Precise model of the core magnetic field over the satellite era

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IPGP, Geomagnetism

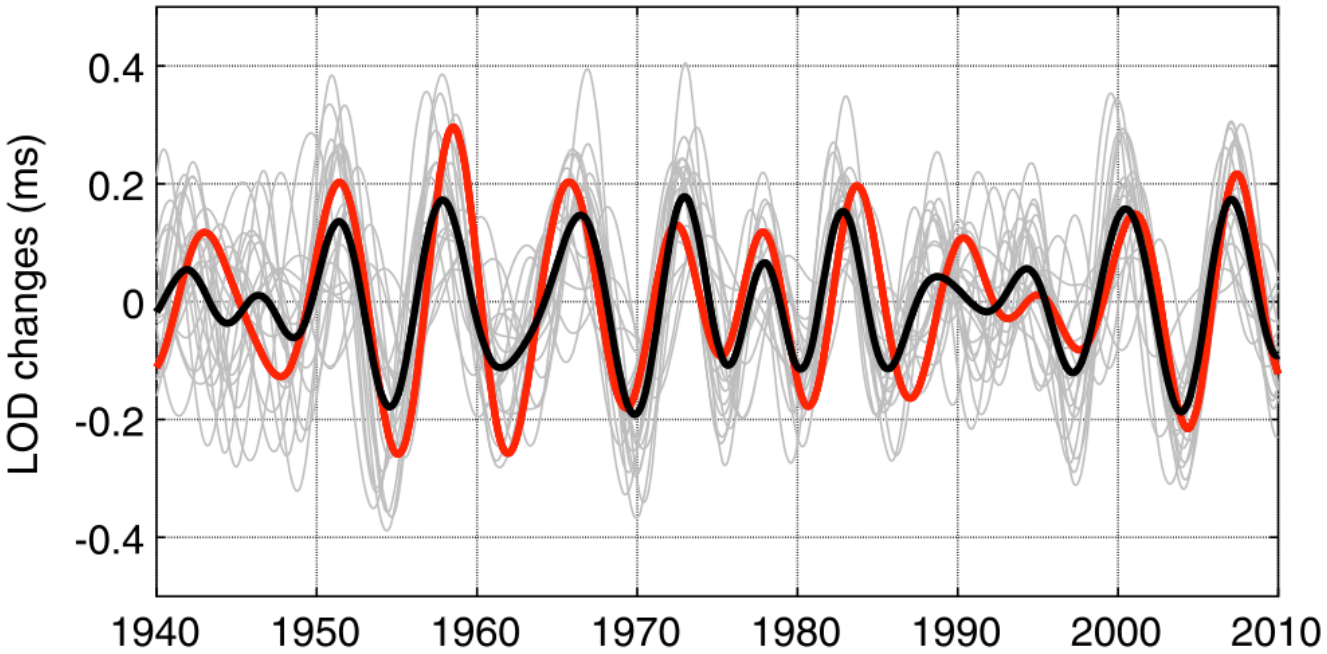
Introduction

- **Motivation**
  - Fast core dynamics
  - Magnetic field inversion and core flow calculations
- **Modelling the core field**: **State of the art**
  - Resolving the field
  - Observatory data
  - Satellite data
- **Future work**

Motivation

Getting to the fast core dynamics → **Torsional waves ?**

- First highlighting of TW in the data (Gillet et al. 2015)

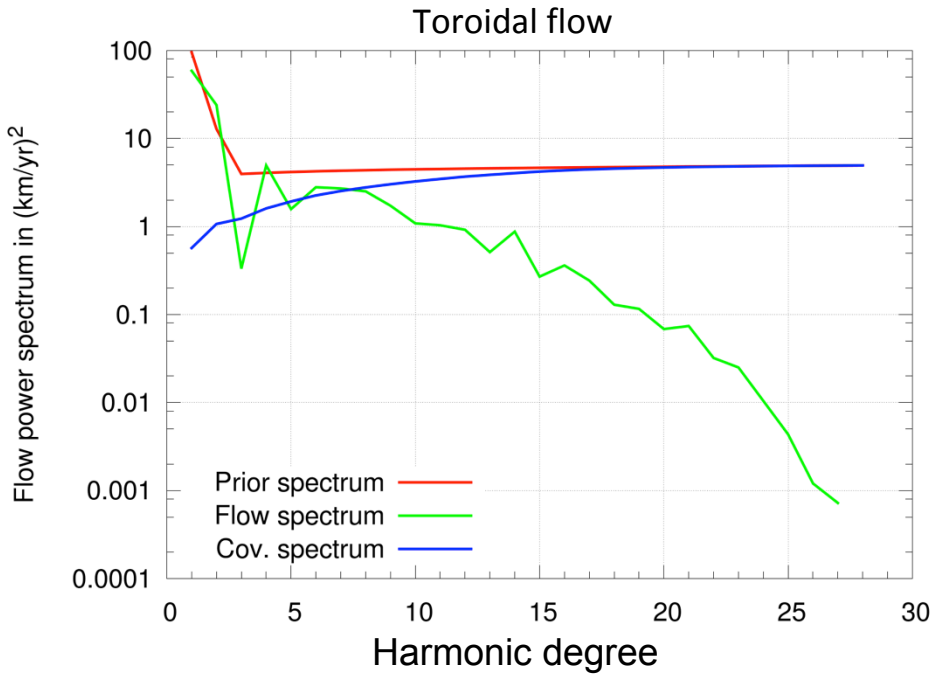


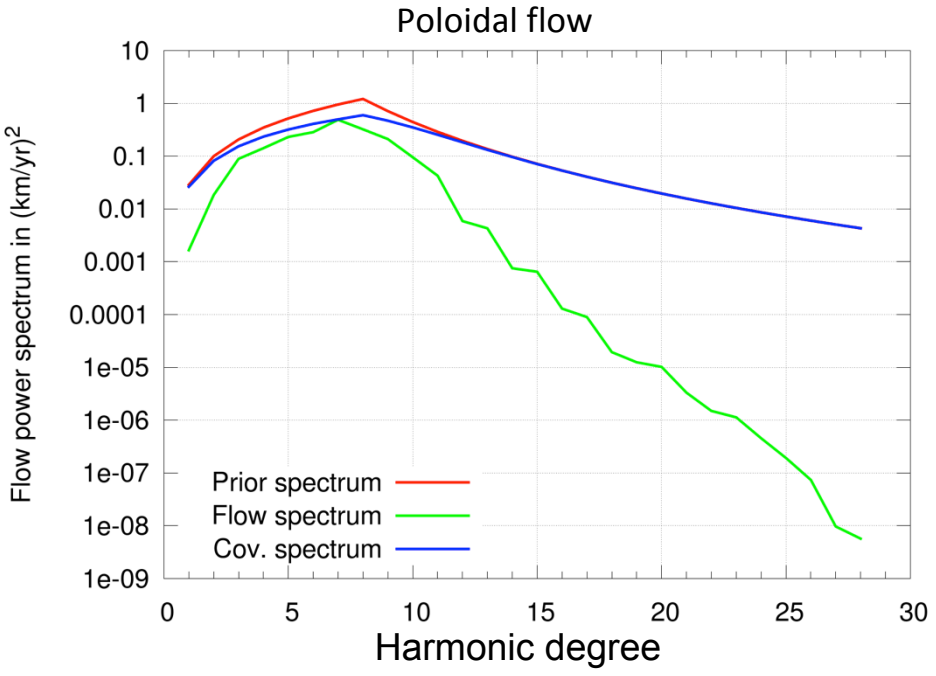
(MF model : COV-OBS)

Motivation

Getting to the fast core dynamics → **Torsional waves ?**

- Surface core flow inverted from the C^{3}FM model (Wardinski & Lesur, 2012)

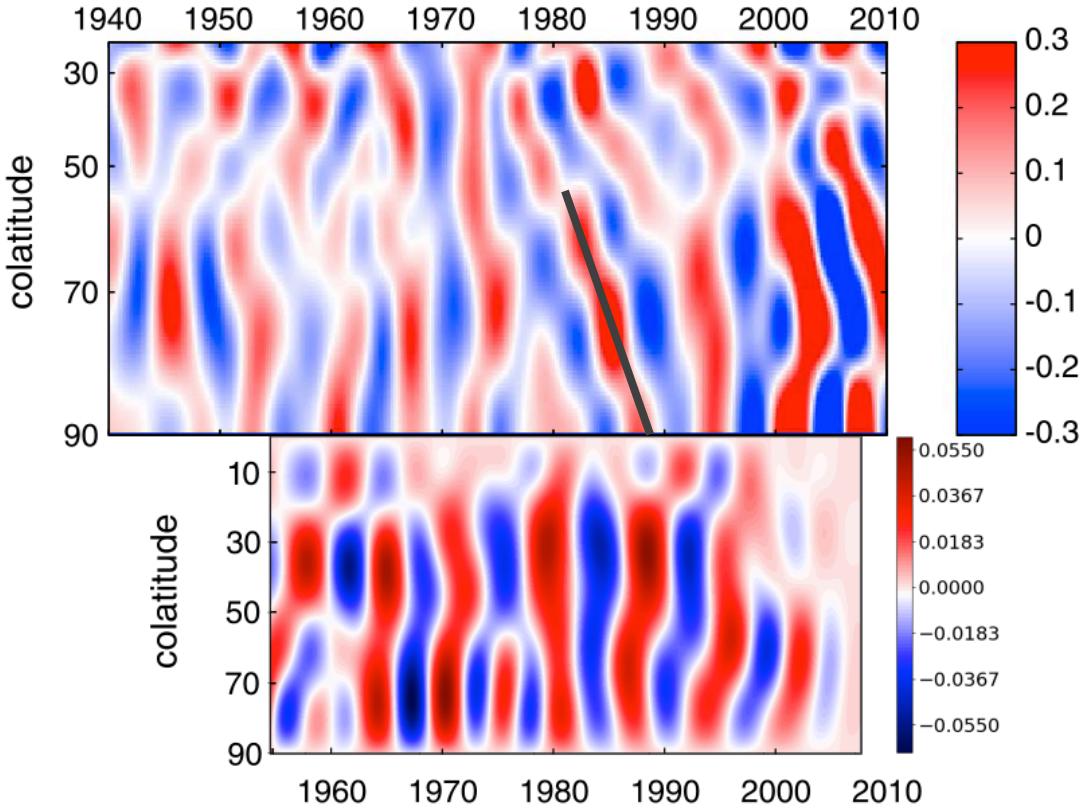




Motivation

Getting to the fast core dynamics → **Torsional waves ?**

Filtered mean geostrophic flow

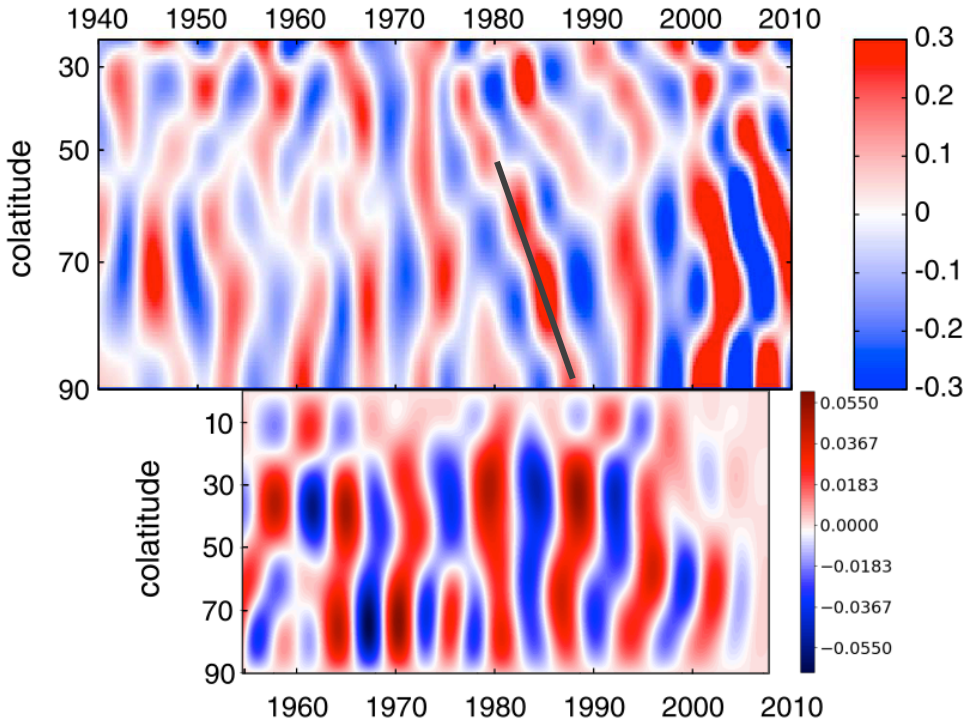


Gillet et al. (2015)
(1940-2010)

G. Ropp (2018)
(1957-2008)

Motivation

Getting to the fast core dynamics → **Torsional waves ?**



- Very little to no signal for TW in our flow model
- Can TW be reached through inversion of magnetic data ?
- How to access these (and other) fast dynamic features of the core flow ?

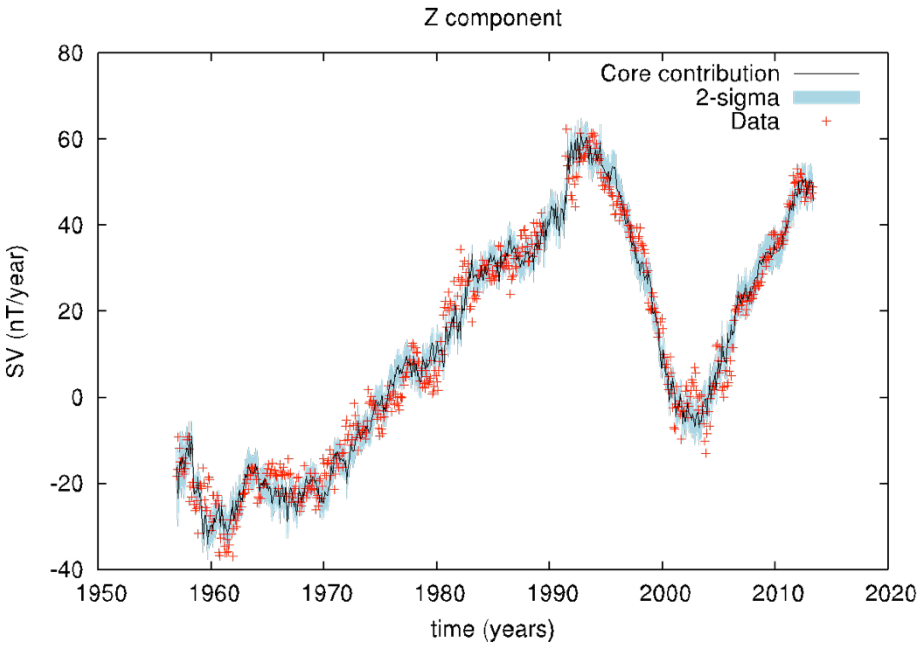
→ Build reliable core field models

State of the art

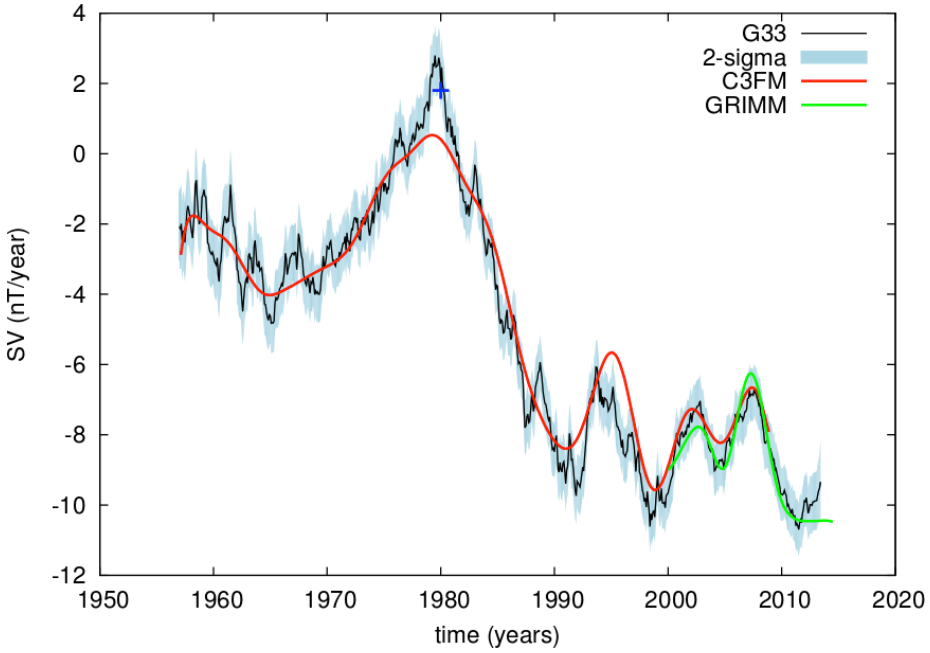
→ Need for reliable core field models at small time scales

- **Describe precisely** the external fields in space and time
  → Complex parameterisation
- **Models** needs to cover several decades to study core dynamics **(TW → T ≈ 6 yr)**, but limited computer capabilities impose to work **sequentially**
  → Limited amount of data
- Introduce realistic **prior information** on the field's spatial and temporal variations
  → Correlation based modelling & Kalman filters

Application to observatory data



Estimated vertical down component of the core magnetic field SV at KAK observatory (Lesur et al. 2017)



Gauss coefficient g_3^3 (Lesur et al. 2017)

Application to satellite data

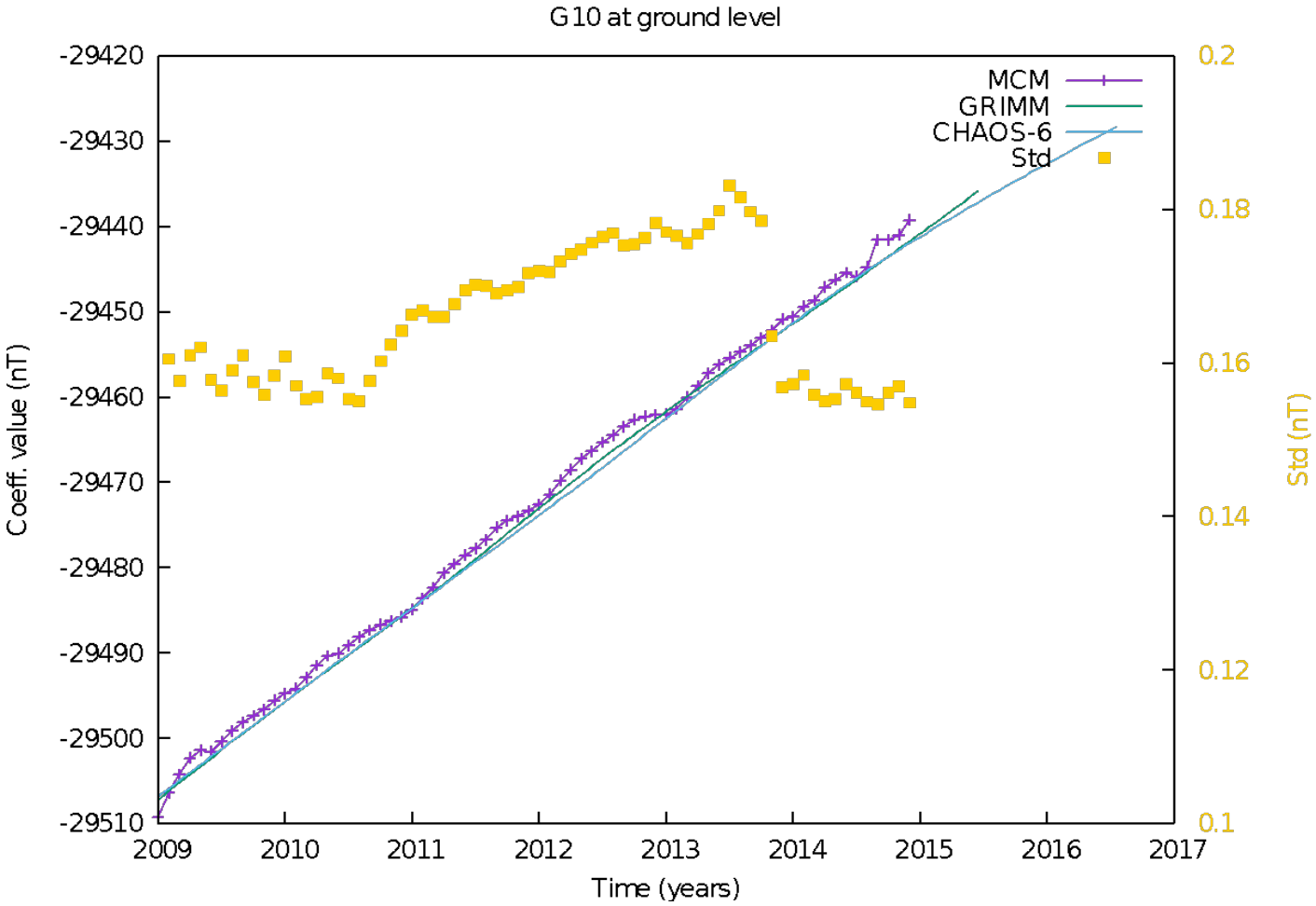
- Data set covers the end of CHAMP satellite and the current SWARM satellite

- Sequence of monthly models

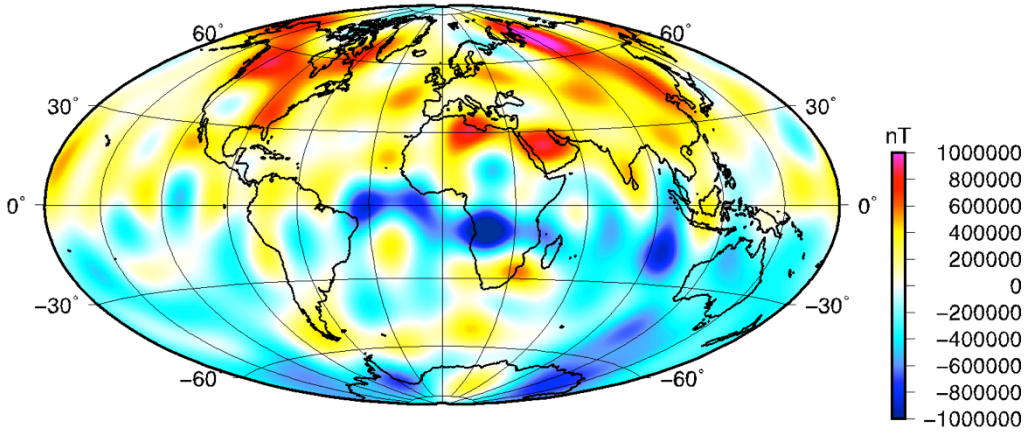
- Within a month are modelled:
  - Static core field (SH degree 1 to 18)
  - SV core field (SH degree 1 to 18) + SA
  - Lithospheric field (SH degree 1 to 30 -- known field subtracted from data for SH 30 to 120)
  - Static external field in GSM coordinate system (SH degree 3)
  - Static external field in SM coordinate system (SH degree 3)
  - Dst dependent fields in SM coordinate systems (SH degree 3)
  - IMFBy dependent field in SM coordinate systems (SH degree 3)
  - Observatory offsets (3X165 observatories)
  - The core flow velocity and acceleration
  - Ionosphere, field aligned currents and tide signals

Model MCM-09-15

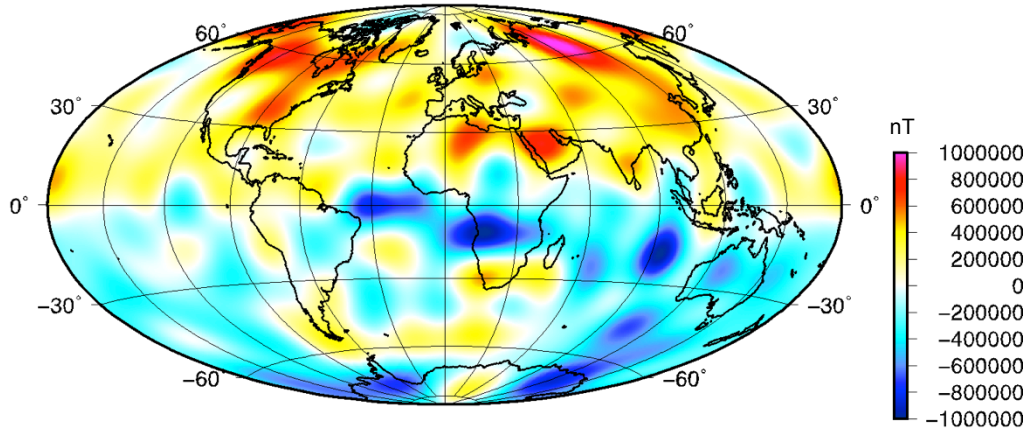
Gauss coefficient g_1^0



Model MCM-09-15

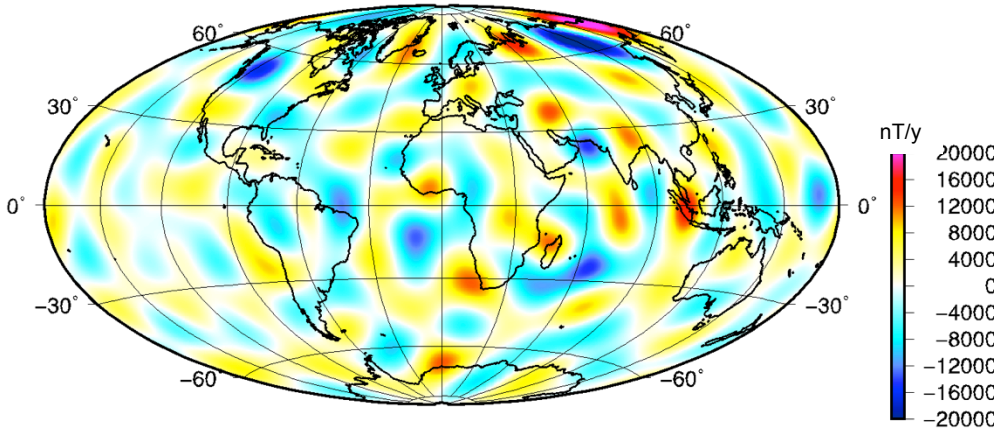


Core SH 1-14
Model 2015.0

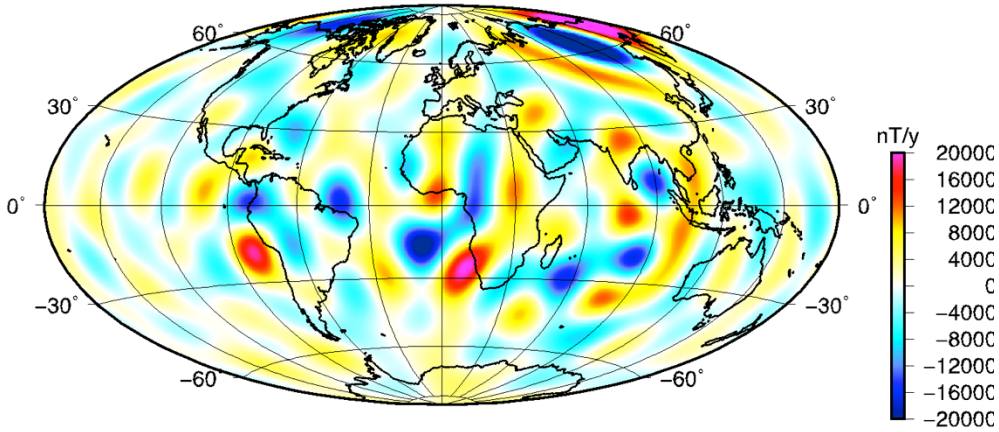


Core CHAOS-6
Model 2015.0

Model MCM-09-15



SV SH 1-14
Model 2015.0



SV CHAOS-6
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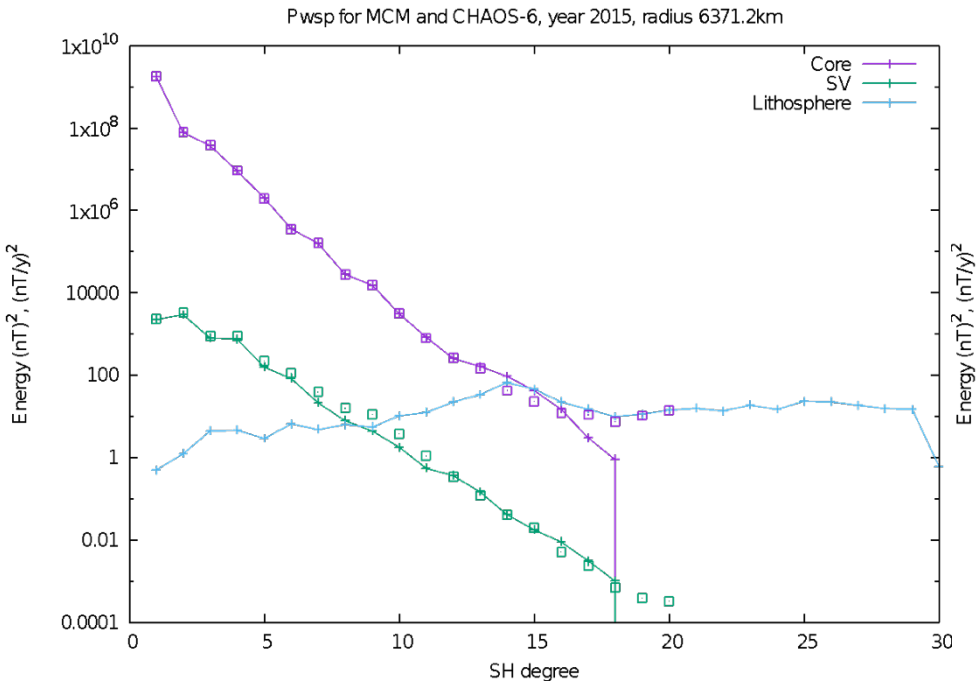
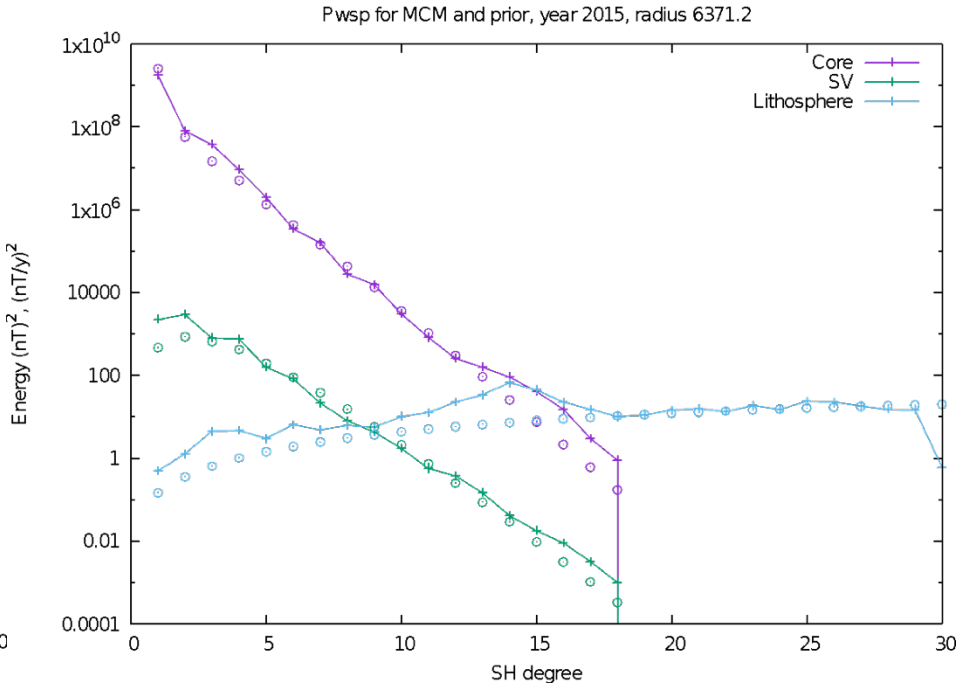
Model MCM-09-15





➔ Fit with CHAOS-6 model

➔ Bad fit with the prior spectrum

Future work

- 1st objective : IGRF candidate model 2019
- Introduction of a Kalman smoother for the time evolution of the model
- Modeling of the SV, SA (access to core dynamics) and the flow
- Numerical dynamo outputs as prior for the flow inversion

→ Access to the fast dynamics of the core flow

Thank you for your attention