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Recovering the crustal and unmodelled external contributions to the geomagnetic field of the European area

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Outline

- Intoduction
- Biases (example Niemegk)
- Recovery of crustal contribution
- Recovery of external contributions
- Analysing the external contribution
- Conclusions

Introduction

- "Crustal bias" (Mandea et al, 2002) in an observatory is estimated by comparing the magnetic components measured in the observatory with those predicted by a geomagnetic model truncated to its nuclear part
- The degree of spherical harmonics where the truncation occurs is based on the magnetic field energy spectrum generated by the model
- The models used to study crustal biases are based on satellite data
- We chose european observatories because there is a more dense network than elsewhere

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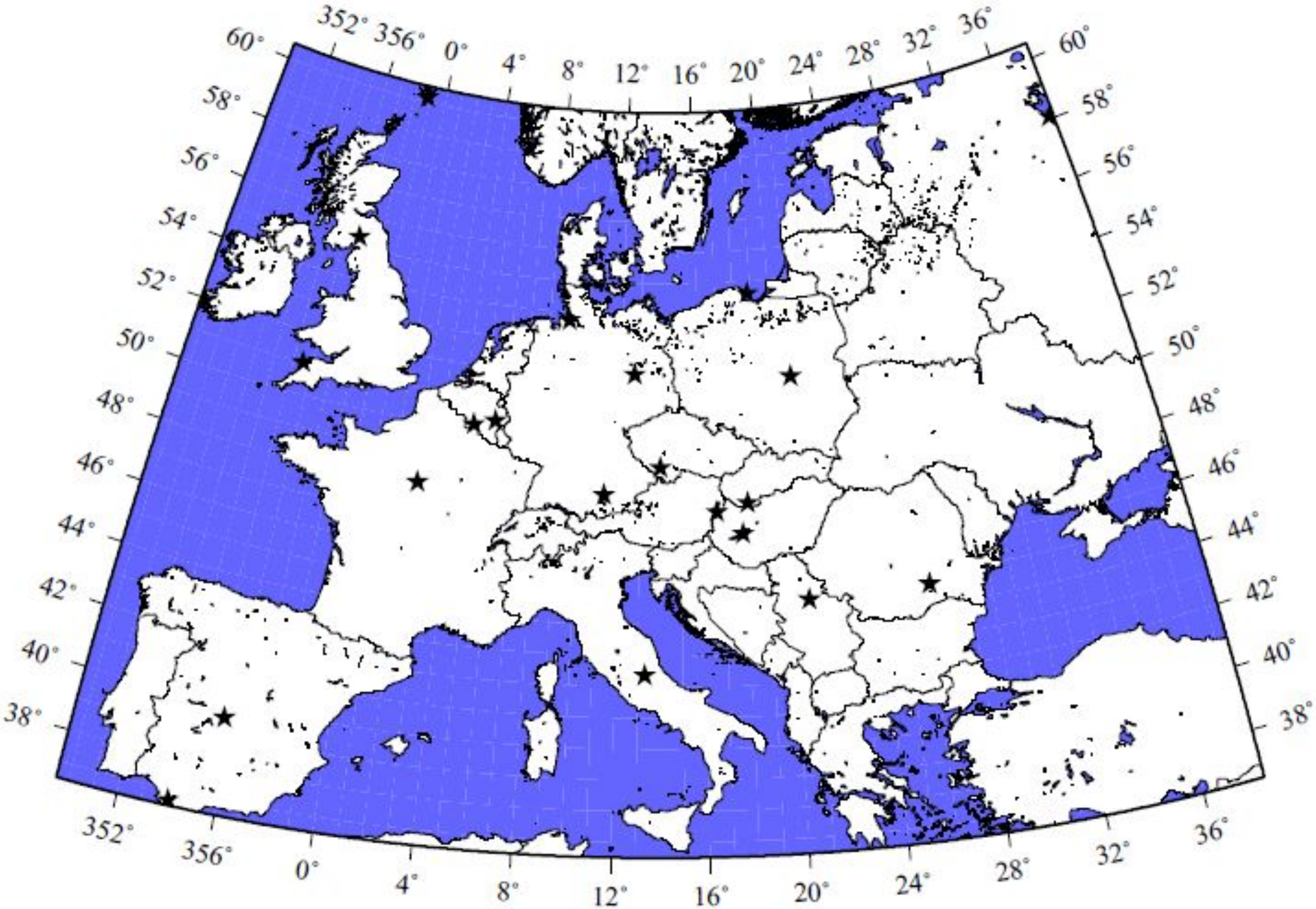
Locations of considered Observatories



Introduction: Models

- In our study we use 3 models:
  - EMM (Enhanced Magnetic Model 2015) whith maximum degree of spherical harmonics 720. Is based mainly on satellite including the European Space Agency's SWARM satellite mission data (https://www.ngdc.noaa.gov/geomag/EMM/EMMSurveySPH.shtml)
  - POMME-9 (POtsdam Magnetic Model of the Earth) whith maximum degree of spherical harmonics 133 is based on data from CHAMP, Ørsted and SWARM satellite missions (Maus et al., 2004)

    (https://geomag.colorado.edu/pomme-9-magnetic-model-of-the-earth.html)
  - CM5 (Comprehensive Model 5) whith maximum degree of spherical harmonics 100 (we use this version) is based mostly on the data from CHAMP, Ørsted and SAC-C satellite missions (Sabaka et al., 2015)

Introduction: Procedure

- Take for each observatory the data files that contain minute-measurements from 2000 - 2015
- Calculate the monthly means that are reduced to the middle of the corresponding month (e.g. monthly mean of April reduced to 15th April etc.)
- Calculate for the same day the field using a given model
- Calculate the difference between time series
- Average the time series of residuals obtained

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- Calculate the difference between time series
- Average the time series of residuals obtained: crustal bias is obtained

Biases (example Niemegk)

- For every observatory (and for each component) are calculated the mean biases and corresponding standard deviations
- For Niemegk in nT (Lat. 52.072, Long. 12.675, Alt. 78 m)

	<X>	SDx	<Y>	SDy	<Z>	SDz
EMM	-24.53	8.98	-1.95	2.55	-7.17	7.53
POMME	1.53	9.02	4.88	4.16	-56.12	8.25
CM5	324.53	9.16	37.48	2.40	-109.42	7.60

- CM5 model has larger biases

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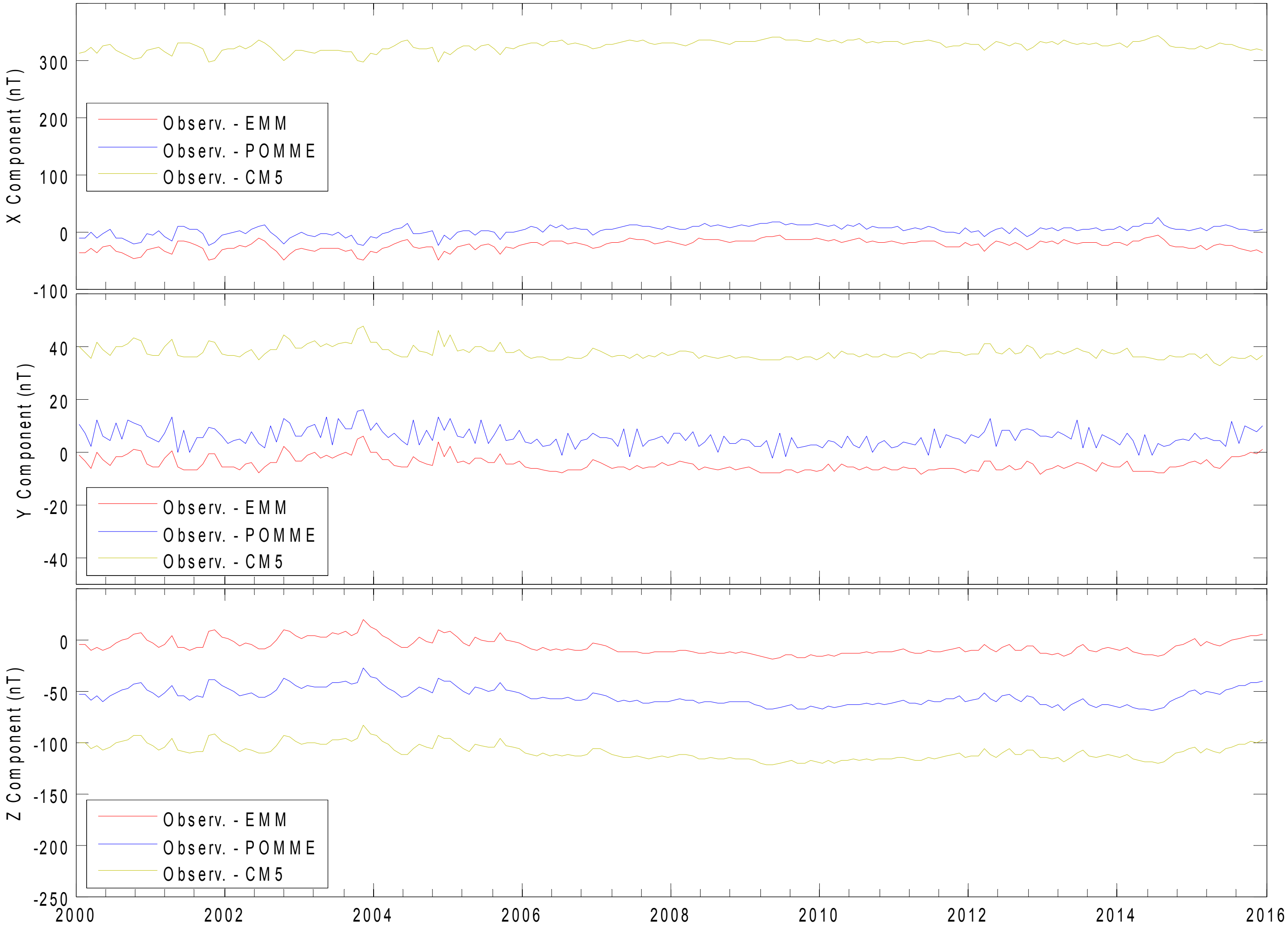
Biases Niemegk (NGK)



Crustal contribution (CM5)

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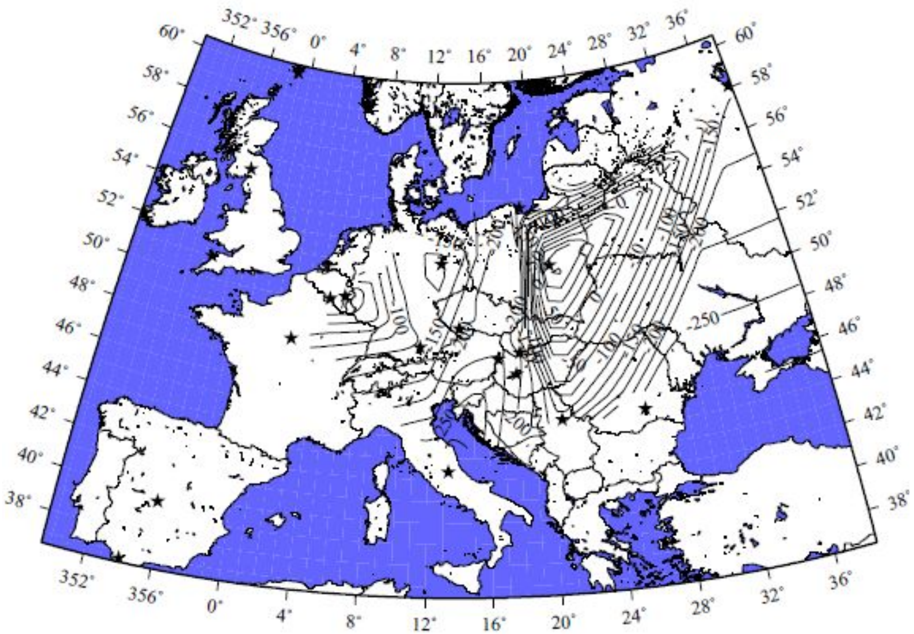
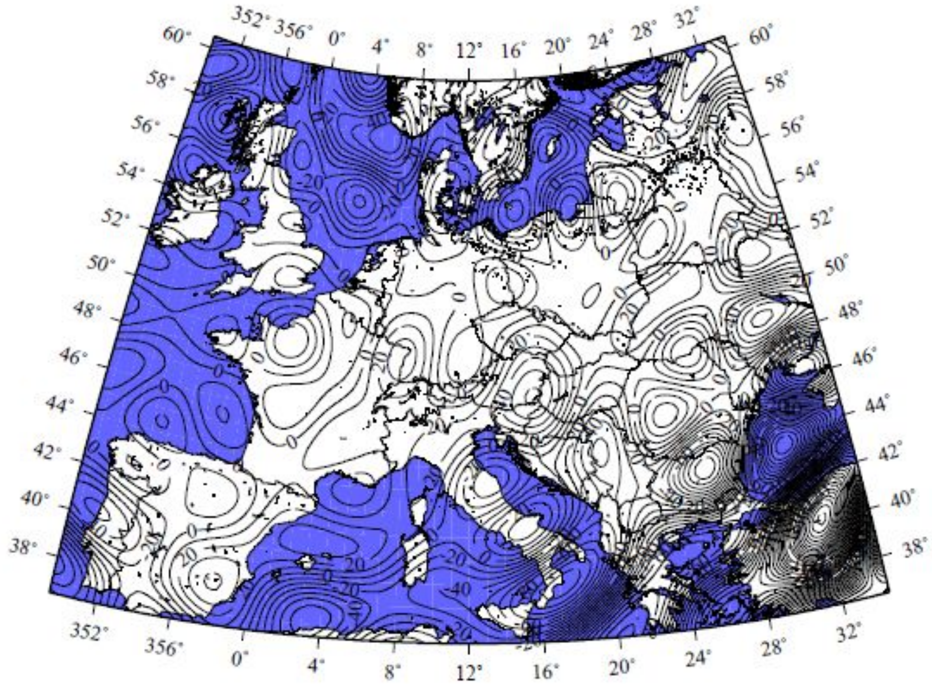
Z-component averaged differences with CM5 model

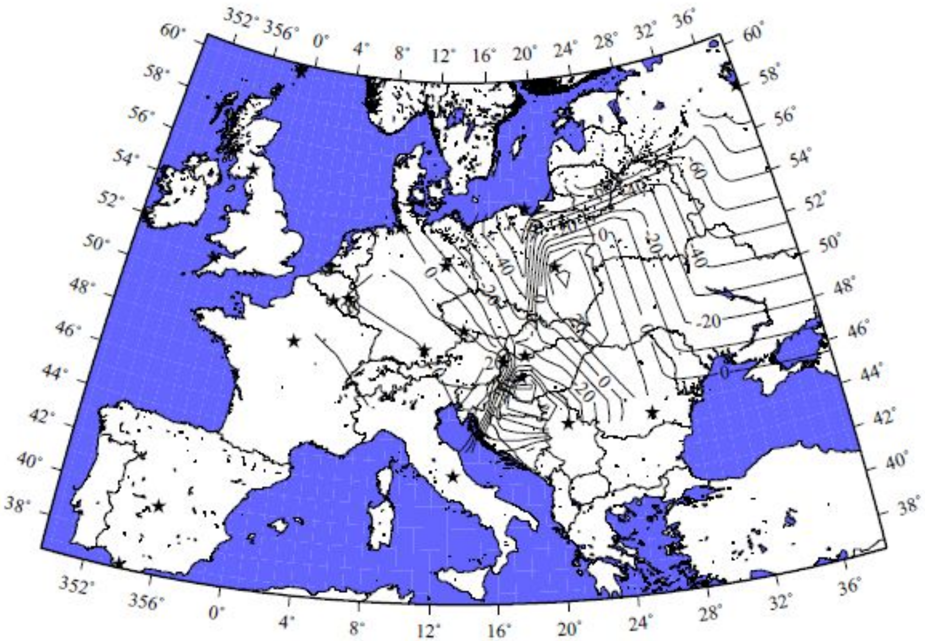


Z-component Crust Field by CM5 model

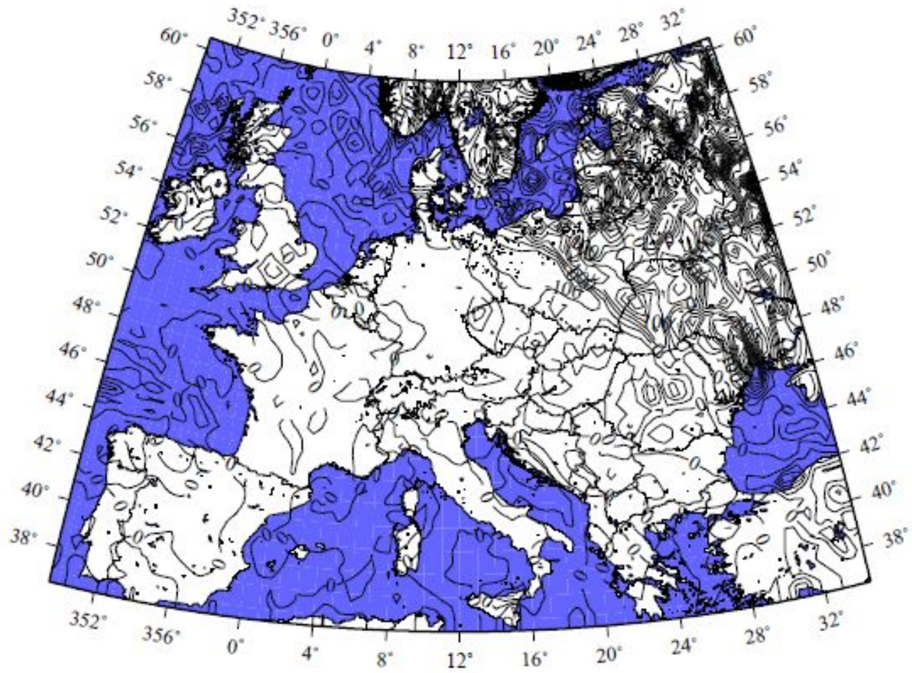


Crustal contribution (EMM)

Z-component averaged differences with EMM model

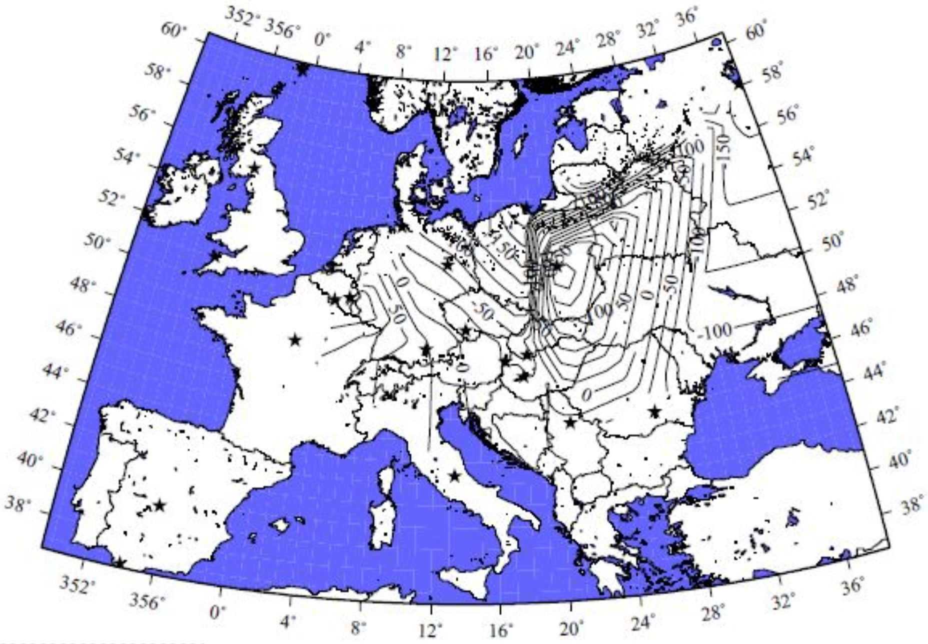


Z-component Crust Field by NGDC model

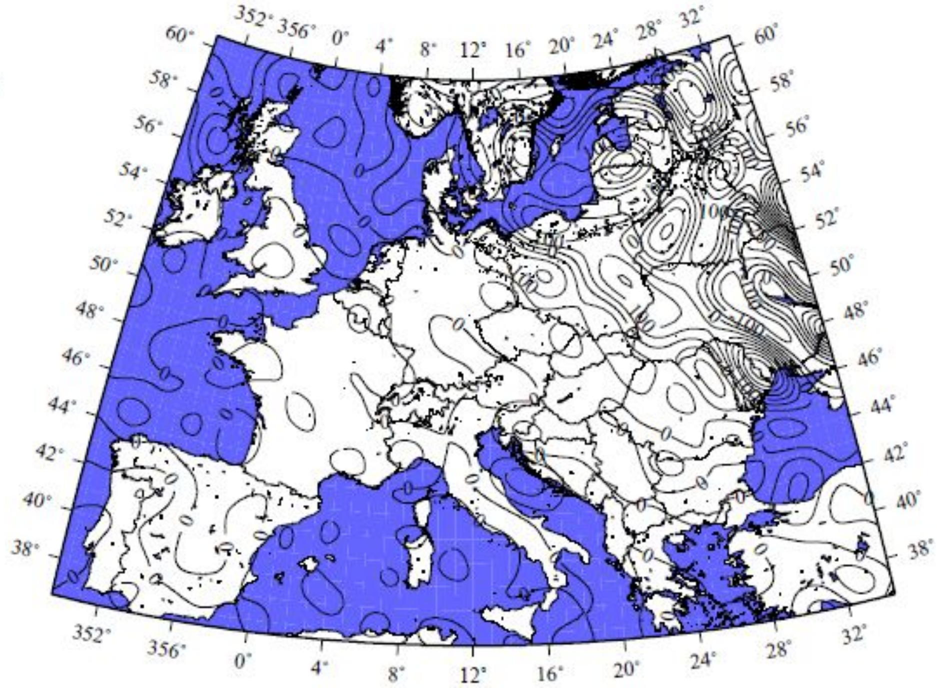


Crustal contribution (POMME-9)

Z-component averaged diffrences with POMME model



Z-component Crust Field by POMME9 model



Recovery of external contribution

$$\Delta x_i^{\mathrm{mod}(k)} = x_i^{obs} - x_i^{mod(k)}(\mathrm{int}) = x_i^{obs}(\mathrm{int}) + x_i^{obs}(ext) - x_i^{mod(k)}(\mathrm{int})$$

$$average(k) = \frac{1}{N}\sum_i x_i^{obs}(\mathrm{int}) + \frac{1}{N}\sum_i x_i^{obs}(ext) - \frac{1}{N}\sum_i x_i^{mod(k)}(\mathrm{int}) = \overline{x}^{non\,\mathrm{mod}(k)}(\mathrm{int}) + \overline{x}^{obs}(ext)$$

$$\Delta' x_i^{\mathrm{mod}(k)} = \Delta x_i^{\mathrm{mod}(k)} - average(k) = x_i^{obs}(\mathrm{int}) + x_i^{obs}(ext) - x_i^{\mathrm{mod}(k)}(\mathrm{int}) - \overline{x}^{non\,\mathrm{mod}(k)}(\mathrm{int}) - \overline{x}^{obs}(ext)$$

$$x_i^{obs}(\mathrm{int}) \cong x_i^{\mathrm{mod}(k)}(\mathrm{int}) + \overline{x}^{non\,\mathrm{mod}(k)}(\mathrm{int})$$

$$\Delta' x_i^{\mathrm{mod}(k)} = x_i^{obs}(ext) - \overline{x}^{obs}(ext)$$

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External contribution to an observatory that is independent of a certain model

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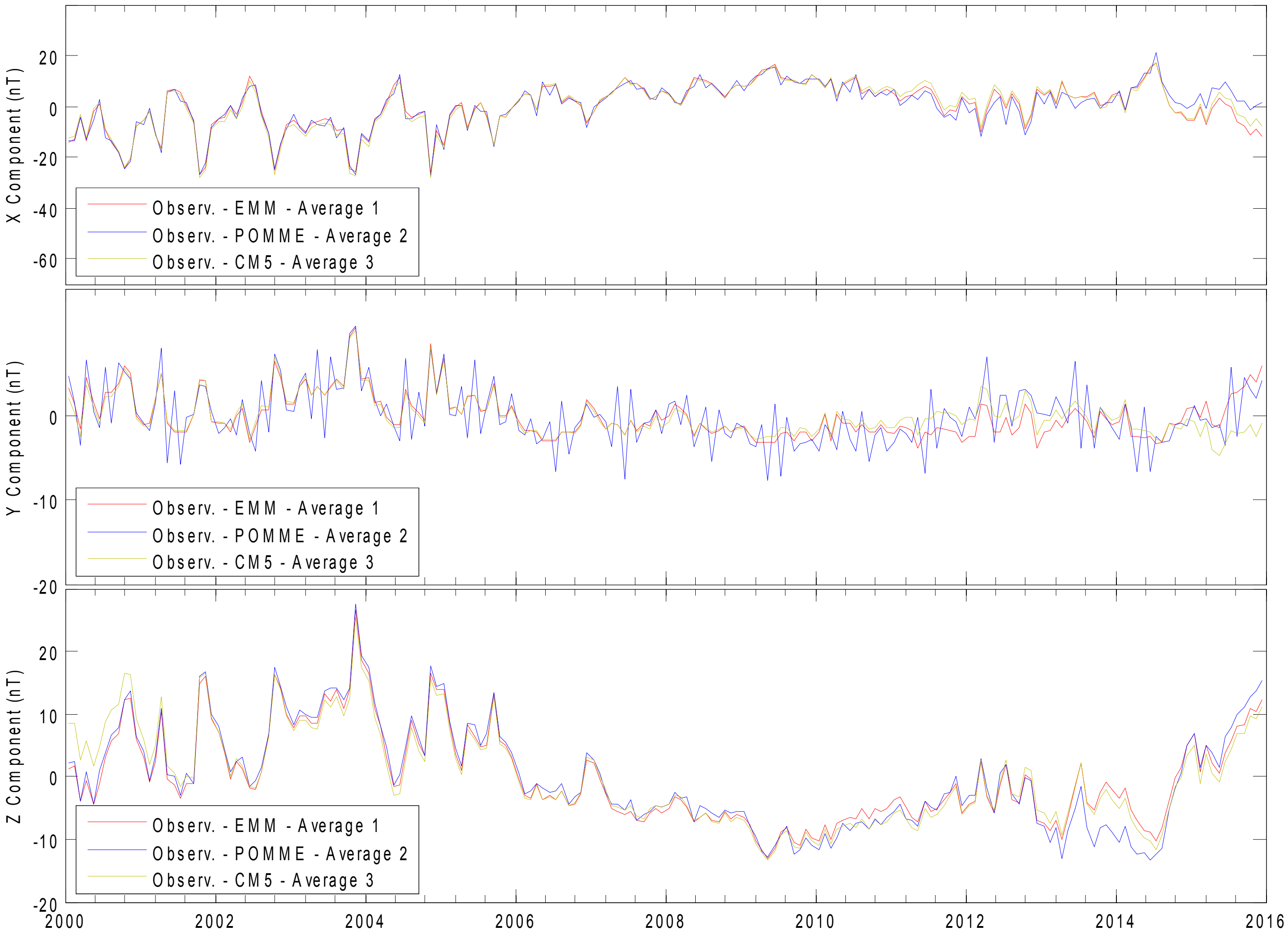
External contribution Niemegk (NGK)



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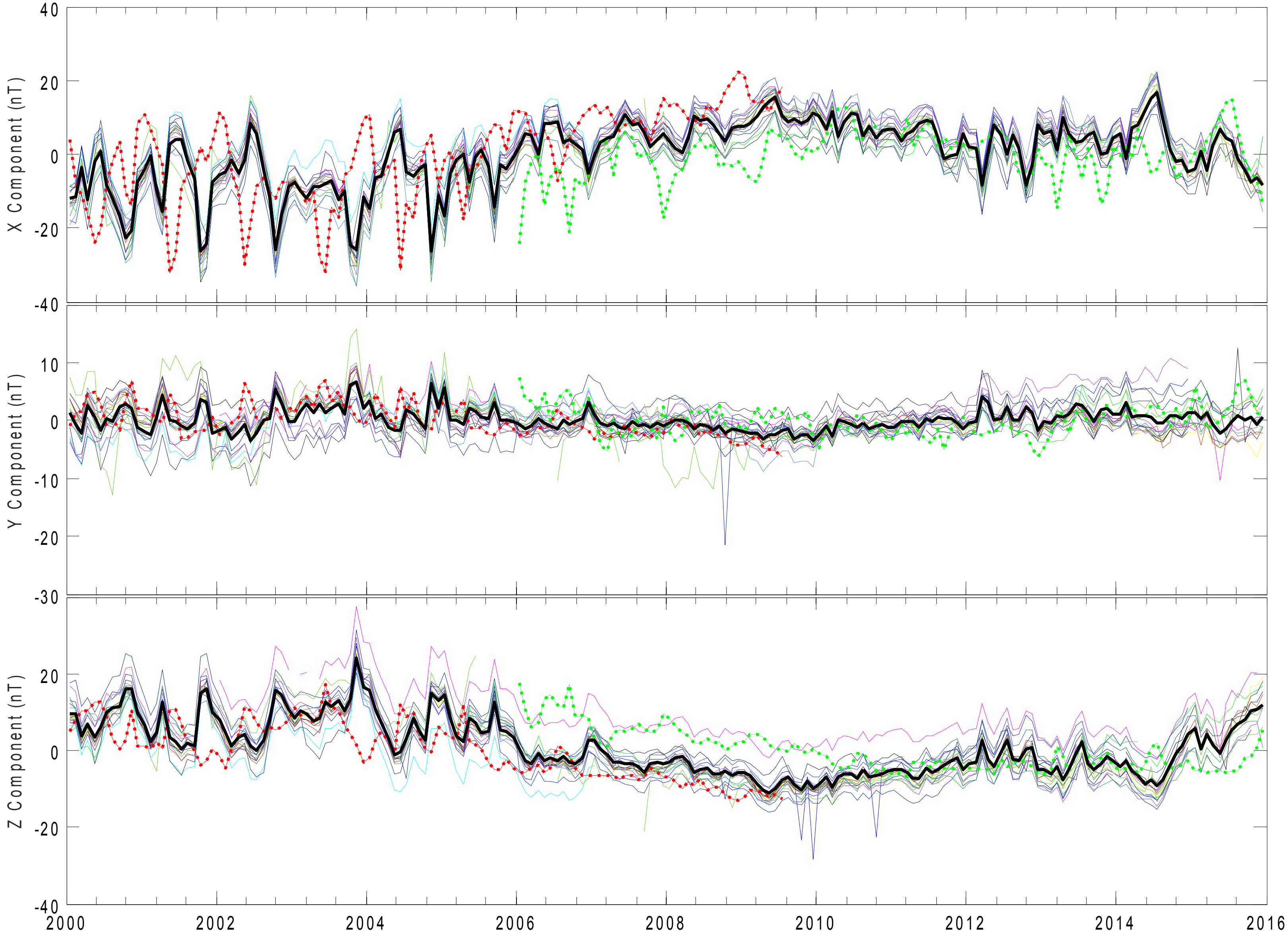
Analysing non-modeld contributions (CM5)



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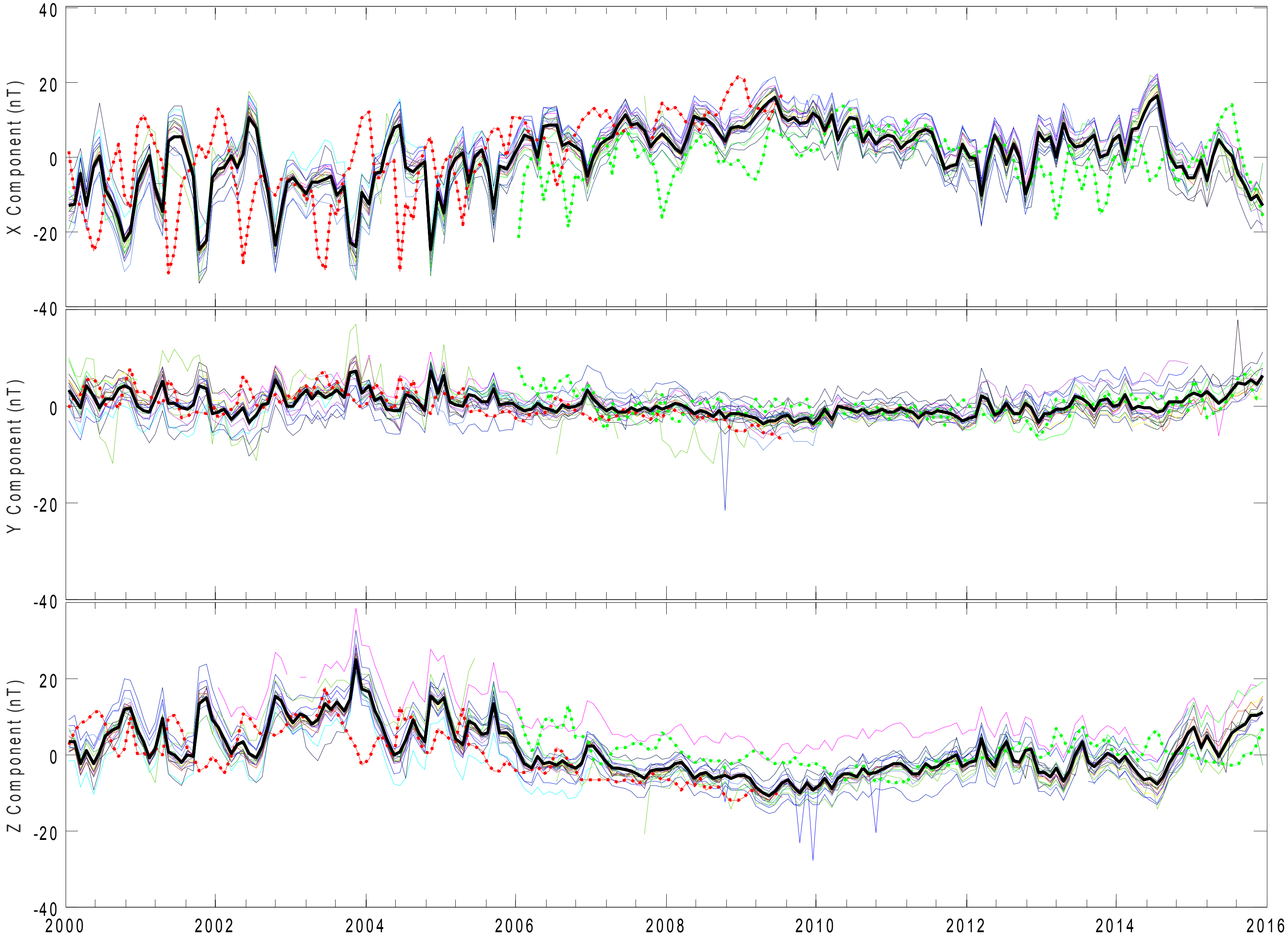
Analysing non-modeld contributions (EMM)



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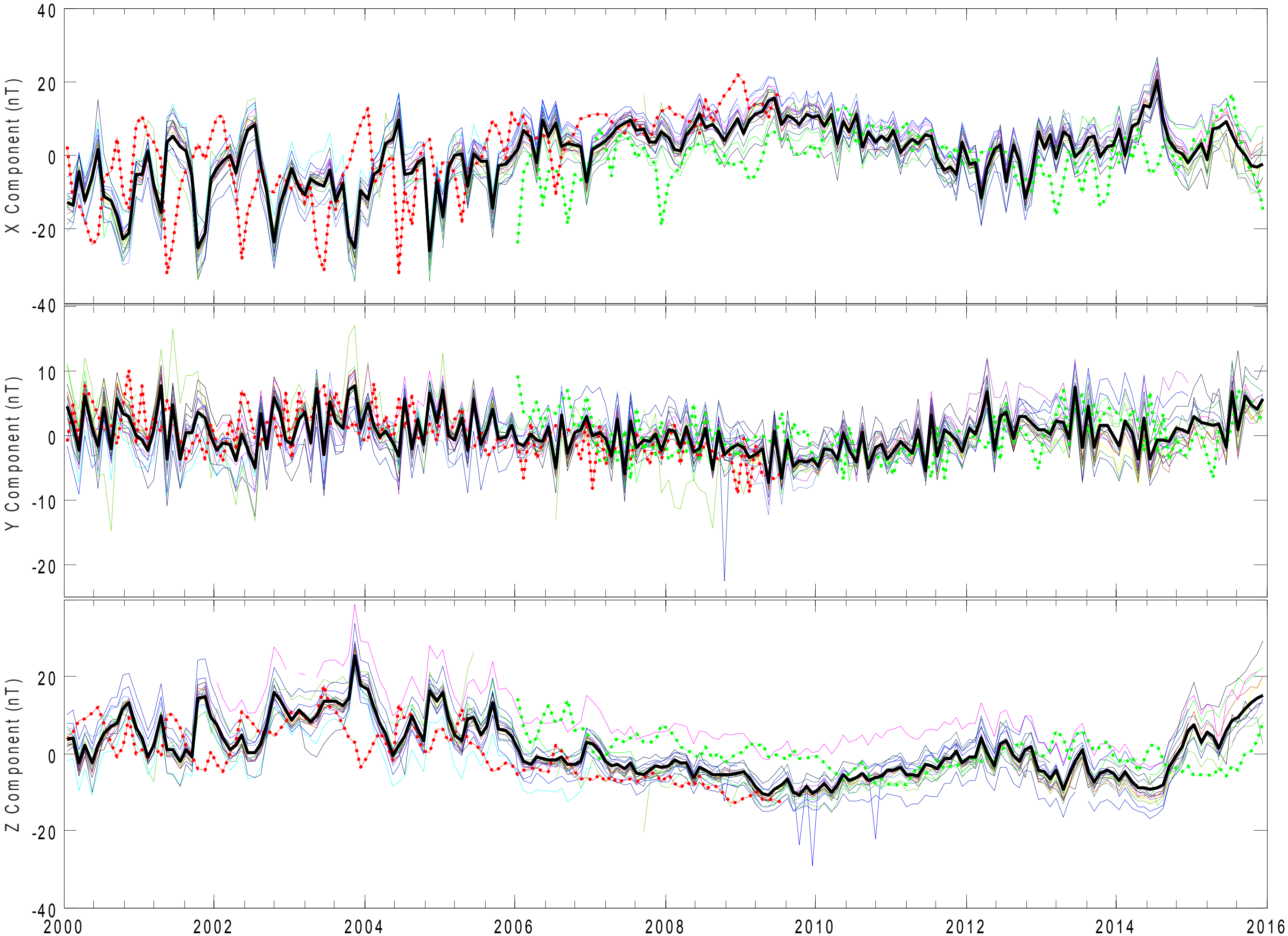
Analysing non-modeld contributions (POMME-9)



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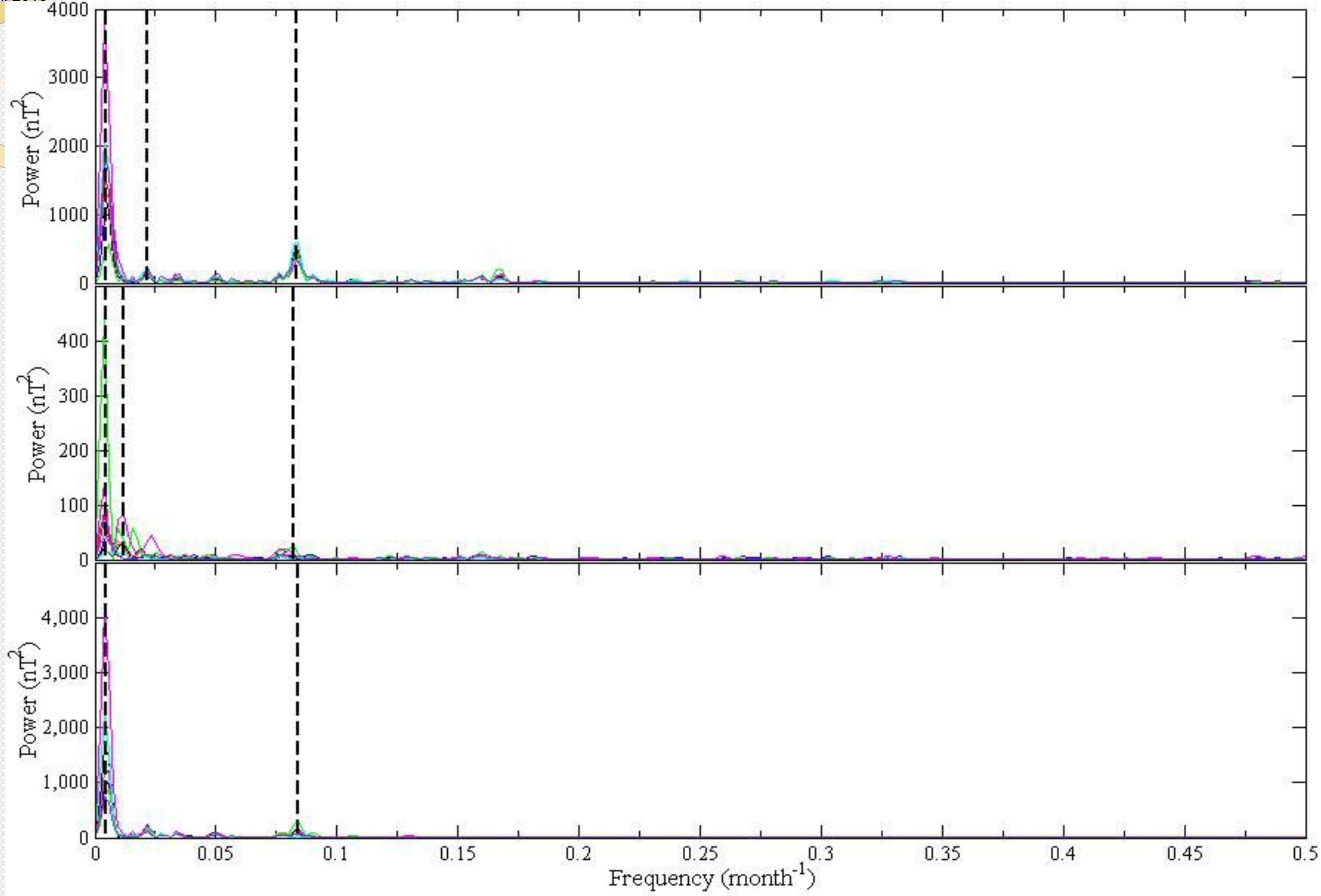

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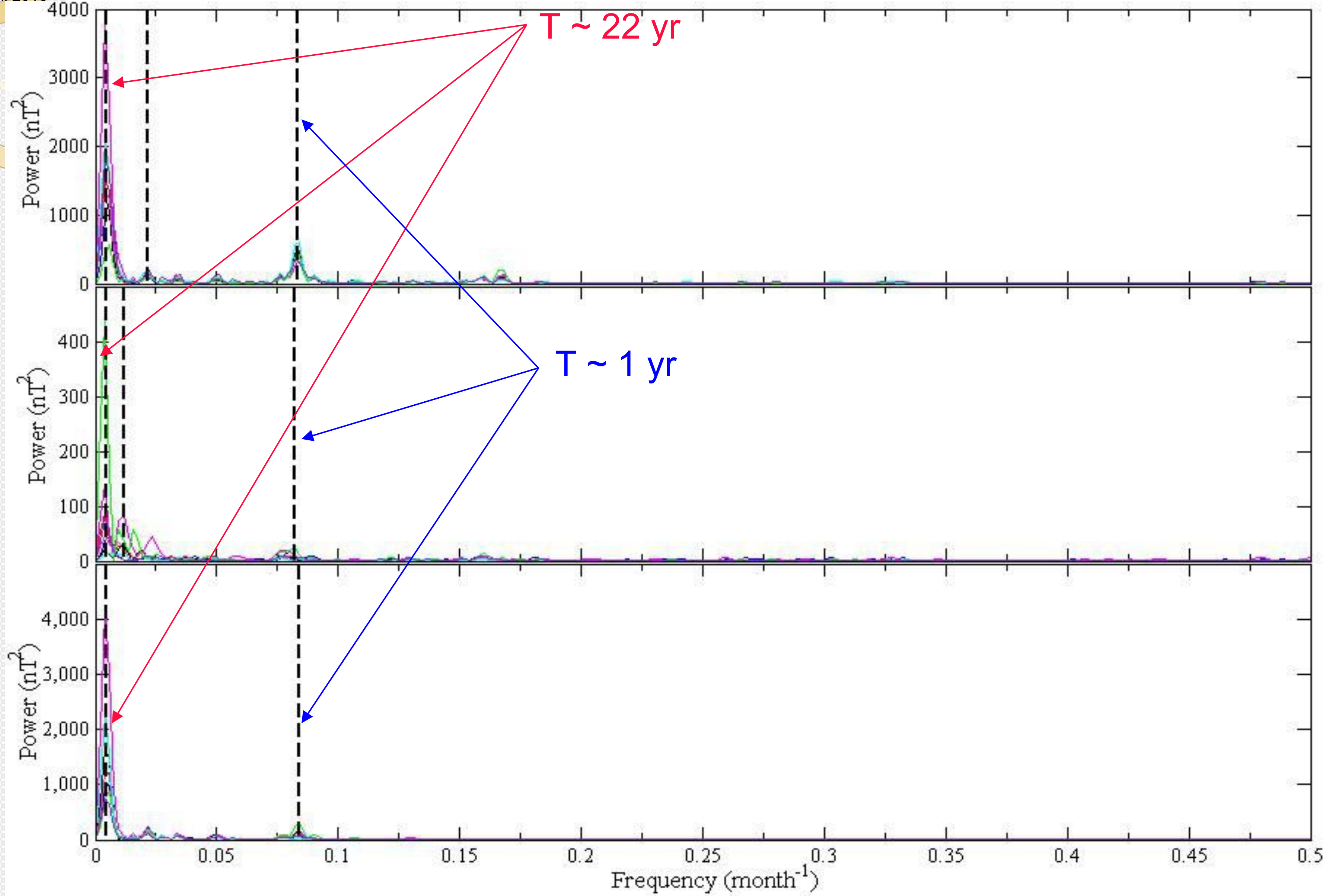
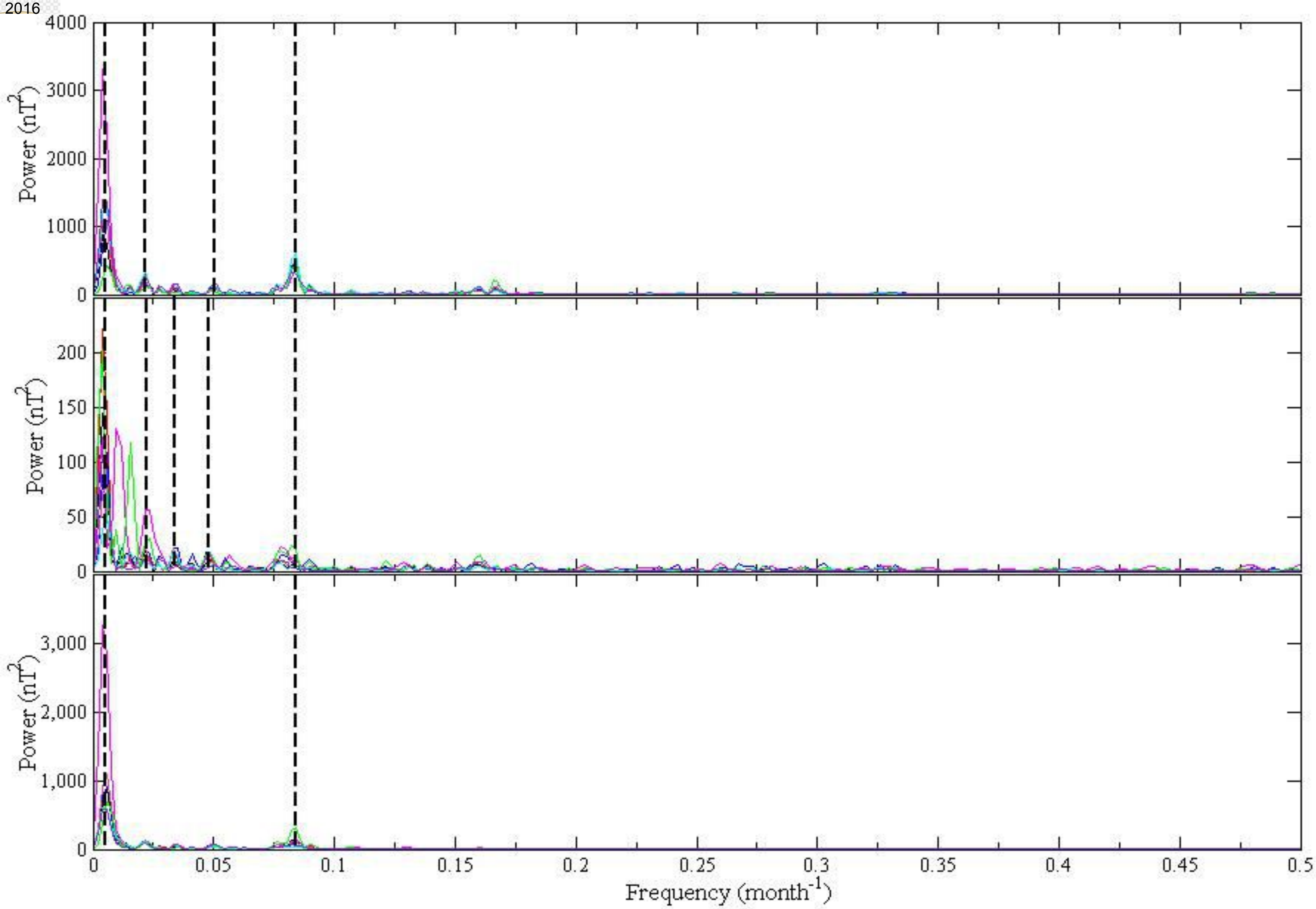


Analysing the external contribution (EMM)



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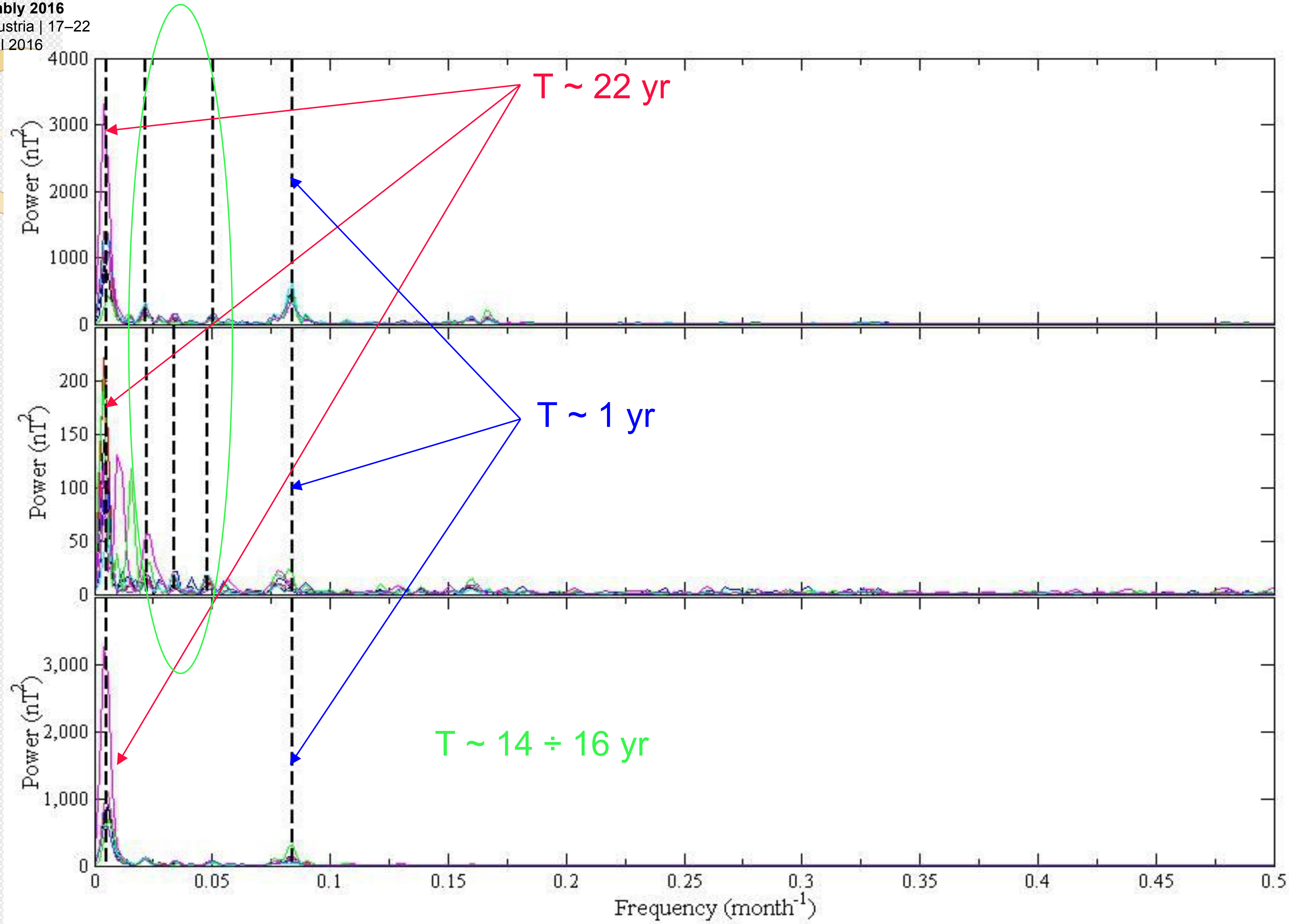

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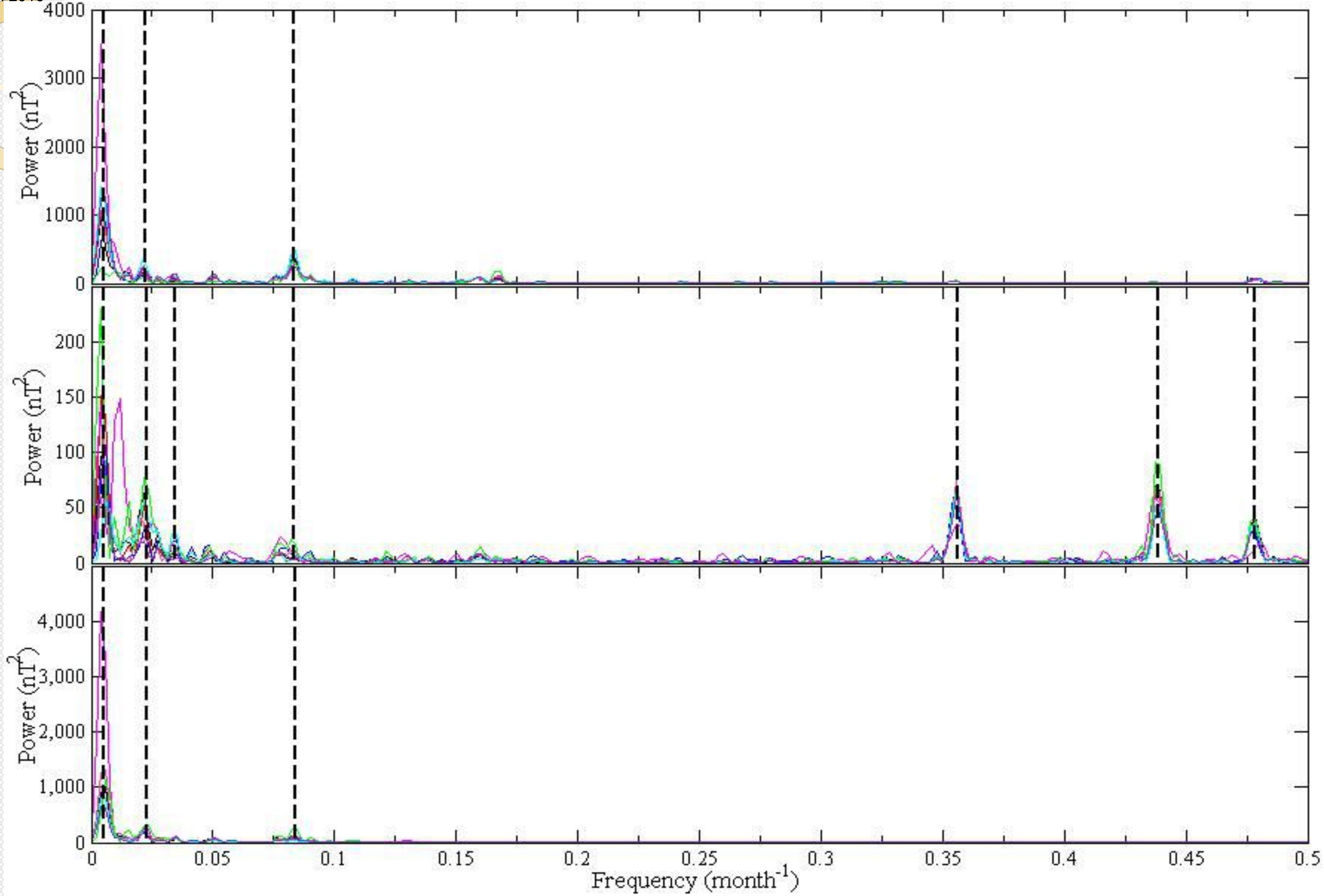

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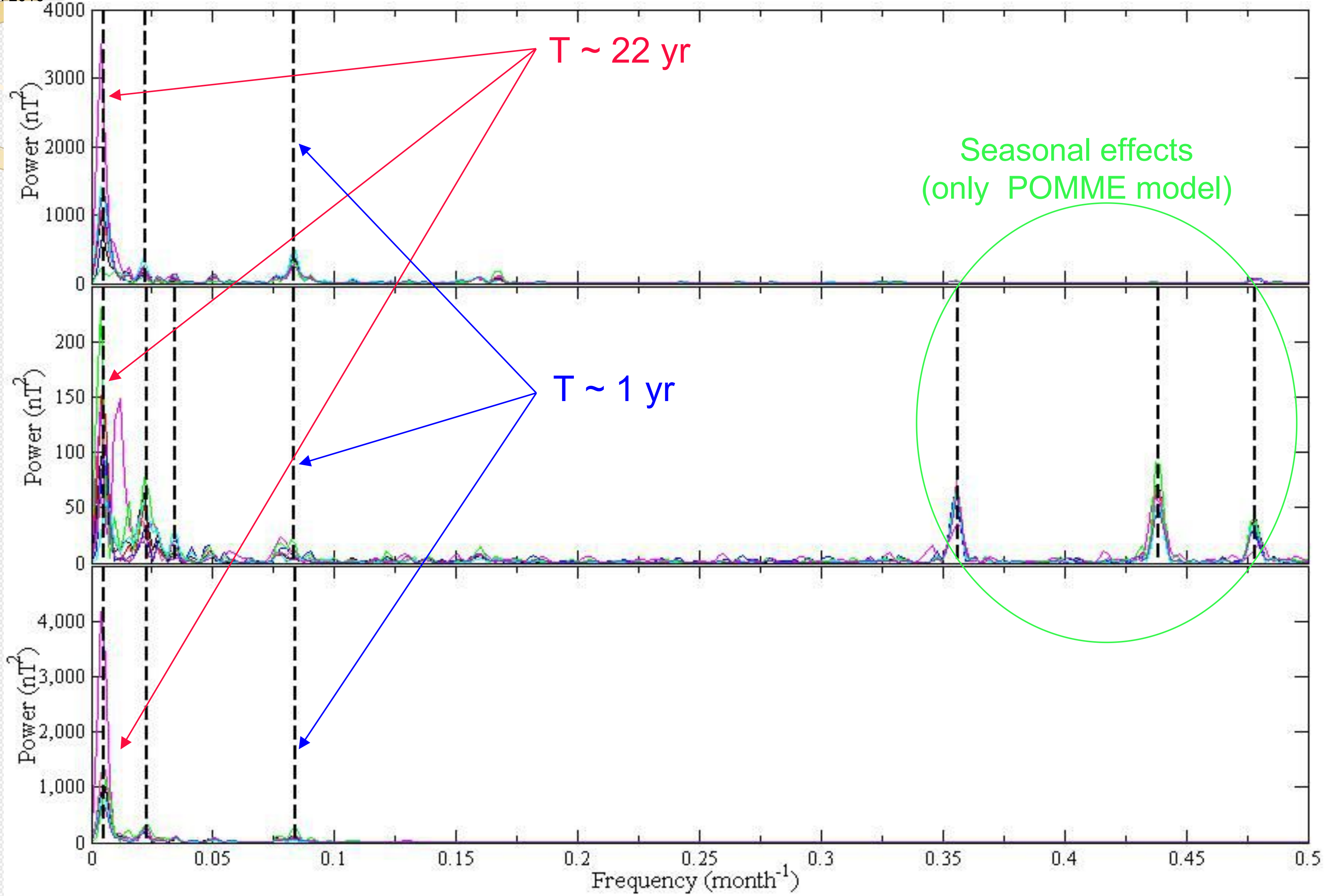

Conclusions

- The crustal contribution to european observatories measurements is not recovered satisfatorily. A denser grid, which benefits repeat station measurements would improve the results
- Generally the european observatories distant from each other and different latitudes and longitudes have low correlated time series of these non-modeled contributions that indicates an external origin of these contributions
- The spectral analysis of the non-modeled external contributions reveals the presence of different time scales: 22 years (polarity solar cycle); 16 years (related to the actual length of measurements time series); 1 year and sporadic cases of seasonal effects

References

- Mandea, M. and B. Langlais (2002), Observatory crustal magnetic biases during MAGSAT and Ørsted satellite missions, DOI: 10.1029/2001GL013693
- Maus, S., Lühr H., Balasis G., Rother M. and M. Mandea (2004,) Introducing POMME, Potsdam Magnetic Model of the Earth, http://www.geomag.us/info/Smaus/Doc/CHAMP-2-Pomme.pdf
- Sabaka, T. J., Olsen, N., Robert H. T. and A. Kuvshinov (2015). CM5, a pre-Swarm comprehensive geomagnetic field model derived from over 12 yr of CHAMP, Ørsted, SAC-C and observatory data", Geophys. J. Int. 200, 1596–1626
- https://www.ngdc.noaa.gov/geomag/EMM/EMMSurveySPH.shtml
- https://geomag.colorado.edu/pomme-9-magnetic-model-of-the-earth.html

Acknowledgements

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