ALBATROSS

ALtimetry for BAthymetry and Tide Retrievals for the Southern Ocean, Sea ice and ice Shelves

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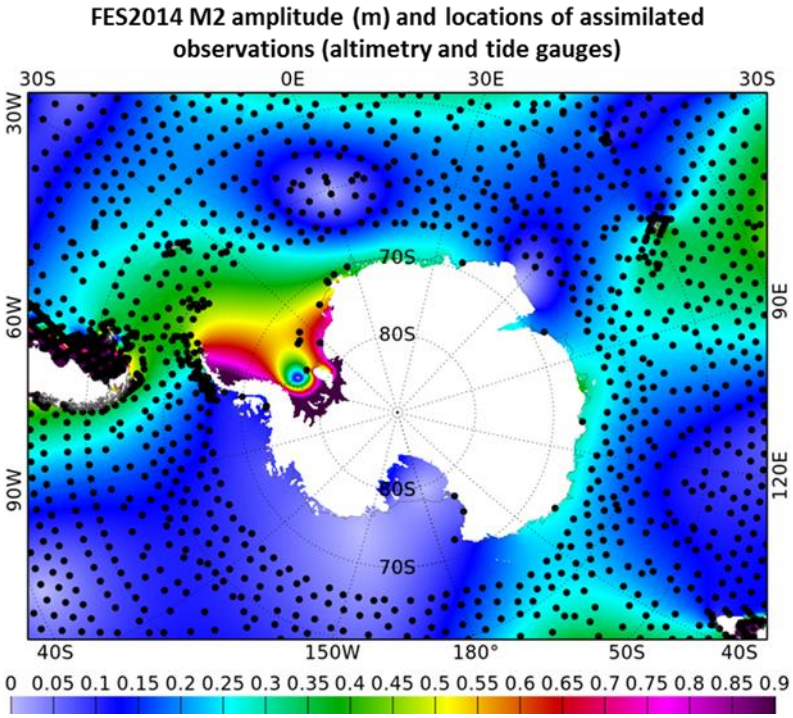
ESA Polar Science Cluster Meeting

ALBATROSS overview

- The knowledge about ocean tides is at the crossroads of many scientific fields, especially in the Polar regions:
  - ocean circulation modelling and better understanding of sea and ice interactions,
  - sea surface height and sea ice estimates from satellite altimetry,
  - understanding of ice-shelf dynamics…
- However, this knowledge is still limited by several aspects:
  - In situ and satellite observations availability,
  - hydrodynamic model resolution
  - bathymetry quality…

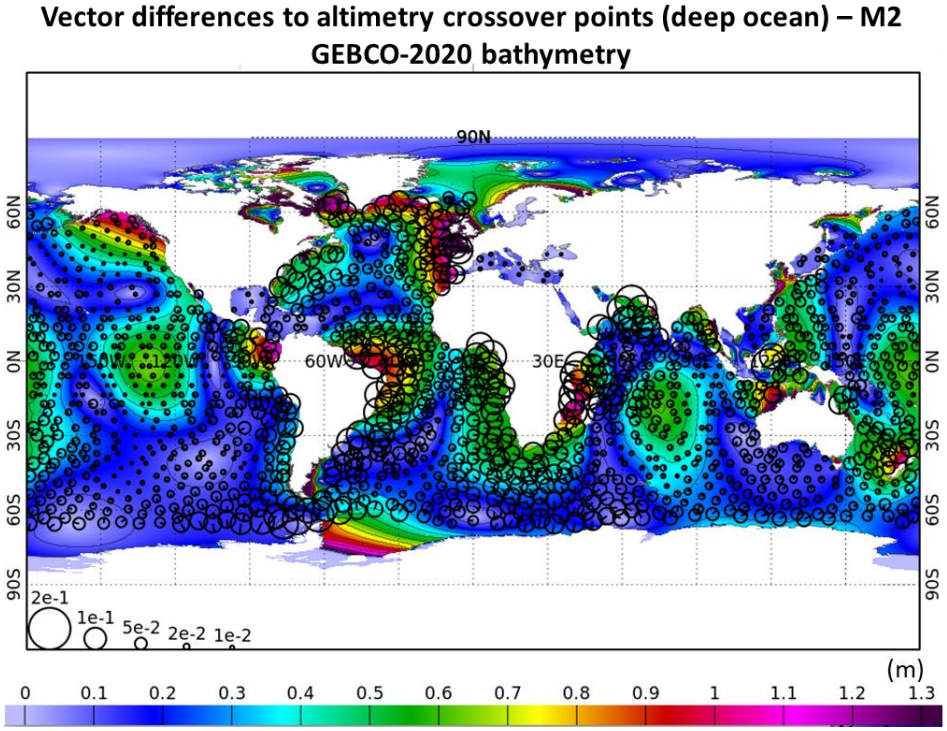
The ALBATROSS project aims to improve knowledge about bathymetry and ocean tides in the Southern Ocean.

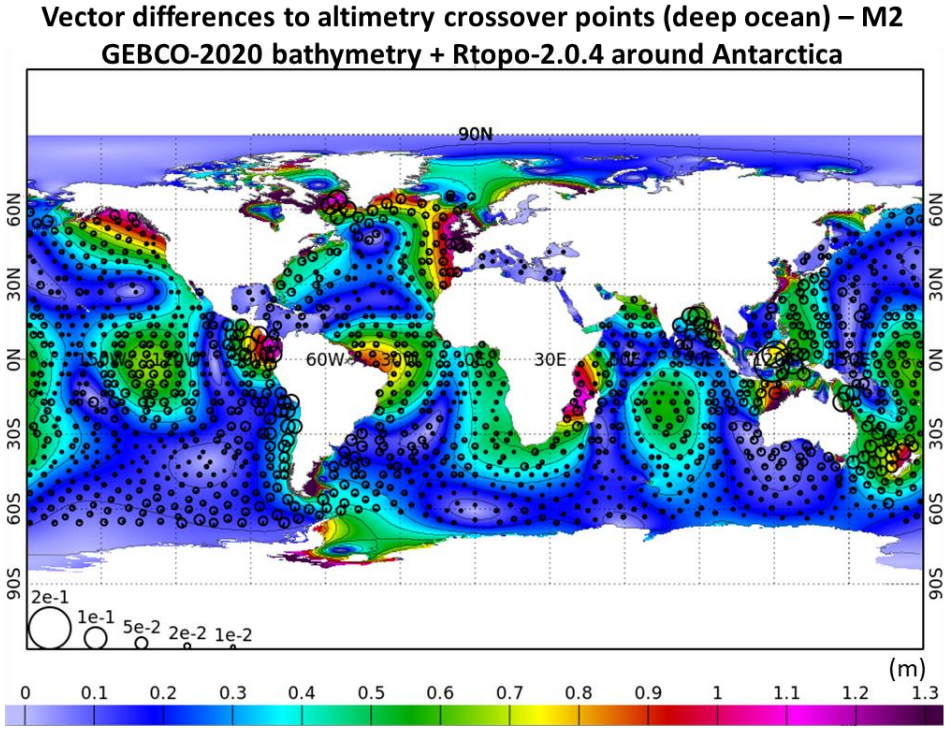


ALBATROSS overview

Tides in the Southern Ocean have influence in the whole global ocean.

And bathymetry information is crucial, in particular beneath the ice shelves.





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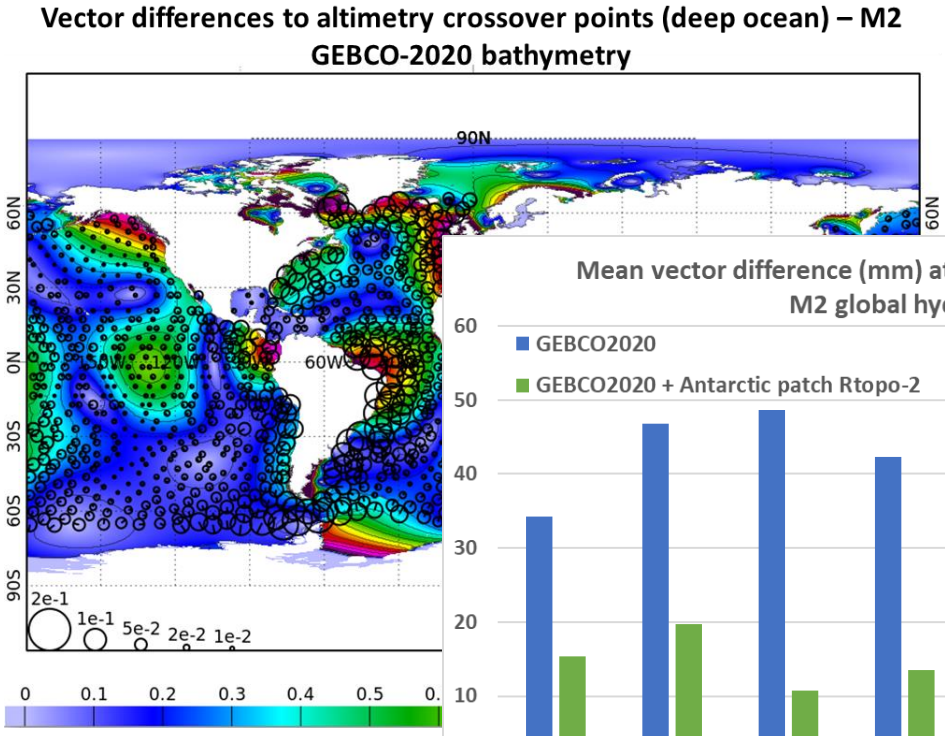
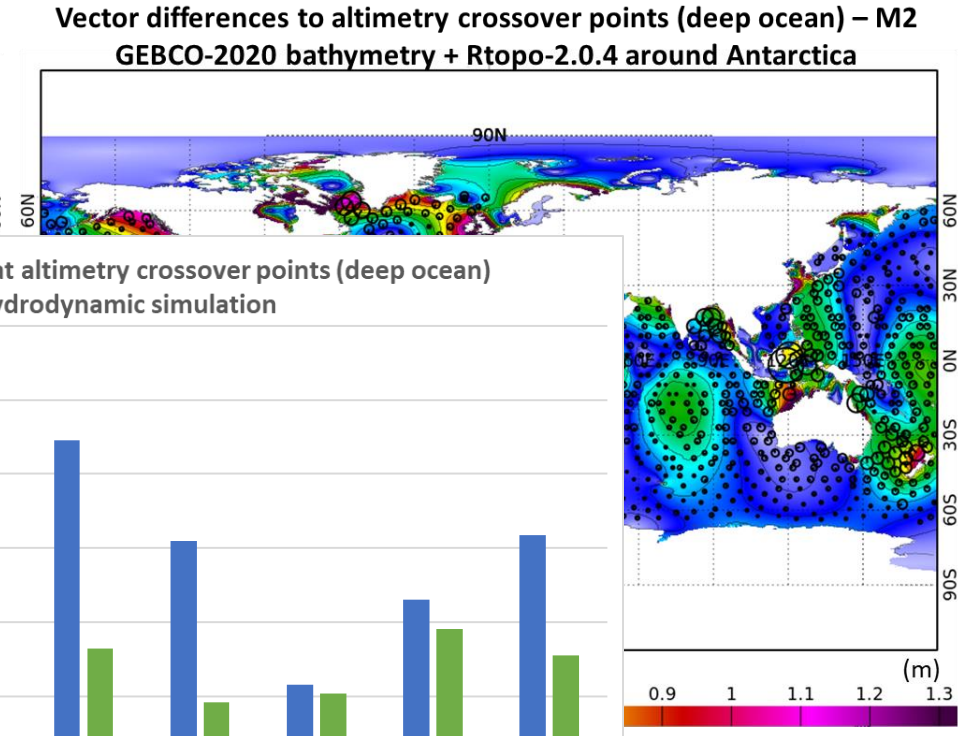
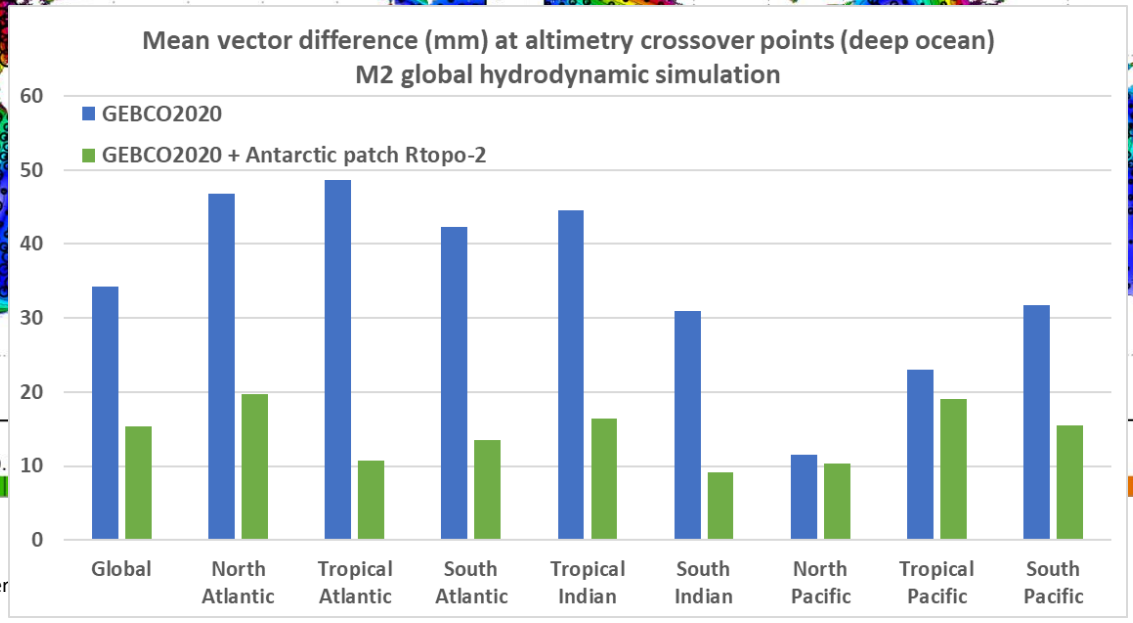






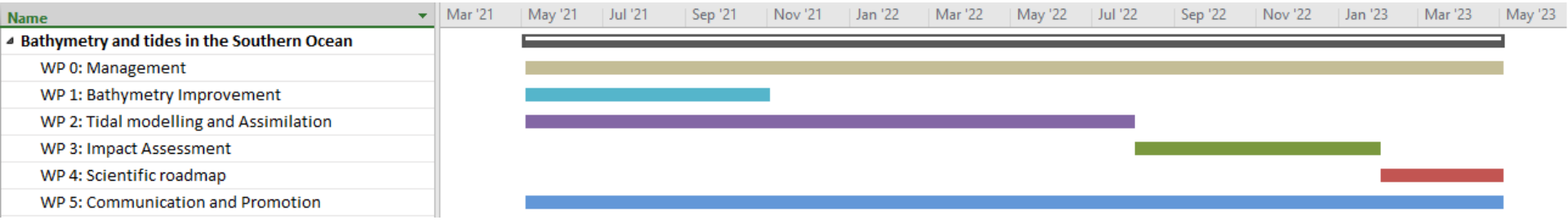
Objectives of the ALBATROSS project

- **Improve the knowledge on bathymetry around Antarctica thanks to**
  - Decade-long most recently reprocessed CryoSat dataset (SAR and SARin modes),
  - Information on bathymetry gradient locations through the analysis of sea ice surface roughness characteristics,
  - The compilation of the best available data in ice-shelf regions.
- **Improve the knowledge on ocean tides in the Southern Ocean**
  - Implementation of a high-resolution hydrodynamic model based on the most advanced developments in terms of ocean tide modelling
  - Data assimilation of observations, including satellite-altimetry derived tidal retrievals from the most recent and relevant satellite altimetry products
- **Improve satellite altimetry retrievals of sea surface heights and sea ice information**
- **Improve the retrievals of ice shelves parameters**
- **Share information and knowledge with other Polar science initiatives and projects**

Planning of the ALBATROSS project (May 2021 – May 2023)

- WP1: Bathymetry improvement (DTU/UCL/NPI/NOVELTIS)
- WP2: Tidal modelling and data assimilation (NOVELTIS/DTU/NPI)
- WP3: Impact assessment (UCL/NPI)

+ provision of products samples to external users & feedback



Bathymetry improvement – in the deep ocean (DTU)

- **CryoSat-2 altimetry mission**
  - Measurements up to 88°S
  - SAR and SARin modes for higher along-track resolution
  - 369-day repeat period: very dense spatial coverage
  - Use ESA GPOD altimetry processed using SAMOSA+ physical retracker.
- **Improvement of the altimetric gravity model in the Southern Ocean**
  - Recently completed DTU21 Global marine gravity field.

➔ Satellite altimetry improves **wavelengths from 20 km to 100 km in the deep ocean**

➔ **On the shelves, the noise increases** and different approaches are needed (satellite imagery, field campaigns, open access to existing data…)

Bathymetry improvement – in the deep ocean (DTU)

Combine a prior bathymetry dataset with gravity field based on CryoSat-2

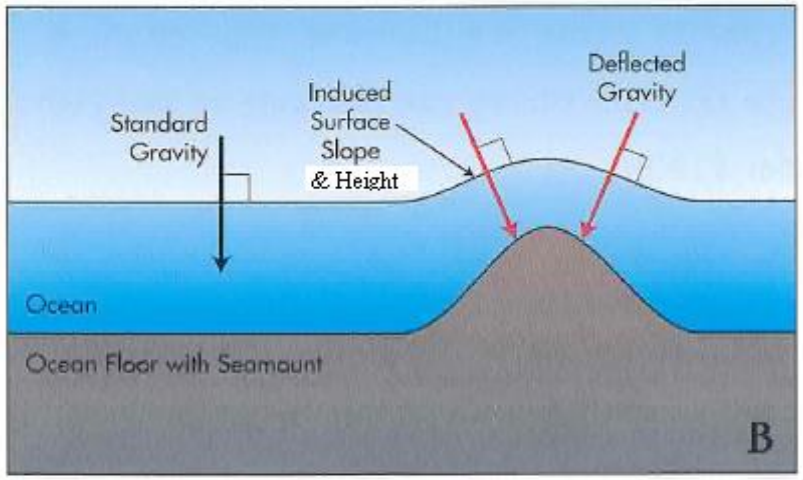
$$H_p(x) = B_{long}(x) + S(x) \cdot G_{BP}(x) + B_{short}(x)$$

H_p : predicted bathymetry

B_{long} : a priori bathymetry (basis)

S : scaling factor to convert gravity to topography, in m/mGal

G_{BP} : band-pass filtered gravity



→ Bathymetry and gravity are correlated only on a limited spectral bandwidth

→ 1 mGal gravity anomaly ~ 15 m bathymetry

→ Inversion only at points where correlation between topography and gravity > 0.5

→ A priori bathymetry kept when correlation is too low for the computation

→ Less effective in shallow waters close to the coasts and in regions with thick sediment layers

→ See *Abulaitijiang et al, 2019, Earth and Space Science,* for more details

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From Abulaitijiang et al, 2019

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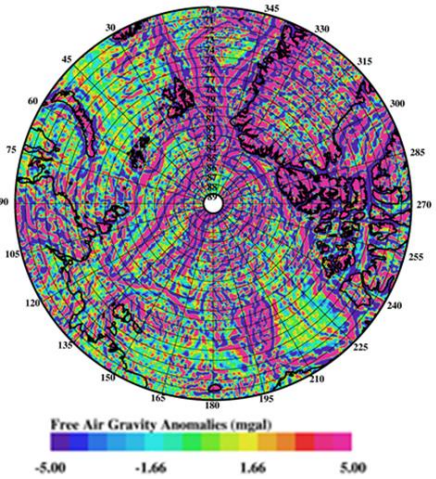
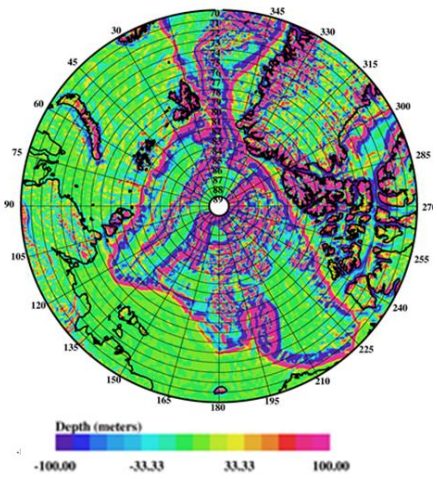
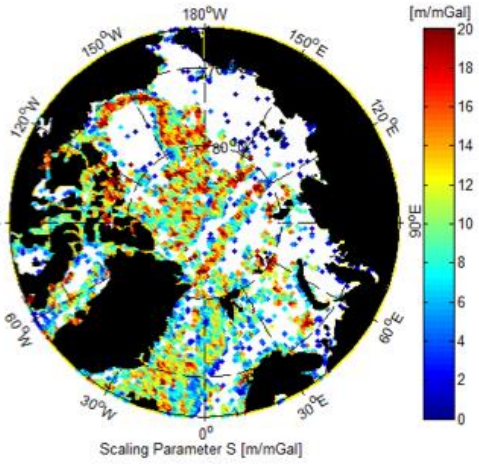
+ evaluation against multi-beam surveys



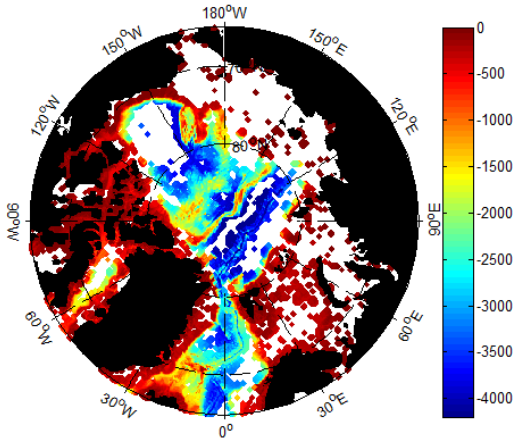
DTU17GRA with CryoSat-2 (20-70 km wavelengths)



LEGOS bathymetry (20-70 km wavelengths)



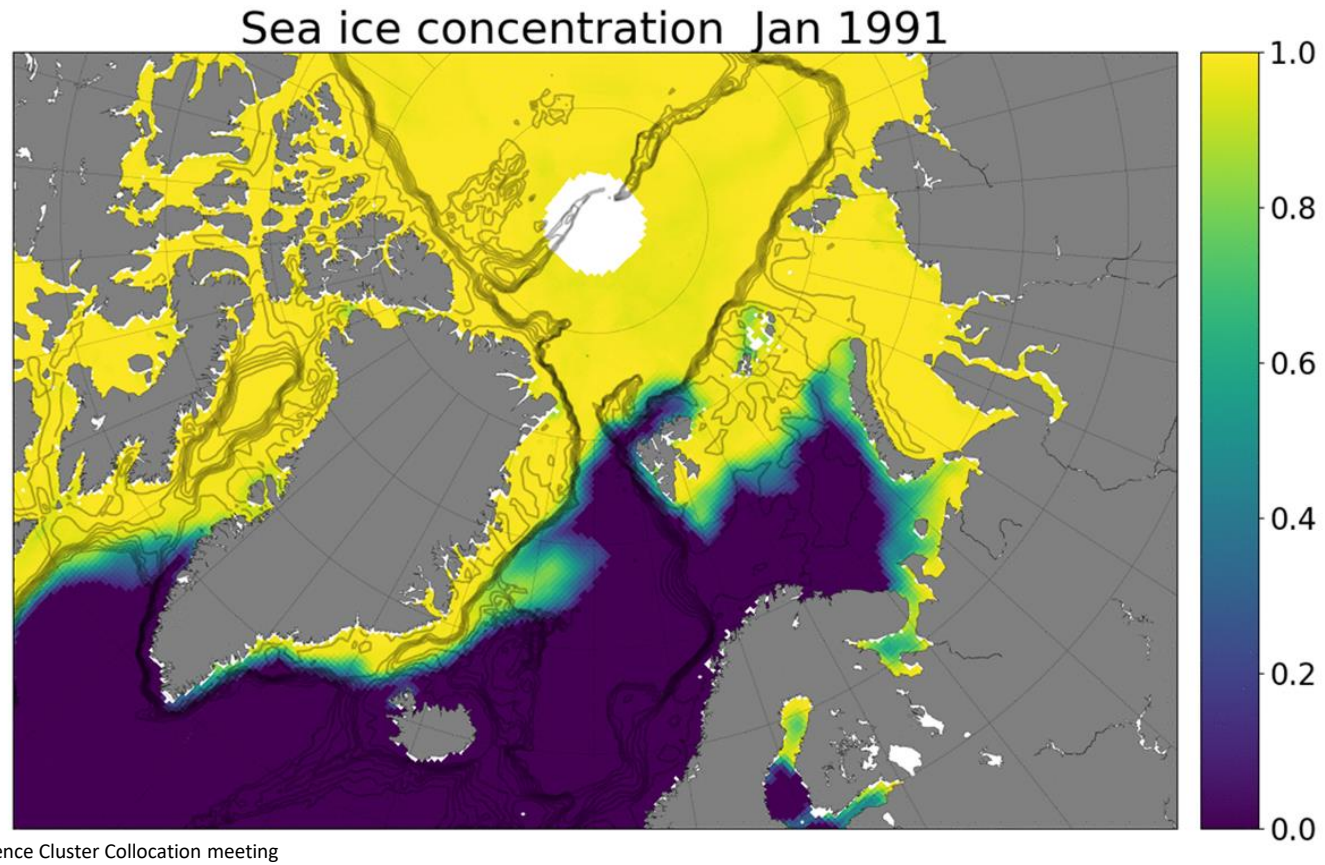
Scaling factor S



Predicted bathymetry

Sea ice surface characteristics to improve bathymetry gradient location (UCL)

Bathymetry controls ocean currents, temperature… and sea ice presence



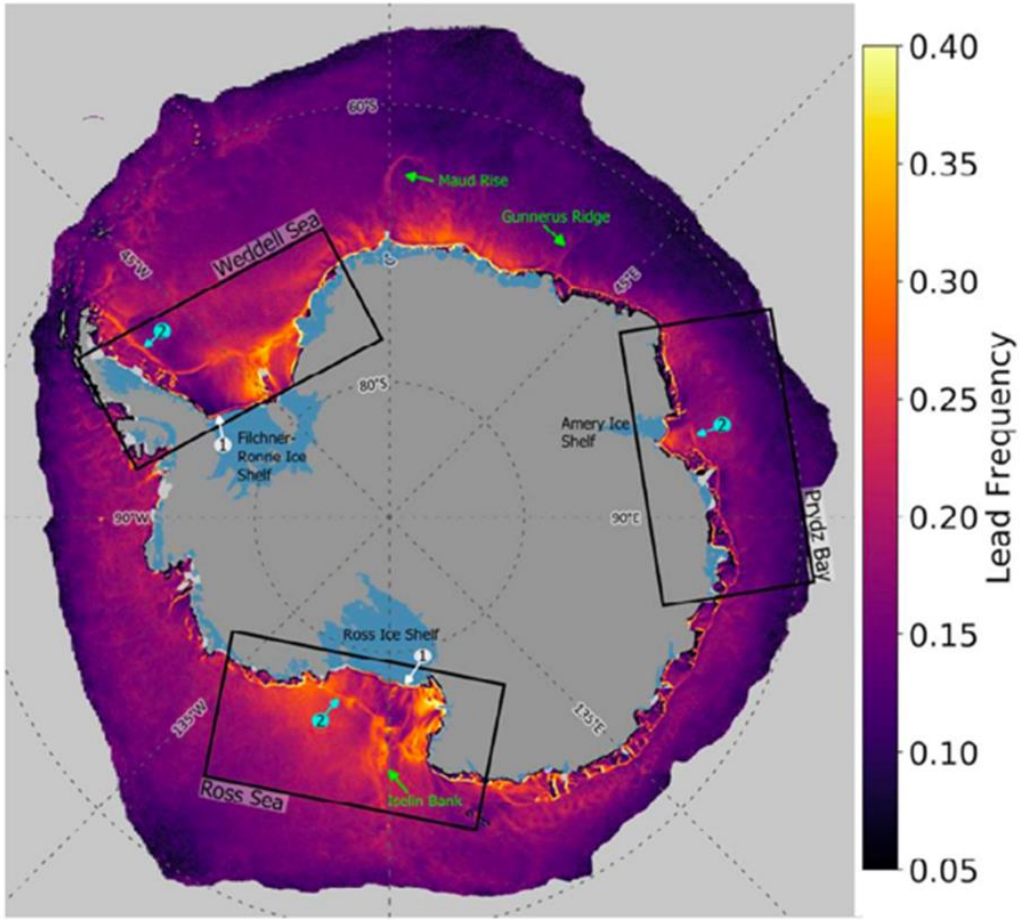
Sea ice surface characteristics to improve bathymetry gradient location (UCL)

Seeking a surface signature of bathymetry

Locations of steep bathymetry act as hot spots of enhanced vertical heat fluxes mediated by tides and increased turbulence.

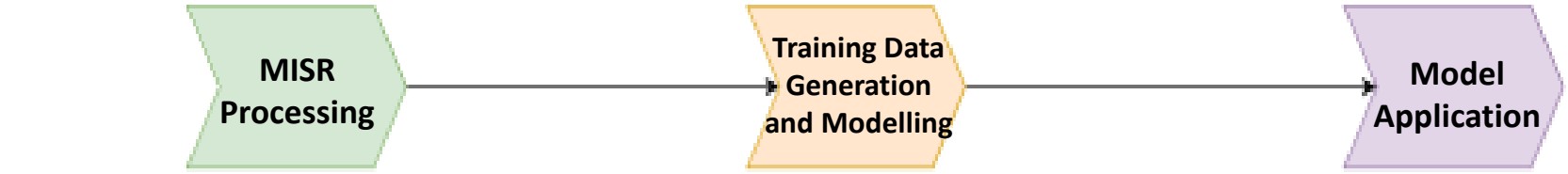
Higher lead density correlates very well with steep bathymetry

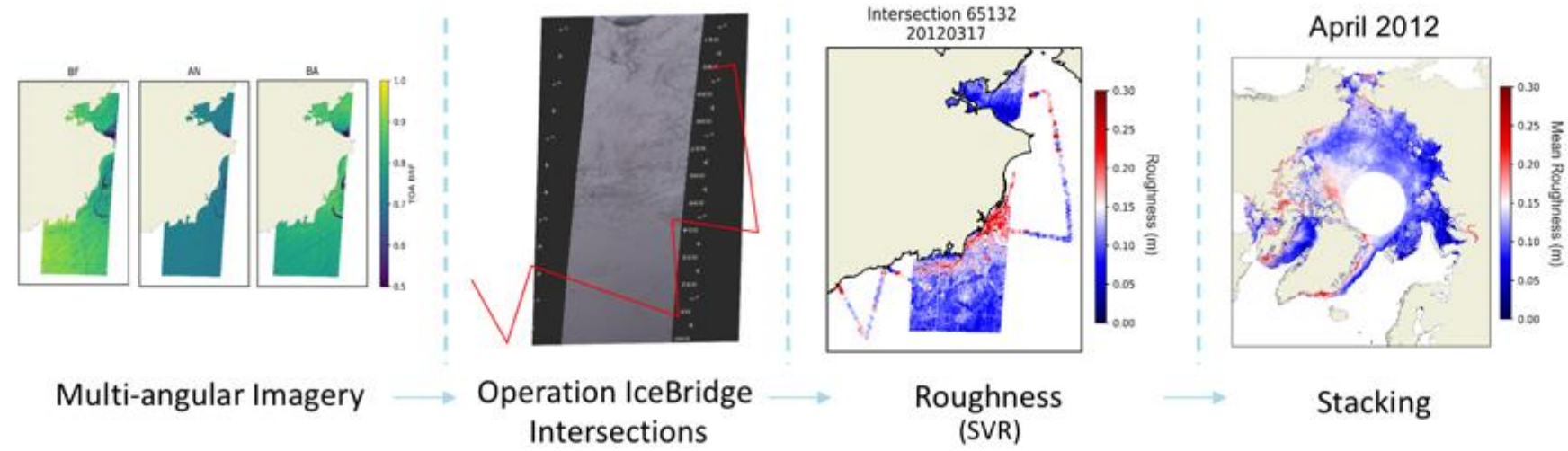
➔ Use the surface properties of the sea ice to locate the bathymetry gradients



Sea ice surface characteristics to improve bathymetry gradient location (UCL)

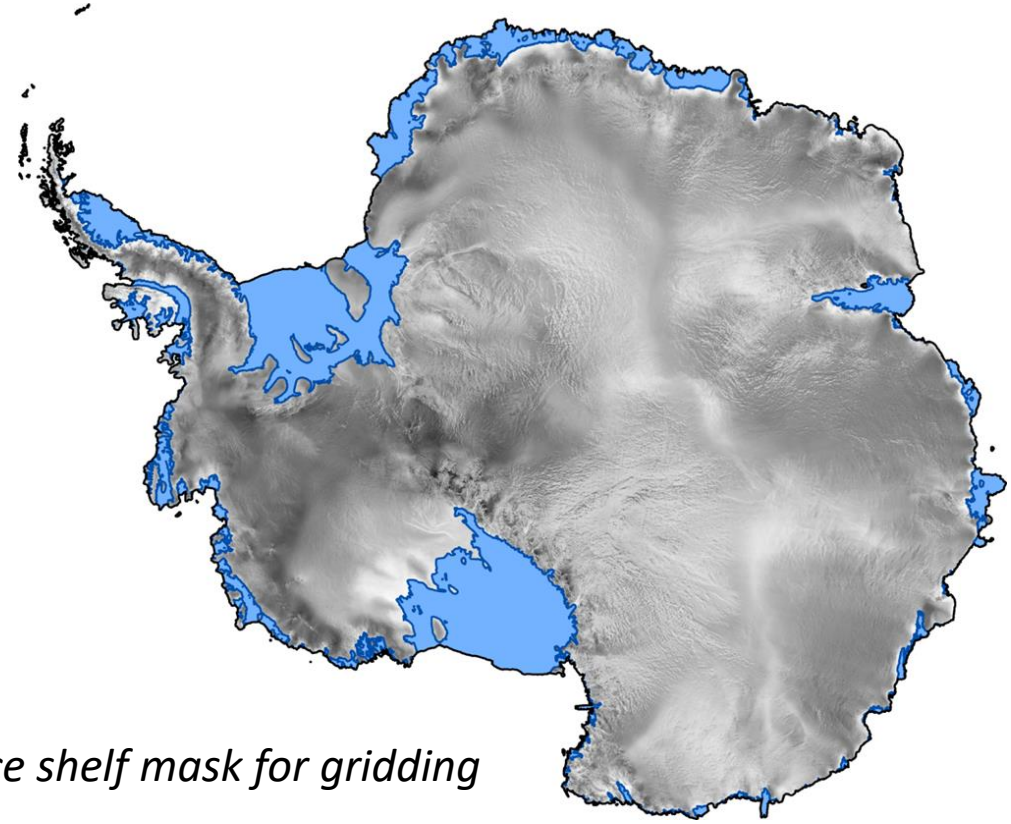
Novel technique developed at ES_UCL using 20 years of NASA MISR (Multi-angle Imaging Spectro-Radiometer)





Bathymetry information under the ice shelves (NPI)

- Update map of **grounding line** locations
- Define **ice shelf grid**, merge with ocean grid
- Implement existing **bathymetry data** (UAVs, ice seismics, airborne gravity…)
- Add **local constraints** for grounded features
- Interpolation/modelling of **bathymetry grid**
- **Check against ice shelf draft** from altimetry

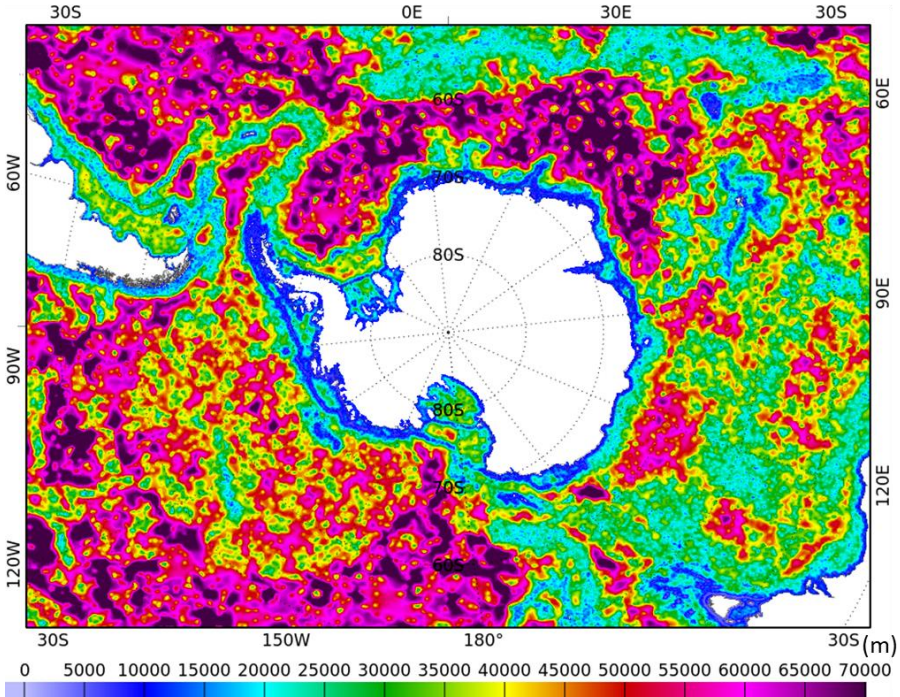


Example, ice shelf mask for gridding

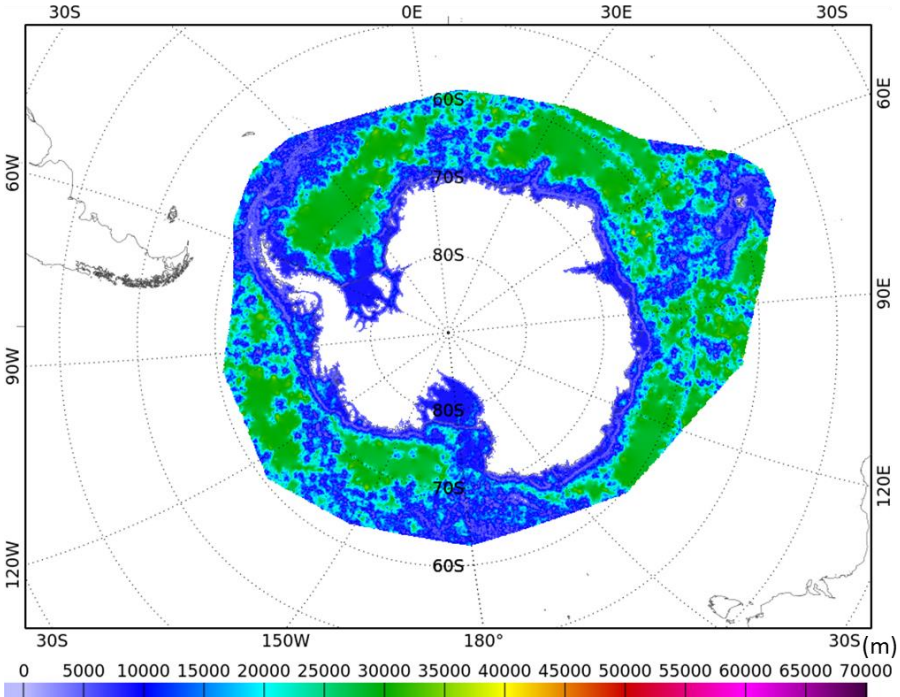
High-resolution regional modelling (NOVELTIS)

- Increase in the model unstructured grid resolution
- Careful definition of the model extent (bathymetry features, tidal energy fluxes)
- Regional/local tuning of the model parameters
- Use of the tight link between the bathymetry and the ocean tides to assess the new bathymetry datasets via the tidal model

Resolution (in m) of the FES2014 global mesh in the Southern Ocean



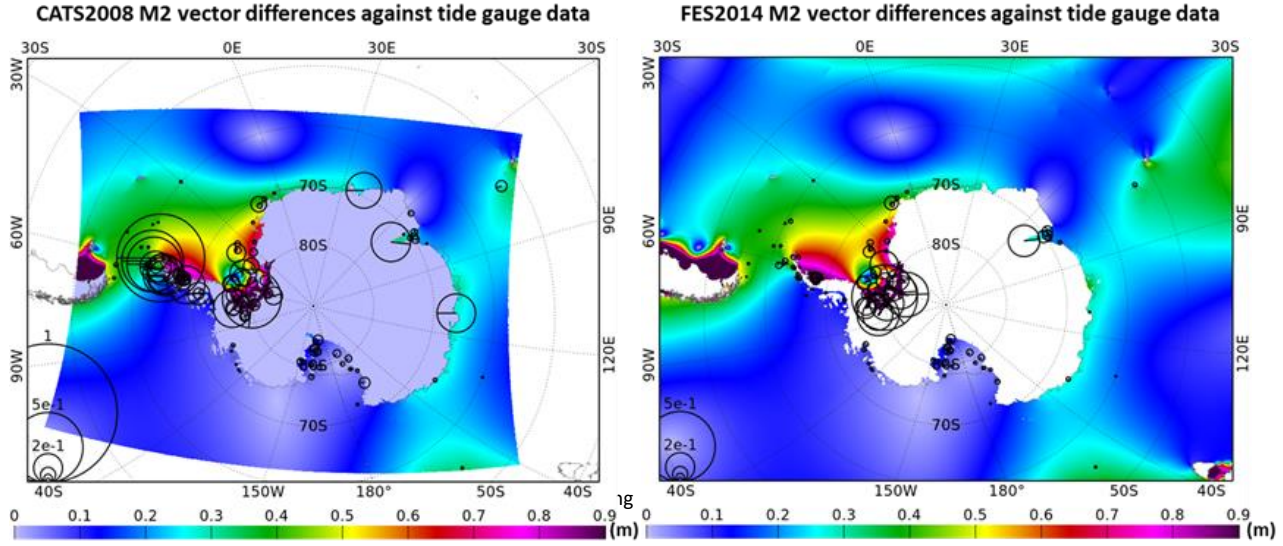
Resolution (in m) of the ALBATROSS regional mesh (first version)



In the ocean, the model validation will be done against altimetry and tide gauge observations

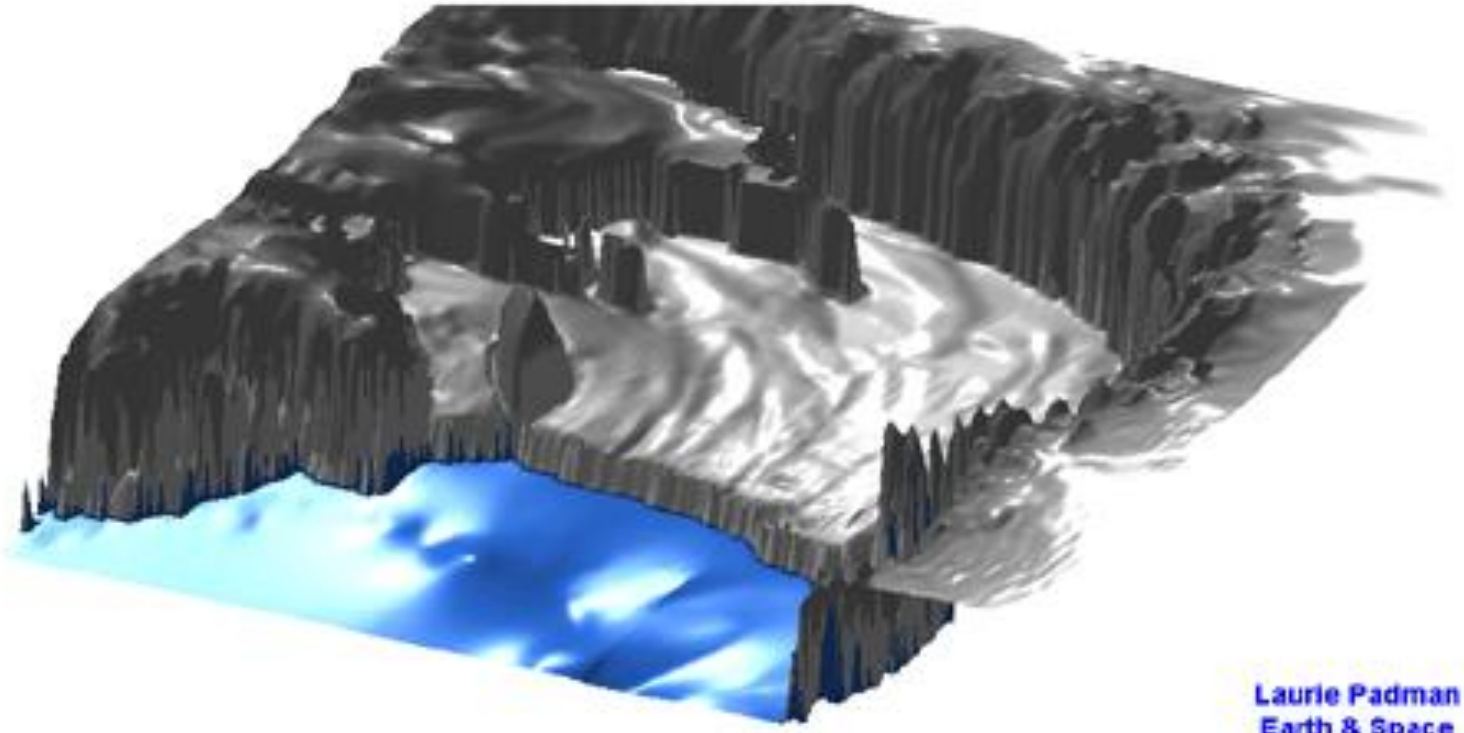
- **In the frequency domain,** wave by wave (altimetry and tide gauges)
- **In the temporal domain,** via time series comparison with tide gauges
- **Comparison with other tidal models** (global and regional)

→ Specific processing of satellite altimetry data (CryoSat-2, Sentinel-3) to retrieve tidal harmonic constituents (DTU)



Tidal model validation in the ice-shelf regions (NPI)

- Local validation from ice-shelf GPS records
- Regional validation from CryoSat-2/ICESat-2 analyses



Laurie Padman
Earth & Space
Research

Impact assessment of the ALBATROSS regional tidal model

- **In the ocean (UCL)**
  - **Evaluation of the impact on the CryoSat-2 SSH and sea ice products** (links with the CryoSat+ Antarctic Ocean project)
- **For the ice shelves (NPI)**
  - **ice-shelf thickness change and basal melting:**
    - parallel calculations with different tidal models, as well as without any corrections
    - deriving ice thickness rates from repeated CryoSat-2 and ICESat-2 measurements using least-squares fits
    - assuming that the residuals of the calculations will reduce when tidal corrections improve
  - **impact on future monitoring of Antarctic ice shelves and the vulnerability to tide-induced instability**

+ Provision of samples of products (tidal elevations for example) to other polar projects and initiatives.

➔ **If interested, please do contact us!**

Thank you for your attention!

albatross.noveltis.fr