Detection of Magnetic Signals from Ocean Circulation with Satellite Altimetry and Magnetometer

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Electromagnetic Signals from Ocean Circulation

Introduction:

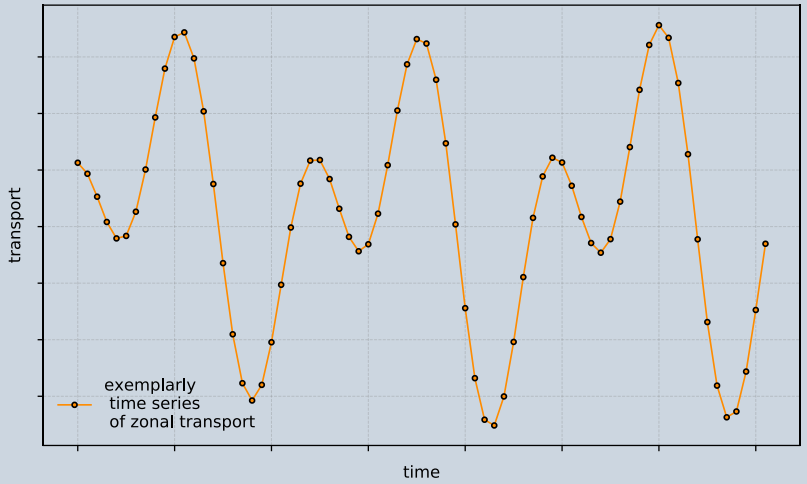
If electrically conducting sea-water moves through the ambient Earth's magnetic field, further electromagnetic signals are generated. Therefore, in addition to ocean tides also the wind-driven ocean circulation generates magnetic signals. The poloidal part of these induced magnetic fields reaches outside the ocean and can be detected by space-borne Earth observations, like the Swarm satellite magnetometer mission. However, the magnetic signals from ocean circulation are still unidentified in Swarm observations.

Here an approach is presented, which uses the geostrophic approximation to derive the temporal behavior of the radial magnetic field component from the wind-driven ocean circulation. This approach was tested with ocean model data and compared to a full model approach.
In the future this approach possibly allows an identification of magnetic signals from ocean circulation in Swarm observations.

Challenge of the Detection of Magnetic Signals from Circulation

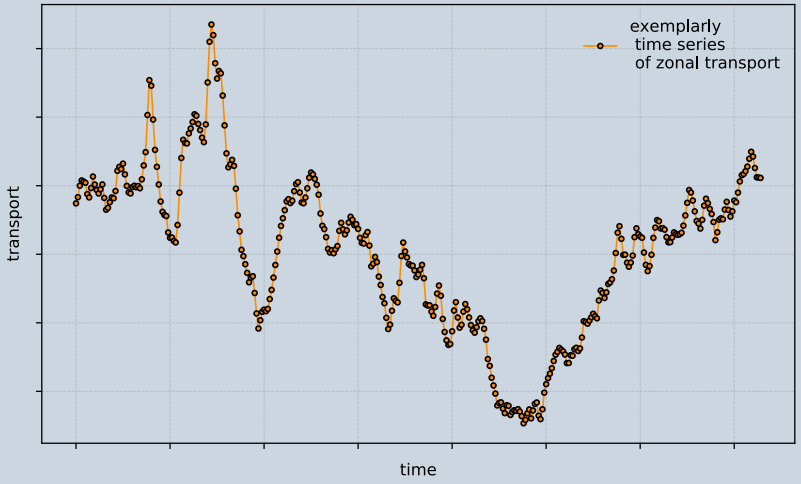
Knowledge about the time behavior is essential for separation from other magnetic field parts

Ocean Tides



Signal can be identified due to a well-known temporal behavior

Ocean Circulation



Signal identification is difficult due to a complex temporal behavior

Geostrophic Model Approach

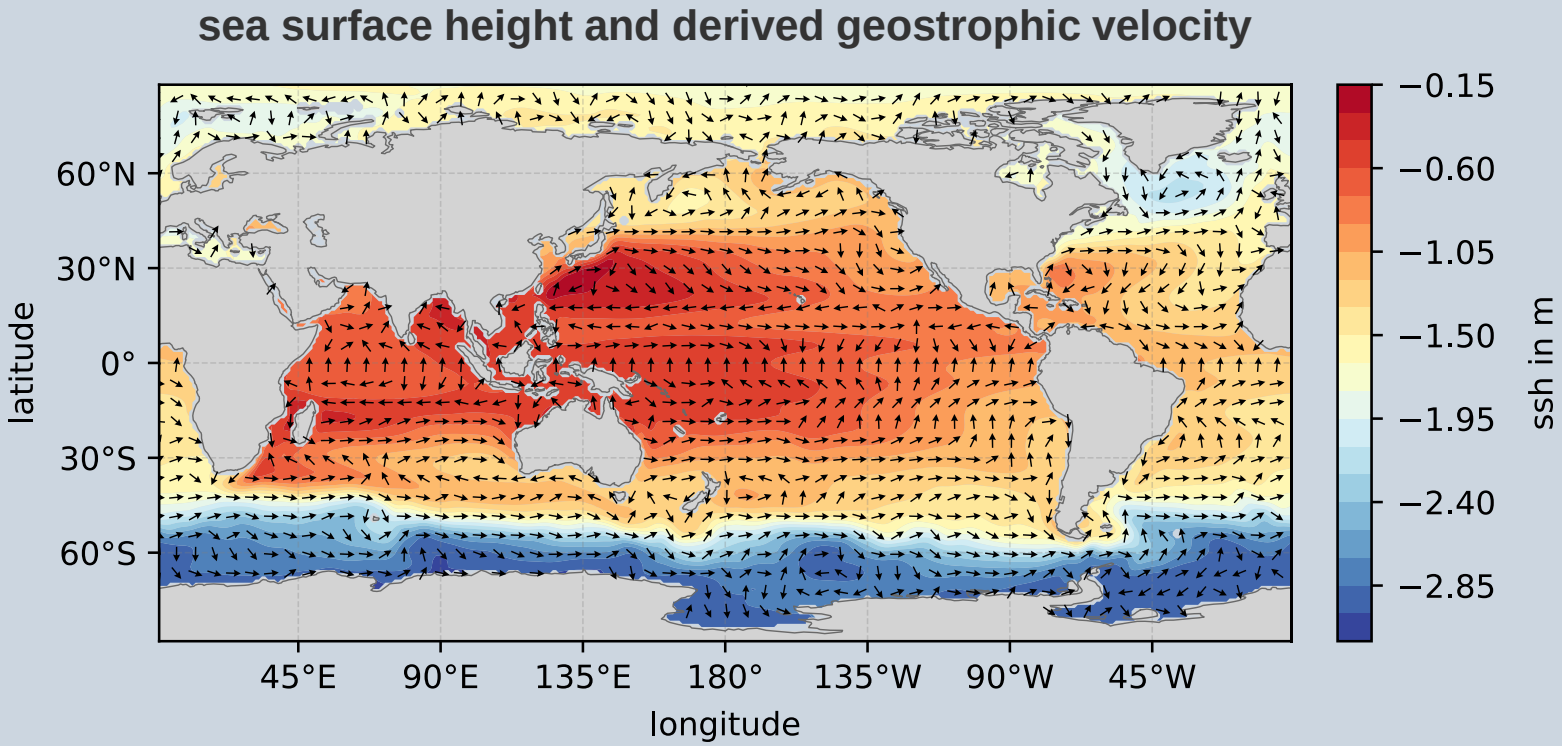
Ocean velocities can be derived from sea surface height

Geostrophic current velocities:

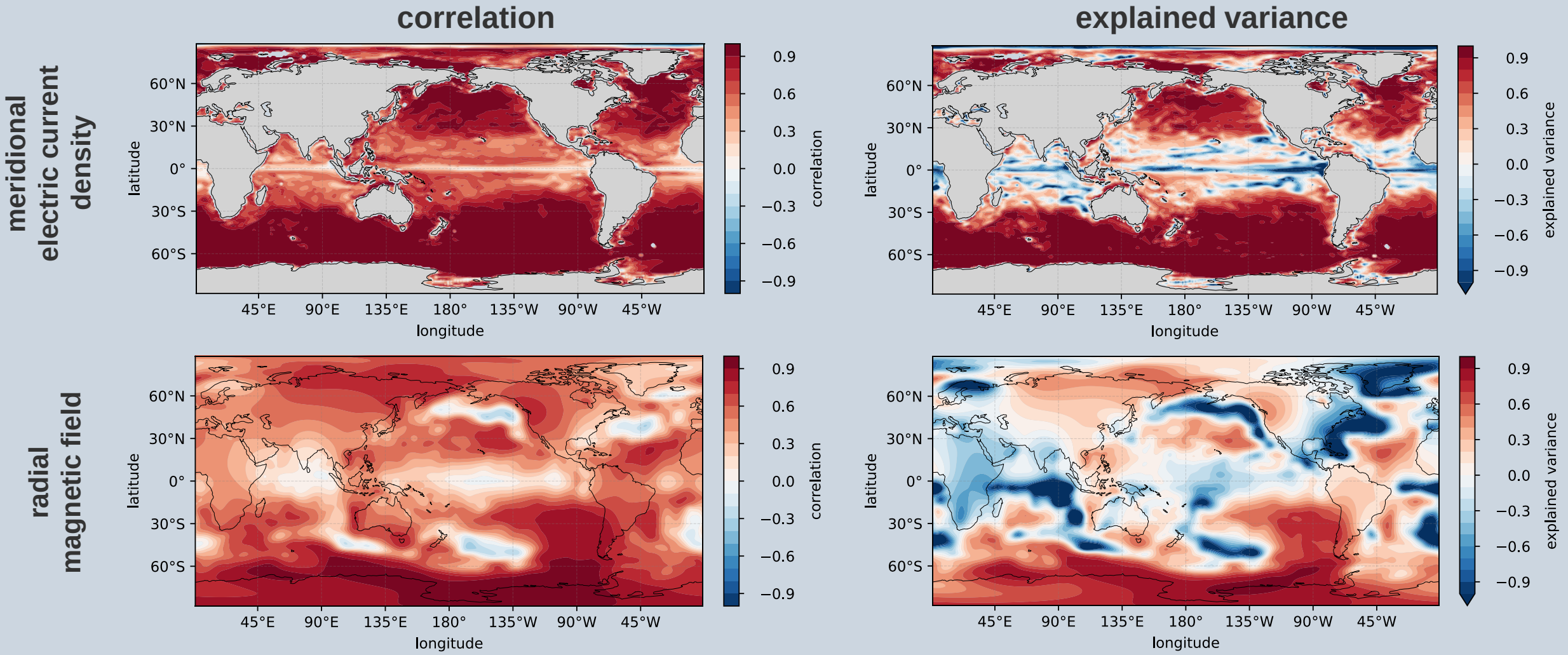
$$v_x^{geo} = -\frac{g}{f}\frac{\partial \zeta}{\partial y} \quad \text{(zonal)}$$

$$v_y^{geo} = \frac{g}{f}\frac{\partial \zeta}{\partial x} \quad \text{(meridional)}$$

g ... gravitational acceleration
f ... Coriolis frequency
ζ ... sea surface height



Comparison of Full Model Approach and Geostrophic Model Approach



Conclusion

⇨ **The sea surface height can be measured by satellite altimetry and used to possibly identify the magnetic signals of ocean circulation in Swarm observations**

- For the identification of magnetic signals from wind-driven ocean circulation in Swarm observations the temporal behavior must be known
- The use of the geostrophic approximation allows to estimate the expected temporal behavior
- This “geostrophic approach” was tested with sea surface height data from an ocean model and compared to the expected electromagnetic signals from the full model data
- The comparison shows a high correlation between these approaches
- This means the temporal variability of the magnetic signal from circulations can mainly explained by the variability of the sea surface height