

Ocean circulation generated magnetic signals and their application in data assimilation methods

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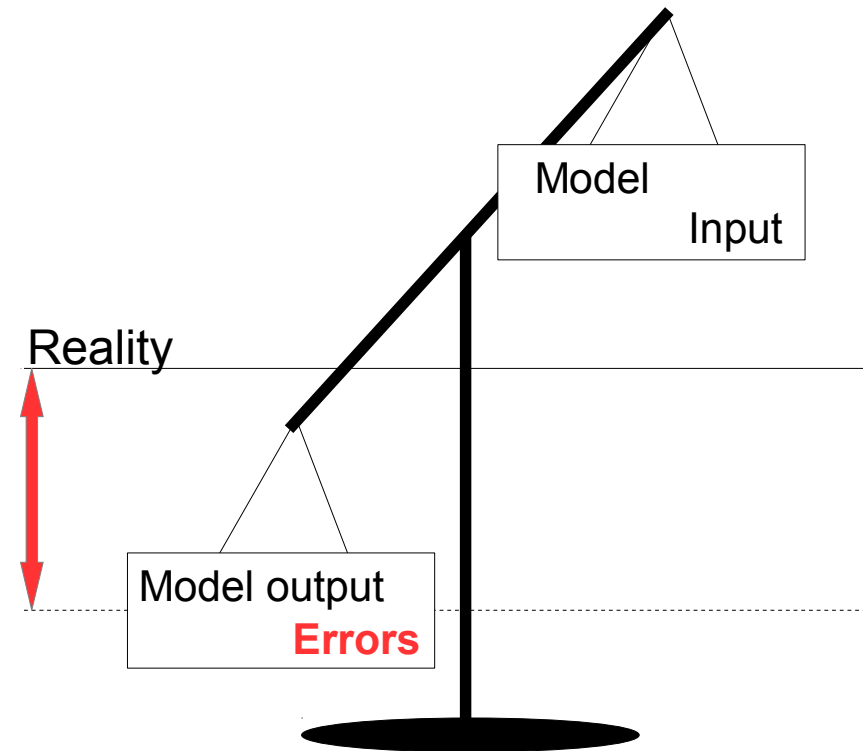
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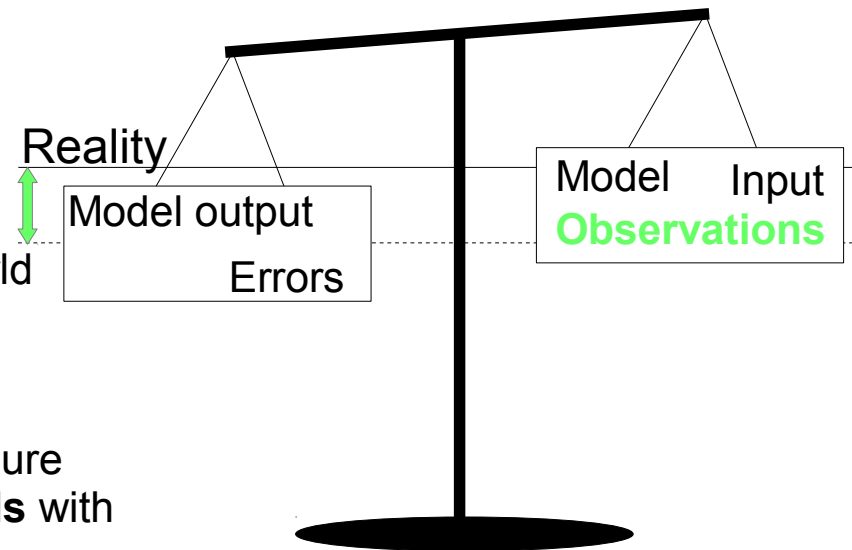
Motivation

- The ocean is a very complex system
- Dynamics on many temporal and spatial scales (periodic and non-periodic), e.g.:
 - Tides
 - Seasonal cycles
 - Global circulation
 - Tsunamis
 - Eddies
- Even a 'perfect' model does not necessarily produce realistic model results



Motivation

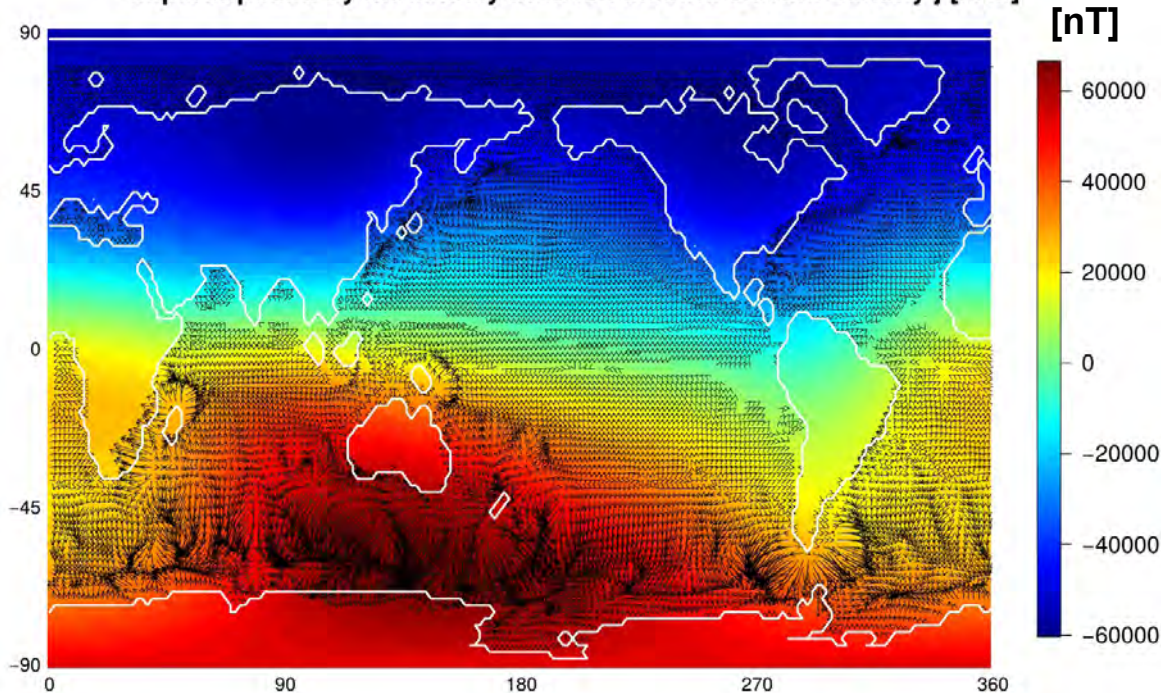
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 - Tides
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 - Eddies
- Even a 'perfect' model does not necessarily produce realistic model results
- Using **data assimilation methods** and real world data, the modelling of unknown model variables can be improved
- Modern satellites (e.g. SWARM) indirectly measure global ocean flow via **induced magnetic signals** with unprecedented precision



Motivation – Motional Induction

Slide 4

Radial component of background magnetic field [nT]
superimposed by motionally induced electric current density j [A/m]

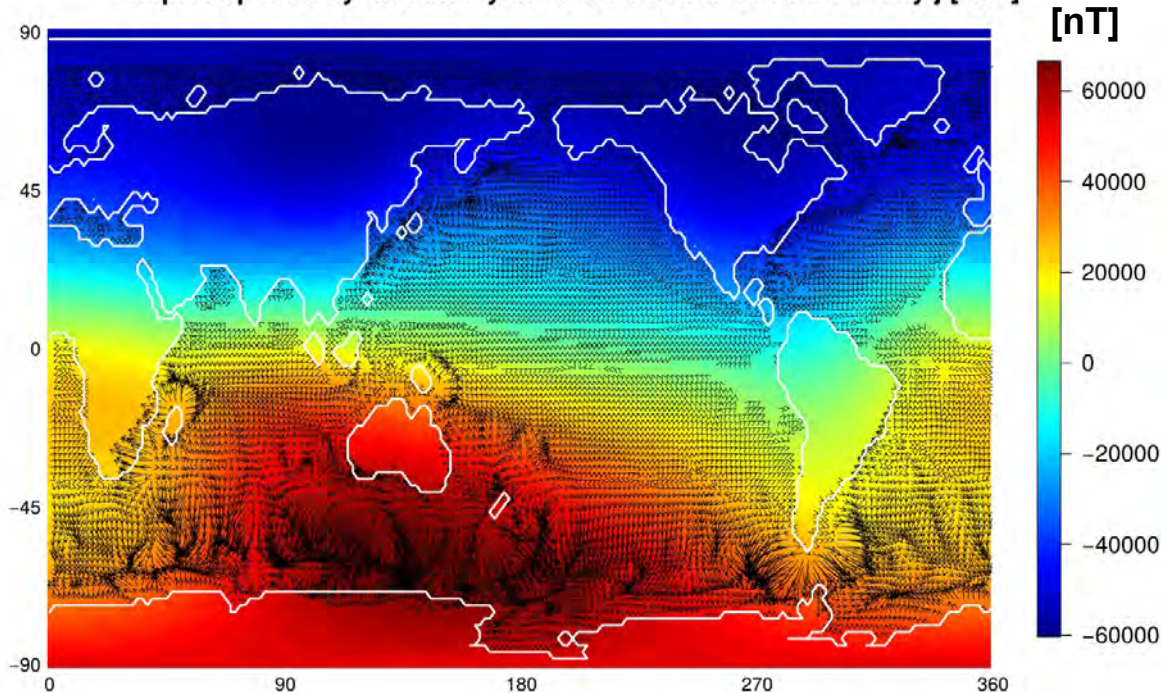


- Conducting sea water moves in the ambient geomagnetic field of the Earth
- Electrically charged ions in the salt water are deflected by the Lorentz' force
- Spatial charge accumulations lead to induction of electric and magnetic fields („*motional induction*“)

Motivation – Motional Induction

Slide 5

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- Significant contribution to the magnetic field (several nano Teslas) that can be measured by satellites (e.g. CHAMP, SWARM)
- Oceanic contributions are mostly of unknown order, precision and origin
- Motionally induced magnetic field data as additional information for modelling global ocean dynamics

Expected results and perspectives

Slide 6

- Range of oceanic magnetic signals induced by global ocean circulation (strength, location and variability)
- Uncertainty of oceanic magnetic signals (forcing, conductivity distribution, covariances)
- Robust spatio-temporal patterns and correlations, i.e., features with small errors that are insensitive to uncertain assumptions

Expected results and perspectives

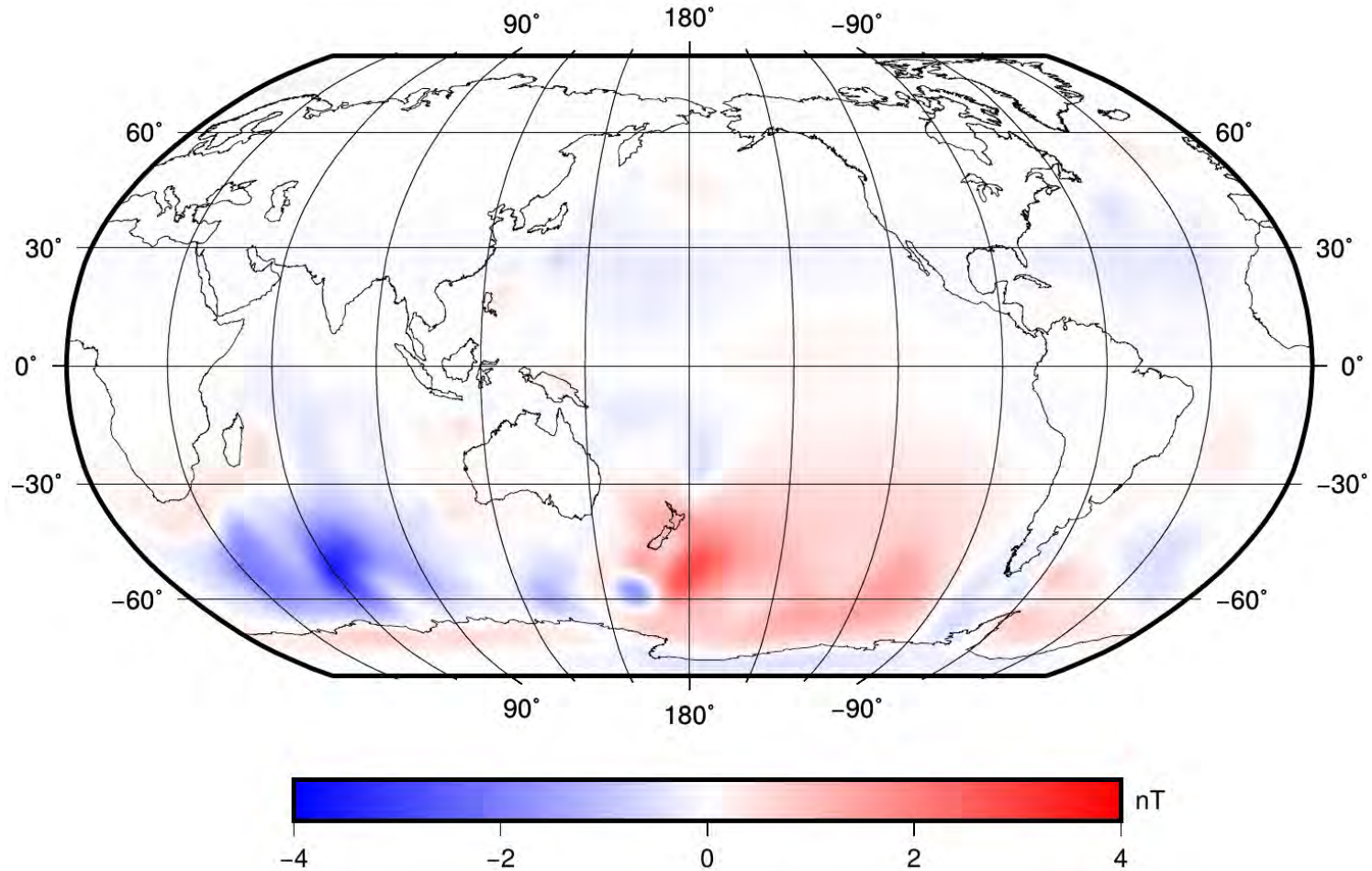
Slide 7

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Implemented the modelling of oceanic induction in the Ocean Model for Circulation and Tides (OMCT)

Motionally induced Magnetic Field

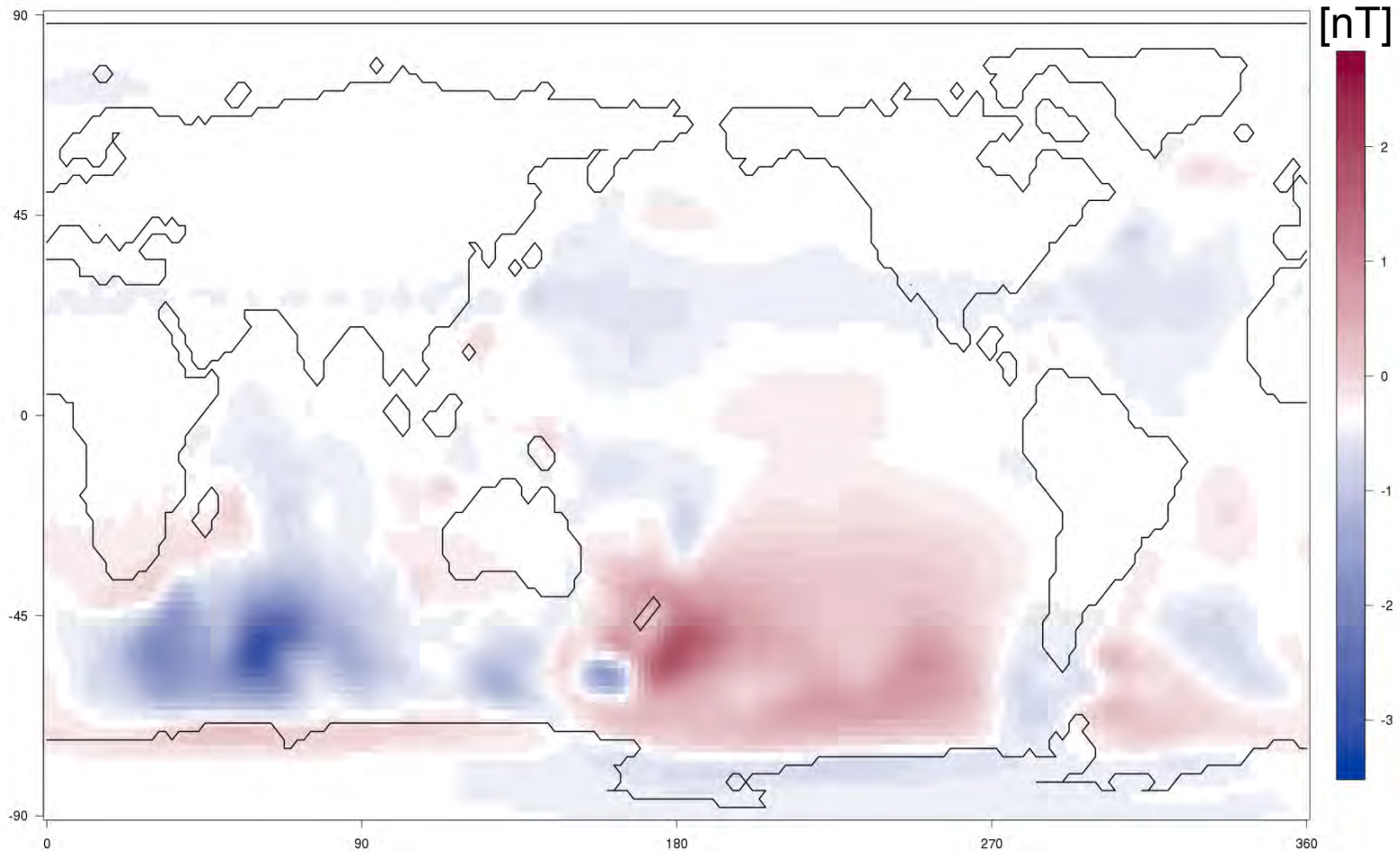
Mean values of the induced magnetic field
due to global ocean circulation at **sea level** (2001)



Motionally induced Magnetic Field

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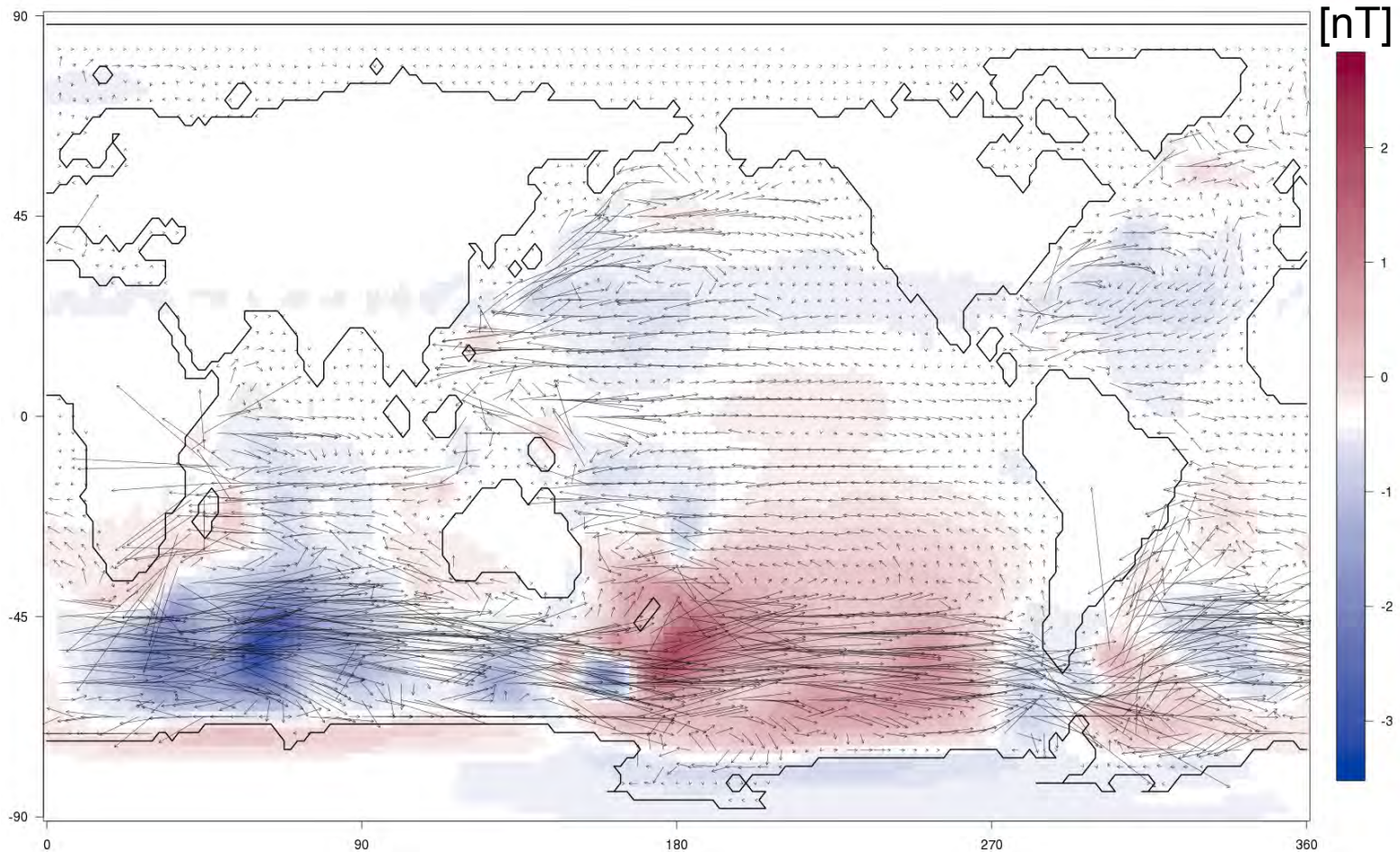
Mean induced magnetic field, superimposed by mean ocean velocities (arrows) and ambient geomagnetic field (contour)



Motionally induced Magnetic Field

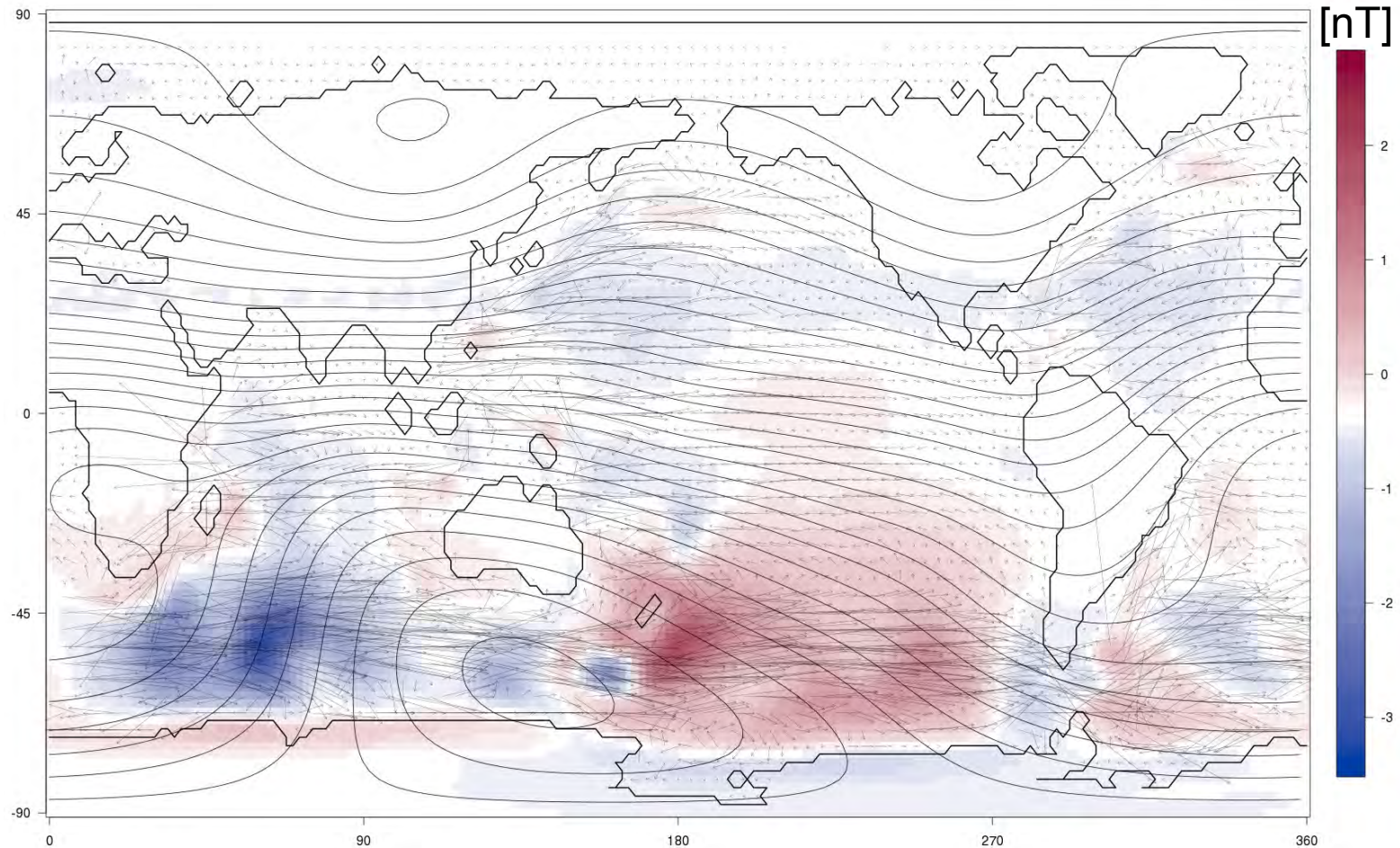
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Mean induced magnetic field, superimposed by mean ocean velocities (arrows) and ambient geomagnetic field (contour)



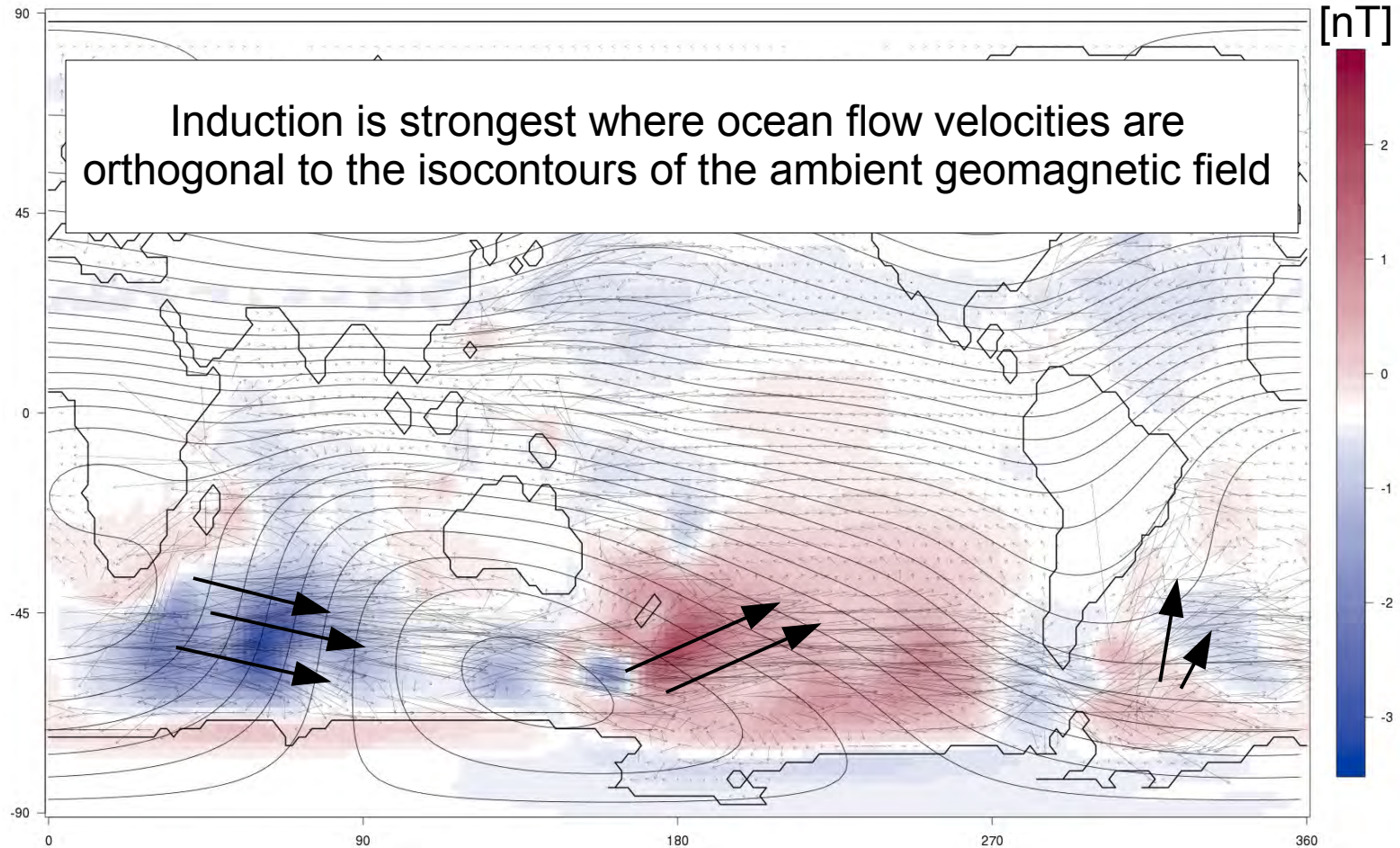
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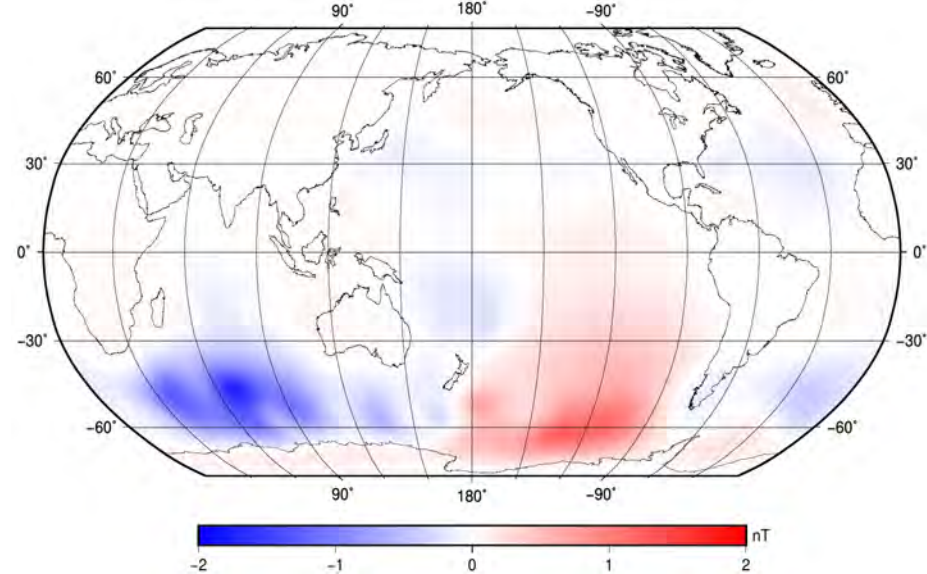
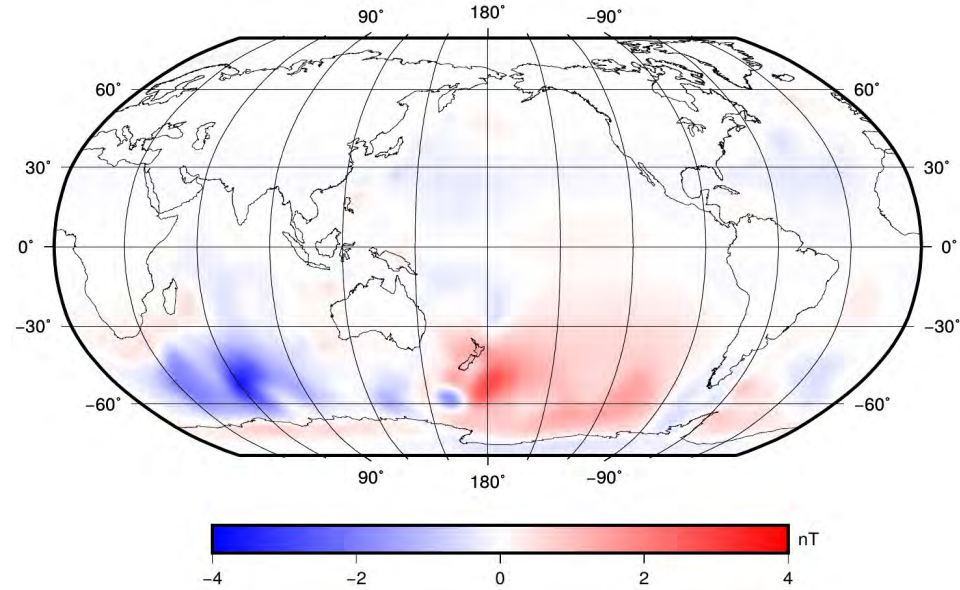


Motionally induced Magnetic Field

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Mean values of the induced magnetic field due to global ocean circulation at **sea level** (2001)

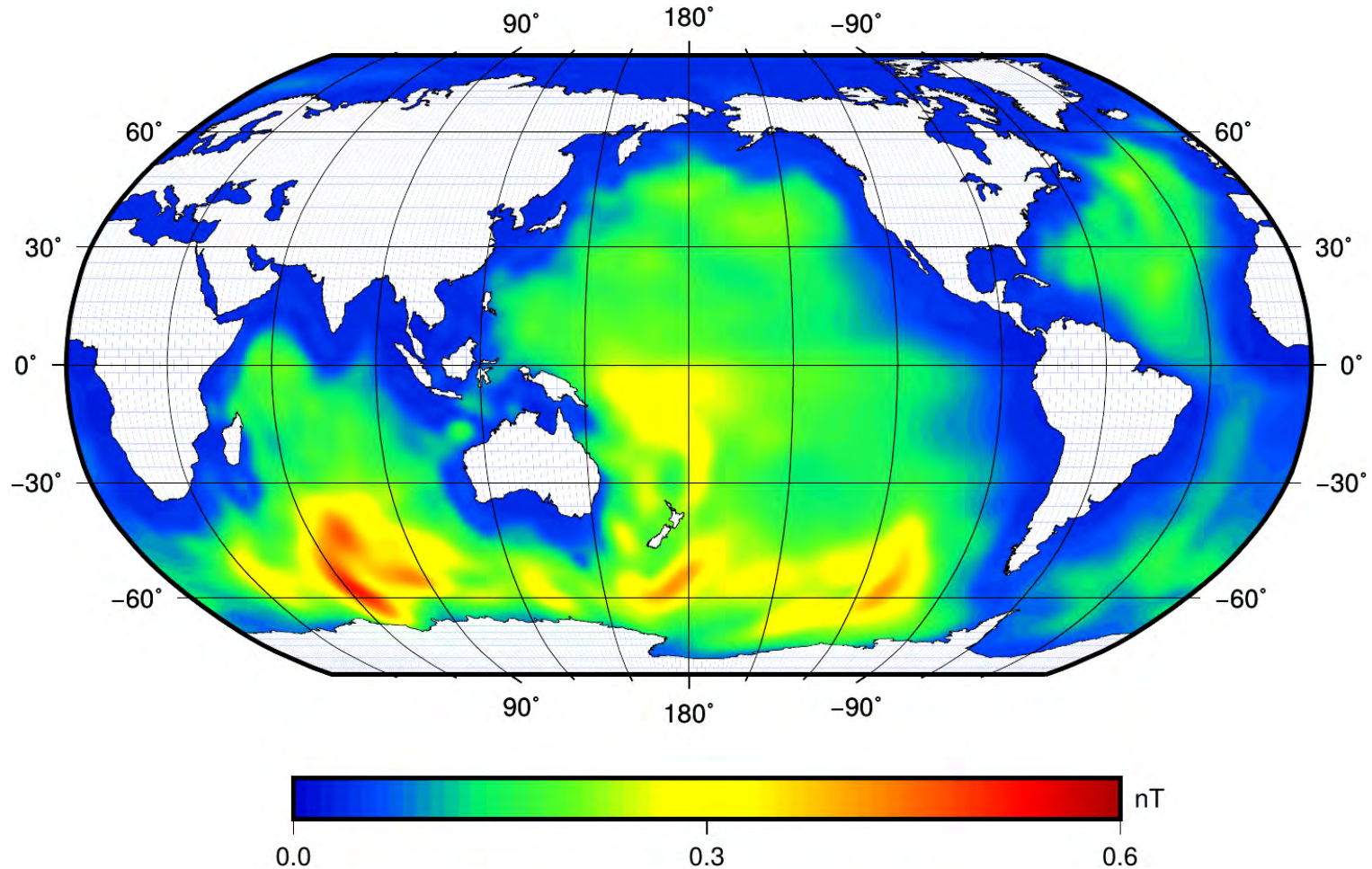
Mean values of the induced magnetic field due to global ocean circulation at **450 km satellite altitude** (2001)



- Weaker signal strength at satellite altitude due to harmonic field continuation
- Small scale patterns and details are blurred
- Large scale patterns are preserved

Motionally induced Magnetic Field

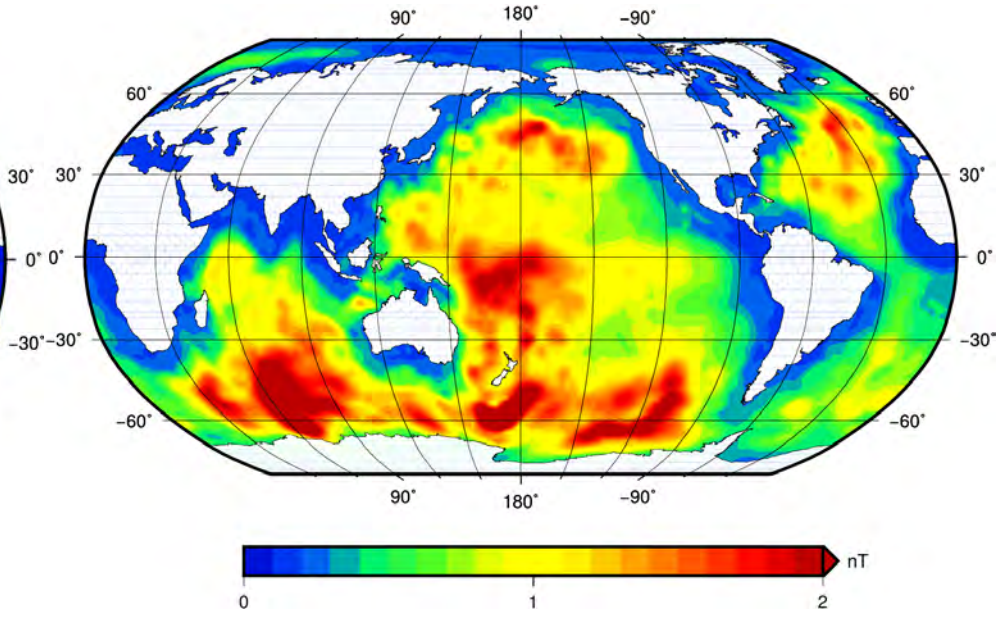
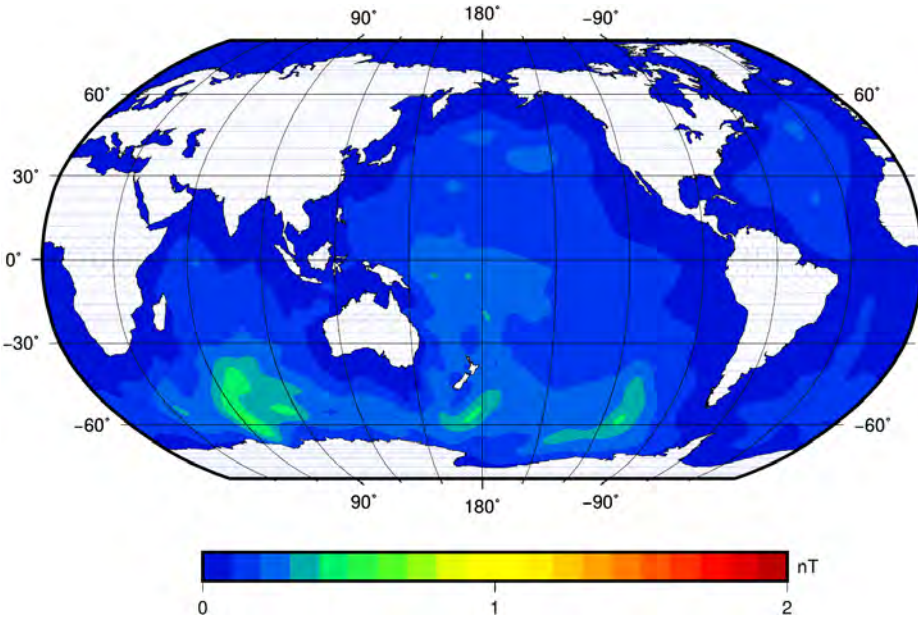
Variability (standard deviation) of the induced magnetic field due to global ocean circulation at **sea level** (2001)



Motionally induced Magnetic Field

Variability (standard deviation) of the induced magnetic field due to global ocean circulation at **sea level** (2001)

Variability (peak to peak) of the induced magnetic field due to global ocean circulation at **sea level** (2001)



	Signal range	Standard Deviation	Peak to Peak
Sea level	-6 to 4 nT	≤ 0.6 nT	≤ 4 nT
Satellite altitude (450 km)	-2 to 2 nT	≤ 0.2 nT	≤ 1.5 nT

Expected results and perspectives

Slide 16

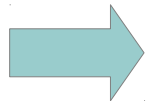
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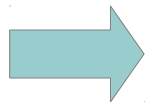
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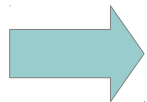
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Combine found ocean dominated patterns with derived error information



Identify separable ocean signals in observation data provided by satellite measurements



Long term goal: inversion/assimilation of observation to improve global ocean modelling and simulations

Thank you for your attention!