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The Dynamic Ocean Topography in the Greenland Sea - Combining Multi-Mission Satellite Altimetry with Ocean Modeling

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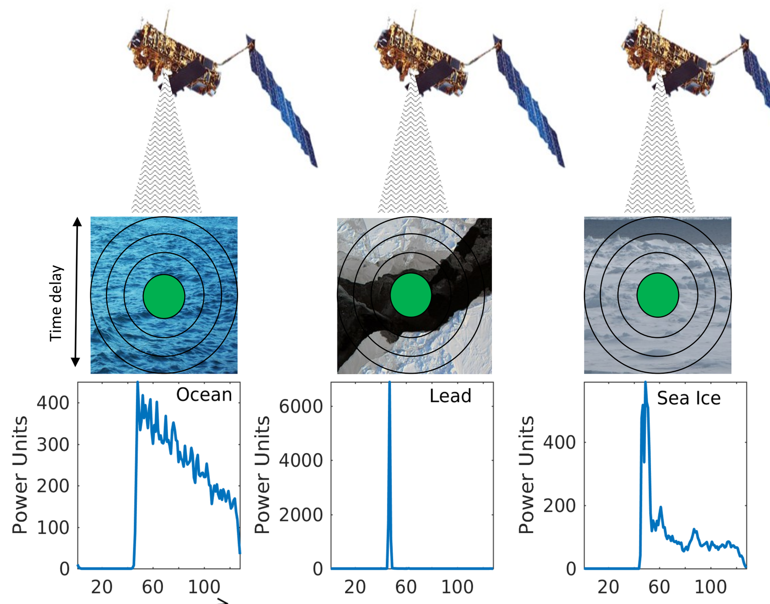
Motivation: The dynamic ocean topography (DOT) is defined as the difference between the sea surface and the geoid and enables studies about ocean surface currents and their variability. Satellite altimetry is an important part of the Global Geodetic Observing System (GGOS) providing precise information on sea level on different spatial and temporal scales. However, in polar regions, altimetry observations are affected by seasonally changing sea-ice cover and difficult ocean conditions leading to a fragmentary data sampling.
In order to overcome this problem, the global Finite Element Sea-ice Ocean Model (FESOM) is used to fill data gaps with the goal to obtain a homogeneous DOT representation enabling consistent investigations of ocean surface current changes. FESOM is based on an unstructured grid and provides daily water elevations with high spatial resolution. Since it also contains a sea-ice component taking into account the main ice drift patterns, it is particularly suitable for polar regions such as the Greenland Sea.
The combination is based on a Principal Component Analysis (PCA) after reducing both quantities by their constant and seasonal signals. In the main step, the most dominant spatial patterns of the modeled water heights as provided by the PCA are linked with the temporal variability of the estimated DOT from altimetry. Finally, the seasonal signal as well as the absolute reference from altimetry is added back to the data set. This poster describes the combination process and shows results in terms of DOT and geostrophic currents.

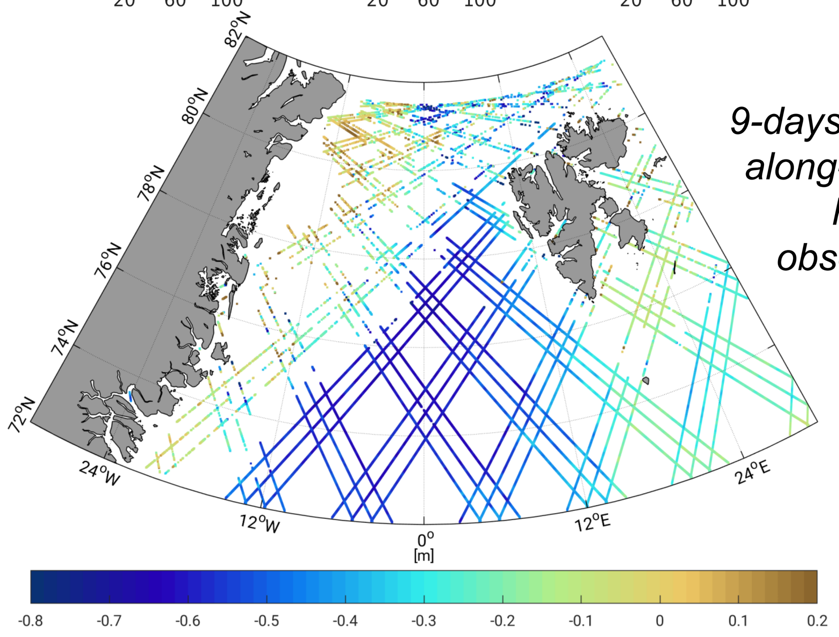
Input datasets

Observational database

- High-frequency along-track altimetry data (ENVISAT, ERS-2)
- Elimination of ice-contaminated observations by an unsupervised classification (K-medoids; Müller et al., 2017)
- Consistent along-track sea surface heights (SSH) for open ocean and sea-ice regions through dedicated waveform retracking (ALES+; Passaro et. al, 2017)
- DOT by referring the SSH to a geoid OGMOC (Fecher & Gruber . 2018)



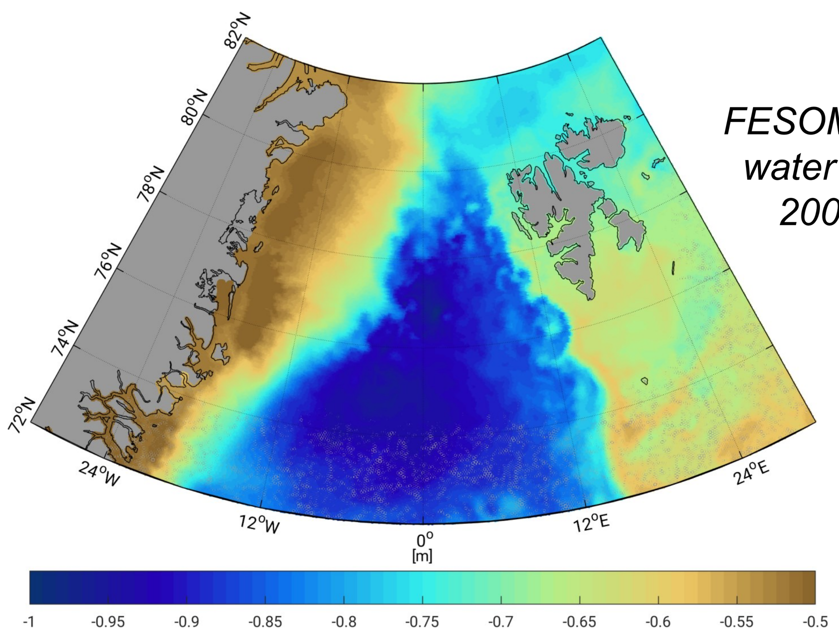
Examples of Envisat radar echoes for three different surface conditions



9-days of altimetry along-track DOT height observations

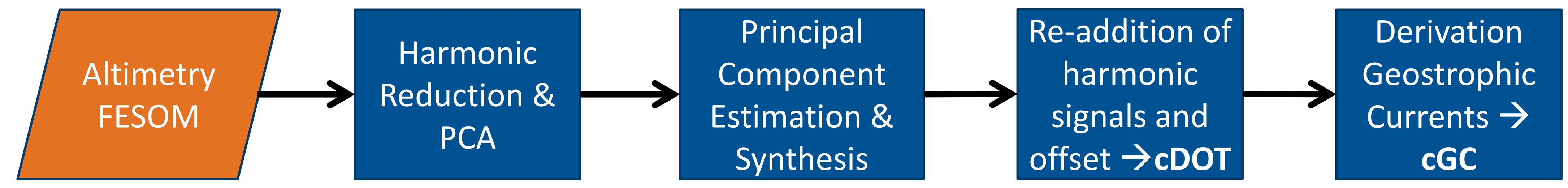
Model database

- Finite Element Sea-Ice Ocean Model (FESOM; Weckerle et al., 2017)
- Unstructured mesh ocean model includes daily differential water heights
- Spatial resolution better than 1km



FESOM differential water heights for 2009-Apr-15

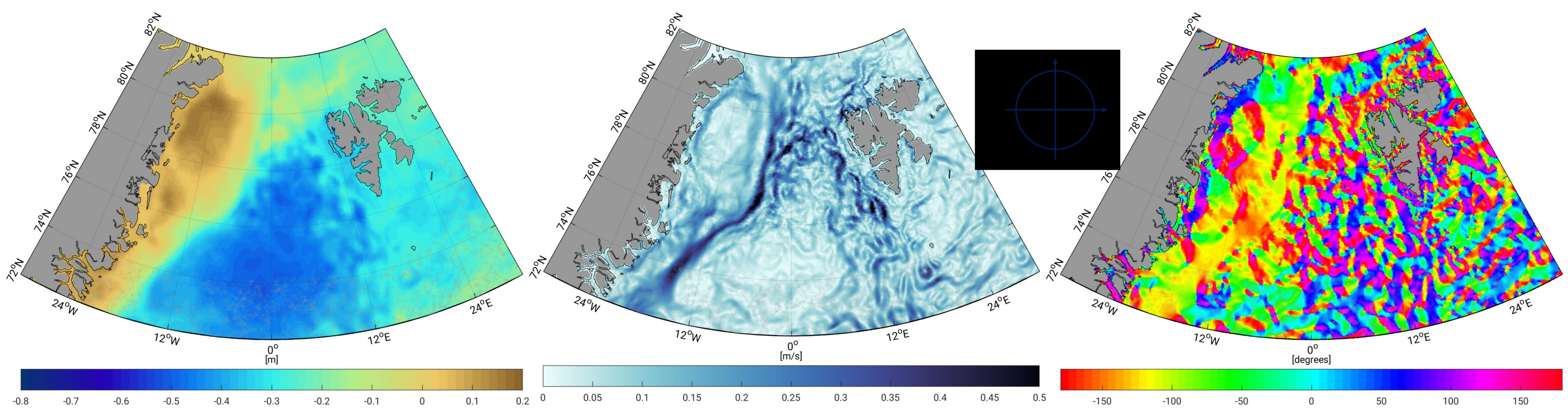
Combination approach



Processing scheme of combination approach based on along-track altimetry observations and FESOM modeled water heights

- Combination of along-track DOT observations with FESOM simulated water heights
- Computation of combined DOT (cDOT) and geostrophic currents (cGC)

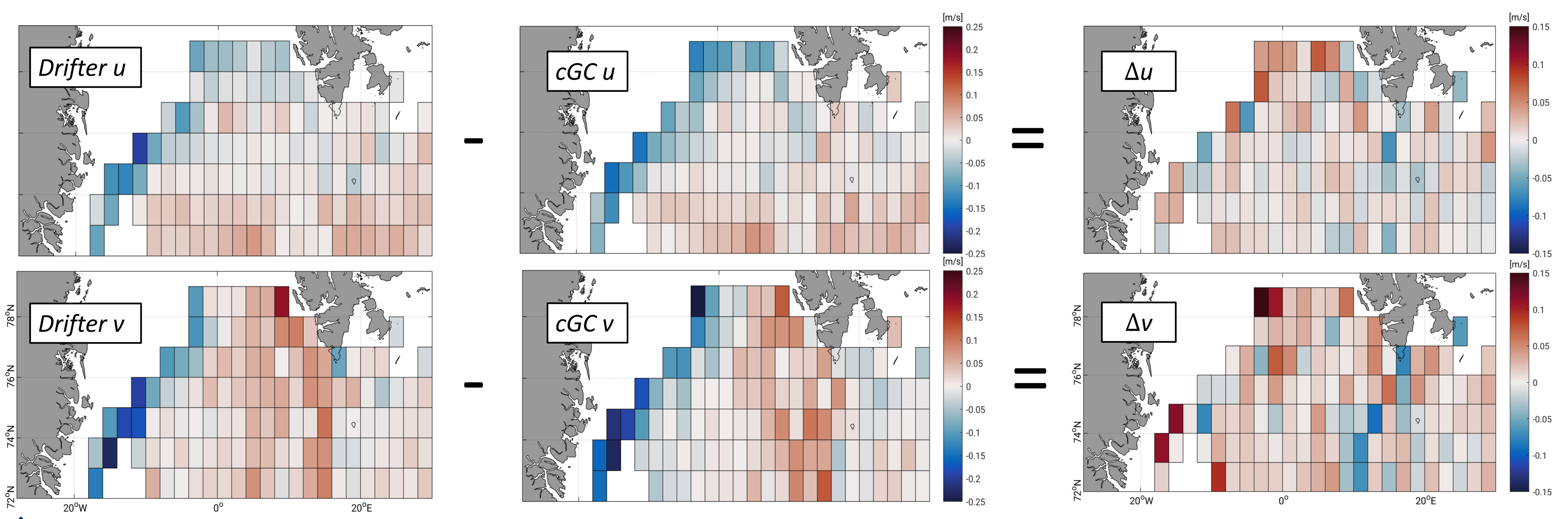
Result: Combined DOT, geostrophic currents (GC)



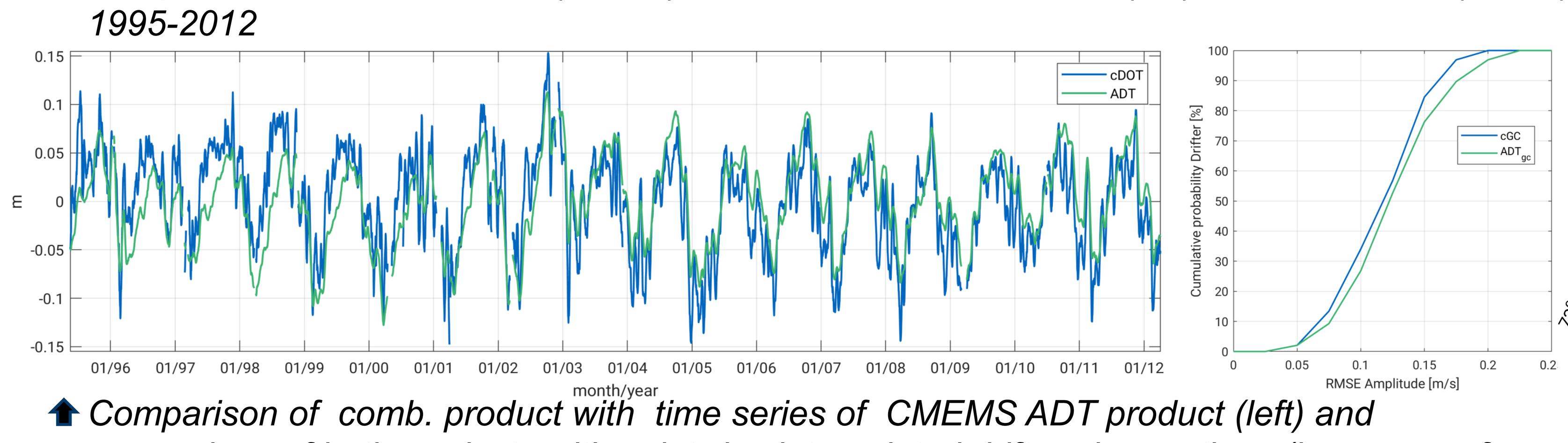
Examples of DOT, absolute velocity and flow direction of geostrophic currents for July, 2008.

- Combined datasets are characterized by spatial resolution of model and temporal variability of altimetry DOT elev.
- Spatial-temporal homogenous representation of ocean variables covering 17 years (1995-2012)
- Model is used to bridge gaps of missing altimetry observations => sea-ice regions are completely covered

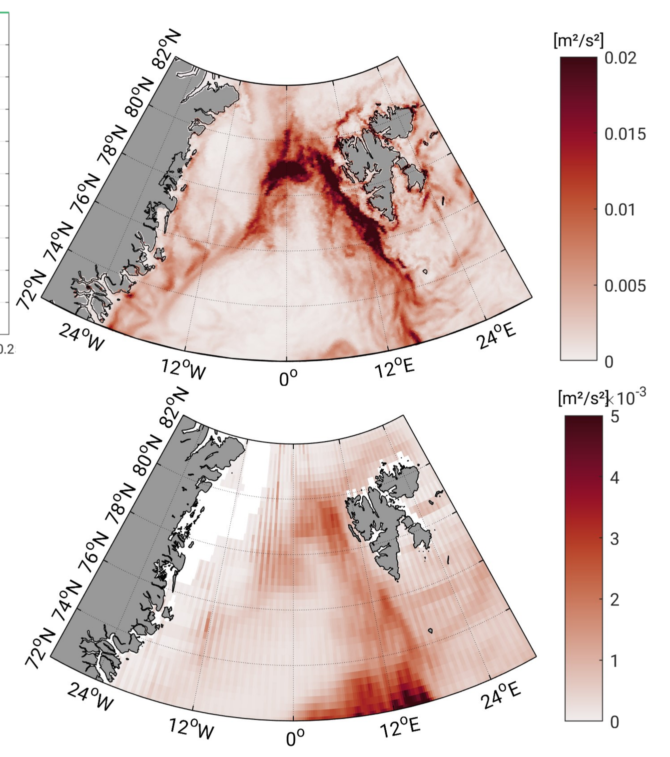
Comparison with in-situ drifter velocities and altimetry only absolute dynamic topography (ADT)



🡅 *Comparison of combined GC (middle) with in-situ drifter velocities (left) binned in 2°x1° (lon,lat) boxes for both components within 1995-2012*



🡅 *Comparison of comb. product with time series of CMEMS ADT product (left) and comparison of both products with pointwise interpolated drifter observations (by means of absolute geostrophic velocities; right).*



Comparison of quarterly averaged (J-M) eddy kinetic energy from cGC (top) and ADT (bottom) grids

Summary and Outlook

- Combination enables spatio-temporally consistent studies of DOT and ocean currents for nearly two decades in sea-ice covered regions
- Results are characterized by the spatial resolution of the input model and the temporal variability of altimetry observations
- Comparison with drifter data shows good agreement of spatial patterns and small residuals in both geostrophic velocity components
- Comparison with ADT displays good agreement (corr. 80%), but more short term structures and higher variability of combined product
- Combined geostrophic currents are characterized by smaller RMSE and higher level of detail in terms of EKE in contrast to ADT derived GCs.

References and Acknowledgements :

More information shortly available in Müller, F. L.; Dettmering, D.; Wekerle, C.; Schwatke, C.; Bosch, W.; Seitz, F. (2019): Geostrophic Currents in the northern Nordic Seas - A Combined Dataset of Multi-Mission Satellite Altimetry and Ocean Modeling, Earth System Science Data Discussions (in prep.)

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Data