Tropospheric impact of Sudden Stratospheric Warmings in Central and Eastern Europe

Robert Hrițac[1], Lucian Sfică[1], Pavel Ichim[1]
[1] Alexandru Ioan Cuza Universit of Iași, Romania
Contact: robert.hritac@gmail.com, lucian.sfica@uaic.ro

INTRODUCTION

- Sudden Stratospheric Warmings (SSWs) are well known to be associated with a downward propagation of circulation anomalies resembling a negative NAM regime.
- However, the actual tropospheric anomalies following SSW events display significant variability.
- Clear links are observed only for a few areas (eg. northern Siberia, Greenland/CAA).
- The relationship between SSWs and tropospheric conditions is less liniar in other areas.

METHODS

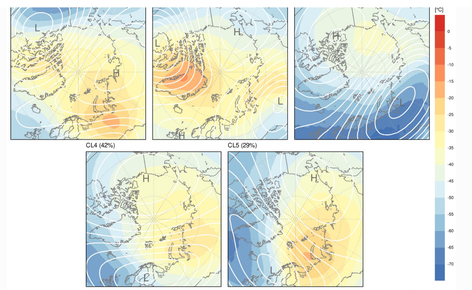
Identification of major SSW events based on 10 hPa 60°N zonal mean zonal wind

→ Classification of SSW events in 5 major types using a k-means cluster analysis method

Main circulation types in Europe were determined using several methods (GrossWetterTypen, k-means)

The tropospheric impact of SSWs was assessed by comparing the frequency of the weather circulation types, along with the mean composite anomalies of several parameters*

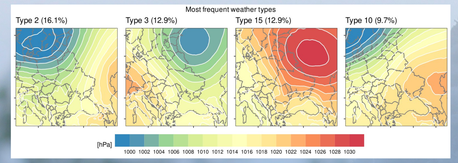
* All parameters were detrended. Statistical significance was tested using a Monte Carlo method; a false discovery rate correction (Benjamini-Hochberg) was applied to account for the effects of multiple testing



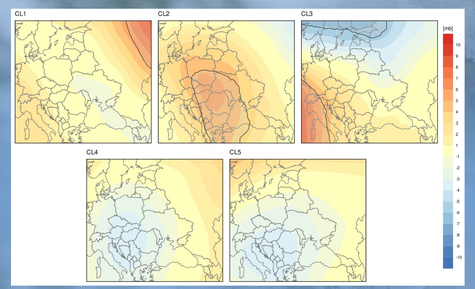
Mean temperature and geopotential height at 10 hPa (60-90°N) on the central date of a SSW for each cluster.

Sudden Stratospheric Warmings can bring both colder and milder weather to Central and Eastern Europe

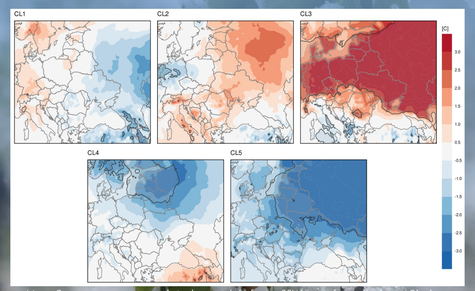
Before SSW



The most frequent continental circulation types one month before a SSW event.

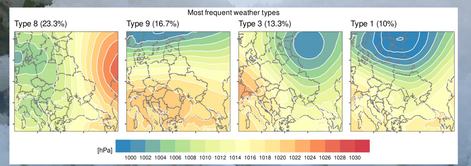


Mean 500 hPa geopotential height anomaly in the month before a SSW event for each cluster. Black contours and shading indicate regions statistically significant at level $\alpha = 0.05$.

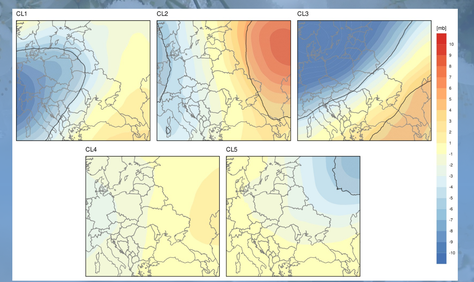


Mean 2m temperature anomaly in the month before a SSW event for each cluster. Black contours and shading indicate regions statistically significant at level $\alpha = 0.05$.

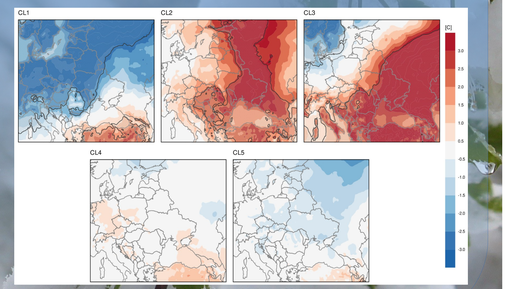
After SSW



The most frequent continental circulation types in the first month after a SSW event.



Mean 500 hPa geopotential height anomaly in the first month after a SSW event for each cluster. Black contours and shading indicate regions statistically significant at level $\alpha = 0.05$.



Mean 2m temperature anomaly in the first month after a SSW event for each cluster. Black contours and shading indicate regions statistically significant at level $\alpha = 0.05$.

RESULTS

- The majority of SSW events (79%) were preceded by either negative or weak temperature anomalies.
- The first 30 days after a SSW event were marked by a significant increase in the frequency of cyclonic conditions, while the second month saw an increase in the frequency of high-latitude blocking. Only 32% of SSWs were followed by negative temperature anomalies in the first month. Positive temperature anomalies persisted even in the second month in 28% of cases.

CONCLUSIONS

- The type and position of the SPV during the SSW event influence the downward propagation of circulation anomalies.
- Split-type SSW events (cluster 1 and 2) tend to be followed by a strong meridional circulation.
- Regular displacement-type events (cluster 4 and 5) are typically preceded by a blocked pattern over Europe and significant negative temperature anomalies. After the SSW, the anomalies are much weaker, reflecting a weaker and slower downward propagation of circulation anomalies from stratosphere to troposphere.

DATASETS USED

- ECMWF Reanalysis v5 (ERA5)
- NCEP-DOE AMIP-II Reanalysis (R-2)