Factors influencing the regional climate variability of the South-Eastern Europe

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GOALS:

- To identify the key internal and external factors influencing regional climate variability in South-Eastern Europe, focusing on the role of the North Atlantic Oscillation (NAO).
- To assess the role of lower stratospheric ozone and geomagnetic field on regional climate in South-Eastern Europe.
- To explore the mechanisms linking geomagnetic activity, cosmic rays, and ozone with NAO dynamics.
- To analyze the impact of NAO phase shifts on atmospheric circulation and climate conditions in the region.

Table 1 Lagged cross-correlation coefficients of some factors potentially influencing the long-term variability of the NAO.

	Secular magnetic field (SV) for Reykjavik	*Secular magnetic field (SV) for Ponta Delgada*	*Sunspot numbers (SSN)*	*Galactic cosmic rays (GCR)*	*CO_2*	*O_3 for Reykjavik*	*O_3 for Ponta Delgada*
Winter NAO Index	***0.65*** *(32 years)*	***0.71*** *(41 years)*	***-0.65*** *(0)*	***0.42*** *(0)* ***-0.52*** *(46 years)*	*0.27 (30 years)*	***-0.48*** *(22 years)*	***-0.65*** *(2 years)*

Sunspot numbers show the strongest instantaneous external influence on NAO (–0.65). The geomagnetic field, an internal factor, has an even stronger effect—correlating with NAO at 0.71 in Ponta Delgada and 0.65 in Reykjavik. NAO also shows high, statistically significant correlations with GCR and lower stratospheric ozone, suggesting that geomagnetic influence is likely mediated through these two variables.

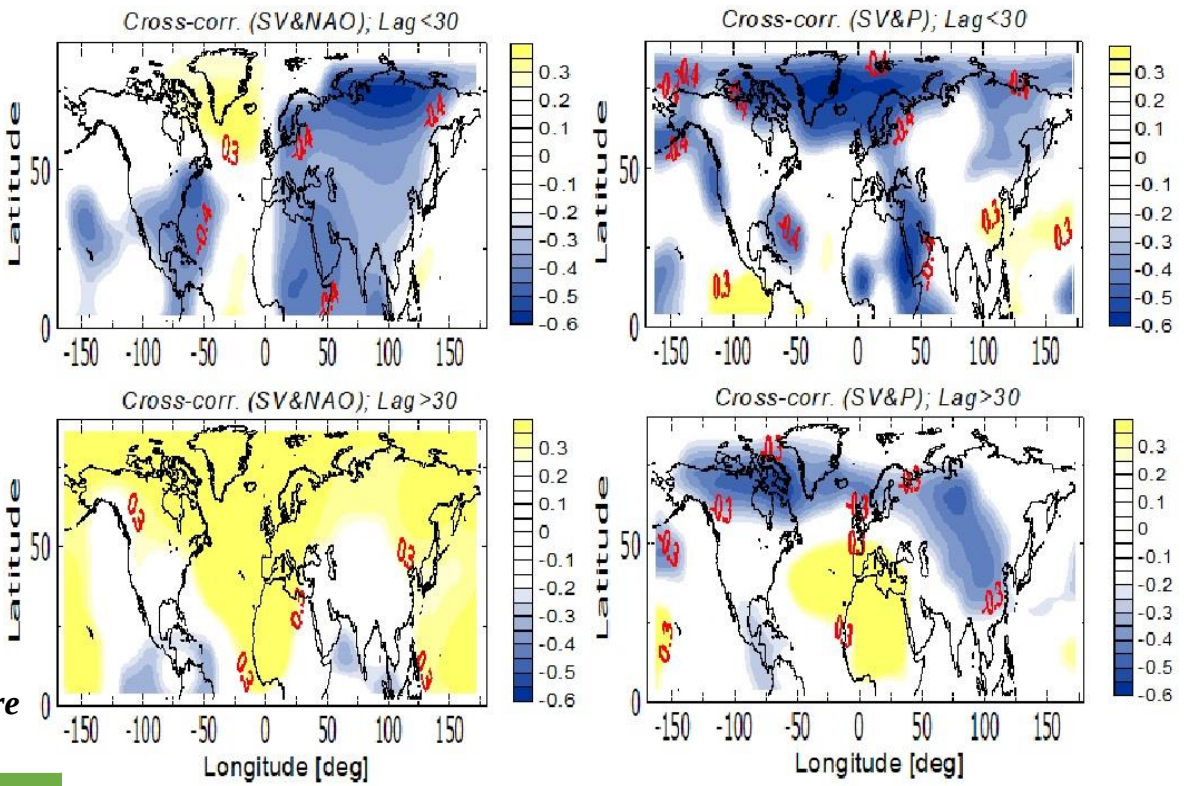

Fig. 1. Correlation maps of secular variations of the magnetic field (SV) with the NAO index (left) and with sea-level pressure (P) (right), for periods shorter than 30 years (upper panels) and longer than 30 years (bottom panels).

The figure shows that geomagnetic–pressure coupling is more informative than geomagnetic–NAO correlation, with two strong coupling regions near the main NAO centers—Azores and Iceland.

Table 2 Correlation coefficients of sea-level pressure P and O_3 at 70 hPa.

O_3 & P correlation	*Instantaneous correlation*
Reykjavik	*-0.83*
Pt. Delgada	*-0.71*

!!! It reveals a strong covariation between the two variables at both NAO centers of action, with no time lag.

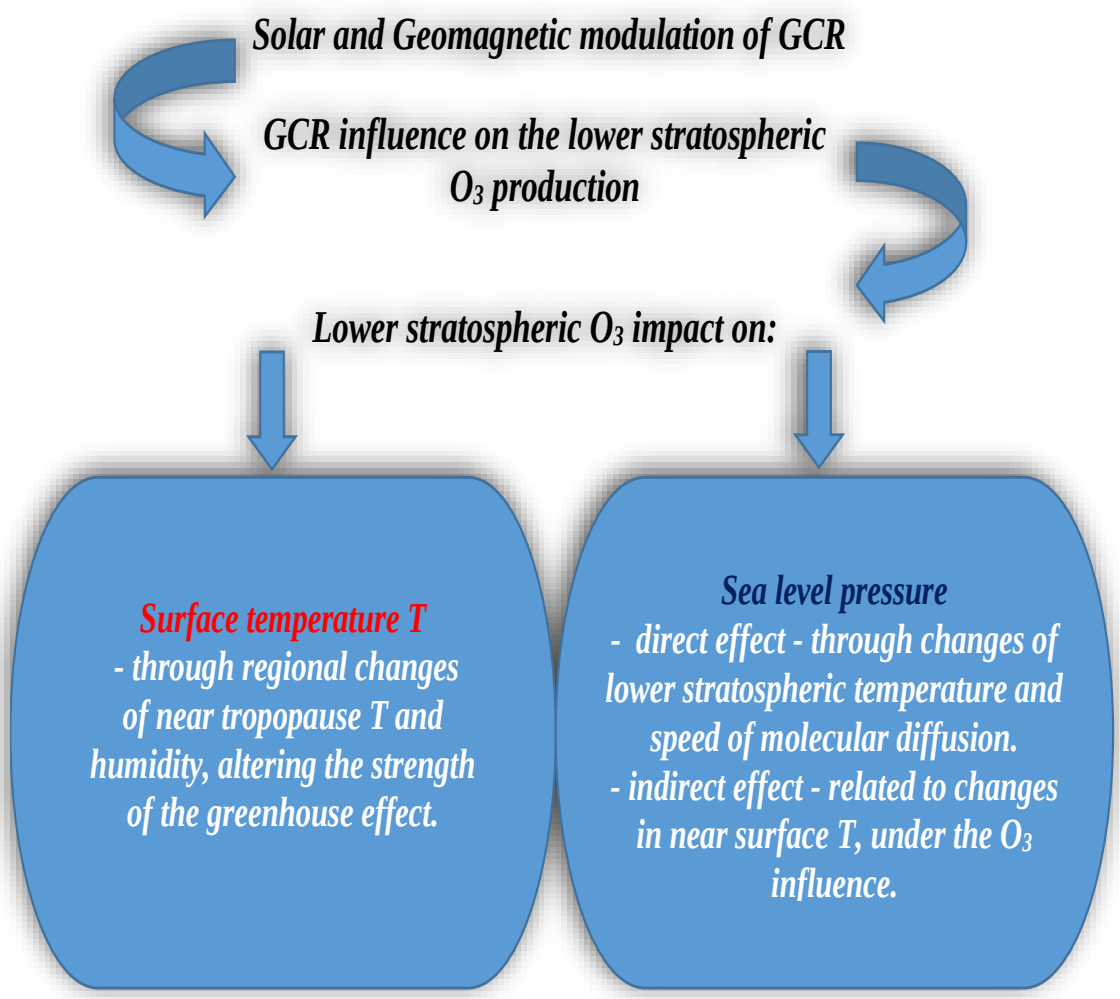

Fig. 2 Scheme of the mechanism of geomagnetic field influence on the surface temperature and pressure.

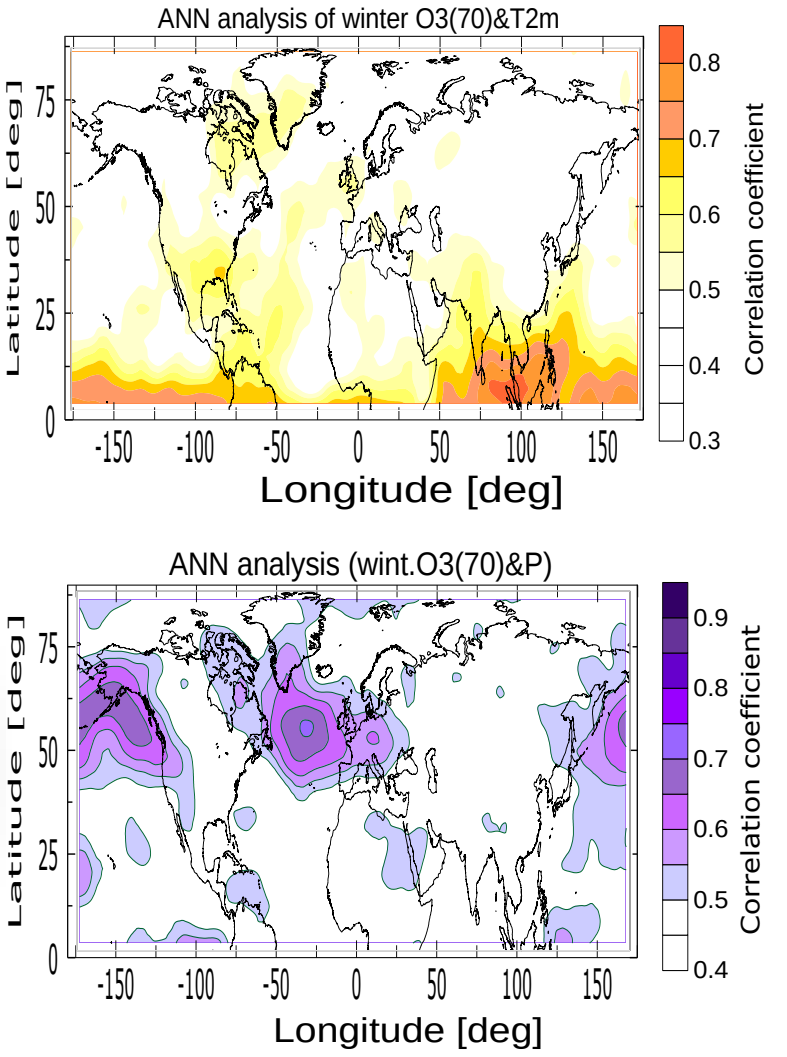

Fig. 3 Spatial distribution of the O_3 at 70 hPa influence on surface temperature (top panel) and sea level pressure (bottom panel).

***Left panel**: Positive NAO shows weak correlation (<0.5) across Northern Europe and the Mediterranean, with stronger signals over Iceland and the central Mediterranean. Westerly flow shifts northward, bypassing the Balkans.*

***Right panel**: Negative NAO yields stronger correlation over Spain, Central–Eastern Europe, and the Black Sea region. Atlantic air masses enter via the Mediterranean, often affecting Greece and Bulgaria through cyclonic activity.*

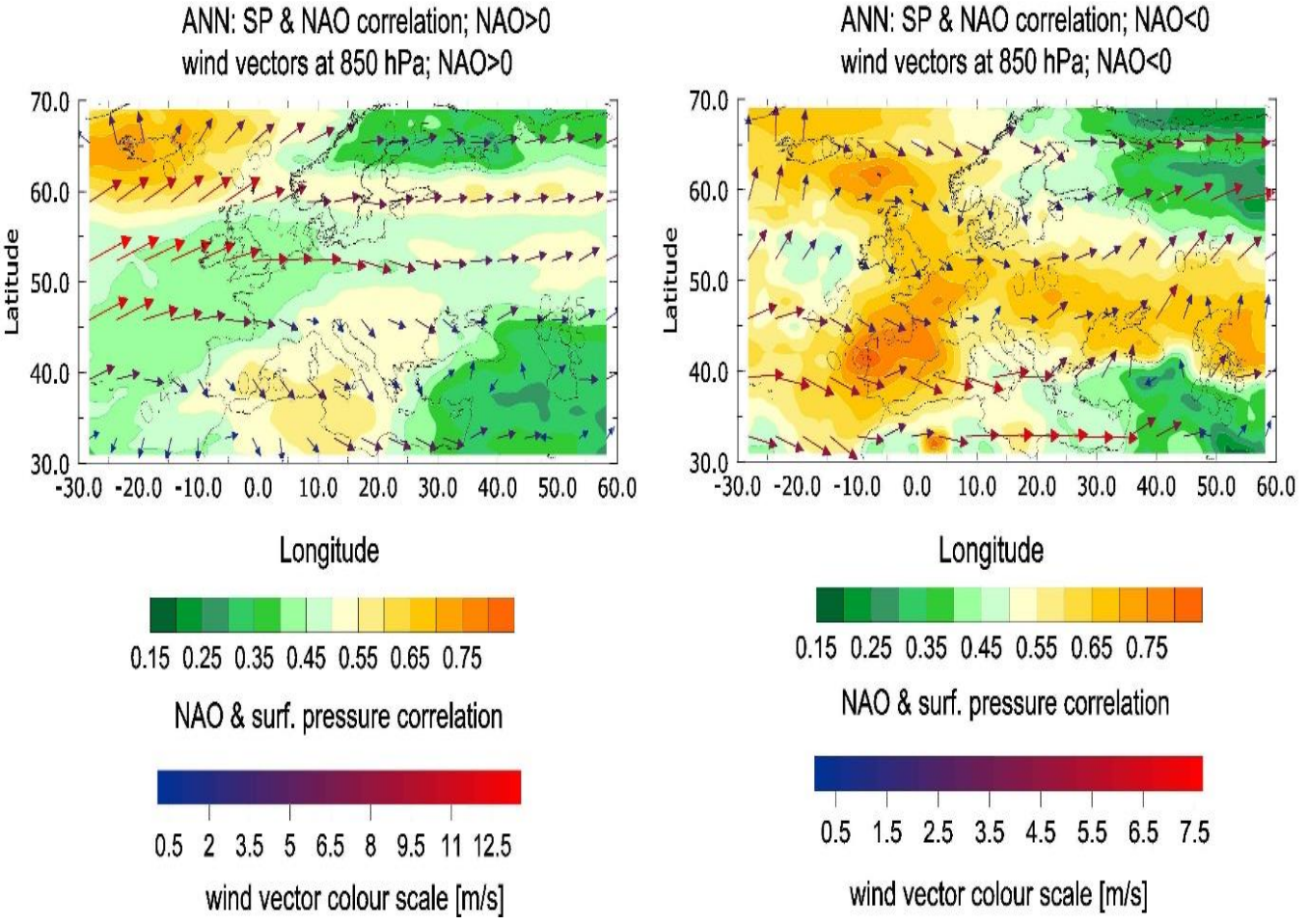

Fig. 4 Correlation map between modeled and observed sea level pressure values during positive and negative NAO phases (1940–2023), with overlaid wind vectors at 850 hPa.

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