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An updated EOT model: first impressions from the North Sea

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Abstract

The accuracy of ocean tide models has largely improved over the last decades as a result of enhanced modelling techniques and the use of satellite altimetry. In the latest comprehensive assessment on ocean tide models by Stammer et al. 2014, the DGFI-TUM's altimetry-based model (the EOT11a, Savcenko and Bosch 2012) showed performances in line with the available coexistent global models. A new intermediate version (t) of the EOT model – namely the EOT18t - was recently implemented, and takes advantage of the latest progresses in altimetry. The method used to derive the single tidal constituents is a least-squares based harmonic analysis, performed on Sea Level Anomalies corrected for the FES2014 tide model. Fifteen tidal constituents are computed on a regular grid with resolution of 1/8°. For each grid node, altimetric observations are selected within a radius of 330 km, and weighted with a Gaussian function dependent on the distance to the node. The data used for this purpose are taken from NASA and ESA missions and cover a period of circa 25 years. In this work we present the first regional assessment of the EOT18t. The region chosen for this purpose is the North Sea, characterized by a large number of in-situ observations, which allow an analysis of the model's open-ocean and coastal performances. A direct comparison with other tide models (such as FES2014, TPXO8, GOT4.8, DTU10, and the former EOT11a) will also be shown, in order to highlight the differences at the coast, where larger discrepancies are expected.

Data and study area

The new EOT model was derived using the 1-Hz sea level data available on DGFI-TUM's open Altimetry Database (openADB). The following missions were included in the computation, reaching a temporal coverage of ca. 25 years: Topex/Poseidon, Jason-1, Jason-2, Envisat, ERS-2, ERS-1. The area of study ranges between 49° and 61° in latitude and from -12° to 4° in longitude. The shelf-sea surrounding Great Britain and Ireland is characterized by a complex tidal regime and sea state. The in-situ data used to compare the different models are taken from two sources: the GESLA dataset (see poster: **A new set of in-situ tidal constants based on the GESLA dataset**) and the measurements used in Stammer et al. 2014 (Ray personal communication). Their location is shown in figure 1. In figure 2 ESA and NASA tracks are shown.

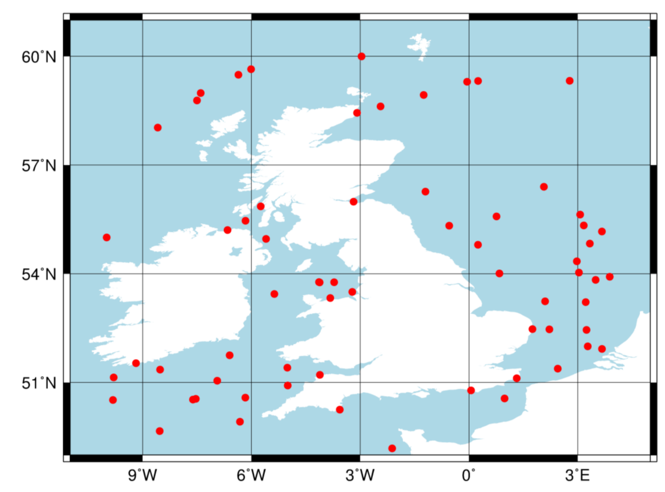


Figure 1: Area of interest and location of in-situ data.

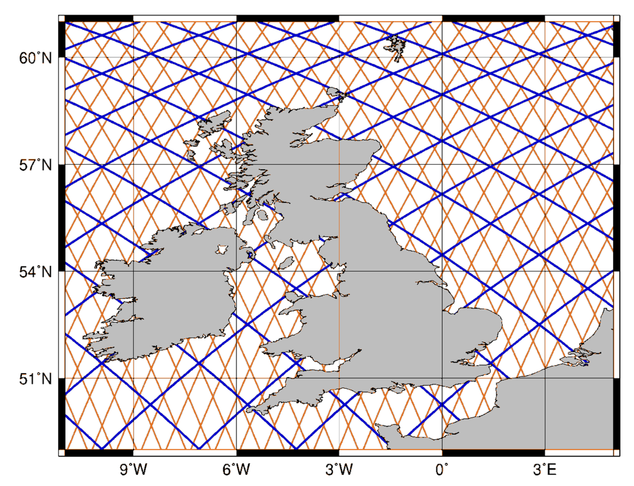


Figure 2: track location of ESA (orange) and NASA (blue) missions

Results – differences with former EOT model

A direct comparison between EOT18t and EOT11a was obtained by computing the Root Sum Squared (RSS) differences against in-situ data. In most of the sites improvements can be observed, figure 3. This result is primarily due to the use of updated altimetry data and the exploitation of FES2014 model, which is characterized by enhanced bathymetry and refined mesh at the coast. For this reason, larger differences between the models were expected in coastal areas, as it is shown in figure 4. Indeed, large discrepancies in the in-phase component difference of the M2 tide are found in proximity of narrow seas with complex coastal areas, such as the Irish Sea and the or the English Channel.

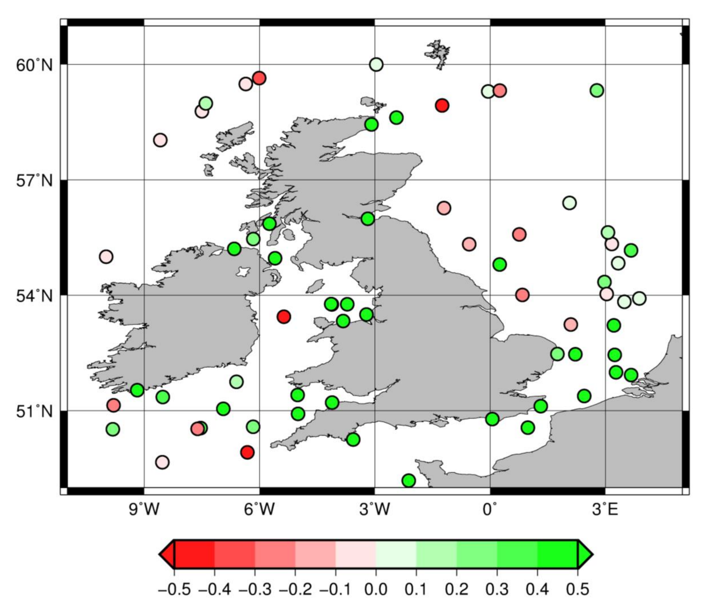


Figure 3: RSS difference (cm) between EOT11a and EOT18 against in-situ data. Improvements of EOT18t are in green.

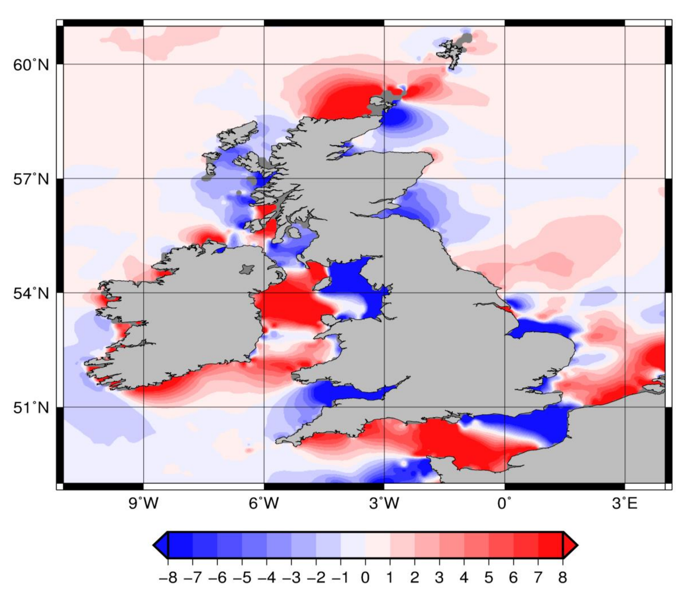


Figure 4: Difference of in-phase component of M2 tide between EOT18t and EOT11a. Scale in cm.

Links to datasets

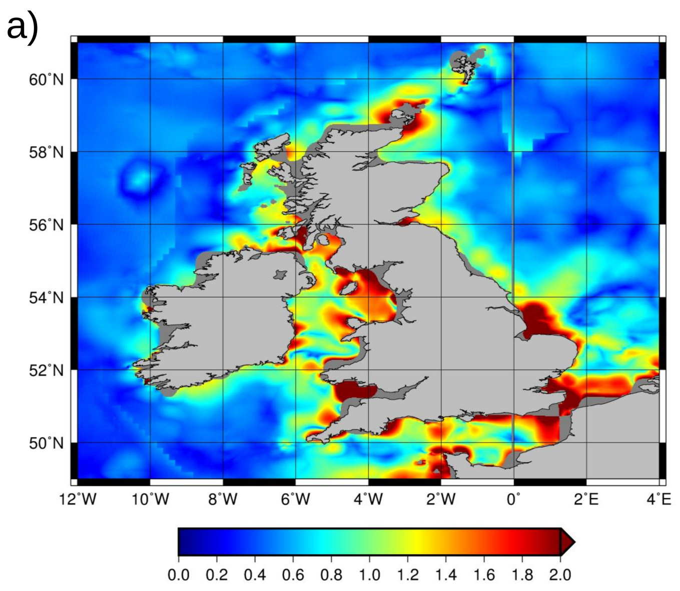
OpenADB: https://openadb.dgfi.tum.de/en/

GESLA: http://gesla.org/

Results – comparison with other models

The different models were directly compared by computing the standard deviation of the amplitudes of the single constituents. As expected, the largest differences are found for M2, for which the standard deviation can reach values ≥ 2 cm at the coast, figure 5a. Another comparison was made between EOT18t and its background model, FES2014. In figure 5b the differences for the in-phase component of M2 (background color) are shown together with the difference in the Root-Mean Square (RMS) against in-situ data. Larger disagreements between the models occur at the coast. In this area, improvements with EOT18t are observed for most of the tide-gauge sites (green dots). However, a loss of performance is still found in narrow coastlines (e.g. English Channel). A summary of the performance of each model against in-situ data is shown in table 1, in terms of RMS and RSS errors. The results are displayed for all the major constituents available from the in-situ measurements. Each value represents the average computed over all the locations. The EOT18t results are in line with the other models. A performance enhancement in EOT18t with respect to its former version is observed for all constituents. In particular, M2, S2, and M4 are improved by more than 1 cm. A lower performance was expected with GOT4.8, because of its spatial resolution of 0.5° (Ray, personal communication).

a)



b)

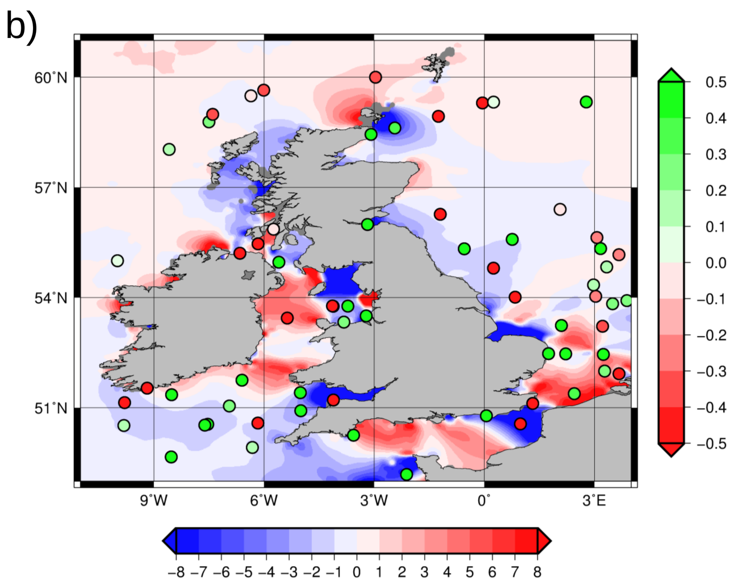


Figure 5a: standard deviation (cm) of the amplitude of M2 computed for all the models.
Figure 5b: difference between EOT18t and FES2014 of in-phase component of M2 tide (background color) and RMS differences for M2 at in-situ locations (dots). Improvements with EOT are in green. Scales in cm.

	EOT18t	EOT11a	FES2014	TPXO8	DTU10	GOT4.8
M2	3.42	5.69	3.47	6.37	4.59	16.14
N2	1.12	1.85	1.17	1.72	1.93	2.37
S2	1.46	2.86	1.49	2.18	2.27	5.90
K1	1.12	1.17	1.04	1.20	1.17	1.87
O1	0.64	0.76	0.66	0.80	0.73	0.95
Q1	0.72	0.75	0.70	0.78	0.72	0.79
M4	0.59	2.75	0.62	0.99	2.19	2.28
RSS	4.11	5.01	4.12	4.90	4.77	6.70

Table 1: Averaged RMS and RSS differences (cm) against in-situ data.

Conclusions

- EOT18t is in line with the results of the most recent tide models and can bring improvements for single constituents at coastal areas.
- An enhanced performance is measured with respect to EOT11a for all constituents, with an overall improvement of ~ 1 cm
- The geographical comparison of the models shows that the amplitude's standard deviation of the major tidal constituents can reach ~ 2 cm at the coast

Outlook

- EOT18t will be extended globally
- Data from Jason-3 and Sentinel-3 will be combined in the model
- A new method for measurement selection at the coast will be tested
- Coast-tailored products and processing techniques are currently evaluated to be integrated in the future

References

Savcenko, R.; Bosch,W. EOT11a - Empirical Ocean Tide Model From Multi-Mission Satellite Altimetry; DGFI Report No. 89; DGFI-TUM Munich, 2012, doi:10013/epic.43894.d001.

Stammer, D.; Ray, R.D.; Andersen, O.B.; Arbic, B.K.; Bosch,W.; Carrère, L.; Cheng, Y.; Chinn, D.S.; Dushaw, B.D.; Egbert, G.D.; et al. Accuracy assessment of global barotropic ocean tide models. Rev. Geophys. 2014, 52, 243–282, doi:10.1002/2014RG000450