The Mansurov effect:
Statistical significance, the role of autocorrelation and non-stationary behaviour
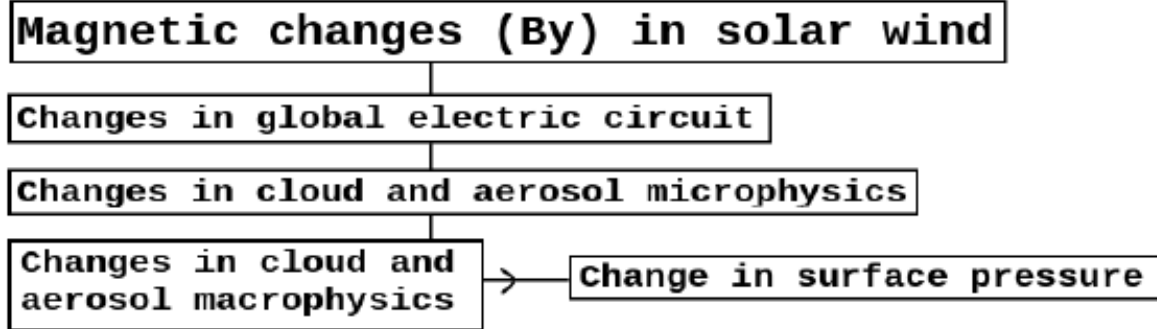
Jone Edvartsen

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- **What is the Mansurov effect?**

  - - Correlation found between the IMF By-component and polar
  -    surface pressure

  - Positive By gives positive pressure anomaly in South, negative By gives
   negative pressure in South (antisymmetric in North)

- **Hypothesised mechanism:**

Magnetic changes (By) in solar wind

Changes in global electric circuit

Changes in cloud and aerosol microphysics

Changes in cloud and aerosol macrophysics	→	Change in surface pressure

- **Problems:**
  - - Correlations limited to specific period, solar cycle 23 (1995-2005)
  - - No significant correlation found in scientific literature between GEC and cloud formation
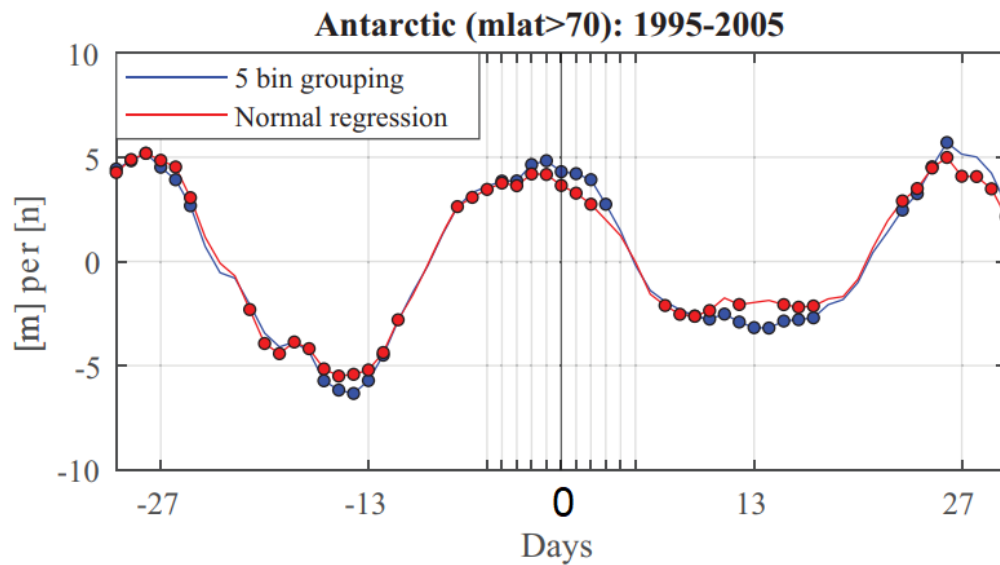 - - Significance only assessed by t-test

-

● Replication of previous results:

●

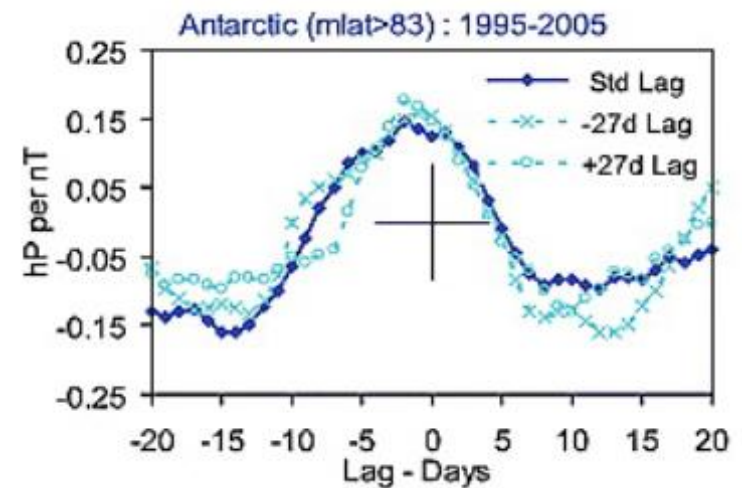# Burns et al. (2008)

Antarctic (mlat>83) : 1995-2005
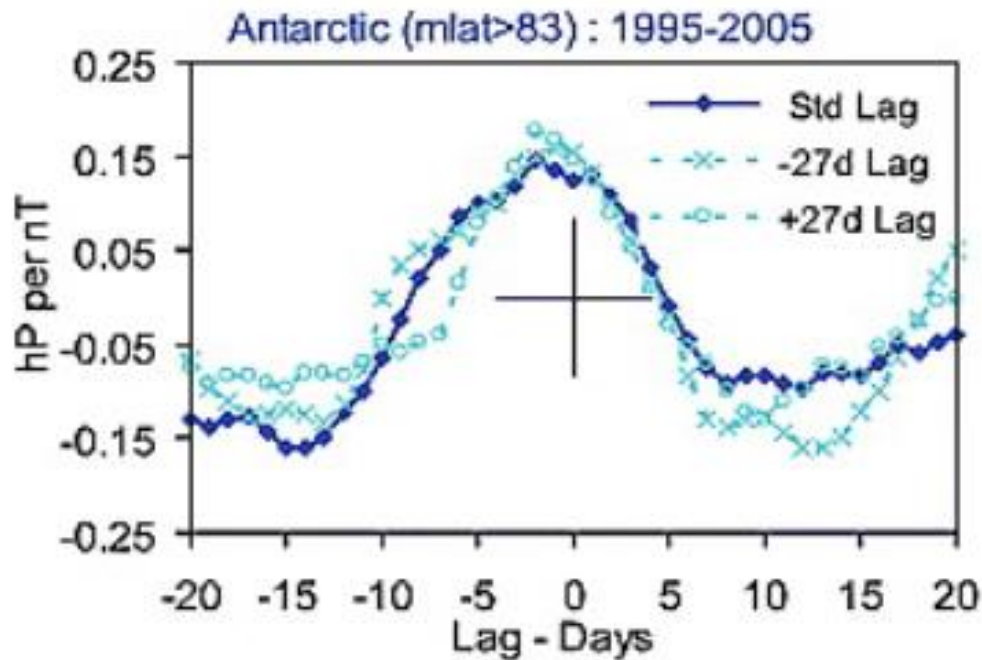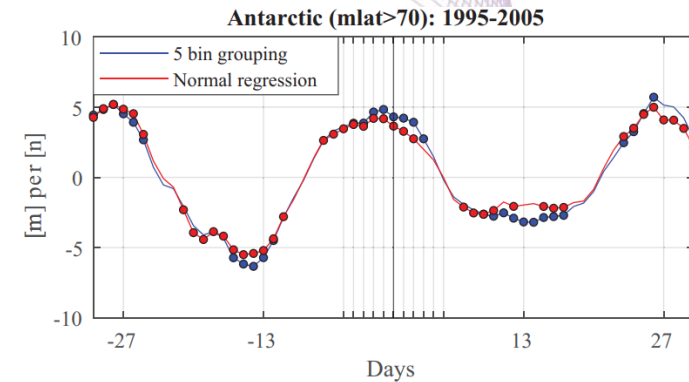
Replication of previous results:

Our results:

Burns et al. (2008)
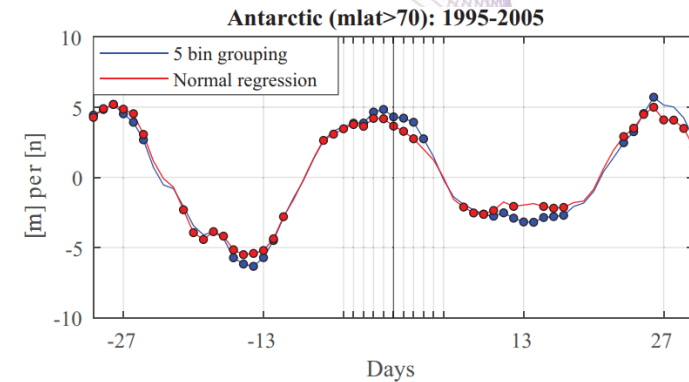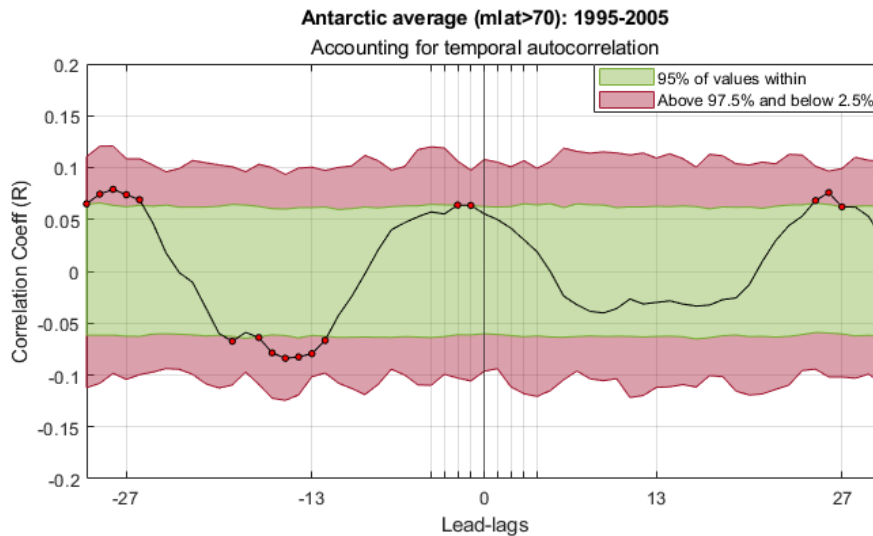
Testing the significance of the response:

- All other studies uses only t-test.
- First step: Applying MC-simulations

- Phase randomization: Scrambles the harmonic phases, preserves autocorrelation function

Antarctic (mlat>70): 1995-2005

•Testing the significance of the response:

•- All other studies uses only t-test.

•- First step: Applying MC-simulations

Antarctic average (mlat>70): 1995-2005
Accounting for temporal autocorrelation
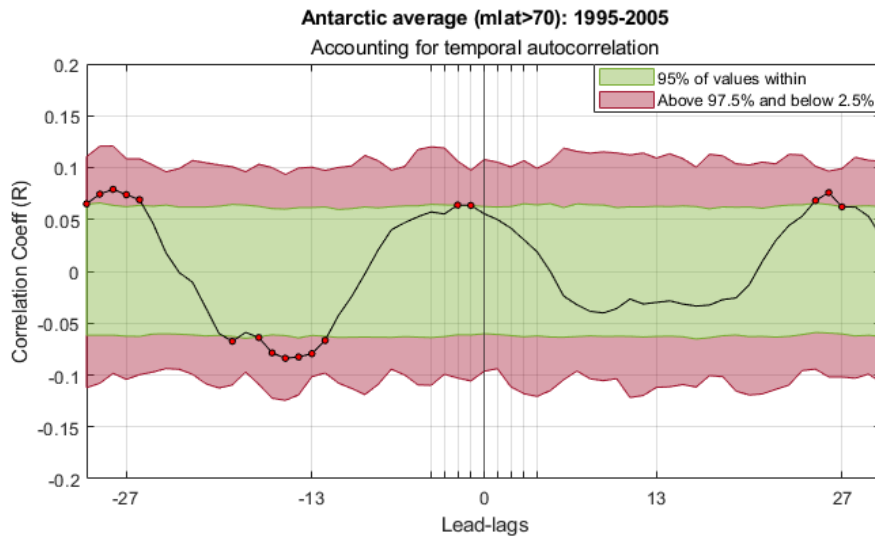

Antarctic (mlat>70): 1995-2005

- Two significant points at day -2 and -1

•Testing the significance of the response:

- •- All other studies uses only t-test.
- •- First step: Applying MC-simulations

- Second step: Introducing False Detection Rate (FDR) (Wilks 2016)

- $$p_{FDR} = \max[p(i) : p(i) \leq (i/N)\alpha_{FDR}], \, i = 1, .., N$$

Antarctic average (mlat>70): 1995-2005
Accounting for temporal autocorrelation

Legend:
- 95% of values within
- Above 97.5% and below 2.5%

Y-axis: Correlation Coeff (R)
X-axis: Lead-lags

Testing the significance of the response:

- All other studies uses only t-test.
- First step: Applying MC-simulations

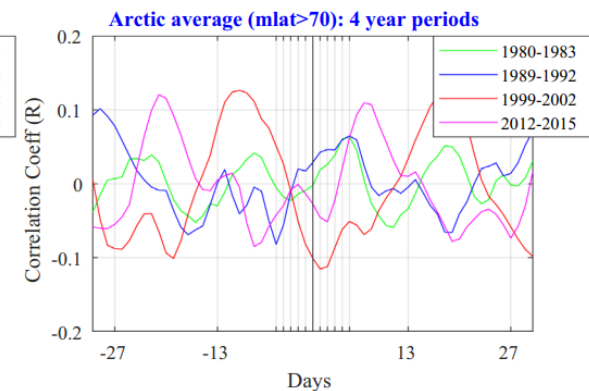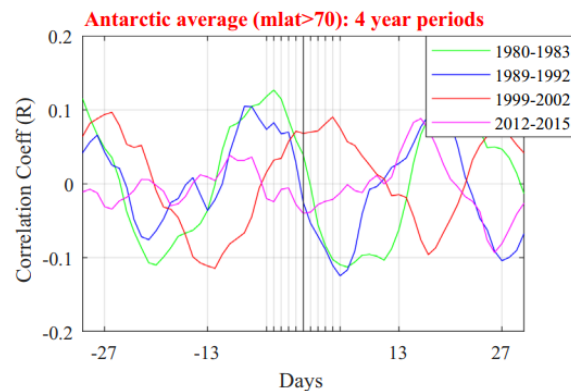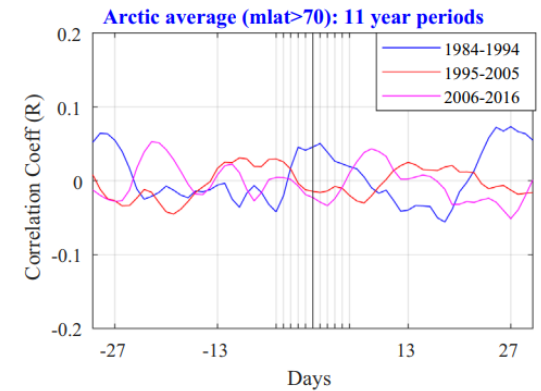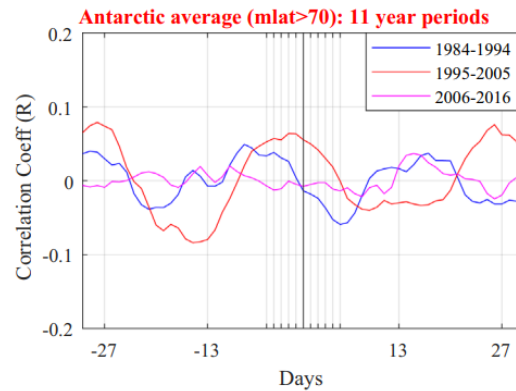- Second step: Introducing False Detection Rate (FDR) (Wilks 2016)

Antarctic average (mlat>70): 1995-2005
Accounting for temporal autocorrelation and multiple hypotheses for the interval: -27 to 27

- 95% of values within
- Above 97.5% and below 2.5%

- $$\mathrm{p_{FDR}} = \max[\mathrm{p}(i) : \mathrm{p}(i) \leq (i/\mathrm{N})\alpha_{\mathrm{FDR}}], \; i = 1, .., \mathrm{N}$$

- All significance disappears
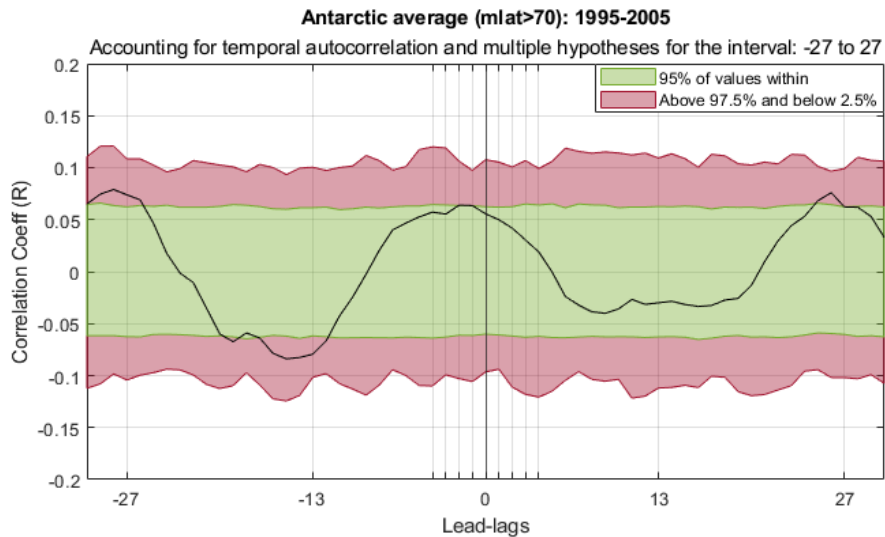
Other periods:

- ~27-cycle seems common
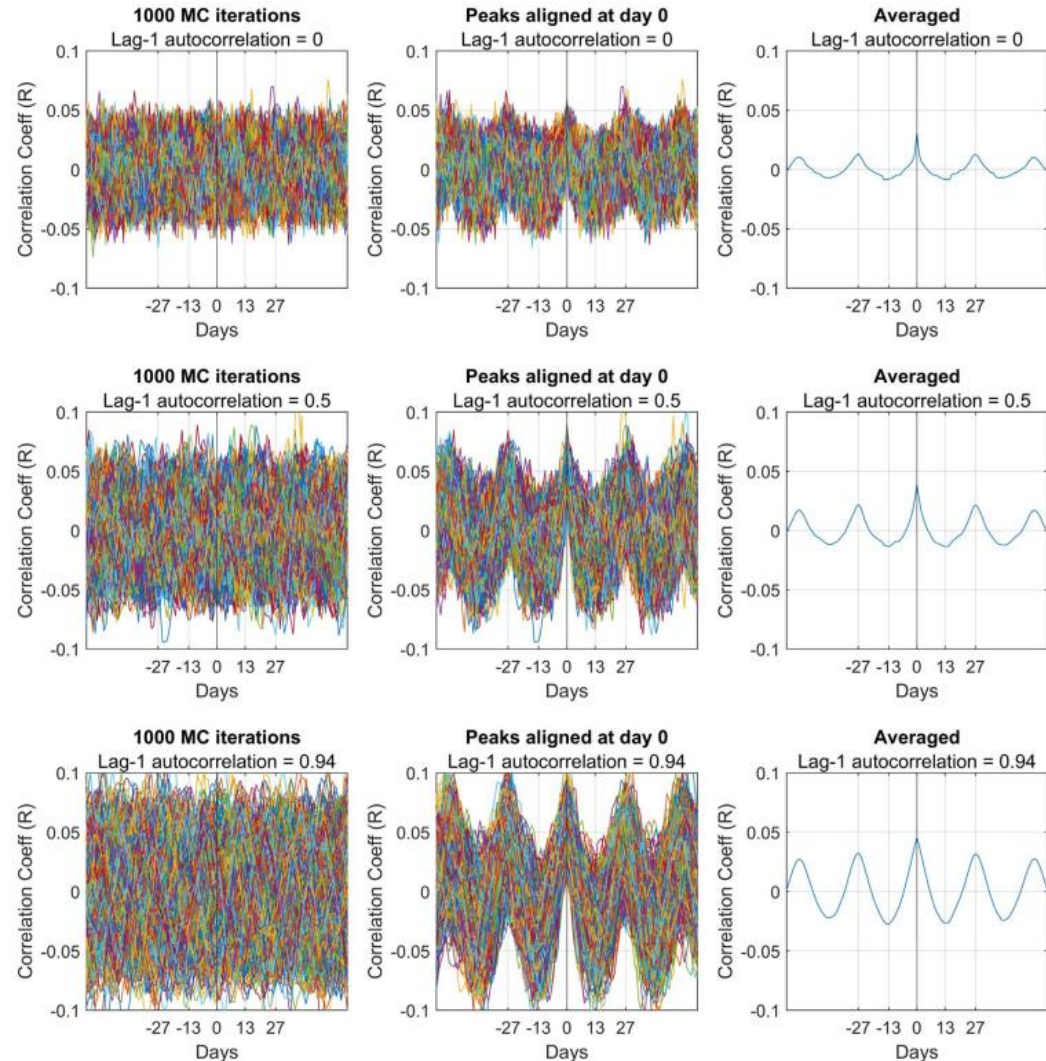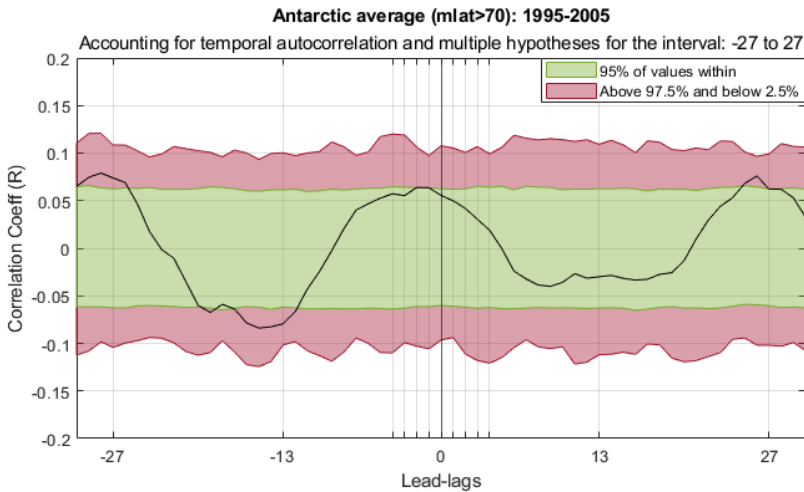
- Solar cycle 23 not unique

•We show this through MC-simulations:

•- Real By data cross correlated with randomly generated normally distributed noise with different levels of temporal autocorrelation
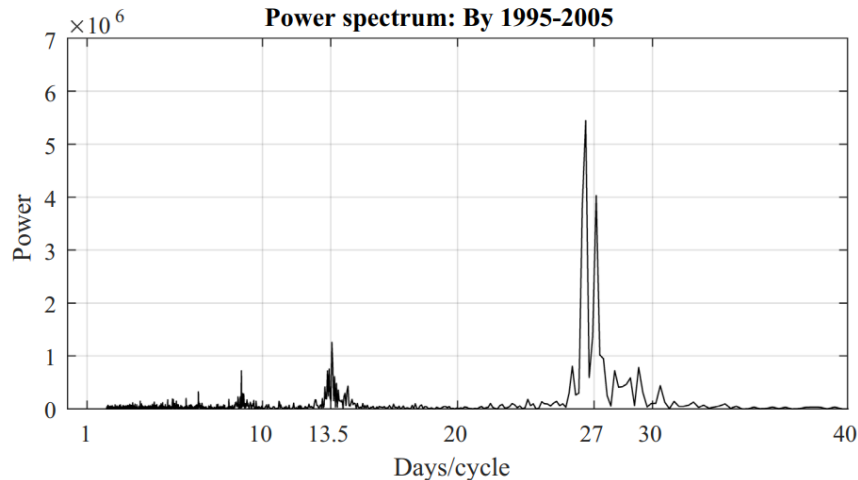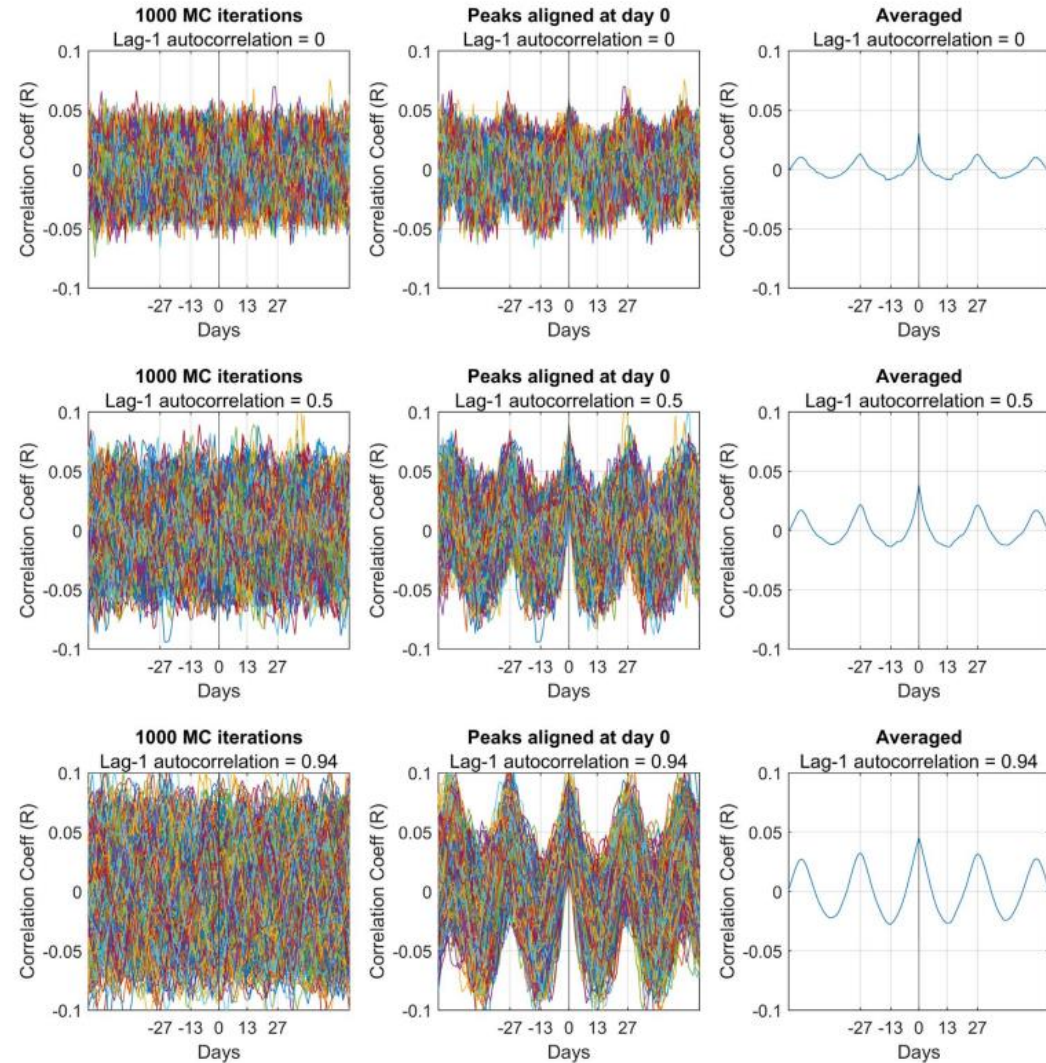
4013 data points (By data from the period 1995-2005)

Power spectrum: By 1995-2005

●Compared to the original results:

Same autocorrelation as real pressure/geopotential

.Conclusion:

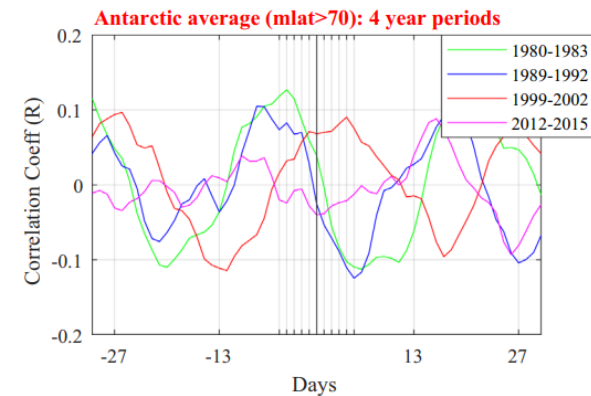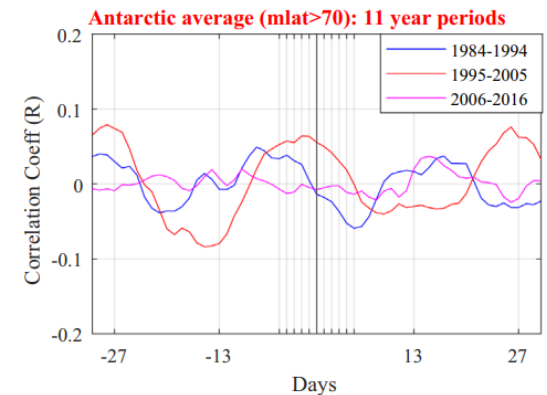ₓThe 27-day cyclic response cannot be used as evidence for the Mansurov Effect

ₓNo significance is found for solar cycle 23 when
ₓaccounting for multiple null hypotheses (FDR)

ₓ*Leading to…*
ₓthat the Mansurov associated response reported for
ₓsolar cycle 23 might occur purely by chance

ₓ**General finding:**
ₓTime-lagged cross correlation/Super epoch method should be used
ₓcautiously when the forcing is periodic and response variable
ₓhas high temporal autocorrelation, as periodic responses always
ₓwill arise

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•Answer to possible critique

ₓIt can be argued that our assessment underestimates the statistical
ₓsignificance

ₓTinsley et al. (2022) argues how the local winter time and a 2-sector structure in the
ₓsolar wind (By) enhances the impact of the Mansurov effect.

ₓ

•Answer to possible critique

It can be argued that our assessment underestimates the statistical significance

Tinsley et al. (2022) argues how the local winter time and a 2-sector structure in the solar wind (By) enhances the impact of the Mansurov effect.

New findings under review:

Edvartsen J, Maliniemi V, Nesse Tyssøy H & Hatch S 2022.
The Mansurov effect: Non-stationary behaviour.

Even when only choosing the preferable sub-periods (local winter + 2-sector structured By) within solar cycle 23, no statistically significant response at the 95% level exists