Rethinking large-scale weekly cycles in Central Europe

Arturo Sanchez-Lorenzo [1], Patrick Laux [2], Martin Wild [1], Josep Calbó [3]

[1] ETH Zürich, Zürich, Switzerland (arturo.sanchez@env.ethz.ch)

[2] Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen, Germany

[3] Group of Environmental Physics, University of Girona, Girona, Spain

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Karlsruhe Institute of Technology

Universitat de Girona

1. Motivation

- Several recent works have generated a controversy about the reliability of non-urban weekly cycles over large-scales in Europe (see Section 3 in **XY83 Poster** for more details).
- Using different climatic variables, Bäumer and Vogel (2007) and Laux and Kunstmann (2008) showed significant annual weekly cycles over Germany. Contrarily, Hendricks Franssen (2008) and Barmet et al. (2009) did not find any significant annual weekly cycles over Switzerland. These two latter works mainly focused their analysis on precipitation, which is well-known as a climatic variable with high variability, and consequently it is more difficult to detect any significant change in their series.
- Recently, Stjern (2011) studied climate series in the border of Germany, Poland and Czech Republic, with no evidence of significant weekly cycles in rainfall variables, being only slightly evident in summer **total cloud cover** (**TCC**) series.

2. Data and methods

Data

- 32 TCC series in Switzerland and Germany (Fig. 1), since the end of the 19th century (Fig. 2). Daily anomalies using **average percent departures** (APD) for each day of the week (Georgoulias and Kourtidis, 2011).

Regionalization

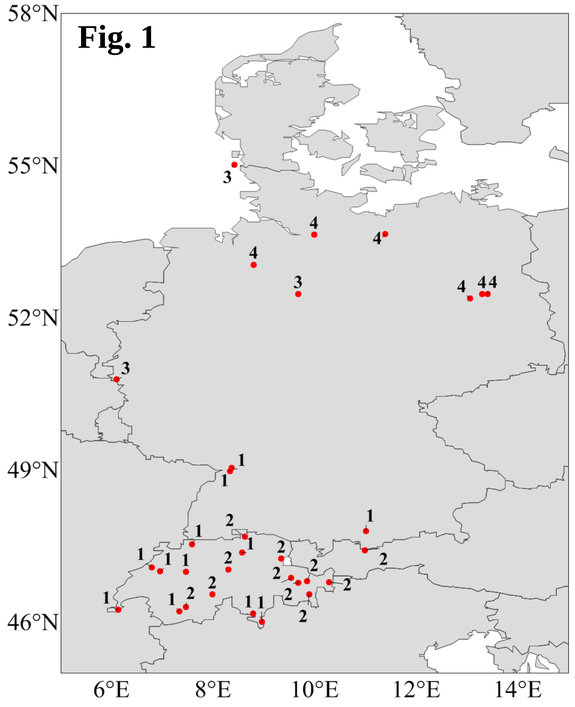
- Monthly means are calculated for each day of the week for the 32 TCC series using the common period. K-means cluster analysis to a matrix with the 32 variables (32 series) and 84 cases (12 months x 7 days) **4 clusters/regions** are defined (Fig. 1).

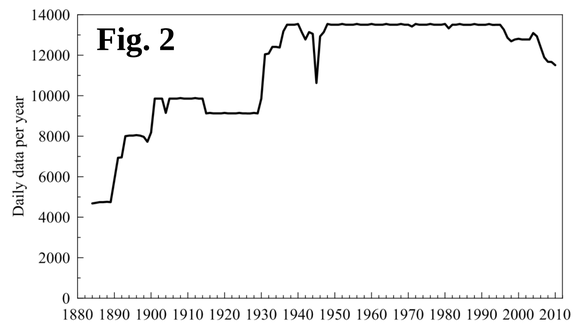
Regional series

- Daily ADP means for each group of the clustered series, and then annual and seasonal means for each day of the week and year.

Statistical tests

- A two tailed t-test and Kruskall-Wallis non-parametric test were performed to decide whether the mean and median week day APD anomalies are significant different from each other. Also a stationary block bootstrap resampling method was applied to prove the existence of weekly cycles.



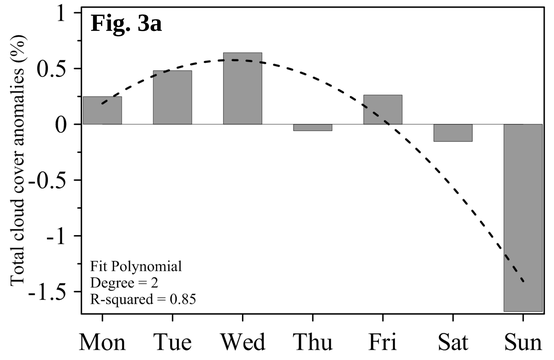


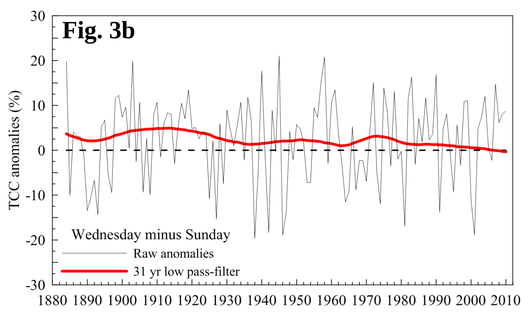
3. Summer weekly cycles

- Although more significant results are found, here only the summer (JJA) results for the Cluster 2 and 4 are showed due they have the largest weekly amplitude. Both t-test and Kruskal-Wallis test indicate that the mean and median differences are significant ($\alpha \leq 0.05$), respectively.
- Cluster 2 series shows a clear maximum centered in Tuesday/Wednesday, and a strong minimum on Tuesday (Fig. 3a). These differences are nearly constant since late 19th century, although with a tendency towards a decrease in amplitude during the last decades (Fig. 3b).
- For Cluster 4, a near opposite weekly pattern is found (Fig. 3c), with minimum (maximum) in Tuesday (Saturday). These results seems to agree with the annual rainfall and JJA TCC weekly cycles found by Bäumer and Vogel (2008) and Stjern (2011), respectively. Interestingly, the time evolution of the weekly cycle amplitude (Fig. 3d) show a tendency towards a change in the sign of the differences during the 1920s-1960s period.
- As Bell et al. (2008) suggested, the spatial and temporal (on inter-annual and intra-annual resolution) expected physical differences in the magnitude of the weekly cycles might be taken into account when weekly cycles are studied. For this reason, the commonly used "weekend effect" differences (Sat-Mon minus Wed-Fri) not seems the most convenient approach to study weekly cycles (Fig. 3e).

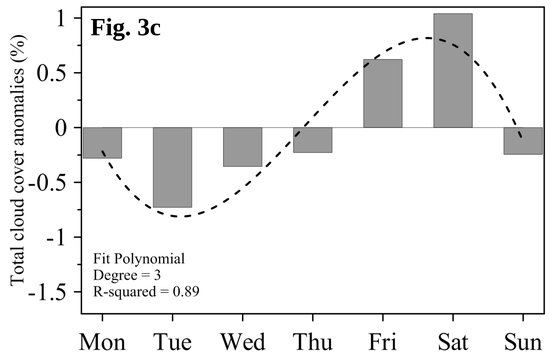
Day of the week | **Time evolution**

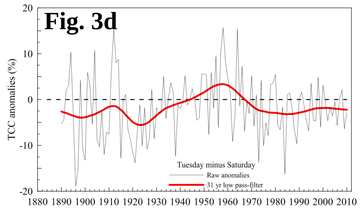
Cluster 2

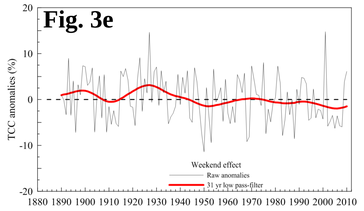




Cluster 4







References

Barmet, P., T. Kuster, A. Muhlbauer, and U. Lohmann *(2009), J. Geophys. Res., 114, D05206, doi:10.1029/2008JD011192.*

Bäumer, D., and B. Vogel *(2007), Geophys. Res. Lett., 34, L03819, doi:10.1029/ 2006GL028559.*

Bell, T. L., D. Rosenfeld, K.-M. Kim, J.-M. Yoo, M.-I. Lee, and M. Hahnenberger *(2008), J. Geophys. Res., 113, D02209,doi:10.1029/2007JD008623.*

Georgoulias, A.K. and Kourtidis, K.A.*(2011), Atmos. Chem. Phys. Discuss., 11, 1385-1428.*

Hendricks Franssen, H. J. *(2008), Geophys. Res. Lett., 35, L05802, doi:10.1029/2007GL031279.*

Laux, P., and H. Kunstmann *(2008), Environ. Res. Lett., 3, 044005, doi:10.1088/1748-9326/3/4/044005.*

Stjern, C.W. *(2011), Atmos. Chem. Phys. Discuss., 11, 1777-1801.*

Acknowledgments: *This research was supported by the Spanish Ministry of Science and Innovation project NUCLIERSOL (CGL2010-18546). The first author was granted by a postdoctoral position funded by the government of Catalonia (2009 BP-A 00035).*