ALBATROSS

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

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ALBATROSS overview

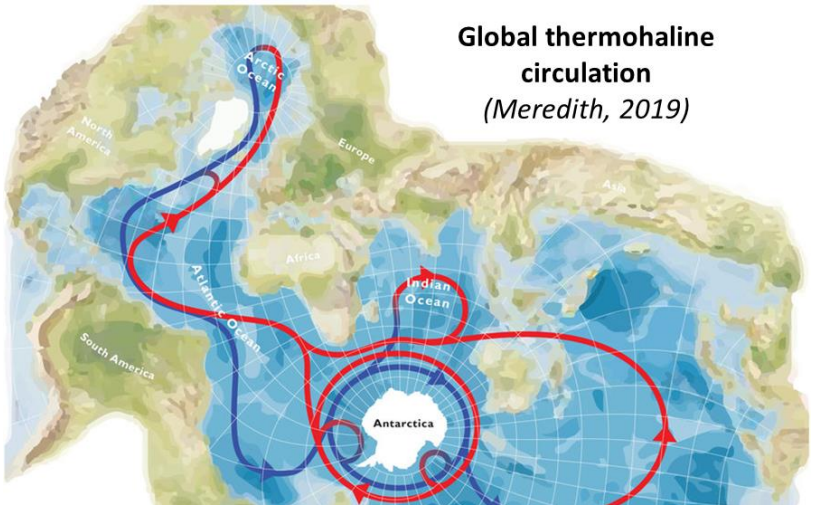
- 2-year project (2021-2023)
- Funded by ESA in the frame of the Polar Science Cluster, EO4Society Programme

More details, documents, and products, ultimately: **albatross.noveltis.fr**

ALBATROSS overview

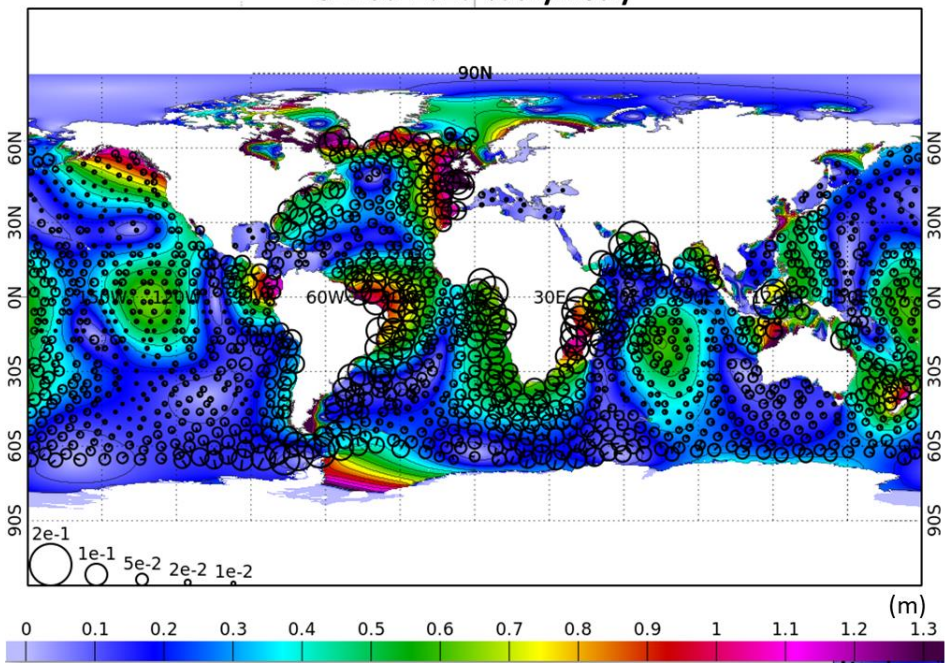
All oceans are connected in one global ocean where the Southern Ocean plays a major role.

Including for the ocean tides, with key role of large ice-shelf regions.

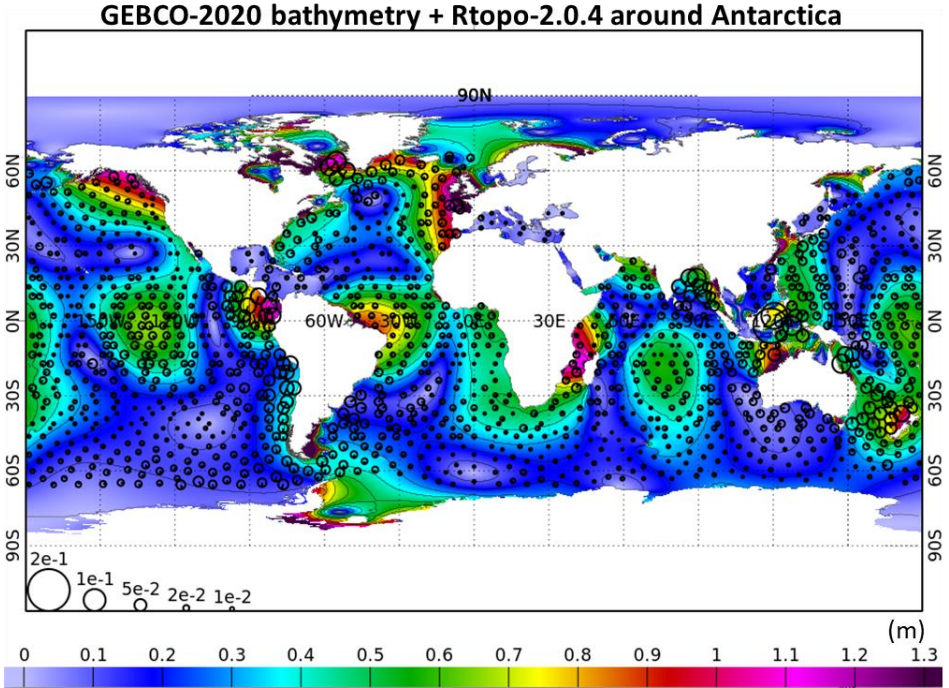


Global thermohaline circulation
(Meredith, 2019)

Vector differences to altimetry crossover points (deep ocean) – M2
GEBCO-2020 bathymetry



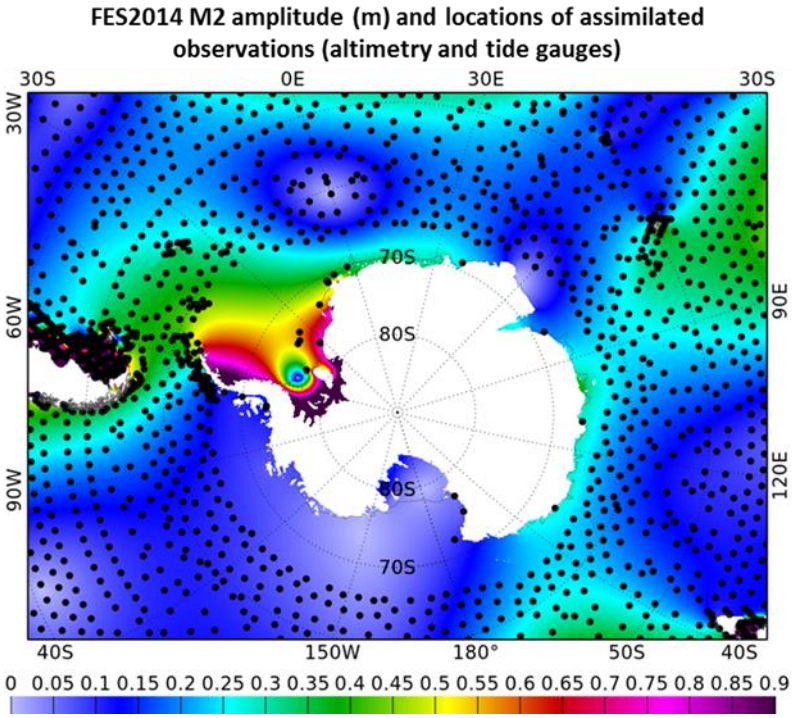
Vector differences to altimetry crossover points (deep ocean) – M2
GEBCO-2020 bathymetry + Rtopo-2.0.4 around Antarctica



ALBATROSS overview

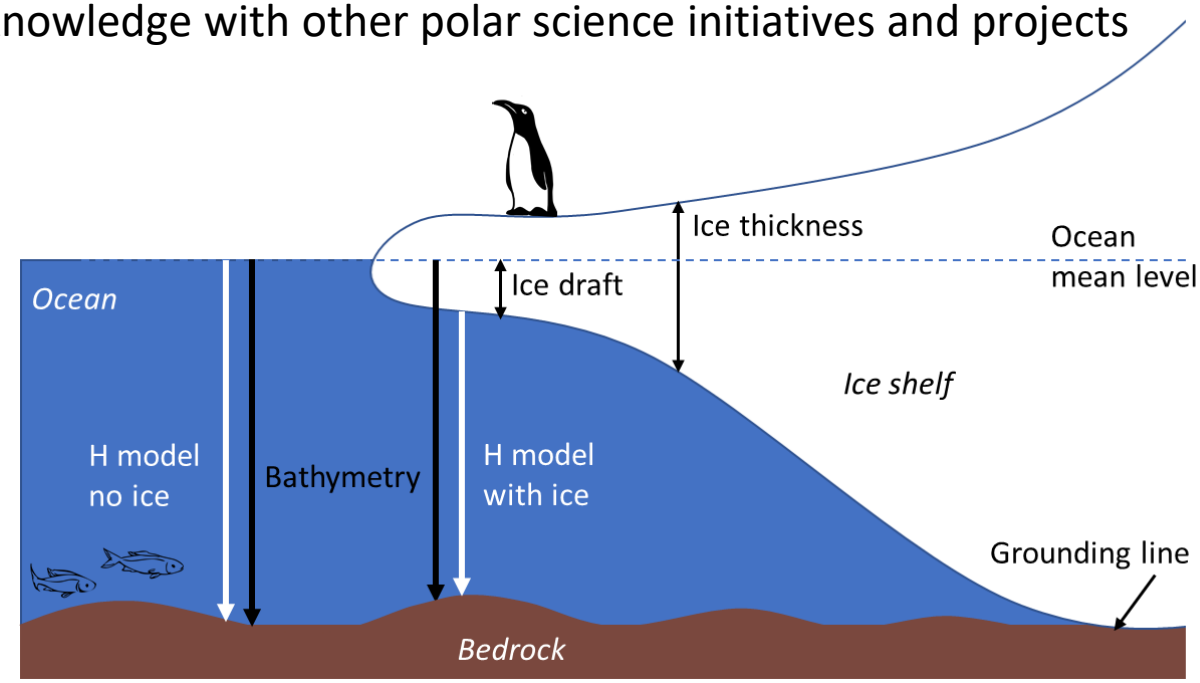
- Knowledge on ocean tides in the Southern Ocean is still limited by several factors:
  - In situ and satellite observations availability and accuracy
  - Bathymetry quality
  - Coastline / grounding line location
  - Friction under the ice…

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



Objectives of the ALBATROSS project

- Use satellite observations to improve the bathymetry, the grounding line and the coastline information
- Explore linkage between sea ice roughness, bathymetry gradients and tides
- Retrieve tidal estimates from CryoSat-2 data (*see O. Andersen's talk*)
- Implement a new high-resolution tidal model with data assimilation
- Share information and knowledge with other polar science initiatives and projects

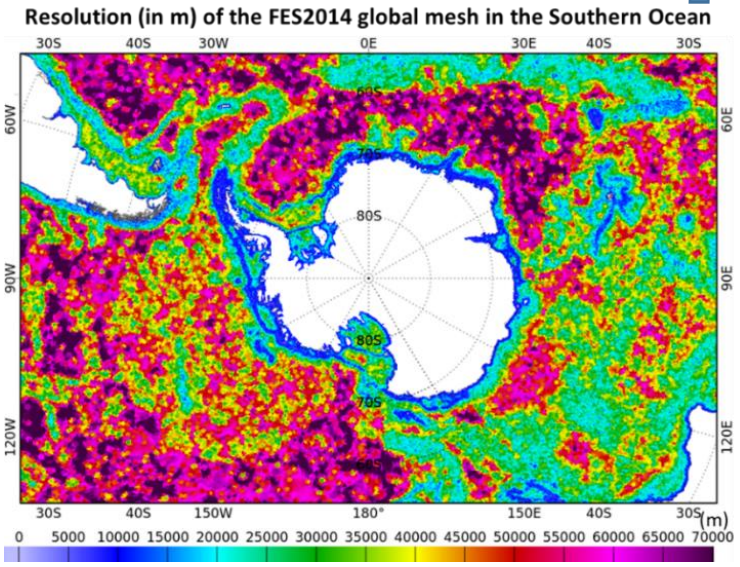


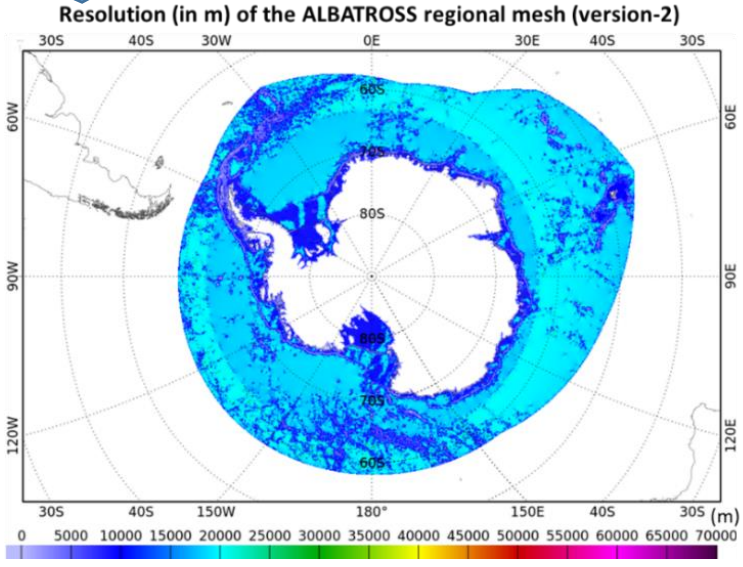
High-resolution regional tidal modelling (NOVELTIS)

Tidal modelling strategy based on TUGO-m hydrodynamic model, same approach as for FES2014 and FES2022 models *(see F. Lyard's talk)*

- High-resolution unstructured mesh grid
- Careful definition of the model extent (bathymetry features, tidal energy fluxes)
- Regional/local tuning of the model parameters
- Altimetry and tide gauge data assimilation (to be done)

nb elements x 7





Bathymetry improvement – in the deep ocean (DTU)

Bathymetry and gravity are correlated only on a limited spectral bandwidth (~20 – 100 km)

1 mGal gravity anomaly ~ 15 m bathymetry

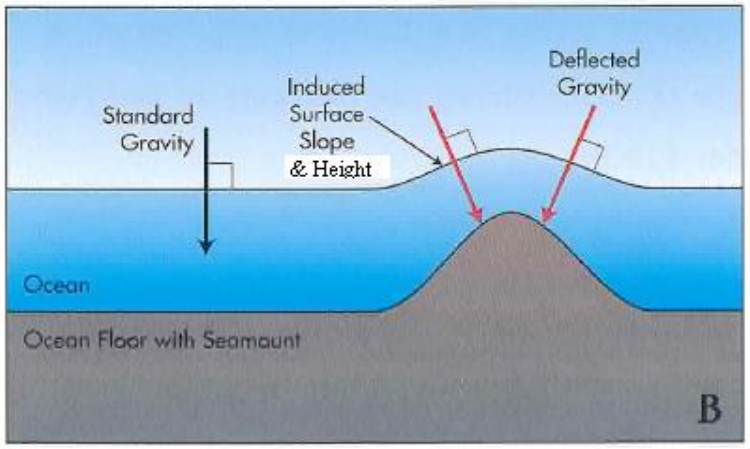
$$H_p(x) = B_{long}(x) + S(x) \cdot G_{BP}(x) + B_{short}(x)$$

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



Combination of a prior bathymetry dataset with the DTU21 gravity field based on CryoSat-2 data reprocessed with SAMOSA+

→ 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, other approaches are needed (satellite imagery, field campaign…)

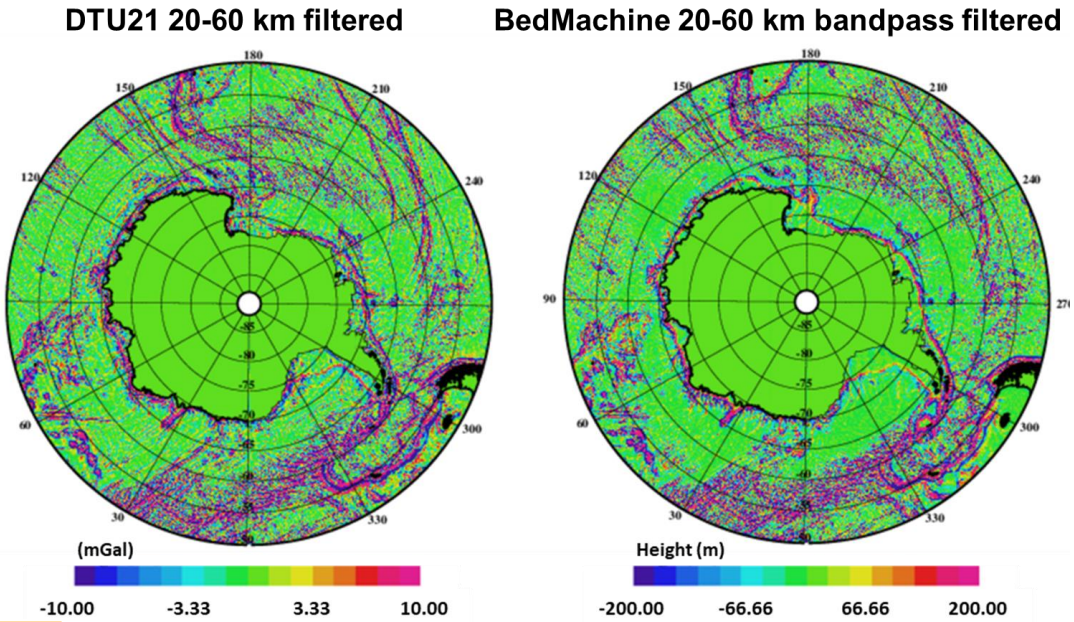
Bathymetry improvement – in the deep ocean (DTU)

Initial sea floor topography: BedMachine_Antarctica-2020-v2 *(Morlighem et al., 2020)* + RTopo-2.0.4 *(Schaffer et al., 2019)* to cover the whole area of interest.

Tested against 5.8 millions bathy observations (std 695 m), available down to 60°S only… and already ingested into BedMachine.

→Local improvement observed but direct validation quite limited due to lack of (independent) data

→Further exploration of the cut-off length values



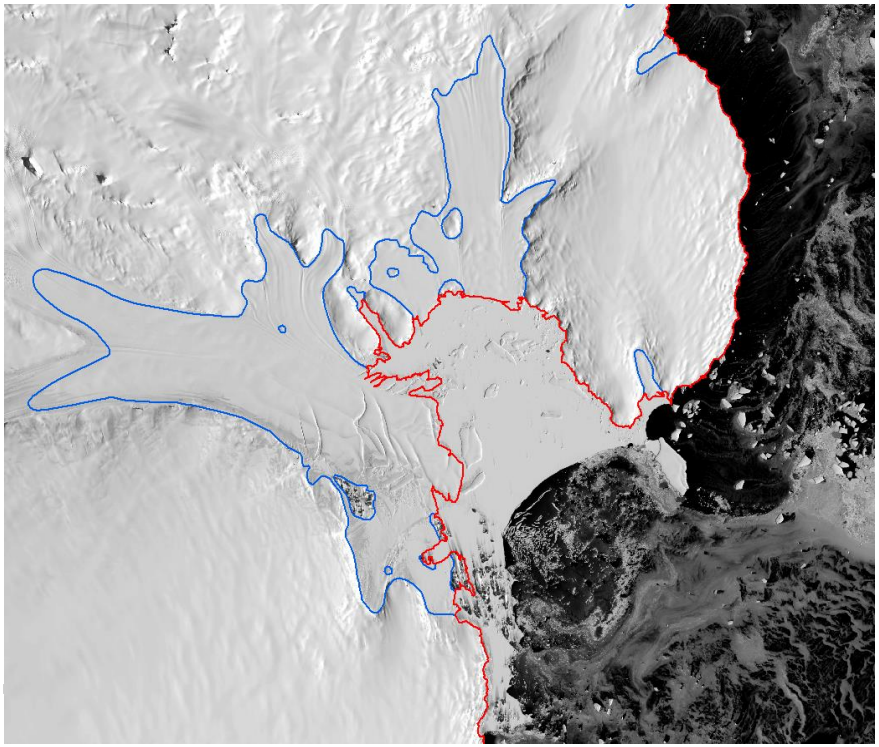
Diff (m) with surveys	mean	std	min	max
BedMachine	-32	235	2453	2678
DTU-ALBATROSS	-33	224	2453	2769

→Hydrodynamic tidal modelling can be used as a proxy to assess the new bathymetry model

Ice shelves bathymetry, coastline and grounding line (NPI)

Accurate information about grounding line location, bedrock topography and ice draft under the ice shelves is crucial to perform accurate tidal simulations.

- Updated masks for grounding line and coastline, based on SAR interferometry, altimetry, and new Landsat-8/Sentinel-2 imagery
- Updated ice-shelf bathymetry and ice draft, based on recent bathymetry datasets.

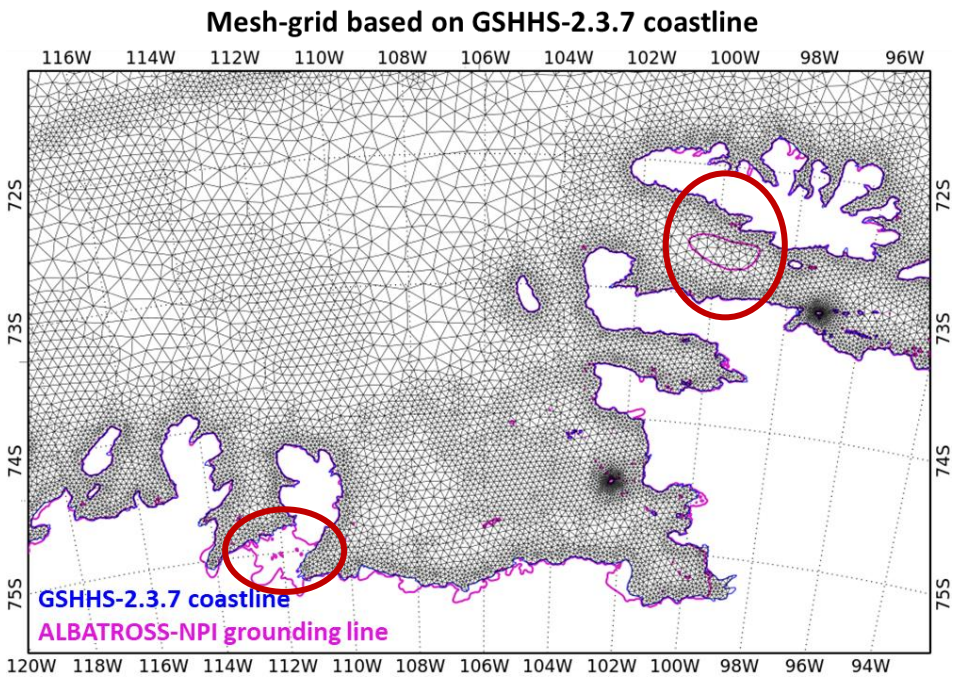


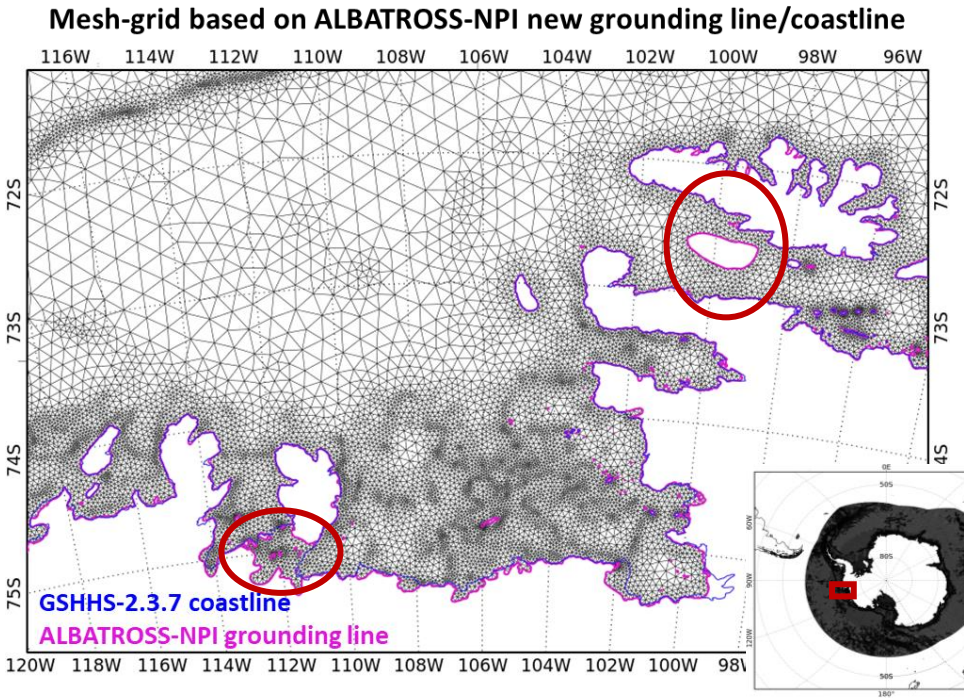
Combine coastline (red) with grounding line (blue), extraction of ice-shelf mask

Ice shelves bathymetry, coastline and grounding line (NPI)

Accurate information about grounding line location, bedrock topography and ice draft under the ice shelves is crucial to perform accurate tidal simulations.

- New combined grounding line & coastline used as model grid land boundary, instead of GSHHG-2.3.7 coastline





Sea ice surface roughness and bathymetry gradient location (UCL)

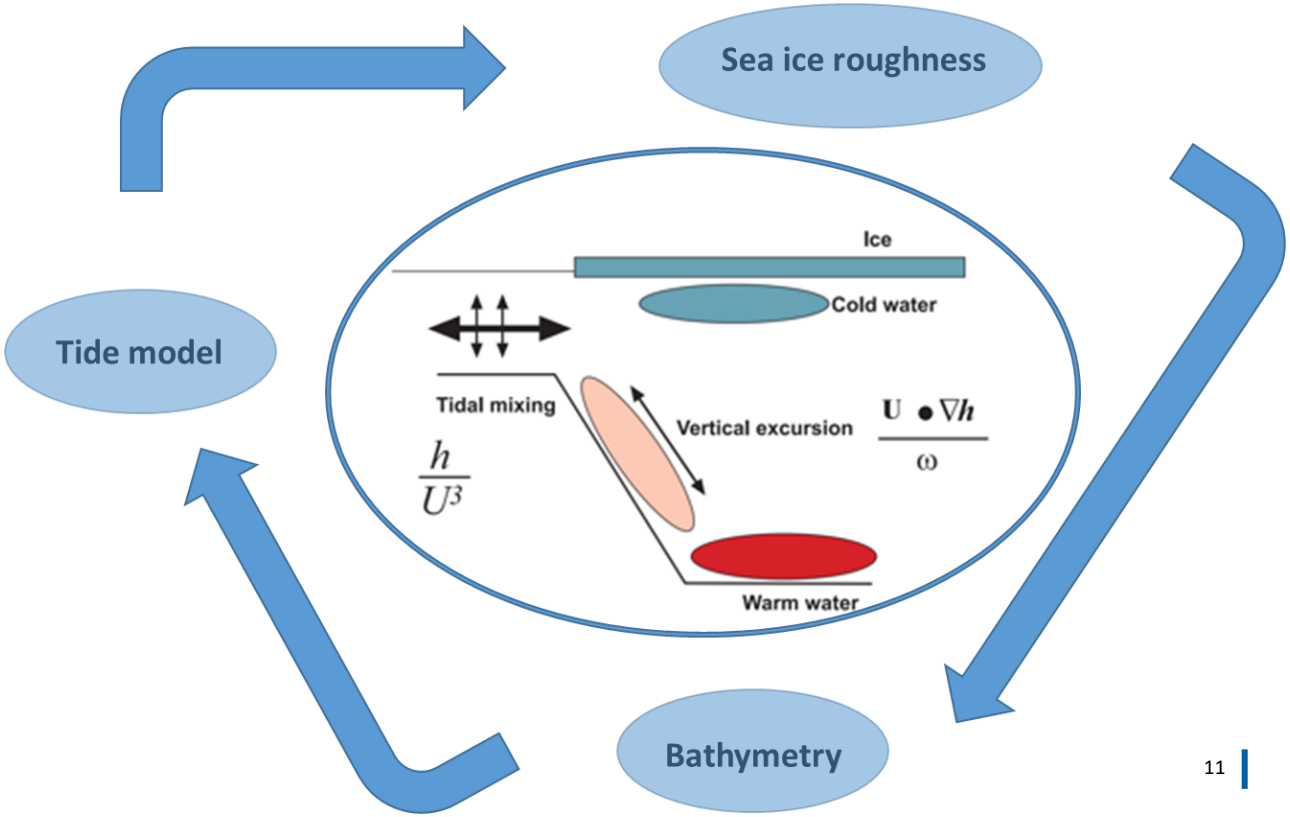
Bathymetry controls ocean currents, temperature… and sea ice presence

Seek a surface signature of bathymetry, in the sea ice roughness

Steep bathymetry acts as hot spots of enhanced vertical heat fluxes mediated by tides and increased turbulence.

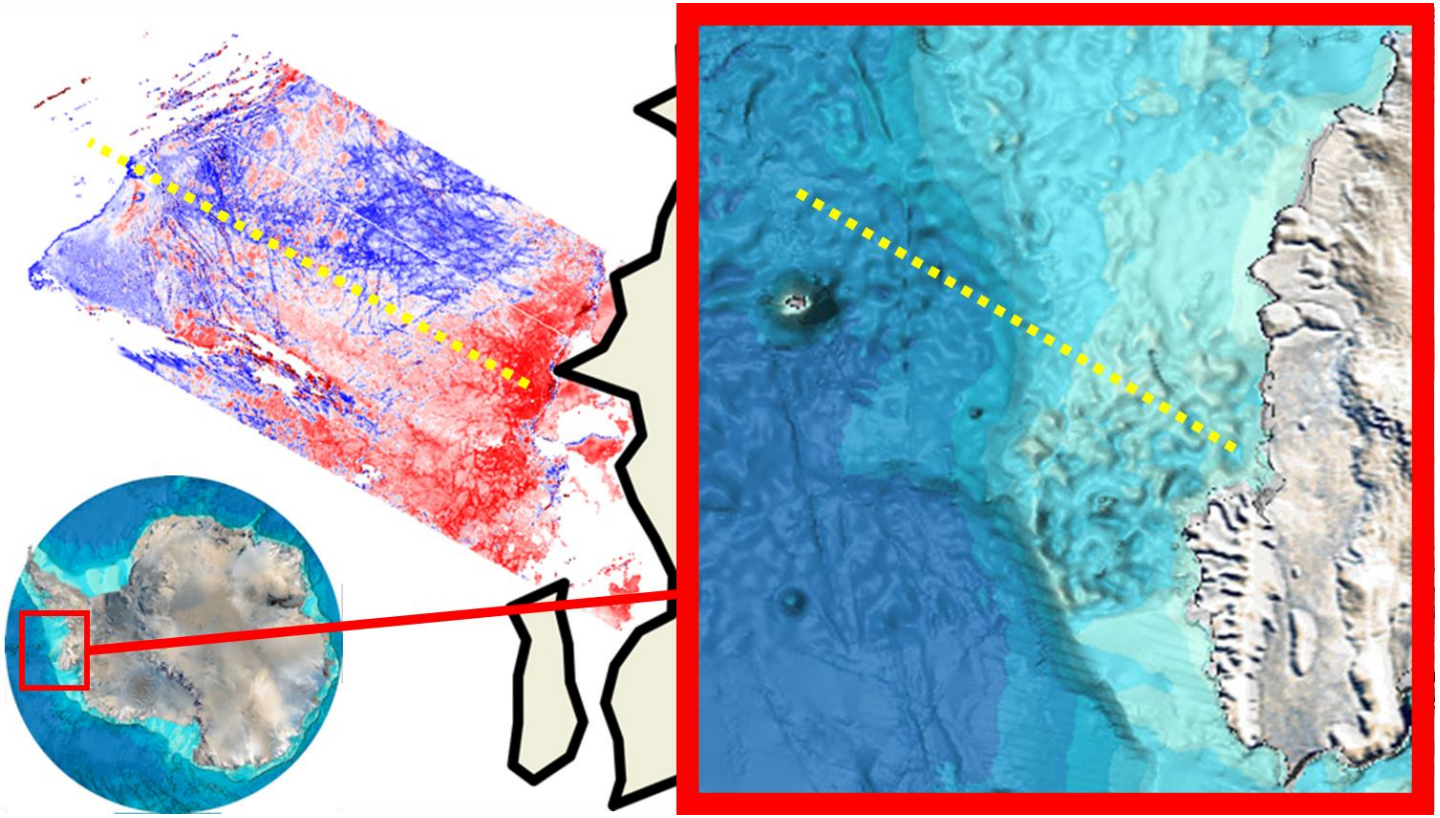
Higher lead density correlates very well with steep bathymetry

➔**Explore linkage between sea ice roughness, bathymetry and ocean tides**



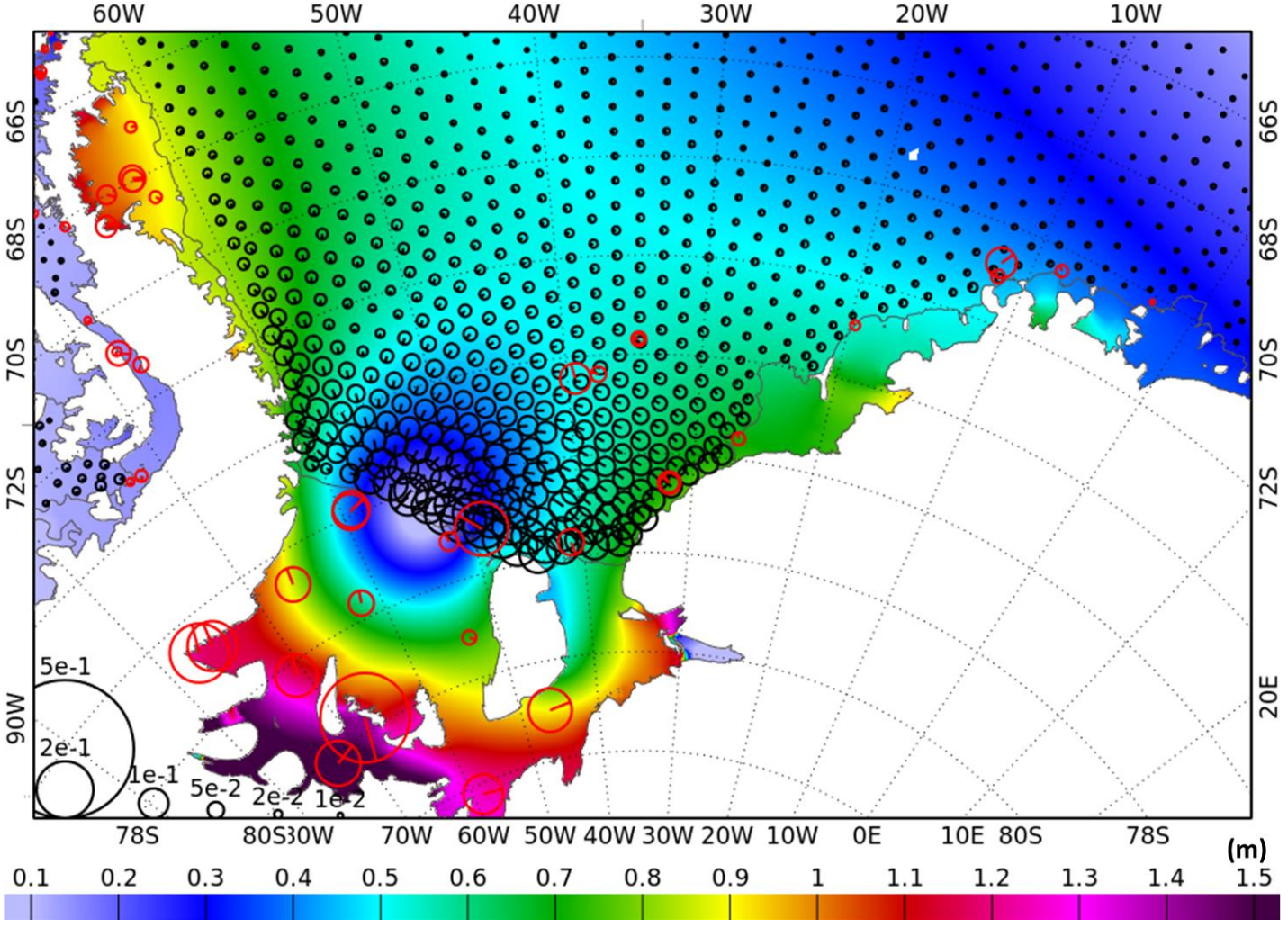
Sea ice surface roughness and bathymetry gradient location (UCL)

Novel technique developed at ES_UCL using 20 years of NASA MISR (Multi-angle Imaging Spectro-Radiometer) with Operation Ice Bridge airborne data for training



Tidal modelling based on the ALBATROSS bathymetry datasets

Vector difference on M2 (m) relative to CryoSat-2 data and in-situ data
ALBATROSS mesh based on GSHHS coastline – BedMachine+Rtopo-2.0.4 bathymetry



Tidal modelling based on the ALBATROSS bathymetry datasets

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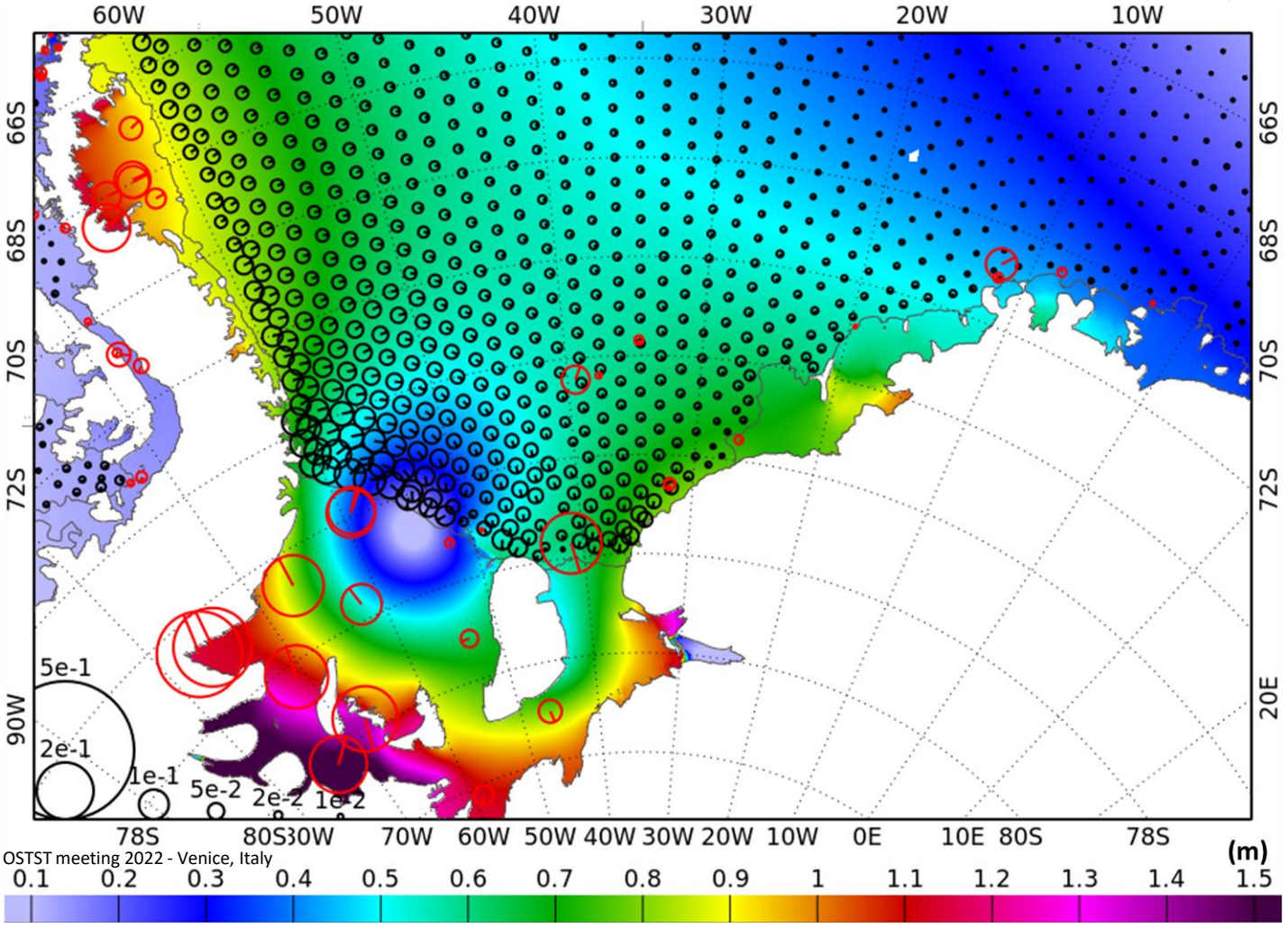

Remaining work

- Final **combination of most relevant bathymetry** datasets
- Final version of model **grid based on new coastline/grounding line**
- **Data assimilation** (ensemble method)

- **Impact assessment** of the new 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, impact on monitoring of Antarctic ice shelves and the vulnerability to tide-induced instability

Planned outcomes

- Southern Ocean composite bathymetry
- Antarctic grounding line and coastline
- Sea ice surface roughness product
- Southern Ocean high-resolution tidal atlas

Interested in taking part in pre-release assessment (Jan.-March 2023)?
Please contact us!

Thank you for your attention!

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