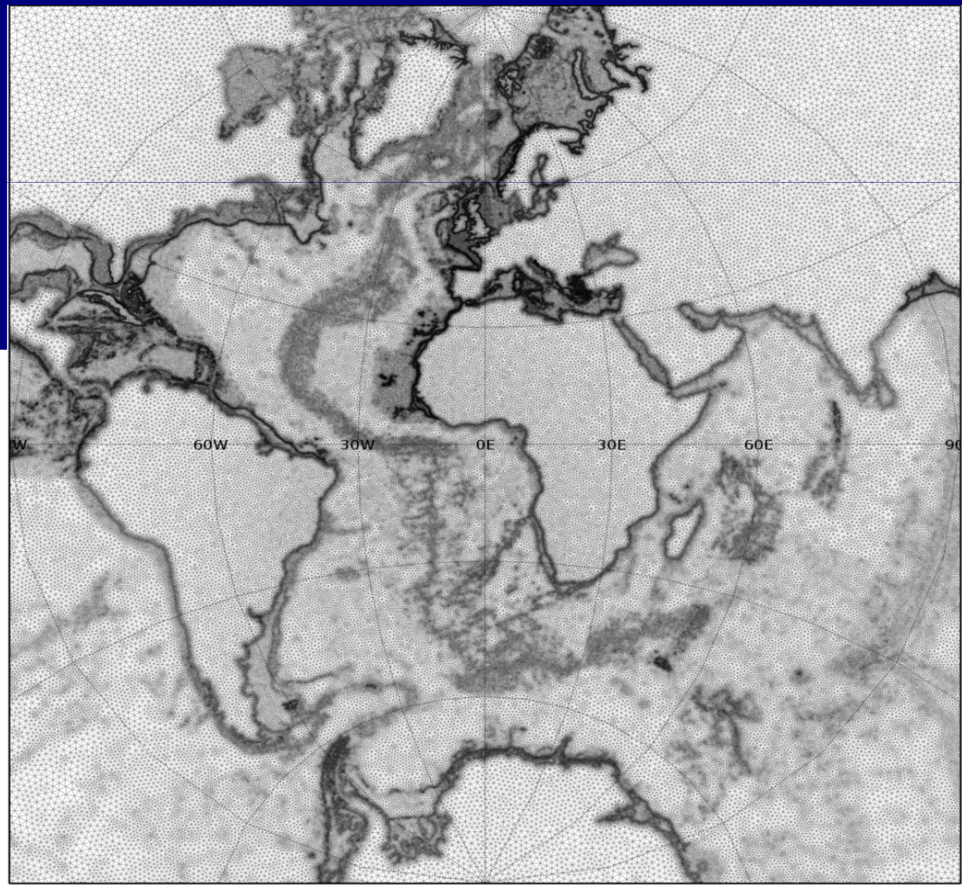
High frequency corrections for altimetry: what are foreseen evolutions for the future



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Ocean sea level high frequency dynamics corrections

- Ocean waves
  - Partially filtered out by instrument footprint size
  - Empirically removed bias
- Storm surges
  - Shallow-water hydrodynamic simulations (hindcast)
  - Forcing physics: wind and pressure
  - Coastal resolution: 10 to 15 km alongshore
- Ocean tides
  - Empirical and semi-empirical (hydrodynamical modeling plus data assimilation)
  - Harmonic prediction
  - Coastal resolution: 2 to 7 km alongshore (FES2014)

- Present concerns
  - Open oceans: high mesoscale energy regions
  - Coastal ocean: insufficent resolution, higher error budget
  - High latitudes: higher error budget
  - Internal tides surface signal: not specifically corrected
  - Overall concern: weaker accuracy out of TP/Jason groundtrack

Future requirements

- Improve data correction homogeneity
  - Narrow the gap in accuracy between open and coastal ocean
  - Narrow the gap in accuracy between low and high latitudes
  - Provide a seamless correction from open ocean toward shorelines

- Improve data coverage
  - Target a 1 km resolution along the coasts
  - Take care of transition areas (estuaries,…)

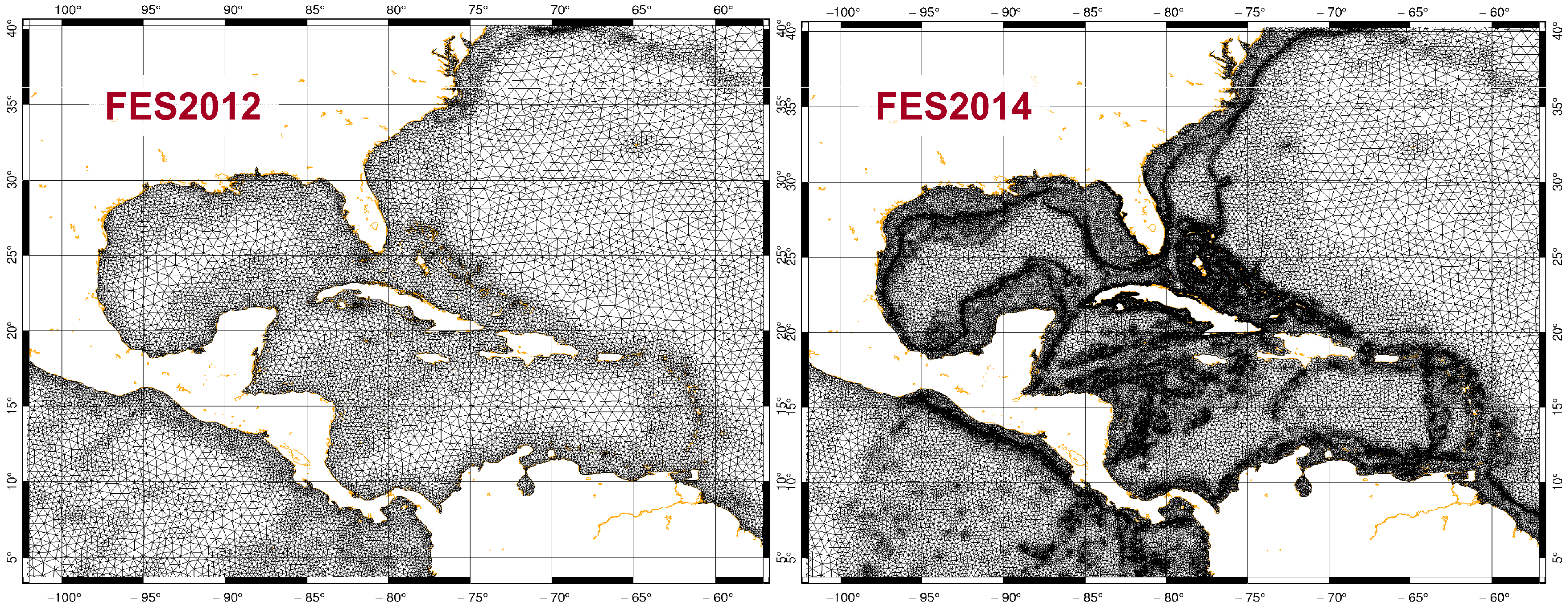
- Predict internal tide signature
  - Extent present knowledge out of TP/Jason groundtracks
  - Account for seasonal (or quicker) variability

- Proper ocean waves de-aliasing
  - Coastal wave setup
  - Infra-gravity waves
  - SWOT aliasing in high resolution mode

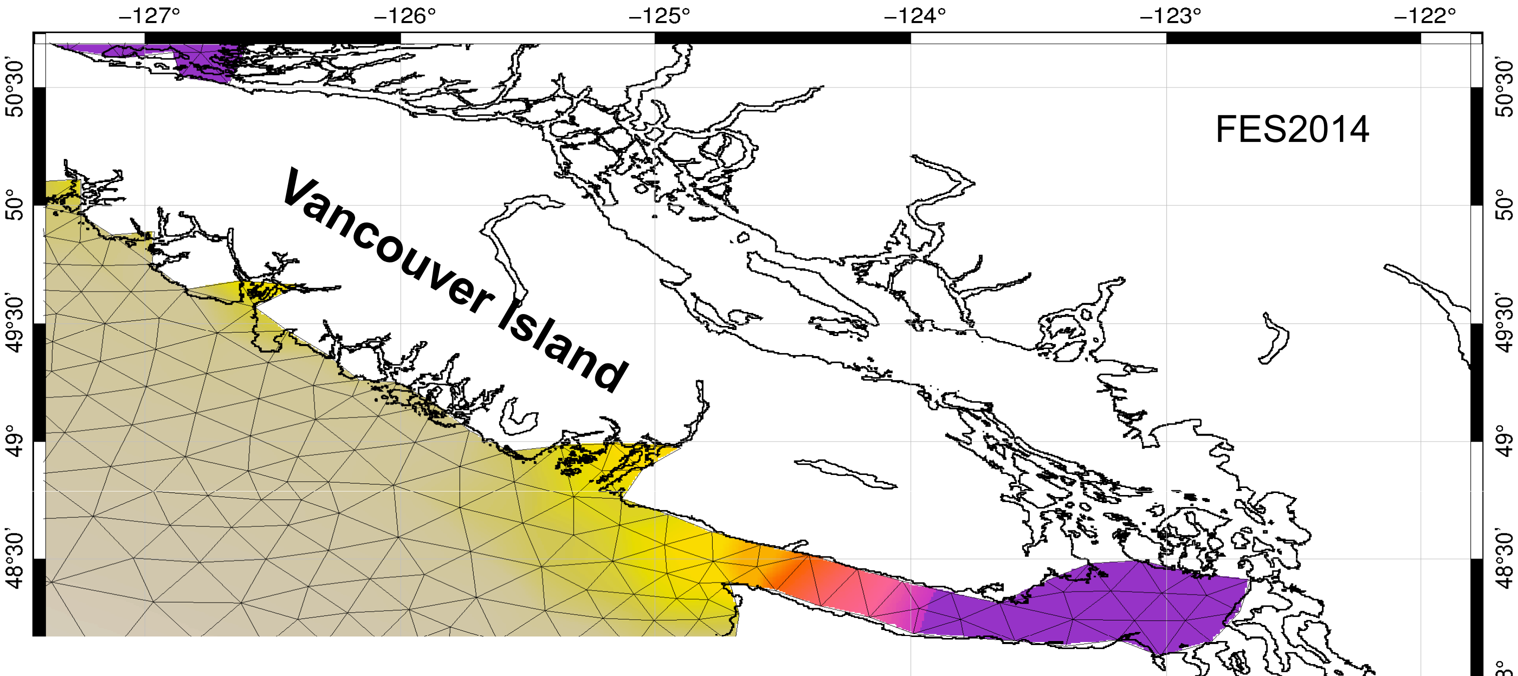
Also to be thought in perspective of altimetry CalVal and gravimetric mission needs

FES2014 unstructured mesh

- Grid resolution
  - ~10 km along shorelines
  - ~20 km along shelf-break
  - ~75 km in abyssal seas
  - (upgrade of FES mesh series)



Model resolution/extent issue



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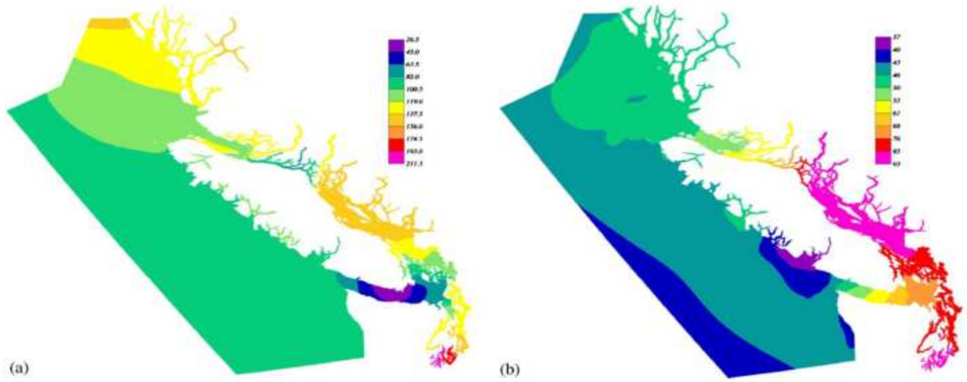
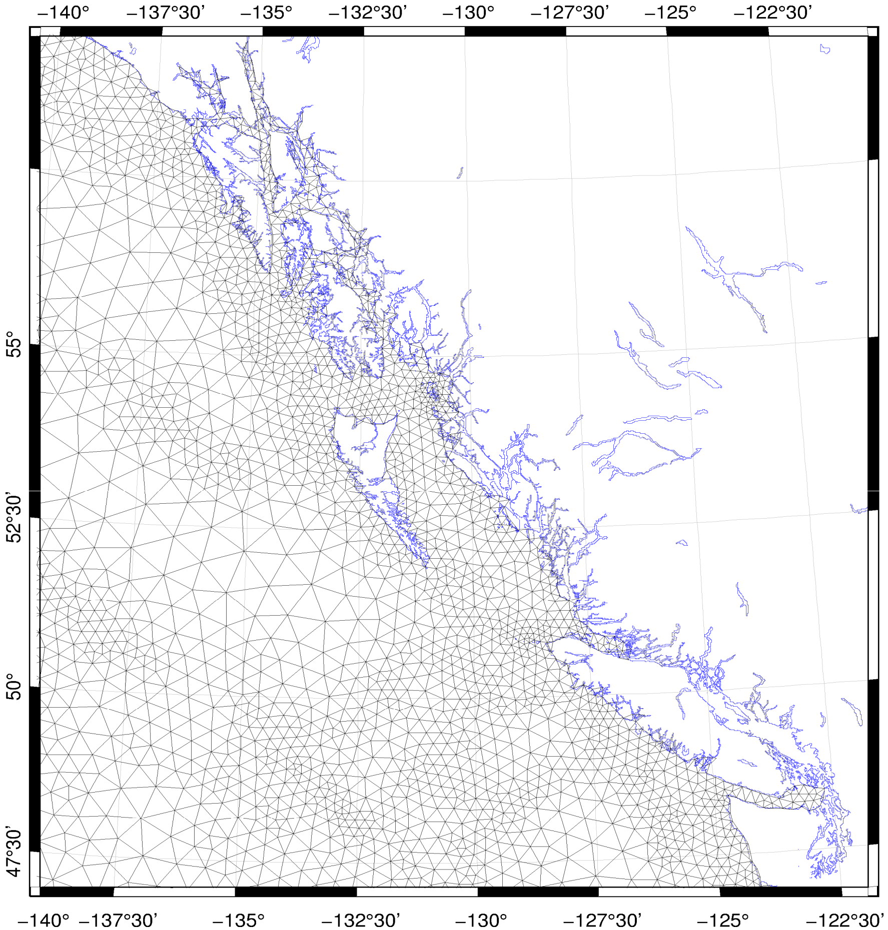
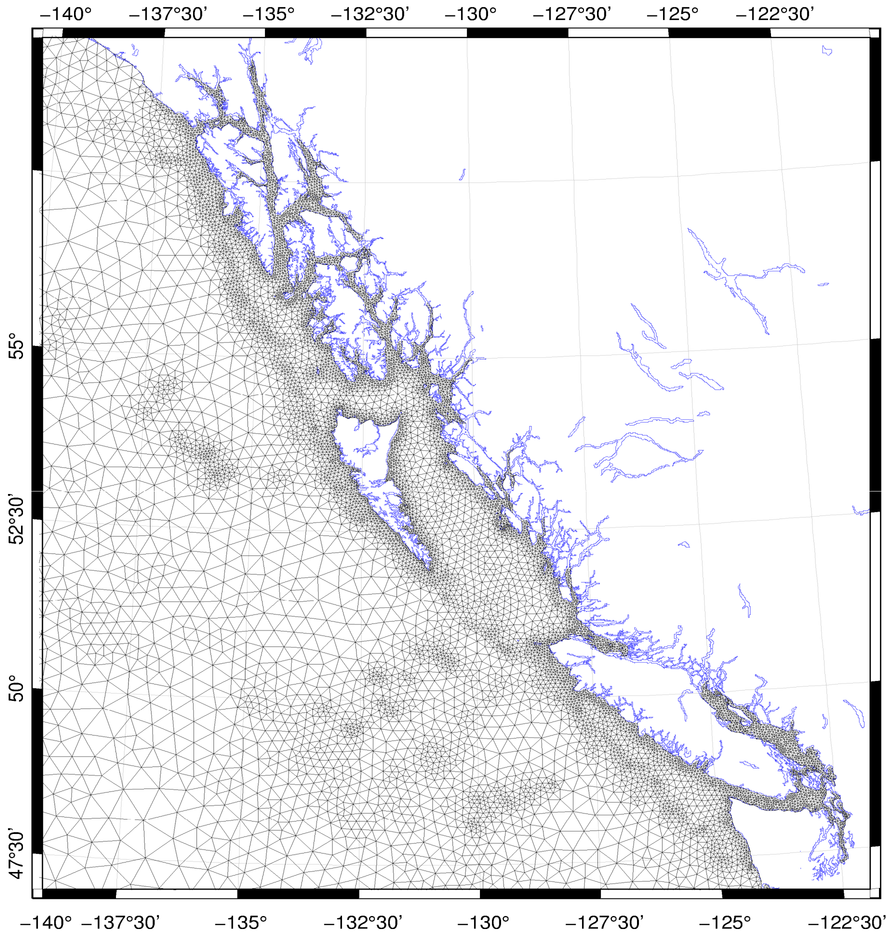


Fig. 4. Prior (a) M_2 and (b) K_1 amplitudes (cm) computed with the Walters (1992) TIDE3D model.

Coastal tides: lot's of region to improve



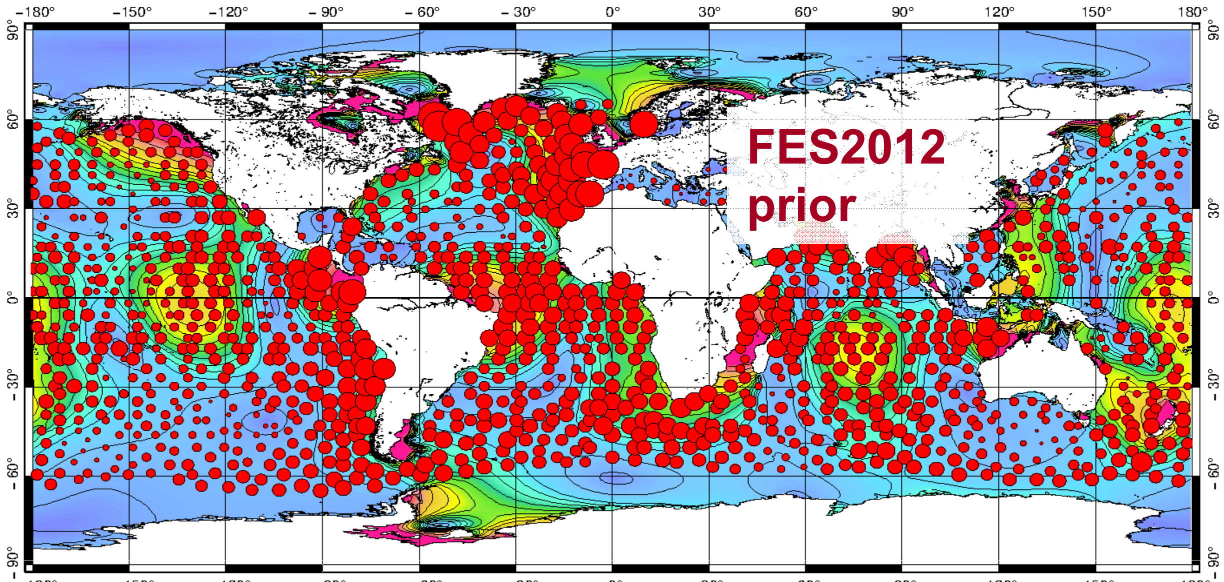
FES2014



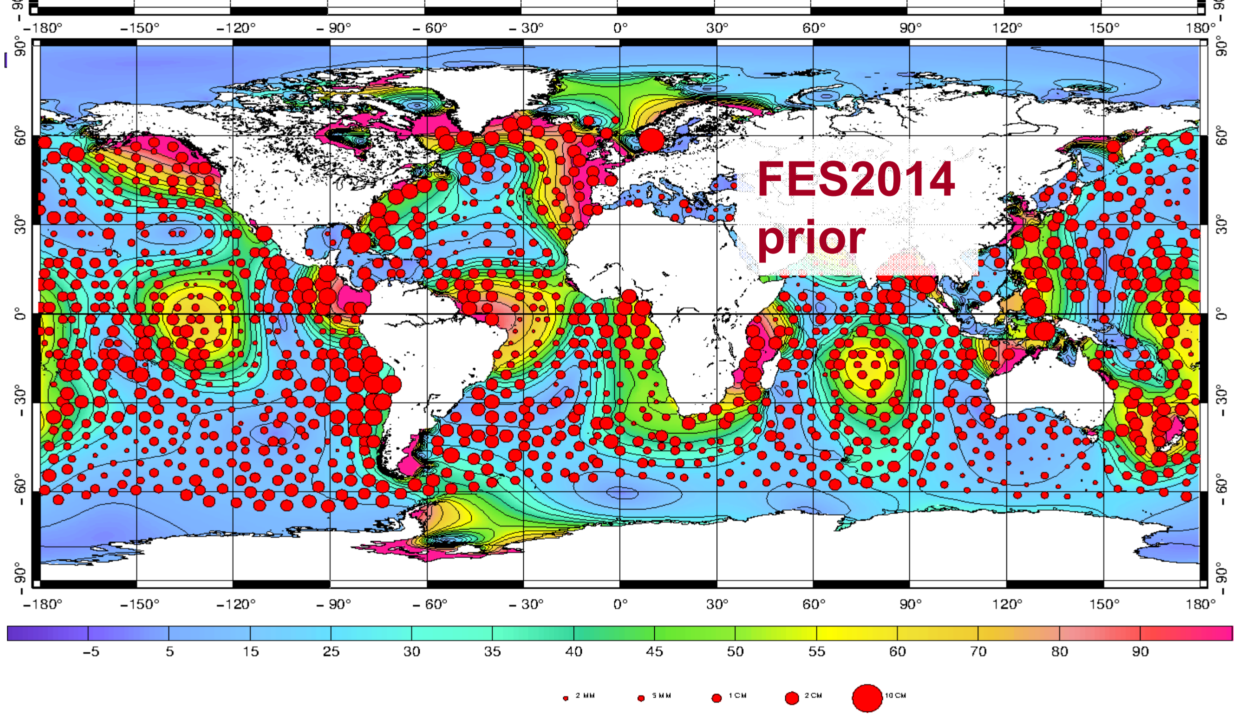
FES20XX

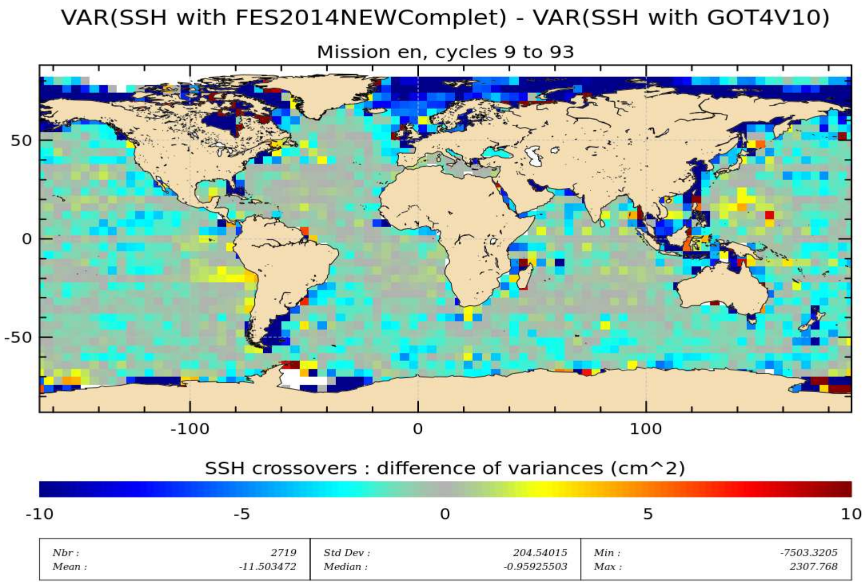
Hydrodynamical simulation accuracy improvement

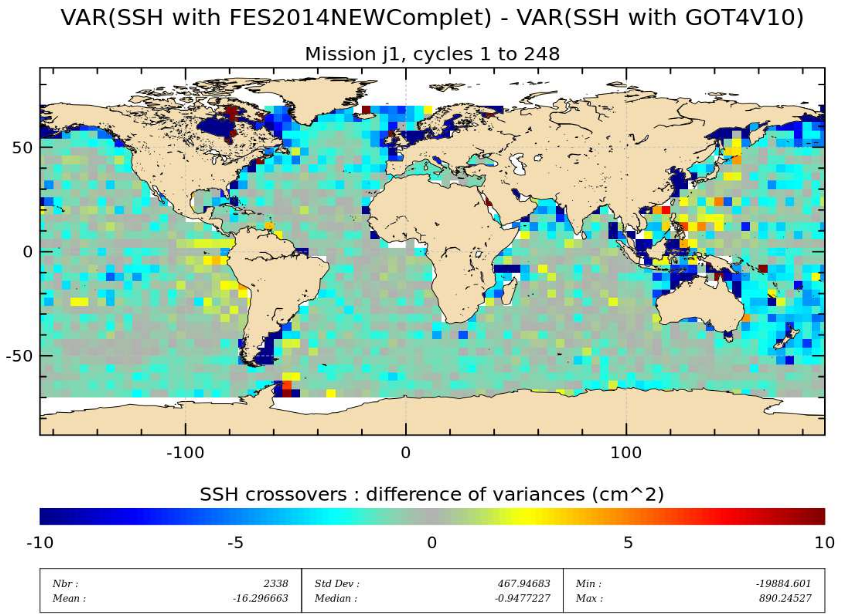
M2 RMS (TP/J1/J2 xovers)
Deep ocean 2.4 cm
Shelf seas 9.3 cm



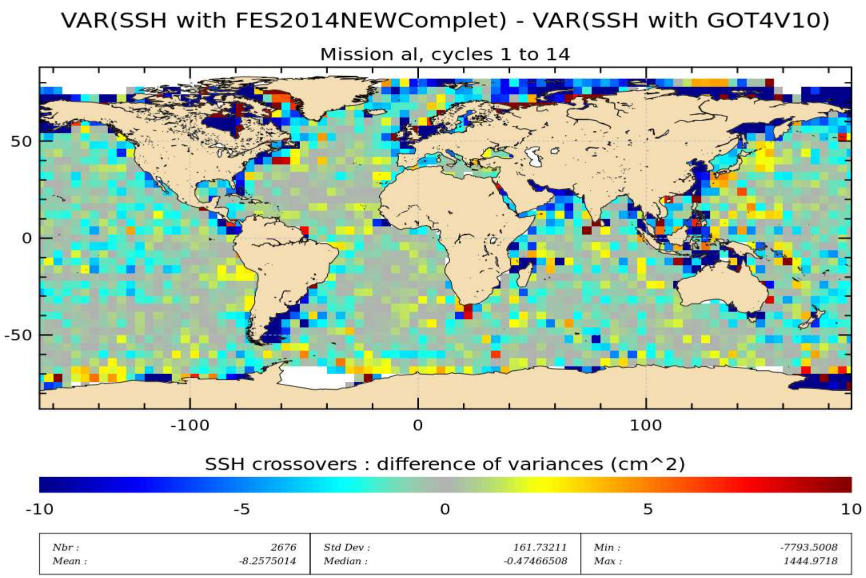
M2 RMS (TP/J1/J2 xovers)
Deep ocean 1.3 cm
Shelf seas 5.5 cm

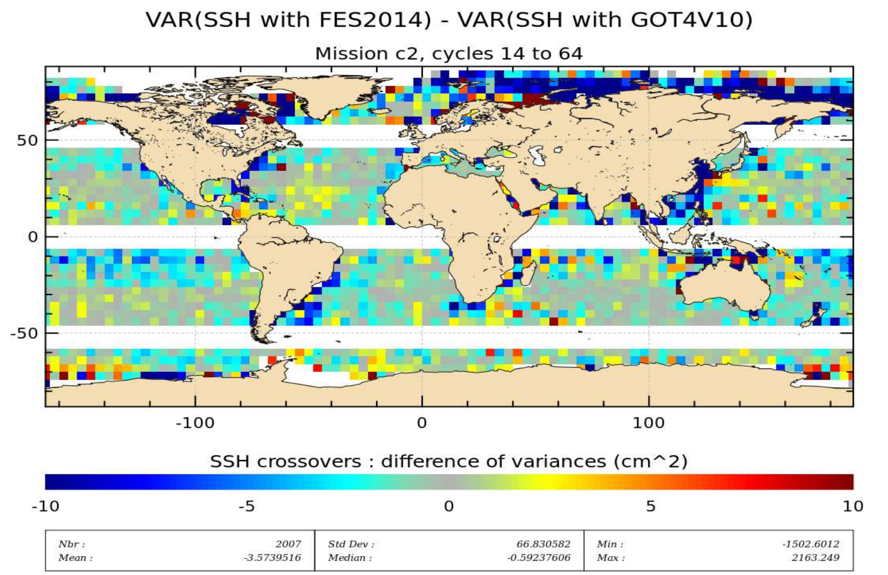






FES2014 vs GOT4V8-10
SSH





Future requirements achievement needs:

- Keep improving model realism/accuracy
  - Bathymetry, resolution, numerics, computational cost optimisation
  - Tidal physics:

    Barotropic to baroclinic energy transfer (shallow-water modeling), loading/self-attraction terms, mean sea surface height (above geoids) effects, floating ice friction, interaction with ocean circulation, …
  - Storm surges physics:

    Interaction with tides and ocean waves, wind stress derivation (bulk formula, ocean waves derived stress,…), atmospheric forcing time sampling (1h?), loading/self-attraction terms, …
  - 2D versus 3D
  - Internal tide regional investigations (global models to heavy)

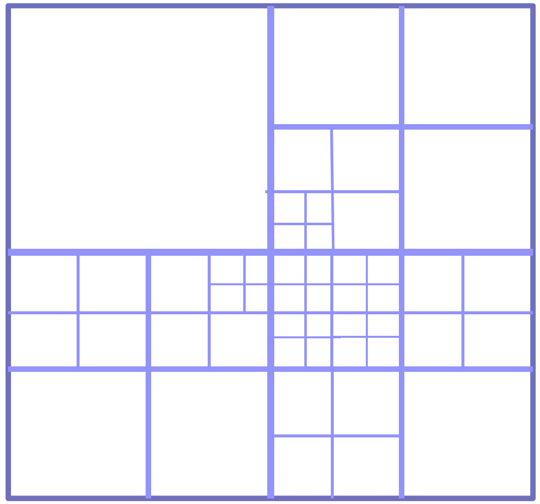
- Manage increased computational load
  - Present shallow-water models will need a x10 to x100 number of DoFs
  - Prognostic 3D hydrodynamic models will be needed for internal tides
    - Internal tides extraction from simulations is an issue (post-processing)
  - Data assimilation will grow with the square of hydrodynamics model size
  - Re-processing issue

- Manage increased data (observations and corrections) archiving load
  - Correction data will follow model grid evolution
  - Seasonal tidal corrections (at least for IT)
  - Observational data size will increase with time and missions, will increase dramatically with SWOT mission

Conclusion

- Need to redefine correction production system
  - Centralized computational centers
  - Performance assessments benchmarks
  - Close to data processing centers
  - Collaboration with atmospheric and oceanographic operational centers

- Imagine new data archiving/delivery formats/standard
  - Keep science applications tractable
  - SWOTcoastal/hydrology products issue: variable resolution/quick access mapping (quad-trees?)

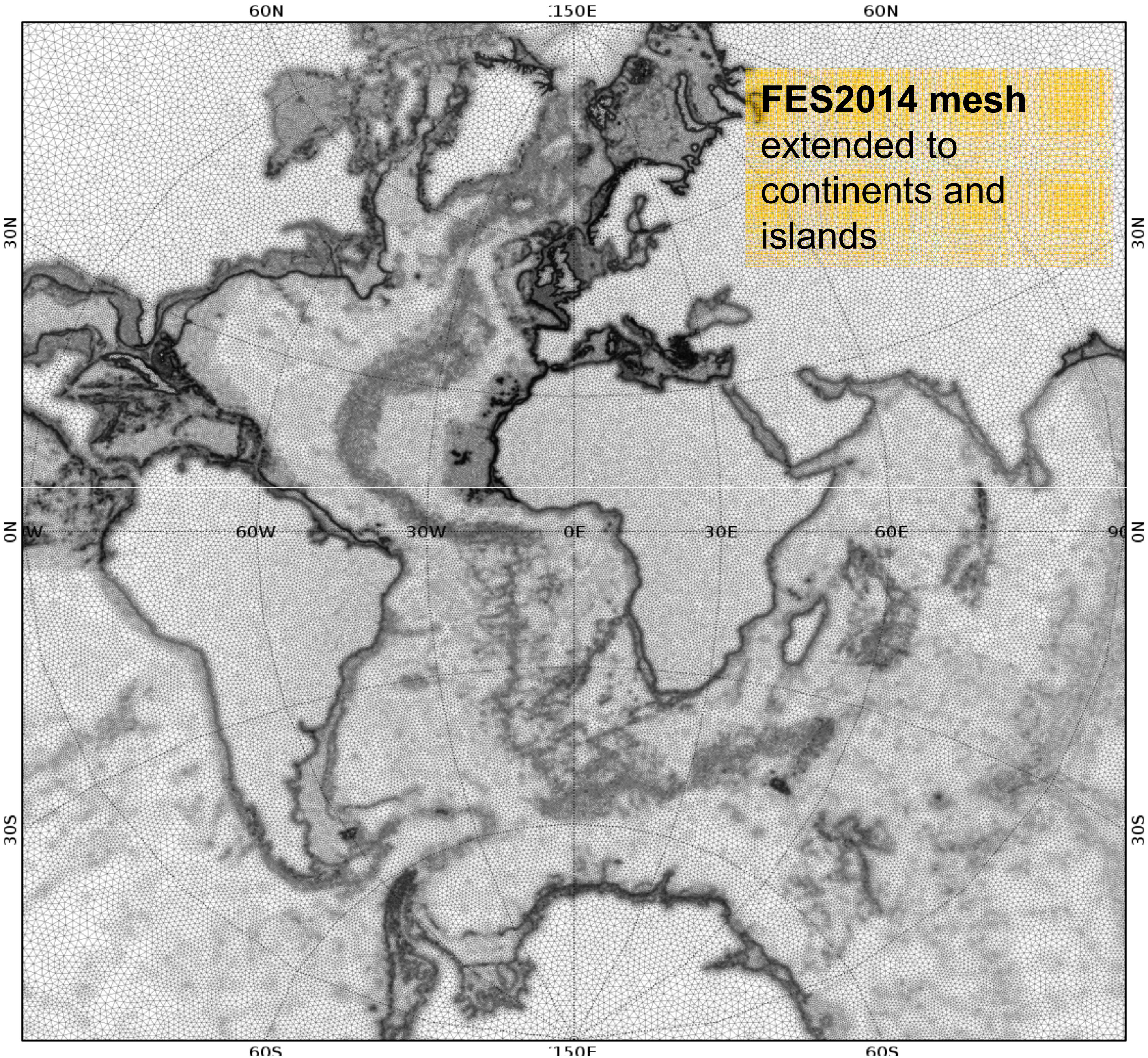


- Promote science collaboration
  - Dealing with ocean dynamical processes (non-linear) interactions will be more and more important
  - Progress will need to combine more and more different type of expertises
  - Ultimate validation found in science applications

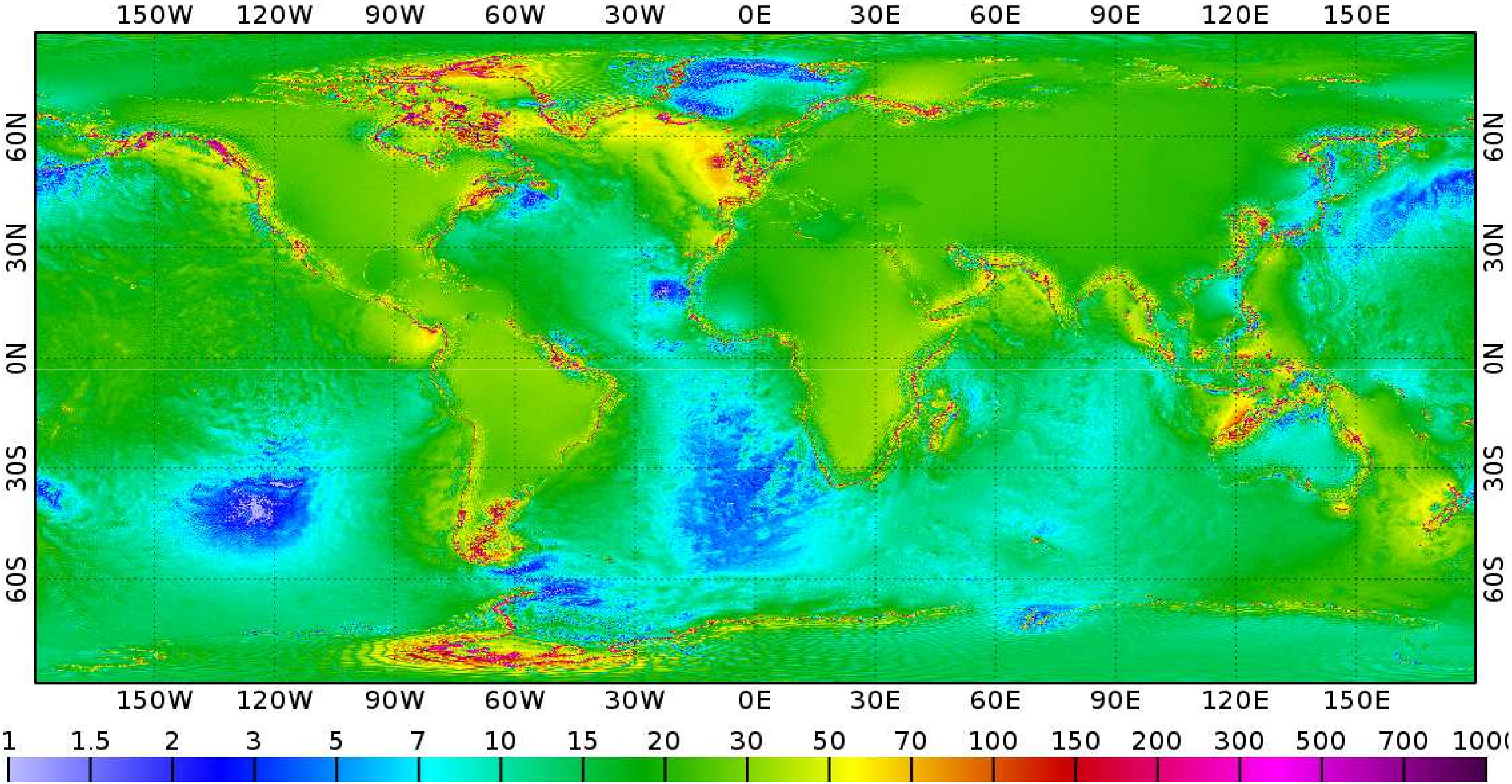
Loading/self-attraction investigations

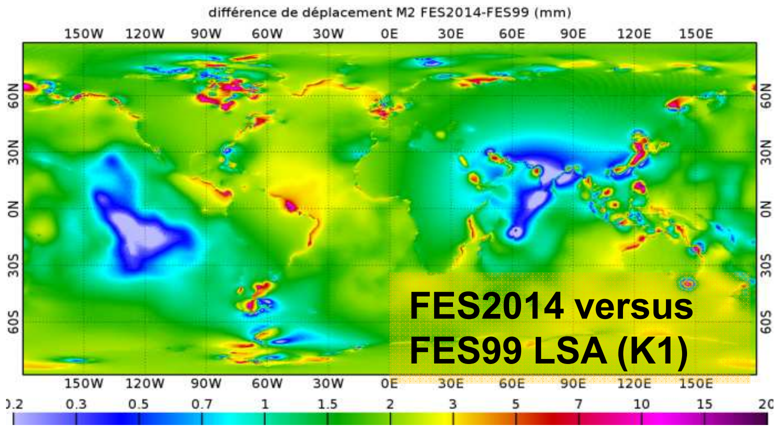
- Tackling CF/CME/CMEOA issue
- Investigate resolution issue (structured versus unstructured computational grid)
- Anticipate non-uniform Earth deformation functions
- Anticipate LSA forcing in non-tidal simulations (storm surges, etc)

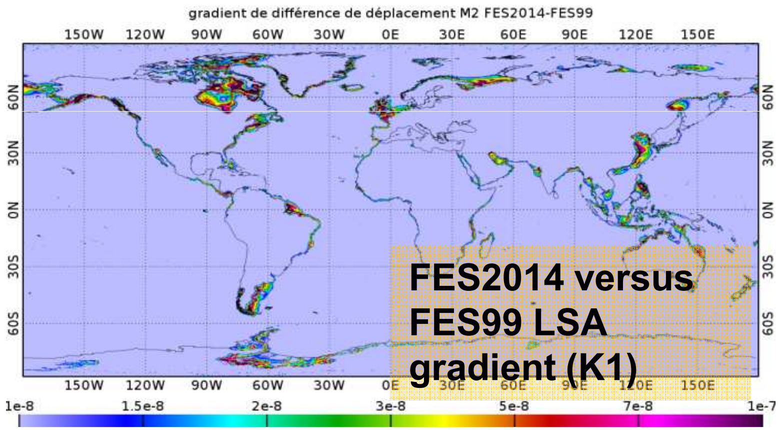
FES2014 mesh extended to continents and islands



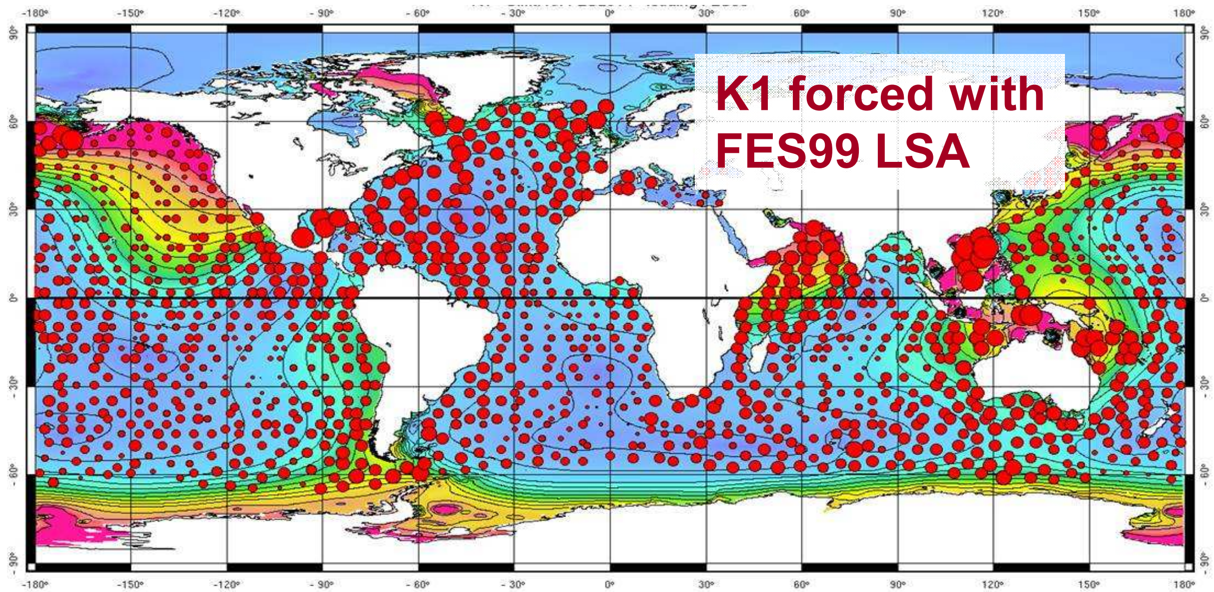
Structured versus unstructured radial displacements (M2, micro-metres)

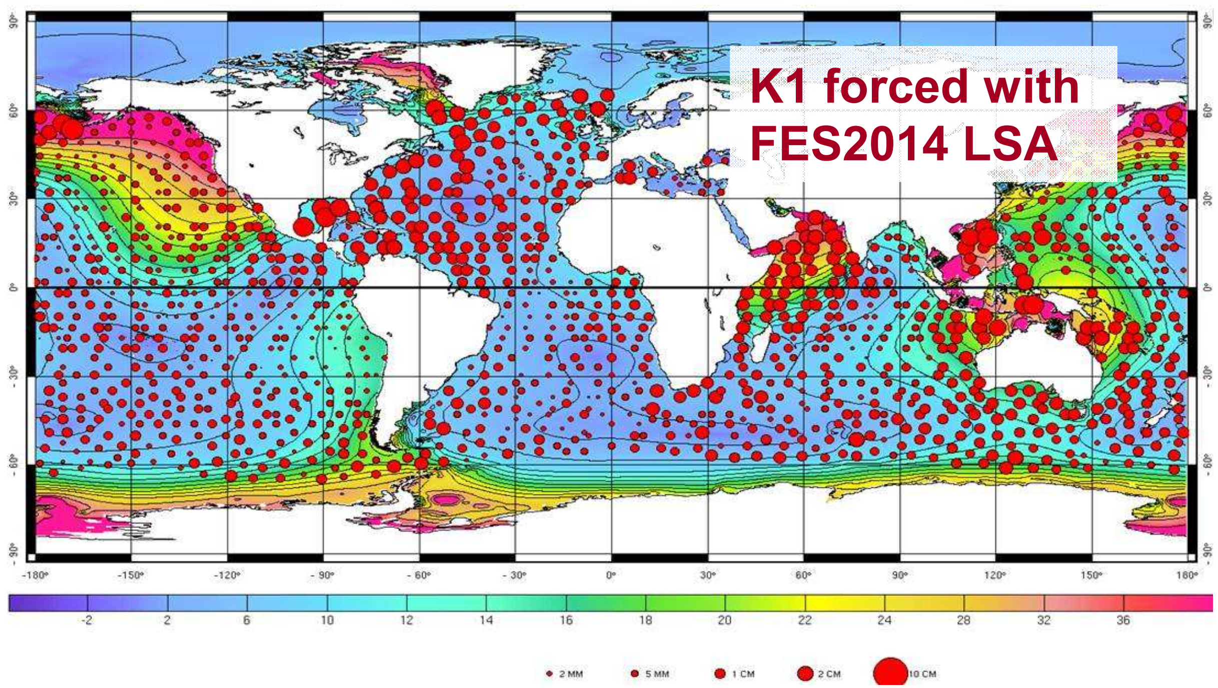






Investigation on LSA forcing





Conclusions/further work

- FES2014
  - Unprecedented prior (hydrodynamic) solution accuracy
  - Show improvements compared to all existing global tides atlases
  - Clearly superior in shelf and costal seas
  - Public release (including tidal currents) : June 2016 (CNES/AVISO)

- FES20XX preparation
  - Continue bathymetry improvement effort
  - Arctic seas investigations (Baffin Bay, Hudson bay)
  - Internal tide drag parameterisation based on actual ocean stratification
  - Increase coastal resolution to fit SWOT interferometer mission needs
  - Baroclinic tides investigations (3D simulations)

FES atlas developments are financially supported by CNRS and CNES