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Using oceanic signatures in the Earth's magnetic field to constrain simulations of the global ocean circulation

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The general ocean circulation generates electromagnetic signals by interactions of the electrically conducting seawater and the ambient geomagnetic field. These oceanic magnetic signals are emitted outside of the ocean and can be recorded with low Earth orbiting satellites like ESA's Swarm mission. Thereby, satellite observations of the magnetic field induced by the general ocean circulation, once available, could provide new constraints on global oceanic water and heat transports. We have investigated this possibility in an observing system simulation experiment (OSSE) by assimilating artificial (model-based) satellite observations of the ocean-induced magnetic field into an ocean general circulation model.

The data assimilation is performed by a localized ensemble Kalman filter. Compared to a reference simulation without data assimilation, zonal and meridional water transports are improved by up to 7% globally, and up to 50% locally. Most Kalman filter improvements extend from the sea-surface down to the deep ocean, where in-situ observations are very scarce. Spurious corrections of the ocean model state are identified in the South Pacific Ocean and are linked to deficient estimates of the ocean model error covariances. In this OSSE, Kalman filter corrections of the wind stress forcing of the ocean model are essential for a successful assimilation.

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