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Towards the optimisation of altimetry corrections for improved ocean tide modelling

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Motivation: Ocean tide models are created for a variety of applications ranging from serving as an altimetry correction to being applied as numerical model boundary forcings. DGFI-TUM's Empirical Ocean Tide (EOT, Hart-Davis et al., 2021) and NASA's Goddard Ocean Tide (GOT, Ray 2013) models are derived based on sea-level anomalies (SLA) from multi-mission satellite altimetry. Although these two models differ in the modelling strategies, the basic processing is the same where along-track SLA are binned into grids from which tidal analysis is conducted to determine a number of tidal constituents. The SLA measurements used in both models are corrected for geophysical corrections which mean the resultant tidal estimations are dependent on the ability of the other corrections to remove effects such as those from the atmosphere, ionosphere and troposphere. Assessments on the resultant estimations of these models have shown non-oceanic tidal effects within several tidal constituents, suggesting that there are tidal affects or processes with frequencies near that of tidal frequencies remaining in the before listed corrections. Depending on the application of the ocean tide model, the appropriate accounting for these processes within the corrections becomes crucial.

Methods

- Three altimetry corrections were analysed: the dynamic atmosphere correction (DAC), the ionosphere correction and the dry troposphere correction.
- For the DAC, harmonic analysis was applied on the gridded 6-hourly data which are derived in Carrere et al. (2015).
- For the ionosphere and dry troposphere corrections, harmonic analysis are conducted on the respective along-track corrections based on 30 years of data from the TOPEX-Jason altimetry series.

Dry Troposphere Correction

- The dry troposphere correction is important to account for influences on altimeter radar returns from gases within the troposphere.
- Harmonic analysis reveals signatures of the major radiational tides (S1 and S2, **Figure 1**) within the VMF3 troposphere correction (Landskorn and Böhm, 2018) used in EOT20, which reaches amplitudes exceeding 2 mm in parts of the ocean.

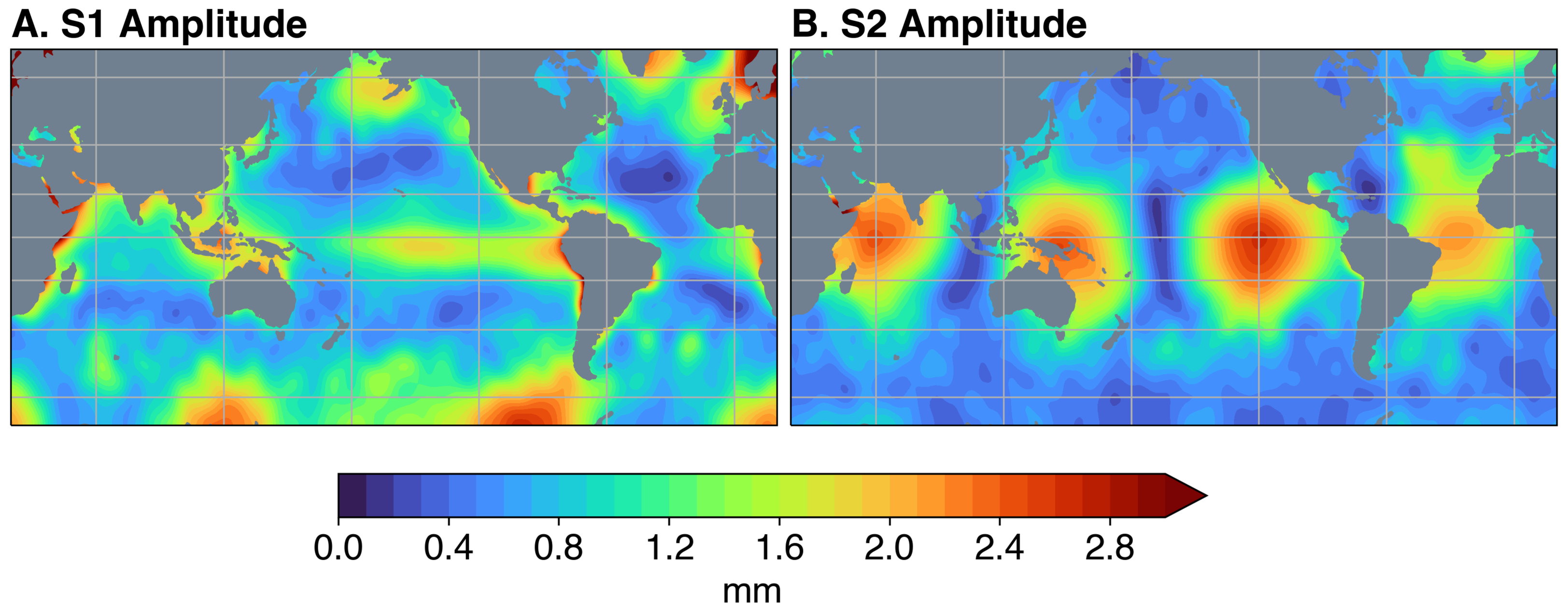

Figure 1: *Results of harmonic analysis on the dry troposphere correction from along-track satellite altimetry, for the two largest tidal signals.*

Dynamic Atmosphere Correction

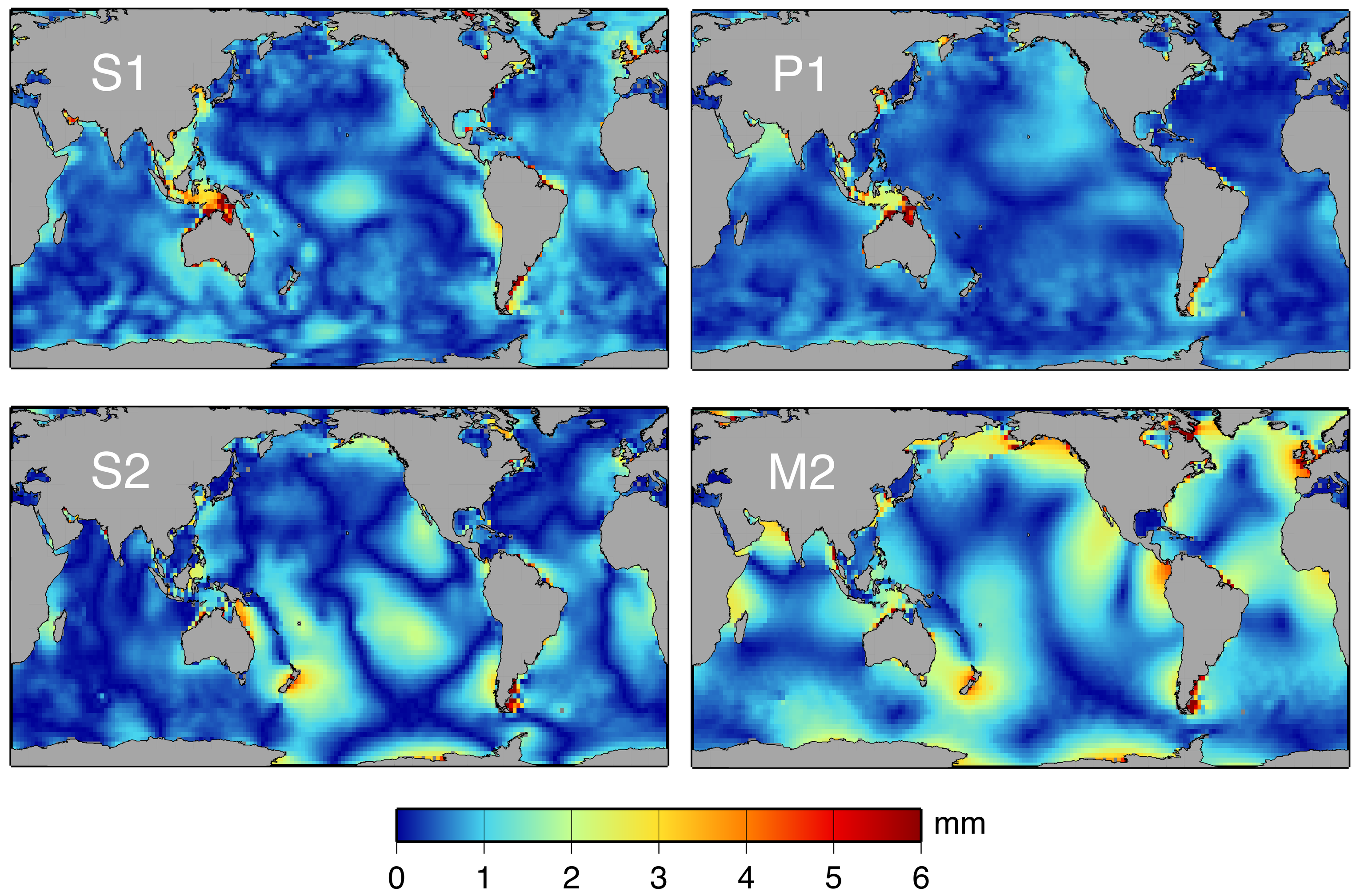

Figure 2: *Results of harmonic analysis on gridded DAC, for four of the major constituents.*

- The Dynamic Atmosphere Correction (DAC) is an important correction for altimetry applications for the removal of the atmospheric forcings. Particular importance is placed on the removal of the S1 and S2 atmospheric tides which influence the altimetry retrieval.
- Results demonstrate that for several of the tidal constituents of interest, there are tidal signals that remain within the DAC **(Figure 2).** This particularly interesting considering the attention paid to the S1 and S2 tides within the DAC processing.

Ionosphere Correction

- The ionosphere correction is applied to satellite altimetry to account for the influence of free electrons in the Earth's ionosphere.
- In EOT20, it was hypothesized that the S1 and S2 ocean tide constituents, at least, were being negatively influenced by the ionosphere correction (NIC09, Scharroo and Smith 2010) not representing the full effect.
- Tidal signals were identified within the eight major tidal constituents (also seen in Ray 2020), with the four tides being presented in **Figure 3**.
- Compared with the altimetry-derived dual-frequency ionosphere correction differences exceed several millimeters for individual constituents, suggesting that the NIC09 correction is not fully capturing the ionospheric signature of these constituents relative to the dual-frequency correction.

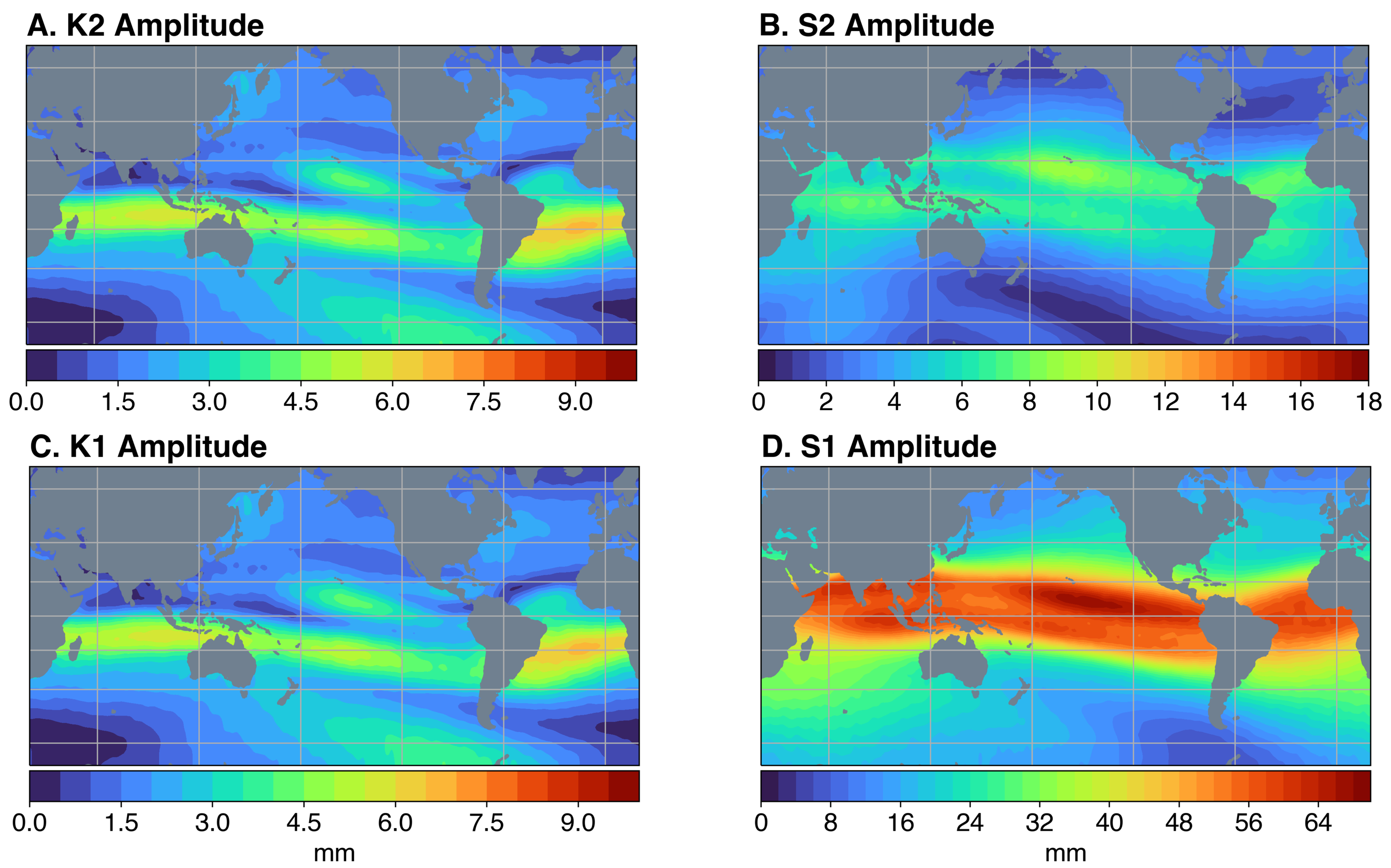

Figure 3: *Amplitude of certain tidal frequencies derived from the along-track NIC09 ionosphere correction.*

Summary and Outlook

- Tidal signals are present in most altimetry corrections which are used to derive the SLA, for some of these corrections these signals are expected and should remain, such as the ionosphere correction but in some corrections these signals should be removed to avoid double counting of these processes such as in the DAC.
- In terms of ocean tide model accuracy, investigations are ongoing to evaluate how to remove the signals that are not wanted but also on how to properly represent the signals within the model.
- Additionally, the mesoscale and internal tide corrections are also currently being included in regional experiments to remove these signals from the SLA before the full tidal analysis is being conducted. The initial results suggest positive impacts on tidal estimations when including these additional corrections.

References

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