Abstract: The aim of the project is to derive global information about the oceanic system in an unprecedented way. We propose to combine the information contained in global satellite-based gravimetric observations with the global information content of terrestrial as well as space-borne electromagnetic observations. Both observation types monitor overlapping physical properties of sea water and the global ocean circulation. The unprecedented joined inversion utilizes the physical links between oceanic density and electric oceanic conductivity as well as the oceanic mass redistribution and motional electromagnetic induction due to ocean currents.
Due to water's high heat capacity, the oceans can store and release large amounts of heat. That makes the world oceans a key agent of Earth's climate system as they effectively diminish the global warming on the continents (Pörtner et al. , 2022). In addition, the oceans transport large fractions of the tropical insolation heat surplus to the poles, where the heat is radiated back into space. To face mankind's global warming related problems, it is mandatory to understand the involved processes as well as possible. However, it is equally important to know, i.e., observe, the current state of the oceanic heat transport and its changes. This is an ongoing challenge since the oceans are in general very large, hostile, and deep and consequently very hard to observe in their entirety. Most measurements are only conducted point-wise in time and/or space (e.g., ship-based profiling and moorings) or do only cover the upper water layers (e.g., radar satellites and floats). However, a few measurements exist that contain information about the global ocean and its entire depth. Apart from the already widely used satellite altimetry (Pham et al. , 1998; Saynisch et al. , 2015b), most prominent are observations of Earth's rotation (Saynisch & Thomas, 2012), satellite measurements of Earth's magnetic field (Irrgang et al. , 2017, 2019; Saynisch-Wagner et al., 2021) and Earth's gravitational potential fields (Köhl et al. , 2012; Quinn & Ponte, 2012; Saynisch et al. , 2015a).
GREMLIN aims at the estimation of oceanic transport time series by a combined inversion of magnetic and gravimetric satellite observations. Hereby, we will focus on the large-scale oceanic circulation. Deriving these transports will crucially improve current estimates of global oceanic mass and heat transports. We will derive trends of major current system as the Antarctic Circumpolar Current (ACC) and the Gulf Stream, i.e., the upper northward arm of the Atlantic Meridional Overturning Circulation (AMOC). We will quantify if still debated climate change related impacts on the current strength can be identified (Shi et al., 2021; Caesar et al. , 2021). Furthermore, our estimates of the oceanic transports will be used as independent validation of Earth orientation parameters (EOP) and altimetry-based oceanic transport reanalyzes. Finally, the project will fulfill the open objective of the current ESA mission Swarm: identification and exploitation of magnetic signatures from the oceanic circulation (Friis-Christensen et al. , 2006).

Summary document:

1. Project overview:

The project is funded by the DFG under the GREMLIN acronym and uses a classic data assimilation approach consisting of forward model, operation operator and assimilation analysis/update operator. In