Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

EOT20: An updated global empirical ocean tide model derived from multi-mission satellite altimetry - First validation results

Michael G. Hart-Davis[1], Denise Dettmering[1], Gaia Piccioni, Christian Schwatke[1], Marcello Passaro[1], Florian Seitz[1]

[1] Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM), Arcisstraße 21, 80333 Munich, Germany
[2] Enel Global Trading S.p.A. Address: V.le Regina Margherita 125,00198 Rome, Italy

Corresponding author: M.G. Hart-Davis – michael.hart-davis@tum.de

Ocean Surface Topography Science Team Meeting
Virtual, 19 October 2020

Hello all and thanks for visiting our presentation in the Tides, Internal Tides and High-Frequency processes session. DGFI-TUM works on the development of global empirical ocean tides models (EOT) derived by residual tidal analysis of multi-mission satellite altimetry for many years. Our presentation entitled ‘EOT20: an updated global empirical ocean tide model derived from multi-mission satellite altimetry’ presents the first validation results of the newest version of the EOT model.

EOT20 Model Configuration

Table. Some differences between EOT11 and EOT20

Model	EOT11	EOT20
Missions	TOPEX/Poseidon, Jason-1/2, ERS-2, ENVISAT	TOPEX/Poseidon, Jason-1/2/3, Envisat, ERS-2, ERS-1c, ERS-1g, TOPEX Extended Mission and Jason-1/2 Extended Mission
Tidal Constituents	M2, S2, N2, K2, 2N2, O1, K1, Q1, P1, S1, Mm, Mf , M4	M2, N2, S2, K2, K1, O1, P1, Q1, SA, SSA, M4, MM, S1, T2, J1, 2N2 and MF
Notable Corrections	**FES2004** Ocean Tide Model	**FES2014** Ocean Tide Model, **ALES Retracker**

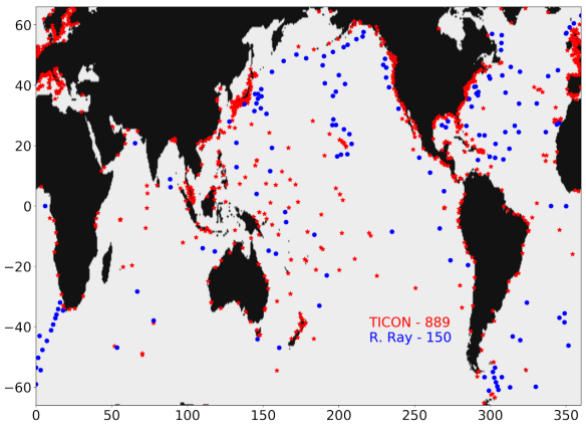
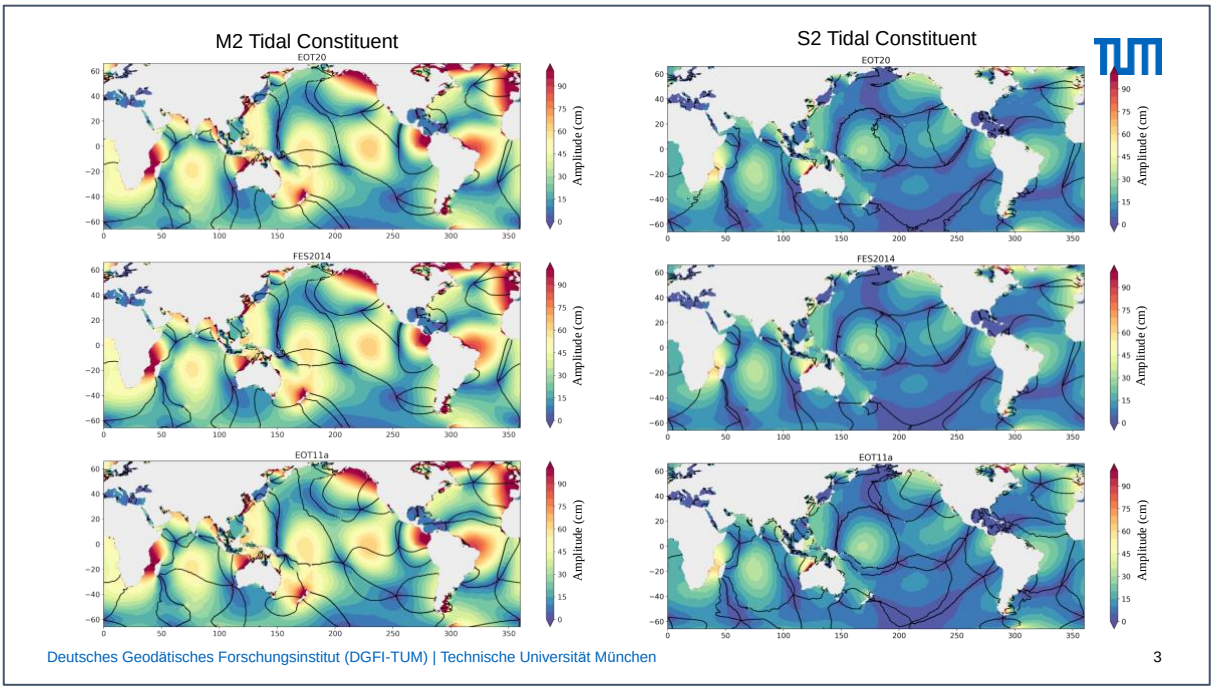


Figure. Tide gauge data used for validation provided by Richard Ray and the TICON dataset (Piccioni et al. 2019)

In this slide, we present some of the major discrepancies between the previous global version of EOT (EOT11). It is important to note that these are not all of the differences, but we simply present the major differences here.

EOT20 utilises the latest version of the FES2014 ocean tide model as the reference model used to estimate residual tidal signals. EOT20 also benefit from an extended timeseries of altimetry data as well as more altimetry missions. Furthermore, the EOT20 model benefits from the use of the ALES retracker is several altimetry missions at DGFI-TUM (Passaro et al., 2014), which allows for the estimation of tidal signals closer to the coast. The number of tidal constituents has increased from EOT11 (13 tidal constituents) to EOT20 (17 tidal constituents). In the figure on the right, we present the positions of the tide gauges in the global ocean from the TICON dataset (Piccioni et al., 2019) and Richard Ray tide gauge dataset (pers. comms. Richard Ray).



In this slide, we demonstrate the amplitude and phase (indicated by the black lines in 30-degree increments) of the M2 and S2 tidal constituents for EOT20, FES2014 and EOT11a. As expected, there are very little differences between the three models with the discrepancies being seen between the phases of the constituents.

Tide Gauge Analysis

Table. The RSS of the eight major tidal constituents compared to tide gauges, which has been separated into three different regions based on distance of tide gauge to coast.

	All Tide Gauges	> 5 km	5 km - 1 km	< 1 km
EOT11a	9.9516	15.6229	8.9819	9.9561
FES14	7.2844	13.9390	7.2111	6.9591
GOT4.8	11.6239	17.8815	9.8245	11.8068
DTU16	7.9094	13.7280	7.8320	7.7817
EOT20	6.9829	14.2765	6.8229	6.5217
No. of TGs	900.0000	88.0000	239.0000	573.0000

- The Root Square Sum (RSS) calculated following Stammer et al (2014) on the 8 major tidal constituents:
  - M2, N2, S2, K2, K1, O1, P1 and Q1.
- For 5 ocean tide models – EOT11a, FES14, GOT4.8, DTU16 and EOT20
- The tide gauges are taken from TICON (Piccioni et al 2019) and the R. Ray ocean bottom pressure gauge dataset.
- Tide gauges are divided into three different regions to demonstrate the capabilities of the models in the varying regions of the ocean.

Here, we present the results of the tide gauge analysis and compare the results between 5 ocean tide models (EOT11a, FES2014, GOT4.8, DTU16 and EOT20) for the major 8 tidal constituents (M2, N2, K2, S2, K1, O1, P1 and Q1). The tide gauges in this study are only from tide gauges that all of the tide models can contain information from, and we have divided the tide gauges into three different regions. These regions are based on distance to coast, being tide gauges 1) further than 5 km, 2) between 5 km – 1 km and 3) closer than 1 km from the coast. These regions are chosen to assess the ability of the ocean tide models in the coastal region.

For each model, the Root Square Sum (RSS-) of the eight tidal constituents is calculated (Stammer et al., 2014) and the mean RSS is presented for each region in the table above. Firstly, EOT20 shows a significant improvement in the RSS compared to EOT11 for all tide gauges and in all of the different regions with the major improvement coming in the region closer to the coast (with an improvement in RSS of ~ 3.5 cm). This demonstrates that the changes made to the EOT model has resulted in a significant improvement in the model's representation of the tidal constituents.

Compared to all of the global ocean tide models, EOT20 performs really well particularly in the region closer to the coast, showing an improvement of ~0.4 cm compared to the reference model used (FES2014). The initial findings from EOT20 show encouraging results that will continue to be assessed following different techniques in the near future.

Summary and Conclusion

- The initial findings of the EOT20 model are presented.
- The results compared to tide gauges, the EOT20 model shows a significant improvement to the EOT11a model.
- Compared to other global ocean tide models, EOT20 performs well closer to the coast.
- The model validation will continue to take place and we hope to present the results in a publication towards the end of 2020 and the beginning of 2021.

References

Passaro, M., Cipollini, P., Vignudelli, S., Quartly, G.D. and Snaith, H.M., 2014. ALES: A multi-mission adaptive subwaveform retracker for coastal and open ocean altimetry. *Remote Sensing of Environment*, *145*, pp.173-189.

Piccioni, G., Dettmering, D., Bosch, W. and Seitz, F., 2019. TICON: TIdal CONstants based on GESLA sea-level records from globally located tide gauges. *Geoscience Data Journal*, *6*(2), pp.97-104.

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. and Erofeeva, S.Y., 2014. Accuracy assessment of global barotropic ocean tide models. Reviews of Geophysics, 52(3), pp.243-282.

In this presentation, we presented the initial findings of the EOT20 model. The results show an improvement compared to the previous EOT model and a good performance closer to the coast. As stated, we are hopeful to complete and do a more thorough model validation, including cross-over variance analysis, before present the results in a publication in the upcoming months. We would like to thank everyone for attending our presentation and we are hopefully for some encouraging input and feedback.