Rescaling of magnetic signals due to ocean circulation by assimilating Swarm satellite observations

Aaron Hornschild[1], Jan Saynisch-Wagner[1], Julien Baerenzung[2] & Maik Thomas[1,3]

[1] GFZ German Research Centre For Geosciences, Potsdam, Germany
[2] TU Technische Universität Berlin, Berlin, Germany
[3] FU Freie Universität Berlin, Berlin, Germany

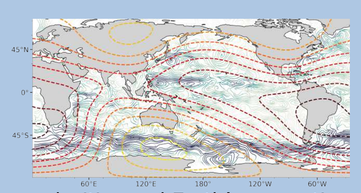
Kalman-filter-based Rescaling of ElectroMagnetic Signals (KREMS)

- Predefined temporal behavior from forward modelling

- Different amplitude rescaling at each location

Ocean-circulation induced magnetic signals

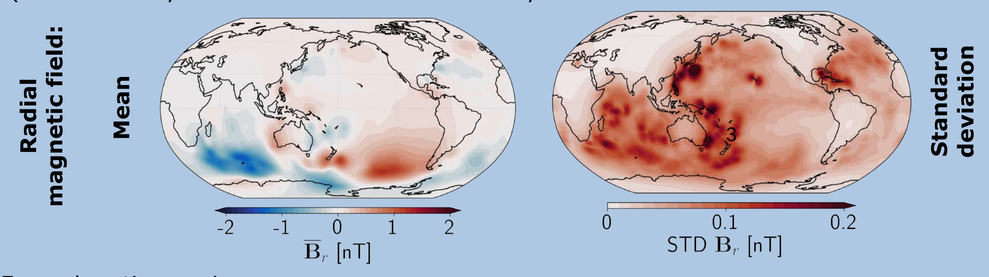
- Movement of conductive sea water through the Earth's ambient magnetic core field induces EM signals



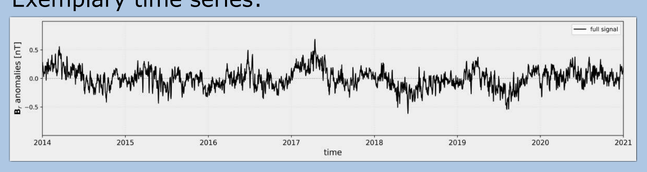
Ocean velocities and Earth's magnetic core field

- Forward modelling using electromagnetic induction solver X3DG [1]

(Based on daily means of Global Ocean Reanalysis GLORYS12v1 dataset from 2014.0 to 2021.0)



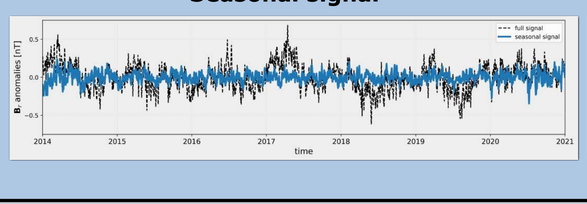
Exemplary time series:



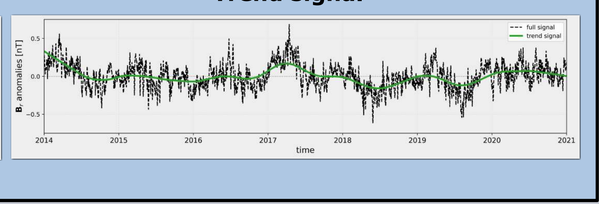
Low amplitude signal with complex and locally very different time behavior

- Temporal decomposition using STL [2]
(*Seasonal and Trend decomposition using Loess*)

Seasonal signal

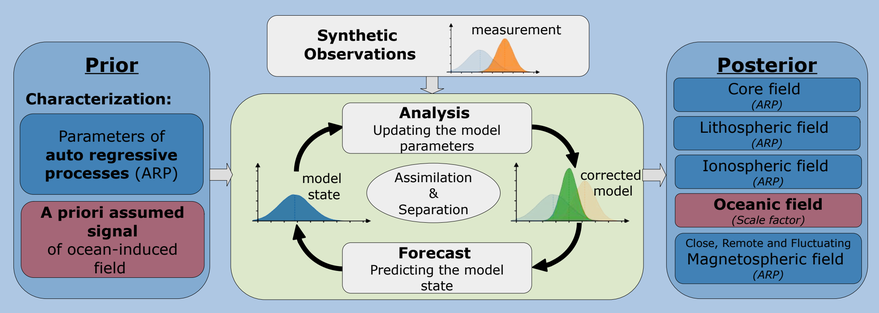


Trend signal



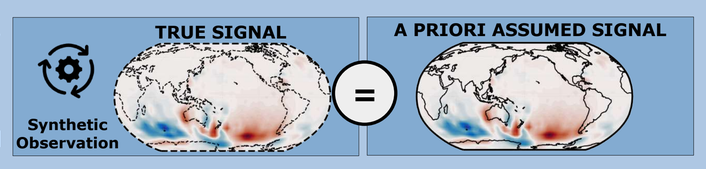
Observing system simulation experiment (OSSE)

- KREMS based on geomagnetic field model Kalmag [3]



- Using an OSSE for validation of KREMS in an ideal scenario [4]

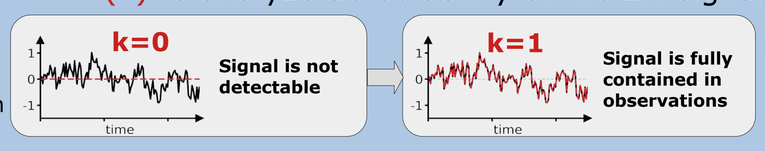
Synthetic Swarm-like observations including oceanic EM signal from ocean model



Ideal scenario, a priori assumed signal is chosen identical to true signal

- Using scale factor (k) to analyze detectability of the EM signal [4]

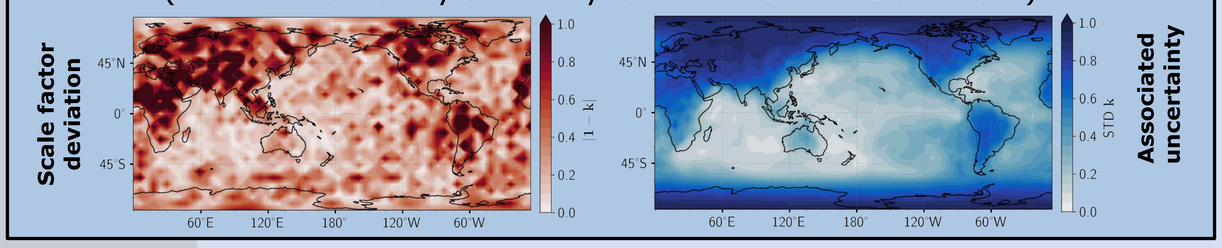
At the beginning of the assimilation



Evaluation at the end of the assimilation

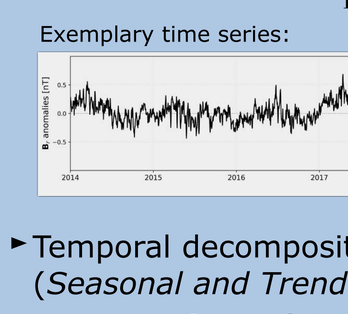
Final results

(assimilation of 7 years of synthetic Swarm observations)



Application of KREMS to Swarm satellite observations

- Final scale factor and associated uncertainty for full ocean-model-based signal and its STL decomposed parts



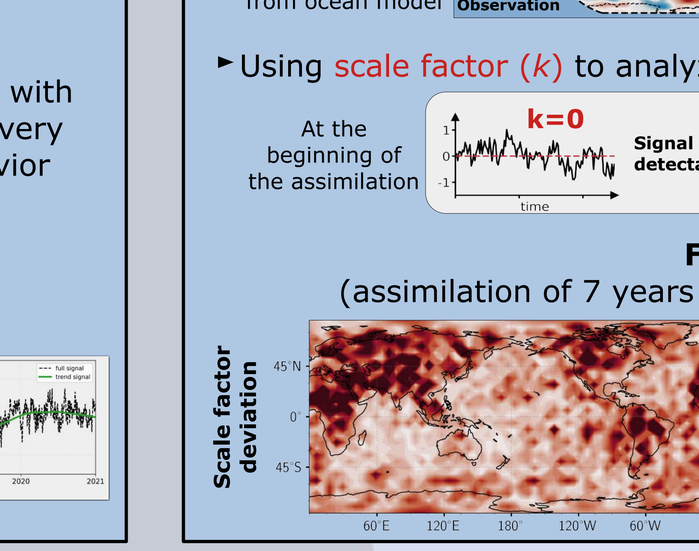
A priori assumed signal from GLORYS dataset

Temporal resolution:
Daily mean from 2014. until 2021.0

Spatial resolution:
Spherical harmonics of degree 15

Results full signal:

Results seasonal signal:



Results trend signal:

Literature

[1] Kuvshinov, A. (2008): 3-D global induction in the oceans and solid earth: recent progress in modeling magnetic and electric fields from sources of magnetospheric, ionospheric and oceanic origin. *Surv Geophys* 29(2):139–186.

[2] Cleveland, R. B. et al. (1990): STL: A Seasonal-Trend Decomposition Procedure Based on Loess. *Journal of Official Statistics,* 6(1):3-73.

[3] Bearenzung, J. et al. (2020): Kalmag: a high spatio-temporal model of the geomagnetic field. *Earth, Planets and Space* 72(1):163.

[4] Hornschild, A. (2022):On the detectability of the magnetic field induced by ocean circulation. *Earth, Planets and Space* 74(1):182.