

# FES 2012, a new tidal model - validation results and perspectives of improvements

L. Carrère - CLS  
 F. Lyard - LEGOS  
 M. Cancet - NOVELTIS  
 A. Guillot - CNES  
 lcarrere@cls.fr

## Abstract

A new global tidal model FES 2012 has developed taking advantage of nearly 20 years of altimeter time series, improved modelling and data assimilation techniques, and more accurate ocean bathymetry. Special efforts have been dedicated to address the major non-linear tides issue and to the determination of accurate tidal currents. Several validation diagnostics have been performed, versus in situ data and altimetry (Jason missions, ENVISAT), in spectral and temporal domains; results are presented here. We also present the future improvements envisioned in the forthcoming FES 2014 version.

## 1. FES2012 hydrodynamic configuration

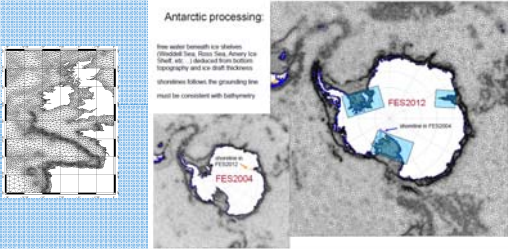
- Bathymetry:** all quality datasets have been used to build a composite global bathymetry:
  - Global: GEBCO (30° & 1'), Smith & Sandwell release14, ETOPO1 (found to be inappropriate)
  - Regional: hydrographic services, PANGEA, IBCAO-IHO
- Mesh:** Initial mesh is FES2004 mesh. Then the following strategy has been applied:
  - Locally resample FES2004 coastlines (Antarctic, Baltic sea...)
  - Diminish open ocean max size (now 75 km)
  - Increase mesh resolution above bathymetry slopes (ridges, continental shelves)
  - Iterative approach
- T-UGO model equations:**

$$\begin{aligned} \text{Momentum equation} \quad j\omega u + f \times u &= -g\nabla(\eta + \delta) + g\nabla\Pi - F - D \\ \text{continuity equation} \quad j\omega\eta + \nabla \cdot \mathcal{U} &= j\omega\eta + \nabla \cdot \mathcal{U} = 0 \end{aligned}$$

$$F = \begin{bmatrix} r^x & r^y \\ r^y & r^x \end{bmatrix} \quad D = c\rho_0 \frac{K^{-1}}{\omega} [(N^2 - \omega^2)(\omega^2 - f^2)]^{1/2} [\nabla h \cdot \nabla h]$$

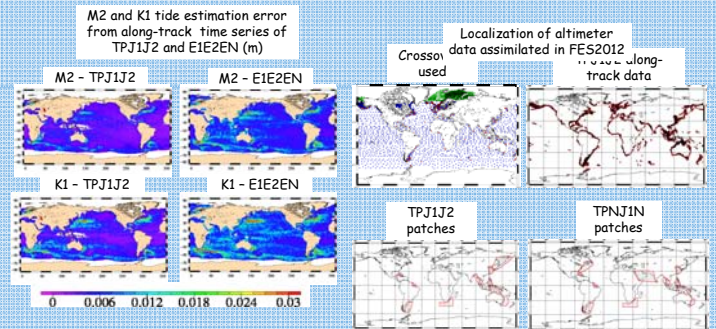
see Lyard et al., 2006, Modelling the global ocean tides: modern insights from FES2004, Ocean Dynamics  
<http://dx.doi.org/10.1007/s10236-006-0008-x>

Zooms of FES2012 Finite Elements mesh on European Shelf and on Antarctic regions



## 2. FES2012 assimilated database

- Nearly 20 years of altimeter data have been used and harmonically analyzed
  - Time series for along-track 1Hz measurements + Crossovers
  - TPJ1J2, TPNJ1N, EIE2EN, GFO
  - CLS/CALVAL/PVA-2010 databases have been used
    - DAC\_ERA\_interim correction is used for TP mission
    - the COG correction is not used
    - A multimissions orbit-error is used for GFO and ERS-EN missions
- Most of the alias issue have vanished in T/P and Jason nominal mission => along-track data of very good quality
- This is not the case for the T/P interleaved mission nor for GFO or ERS/EN missions => need to use crossovers.

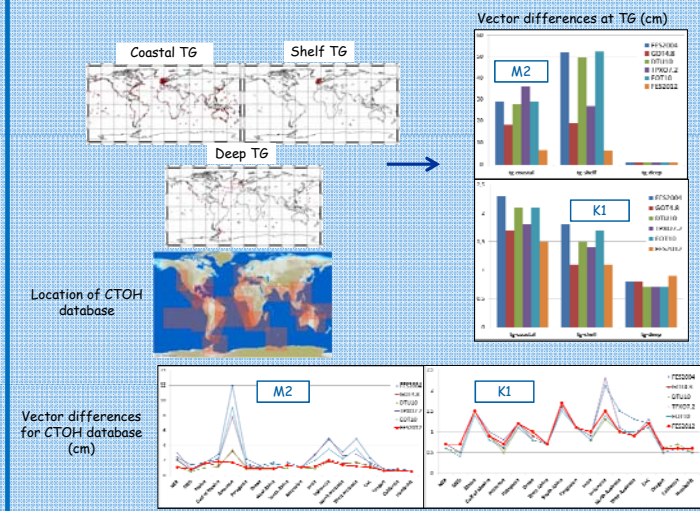


## 4. Validation results in temporal domain

- Validation versus altimetry in multi-missions context (J1, J2, EN and C2), vs. tidal gauges (TG) and also focusing on mesoscale and climate signals.
- Strong improvement of FES2012 vs FES2004, particularly in continental shelves regions
- Comparing FES2012 with GOT4.8:
  - seasonal improvement due to very high latitudes impact (ice cover)
  - improvement in some coastal/shelves regions
  - if looking only at |LAT| < 60°, FES2012 is equivalent to GOT4V8
- The SSH crossovers variance is raised in some regions (red areas) showing a local degradation of FES2012, likely due to some local bathymetric issues (such as the Hudson bay), mesh issues or a lack of assimilated data
- Validation with C2 shows similar results as J1-J2 and EN:
  - Improvement in Pacific, south Atlantic, China seas, Bering, north Russia (blue areas)
  - Variance raised in same regions (red points)
- Impact on climate temporal scales:
  - no significant impact on long term trends
  - decreasing of residual MSL 58.74 days signal except in southern Ocean
  - some impact on annual/semi-annual signals is detected for EN only

## 3. Validation results in spectral domain

Performances estimated for 3 tidal gauges databases and for a global altimeter tidal constituents database from CTOH: <http://ctoh.legos.obs-mip.fr/products/coastal-products/>



## 5. Conclusions and perspectives for FES2014

FES2012 shows good performances compared to other global tide models (FES2004, GOT4.8, DTU10) particularly in continental shelves regions, although it does not assimilate tidal gauges yet. However we have identified a few regions where the new model tends to raise the residual SSH crossovers variance. Note that FES2012 tidal atlas (elevations and currents) are available on a regular grid of 1/16° and can be downloaded on the AVISO website: <http://www.aviso.oceanobs.com/en/data/products/auxiliary-products.html>

A new FES 2014 version is planned for mid-2014; the objective is to improve the tide model performances particularly in the regions where a raise of the SSH variance has been identified. First, FES 2014 will benefit from recent developments in the physical and numerical modelling of T-UGOm and that already allow for dividing the error of the pure hydrodynamic model by a factor 2. Additional upgrades will be carried out, such as improvement of the bathymetry and local increases of the resolution, which would be of great interest for coming SWOT mission; moreover a larger assimilation dataset (including tidal gauges and high latitudes data) will be used.

