Large-scale weekly cycles of meteorological variables: a review

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Abstract

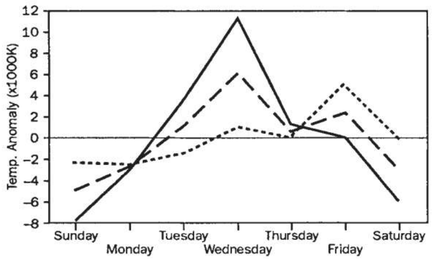
There is still an ongoing scientific debate whether weekly cycles of meteorological variables (temperature, precipitation, cloudiness, etc.) in large domains, which can hardly be related to urban effects, exist or not. In addition to the lack of the positive proof for the existence of these cycles, their possible physical explanations have been controversially discussed during the last years.

In this work we review the main results about this topic published during the recent two decades, including a summary of the existence or non-existence of significant weekly weather cycles across different regions of the world. Also a brief summary of the suggested reasons, especially focusing in the aerosol-cloud-radiation interaction, are presented.

1. Brief history of the non-urban weekly cycles

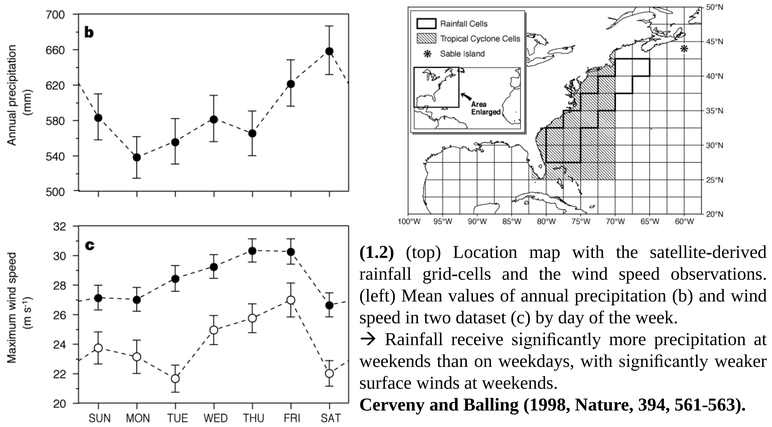
- First paper by Gordon (1994, **1.1**), analyzing temperatures for the lower troposphere recorded by NOAA satellites.
- The second main work published in 1998 by Cerveny and Balling (**1.2**), focusing in the Atlantic coast of the U.S.
- Forster and Solomon (2003, **1.3**) analyzed the "weekend effect" in diurnal temperature range (DTR) for many stations worldwide.
- Subsequent interest on the topic until nowadays.

1.1



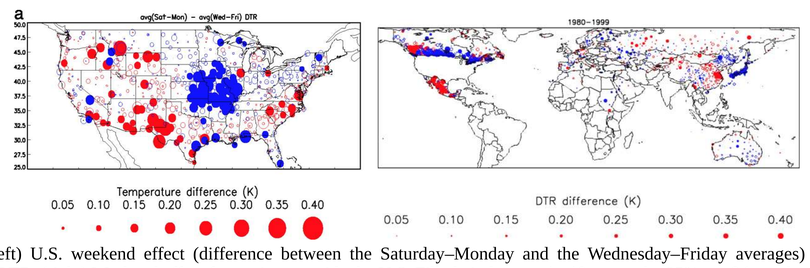
(1.1) Mean temperature anomalies for the lower troposphere. Solid line, Northern Hemisphere; dotted line, Southern Hemisphere; dashed line, globe.
→ The results showed significant temperature differences between the Wednesday and Sunday in the Northern Hemisphere, whereas not significant differences are found for the Southern Hemisphere.
Gordon (1994, Nature, 367, 325–326).

1.2



(1.2) (top) Location map with the satellite-derived rainfall grid-cells and the wind speed observations. (left) Mean values of annual precipitation (b) and wind speed in two dataset (c) by day of the week.
→ Rainfall receive significantly more precipitation at weekends than on weekdays, with significantly weaker surface winds at weekends.
Cerveny and Balling (1998, Nature, 394, 561-563).

1.3

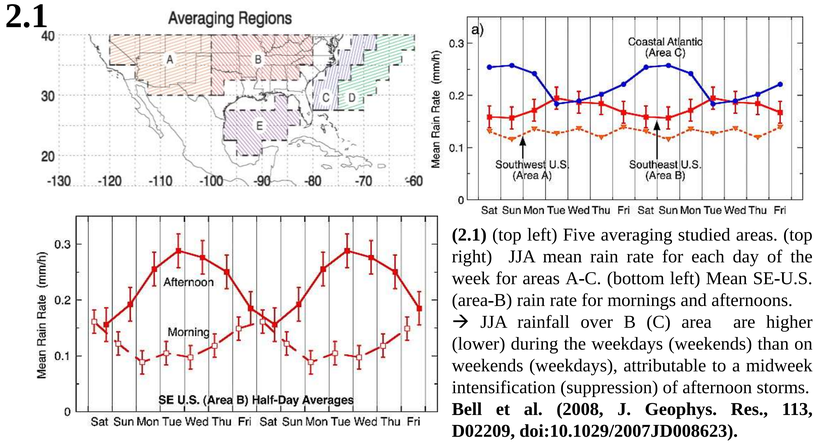


(1.3) (left) U.S. weekend effect (difference between the Saturday–Monday and the Wednesday–Friday averages) in annual DTR. (right) Weekend effect for stations outside the U.S. Filled circles are significant at the 95% confidence level.
→ Evidences of a weekly cycle in DTR for many stations in the U.S., Mexico, Japan, and China. This weekend effect has a distinct large-scale pattern and its sign is not the same in all locations.
Forster and Solomon (2003, PNAS, 100, 11225–11230)

2. North America: summer evidences

- Although there are some papers with no evidences of weekly cycles over the U.S. (De Lisi et al., 2001; Schultz et al., 2007), numerous papers lead Dr. Thomas Bell (Bell et al., 2008 **2.1**, 2009a, 2009b) suggest recent summer weekly cycles over S.E. U.S.
- Interesting results by Kim et al. (2010, see **XY90** Poster)

2.1

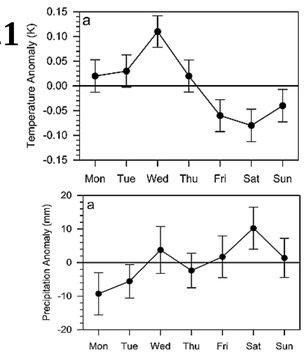


(2.1) (top left) Five averaging studied areas. (top right) JJA mean rain rate for each day of the week for areas A-C. (bottom left) Mean SE-U.S. (area-B) rain rate for mornings and afternoons.
→ JJA rainfall over B (C) area are higher (lower) during the weekdays (weekends) than on weekends (weekdays), attributable to a midweek intensification (suppression) of afternoon storms.
Bell et al. (2008, J. Geophys. Res., 113, D02209, doi:10.1029/2007JD008623).

3. Europe: controversies and uncertainties

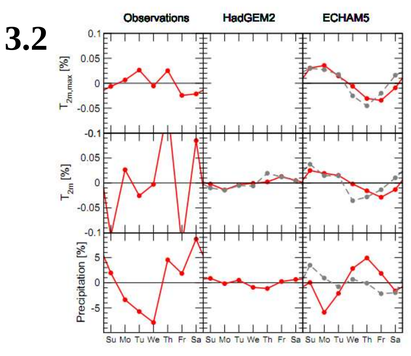
- Few (no) studies considering (whole) Europe.
- Controversies regarding the results' significance: Bäumer and Vogel (2007 **3.1**), Hendricks Franssen (2008), Laux and Kunstmann (2008), Sanchez-Lorenzo et al. (2008, 2009), Hendricks Franssen et al. (2009), Quass et al. (2009 **3.2**).

3.1



(3.1) Annual (top) mean temperature (bottom) accumulated precipitation anomalies by day of the week over 12 stations in Germany.
Bäumer and Vogel (2007, Geophys. Res. Lett., 34, L03819, doi:10.1029/ 2006GL028559.

3.2

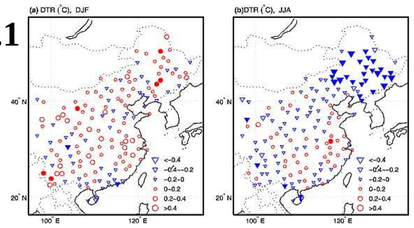


(3.2) Weekly cycle of Tmax (top), Tmean (middle), and rainfall (bottom) over Germany using observations (1st column) and GCM: HAdGEM2 (2nd column) and ECHAM5 (3rd column). Runs with weekly cycle in anthropogenic aerosol emissions (control) in red (grey).
Quaas et al. (2009, Atmos. Chem. Phys., 9, 8493–8501)

4. Asia: ongoing interest in the weekly cycles

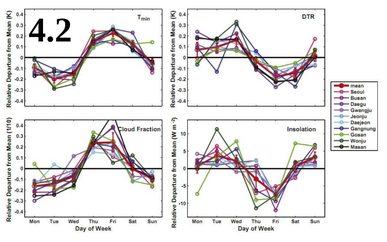
- Increasing evidences of weekly cycles in Asia: China (Gong et al., 2006 **4.1**, 2007; Ho et al., 2009; You et al., 2009), Korea (Kim et al., 2009 **4.2**) and Japan (Fujibe, 2010).
- Necessity of a future comprehensive assessment of the results in the whole area.

4.1



(4.1) Weekend effect in DTR for (left) winter and (right) summer. Stations significant at the 99% confidence level are filled.
Gong et al., (2006, J. Geophys. Res., 111, D18113, doi:10.1029/2006JD007068)

4.2

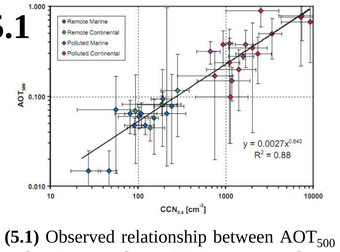


(4.2) Weekly cycles of Tmin, DTR, cloud fraction, and solar insolation of 10 stations for the autumn in Korea and their average value (red thick line)
Kim et al. (2009, Atmos. Env., 43, 6058–6065)

5. Possible causes

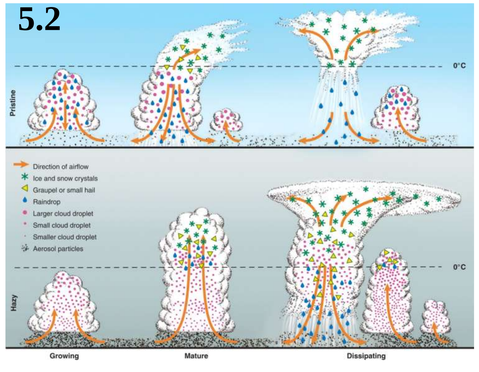
- If real, the most plausible explanation of the weekly cycles should be linked to the direct and indirect effects of anthropogenic aerosols, although further research is needed to confirm this hypothesis.

5.1



(5.1) Observed relationship between AOT_{500} and $CCN_{0.4}$ **Andreae (2009, Atmos. Chem. Phys., 9, 543–556).**

5.2



(5.2) Evolution of deep convective clouds developing in a pristine (top) and polluted (bottom) atmosphere. **Rosenfeld et al. (2008, Science, 321, 1309-1313**

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