From open ocean to the coastal zone: benefits from SWOT in the Mean Sea Surface

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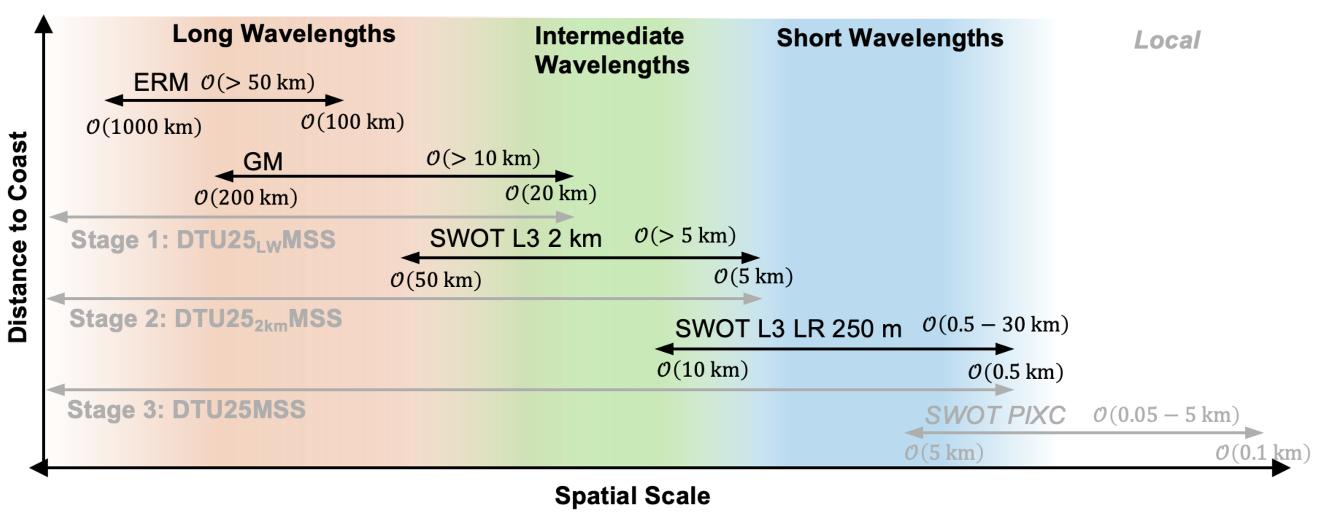
1. Introduction

During the last 30 years, we have several generations of satellite altimeters to build upon, and with the inclusion of SAR processing, we are reaching the limit of conventional satellite altimetry. With the breakthrough that is the Surface Water and Ocean Topography (SWOT) mission, we can significantly improve our knowledge of ocean geodesy and provide greatly improved references for oceanography and climate research.

With the inclusion of two-dimensional satellite altimetry, we go beyond the limitations obtained from nadir looking altimetry, and with almost two years of SWOT data available, we have a near complete global coverage. Longer wavelengths are already well resolved with the 30 years of conventional altimetry, and utilizing the short-wavelength improvement obtained from SWOT, we can get a combined solution with the best from both sides.



2. SWOT Data Processing

The DTU25 MSS model is constructed in a remove-restore fashion, consisting of long-wavelengths from conventional altimetry, and short wavelengths from SWOT. This ensures the reference period is consistent with the current standard, as well as corrects for long-wavelength errors in the SWOT data.

The process of combining the two datasets consists of a long-wavelength correction to the SLA computed between each SWOT pass and the reference MSS. After subtracting this, we remain with the short-wavelength features, as observed with the example below.

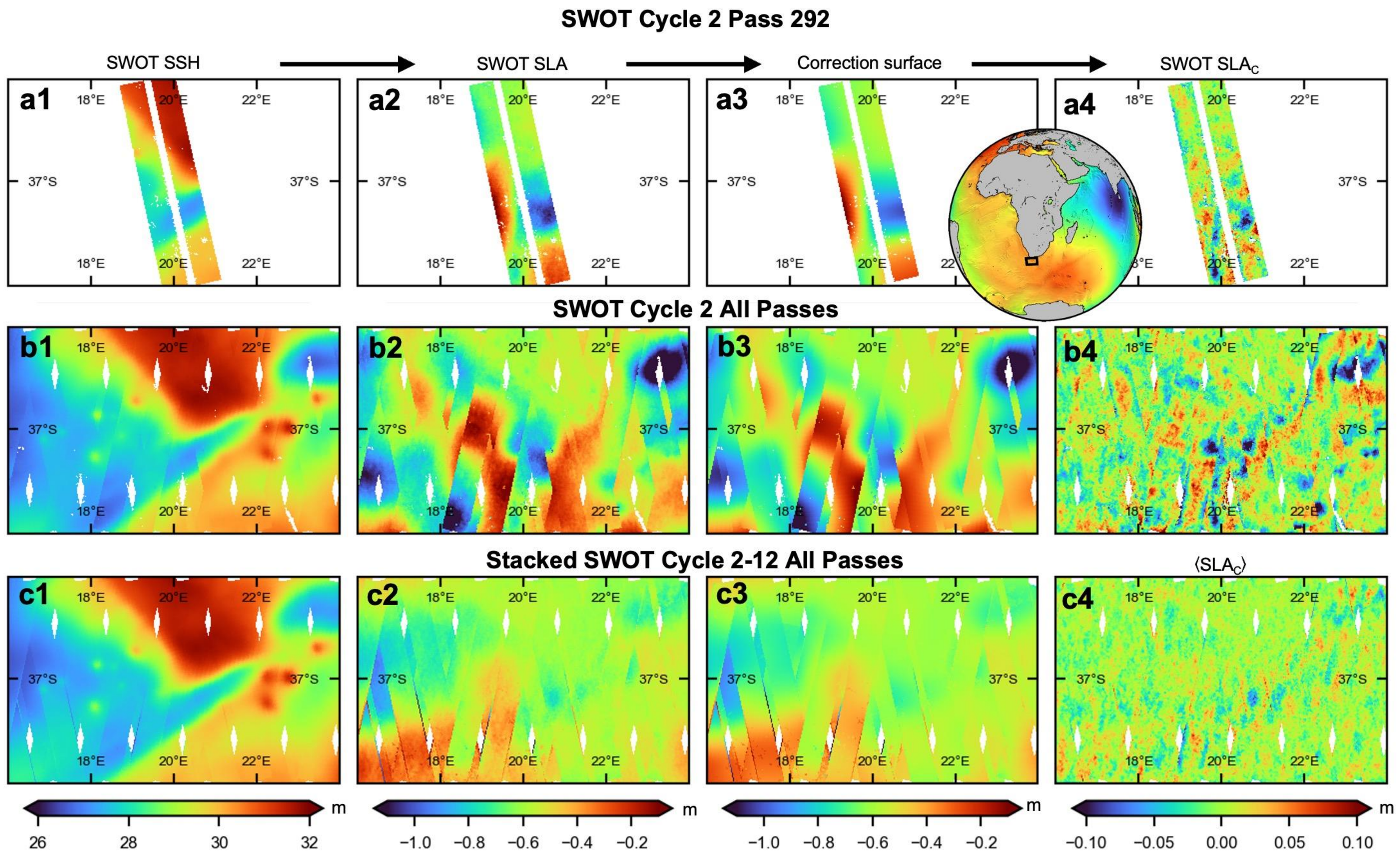


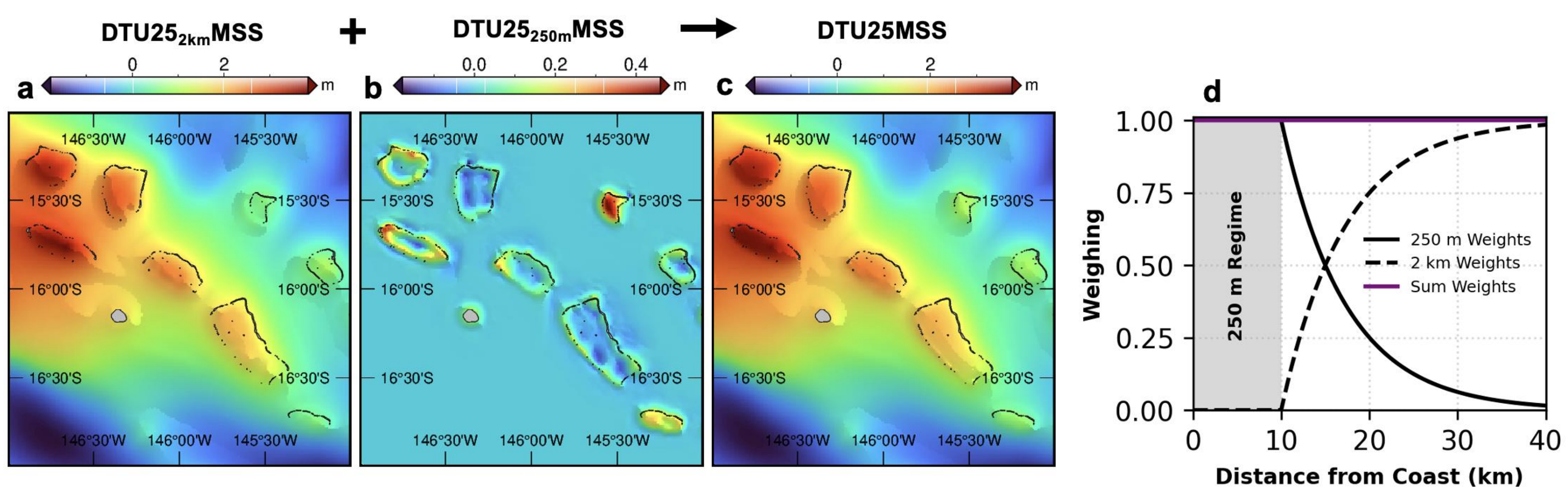
Figure 1 (left): **a1**) SSH from a SWOT pass south of Africa **b1**). SLA from a SWOT pass **b1**). Long-wavelength fit to the SLA. **C**). New SLA obtained after subtracting the long-wavelength fit.

3. Coastal Zone Processing

While the 2 km data is sufficient in the open ocean, we see a great benefit in including 250 m data in the coastal zones, to complete the interface between land and sea products.

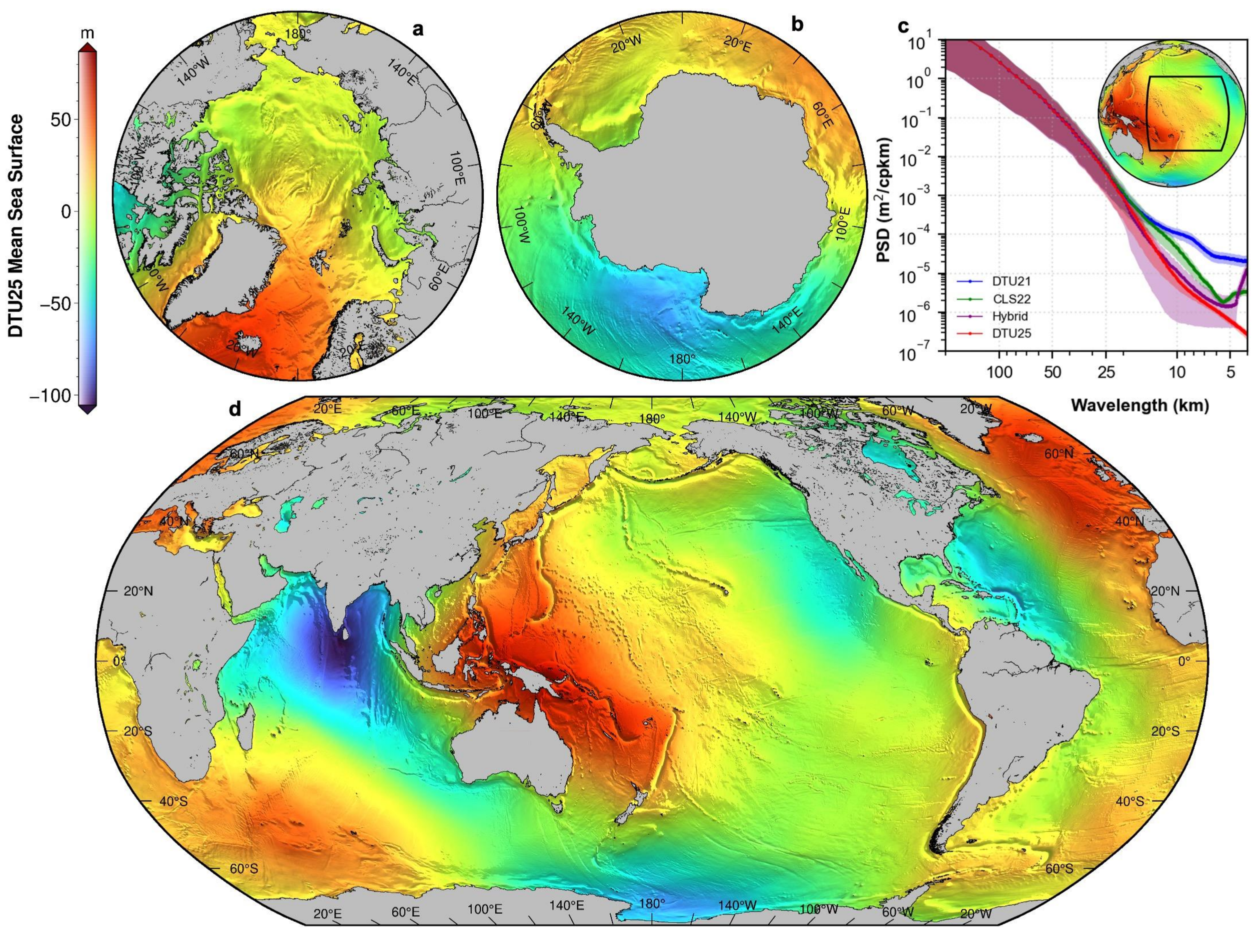
In the figures below, we see that we can obtain large signals in the Atolls internal lagoons, where we had no data from the 2km SWOT data. The inclusion of these data will improve the MSS in the coastal zone, but with the large amounts of data, we limit this to 30 km from the coast.

These two datasets are combined with the weighting function as seen in the figure below (d)



4. The DTU25 Mean Sea Surface

Combining each corrected pass into a grid, we use least-squares collocation. We use a correlation length of 2.5 km (5 km full) to correspond to the SWOT ocean data product processing. Using 29 cycles currently available, we obtain the MSS correction, and then restore the full field, by adding back the long wavelengths obtained from nadir altimetry. The model obtained is seen in the figure below



Preprint!

Dataset!

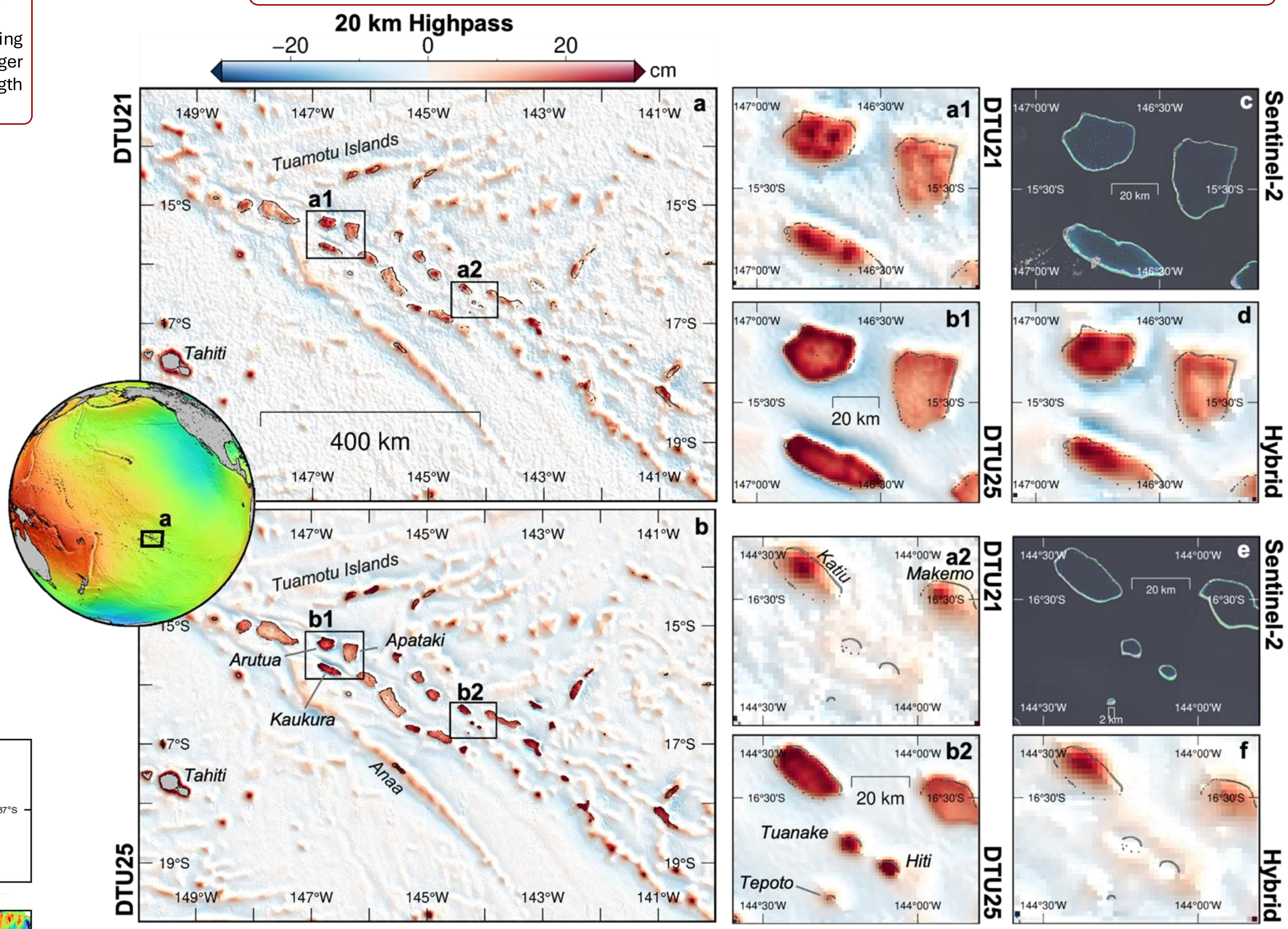
5. Moving the reference from 2003 to 2023

As conventional MSS, the DTU25 is defined with zero-height in 2003. However due to sea level rise, this results in a general higher level in all current observations. We have therefore determined an experimental MSS which incorporates regional sea level rise, to move the reference to 2023, and therefore provide a more current view of the mean sea level. This experimental product is available along with the conventional MSS centered in 2003.

The DTU25MSS is available on data.dtu.dk! And as a preprint at: doi 19.5194/essd-2025-404

6. Results

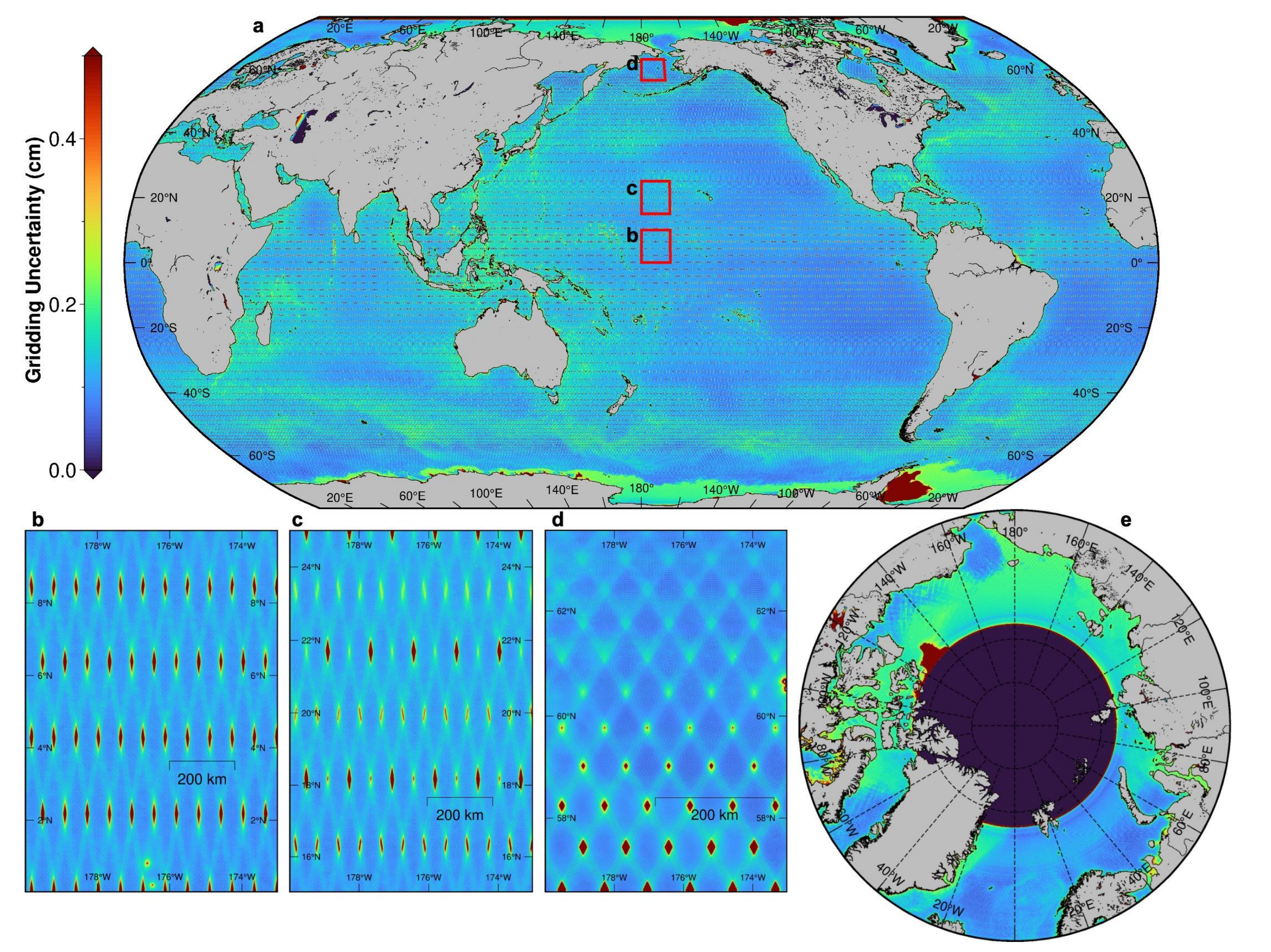
Inspecting the differences between the MSS models is best done with a highpass filter, as most of the improvement is done in the short wavelength band (see power spectra in section 4). This showcases the ability to model smalls cale features, such as the central lagoons in the atolls seen below.



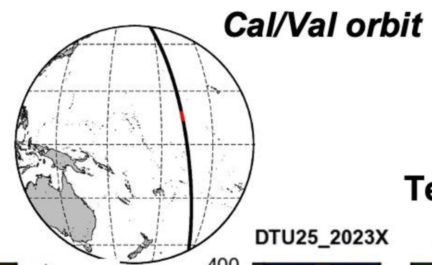
Gridding Uncertainty

The uncertainty of the gridding is determined at the same time as the model. This enables us to provide high confidence in oceanographic quiet regions and allow for a higher uncertainty in regions with high oceanographic variability (see the large currents below).

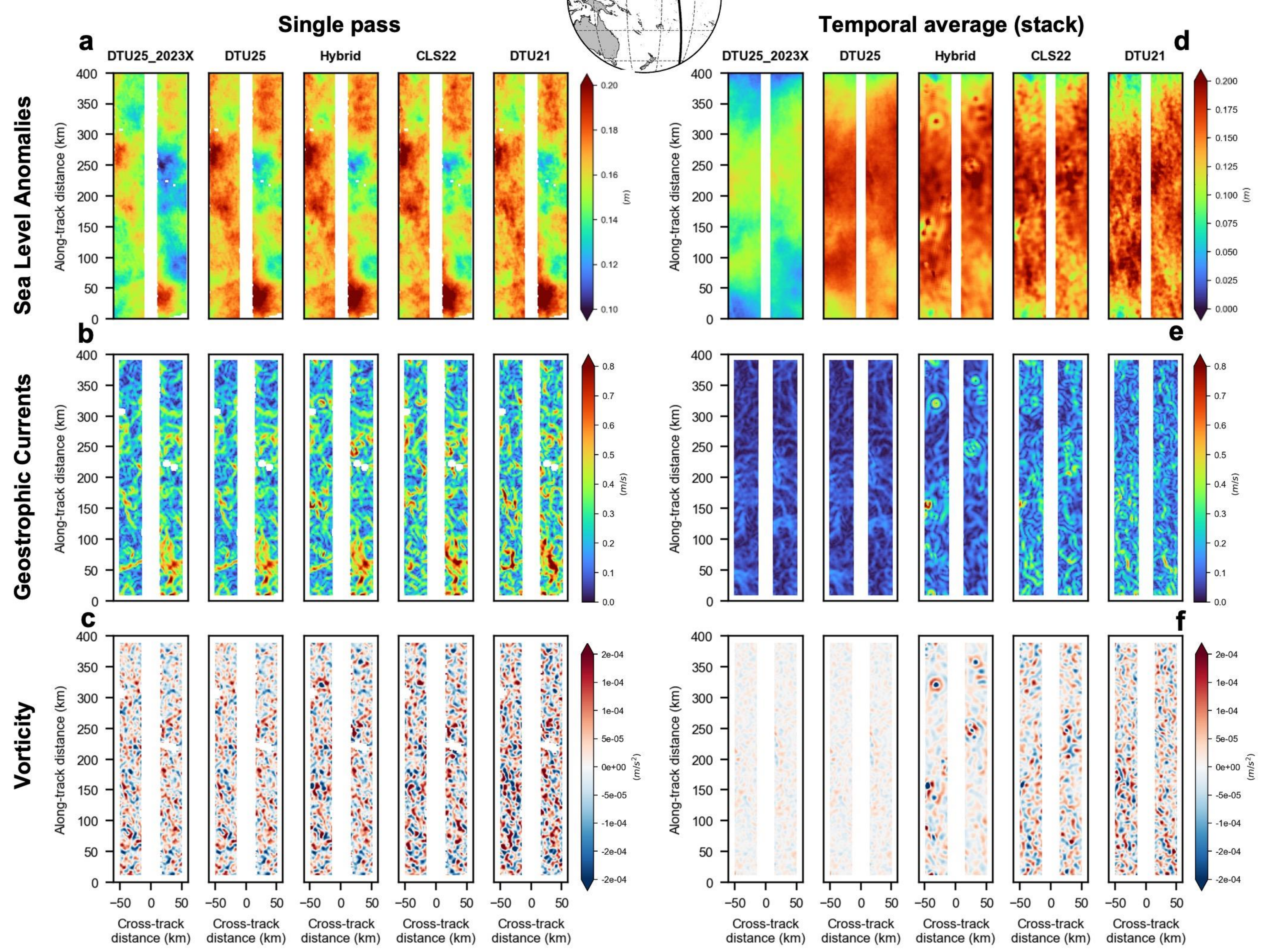
This also enables us to determine regions with no data – the diamond shaped gaps in the SWOT coverage stemming from the orbital configuration of the satellite mission. With no data, no improvement of the MSS field is possible.



An important effect of improving the MSS, is reduction of geodetic signals that would leak into sea level anomaly observations as false oceanographic signals. Below is the effect of different MSS models, and different oceanographic variables.



The left side shows the effect on a single pass, indicating that the majority of the signal is still from the observation. To the right is the time average, which is where we see the leakage of geodetic signals into oceanographic features.



8. Conclusions and Data Availability

We have incorporated almost 2 years of SWOT data into a MSS model, that reduces the effect of unresolved geodetic signals as well as captures many small scale coastal features previously unobserved by conventional altimetry. The effect of SWOT will only be improved as we learn how to better utilize the data and separate the oceanographic and geodetic signals. The MSS is available on data.dtu.dk, and a data-description paper is currently under review and available as a preprint, with an in depth description of the methodology behind the data processing.