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Estimating global ocean heat content from tidal magnetic signals in space

Christopher Irrgang (1), Jan Saynisch (1), Maik Thomas (1,2)

(1) GFZ German Research Centre for Geosciences, Potsdam, Germany, (2) Institute of Meteorology, Freie Universität Berlin, Germany

The majority of the Earth's energy imbalance (global warming) is absorbed by and stored in the ocean. As a consequence, the upper ocean temperature is increasing continuously and heavily affecting global sea-level, biodiversity, sea-ice, and humanity. In the context of climate change, global ocean heat content is an important diagnostic variable, which is subject to broad research activity. We demonstrate that the global ocean heat content can be recovered from ocean-induced magnetic signals that are emitted into space and observable by low-Earth-orbiting satellites.

Ocean tides generate electromagnetic (EM) signals, as the electrically conducting sea-water is moving around the Earth and interacting with the ambient geomagnetic field generated in the Earth's core. Thus, space-borne observations of oceanic EM signals contain depth-integrated information about global transports of water, heat, and salinity. We utilize an artificial neural network (ANN) as a non-linear inversion scheme and demonstrate its ability to infer ocean heat content (OHC) estimates from magnetic signals of the lunar semi-diurnal tide.

The ANN is trained with monthly OHC estimates based on in-situ data from 1990-2015 and the corresponding model-based tidal magnetic fields at satellite altitude. The trained ANN can closely recover inter-annual and decadal OHC variations within the 1990-2015 time period. In the future, this method could complement and extend the currently available ocean observations techniques (e.g., in-situ measurements from floats, buoys, etc.) and could also lead to new insights about the abyssal ocean, where still only very few in-situ observations exist.