The effect of space weather, proxy parameters of solar activity, and stratospheric phenomena on the concentration of cosmogenic radionuclide ^{7}Be (in the Czech Republic)

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- **Cosmogenic radionuclides concentrations** are predominantly determined by the **solar activity** and **space weather** around the Earth, forming an important source of cosmic-origin background radiation in the terrestrial environment.
- The **highest values** of such radiation are observed **during the solar minima** because the penetrability of the Earth's magnetosphere is greatest at that time.
- We compare periods of strong solar and geomagnetic storms with periods of very low solar activity in the **longitudinal view during the years 1986 – 2020**.
- When **solar activity is at a maximum, the cosmic radiation dose is 10 % smaller** than when solar activity is at a minimum (UNSCEAR: Annex B, 2000).
- **Cosmic origin radiation represents 8% of the total radiation exposure** in the Czech Republic.

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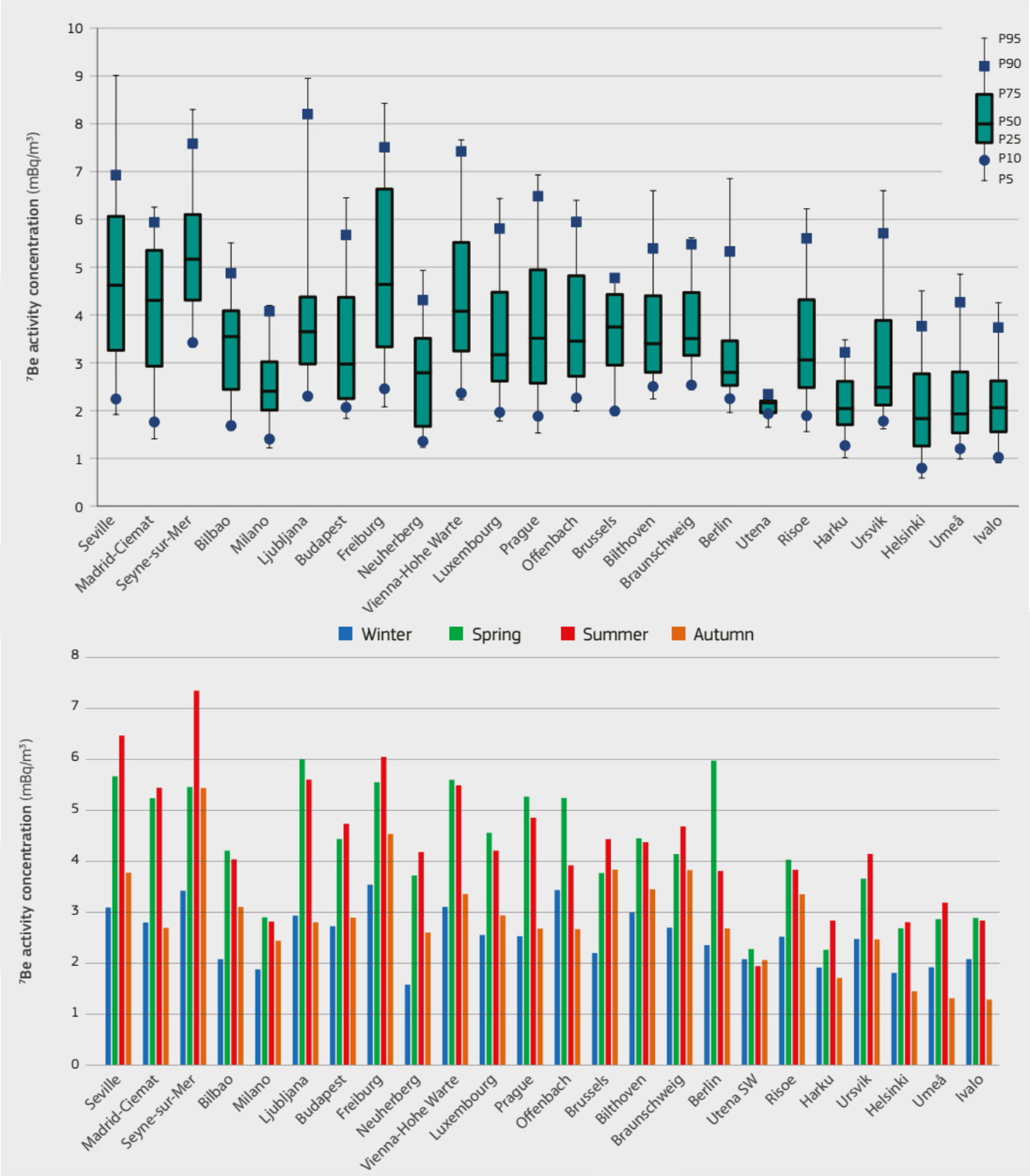

Beryllium ^{7}Be binds to aerosols and is transported within a few years to the Earth's surface.

Box-plots of ^{7}Be frequency distribution at EU different sampling stations for 2006.

Seasonal average of ^{7}Be concentrations at different sites.

Source: EANR, EC-JRC, 2019., European Atlas of Natural Radiation

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The beryllium radionuclide ^{7}Be concentration monitoring

- The beryllium radionuclide ^{7}Be concentration was evaluated by the corresponding activity in aerosols on a weekly basis at the National Radiation Protection Institute Monitoring Section in Prague.

- Radiation Monitoring Network “MonRaS”

Large-capacity sampling device *Snow White* used to measure the concentrations of natural and artificial radionuclides in the air.

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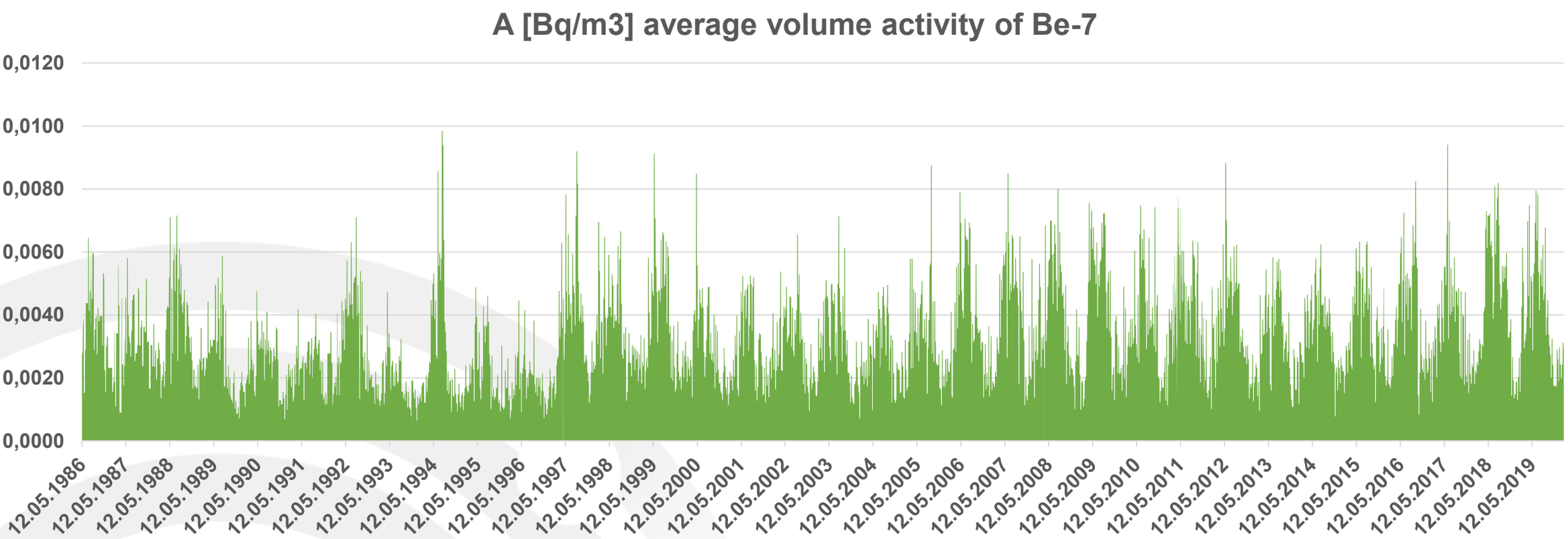
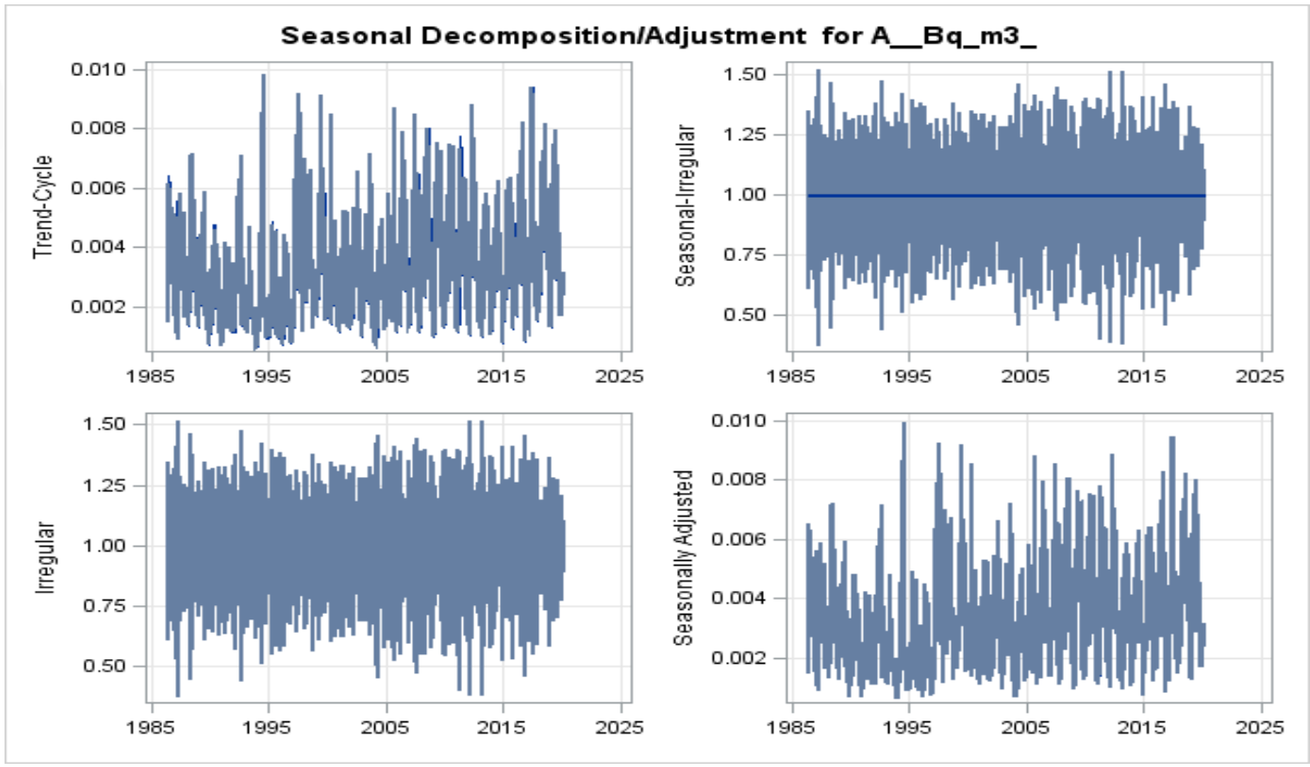
Rulík et al. (2009); Pöschl et al. (2010)

The beryllium radionuclide ^{7}Be concentration

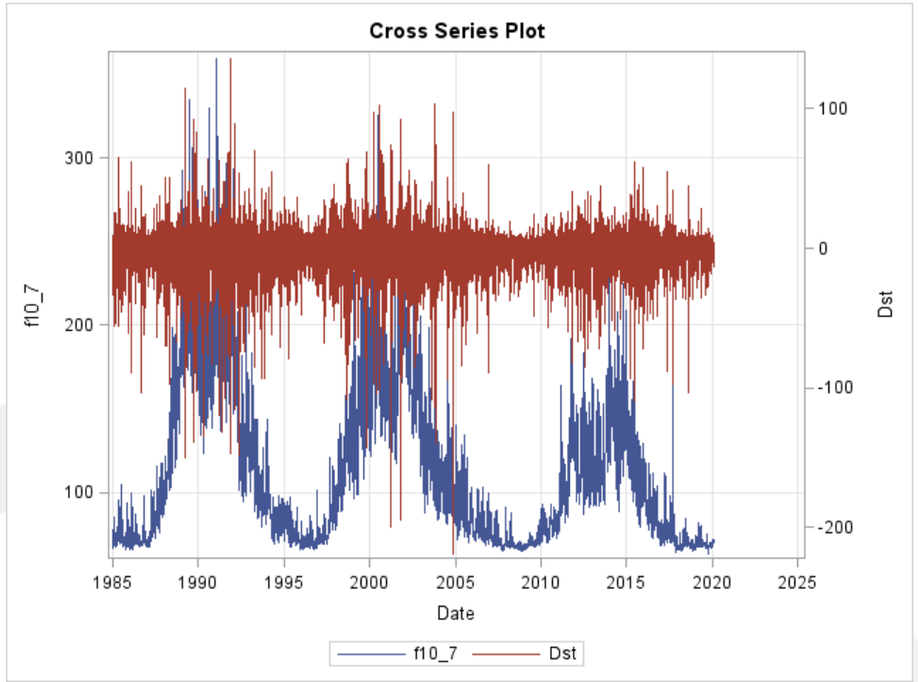


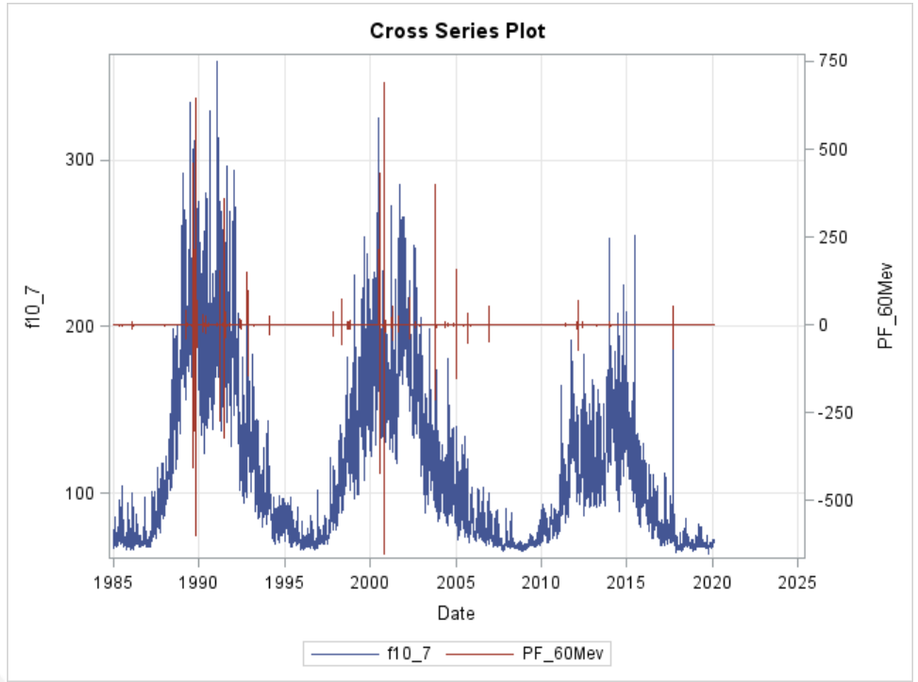
Time series of activity concentration of ^{7}Be in aerosols during the period 1986 – 2020, station Prague.

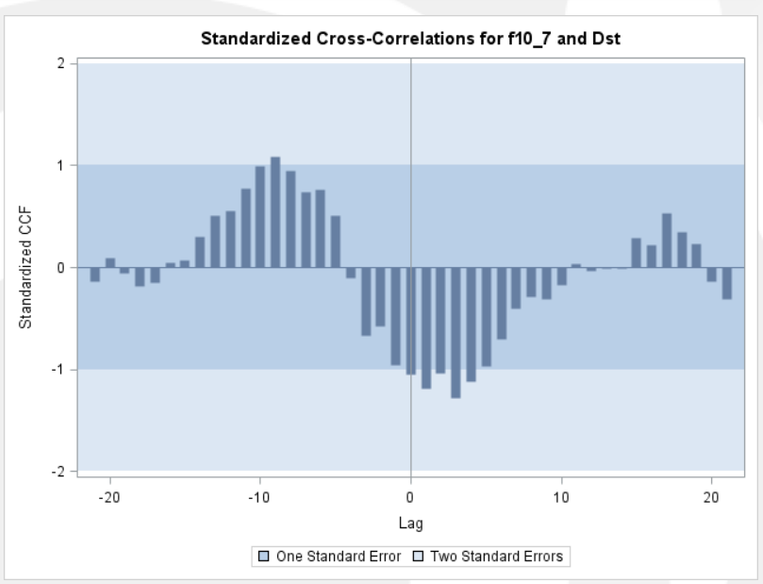
The values express the average volume activity of ^{7}Be in Bq/m^{3} in a given period with a combined standard uncertainty (1 sigma).

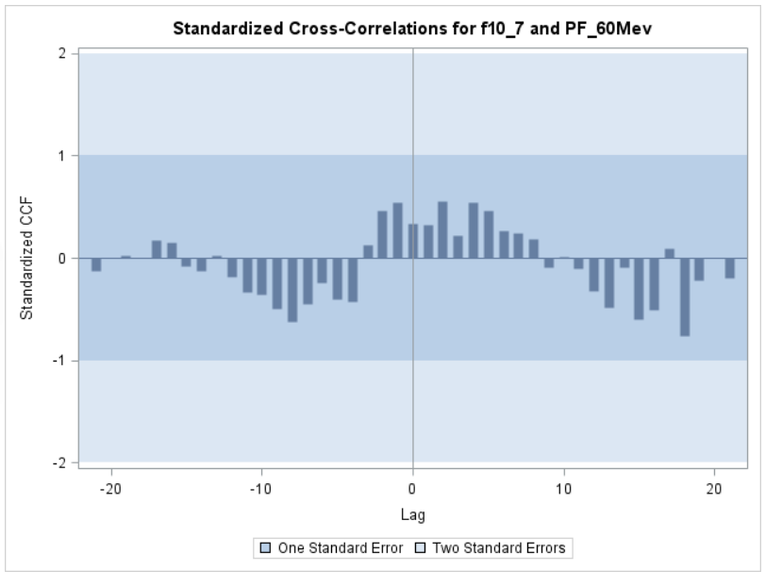


Active periods from years 1986 to 2020, Solar Cycles No.22 – No.24



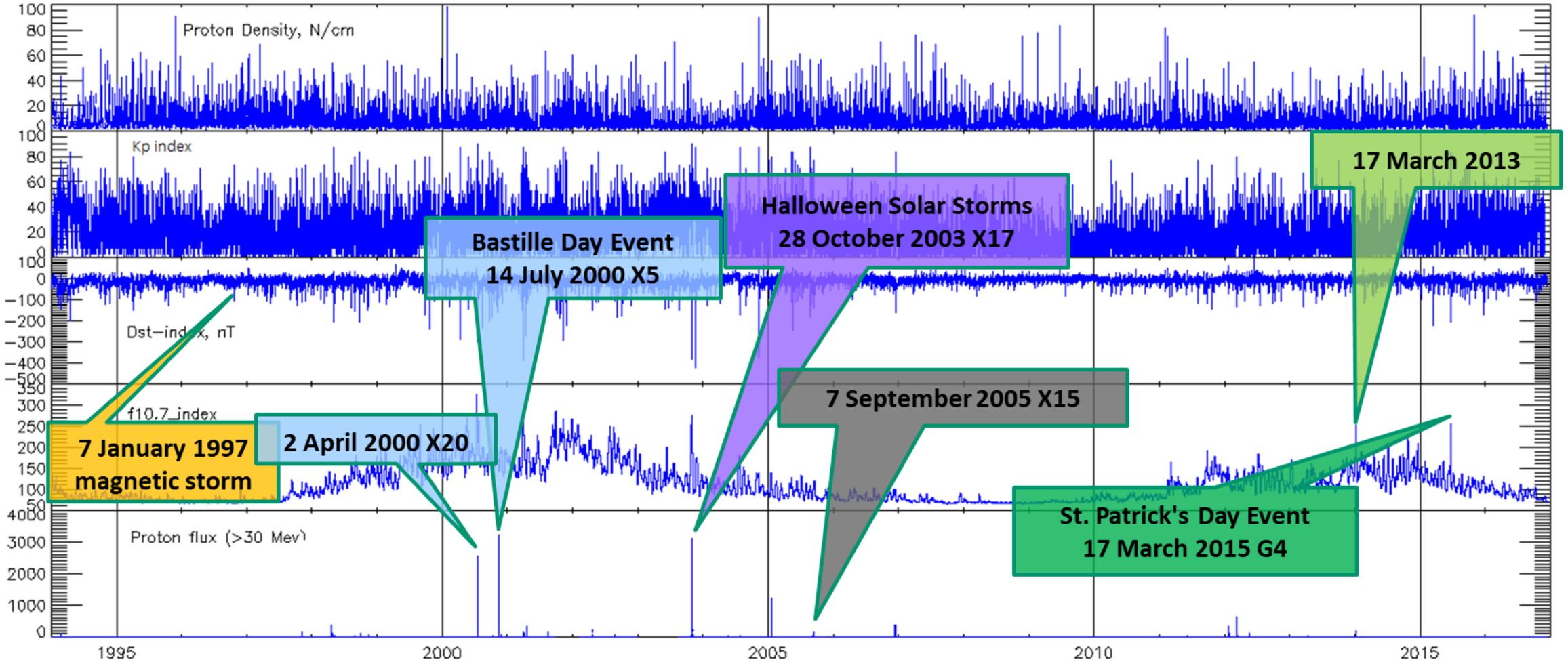






The strong dependence of the galactic cosmic rays and solar activity (e.g. Dorman et al., 2001)
Solar proxy solar radio flux F10.7, Disturbance storm time Dst, Solar Proton flux 60 MeV.
High sunspot activities/solar radio flux are highly correlated with low cosmic rays intensity.

Active periods from years 1986 to 2020, Solar Cycles No.22 – No.24



Long and short timescales changes of the solar radio flux, geomagnetic activity and quantity of high energetic particles during 11-year variations of solar cycle.

Versus periods with very low solar activity (SSN~=0, >30 days)

13. 9. 1996 – 24. 10. 1996, 42 days
21. 7. 2008 – 20. 8. 2008, 32 days
31. 7. 2009 – 31. 8. 2009, 31 days
14. 11. 2019 – 23. 12. 2019, 40 days

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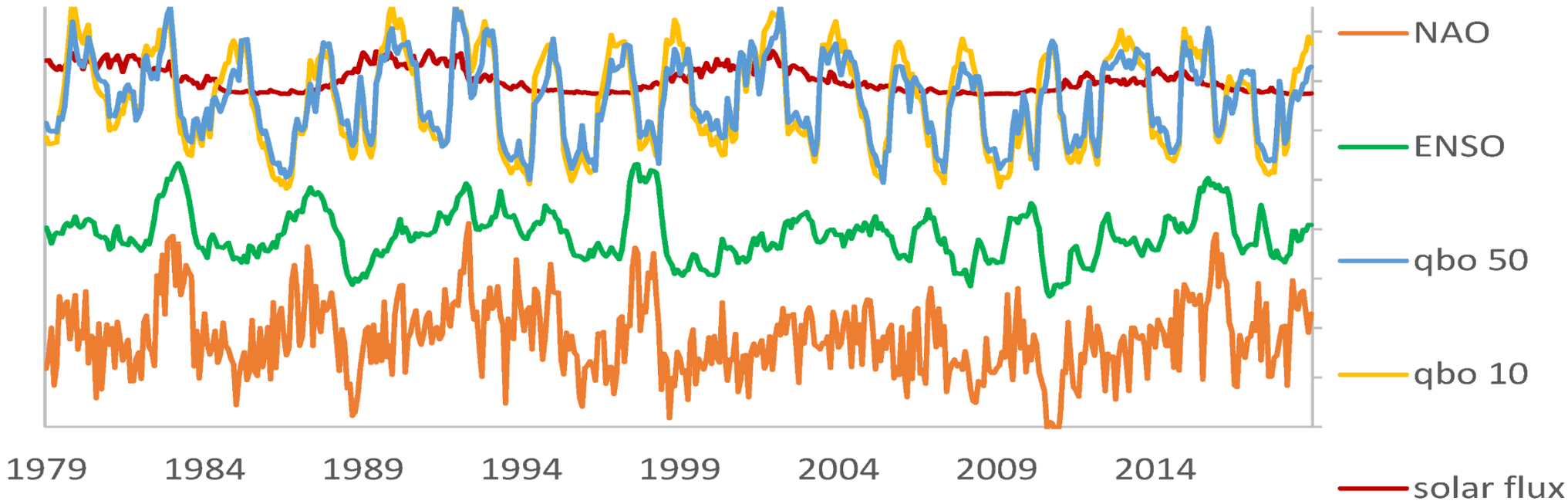
Stratospheric warming related to model data

- ^{7}Be concentrations are higher during the spring and summer months when the stratospheric **^{7}Be penetrates the troposphere** as a result of the exchange of air masses between the troposphere and stratosphere.
- The behavior of **solar radio flux F10.7** is similar for the first three decades but solar activity is clearly weaker during 2010–2020.
- This coincides with our results where the **zonal wind climatology differences** between the decade of 2000–2010 are much larger than those among other decades.

Time series of NAO, ENSO, F10.7 cm, and QBO at 10 and 50 hPa for period 1979–2019

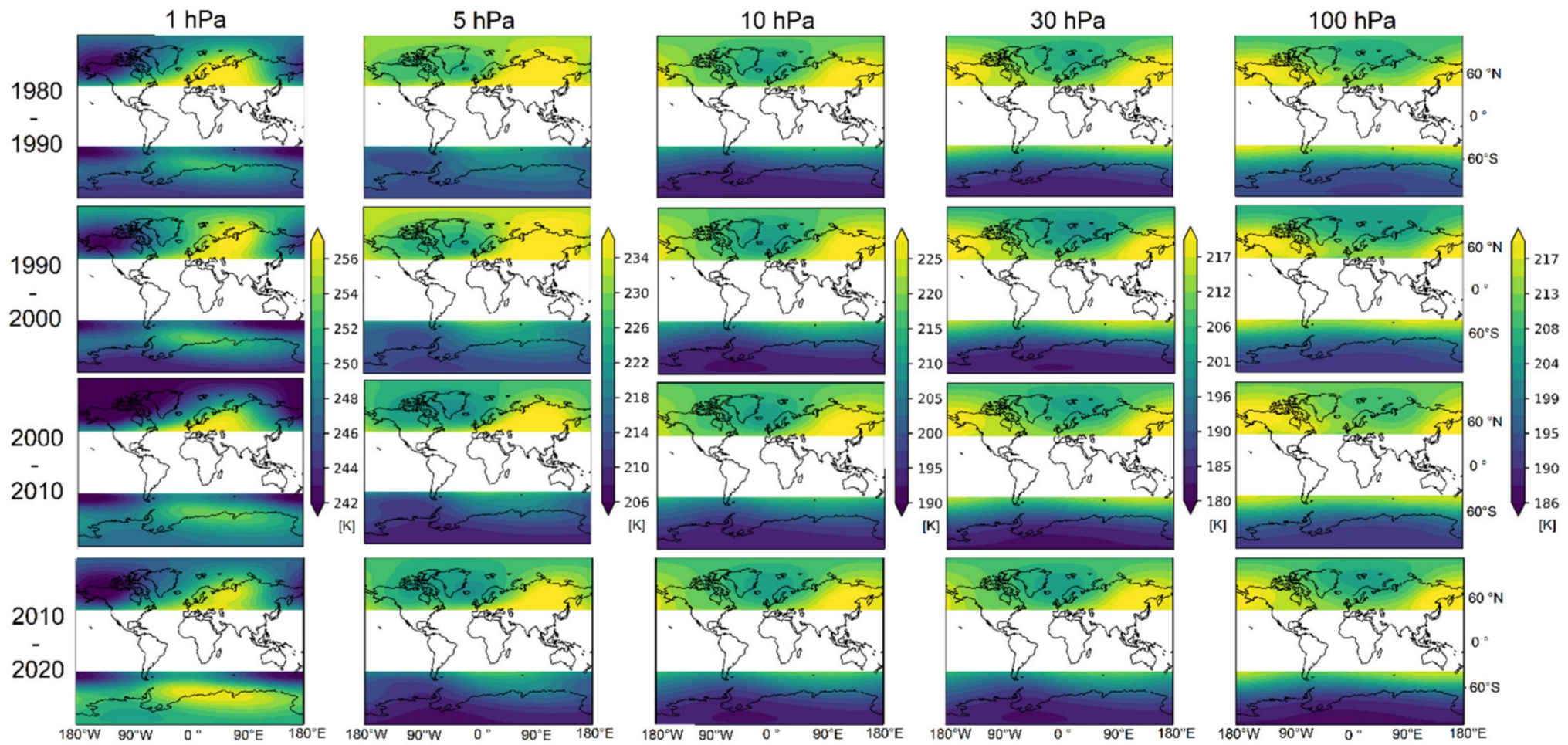


Kozubek M, Laštovička J, Zajicek R. Climatology and Long-Term Trends in the Stratospheric Temperature and Wind Using ERA5. *Remote Sensing*. 2021

Stratospheric warming related to model data

- Stratospheric dynamics parameters (temperature, zonal component of wind, O3)
- ^{7}Be is created in the stratosphere and in the upper troposphere, binds to aerosols and is transported horizontally and vertically by wind and gravity.
- A negative difference between 2000–2010 and 1990–2000 at 5, 10 and 30 hPa.
- This feature is supported by negative change between 2000–2010 and 1980–1990.

Temperature climatology (K) for 1980–1990, 1990–2000, 2000–2010 and 2010–2020 using ERA5 reanalysis at 1, 5, 10, 30 and 100 hPa



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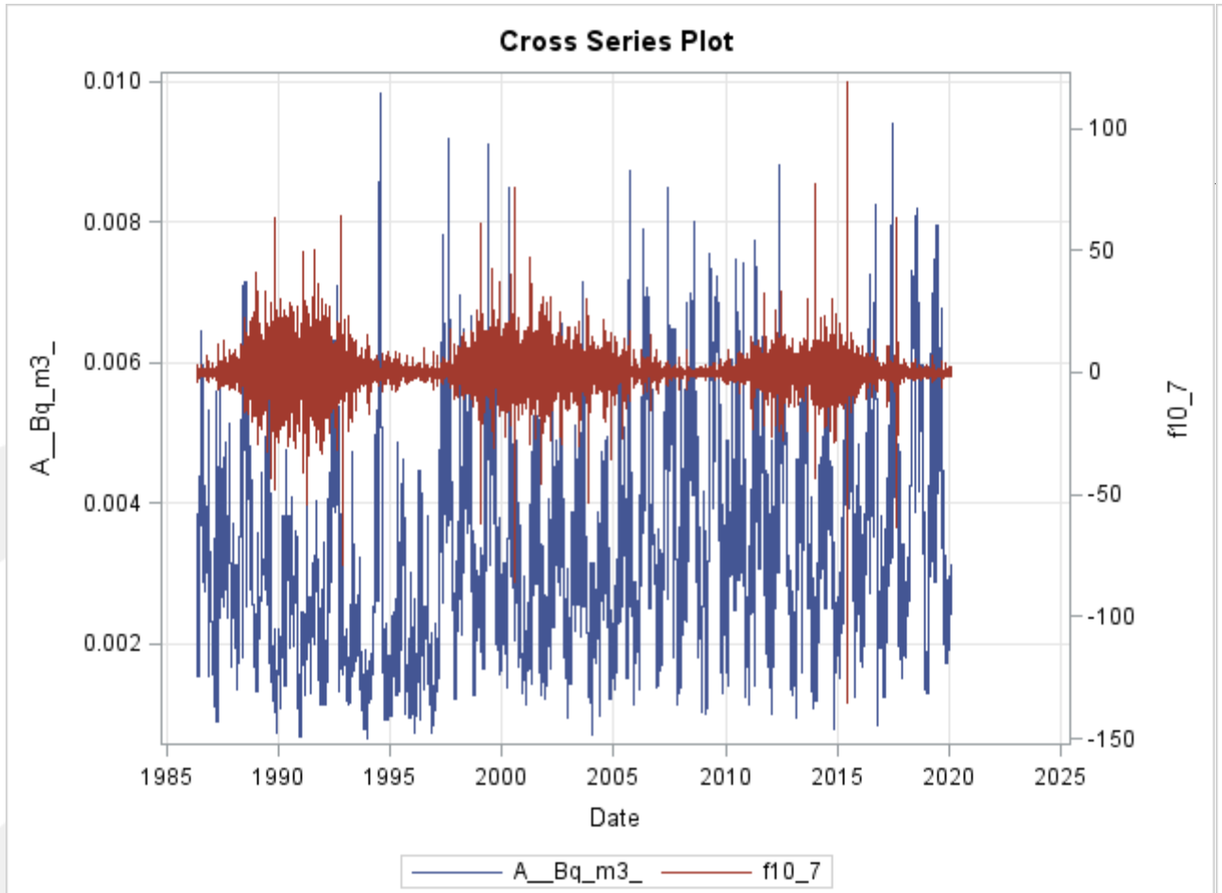
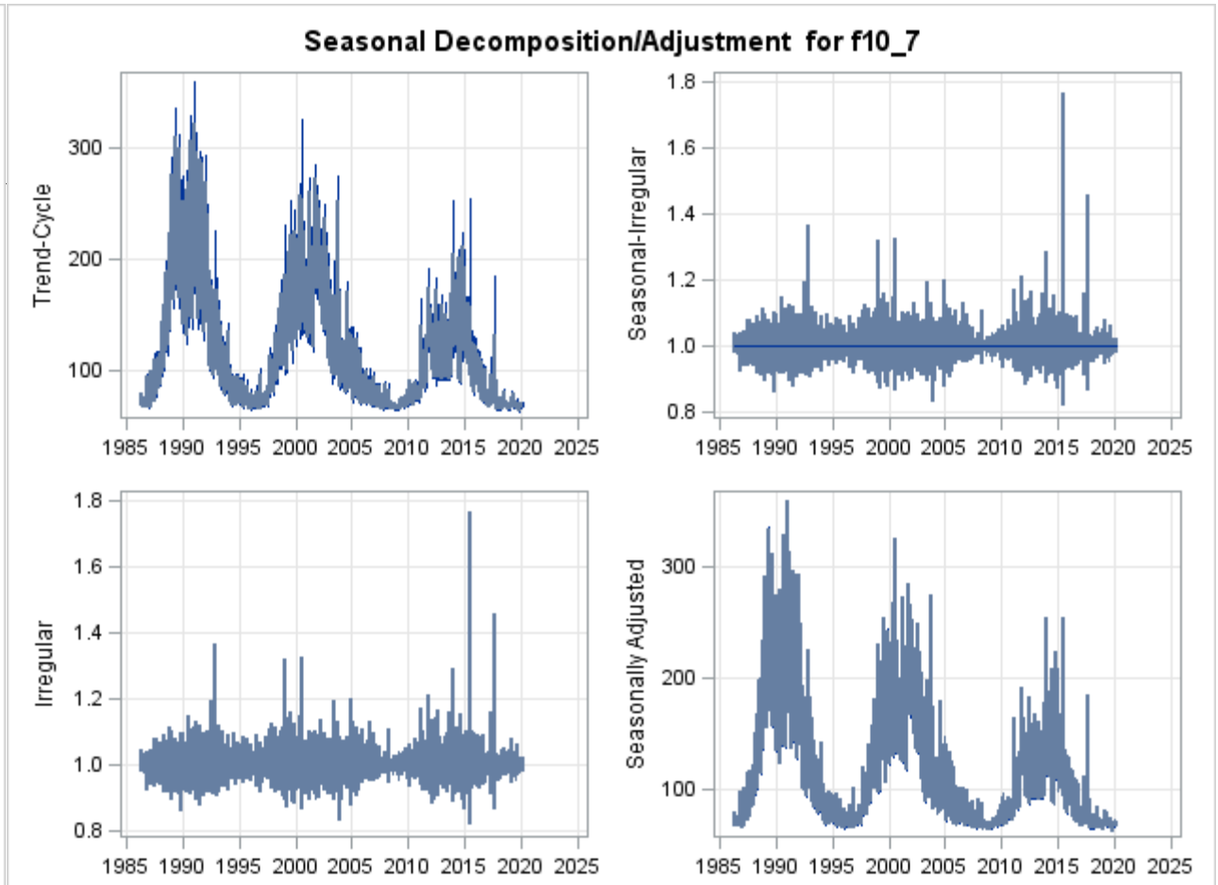
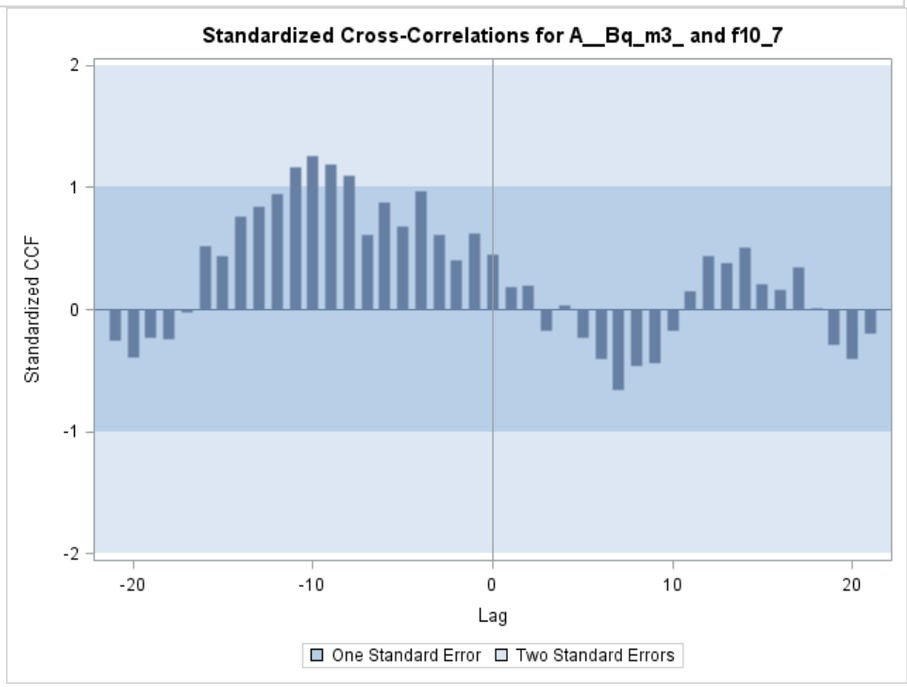
Main results - The effect of space weather, proxy parameters of solar activity, and stratospheric phenomena on the ^{7}Be concentration

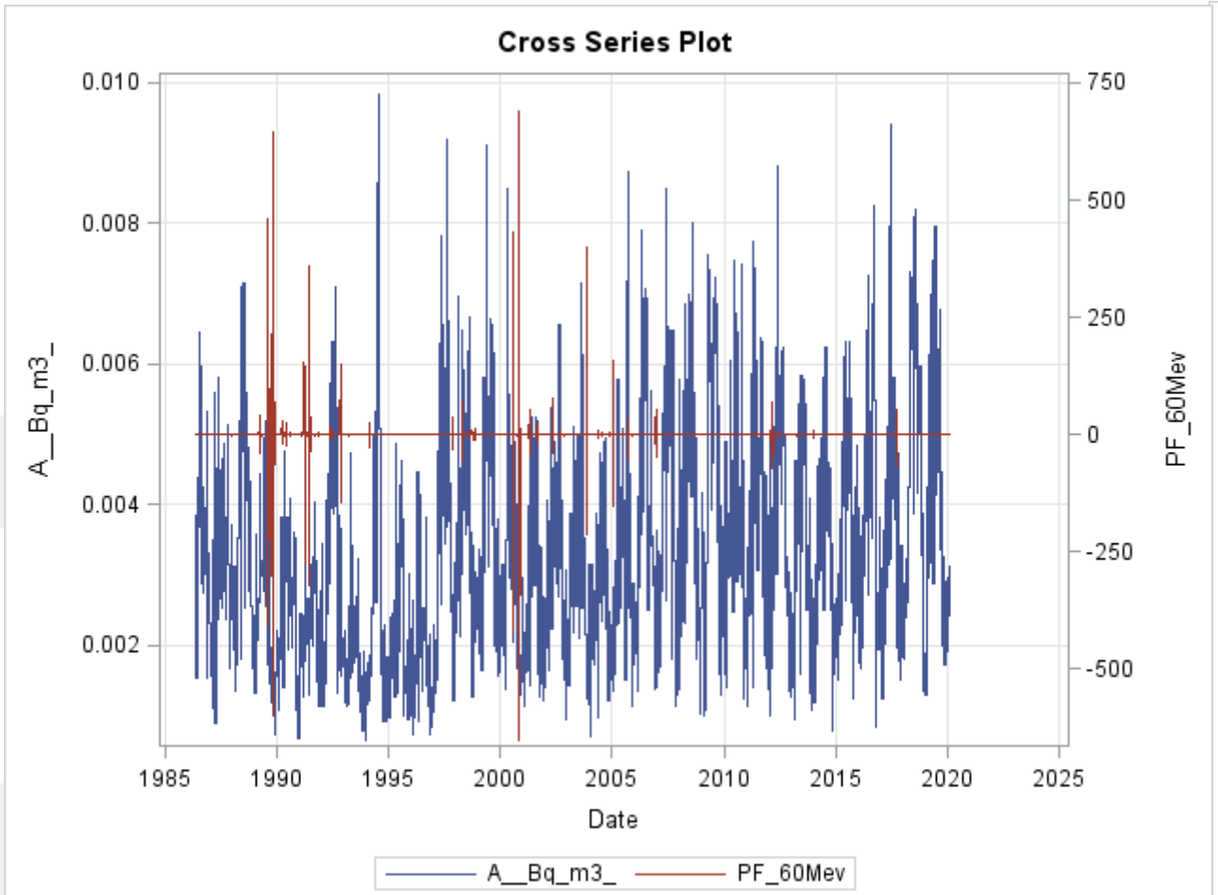


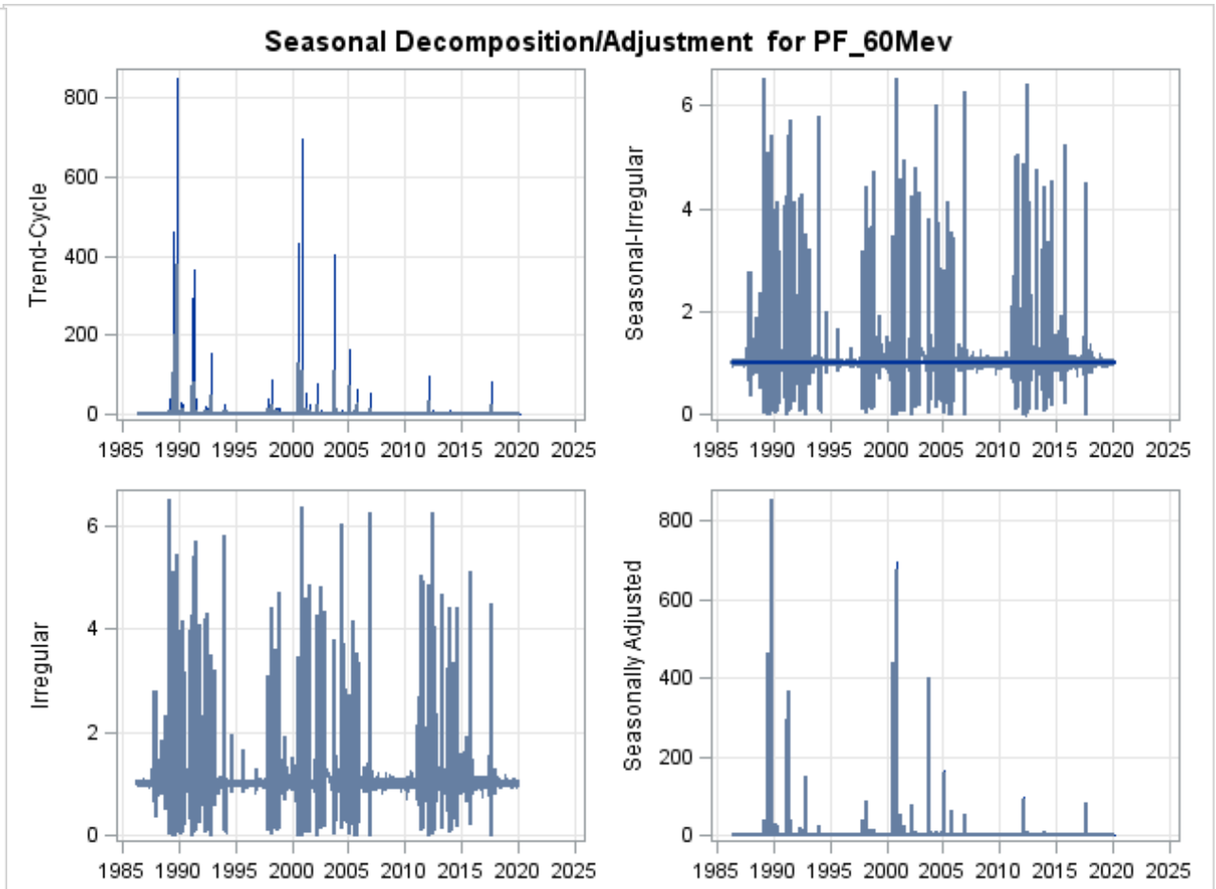


- On **short timescales**, decrease of the intensity of cosmic radiation by few percents in several days.
- In accordance with the assumption, we detected an increase of ^{7}Be concentration.
- Vice versa, during solar maxima the geomagnetic shield is reinforced so that less cosmic radiation reaches the Earth's surface.



Main results - The effect of space weather, proxy parameters of solar activity, and stratospheric phenomena on the ^{7}Be concentration





- On a **longer timescale** and with stronger influence, the intensity of galactic cosmic rays is influenced by the degree of solar activity and by variations in the geomagnetic field.
- Association with long-term trends of stratospheric temperature dynamics.
- During solar maxima the cosmic radiation dose is 10% smaller than when the solar activity is at minima.