High resolution tidal modeling in the Arctic Ocean

M. Cancet, O. Andersen, F. Lyard, A.-T. Schulz, D. Cotton, J. Benveniste

Presented by Muriel LUX
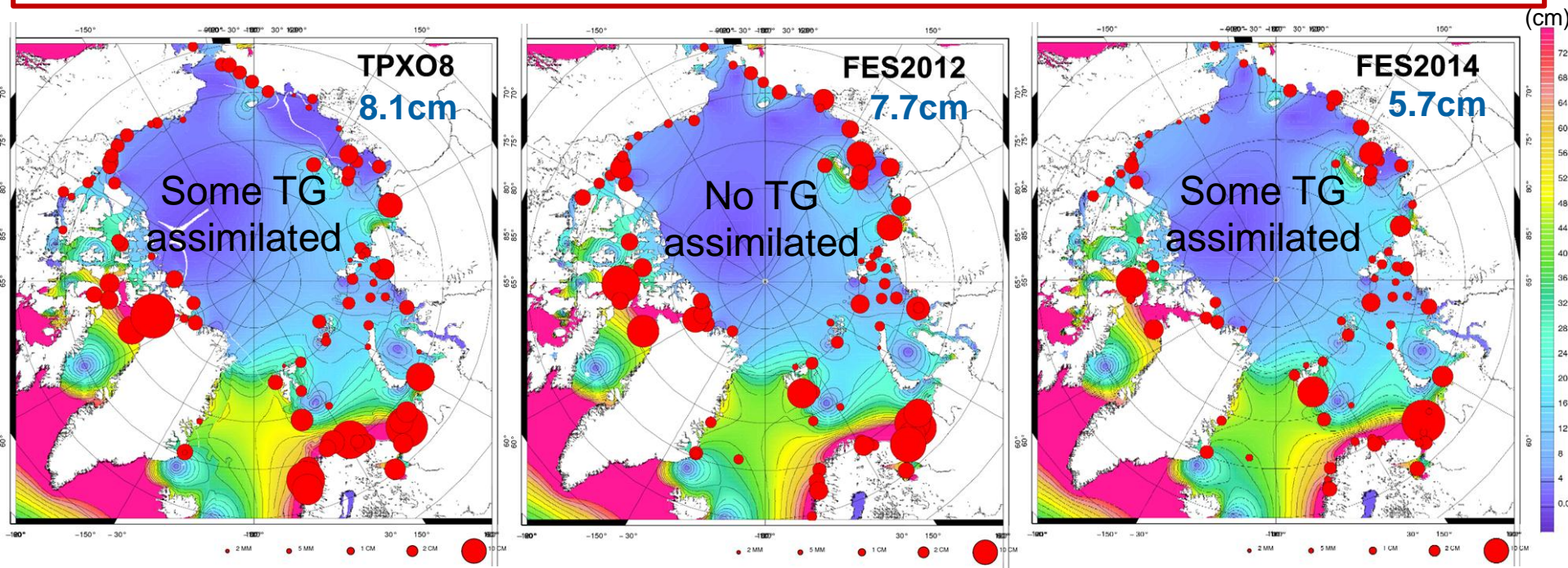
CryoSat Plus for Ocean (CP4O) ESA project

NOVELTIS

- Strategic region

  ▸ Fragile environment, oil and gas resources, shipping opportunities through the North-West Passage…

  →Need for high resolution ocean modelling

  →Need for high precision sea observations (ex: satellite altimetry)

- Lack of accuracy of the global tidal models in the Arctic Ocean

  ▸ Large errors on the shelves

  ▸ Low mesh resolution

  ▸ Bathymetry:

    • Huge work to check the whole bathymetry in detail in a global model

    • ~~Not well known~~ difficult to have access to the data in the Arctic Ocean

  ▸ Assimilation: scarce tide gauge data, altimetry limited in latitude

→Regional tidal modeling
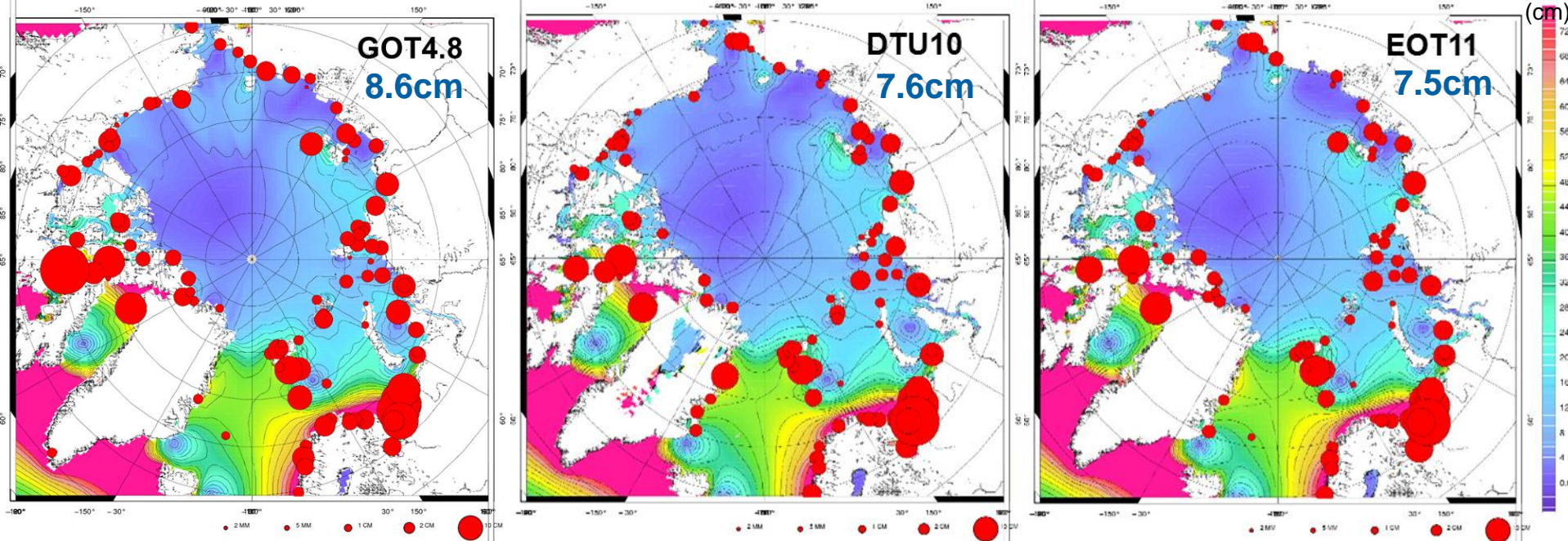
Global models vs tide gauges → large errors on shelves in the Arctic Ocean

- CryoSat Plus for Ocean (CP4O) ESA project:

  - CryoSat data processing

  - Development and evaluation of new corrections and products

- Regional tidal modeling in the Arctic Ocean (on-going project)

  ▸ Same method as for

    - COMAPI regional models (CNES/NOVELTIS project)
    - FES2012 and FES2014 global models (CNES/CLS/NOVELTIS/LEGOS projects)

  ▸ Hydrodynamic modeling (elevation, currents)

  ▸ Ensemble assimilation
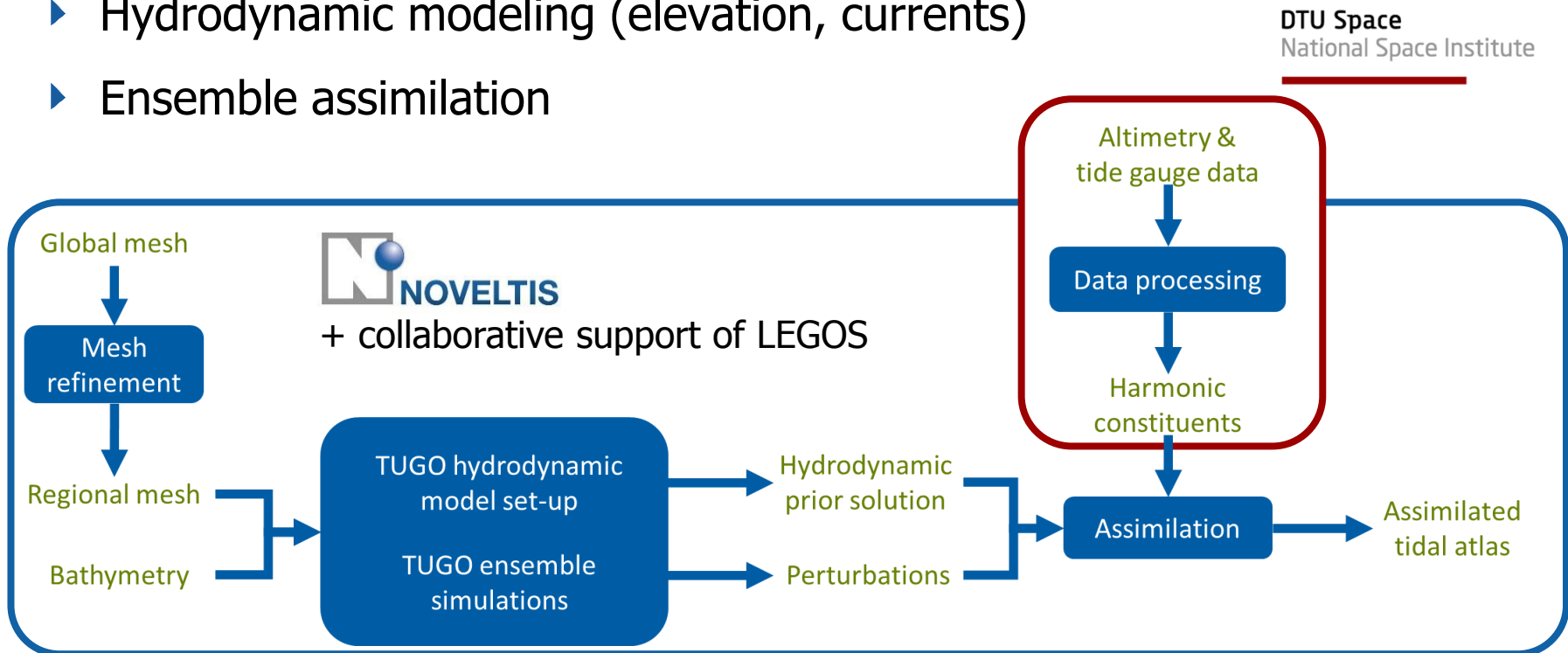
- Start with a global mesh (FES2014 +)

  → consistent for patching the regional solution in a global one
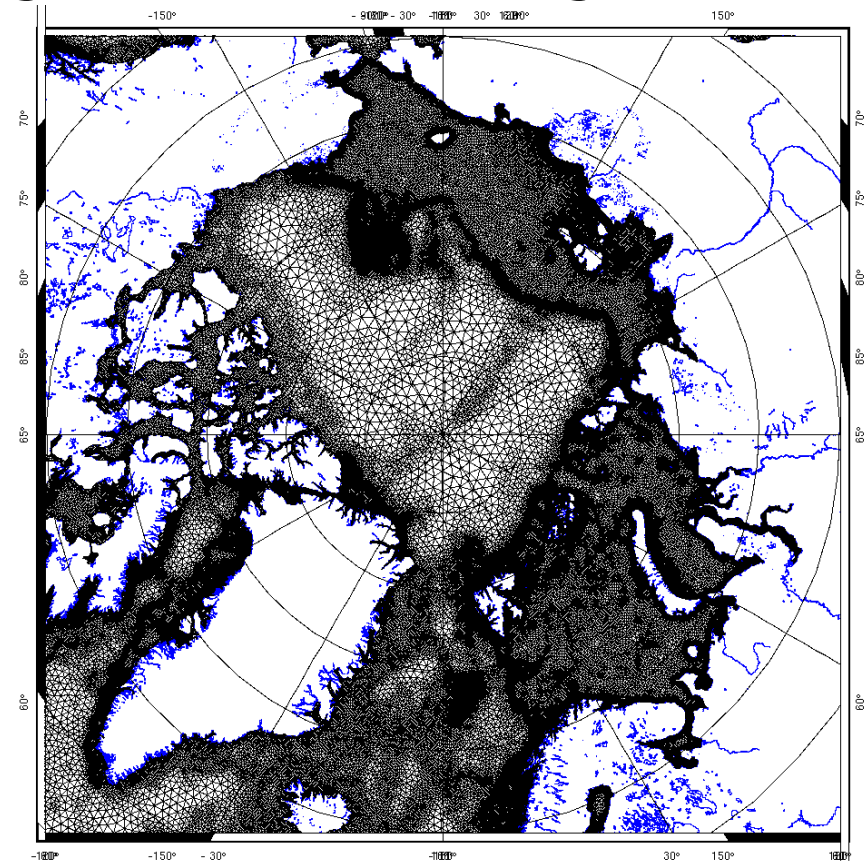
- Locally refine the resolution

  ▸ Greenland East coast

  ▸ Northwest Passage

  ▸ North Pole…

- extract the Arctic mesh

  Number of vertices over the Arctic:

  Final refined mesh: 267 980
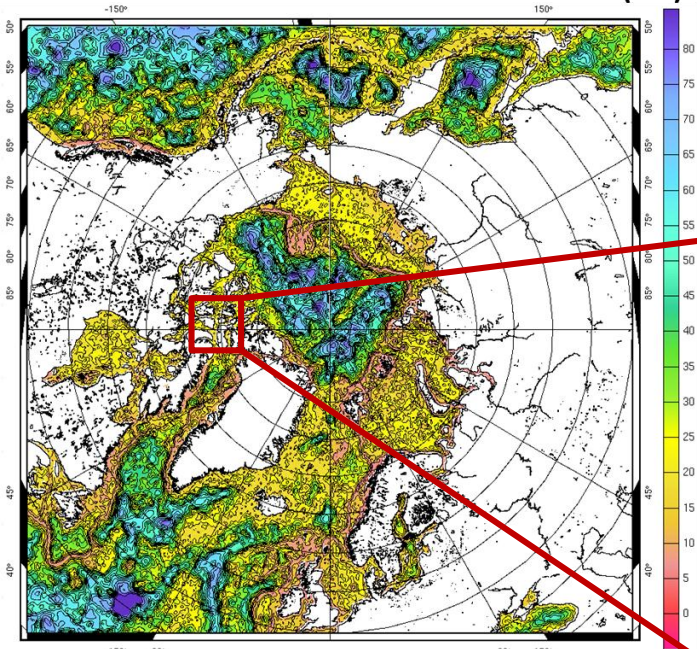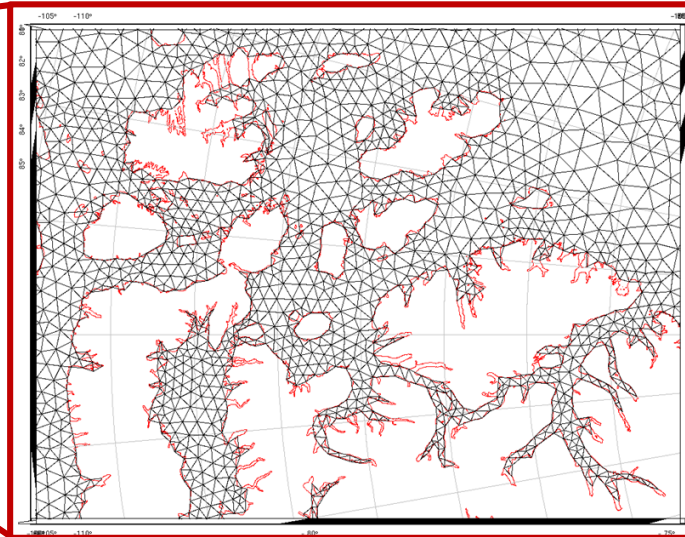
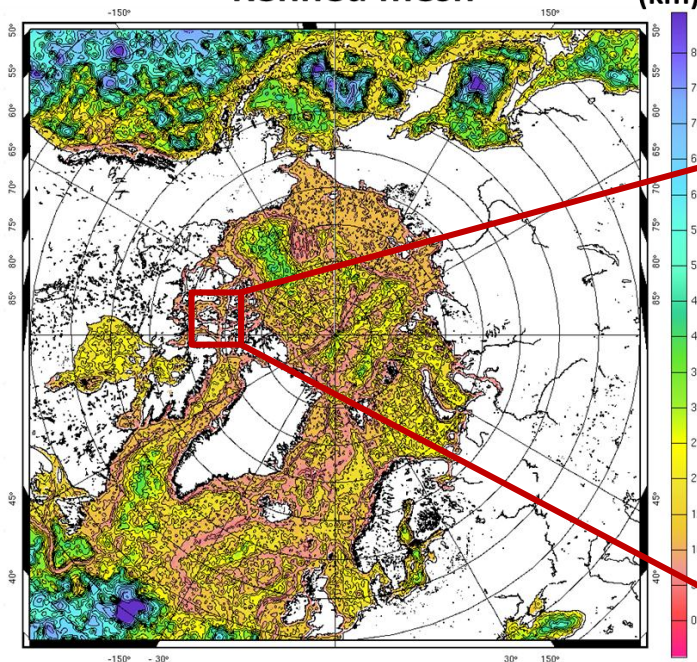 FES2014: 88 271 *(total: 797 366)*

Mesh refinement
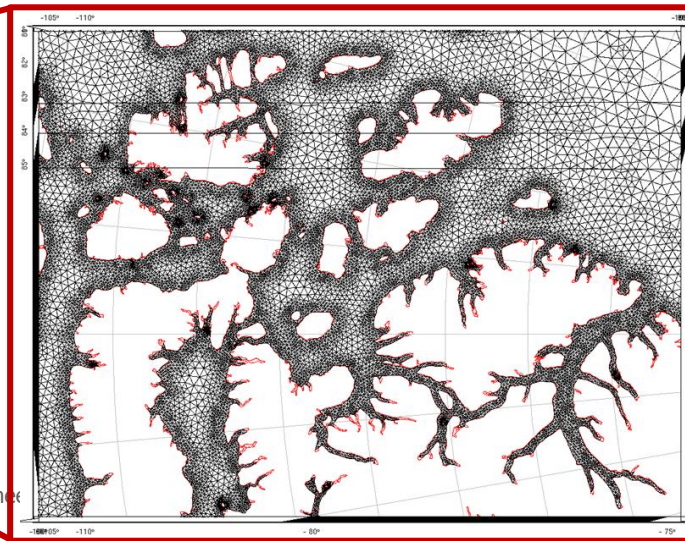
Initial mesh

Refined mesh

Initial mesh

Coast: 15 km

Offshore: ~25 km

Refined mesh

Coast: 4 km

Offshore: ~8 km

- Start with a global mesh (FES2014 +)

  → consistent for patching the regional solution in a global one

- Locally refine the resolution

  ▸ Greenland East coast

  ▸ Northwest Passage

  ▸ North Pole…

  → Automatization of the mesh generation

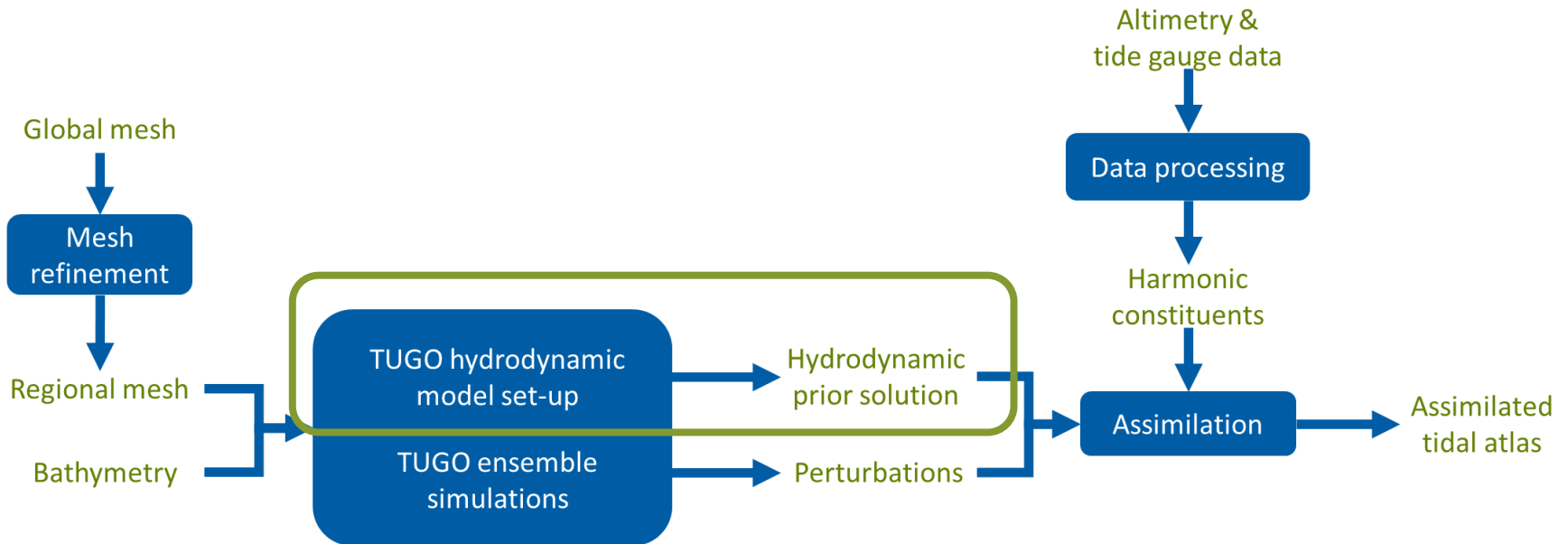- Define and extract the Arctic mesh

  Number of vertices over the Arctic:

  Final refined mesh: 267 980
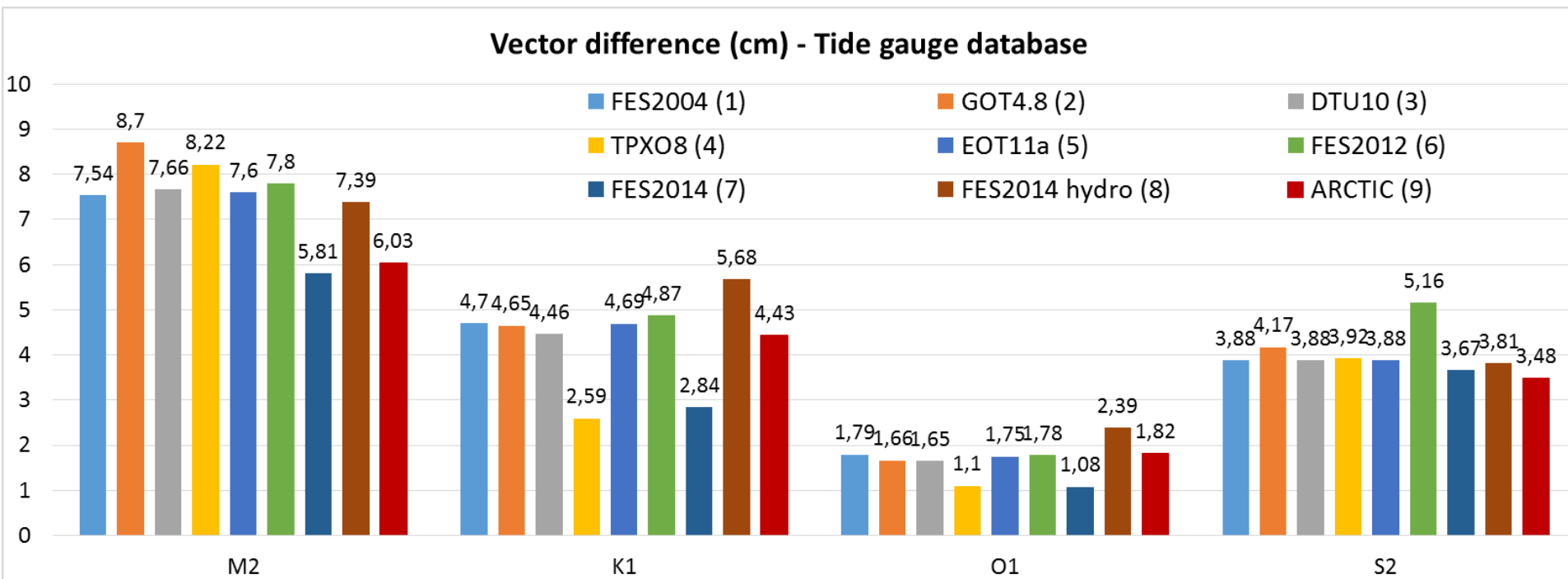
  FES2014: 88 271 *(total: 797 366)*
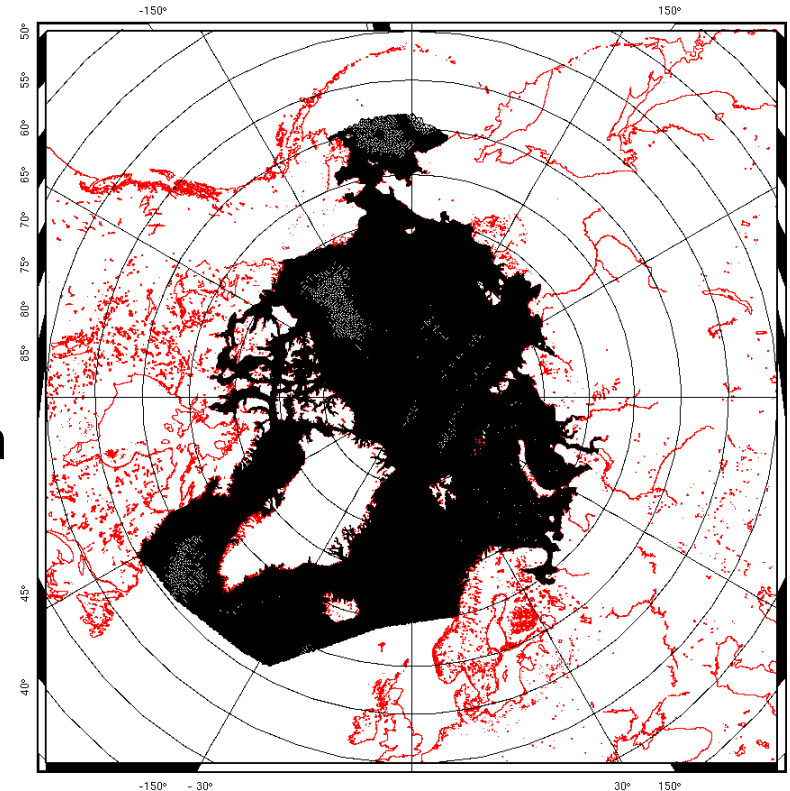
- TUGO hydrodynamic model from LEGOS

  ▸ Bathymetry: IBCAO

  ▸ Boundary conditions: FES2014

- TUGO hydrodynamic model from LEGOS

  ▸ Tuning of the bottom friction coefficient *(on-going work)*

Vector difference (cm) - Tide gauge database

Legend:
- FES2004 (1)
- GOT4.8 (2)
- DTU10 (3)
- TPXO8 (4)
- EOT11a (5)
- FES2012 (6)
- FES2014 (7)
- FES2014 hydro (8)
- ARCTIC (9)

M2: 7,54 / 8,7 / 7,66 / 8,22 / 7,6 / 7,8 / 5,81 / 7,39 / 6,03

K1: 4,7 / 4,65 / 4,46 / 2,59 / 4,69 / 4,87 / 2,84 / 5,68 / 4,43

O1: 1,79 / 1,66 / 1,65 / 1,1 / 1,75 / 1,78 / 1,08 / 2,39 / 1,82

S2: 3,88 / 4,17 / 3,88 / 3,92 / 3,88 / 5,16 / 3,67 / 3,81 / 3,48

→ The best regional hydrodynamic (non-assimilated) solution obtained with bottom friction tuning has equivalent performances to the assimilated global models.

- TUGO hydrodynamic model from LEGOS

  ▸ Double friction coefficient in sea ice regions *(under dev.)*
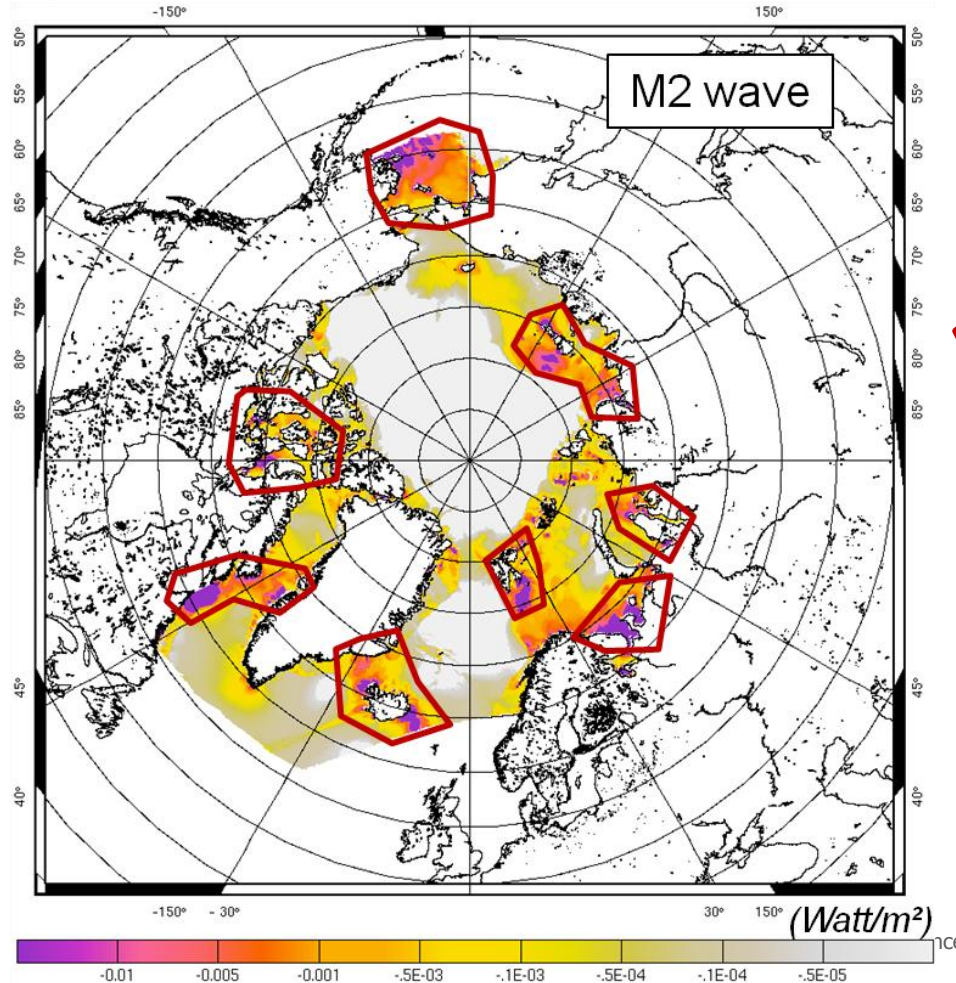
  →based on sea ice extent maps from NSIDC (shapefiles)
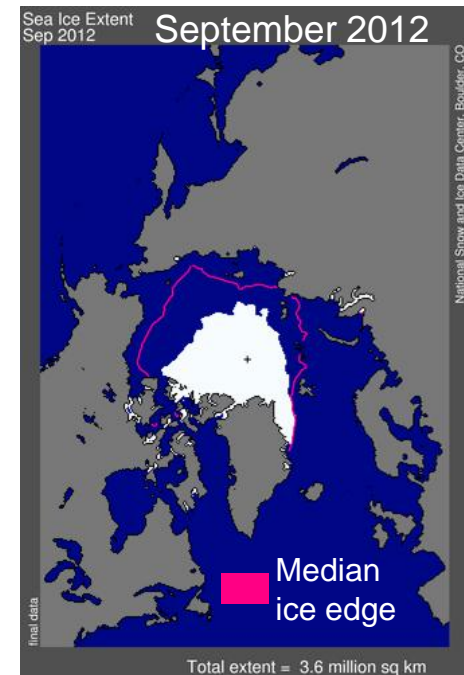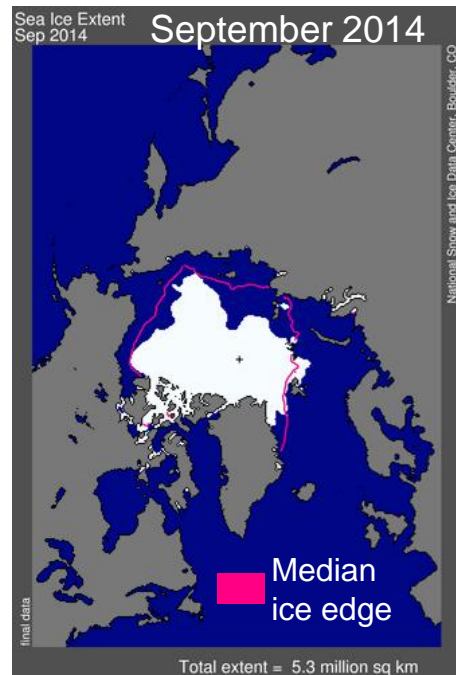
→ Several configurations to be tested: Summer median extent, Winter median extent, Summer extremely small extent, …

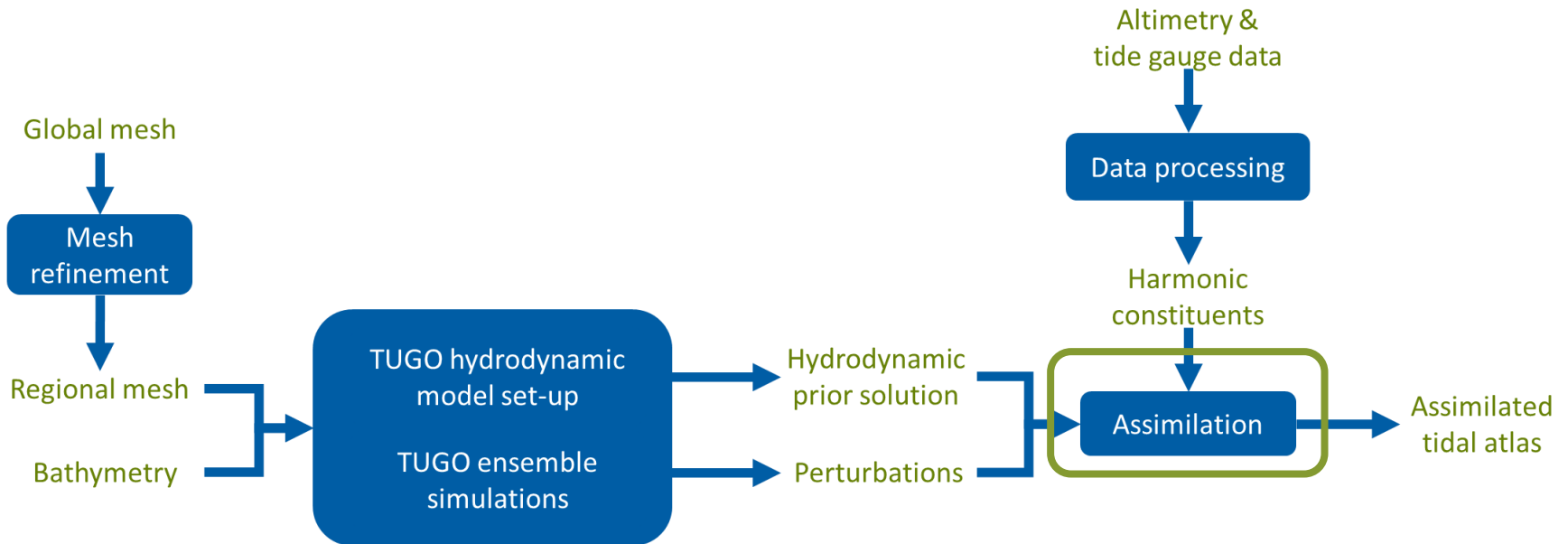# Preparation of the parameters perturbations

NOVELTIS
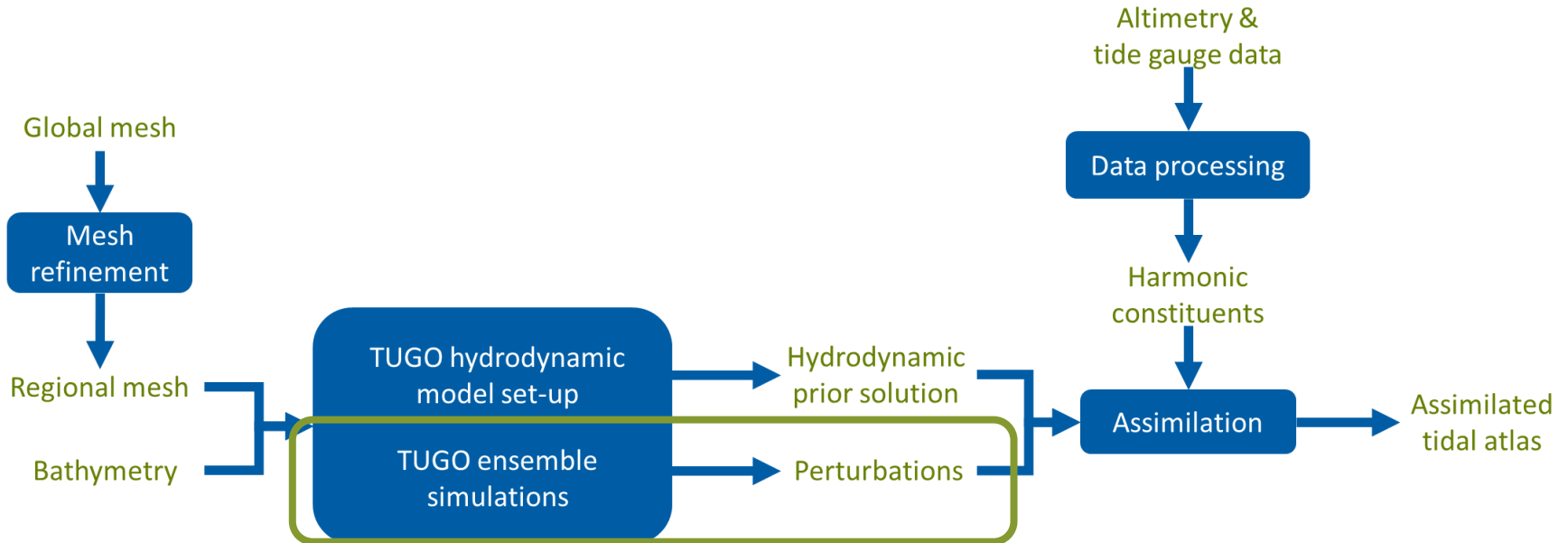
- Preparation of the parameters perturbations

  ▶ Local perturbations of the bottom friction coefficient : energy dissipation

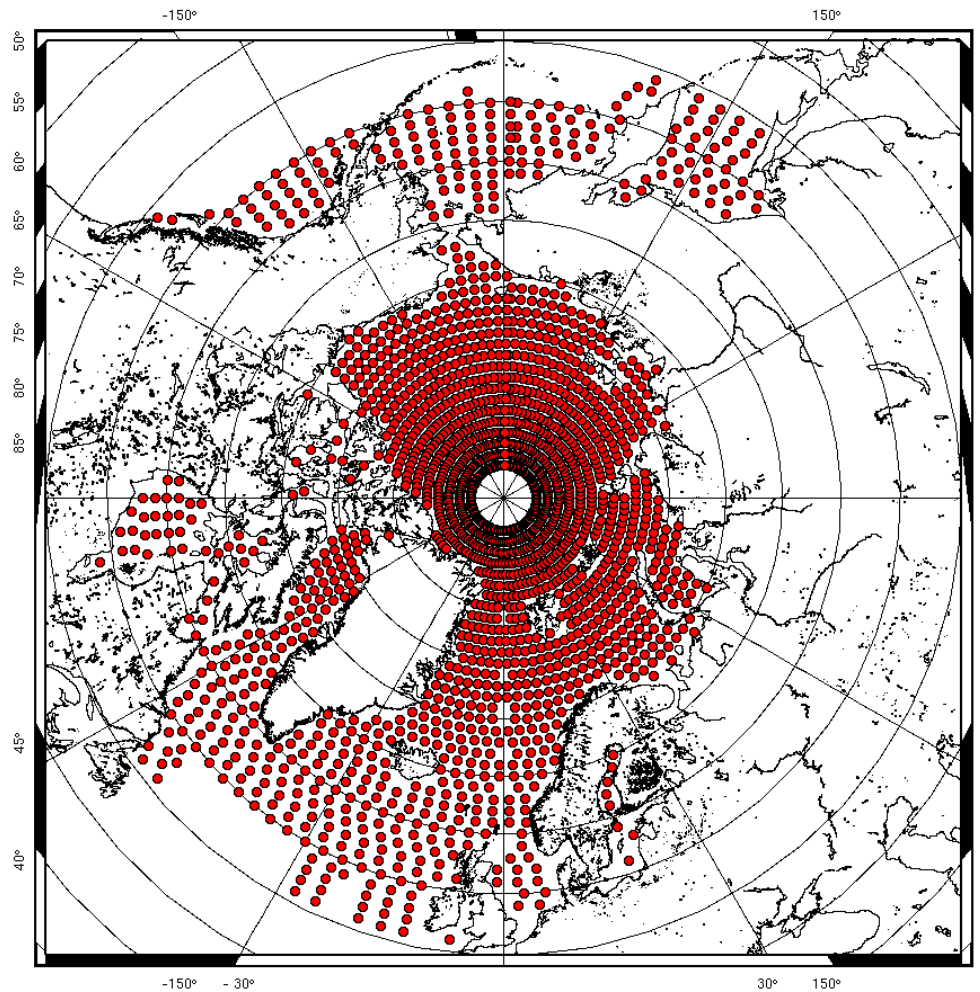Potential zones for bottom friction perturbations (TBC)

Preparation the assimilation process

Preparation of the assimilation process

- Altimetry data prepared by DTU Space: Envisat and CryoSat-2 missions

- Regional tidal model in the Arctic

  ▸ The regional purely hydrodynamic model shows equivalent performances to the global assimilated models

  ▸ Assimilation will improve the model performances

  ▸ The tidal currents will be computed together with the elevations

- Next steps

  ▸ Analysis of the influence of the sea ice extent

  ▸ Simulations with local perturbations of the bottom friction coefficient and the bathymetry to prepare the assimilation

  ▸ Assimilation of altimetry and tide gauge data

  ▸ The Arctic tidal atlas will be delivered to ESA in December 2015

NOVELTIS

● Exploitation of the model

▸ **Improvement of the altimeter products at high latitudes:** CRYOSAT-2, SARAL/AltiKa, Sentinel-3, CRYOSAT-3…

▸ **Improvement of ocean modeling and forecasting** in the Arctic Ocean: tide boundary conditions for ocean circulation, sea-ice drift, …

- Perspectives of new developments

  ▸ Bathymetry improvement in the Arctic

    - In situ data release ?

    - Inversion of altimetry data

  ▸ Other strategic regions with a need for high resolution tidal modeling

    - Regional basins

    - Shelves and estuaries

  ▸ Development of NOVELTIS tidal prediction service (TIPS)

http://tips.noveltis.com