1 General Information

Description of a project for a PhD student

1.1 Topic

Possible magnetic signature of decadal climate variability

1.2 Supervision

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1.3 Summary

Apart from the dominant internal magnetic field and external field variations, a tiny field variability due to the tidal motion of the Ocean can be found in geomagnetic records. The aim of this study is to sense magnetic signals of the main oceanic tides (M2, N2 and O1) and their long-term behavior within the data set of EOST's magnetic observatories. Results of this analyses will jointly be interpreted with other geophysical observations of the oceanic system. In particular, we propose comparisons with decadal sea-level variations which are tightly related to variations of the thermohaline circulation that is subject to climate variability.

2 Project description

Measurements of the geomagnetic field taken at Earth's surface contain signals of several sources which are dominated by the internal magnetic field signatures. Magnetic field variations due to the tidal motion of the Ocean can also be found in geomagnetic records (Tyler et al., 2003; Love & Rigler, 2014). To uncover these weak signals (about 10nT compared to 50000 nT of the main field), it requires a removal of signals of other known sources. Though amplitudes of ocean magnetic tidal signals are small, they can be easily detected with classical time-series analysis, as the signals vary during the day upon a static geomagnetic background. Based on a detected seasonality of tidal magnetic signals in geomagnetic observatory data (Jones & Wardinski, 2021), we attempt to continue these initial studies and to quantify the annual and decadal behavior of tidal signals. Likely, a long-term behavior of the ocean magnetic tidal signal indicates an interaction between tidal

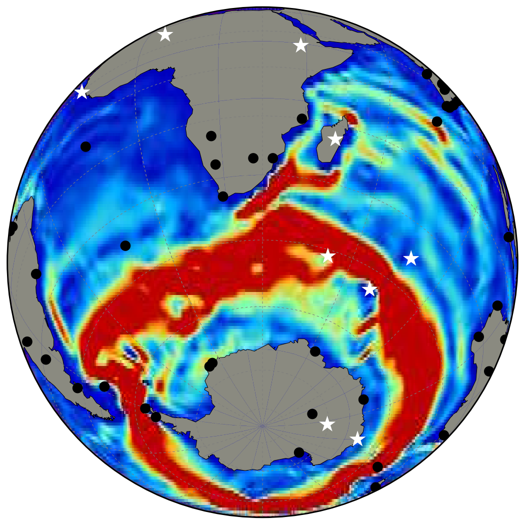

Figure 1: Absolute values of depth-integrated velocities of Oceanic currents for the epoch February 2005 derived from the ECCO model (Wunsch et al., 2009). Large sea-water transports occur in red areas, whereas transports in blue areas are rather low. Antarctic Circumpolar Current which is the strongest ocean current is clearly visible. White stars indicate sites of the geomagnetic observatories maintained by EOST and IPGP.

and thermohaline forcing of oceanic motion. The thermohaline forcing is causing a global ocean circulation pattern (the global conveyor belt) which is driven by the heat transfer between ocean and the atmosphere and also by density gradients within the seawater due to different salt content. The global ocean current system is described by models (e.g. ECCO (Wunsch et al., 2009)) wich are tightly linked to the availability of satellite data. So far, the magnetic signature of the thermohaline circulation has not been detected. However, variation of the thermohaline forcing due to climate variability (change of ocean temperature, freshwater fluxes caused by icemelts) will notably change the interaction of tidal and thermohaline forcing of the ocean motion. A comparison of results for different epochs should highlight variations of this interaction, and EOST geomagnetic observatories close to the Antarctic Circumpolar Current (see Figure 1) provide excellent 'tools' to detect this varying interaction and to sense possible magnetic signatures of global ocean circulation (possibly) related to decadal climate variability.

2.1 Research topics

The aim of this study is to sense magnetic signals of the main oceanic tides (M2, N2 and O1) and to describe their effect at different observatory sites. Eventually, these results from long-term records of geomagnetic observatories in the french southern territories that cover the period 1957 to 2021 should be interpreted with respect to the variability of the oceanic transport and its relation to climate variations. This will be achieved by:

- analyses of the temporal variability of magnetic ocean tidal signals, i.e. their seasonality, annual and decadal variations.
- The verification with numerical predictions of the oceanic tidal signal (a formalism developed by (Kuvshinov et al., 2006)) to assess the geomagnetic observation.
- Retrieval of magnetic signatures related to the global ocean circulation and their assessment to improve global circulation models.
- Analyses of the geomagnetic data will be interpreted with respect to temporal behavior of sea-level variation (geodetic data), ocean surface temperature and ocean salinity.

2.2 Scientific partners

Close collaboration will be sought with scientific colleagues.

- **Dr. Jan Saynisch–Wagner** at the GFZ German Research Centre for Geosciences, who is leading the group Data Assimilation and Inverse Sensitivities (DAIS) in the Earth System Modelling Department of GFZ. He will provide simulation results of the global ocean current model (OMCT Thomas (2002)) for the period of this study.
- **Dr. Severine Rosat** at University of Strasbourg. She will act as the formal host for the PhD study and also will discuss geodetic data sets to be used for the joint geodetic-geomagnetic interpretation of the long-term behavior of oceanic tidal signals.

References

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