

A new high resolution tidal model in the Arctic Ocean

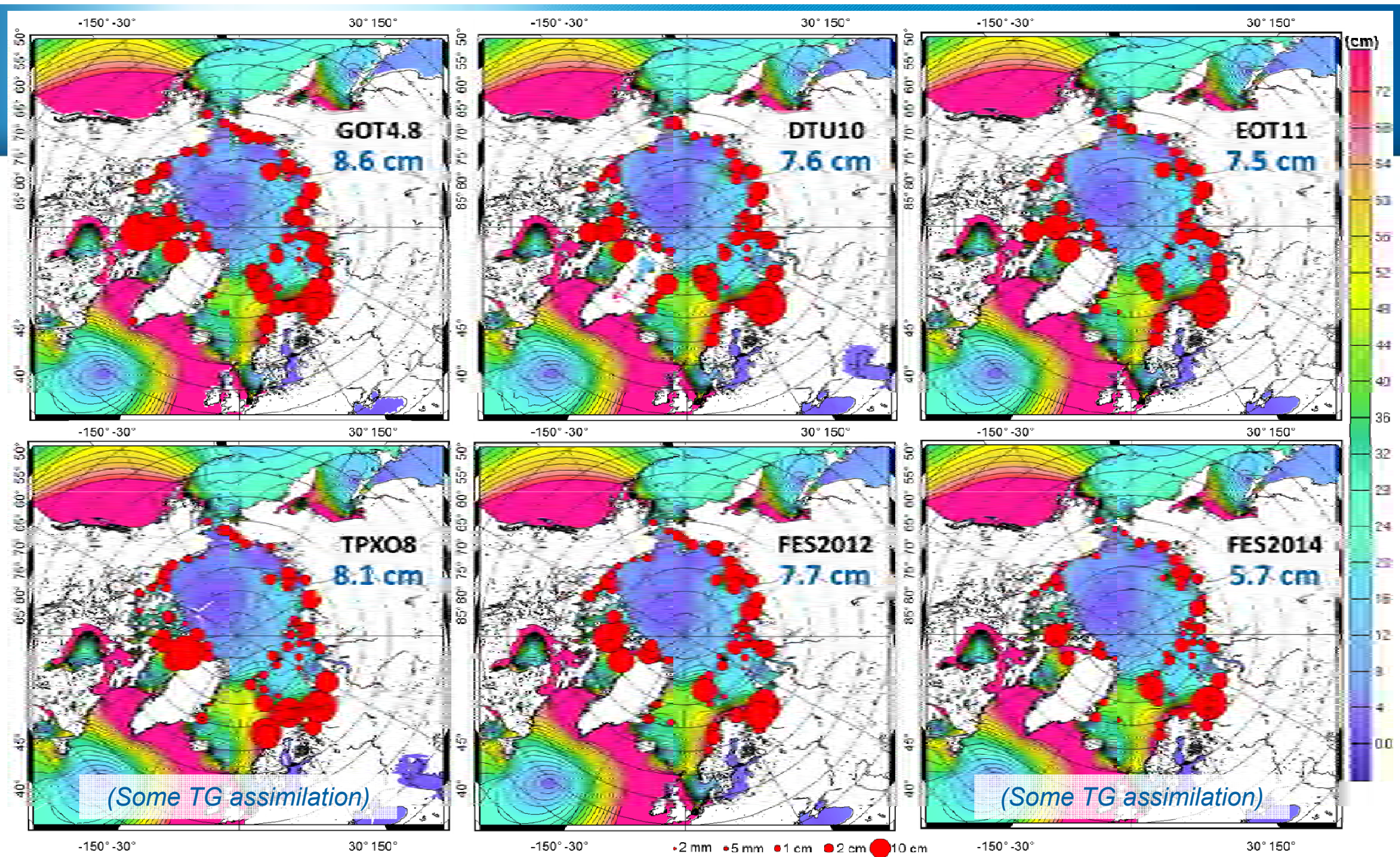
M. Cancet, O. Andersen, F. Lyard, D. Cotton, J. Benveniste

CCN to CryoSat Plus for Ocean (CP4O) ESA STSE project

Previously...

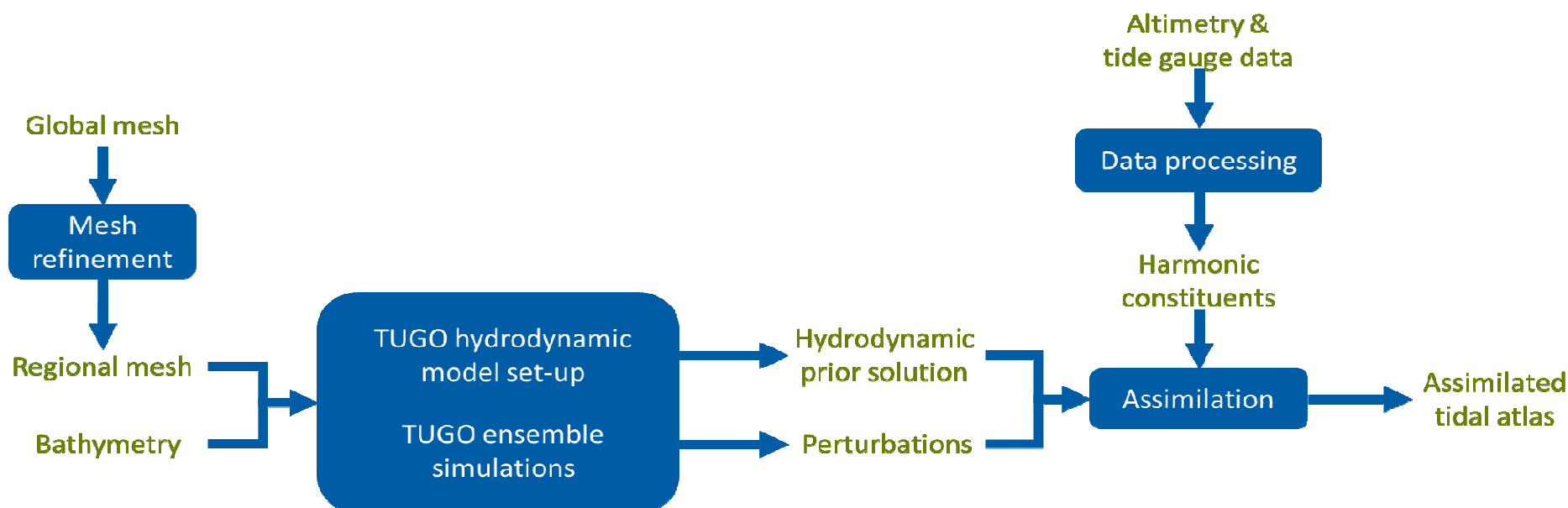
Episode 1: Cancet et al., OSTST 2015

(Downloadable on <http://meetings.aviso.altimetry.fr/>)

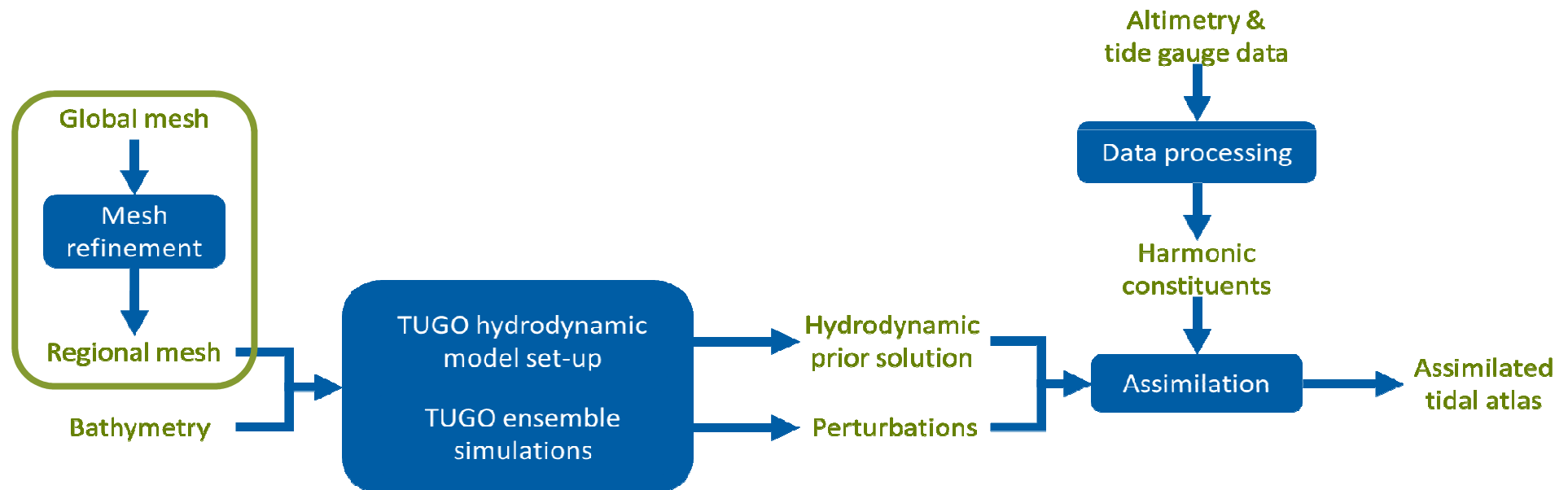


Global models vs tide gauges (M2) → large errors on shelves in the Arctic Ocean

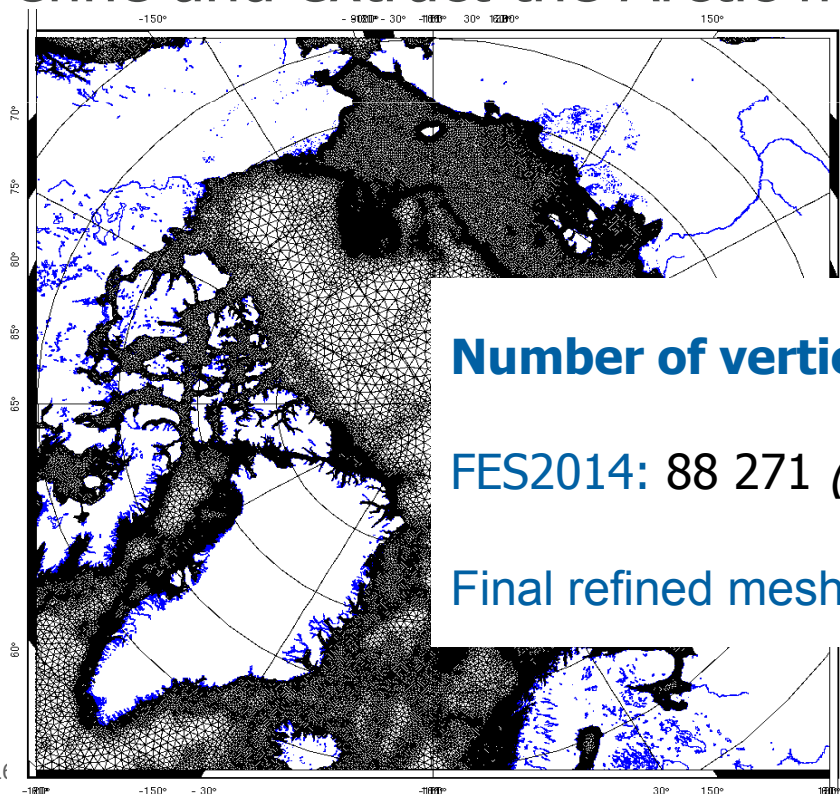
- Regional tidal modeling in the Arctic Ocean
 - ▶ Same method as FES2012 / FES2014 / COMAPI (CNES projects)
 - Hydrodynamic modeling
 - Ensemble data assimilation



- Implementation of the regional high resolution mesh



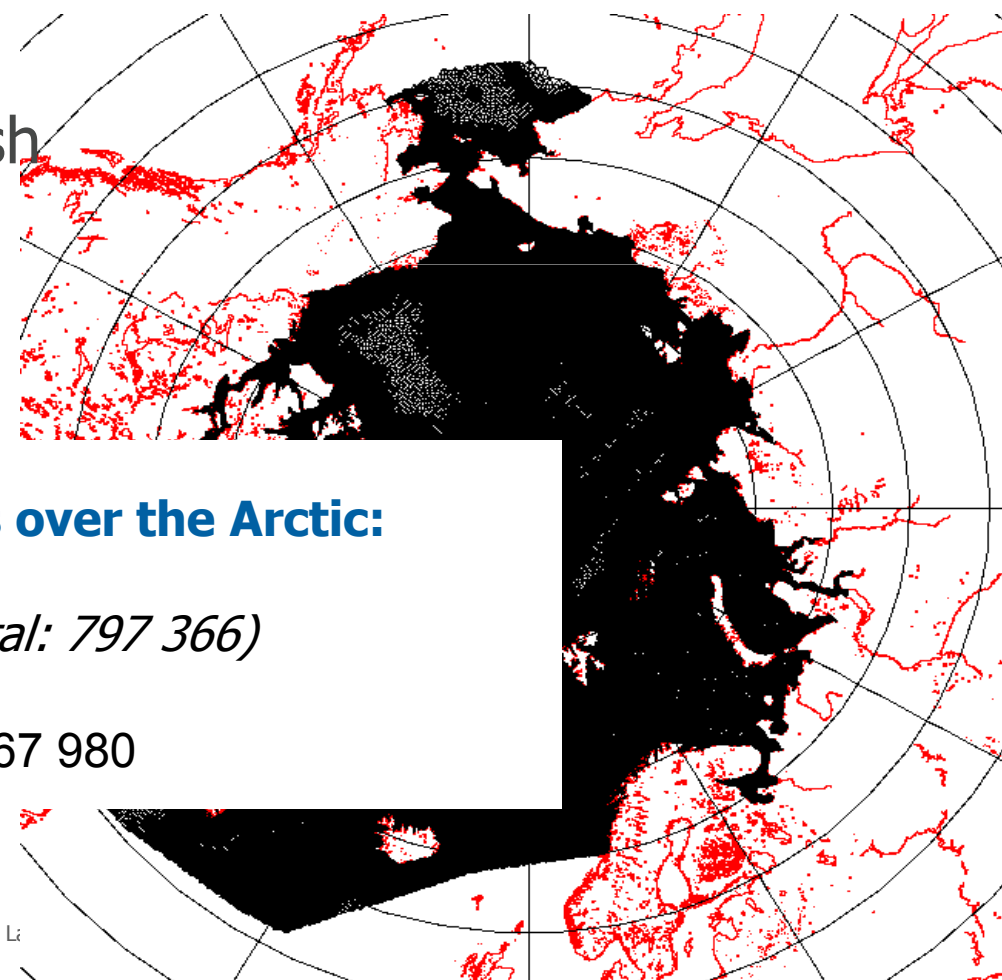
- 1/ Start with a global unstructured mesh (FES2014 +)
→ consistent for patching the regional solution in a global one
- 2/ Locally refine the resolution
- 3/ Define and extract the Arctic mesh



Number of vertices over the Arctic:

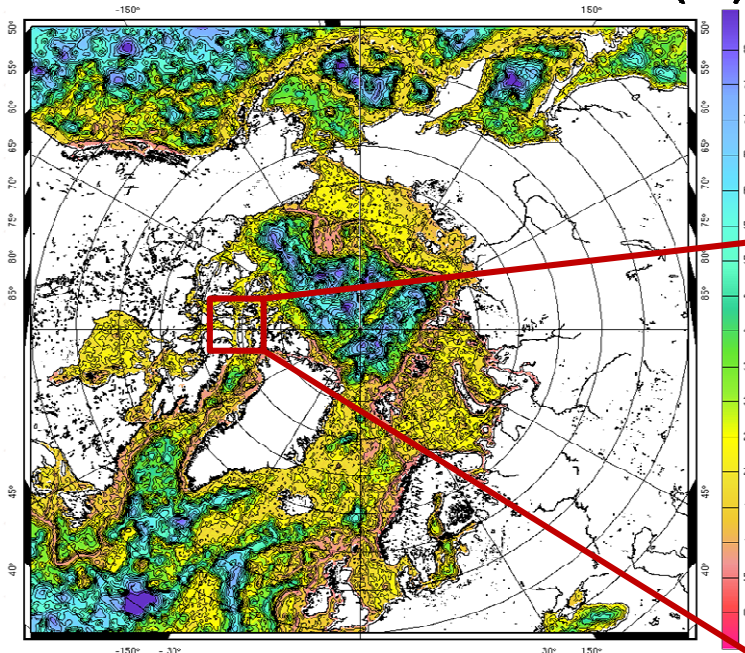
FES2014: 88 271 (*total: 797 366*)

Final refined mesh: 267 980

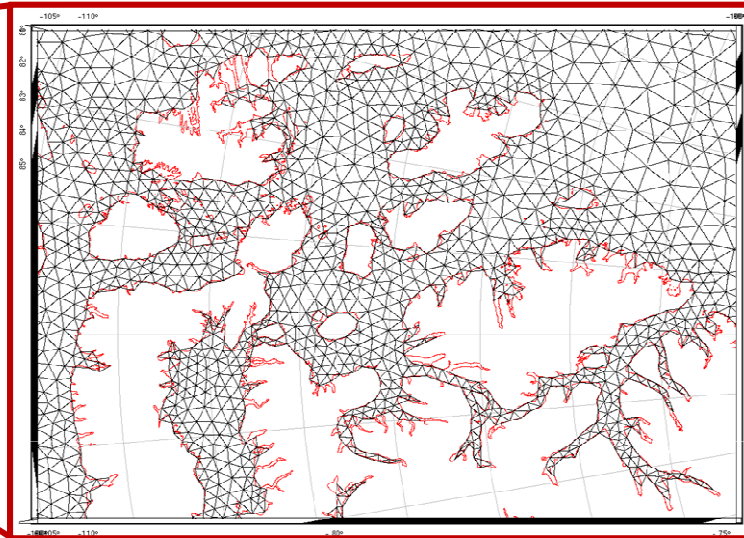


Mesh refinement

Initial mesh (km)



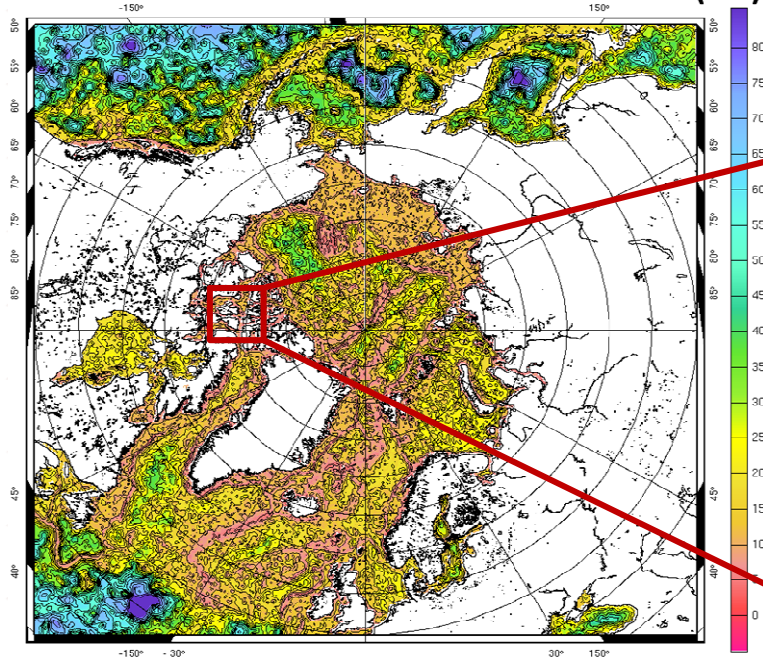
Initial mesh



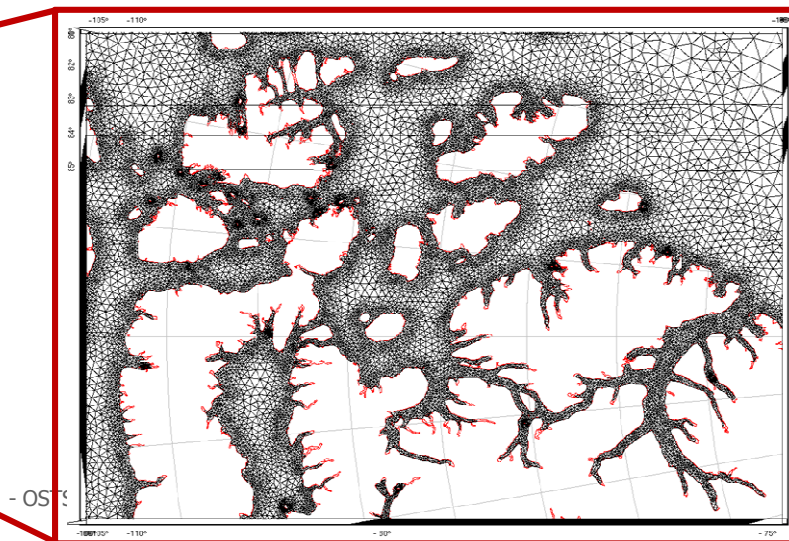
Coast: 15 km

Offshore: ~25 km

Refined mesh (km)



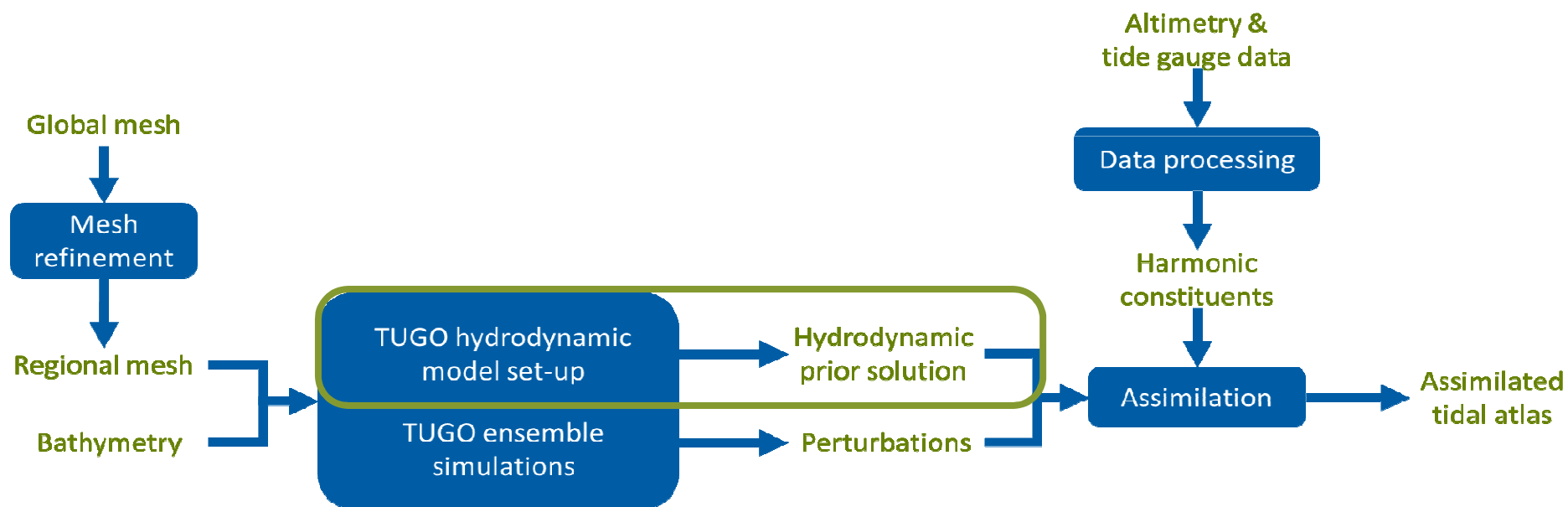
Refined mesh



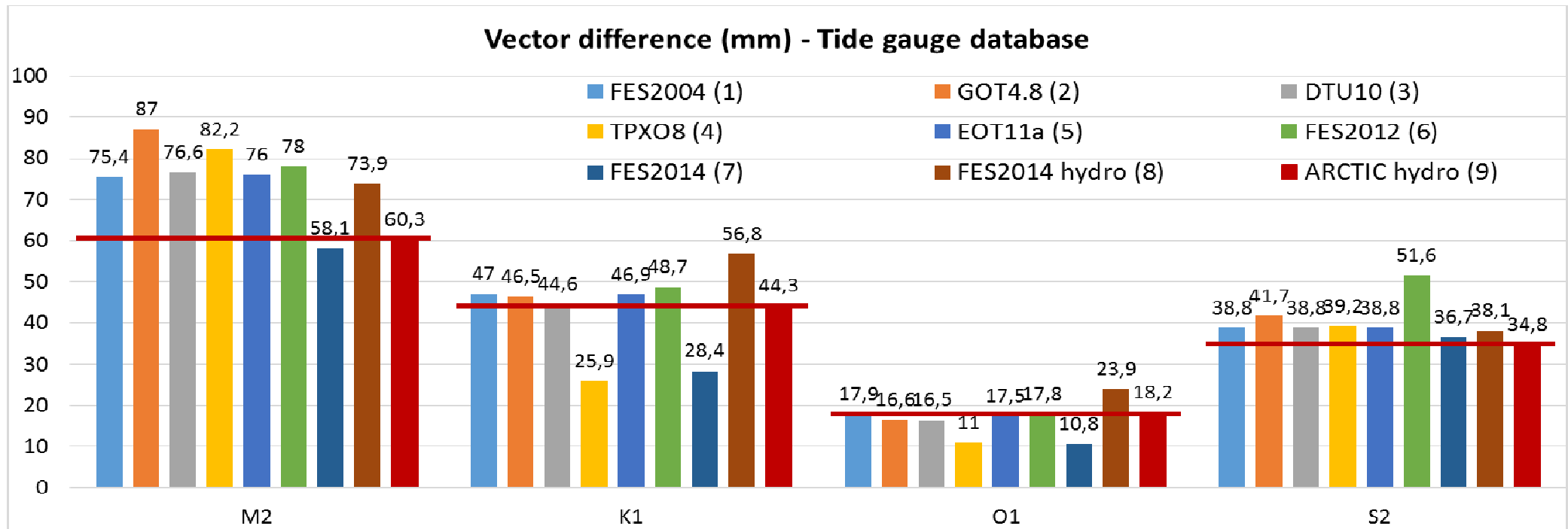
Coast: 4 km

Offshore: ~8 km

- Generation of the prior hydrodynamic tidal solution

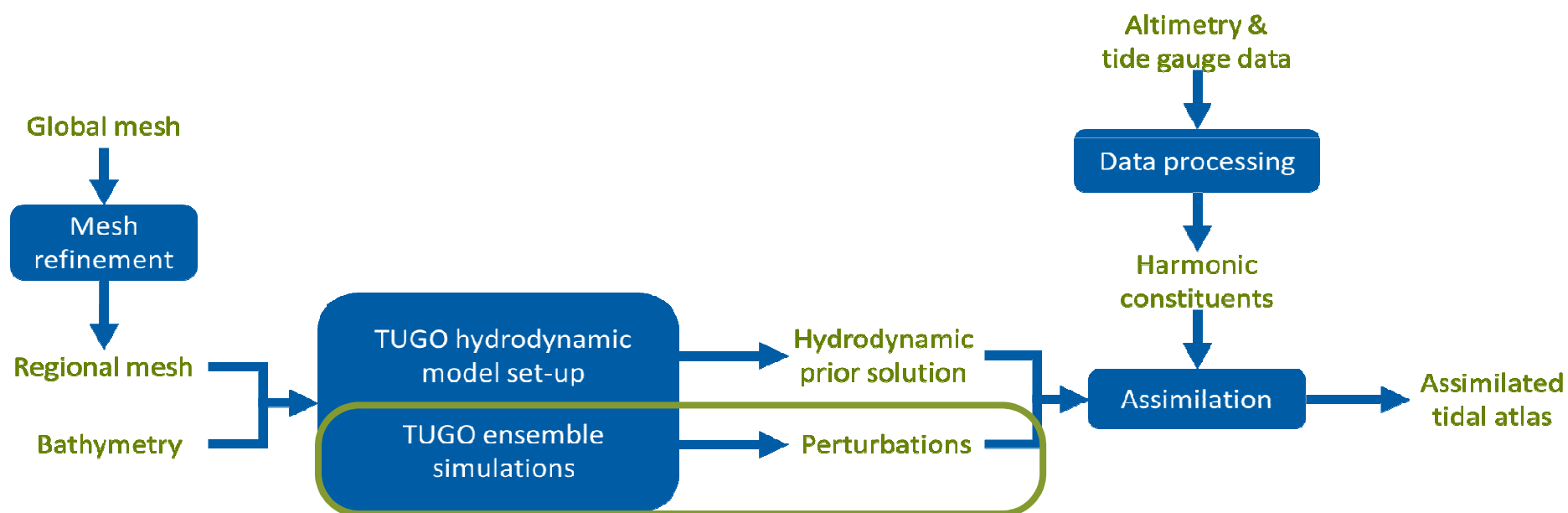


- TUGO hydrodynamic model from LEGOS (barotropic, FE)
 - ▶ Boundary conditions : FES2014a
 - ▶ Tuning of the bottom friction



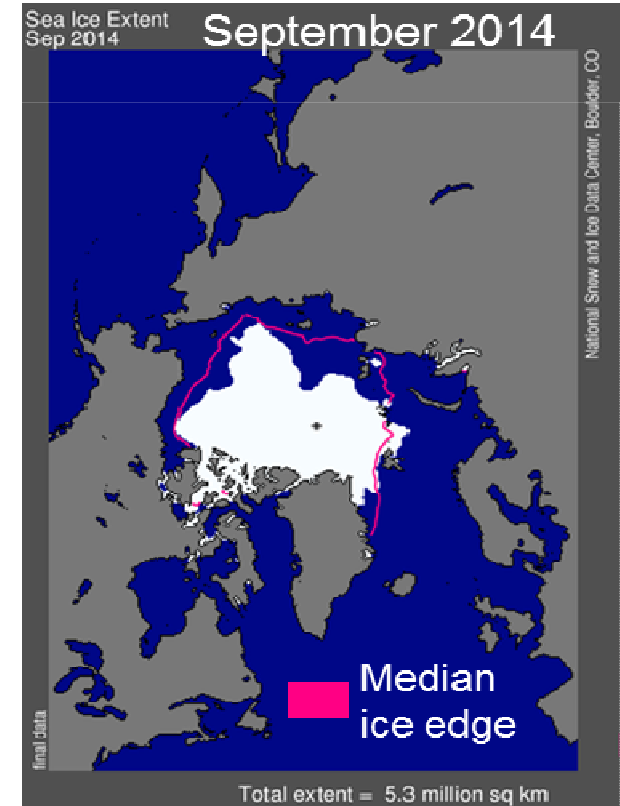
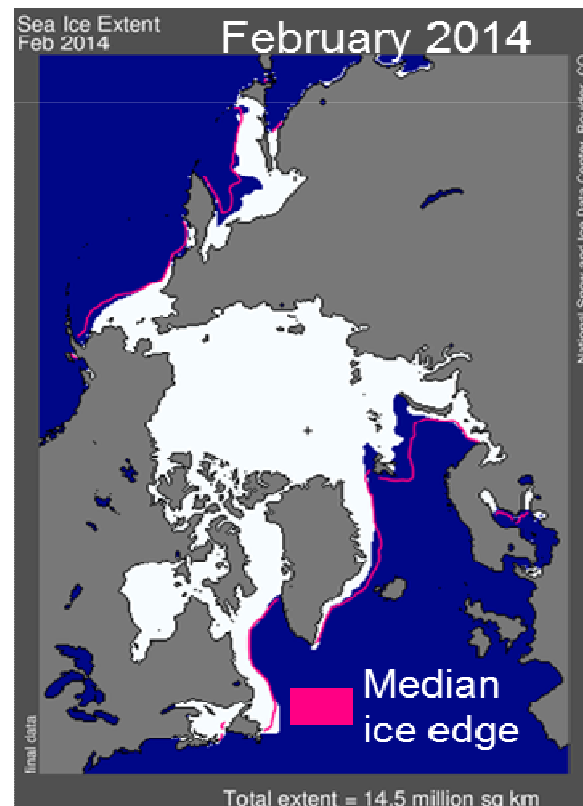
→ The regional hydrodynamic (non-assimilated) solution has equivalent performance to the assimilated global models.

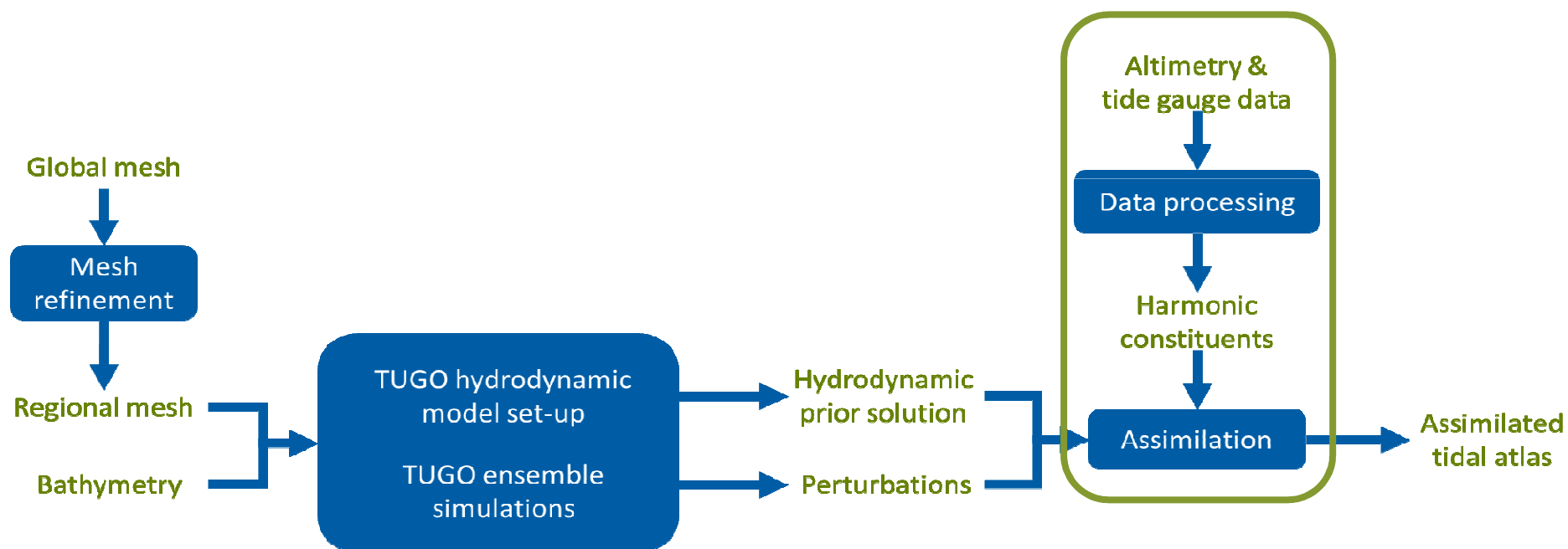
➔ Describe the hydrodynamic model errors



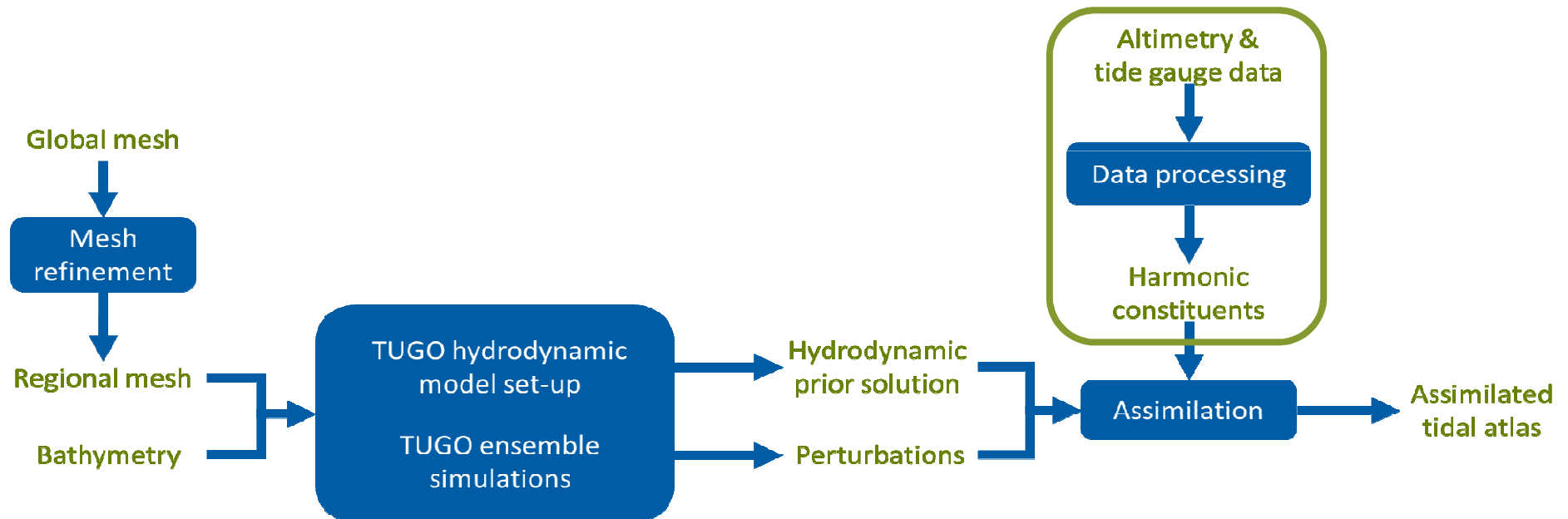
- Local perturbations of the bottom friction
- **Sea ice extent:** double the bottom friction under the ice
 - ▶ Median Summer extent
 - ▶ Median Winter extent

→ Total of 312 perturbed hydrodynamic simulations



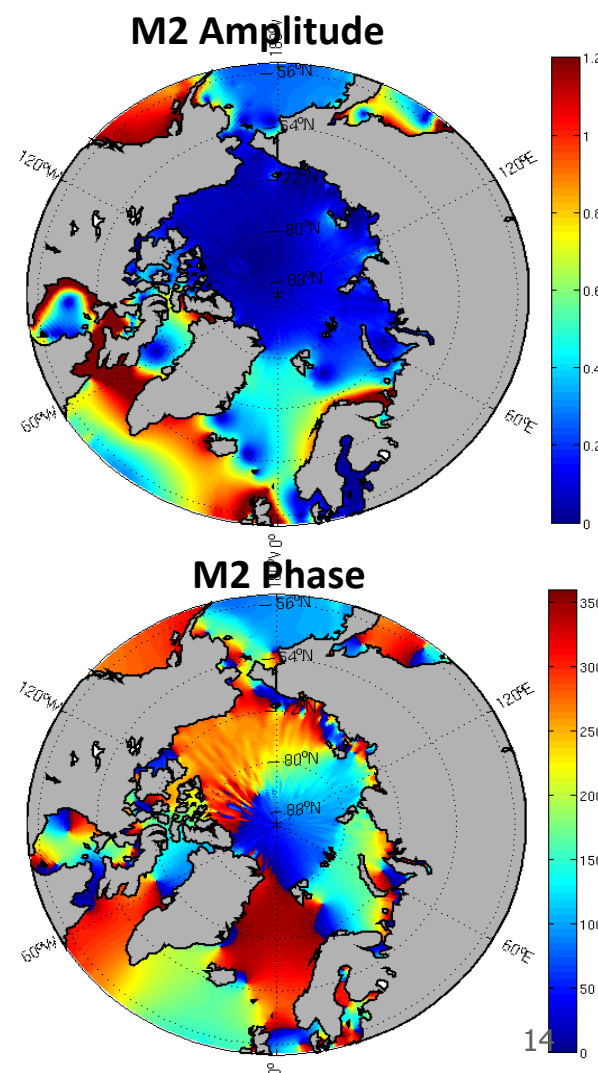


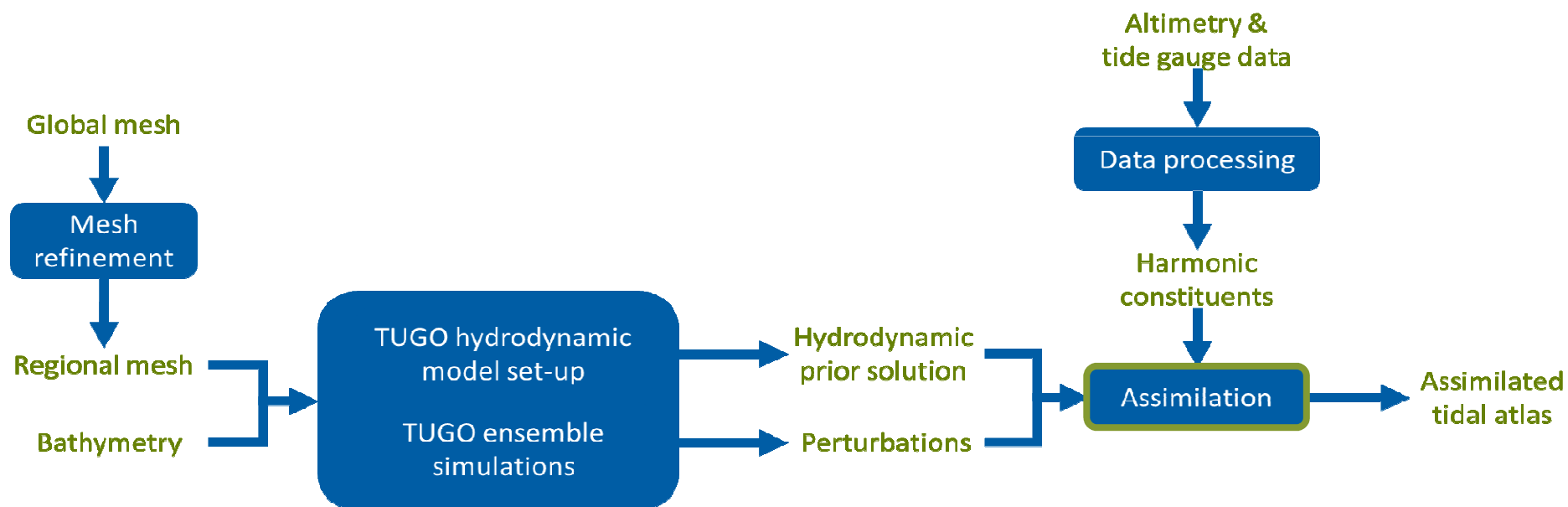
- Computation of the altimeter tidal harmonic constituents



● Computation of the altimeter tidal harmonic constituents

- ▶ CryoSat-2 data in LRM, SAR and SAR-in modes (2010-2014)
- ▶ Envisat data (2002-2010)
 - CryoSat-2 LRM and ENVISAT data from RADS
 - CryoSat-2 SAR and SAR-in retracked using primary peak retracker (DTU-LARS retracking system)
- ▶ Remove/restore methodology: FES2004 is removed prior to tidal prediction and then restored to obtain the final tidal signal
- ▶ Altimetry data in boxes of $1^\circ \times 3^\circ$ from 55° N to 88° N

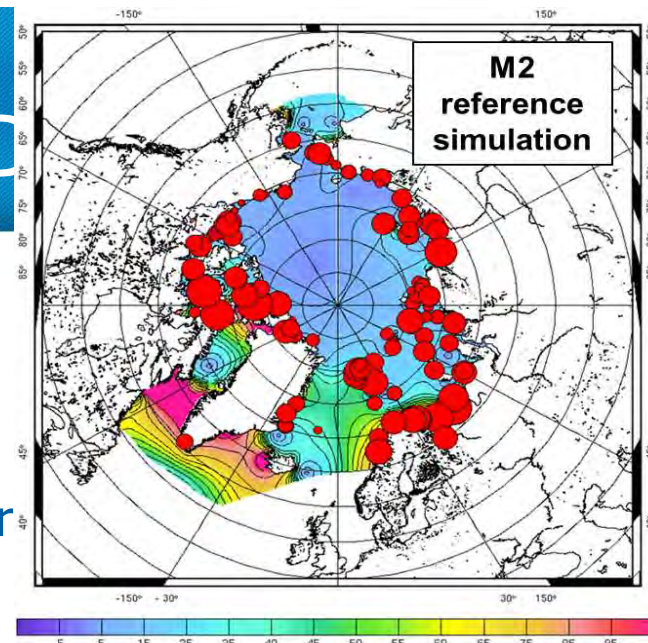




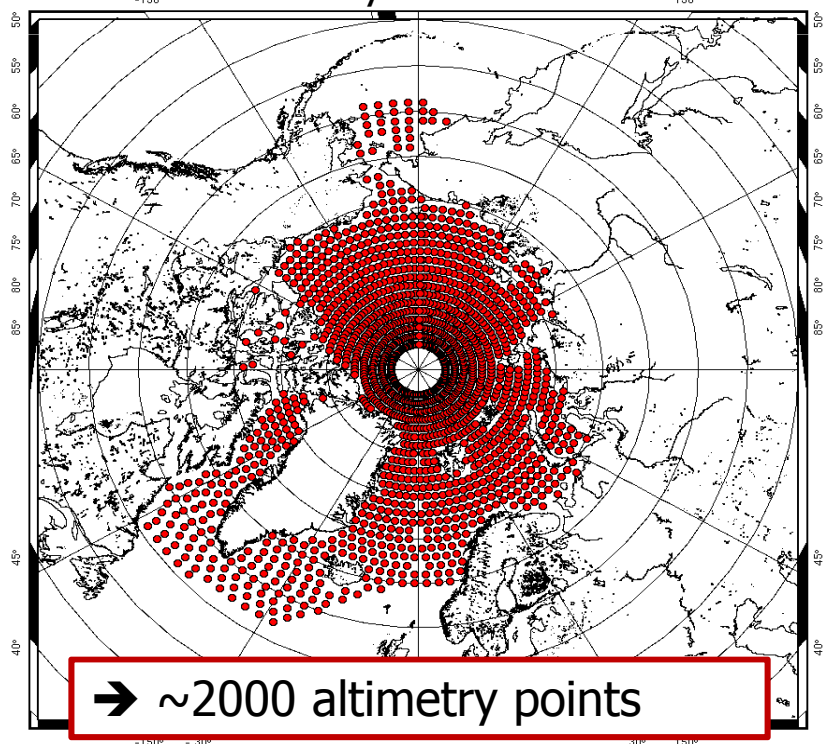
● Selection of the altimetry data

▸ Decimation of the altimetry data offshore

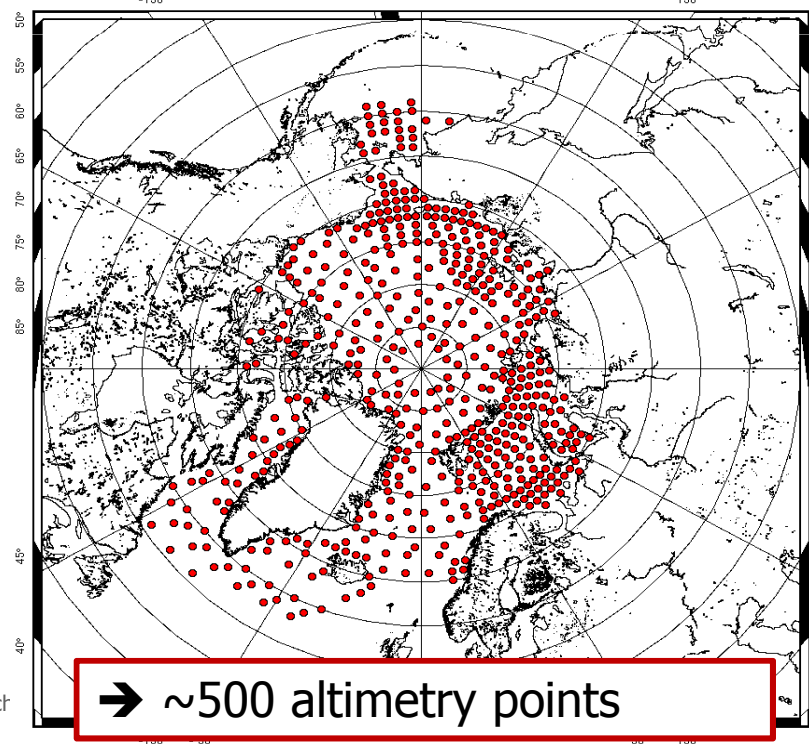
➔ Maintain the **balance** between the **weights of the hydr** small errors) and the **altimetry data** (not perfect)



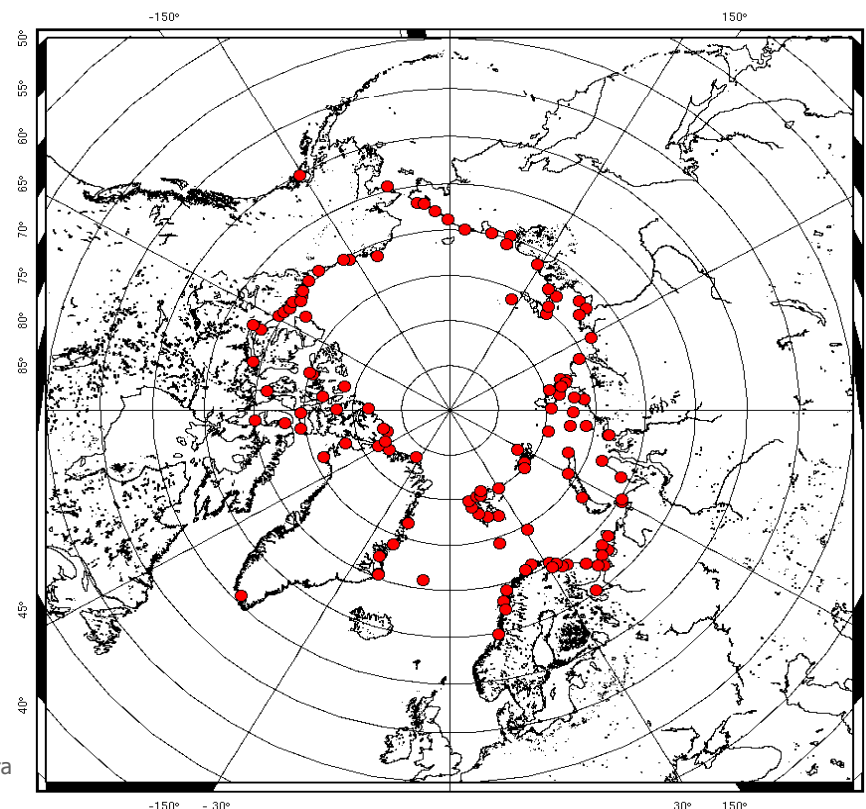
Initial altimetry dataset from DTU



Decimated altimetry dataset for assimilation

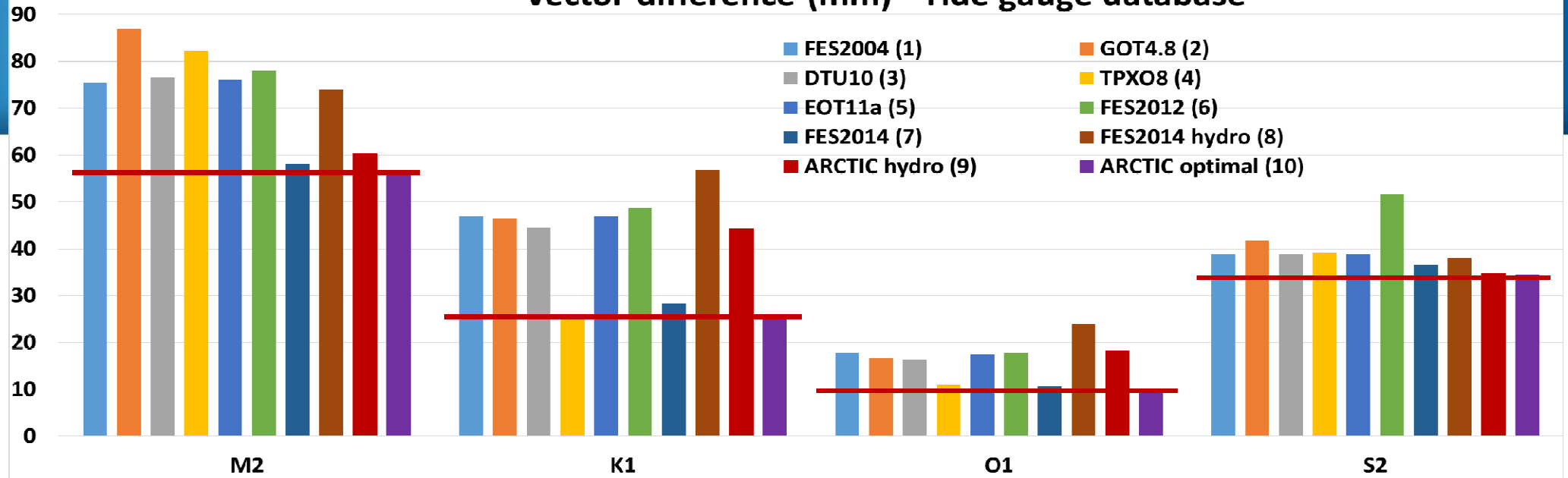


- Selection of the tide gauge data
 - ▶ Not much confidence in the available data: old datasets, few tidal components, time series not available, short periods of measurements (when ? sea ice ?), local time...
 - ▶ Strict editing performed by LEGOS and NOVELTIS over the years (ex: detection of clock problems)
- ➔ Starting with more than 400 stations, the final dataset contains about 120 stations

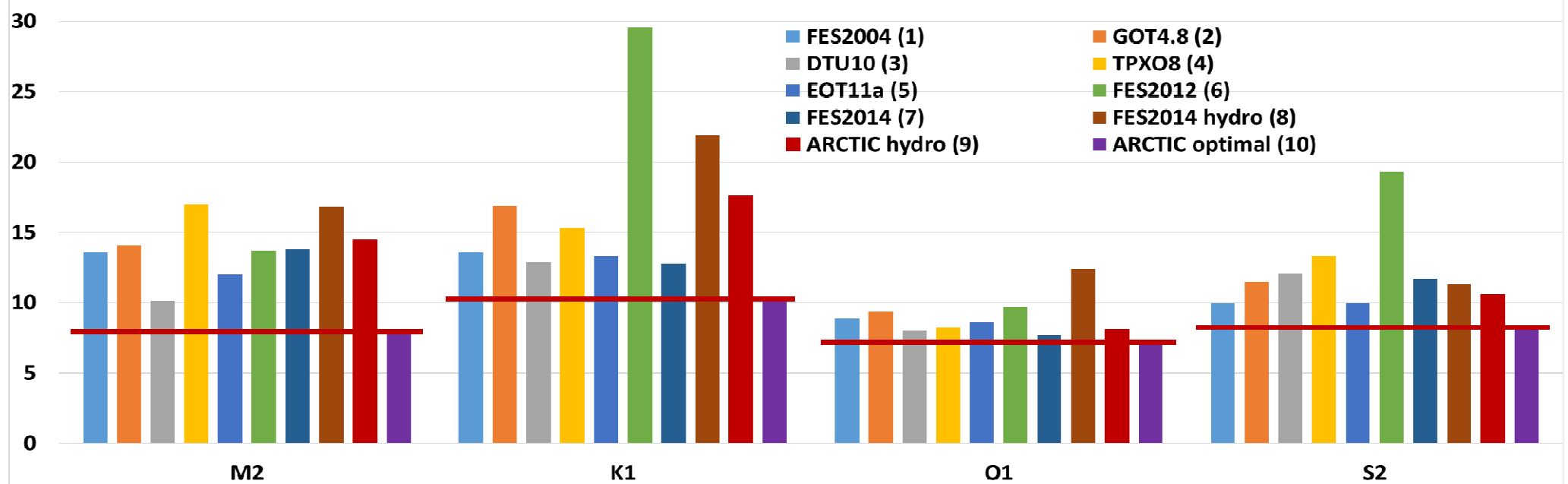


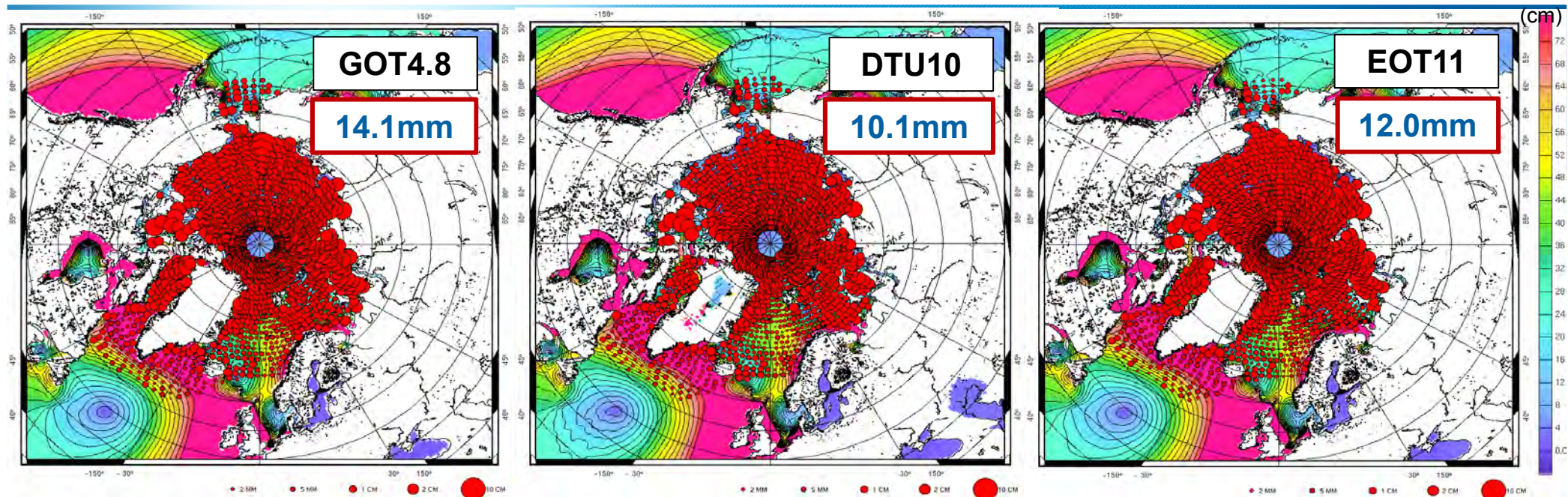
- Validation of the optimal tidal atlas

Vector difference (mm) - Tide gauge database

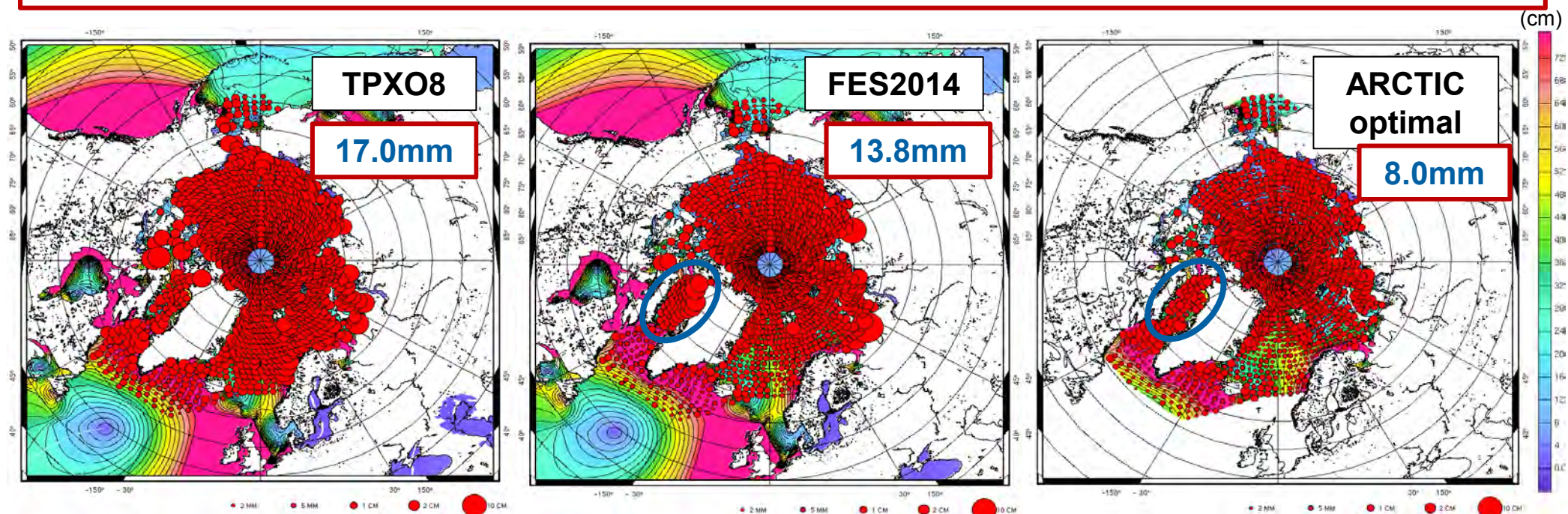


Vector difference (mm) - Altimetry database





M2 tidal component – Comparison to the (*partly assimilated*) altimetry observations



● Conclusions

- ▶ The regional purely hydrodynamic model shows equivalent performance to the global data-assimilated models
- ▶ Data assimilation works well and improves the model performance
- ▶ Globally, high accuracy of the regional tidal model

- ▶ Independent validation is welcome !
 - Comparison to independent in situ data
 - Sea ice freeboard computation
 - Evaluation as tide correction for altimetry data

➔ We can provide tidal time series for validation, please ask !

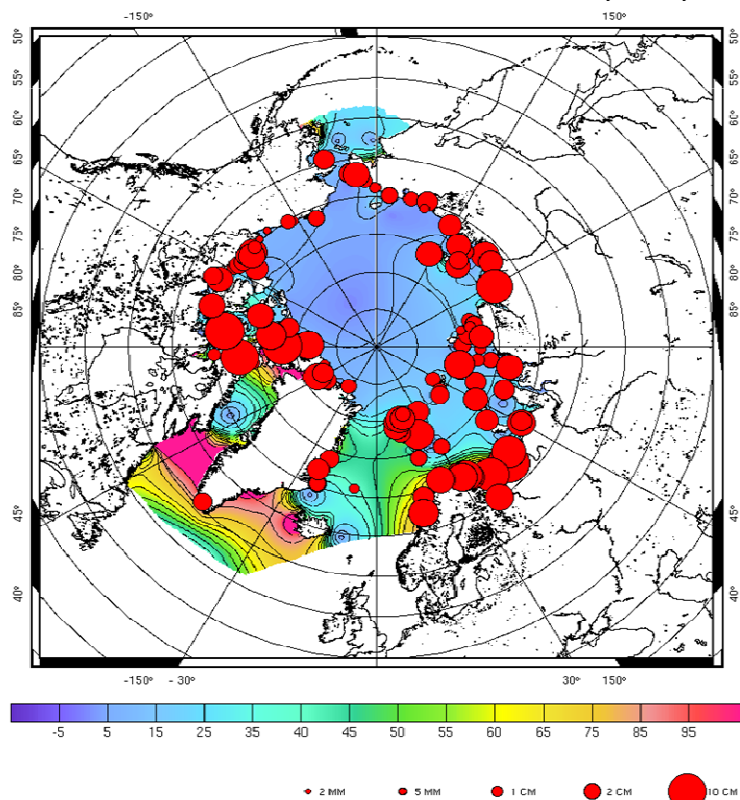
- Perspectives of use
 - ▶ Improvement of high-latitude altimeter products (tide correction): CryoSat-2, Sentinel-3, Envisat, SARAL...
 - ▶ Ocean and sea ice modeling and forecasting for Arctic studies: ocean circulation, sea ice drift, sea ice freeboard computation...

- Perspectives for tidal model improvements

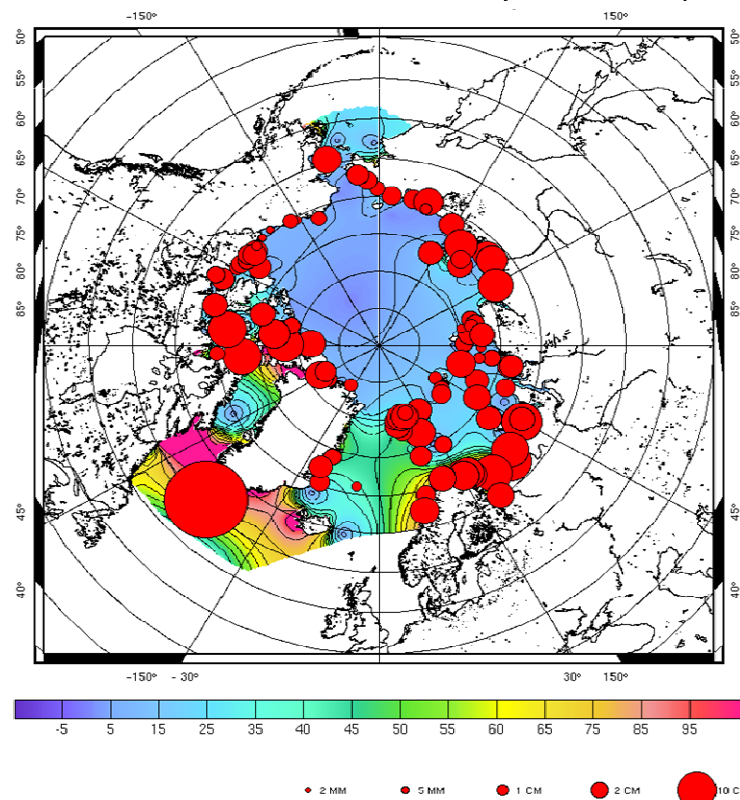
- ▶ Bathymetry improvement in the Arctic

- Design of a new bathymetry including CryoSat-2 data
 - Evaluation of new bathymetry dataset release

M2 – reference simulation – IBCAO bathymetry



M2 – reference simulation – R-Topo 1.0.5 bathy



- Perspectives for tidal model improvements
 - ▶ Bathymetry improvement in the Arctic
 - Design of a new bathymetry including CryoSat-2 data
 - Evaluation of new bathymetry dataset release
 - ▶ Altimetry data processing: better resolution of diurnal waves
 - ▶ Update of the optimal tidal model
 - ▶ Enlargement of the tidal spectrum (time-stepping simulation)
- Perspectives of development
 - ▶ Other strategic regions with a need for high resolution tidal modeling (SWOT...)

Thank you for your attention !

