

# Different approaches for removing the external field influences from the European geomagnetic observatory annual means

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- (4) Sources and characteristics of various external field contributions

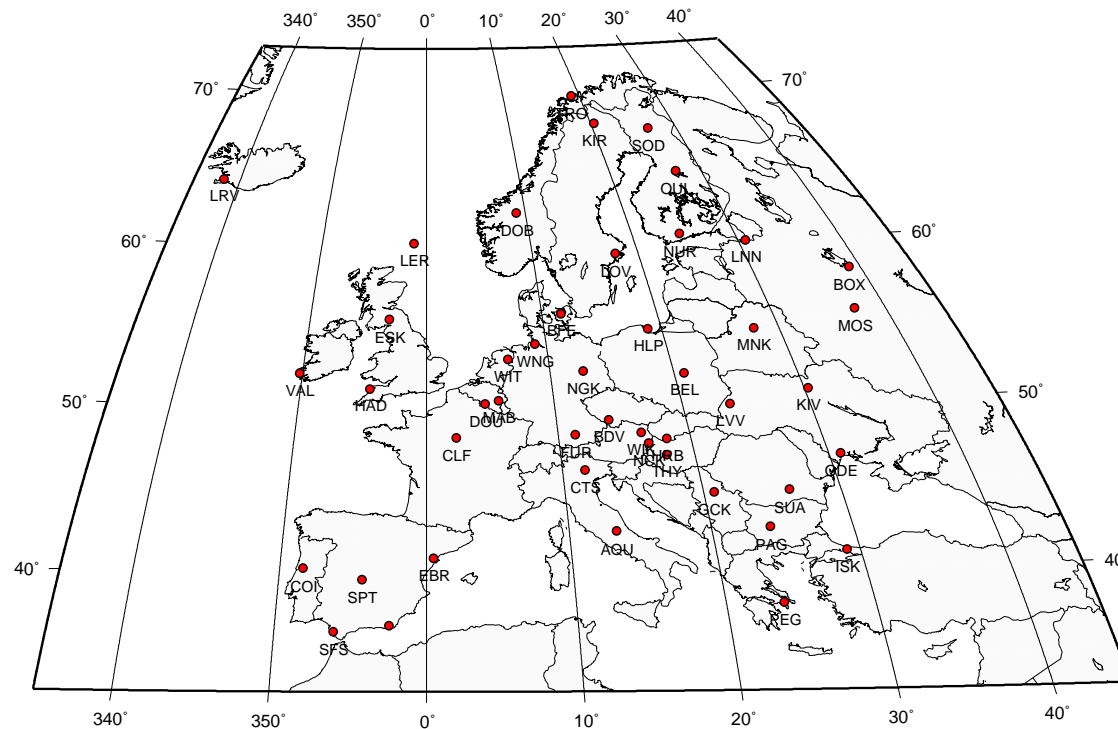
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- (5) Conclusion



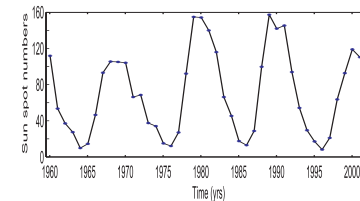
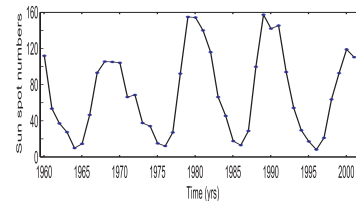
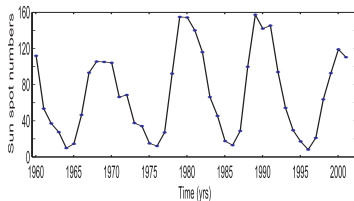
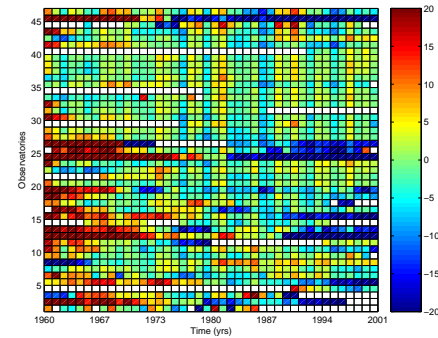
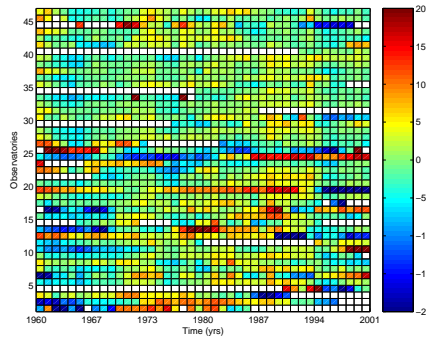
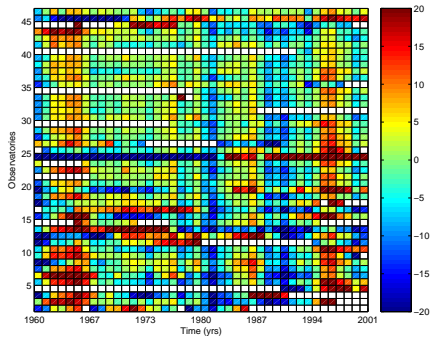
# Introduction - Magnetic observatories

- Magnetic observatories play a crucial role in reduction of repeat stations measurements made in the MAGNETE network.
- Annual means should reflect as much as possible the core field.
- We investigated data from 46 European geomagnetic observatories collected over 42 years (1960 - 2001).



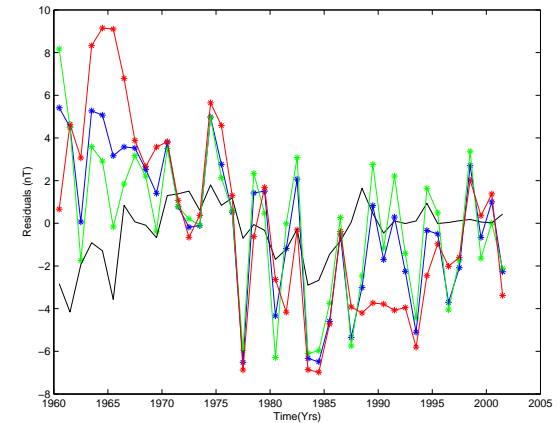
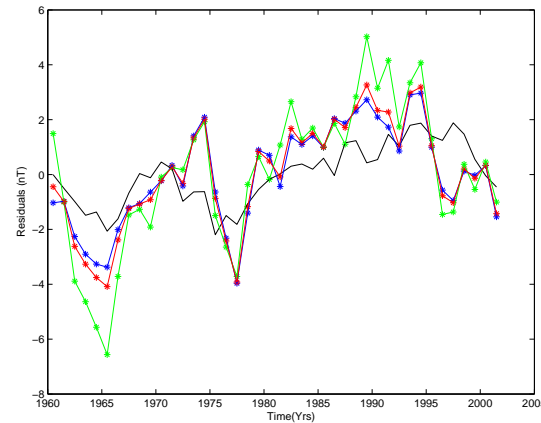
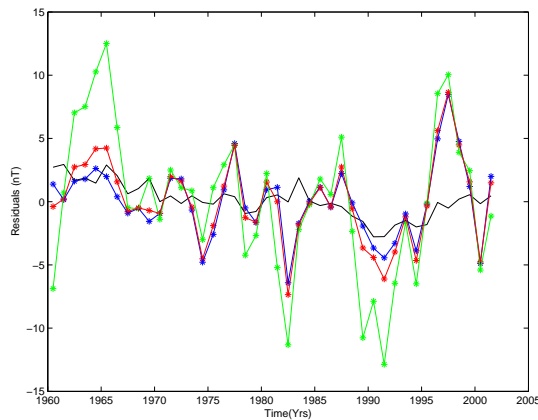
# Detection of the external field

- After removing the core field, as predicted by the CM4 model (Sabaka et al., 2004), the apparent link to the solar cycle was noticed as short period variations in the order of  $\pm 10$  nT.



# Reduction of the external field - Approach 1

- Removal of the external and induced contributions provided by CM4, modulated by storm-time-disturbance (Dst) and Solar flux (F10.7).
- Not successful enough
- NGK: x, y and z component

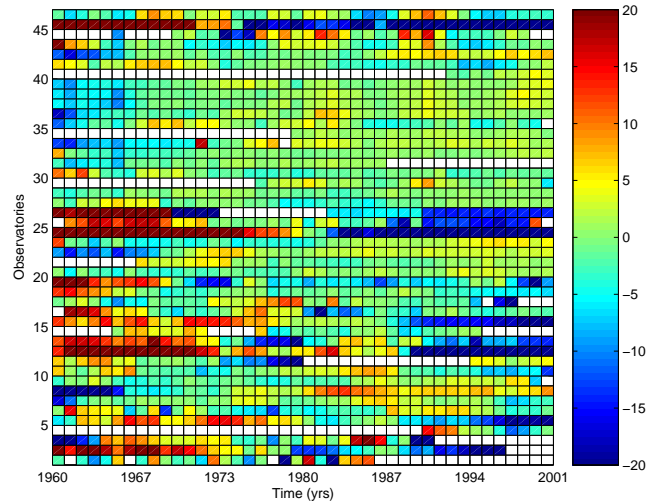
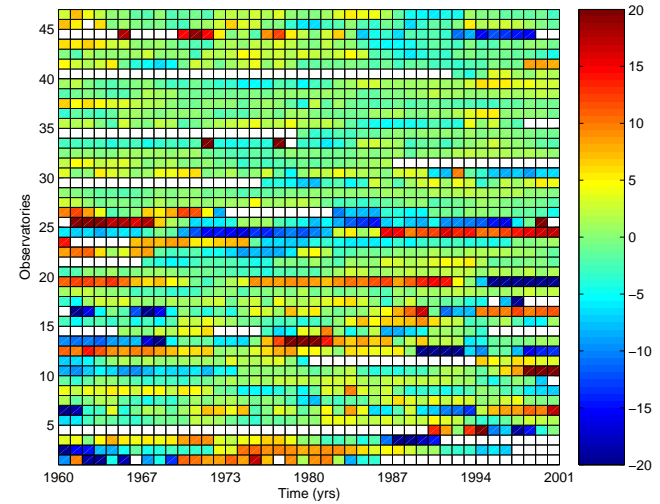
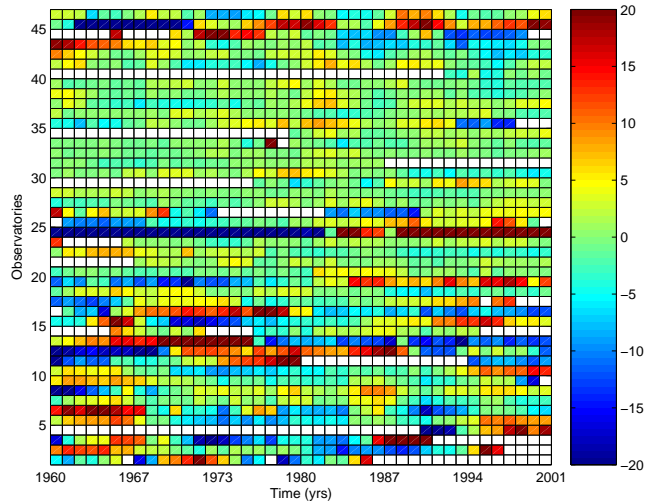


subtracted fields: core (green), core+external (red), core+external+induced (blue)

## Reduction of the external field - Approach 2

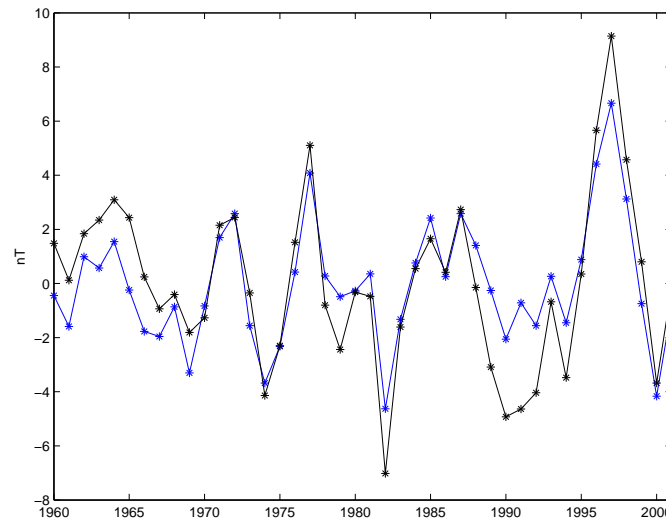
- Based on the homogeneity of the external influences in the whole European region we developed an empirical procedure for estimating the remaining external field variations
- Detect and exclude those observatories with temporal patterns different from the generally observed.
- Template construction - a median average of observatory residuals in each year.
- Subtraction of the template from all observatory residuals.
- The procedure works well.

# Pictograms after removing the templates



# Sources and characteristics of various external fields

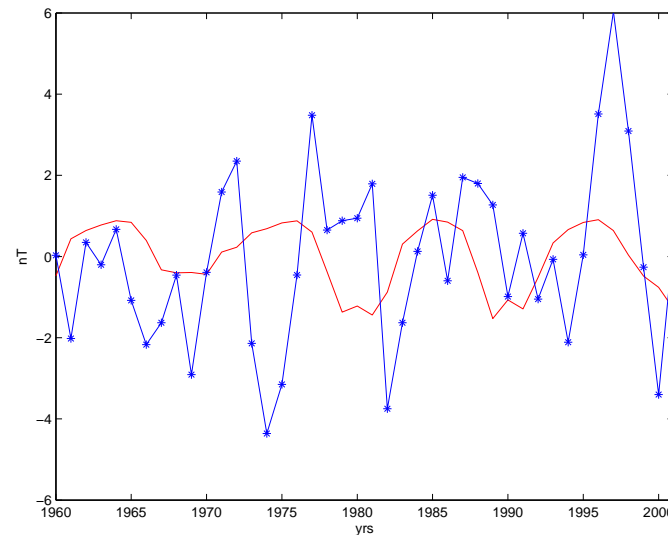
- X component
- The magnetospheric contributions are characterized by the POMME-2.5 model [Maus et al., 2005].



**Blue:** Vertical average through all observatories after subtracting an average variation , Res1

**Black:** Res1 at NGK

- The remaining signal is regarded as caused by ionospheric currents.
- Firstly, the annual averages of the Sq variation estimated by the CM4 model were subtracted from the residuals (Res2)



Blue: Res2

Red The annual average of the Sq signal

- Still significant remaining signal
- Bi-variant correlation considering the  $A_p$  index and regional ring current effect ( $R_c$ ) simultaneously
- Ionospheric signal is represented by:

$$X_{iono} = Sq - 0.60 \cdot (A_p + 0.82 \cdot R_c) + 3.84nT$$

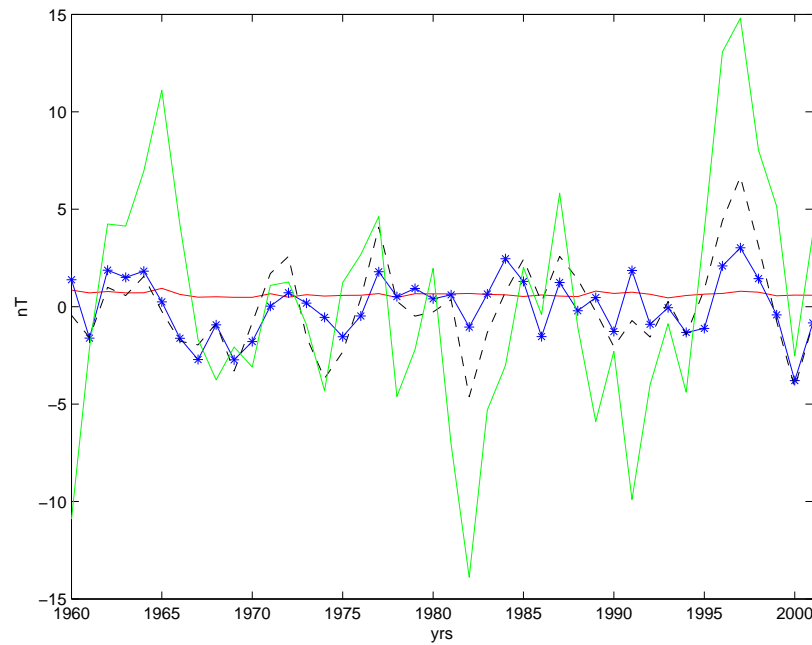


**Green:** Residual of the annual means  $X$  component: prior to any external field correction;

**Black dashed curve:** after removal of the magnetospheric field;

**Blue:** after  $S_q$  and  $A_p$  corrections;

**Red:** mean uncertainty of averaged annual means



# CONCLUSIONS

- (1)** We found the apparent link between observatory annual means and the solar cycle as short period variations in the order of  $\pm 10$  nT.
- (2)** We developed a new approach for estimating the remaining external field variations in the data taking the advantage of the homogeneity of the external influences in the European region [Verbanac, Korte and Manda, 2007].
- (3)** The obtained results are much better than when using the external field description included in the CM4 model.
- (4)** We further systematically study, interpret and explain the different external field contributions in the observatory annual means [Verbanac, Lhuer, Rother, Korte and Manda, 2007].

- **Removal of the magnetospheric contributions.**

We successfully removed the magnetospheric contributions by the POMME-2.5 model external field module parametrized by the Dst index.

- **Removal of Sq.**

The remaining ionospheric signal has an amplitude  $\pm 6$  nT.

We subtracted the estimated annual averages of the Sq variation from the CM4 model.

- **Removal of Ap dependence.**

We found still a variation left which is in anti-phase with the Ap index.

- **Quality of the result.**

The remaining residuals of the European observatory annual means over the considered 42 years could be explained to a level of  $\pm 2$  nT.

## The present investigation shows:

- The external field signals contained in the observatory annual means is significant and their elimination is a prerequisite for obtaining reliable and physically meaningful results when such data are used in studies of the core field and its secular variation.
- Accurate estimation of the external field plays also a key role in identifying spurious readings in observatory data.