The aim of this poster is to present the first results obtained from a new version of our **Hydrodynamic Finite Element Tide Model** combined with a revised data assimilation procedure. The hydrodynamic model previously used to obtain the solution FES94.1 [*Le Provost et al.*, 1994] has been improved and allows now to compute tidal solutions at the global scale without being obliged to divide the ocean in sub-domains. "Free" solutions, forced by the astronomical potential and secondary effects of loading and self-attraction, have been computed both for M2 and K1. These solutions are presented on figure 1a and figure 2a respectively for **M2** and **K1**. On figure 1b and 2b, the FES95.2 solutions are displayed for comparison (FES95.2 are the best solutions obtained previously by our model and assimilation system, cf. *Le Provost et al.* [1998]).

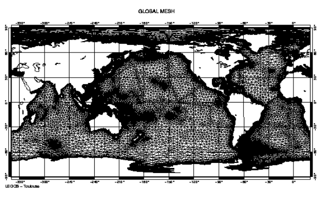
Comparison of figure 1a and figure 1b lead to the conclusion that the M2 "free" solution is qualitatively too large: note that the amplitudes of the anti-amphidrome in the middle of the Indian Ocean too large by 10 cm, and the one near the dateline in the Equatorial Pacific too large more than 15 cm. Note also nearly 20 cm in excess in the North West Indian ocean, on the East coast of Australia, 30 cm in the Gulf of Guinea...

Comparisons of figure 2a and figure 2b lead also to the conclusion that K1 "free" solution is too large by to 2 to 5 cm.
One possible explanation for these discrepancies is the absence in the hydrodynamic model of dissipation by internal tides, which is now thought to dissipate up to 20% of the tidal energy input by the astronomical forcing.

The **assimilation method based on the representer approach** [*Le Provost et al.*, 1998; *Lyard*, 1998] has been revisited, and the anomalous resonance observed over some specific coastal areas in FES95.2 (see the red dots in figure 4b) have been eliminated.
A careful selection of in situ tide gauge data from the different tidal data banks (IAPSO, WOCE and BHI) has allowed to compose a collection of **730 data for M2** and **868 data for K1**. Their positions are given on figure 3, including pelagic (in blue), shelf (in green), island (in yellow) and coastal sites (in red). These data sets have been assimilated in the free hydrodynamic model. New solutions have thus been obtained for M2 and K1 referred as **FES98**. Vectorial differences (including amplitude and phase differences), by reference to different previous solutions, are displayed on figure 5a to figure 5e : with FES94.1 [*Le Provost et al.*, 1994], FES95.2 [*Le Provost et al.*, 1998], CSR3.0 [*Eanes et al.*, 1995], DW95.1 [*Desai and Wahr*, 1995], SR95 [*Schrama and Ray*, 1995]. All these solutions, except the hydrodynamic solution FES94.1, are very similar [*Shum et al.*, 1997]. The interest of FES98 is that this new solution is independent of any altimetric data.
For M2, FES98 solution appears to be quite close to SR95, with 1 or 2 cm of differences, except East of the dateline in the Equatorial Pacific (more than 3 cm), around New-Zealand (more than 4 cm) and at a few other places up to or more than 7.5 cm (between Madagascar and Africa, East of India, North of Australia, in the South China Sea, East and West of Panama...). Major differences are also noticeable in many place along the coasts.
For K1, FES98 solution is quite close to FES94.1 (our first hydrodynamic solution!) except in some areas where this new solution, by contrast, seems to agree with the altimetric solutions: along the Antarctic continent (see figure 5b), the Drake Passage, East of India, East of Australia (differences of more than 5 cm!). On the other side, it must be observed that FES98 differs from all the altimetric solutions in the North Pacific, by more than 3 cm, retrieving here the hydrodynamic solution FES94.1..
Comparisons with *in situ* data are presented in figure 6 and figure 7. A set of 95 pelagic and island sites (the classical ST95), and 607 coastal stations have been selected for these comparisons. They are displayed on figure 6.
FES98 appears to better fit both the ST95 and the coastal data set, although only 57 (respectively 62) stations for M2 (respectively K1) from ST95, and 73 (respectively 83) for M2 (respectively K1) from the coastal data set, have been used in the assimilation. The RMS differences to ST95 is only **1.56 cm for M2** and **0.99 cm for K1**. For the coastal areas, the differences to the coastal data set is reduced to **14.1 cm for M2** and **3.5 cm for K1**, which is much better than any other solutions.

**FES98 is a new solution:**

- **Independant of any altimetric data;**
- **At the level of accuracy of the best published solutions over the deep ocean;**
- **Much improved along the coasts.**




**Global finite element mesh used in hydrodynamic models**

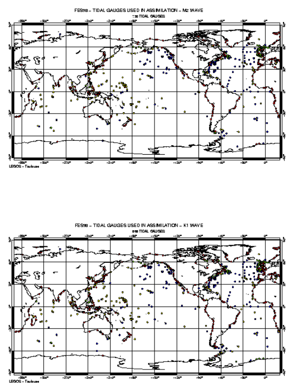


**Figure 3 :**
**Positions of the tide gauge data sites used for assimilation**

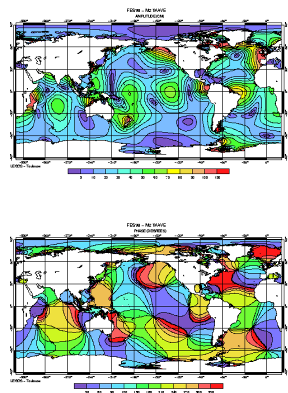


**Figure 4a :**
**FES98 NEW TIDAL SOLUTION for M2**

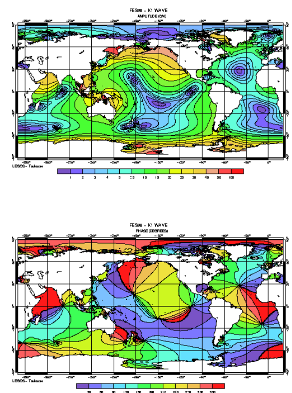
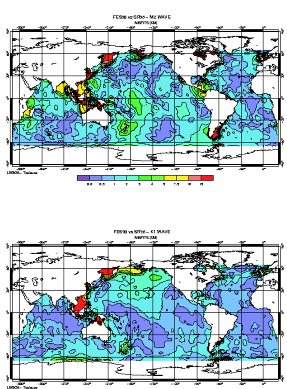


**Figure 4b :**
**FES98 NEW TIDAL SOLUTION for K1**



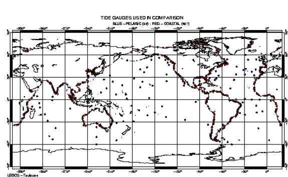


**Figure 6 : Tide gauge data set for comparison**

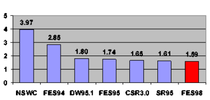



**Figure 7a :**
**RMS differences (cm) between some tide solutions and *in situ* data - open ocean - M2 wave**

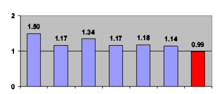



**Figure 7b :**
**RMS differences (cm) between some tide solutions and *in situ* data - open ocean - K1 wave**

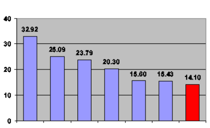



**Figure 7c :**
**RMS differences (cm) between some tide solutions and *in situ* data - coastal areas - M2 wave**

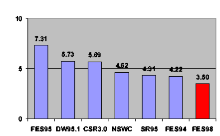



**Figure 7d :**
**RMS differences (cm) between some tide solutions and *in situ* data - coastal areas - K1 wave**

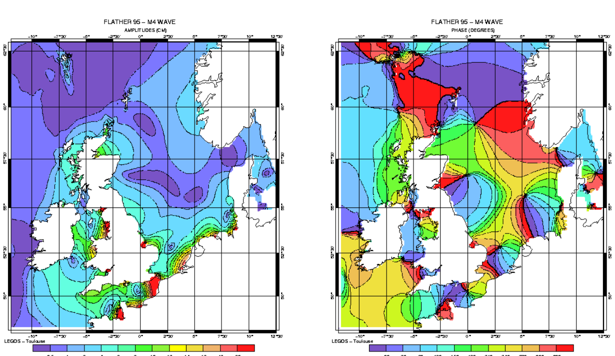



**Figure 10 : M4 solution issued from the Flather's North-East Atlantic solution [1995]**

In order to test the potential of our model to simulate the nonlinear harmonics and interactions waves, as was already demonstrated at a regional scale of the English Channel by *Le Provost et al.* [1985], a preliminary **M4** solution has been produced. This solution is presented on figure 8. Note the important elevations near the coasts, but also the structures which are present in the middle of the Pacific Ocean and the South Atlantic (more than 1 cm). Moreover, notice the complex network of phases which reveals the numerous amphidromes all over the oceans for the M4 wave.
This solution seems qualitatively correct if we refer to some local solutions already known and validated, such as over the European continental shelf. On figure 9 and figure 10, a zoom of the M4 FES98 (purely hydrodynamic, no assimilation) is compared to the regional solution of *Flather* [1995]. Qualitatively, the two solutions are very similar. Observe for example, the solution over the English Channel and East of Dover Strait. However, M4 amplitudes are too large.

Two ways can be investigate to improve this solution:
- Assimilate *in situ* (or altimetric) data if available;
- Improve the hydrodynamic M2 solution, by parameterizing internal tide dissipation, and by other possible improvements as recently presented by *Lefevre et al.* [1998].