Aerosol and cloud relations and weekly cycles over Central Europe

Kourtidis K.A.[1] , **Georgoulias A.K.**[1] **and Alexandri G.**[2]

[1]Laboratory of Atmospheric Pollution and Pollution Control Engineering of Atmospheric Pollutants, Department of Environmental Engineering, Democritus University of Thrace, Xanthi, Greece
[2]Aristotle University of Thessaloniki, Physics Department, Laboratory of Atmospheric Physics, Thessaloniki, Greece

kourtidi@env.duth.gr
argeor@env.duth,gr

EGU General Assembly
Vienna, 22-27 April 2012

1. Introduction

Here, we present results from the satellite-based research we have implemented during the last years on the detection and interpretation of the weekly cycle of aerosols and clouds. Our target was to find common weekly patterns and variabilities which manifest the modification of climate by the human working cycle. Despite working with global datasets our research was focused on Europe. Previous satellite and ground-based studies (e.g. Bäumer et al., 2008; Xia et al. 2008; Barmet et al., 2009; Quaas et al., 2009) had shown that, in general, aerosols exhibited a weekly variability over Europe suggesting that Europe consists an ideal natural laboratory for the detection and interpretation of large scale weekly cycles of aerosols, clouds and other meteorological parameters. Several answers had to be answered: 1) Is there any spatiotemporal variability of the weekly cycle of aerosols and clouds over Europe? 2) Are there any regions with a homogeneous weekly cycle? 3) Are the results statistically significant?

2. Aerosol Weekly Cycle over Europe

For the investigation of the aerosol weekly cycle over Europe [30°N-70°N, 15°W-60°E] we proceeded to a comprehensive spatiotemporal analysis using L3 AOD_{550nm} data from MODIS TERRA (2/2000-2/2009) and AQUA (7/2002-12/2008) (**Georgoulias and Kourtidis, 2011**). We used the so-called Weekly Cycle Index (WCI) in order to reveal the spatial patterns of the aerosol weekly cycle (see Fig. 1a). A strong positive (higher values during midweek) weekly cycle plume appears over **Central Europe** (maximum-minimum day difference of 6.4%/7.6% for MODIS TERRA/AQUA). On the contrary, a strong negative (higher values during weekend) weekly plume appears over the Iberian Peninsula (8.4%/10%) and North-eastern Europe (6.8%/9.9%). The seasonal analysis revealed that the annual weekly cycle pattern over Europe is driven by the summer weekly pattern (see Figs. 1a and 1b). The use of a Fourier-based spectral analysis and a red noise fit indicated the existence of a statistically significant 7-day cycle over **Central Europe** and the Iberian Peninsula.

The strong weekly patterns over **Central Europe** [2.5°W-22.5°E, 42.5°N-55°N] were put under the "microscope". **Georgoulias and Kourtidis (2012)** used a decadal L2 MODIS TERRA dataset to compile a high resolution (0.1°x0.1°) gridded dataset. The positive weekly cycle plume extends over the central part of Central Europe, with the WCI levels gradually decreasing until the weekly cycle becomes negative when moving away (see Fig. 1c). No clear connection between the WCI patterns and industrial activity or topography was found while there is an apparent correlation between positive weekly cycles in summer and population density (see Figs. 1c and 1d).

A clear Monday minimum appears over regions with high positive WCI (Fig. 1f). Monday shifts to Tuesday when moving to the East (Fig. 1g), indicating aerosol transport from the dominating westerly wind flow. The WCI values and the average percent departures (APDs) for the day of weekly maximum and minimum were examined for 22 selected stations from previous ground-based studies. The weekly cycle is positive and statistically significant for only a few stations situated in France, Germany, Czech Republic and Belgium.

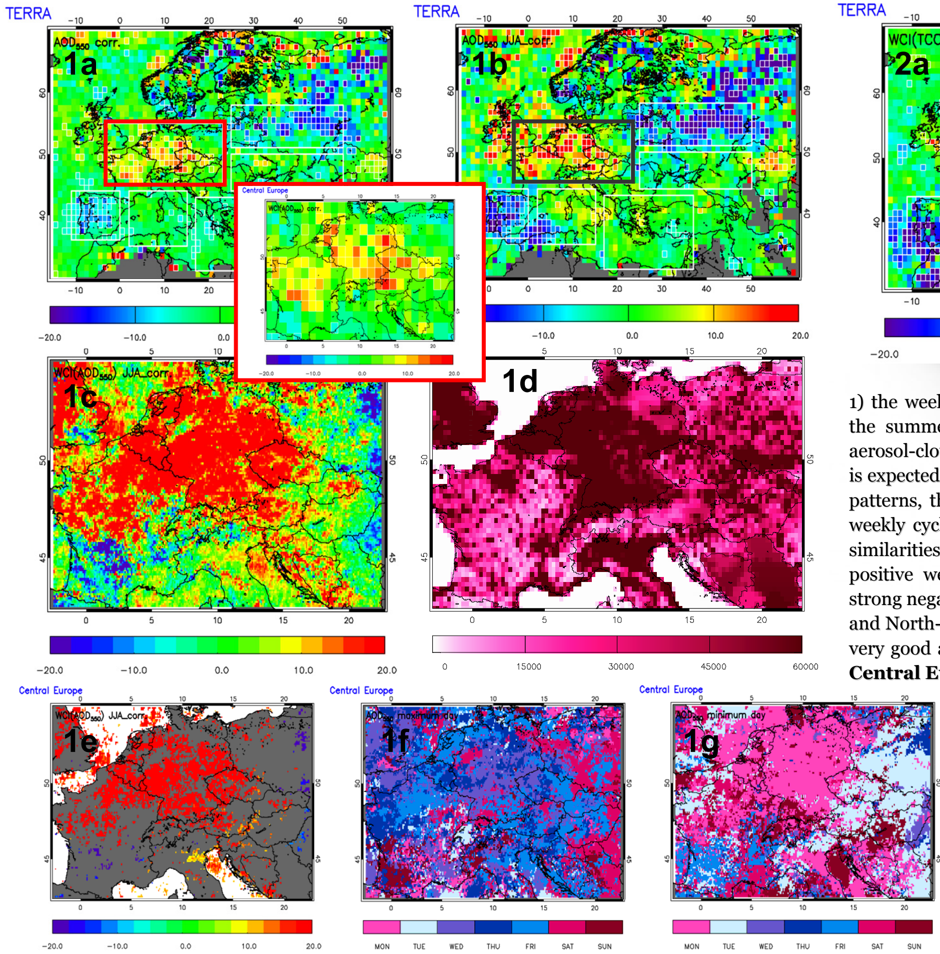
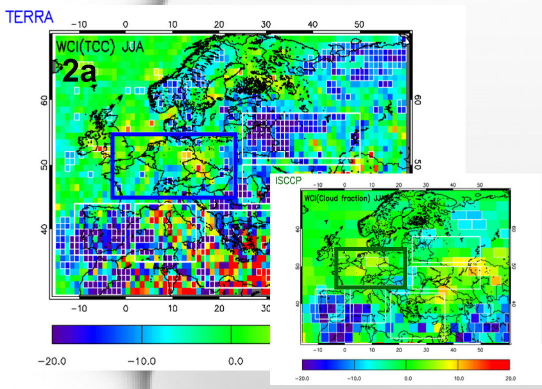


Figure 1: *a) WCI patterns over Europe from TERRA MODIS L3 AOD_{550nm} data, b) Summer WCI patterns, c) High resolution summer WCI patterns over Central Europe from TERRA MODIS L2 AOD_{550nm} data (0.1°x0.1°), d) Population density data (num of persons/grid cell), e) High resolution WCI patterns for significant grid cells at the 90% conf. level according to a two-tailed t-test, f) Day of maximum summer patterns, g) Day of minimum summer patterns.*

3. TCC Weekly Cycle over Europe

Following the works of Georgoulias and Kourtidis (2011, 2012), we further investigated the summer Total Cloud Cover (TCC) weekly cycle over Europe also using L3 data from MODIS TERRA and AQUA (**Georgoulias et al., 2012 manuscript in preparation**). We focused on summer for two main reasons:



1) the weekly variability of AOD_{550nm} over Europe is driven by the summer weekly patterns 2) convection, which favors the aerosol-cloud interactions, is intense during summertime. So, it is expected that if aerosol-cloud interactions partly drive the TCC patterns, this would be more evident in summer. Although the weekly cycle patterns of TCC are rather noisy they show some similarities with the AOD_{550nm} patterns (Fig. 2a). Regions with a positive weekly cycle appear over **Central Europe**, while a strong negative weekly plume appears over the Iberian Peninsula and North-eastern Europe. The TCC weekly variability exhibits a very good agreement with the AOD_{550nm} weekly variability over **Central Europe** (see Fig. 2b), SW Europe and NE Europe and a moderate agreement for Central Mediterranean. Comparison of the MODIS derived TCC weekly variability with independent observations from the ISCCP (Fig. 2a) shows reasonable agreement between the two datasets. This supports the credibility of the results, showing that the observed weekly cycles are not an artefact created by MODIS orbital characteristics. Statistical significance of the TCC weekly cycle was indicated using a two-tailed t-test (TERRA and AQUA), comparison of maximum-minimum difference to corresponding differences for hypothetical 6 and 8-day weeks (TERRA and AQUA) and a Kruskal-Wallis non-parametric test (AQUA only).

4. TCC-AOD_{550nm} Relations over Central Europe

Coincident TCC and AOD_{550nm} measurements were divided into "0.01" AOD_{550nm} bins and the average TCC for each bin was calculated (Fig. 2c) for AOD_{550nm} less than 0.6. The TCC/AOD550 relationships can then be approximated very well with linear fits. The TCC/AOD_{550nm} slopes are (0.85/0.98) for (TERRA/AQUA) for AOD_{550nm} values <0.2 and (0.51/0.52) for values >0.2. The striking difference for values less/greater than 0.2 is probably a sign of the so-called "aerosol semi-direct effect". This analysis along with the fact that TCC and AOD_{550nm} weekly variability is of the same order and has nearly the same phase shows that the weekly cycle of TCC could be due to the aerosol indirect effects. A co-examination of AOD_{550nm}, TCC and NCEP/NCAR sea level pressure showed that the positive TCC-AOD_{550nm} correlation holds separately in all pressure bins, thus indicating that the correlation is not a synoptic artefact (Fig. 2c).

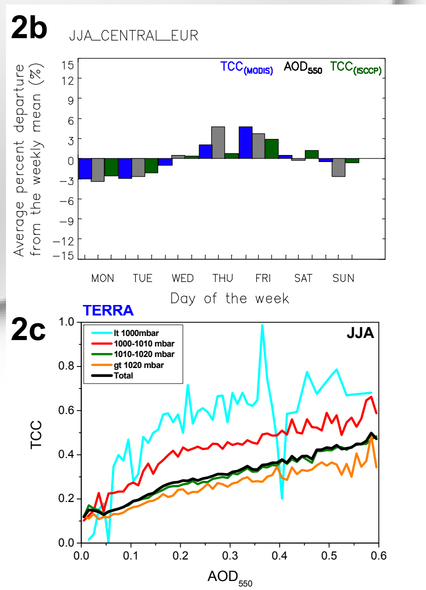


Figure 2: *a) Summer WCI patterns over Europe from TERRA MODIS L3 TCC and ISCCP (subfigure) data, b) MODIS TCC (blue), AOD_{550nm} (grey), ISCCP TCC (green) weekly variability over Central Europe, c) Summer TCC-AOD_{550nm} relationships over Central Europe (SLP bins).*

References

1) Bäumer et al., 2008, ACP, 8, 83-90.
2) Xia et al., 2008, JGR, 113, D14217.
3) Barmet et al., 2009, JGR, 114, D05206.
4) Quaas et al., 2009, ACP, 9, 8493–8501.
5) Georgoulias & Kourtidis, 2011, ACP, 11, 1385-1428.
6) Georgoulias & Kourtidis, 2012, Atmos Res, 107, 145-160.
7) Georgoulias et al., 2012, manuscript in preparation.