Variations of the geomagnetic field and cosmic ray flux in relation to the variability modes of the mid-latitude troposphere

Anna Morozova¹, Juan Jose Blanco², Paulo Ribeiro¹, ³

The Principal Component Analysis of locally measured meteorological parameters (air temperature, T, and geopotential heights, gph) at different pressure levels in troposphere-lower stratosphere regions was used to extract variability modes which strongly resemble variations of space weather (SW) parameters. The study is based on the analysis of locally measured parameters on the Iberian Peninsula (Coimbra-COI, Madrid-CalMa). The time scale of the atmospheric variations analysed in this study is from weeks to months. Three modes of the variations of T and gph at different pressure levels in the mid-latitude low atmosphere show co-variability with global and locally measured SW parameters:

1st mode (common for the whole non-tropical NH stratosphere and include SSW events):
• correlates with the local ground measured CR flux (r = -0.45) and with O₃ (r = 0.75);
• correlates with the QBO phase (r = -0.46).

2nd mode:
• correlates with CR flux, geomagnetic field (COI H, Dst) and ionospheric parameters (TEC): r = -0.3.

3rd mode:
• correlates well with Dst index and COI H (r = -0.45), TEC and solar UV flux: r = 0.25-0.3;
• correlates with the QBO phase (r = -0.4).

1. Variations of the SW parameters measured on the ground (CR, geometric and ionospheric parameters) are related to the solar activity (flares, CMEs etc.).
2. Upper atmospheric conditions (in the thermo/meso/stratospheres) depends also on solar activity (O₃, NOₓ/NOy content, temperature, in particular on the CR and the solar UV flux variations.
3. Lower atmosphere (troposphere, tropopause & lower stratosphere) depends on the upper atmospheric conditions through, mainly, gravity waves propagating both in the vertical and horizontal directions.

3a. Midlatitude troposphere can be affected both from the top (midlatitude the thermo/meso/stratospheres) and through the meridional circulation (influenced by QBO).
3b. Co-variability of the midlatitude tropospheric and SW parameters can be due to:
- the direct regional effect of the SW events on both ionosphere and atmosphere;
- the indirect effect when polar atmosphere reacts first to the SW events and later transfer disturbances at the middle latitudes through circulation.