The use of classifications from the COST733 database to detect effects of the 11-year solar cycle on atmospheric circulation over Europe

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• Wolf numbers (R) (~numbers of sunspots)
• solar radio flux 10.7 cm (F10.7)
• (the choice of variable has only a minor effect on results)

• modes of low-frequency variability
• Arctic Oscillation
• teleconnectivity
• blocking activity
• cyclonic activity
• circulation effects on surface climate
• frequency of synoptic types

mechanisms?
Mechanisms of the effects
Sun → Earth

- several potential mechanisms
- so far unclear, which of them are really acting and how much they contribute
- a new COST Action on it
**Potential mechanisms**

- stratospheric ozone: change in UV radiation $\rightarrow$ $O_3$ concentration $\rightarrow$ stratospheric temperature $\rightarrow$ stratospheric circulation $\rightarrow$ downward propagation of the signal to the troposphere
- change of currents in the global electric circuit $\rightarrow$ atmospheric circulation
- changes in concentrations of particles of cosmic origin $\rightarrow$ condensation nuclei $\rightarrow$ clouds
- direct heating of ocean surface $\rightarrow$ feedbacks with cloudiness $\rightarrow$ atmospheric circulation
Data & Methods

- monthly mean values
- extended winter (XII – III)
- main methodological concept: division of data according to the solar activity into three groups (low, medium, high)
- separate analysis in each solar activity class
Solar activity classes

- a) division into halves
- b) division into thirds
- c) division 25:50:25
- d) max / min defined subjectively regardless of the amplitude
SYNOPTIC TYPES

- grouped into 10 ‘major types’ and 6 ‘supertypes’
- mean SLP anomaly maps

from COST733 database v2.0
- for SLP
- have 11 types or fewer
- for domain D07 (central Europe)
- SANDRA and SOM are identical ➔ only SANDRA is retained
- altogether 17 class’s
- types are characterized by mean anomaly maps (centroids) for 500 hPa heights
METHODOLOGY

what’s calculated:
- mean frequencies of types (supertypes)
- for each solar activity class

statistical significance testing
- is the frequency in the given solar activity class different from the (long-term) mean frequency of the type?
- using block resampling
westerly

<table>
<thead>
<tr>
<th></th>
<th>low</th>
<th>medium</th>
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<tbody>
<tr>
<td>solar</td>
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northwesterly

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northerly

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northeasterly

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easterly

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The southeasterly region is depicted with two diagrams labeled SEz and SEa, each showing a color-coded map with low, medium, and high intensity levels.

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southerly

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southwesterly

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central European high

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central European low

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<td>1,4</td>
<td>1,1</td>
<td>2,5</td>
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Relative frequency
(1.0 = climatological mean)

**major types**

- **W / E types** – less / more frequent in solar minima
  - moderate vs. high solar activity – little difference

- **A / C types** – less / more frequent in moderate solar activity

**supertypes**

- **NW + NE types** – most frequent in moderate solar activity

- **N types** – less frequent in solar maxima
Most striking effect – for quarters stratification:
- low solar activity: W types less than twice as frequent as E types (39.5% vs. 20.4%)
- moderate solar activity: W types almost four times more frequent than E types (49.5% vs. 12.8%)
COST733 class's

ordered by the frequency ratio high / low solar activity

i.e.

- (top) left: types most frequent under low solar activity / least frequent under high solar activity
- (bottom) right: types most frequent under high solar activity / least frequent under low solar activity
Example 1: GWT
Example 2: JCT
All classifications together: types significantly more frequent in minima / types with easterly flow prevail.
All classifications together: types significantly more frequent in maxima / less frequent in minima

types with westerly flow prevail
CONCLUSIONS

- effects of solar activity on NH tropospheric circulation are significant, some are surprisingly strong

- in solar maxima:
  - zonalization of flow over North Atlantic and Europe