Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

Insights from the EOT20 model

Michael Hart-Davis*, Denise Dettmering, Christian Schwatke, Marcello Passaro, Florian Seitz

* michael.hart-davis@tum.de

Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
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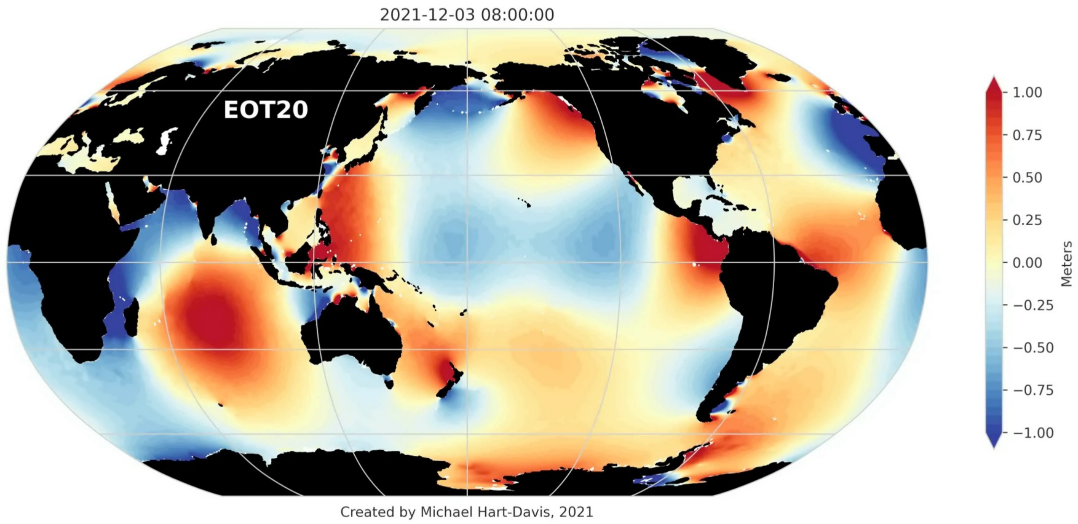

https://www.youtube.com/watch?v=L7vtDhPzq6w

Ocean Surface Topography Science Team Meeting: Tides, internal tides and high-frequency processes
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Introduction to EOT

- EOT20 is the latest in a series of global Empirical Ocean Tide (EOT) models derived using residual tidal analysis of multi-mission satellite altimetry at DGFI-TUM.

- The aim of the EOT20 model is to provide a coastal improved estimation of tidal constituents without harming the open ocean performance

- EOT20 takes advantage of the inclusion of more recent satellite altimetry data as well as more missions, the use of the updated FES2014 tidal model as a reference to estimated residual signals, the inclusion of the ALES retracker and improved coastline representation.

- **Hart-Davis, M. G.,** Piccioni, G., Dettmering, D., Schwatke, C., Passaro, M., and Seitz, F. 2021. EOT20: a global ocean tide model from multi-mission satellite altimetry, *Earth Syst. Sci. Data,* 13, 3869–3884, https://doi.org/10.5194/essd-13-3869-2021. Data is available at: https://doi.org/10.17882/79489.

Satellite Altimetry – Sea Level Estimation

Table 1. The ***multi-mission*** satellite altimeter data used in this study obtained from OpenADB at DGFI-TUM (Schwatke et al., 2014).

Mission	Cycles	Period
TOPEX	001 - 365	1992/09/25 - 2002/08/15
TOPEX Extended Mission	368 - 481	2002/09/16 - 2005/10/08
Jason-1 †	001 - 259	2002/01/15 - 2009/01/26
Jason-1 Extended Mission †	262 - 374	2009/02/10 - 2012/03/03
Jason-2 †	000 - 296	2008/07/04 - 2016/07/25
Jason-2 Extended Mission †	305 - 327	2016/10/13 - 2017/05/17
Jason-3 †	001 - 071	2016/02/12 - 2018/01/21
ERS-1c	082 - 101	1992/03/25 - 1993/12/24
ERS-1g	144 - 156	1995/03/24 - 1996/06/02
ERS-2	000 - 085	1995/05/14 - 2003/07/02
Envisat †	006 - 094	2002/05/14 - 2010/11/26

Table 2 . List of corrections and parameters used to compute SLA for tidal residuals estimation.

Parameter	Model	Reference
ALES sea state bias	ALES	Passaro et al. (2018)
ERS sea state bias	REAPER	Brockley et al. (2017)
TOPEX sea state bias	TOPEX	Chambers et al. (2003)
Inverse barometer before 2017	DAC-ERA	Carrere et al. (2016)
Inverse barometer from 2017	DAC	Carrère et al. (2011)
Wet troposphere	GPD+	Fernandes and Lázaro (2016)
Dry troposphere	VMF3	Landskron and Böhm (2018)
Ionosphere	NIC09	Scharroo and Smith (2010)
Ocean and load tide	FES2014	Lyard et al. (2020)
Solid earth and pole tide	IERS 2010	Petit and Luzum (2010)
Mean sea surface	DTU18MSS	Andersen et al. (2016)
Radial error	MMXO17	Bosch et al. (2014)

Global Tide Gauge Analysis

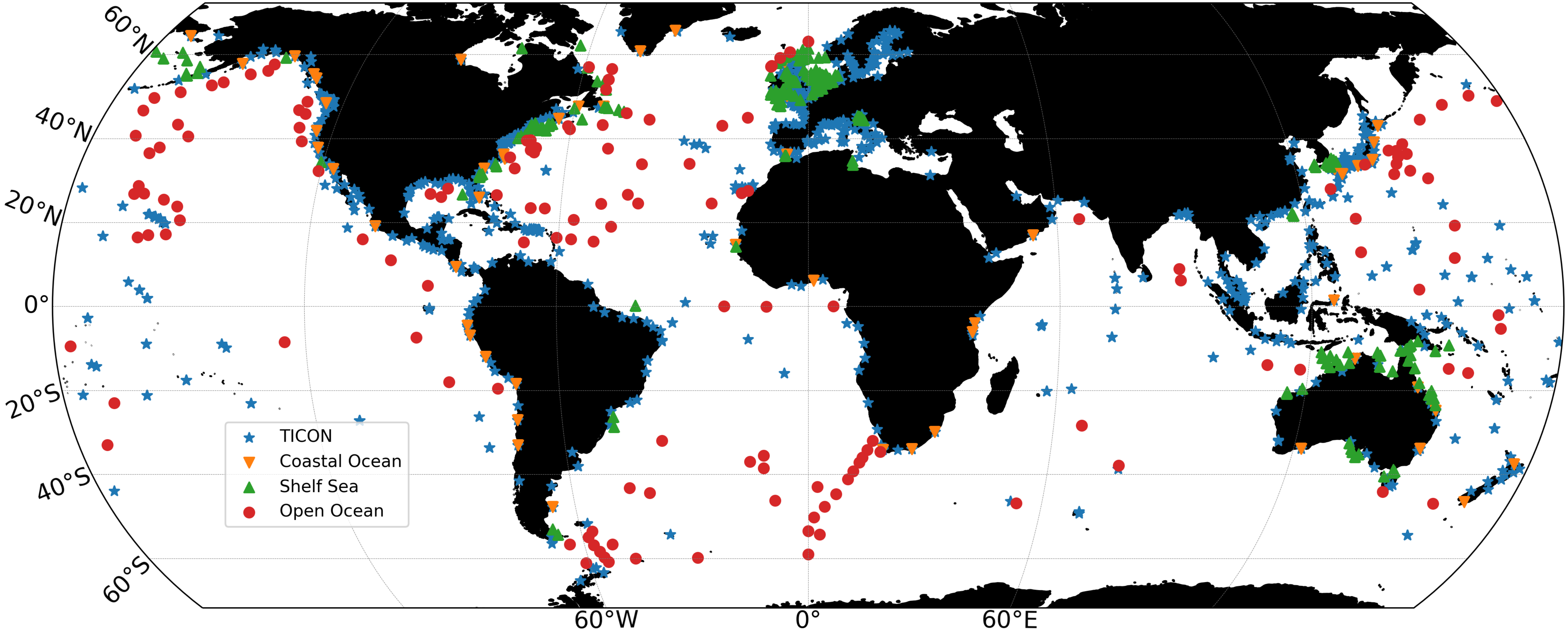


Figure. The tide gauge distribution used in the validation of the models.

Global Tide Gauge Analysis

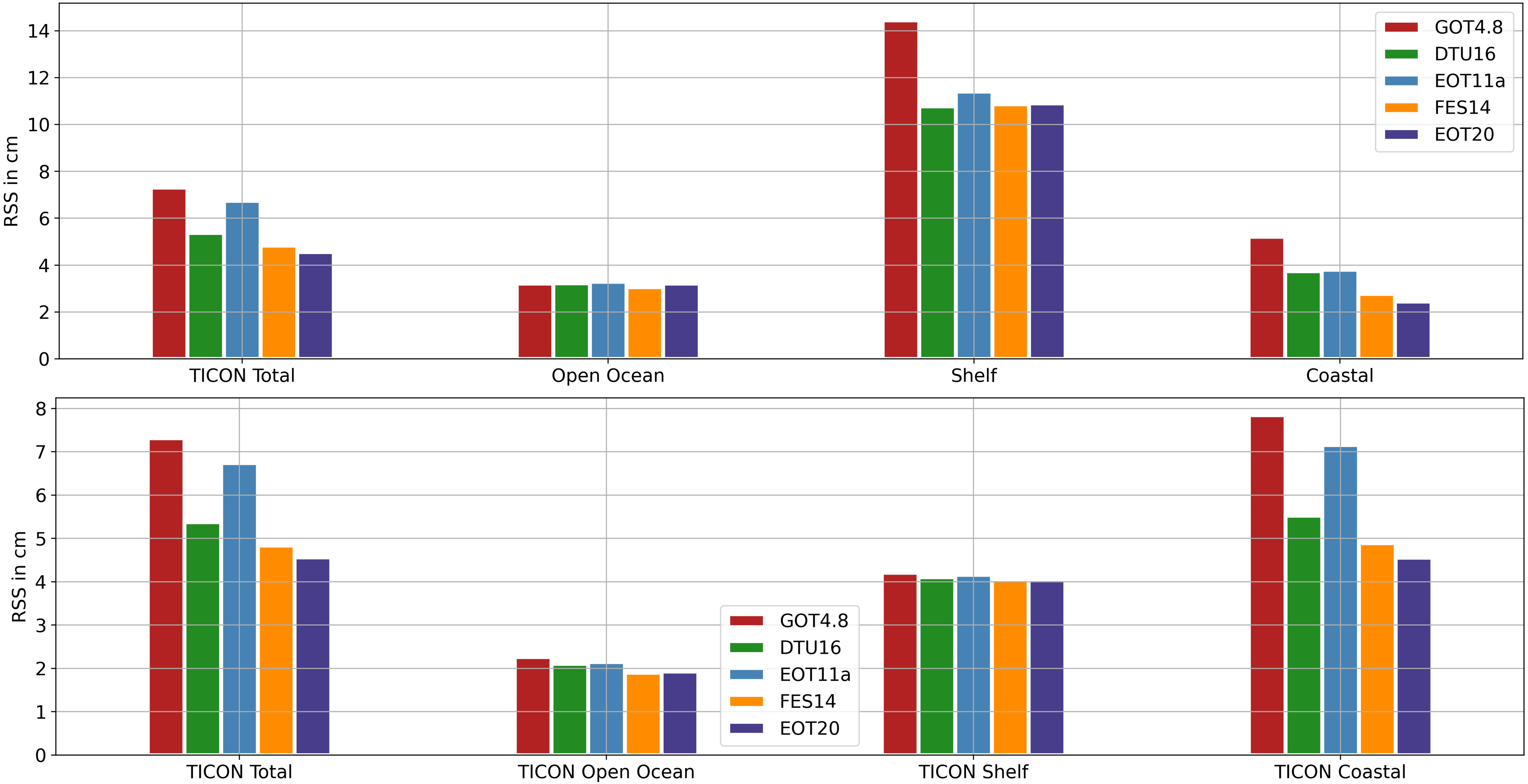


Figure. The Root Square Sum (RSS) for the eight major tidal constituents from the five tide models in the different regions.

First Uncertainty Estimations

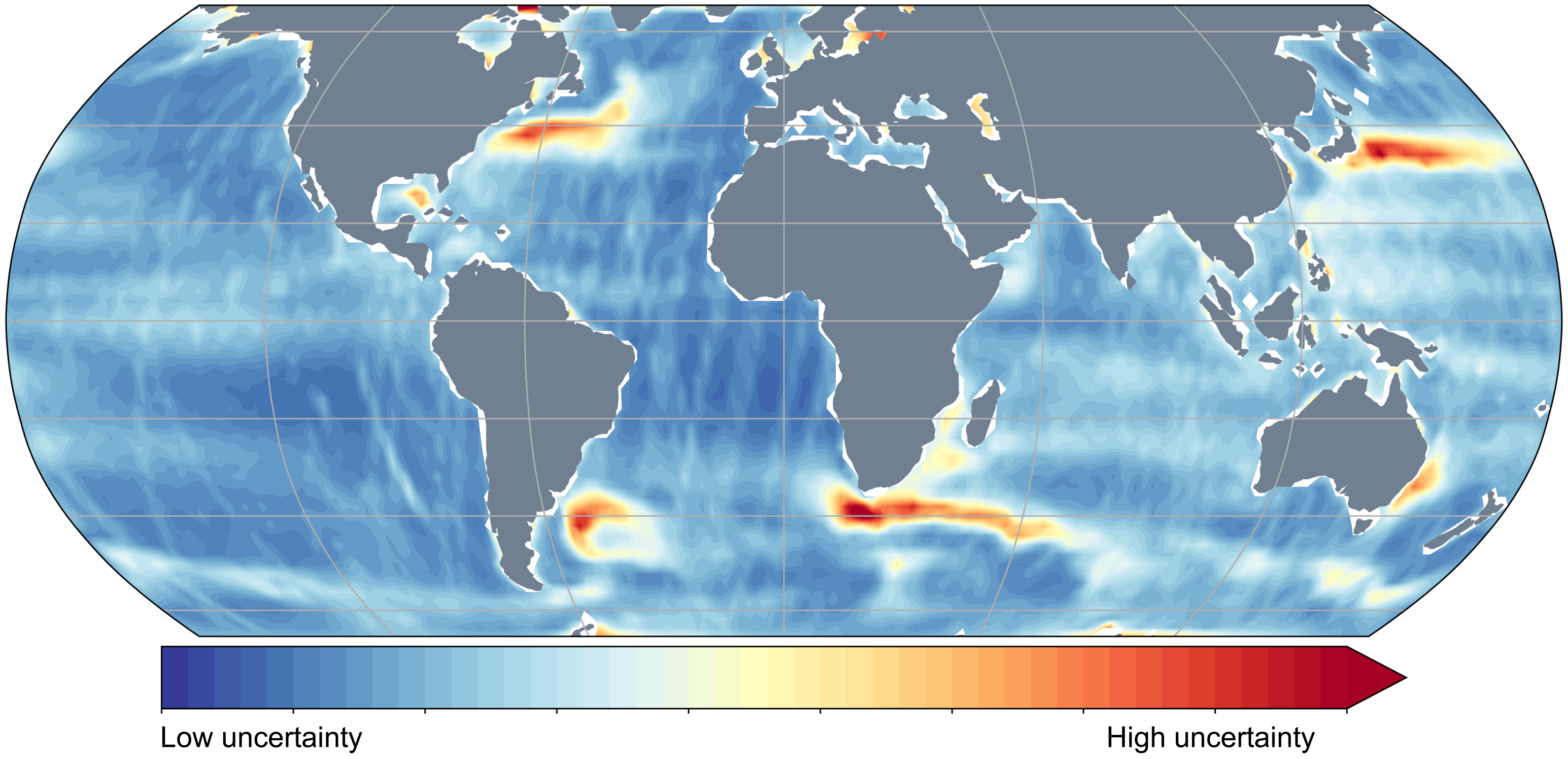


Figure. The first uncertainty estimation derived during the estimations of the global EOT20 model. The mean sigma0 was found to be 4.5.

- The uncertainty estimation where the uncertainty of each individual node of the model was estimated is presented here.
- Estimations are based on the residual analysis as know prior knowledge of uncertainty is available from the reference tidal model.
- Individual tracks of certain altimetry missions can be seen which is likely due to there being periods when a certain pass of a mission will be missing or unavailable.
- It can be seen, that in the western boundary currents, there are high uncertainties.
- In regions with temporary sea ice coverage, as can be seen around 66 S and in parts of the Baltic / Hudson Bay are also regions of high uncertainty.

Investigation on Mesoscale Corrections

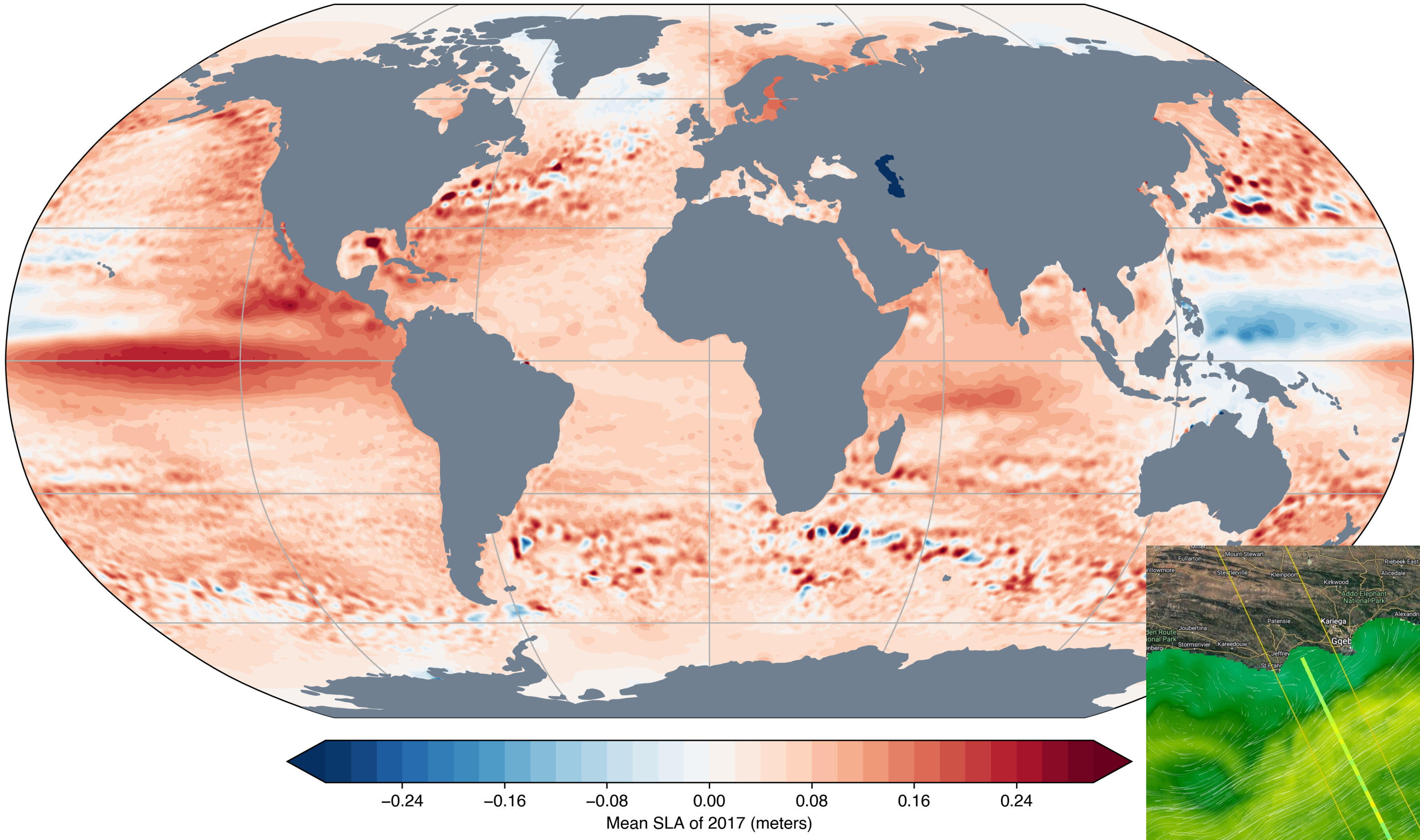


Figure (a). The mean SLA (top) from the year of 2017 derived from the Zaron mesoscale dataset available: https://ingria.ceoas.oregonstate.edu/~zarone/downloads.html

- Can we reduce the uncertainties of estimations of tides when applying a mesoscale correction?
- The idea being that there might be certain mesoscale frequencies affecting the accurate determination of certain tidal frequencies.
- Tests ongoing using the Zaron (more information: Zaron and Ray 2018) mesoscale correction seen in Figure (a).

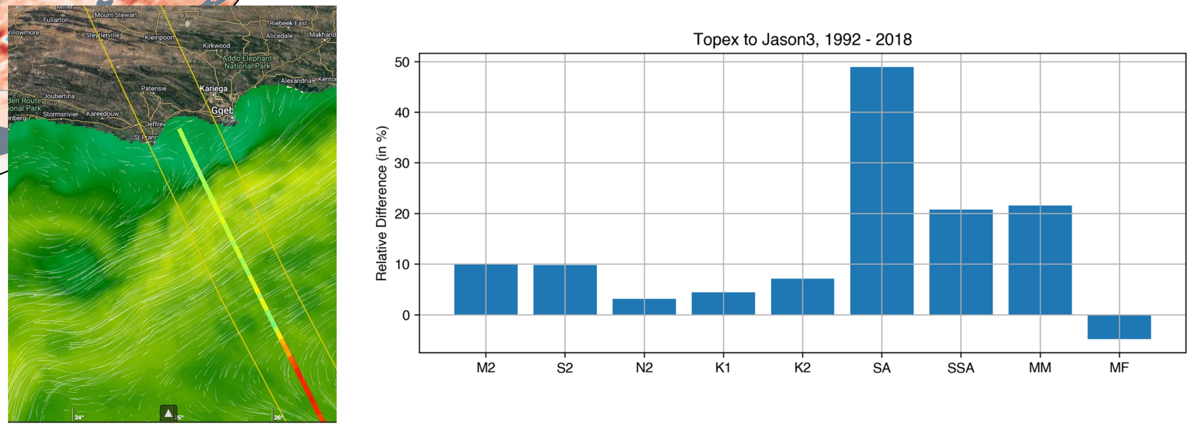


Figure (b). Track from the Agulhas Current used (left), and the relative difference in tidal amplitudes (right) for a single point along-track from 1992-2018.

Investigation on Ionospheric Corrections

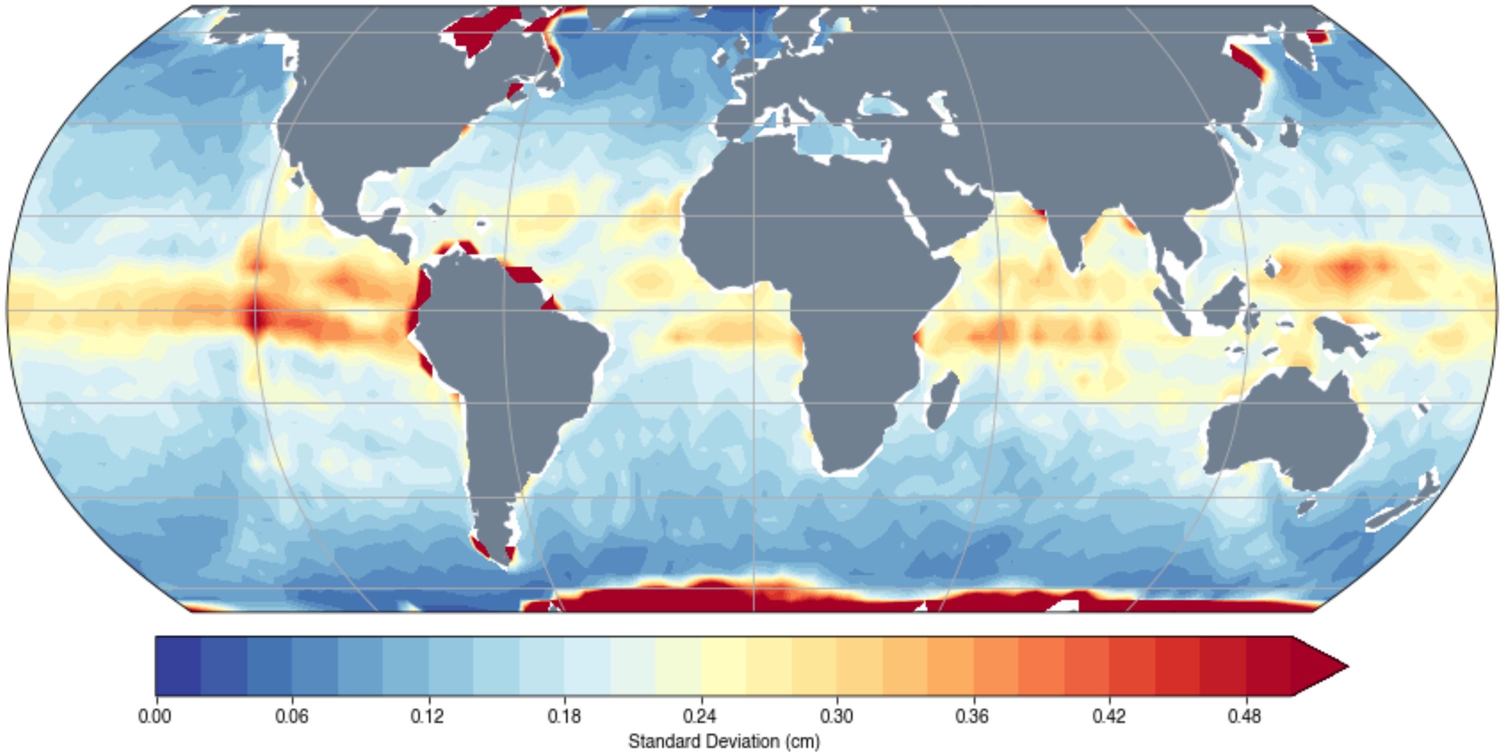
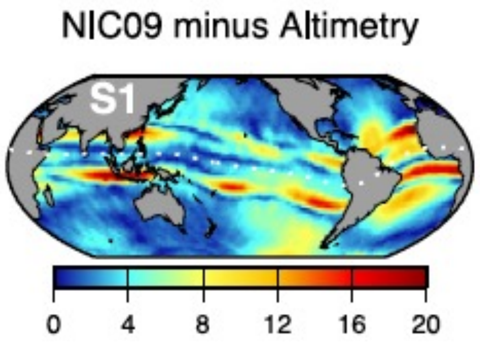


Figure. The standard deviation of the S1 residual tidal amplitude in cm. These data are available for the real, imaginary, amplitude and phase components of all tidal constituents.

- In EOT20, the ionospheric correction used is the NIC09 model which was chosen to optimise the retrieval of optimal tidal estimations in the coastal region.

- Looking at certain constituents as well as look at the standard deviations of individual constituents on a few solar tides (the S1 shown here for example) suggested problems in the ionospheric correction used in the open ocean.

- A publication, by Ray 2020 supports our suspicion on a strong influence from the ionospheric correction:



- Tests ongoing in regional models in attempt to solve this and improve these tidal estimations.

Adding more altimeters

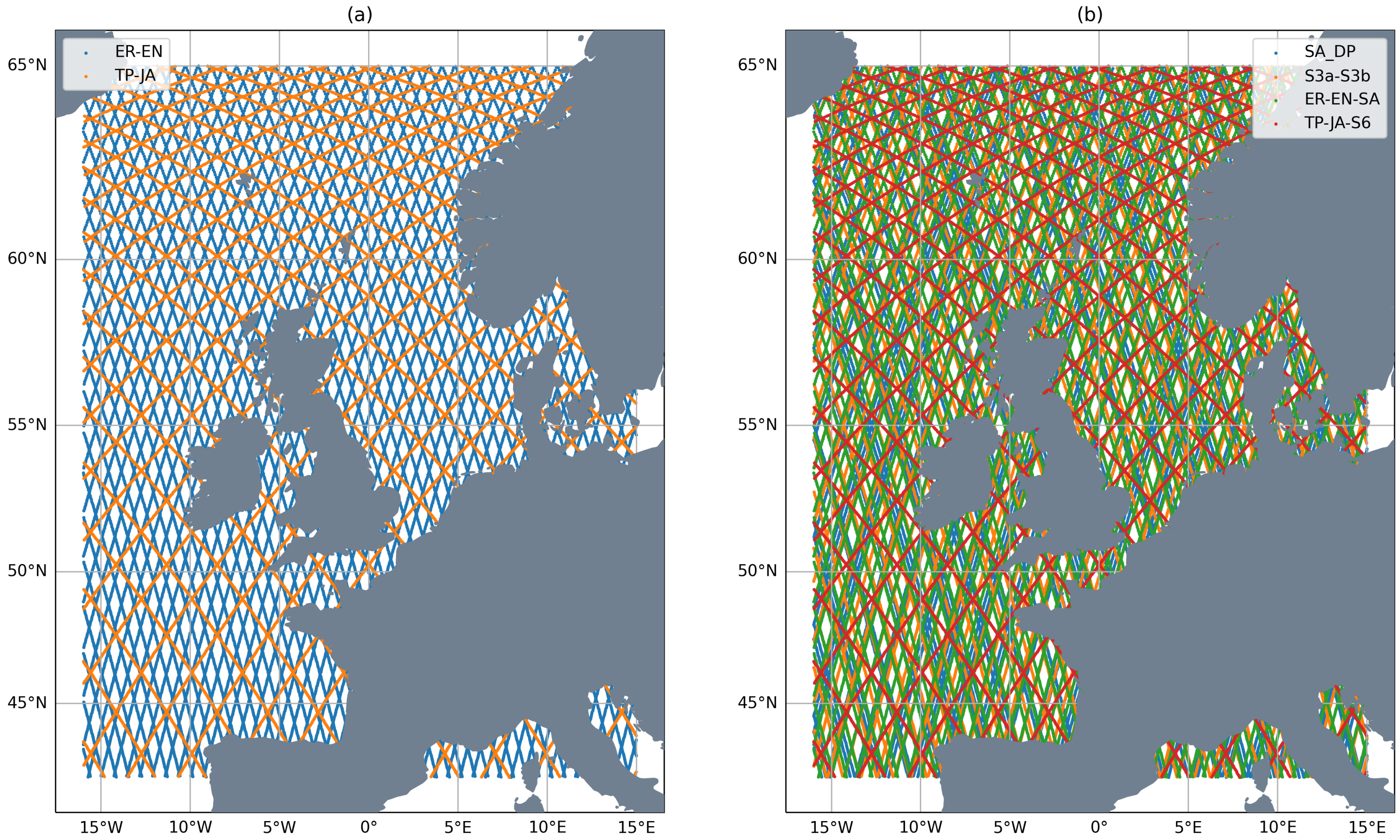


Figure. The altimetry data used in the (a) EOT20 and (b) an updated regional EOT model configuration of the North-West European Shelf.

- Incorporation of Sentinel-3a, Sentinel-3b, Saral, Saral Drifting Phase, Sentinel-6a.
- Extension of temporal coverage to 2022 (as recent as possible), while EOT20 stopped at 2018.
- The TP-JA-S6 line will now contain a continuous sampling from 1992 to 2022.
- First regional models, suggest a reduction in RSS of 0.35 cm when using this altimetry coverage compared to EOT20s results for the eight major tidal constituents.

Adding more constituents

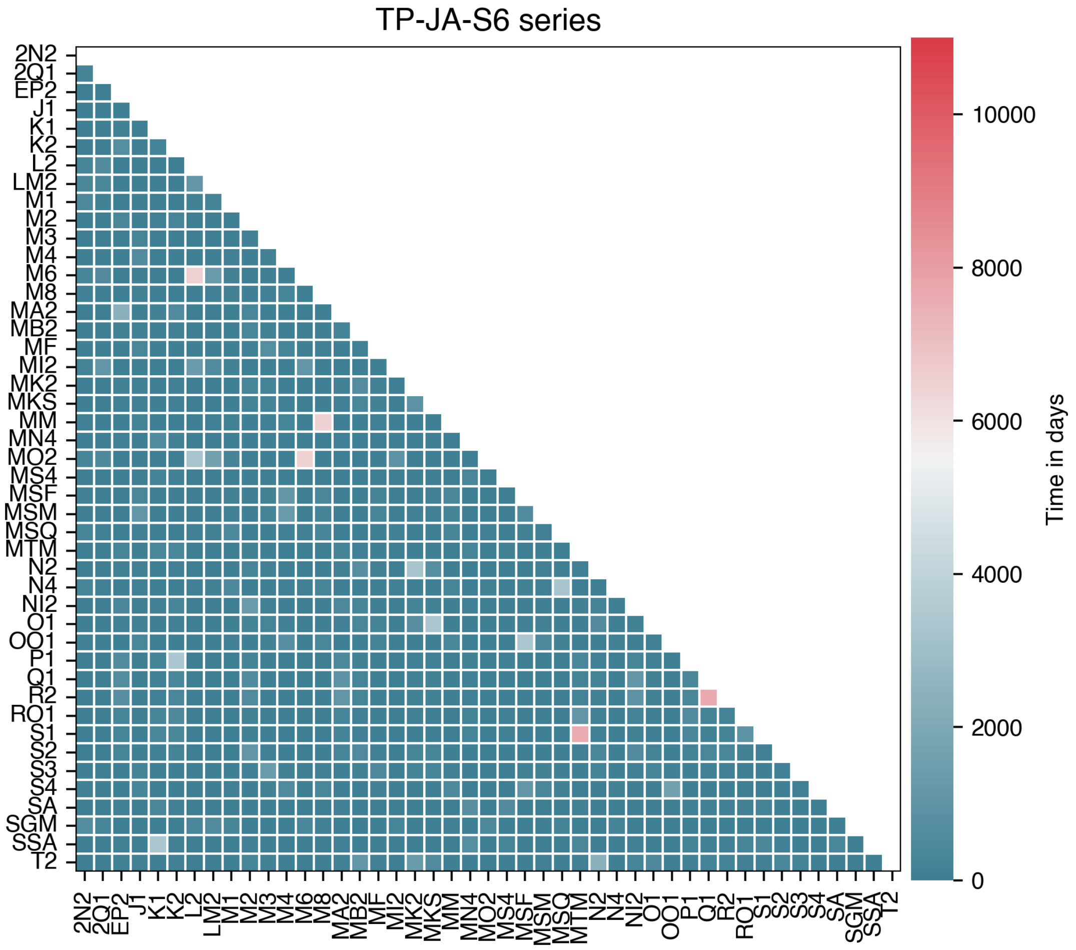


Figure. Rayleigh coefficient of the TP-JA-S6 orbits

- In Hart-Davis et al (2021b), we demonstrated our intent to incorporate additional constituents in our global estimations.
- This is to reduce potential error in using linear admittance approaches and to incorporate some interesting tides that could influence positively the tidal correction.
- We produced a tidal aliasing and Rayleigh criteria study based on the Jason-orbit altimetry dataset.
- Additional constituents will be added in future iterations of the model to support altimetry and geodetic applications as well as the assessment of purely numerical models [such as the TiME model (Sulzbach et al 2021)].
- Obvious limitations on constituents will also come from assessing their signal-to-noise ratios.

Tides in the Polar Regions

- Influence of sea ice as well as poor data bias and poor bathymetry mean that the polar region is an extremely difficult region for both ocean tide models.
- Incorporation of Cryosat-2 alongside previously discussed altimeters.
- Plans to incorporate our own sea-ice classification (Mueller et al 2017) to optimize the retrieval of data in near-ice regions.
- We also plan to compare our new Arctic and Antarctic model with data of other models in order to identify the suitability of individual tide models for along-track altimetry.
- With that in mind, we also plan to update our in-situ observations dataset to assist in validation purposes as much as possible.

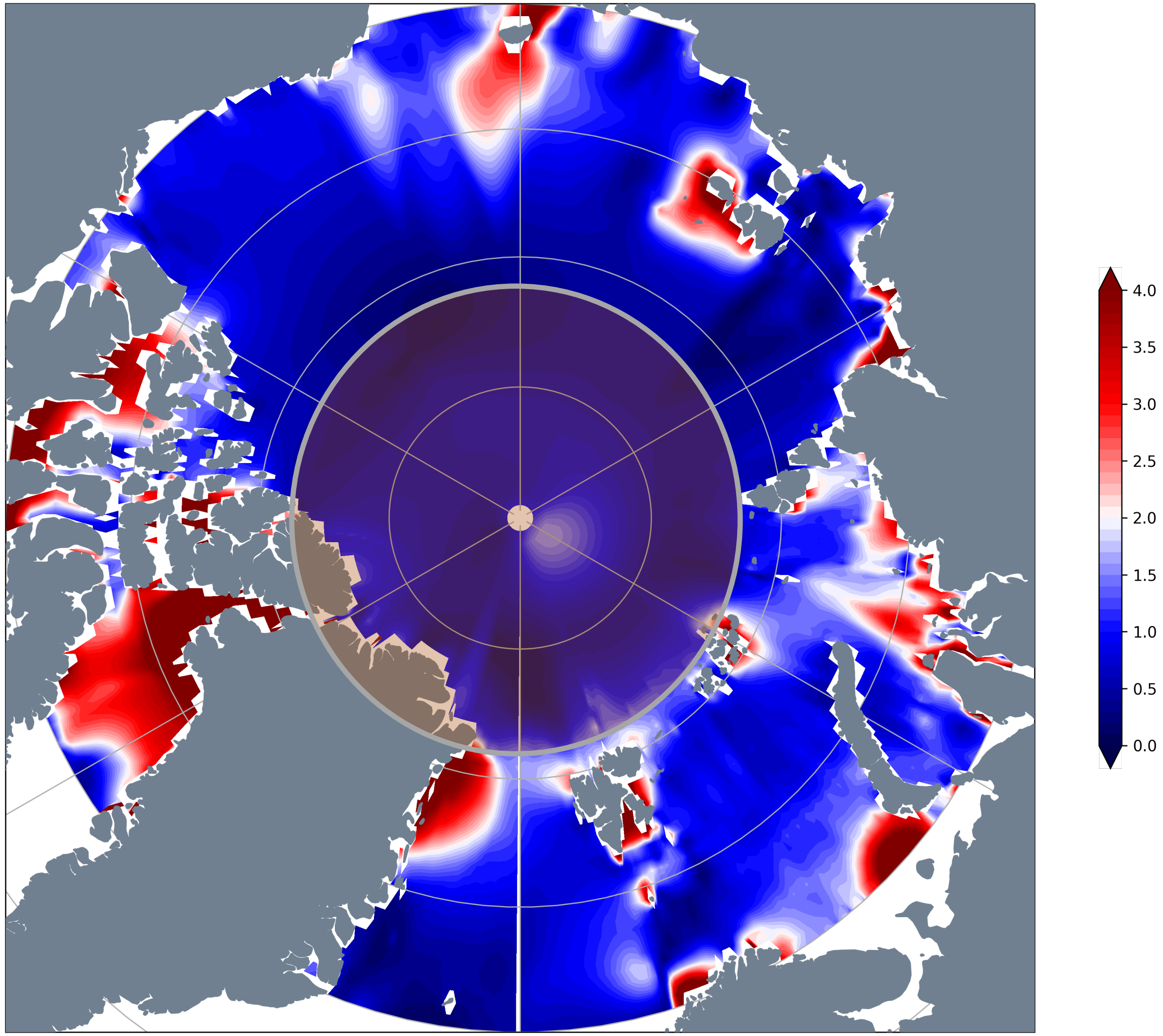


Figure. The standard deviation (cm) of only the amplitude of the M2 tide for five major tide models.

Outlook and Conclusion

Summary and Conclusion

- EOT20 builds on the previous EOT global models by incorporating ALES retracked data, the FES2014 tide model as a reference model and an improved coastal representation

- EOT20 demonstrates a clear improvement in the coastal region compared to EOT11a and compares very well with other global ocean tide models.

Ongoing

- Inclusion of additional datasets
- Updated TICON dataset
- Studying the influence of currently used altimetry corrections (ionosphere, DAC, reference model)
- Apply additional corrections (e.g. mesoscale and internal tides)

Future Work

- Expansion into the polar regions
- The inclusion of additional constituents
- Model configuration refinements and adjustments for improved coastal and polar estimations
- Future global EOT model

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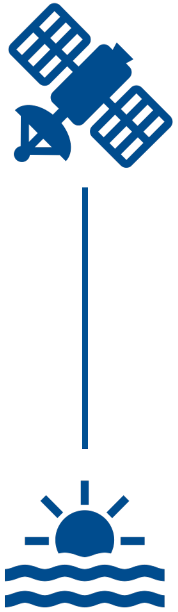

Thank you! Questions?

Email: michael.hart-davis@tum.de