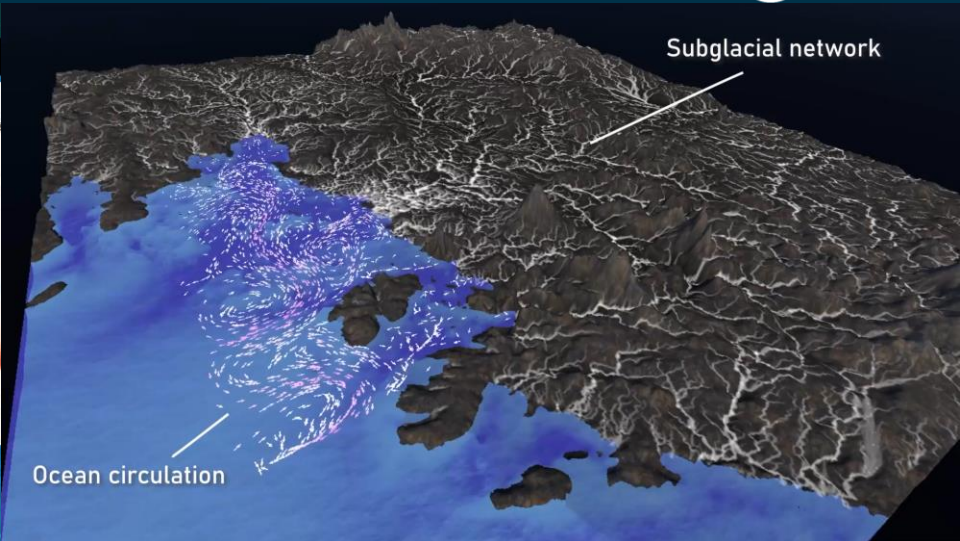
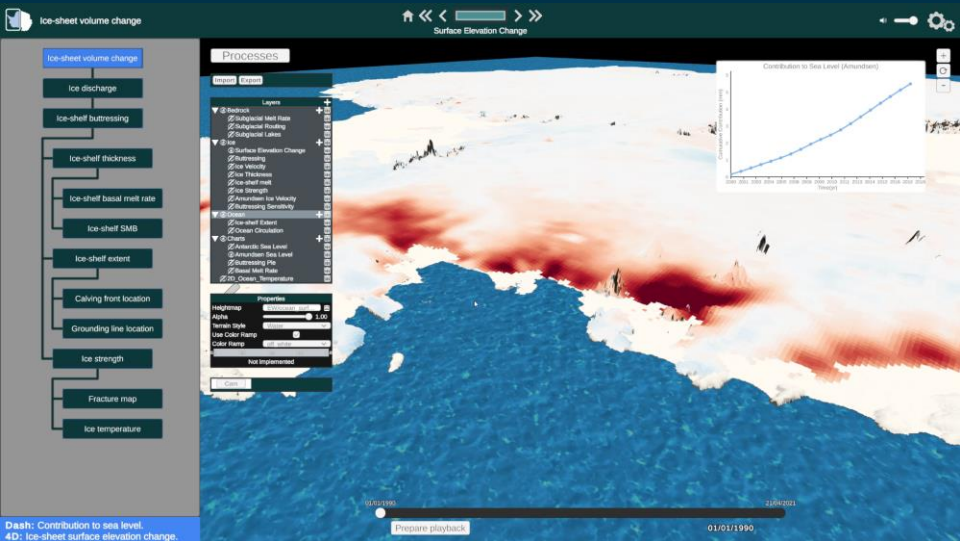
Davison et al., (2023)

EO Datasets

- Ice-sheet surface:
 - Advanced surface velocity
 - High-resolution surface elevation change
 - Dynamic surface hydrology: supraglacial lake, supraglacial hydrology
 - Snow cover and properties (e.g., albedo)
 - Surface melt status and meltwater quantity.
 - Surface mass balance
- Ice shelves:
 - Basal melt rate
 - Calving front location
 - Grounding line location
 - Grounding line discharge
 - Ice damage/fracturing
 - Ice-shelf mass balance
- Englacial:
 - Englacial temperature profiles
 - Inferred ice stiffness/strength
- Ice-sheet base/Subglacial hydrology
 - Geothermal heat flux
 - Subglacial melt rate: separation of components
 - Subglacial drainage: distributed/channelized, GL discharge
 - Subglacial lakes: location and activity

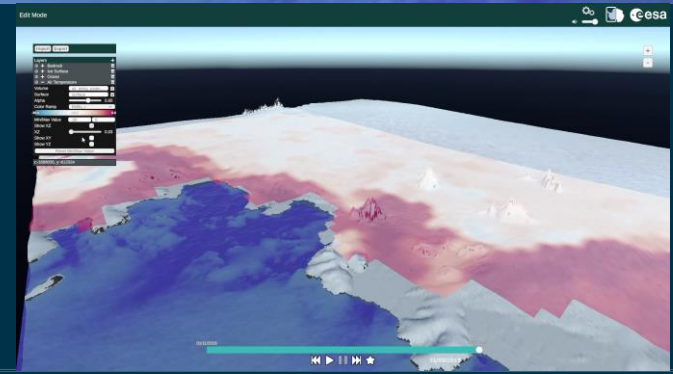
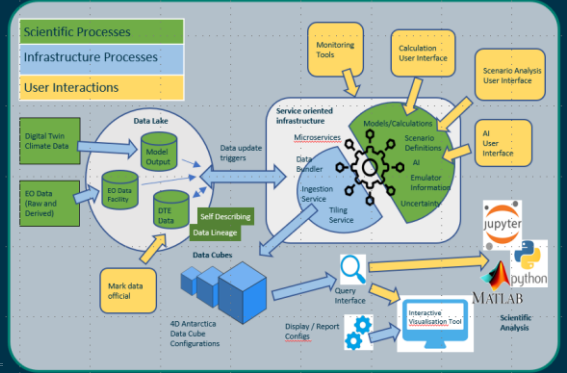


ESA Science Cluster Projects: Digital Twin Antarctica

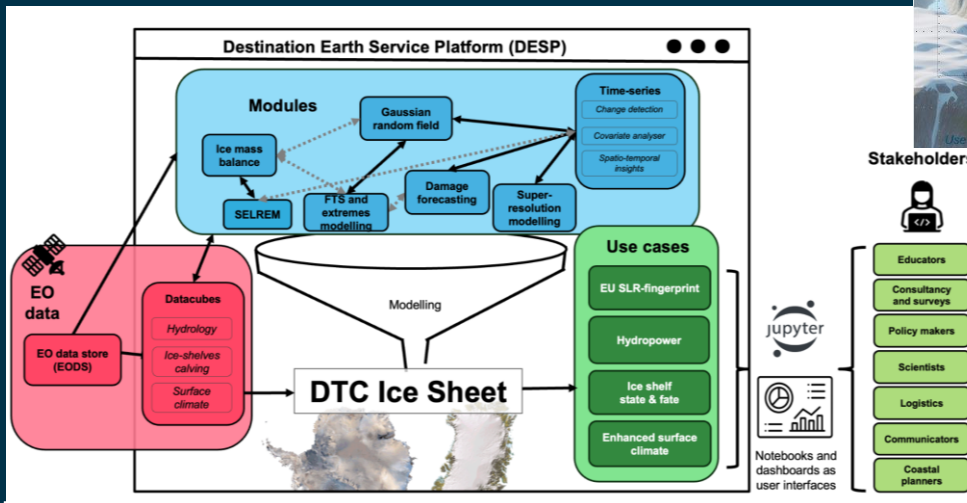
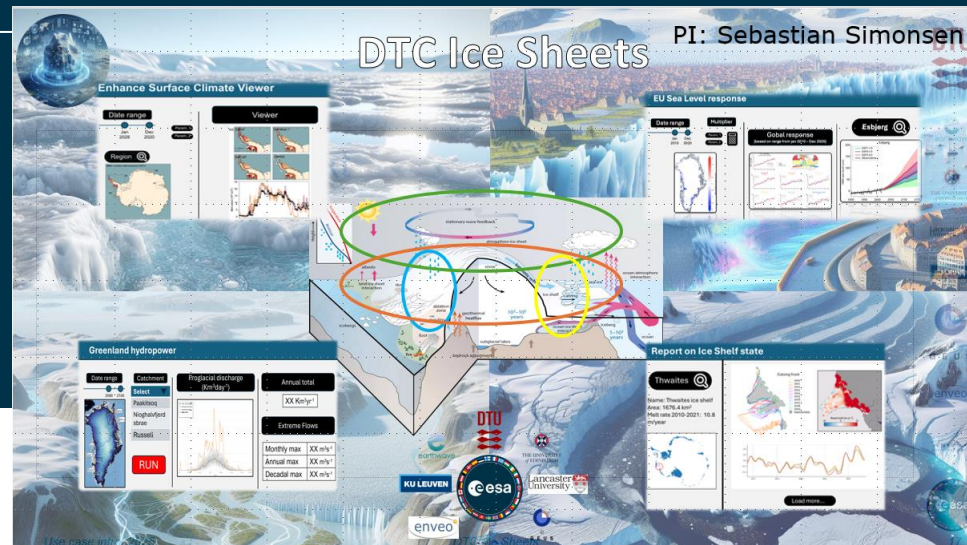


Dash: Contribution to sea level.
4D: Ice-sheet surface elevation change.

ESA Digital Twin Earth Precursor Activity



- **ESA Digital Twin Earth Programme**
 - Companion programme to EC Destination Earth - DestinE
- **EO-based Digital Twin Components**
 - Advanced digital replicas of key components of the Earth system



- Maximise the potential offered by the latest advances in EO capabilities.
- Data analytics capabilities, advanced simulations, and what-if scenarios.
- Scientifically-validated decision support tools

New Opportunities...

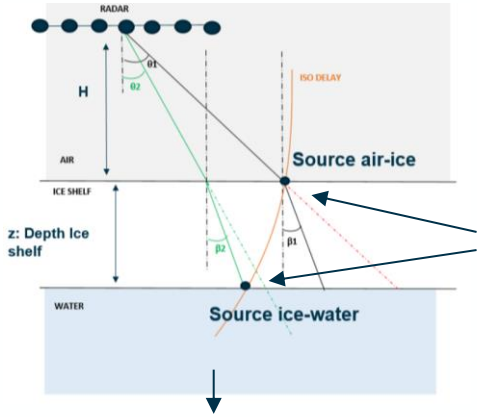


BIOMASS: ICESHELVES BASAL TOPOGRAPHY MAPPING

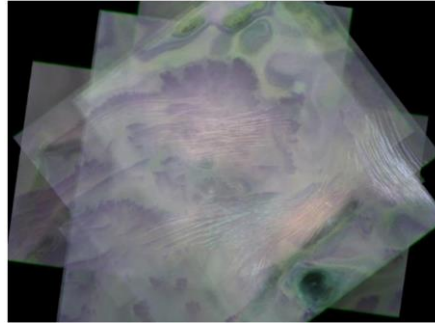
Launched:
April 29, 2025



BIOMASS SYNTHETIC LINEAR ARRAY (7 ACQUISITIONS)



2 scattering sources

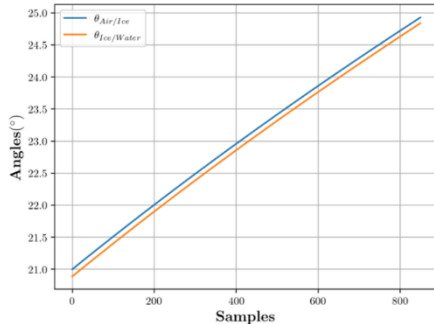


SAR IMAGE at P-band in Greenland (ONERA measurements [1])

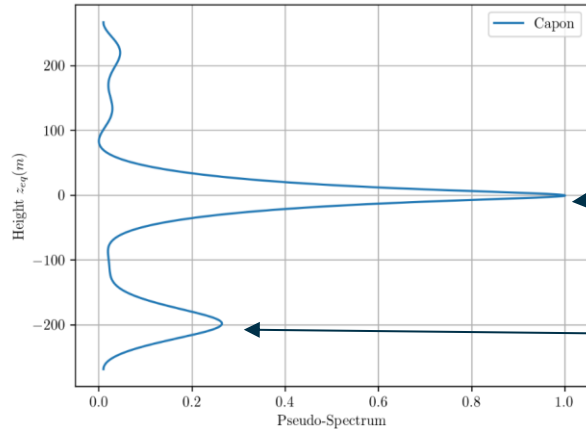


10 km

We can exploit the different direction of arrival from each interface



Tomographic processing



Simulated Tomographic reconstruction from 7 acquisitions

interface air-ice

Interface ice-water

1. Ensure coordination and involvement of EO community
2. New funded scientific activities dedicated to Antarctica Insync
 - Topic selection guided by science community consultation
 - Involving both in-situ and space elements
3. Coordinate EO efforts
 - Support development of dedicated datasets
 - Facilitate collaborations between space agencies, remote sensing community, and others
4. Support cloud-based open science platforms for collaborative research (Antarctica Insync Data Space)
5. Support scientific consultation and dialogue (e.g., workshops) and training activities



ANTARCTICA INSYNC

