DAROTA
Project 447

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Dissipation of 11 major tidal constituents estimated using the data-assimilative HAMTIDE model

E.Taguchi (IFM), D. Stammer (IFM), W. Zahel (IFM)

DYNTIDE

1. General:

Aliasing of tidal variations in the oceans are a major cause for uncertainties in gravity field measurements by the GRACE and GOCE missions. A best possible simulation of ocean tides is therefore required. Owing to the existence precise altimeter data, various ocean tides models exist now. Taking the semi-diurnal tide M2 as an example, their accuracy is 2.90 ± 0.1 cm over the in deep-ocean and around 15.5 ± 0.5 cm in shallow water regions, as evaluated against pelagic data set.

In contrast to empirical tide models, data assimilative hydrodynamic models, such as HAMTIDE, supply tidal currents that enable us to compute tidal dissipation due to bottom drag and eddy viscosity. In addition, HAMTIDE potentially provides information about an additional dissipation mechanism, namely, barotropic-to-baroclinic conversion rate, and this rate can be used to construct vertical mixing parameterization for GOC models.

2. Mathematical methods:

- **NL shallow water data assimilation HAMTIDE using pelagic/tide gauge data**
- **Linear Global data assimilation with luni-solar ephemerides forcing Φ_2**

$$\frac{\partial \mathbf{v}}{\partial t} + \mathbf{f} \times \mathbf{v} + r h^{-1} |\mathbf{v}| \mathbf{v} + \mathbf{F} + g \nabla \zeta - g \nabla \iint_S \zeta(t,\lambda',\phi') G(\lambda,\phi,\lambda',\phi') R_e^2 \cos\phi' \, d\lambda' \, d\phi' - (1 + k_{\tilde{m}} - h_{\tilde{m}}) \nabla q_2 = q$$

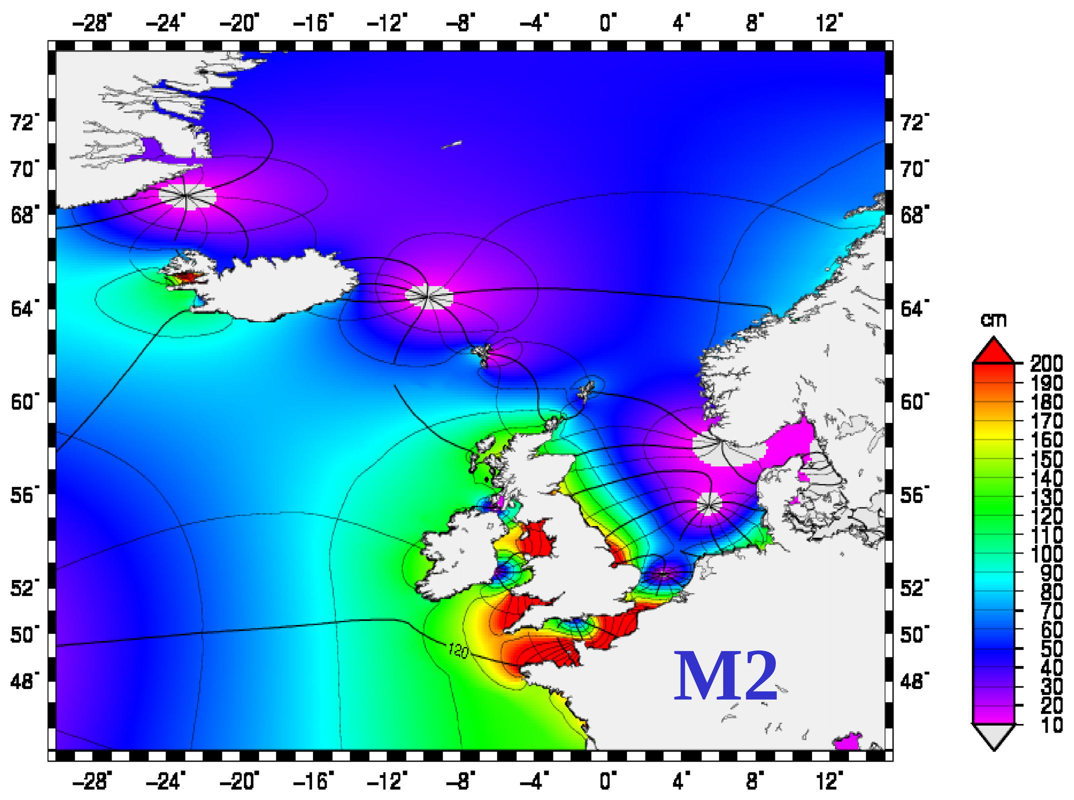
$$\frac{\partial \zeta}{\partial t} + \nabla \cdot (h \mathbf{v}) = 0$$

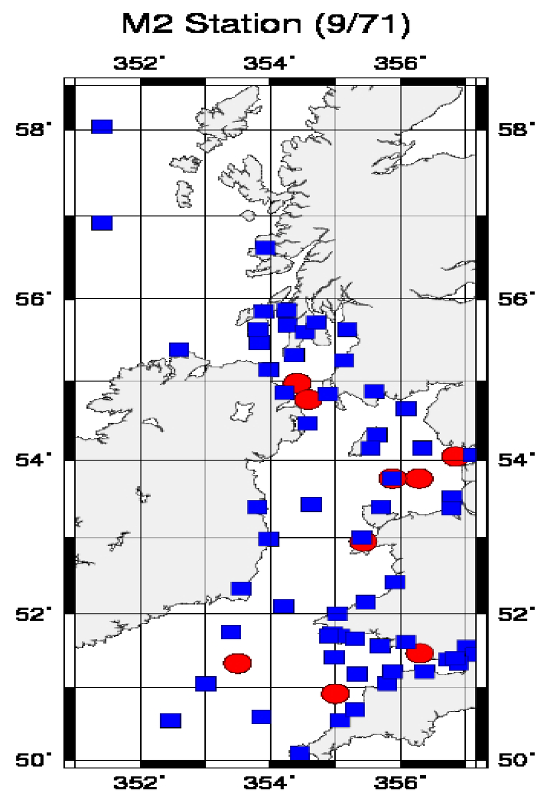
ς : water elevation, **v**: current velocity, r: bottom drag, h: water depth, g: gravity acceleration, G: Green's function for point load, **q**: dyn. res.

Φ_2: the second degree astronomic tidal potential

3. Hybrid solutions (shallow water- + global-models):

Results obtained using NL HAMTIDE can be assimilated into the linear global model (above mentioned). The first trial is done by assimilating data from Irish Sea (left Fig. below) into the global model giving smooth solutions (right Fig. below). RMS differences against 71 pelagic data from Irish Sea (right Fig. below) reduce substantially (s. table below).

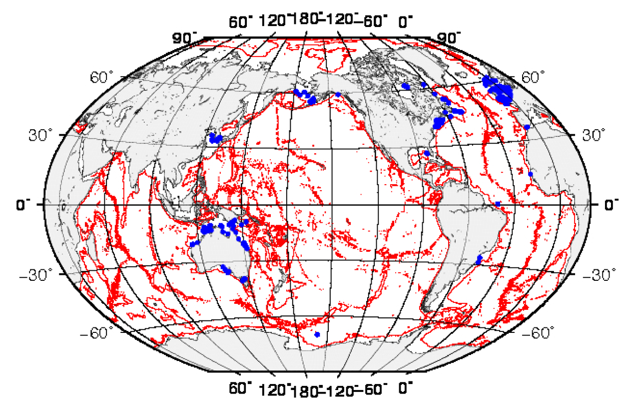




Model	HAMTIDE	TPXO	EOT11a	FES2004
RMS differences	16.2 cm	22.1 cm	96.5 cm	96.0 cm

4. Hybrid solutions (using results from other models):

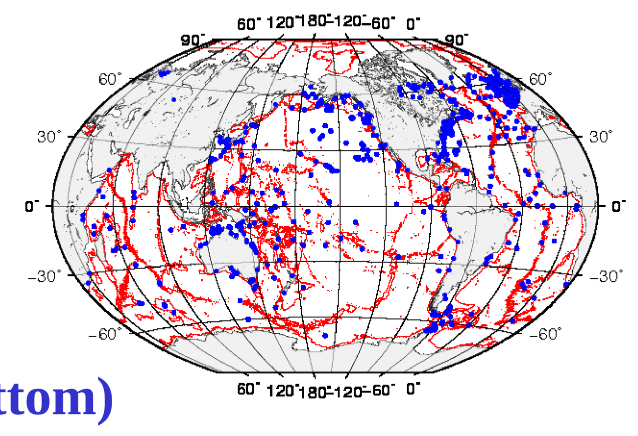
Advantage of the HAMTIDE model is flexibility in assimilating data. The model is able to use data from different sources and of different quality. We show this by assimilating results from EOT11a, FES2004, DTU and TPXO7.2 with respect to the M2 constituent.



Against shallow water pelagic data(179 stations, Fig., right top)

Model	HAMTIDE	TPXO	EOT11a	FES2004
RMS differences	5.0 cm	7.0 cm	6.4 cm	7.6 cm

RMS differences are computed against shallow water (347 stations, top) and deep-sea (633 stations, bottom) pelagic/gauge data. Great improvement in tidal constants suggests the use of hybrid method as shown.



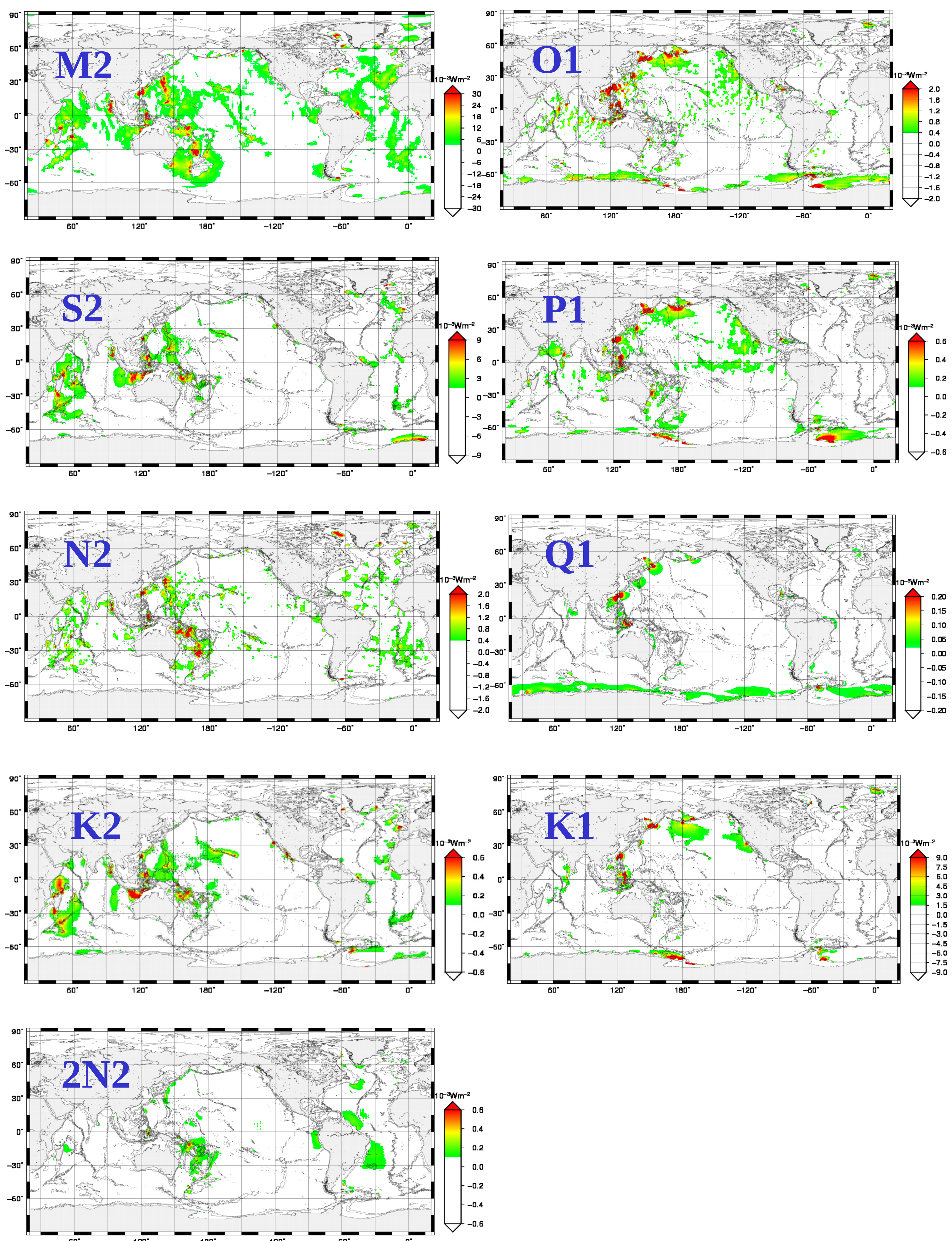
Against 980 mixed stations(Fig., right bottom)

Model	HAMTIDE	TPXO	EOT11a	FES2004
RMS differences	12.7 cm	13.3 cm	28.2 cm	28.2 cm

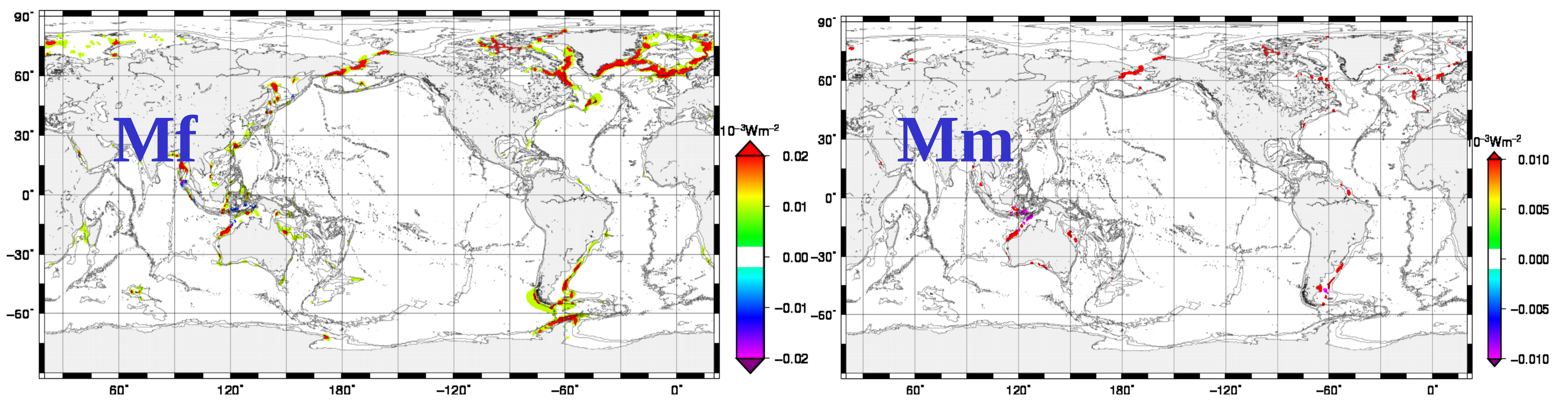
5. Tidal dissipation

Deep-sea tidal dissipation was long time not known and hence global tide modeling was not successful. Highly accurate altimetry (T/P) makes this dissipation visible by assimilating these data. The data assimilative HAMTIDE model is a barotropic one and not able to generate internal tides. However, special mathematical formulation used by the HAMTIDE model (generalized inverse method) enables us to see into the inside of the ocean, namely, the so-called baroclinic conversion (BR2BC).

BR2BC; Diurnal & Semi-Diurnal Tides



Dissipation; Long period tides



Semi-diurnal tides lose their energy everywhere in the ocean (except in both pol regions), mainly on the shelf regions but also in the deep ocean (30-40% in our models). Diurnal tides lose their energy mainly in the Pacific Ocean and along the coast of Antarctica. This is because that diurnal tides do not swing resonantly in the Atlantic and in the Indian Oceans. Both long period tides (Mf and Mm) dissipate their energy nearly all over shelf regions and often in higher latitudes.

6. Conclusions:

1. **Baroclinic conversion rates are important for modeling of abyssal circulation and the HAMTIDE model is able to supply this.**
2. **Hybrid HAMTIDE provides more accurate tidal harmonic constants.**