High resolution tidal modeling in the Arctic Ocean

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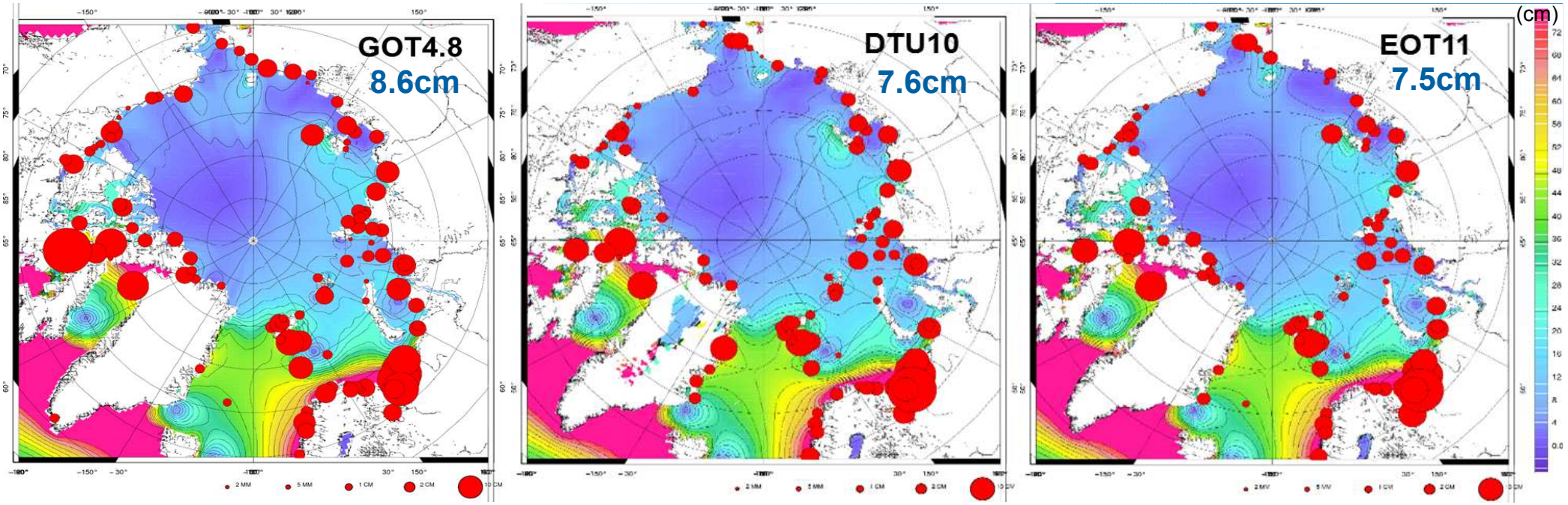
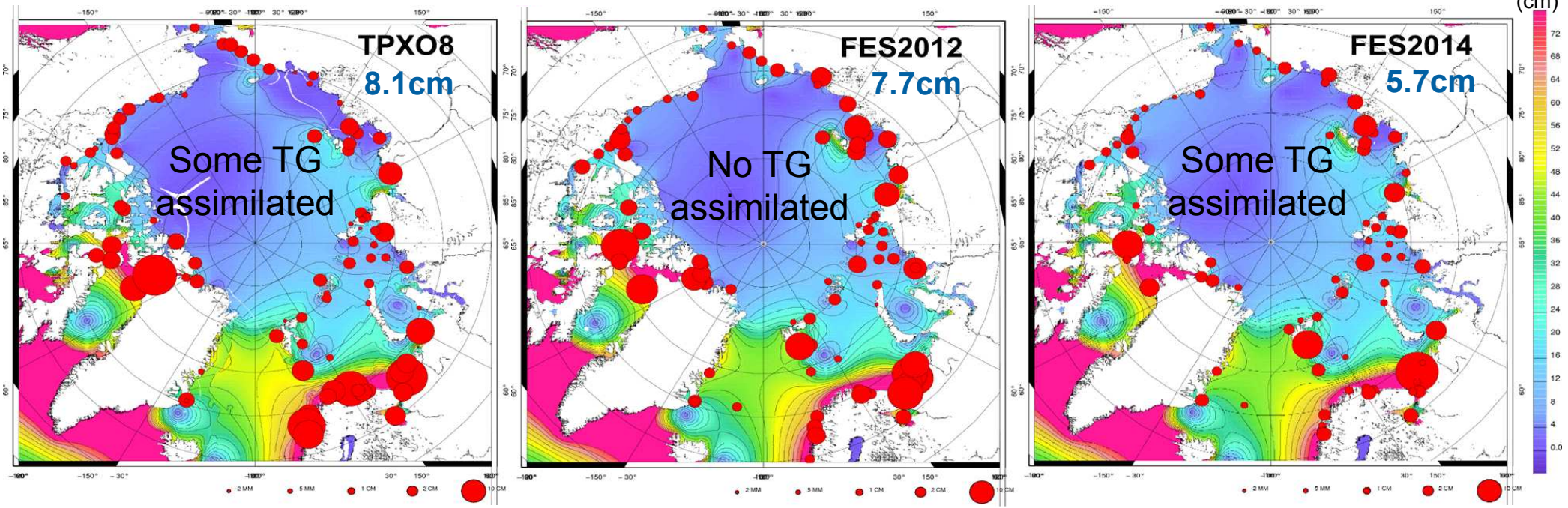


Global models vs tide gauges → large errors on shelves in the Arctic Ocean



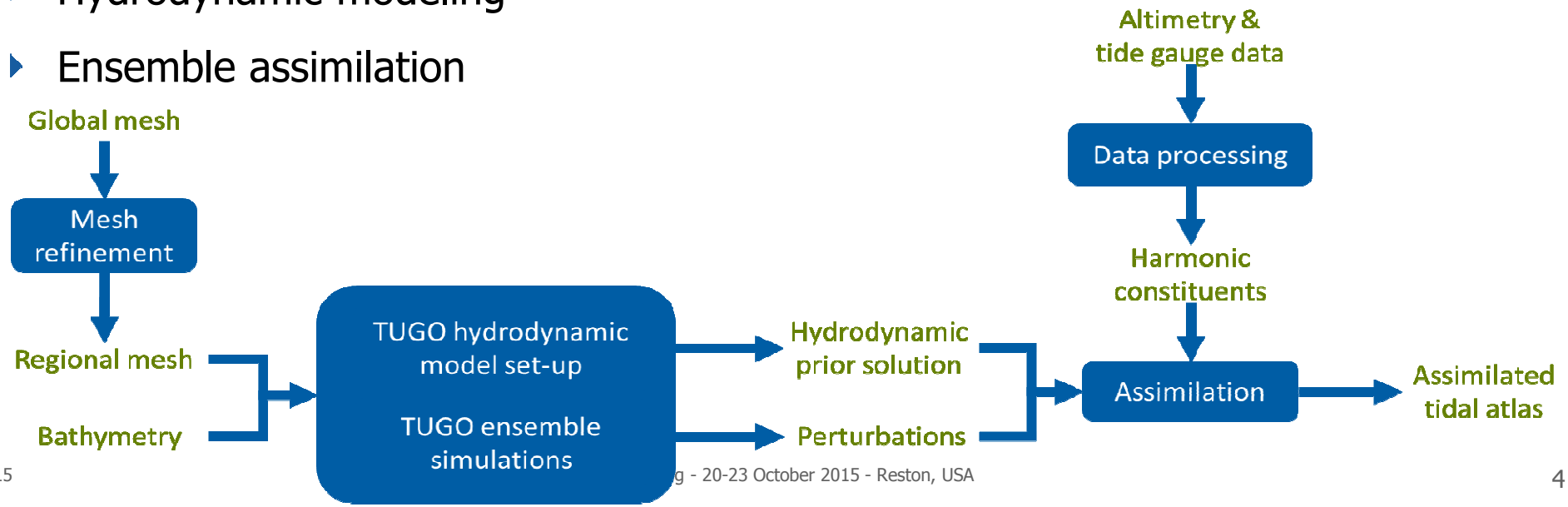
Context and objectives

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

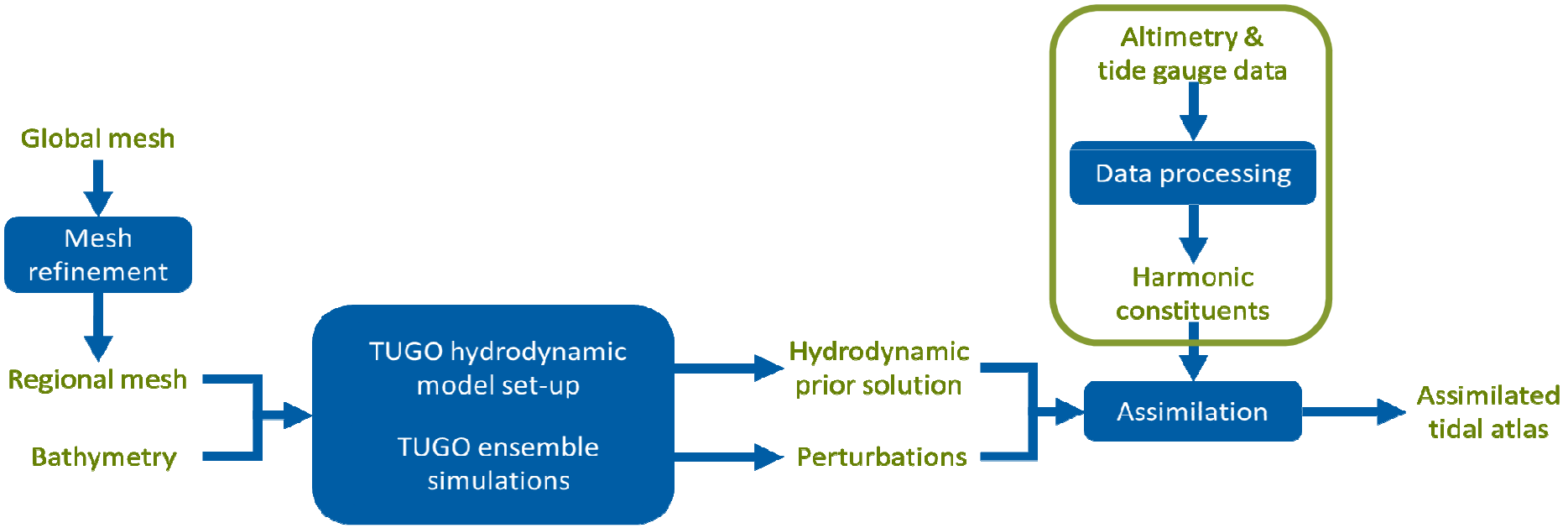
Context and objectives

- 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 FES2012 / FES2014 / COMAPI (CNES projects)
  - Hydrodynamic modeling
  - Ensemble assimilation



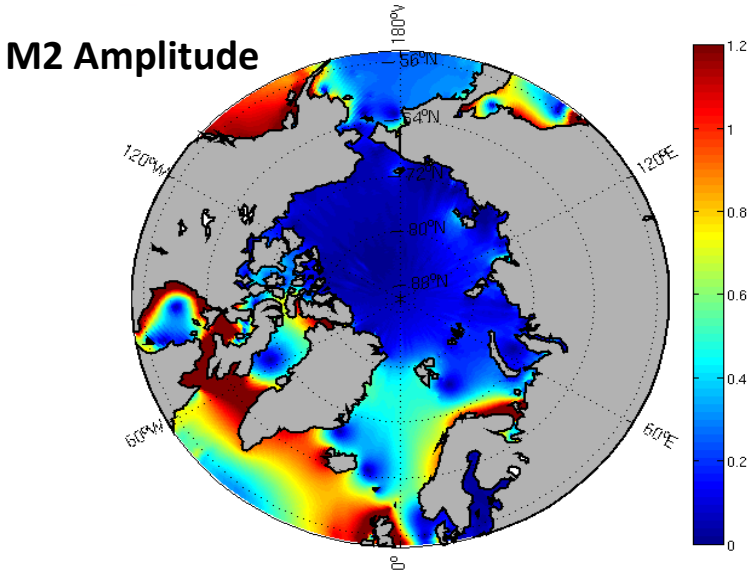
Data processing

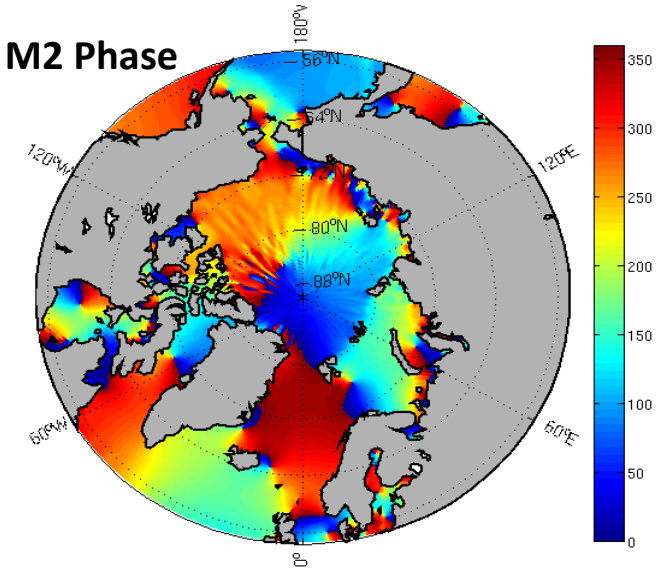
- Computation of the altimeter tidal harmonic constituents



Data processing

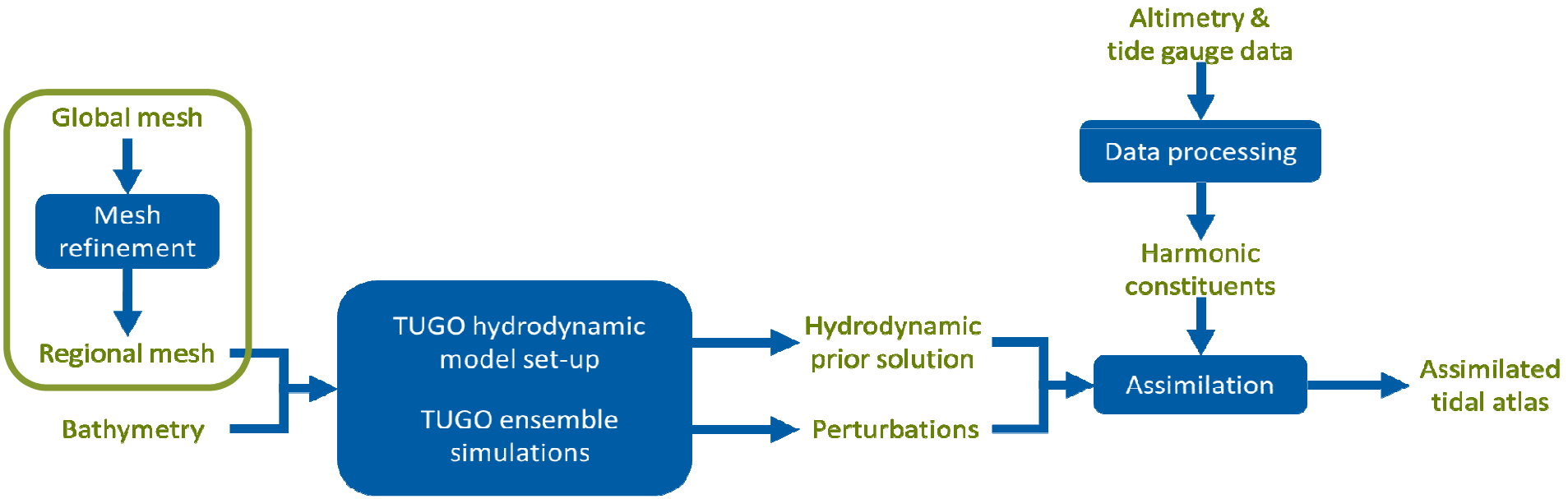
- Computation of the altimeter tidal harmonic constituents
  - Remove/restore methodology: FES2004 is removed prior to tidal prediction and then restored to obtain the final tidal signal
  - Altimetry data in boxes of 1° x 3° down to 55° N
    - CryoSat-2 data in LRM and SAR mode (2010-2014)
    - Envisat data (2002-2010)
    - C2 LRM+ENVISAT from RADS, SAR retracked using primary peak retracker





Mesh refinement

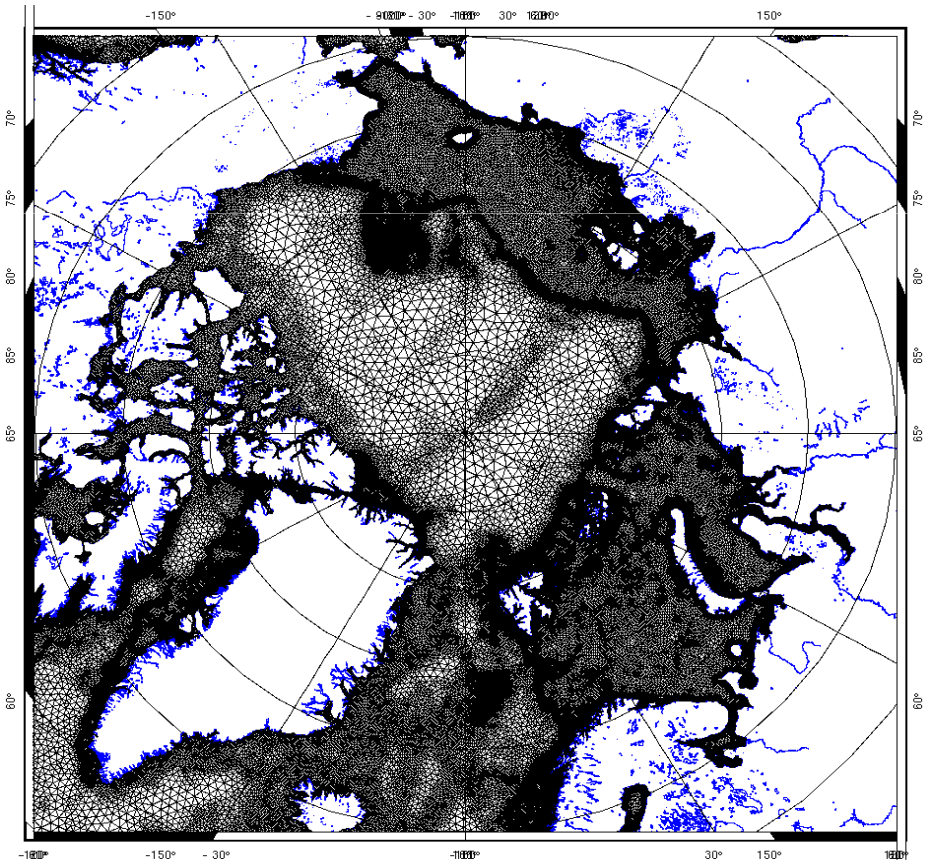
- Start with a global mesh (FES2014 +)



Mesh refinement

- Start with a global mesh (FES2014 +)

  → consistent for patching the regional solution in a global one



Mesh refinement

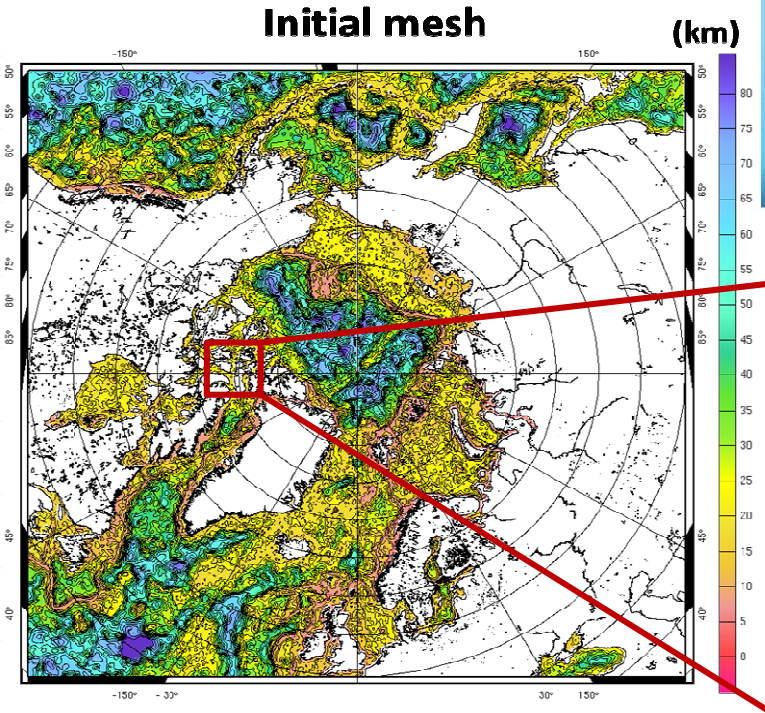
- Start with a global mesh (FES2014 +)

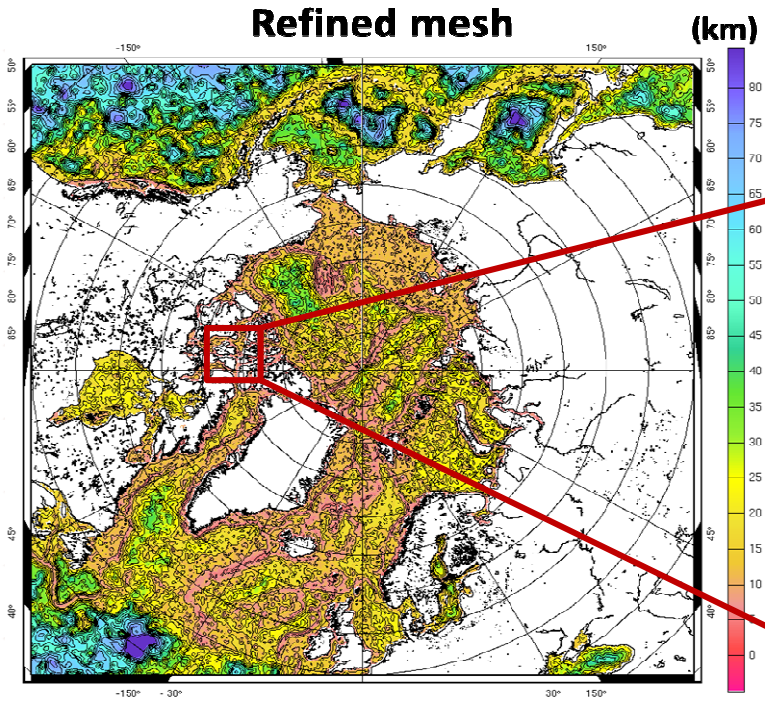
  → consistent for patching the regional solution in a global one

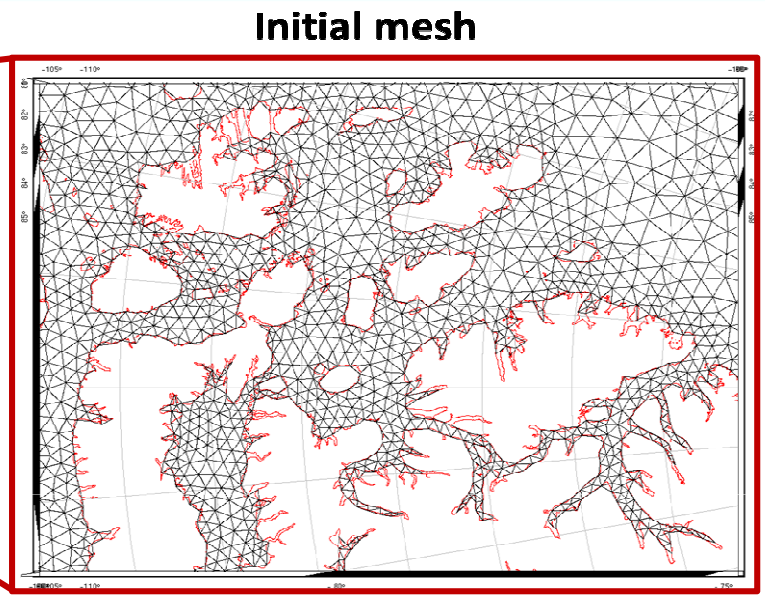
- Locally refine the resolution
  - Greenland East coast
  - Northwest Passage
  - North Pole…

  → Automatization of the mesh generation

Mesh refinement

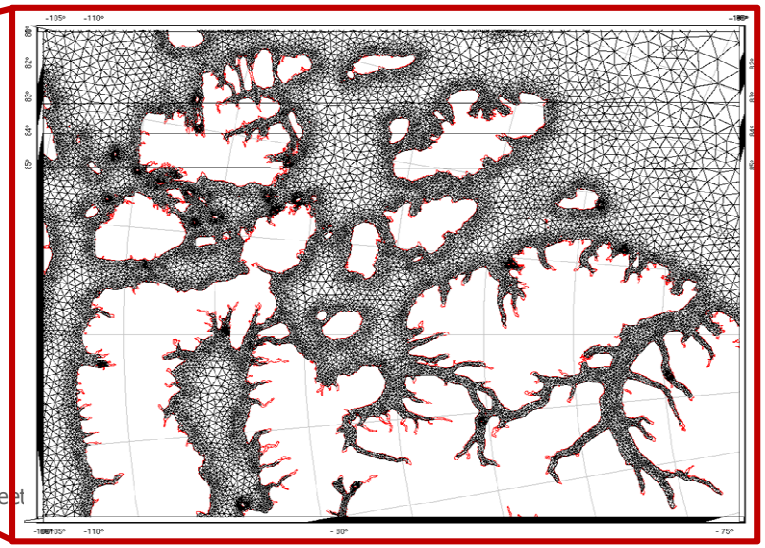






Coast: 15 km

Offshore: ~25 km



Coast: 4 km

Offshore: ~8 km

Mesh refinement

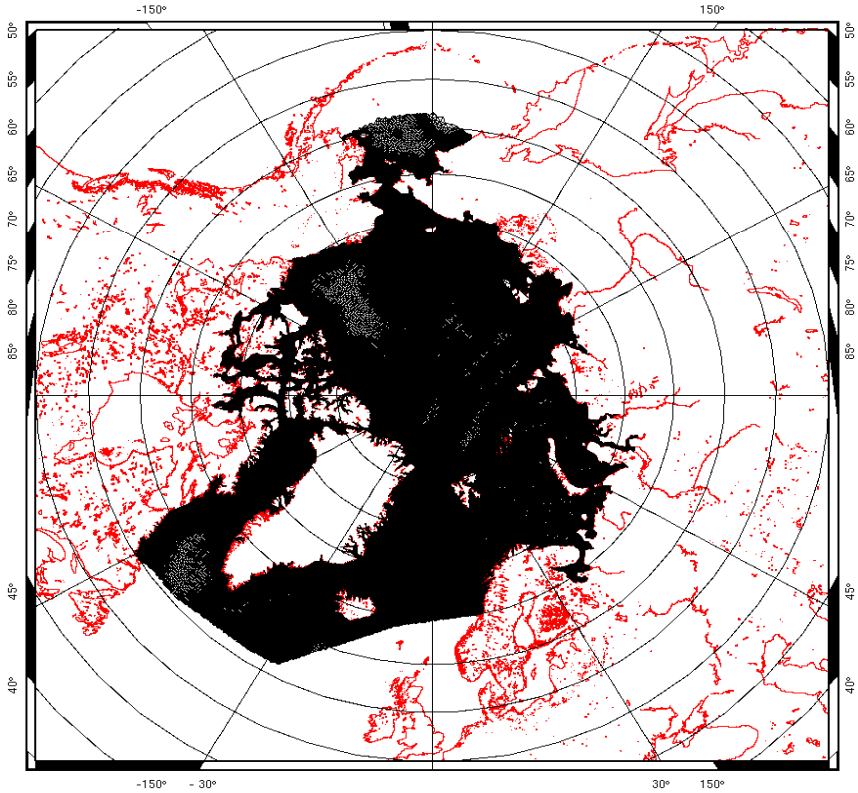
- Start with a global mesh (FES2014 +)

  → 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



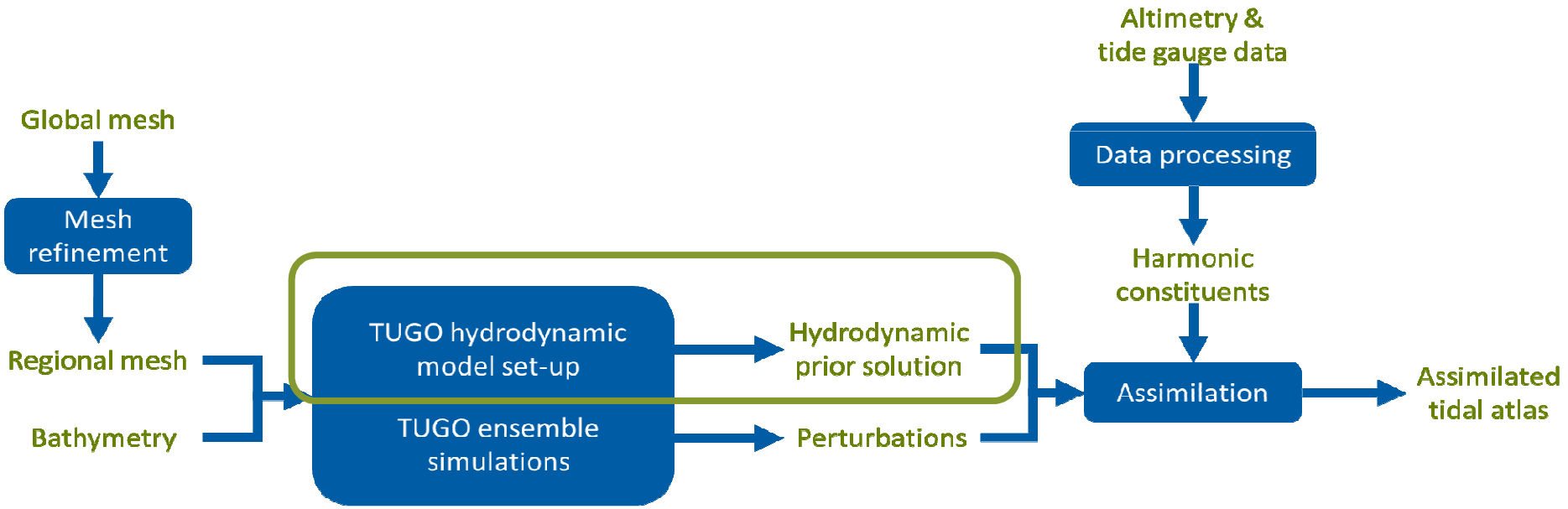
Number of vertices over the Arctic:

Final refined mesh: 267 980

FES2014: 88 271 *(total: 797 366)*

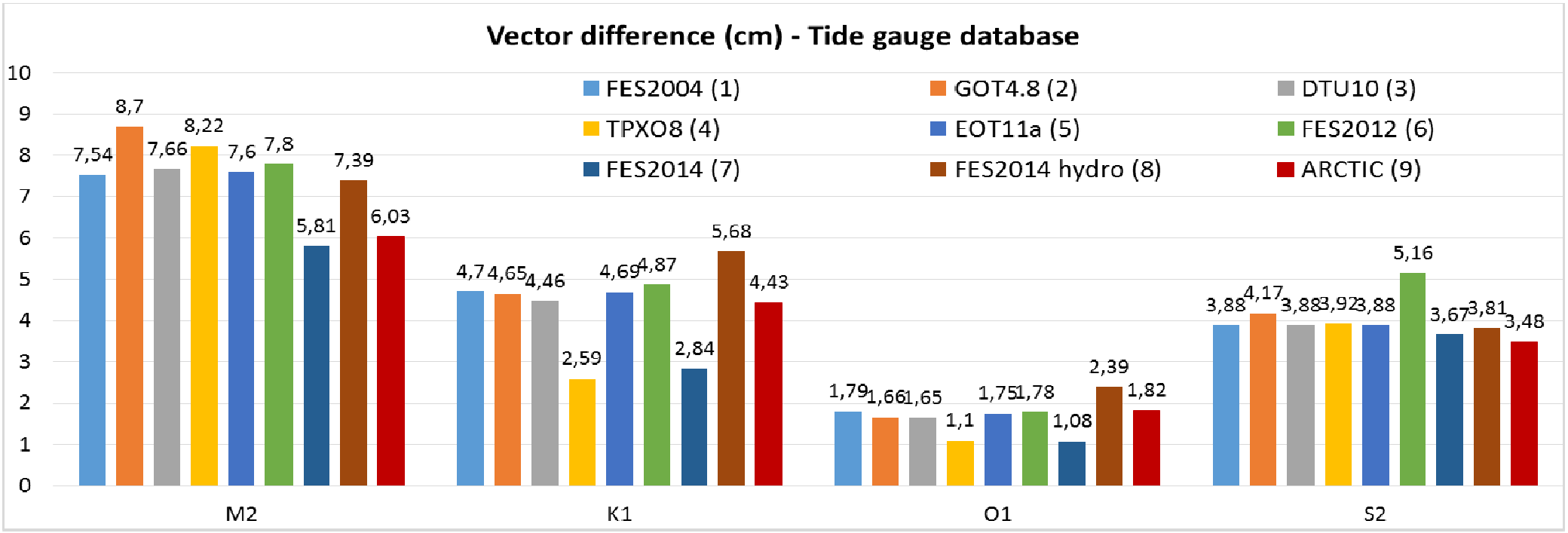
Hydrodynamic model set-up

- TUGO hydrodynamic model from LEGOS



Hydrodynamic model set-up

- TUGO hydrodynamic model from LEGOS
  - Tuning of the bottom friction coefficient

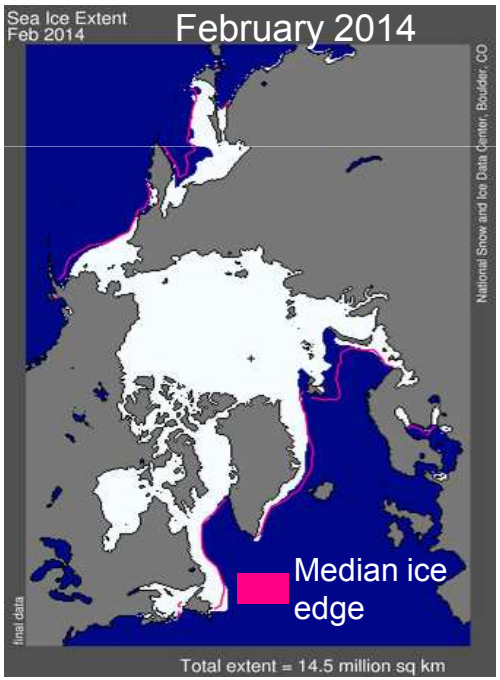


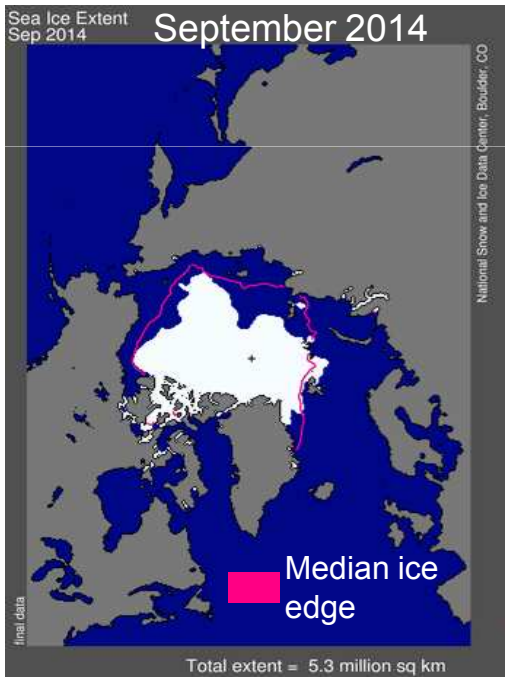
→ The best regional hydrodynamic (non-assimilated) solution obtained with bottom friction tuning has equivalent performances to the assimilated global models.

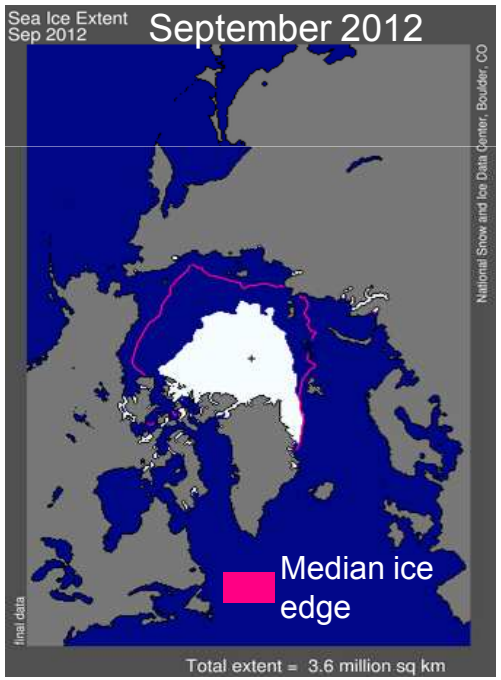
Hydrodynamic model set-up

- TUGO hydrodynamic model from LEGOS
  - Double friction coefficient in sea ice regions *(under dev.)*

→based on sea ice extent maps from NSIDC (shapefiles)



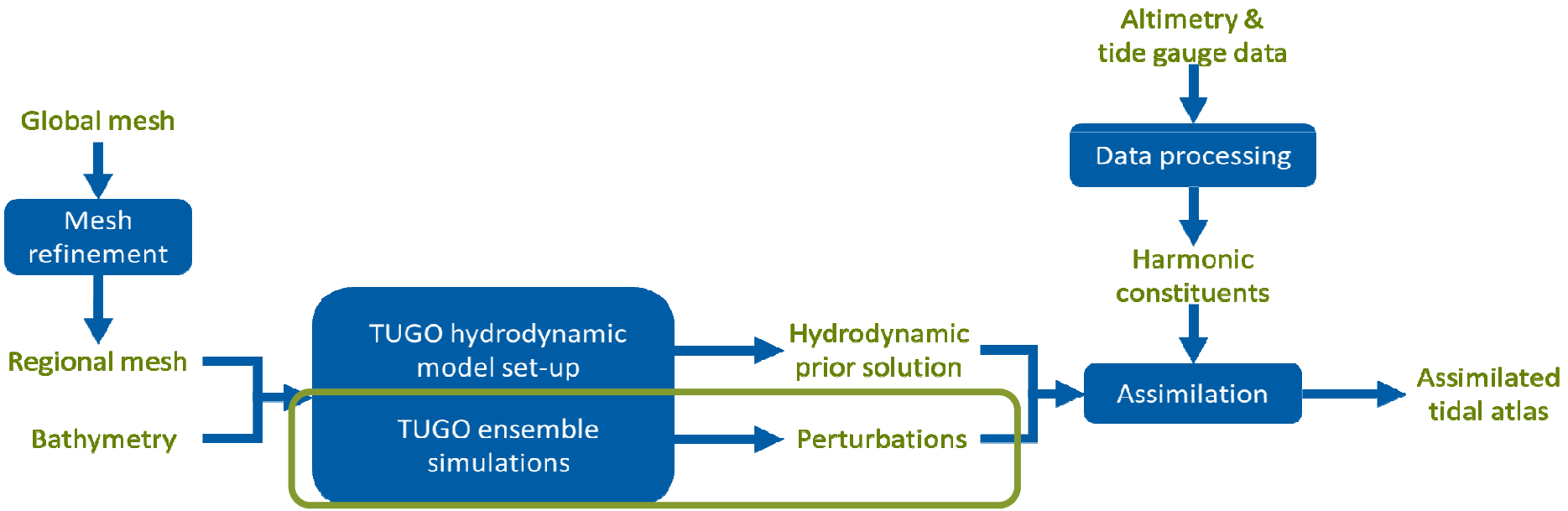




→ Several configurations to be tested: Summer median extent, Winter median extent, Summer extremely small extent, …

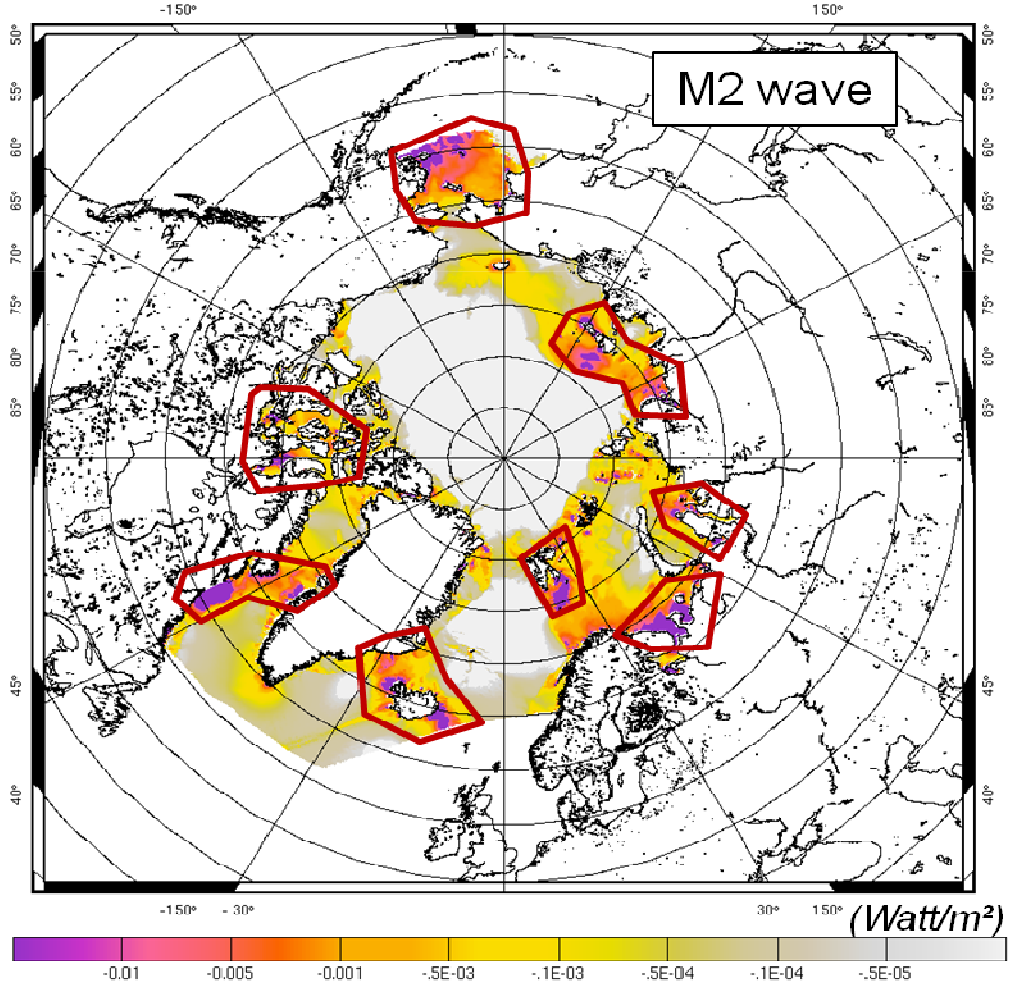
Ensemble simulation

- Preparation of the parameters perturbations



Ensemble simulation

- Preparation of the parameters perturbations
  - Local perturbations of the bottom friction coefficient : energy dissipation



Potential zones for bottom friction perturbations (TBC)

Conclusions and perspectives

- Conclusions
  - For the semi-diurnal waves (M2, S2), the regional purely hydrodynamic model shows equivalent performances to the global assimilated models
  - For the diurnal waves (K1, O1), still some work to do
  - Assimilation will improve the model performances
- 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

Conclusions and perspectives

- Perspectives
  - Exploitation of this new tidal model to improve CRYOSAT-2 altimeter products (and any mission reaching high latitudes: SARAL/AltiKa, Sentinel-3) and prepare CRYOSAT-3 (tide correction)
  - Exploitation of this model to improve ocean modeling and forecasting for Arctic studies: ocean circulation, sea-ice drift, …
  - Bathymetry improvement in the Arctic
    - In situ data release ?
    - Inversion of altimetry data
  - Other strategic regions with a need for high resolution tidal modeling
    - Ex: shelves and estuaries, in preparation of SWOT
    - Automatization of the hydrodynamic simulations for model tuning and perturbations

NOVELTIS

DTU Space
National Space Institute

LEGOS

TU Delft

SATOC
Satellite Oceanographic Consultants

Thank you !