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Detecting Regional Patterns of Weekly Weather Cycles across Europe

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Introduction

Daily rainfall and temperature data of 158 weather stations in 8 European countries and Iceland are investigated to set up a weekly cycle. The time series are divided into 5 time slices that are analysed separately. The time series have different levels of urban influence. Analysis covered the variables of *precipitation*, *mean temperature*, *minimum temperature*, *maximum temperature*, and *diurnal temperature range* (DTR) in the following past and ongoing climatological normal periods: i) **1871-1900**, ii) **1901-1930**, iii) **1931-1960**, iv) **1961-1990**, and v) 1**991-2005**..

Methodology

1. *Each value of the time series day is assigned to the respective weekday (7 bins); gaps in data are excluded from calculations;*
2. *The* ***anomalies*** *are calculated for the temperature variables by removing the annual cycle. For rainfall, the weekday means are analyzed instead of their anomalies;*
3. *The mean values of each weekday (bin) is calculated. These mean values represent the weekly cycle;*
4. *The weekday with the maximum and minimum mean values are determined, and the* ***difference between maximum and minimum mean value Θ*** *is calculated;*
5. *A* ***t-test*** *is carried out on the α = 0.05 and α = 0.01 significance levels to decide whether the mean values of the highest and lowest weekday populations differed significantly from each other.*
6. *Additionally, a* ***stationary block bootstrap resampling method*** *is applied to prove the existence of weekly cycles. Blocks of a measured time series of fixed lengths are drawn randomly in order to maintain the temporal dependence structure of the time series. These blocks are randomly rearranged. The block length is varied successively from 1 to 50 and 100 rearranged time series (realizations) are taken for each block length. For each realization, the steps 1 - 4 are performed.*

Results

Fig. 1 shows clear weekly signal for the ***mean temperature*** anomaly for the period 1991-2005. A clear weekly signal can be observed: Thursday is found to be the day with the highest mean temperature anomaly for the bulk of the stations. The lowest mean temperature anomaly occurs on Saturday.

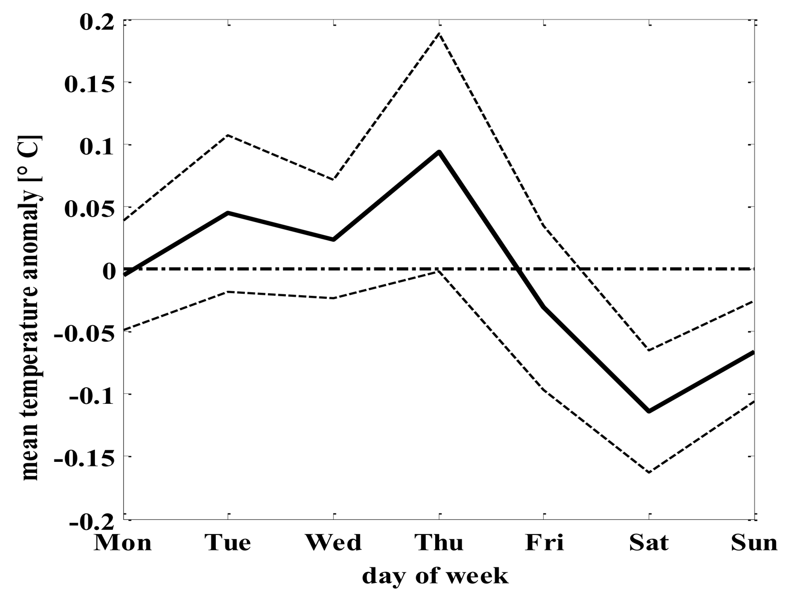


Fig. 1: Mean temperature anomaly of 43 meteorological observation stations in Germany by day of week (1991-2005). The thick solid line represents the mean values and the dashed lines the standard deviation.

The ***mean DTR*** and the ***maximum temperature*** anomalies show weekly periodicities similar to those of the mean temperature anomalies (Laux & Kunstmann, 2008). The cross-national distribution of the weekly cycle in terms of the weekday holding the maximum and minimum mean temperature is illustrated in Fig. 2. Clear regional patterns are observed. For the coastal region of the North Sea, the mean temperature anomaly is maximal for Tuesday and.minimal for Saturday for many observation stations. Similar regional patterns are observed for the other temperature variables. For ***precipitation***, no significant weekly cycle can be identified. Fig. 3 shows the difference

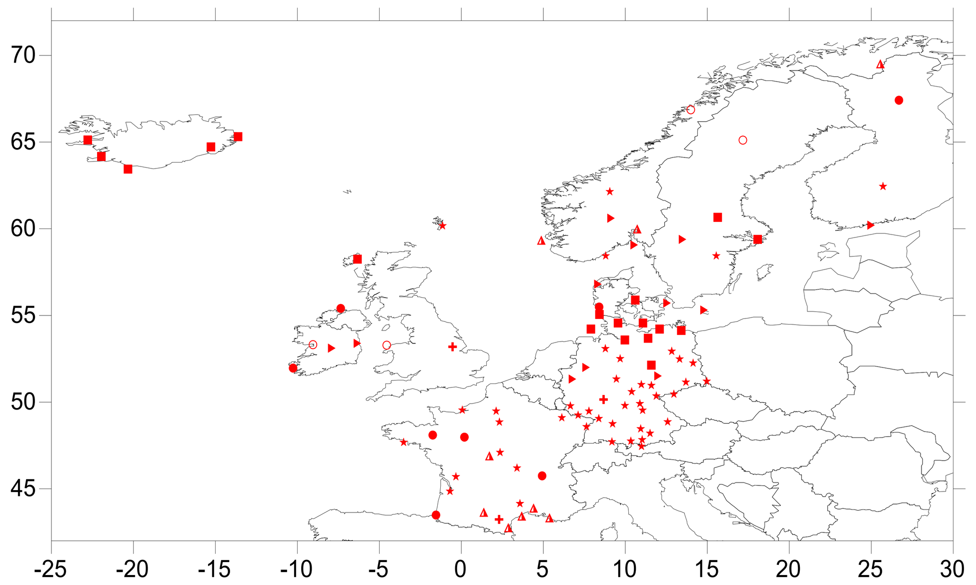
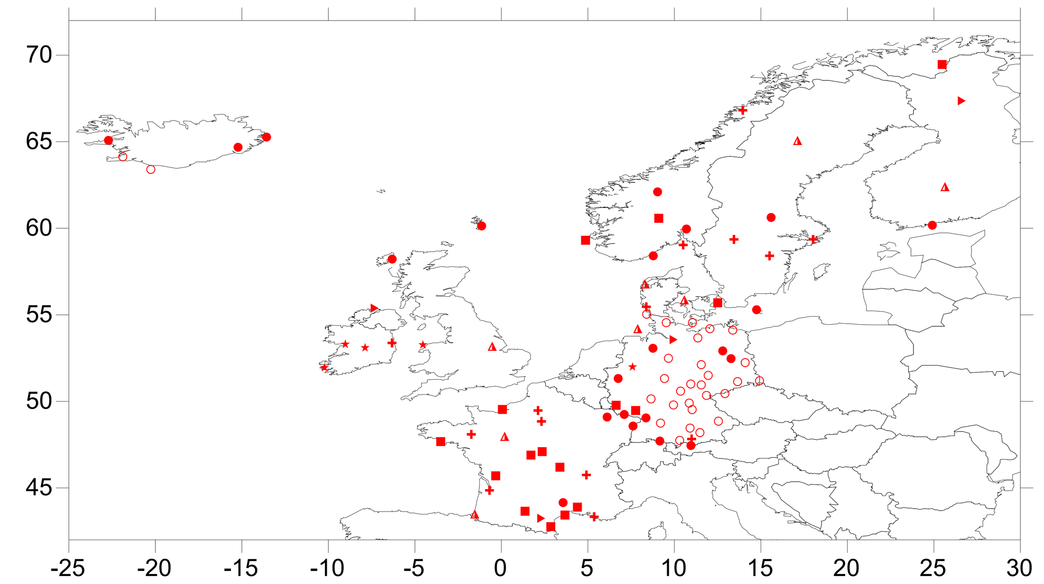


Fig. 2: Weekday with maximum (left) and minimum (right, top) mean temperature from 1991-2005. (✚ Monday; ■ Tuesday; ▶ Wednesday; ★ Thursday; ▲ Friday; ○ Saturday; ● Sunday).

between minimum and maximum mean values Θ for the bootstrap samples in dependence of the block lengths for T_{max} in Augsburg(1991-2005). Rearranging the artificial time series in blocks of 7 or a multiple of 7 days leads to



the highest cycles in the meteorological variables in terms of the difference of the maximum and the minimum mean weekday values. Choosing block lengths greater or less than 7 reduces Θ, a measure for the magnitude of a cycle. The only conclusion one can draw is that there **must exist a significant weekly weather cycle.**
The most frequent circulation pattern CP1 (cyclonic west) is found to follow a weekly cycle (Fig. 4) which is in good agreement with the weekly cycle of the mean temperature anomaly for the stations in Germany. We conclude that the weekly temperature cycles might be influenced by the ***atmospheric circulation***, which is possibly ***triggered by regional accumulation of air pollutants*** in the lower atmosphere.

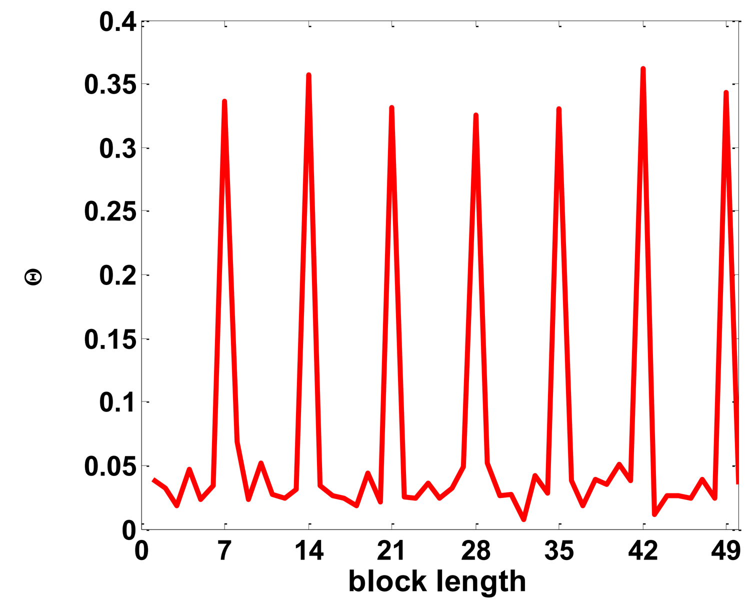


Fig. 3: Difference of the minimum and maximum mean values Θ for 100 bootstrap samples in dependence of the block lengths for T_{max} observation station Augsburg (1991-2005).

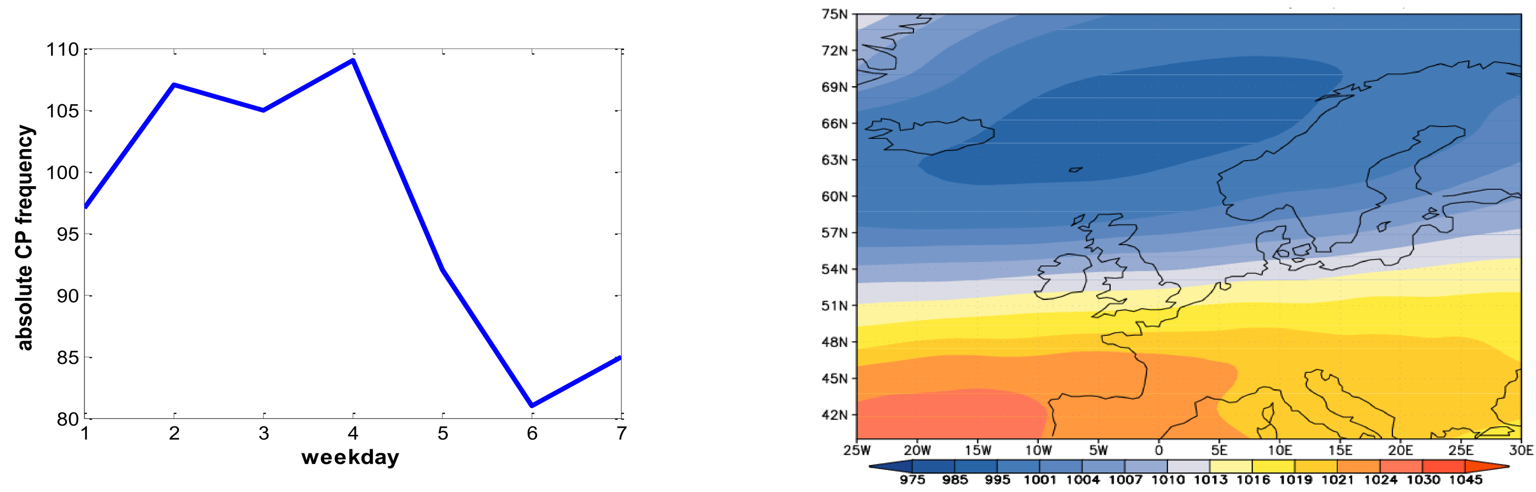


Fig. 4: Occurrence frequency of circulation pattern CP1 for each weekday for 1991-2005 (left). SLP composite of CP1 (*cyclonic west situation)* (right).

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