

# Impact of large cities on the spatial distribution of aerosol optical depth in the Central Europe



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## Objectives

The analysis of the long-term observations of aerosol optical depth (AOD) and concentrations of particulate matter with an aerodynamic diameter  $< 10 \mu\text{m}$  ( $\text{PM}_{10}$ ) in the Warsaw extended area is presented. Measurements of the AOD in Warsaw and in Belsk (about 45 km away from Warsaw), provide information about the influence of Warsaw emissions on the AOD and the  $\text{PM}_{10}$ .

## Localization and data

**AOD:** 2005 - 2011, Belsk (CIMEL) and Warsaw (Microtops),  
**PM<sub>10</sub>:** 2007-2011, three Warsaw stations, one in Belsk,  
**NAAPS:** aerosol transport model 1996-2006,  
**MODIS:** 2000-2010,  
**SEVIRI:** 2009-2011.



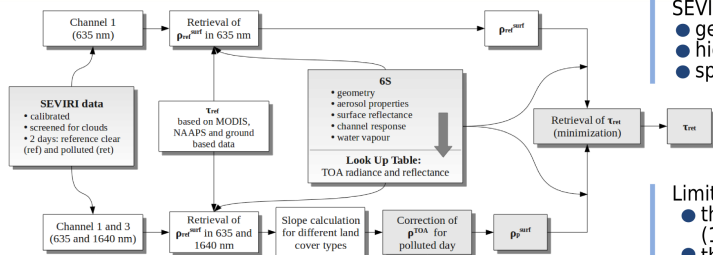
Location of the research area.

## Retrieval of AOD from SEVIRI data

### Algorithms

- **one-channel** (635 nm),
- **two-channel** (635 and 1640 nm, Land Cover Map),
- the surface reflectance estimated for a **reference clear days** (small AOD) based on AOD spatial distribution (model/satellite data),

- NAAPS/MODIS AOD corrected by the ground based data with use of **optimal interpolation methods [2]**,
- can be easily applied to different geographical regions and other satellites.



SEVIRI data:

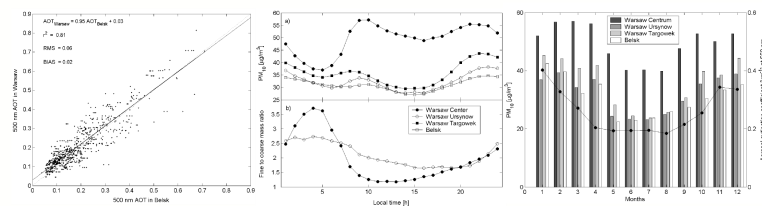
- geostationary satellite (MSG2),
- high temporal resolution (15 min),
- spatial resolution 5.5km (Poland).

Limitations:

- the surface hot-spot effect (10:00 - 14:00 UTC),
- the presence of the sub-pixel clouds.

Flow chart of the one- and two- channel algorithm.

## Long term results



Comparison of the AOD at 500 nm from CIMEL (Belsk) and Microtops (Warsaw).

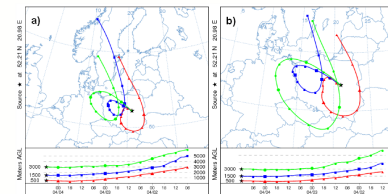
Diurnal cycle of  $\text{PM}_{10}$ .

Monthly means of the  $\text{PM}_{10}$  (bars) and the surface (0-70 m.a.g.l.) aerosol extinction coefficient (dotted line, NAAPS).

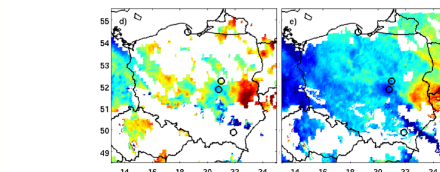
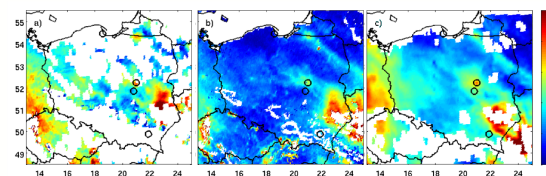
[1] Zawadzka, O., K.M. Markowicz, A. Pietruczuk, T. Zielinski, J. Jaroslowski. **Impact of urban pollution emitted in Warsaw on aerosol properties.** Atmos. Env. 2013, 69, 15-28.

[2] Zawadzka, O. and K.M. Markowicz. **Retrieval of aerosol optical depth from optimal interpolation approach applied to SEVIRI data.** Accepted in Remote Sensing.

## Case study: 4 April 2009

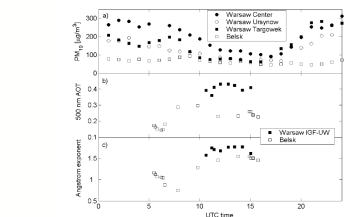


Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) back-trajectories obtained for Warsaw at (a) 06 and (b) 12 UTC. HYSPLIT model was run for 72 hours with meteorological data from The Global Data Assimilation System (GDAS).



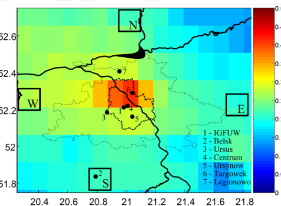
Successive plots correspond to:  
a) 1-channel method AOD,  
b) 2-channel method AOD,

c) MODIS AOD,  
d) (1-channel method AOD - MODIS AOD),  
e) (2-channel method AOD - MODIS AOD).



Variability of the  $\text{PM}_{10}$  concentration, AOT at 500 nm, and Angstrom exponent.

MODIS AOT at 550 nm observed in the Warsaw region.



## Summary

Relatively small impact of Warsaw emissions on the AOD (about 10-15%).

Differences:

- **0.02** (at 500 nm) based on the sun photometers,
- **0.03** (at 550 nm) based on the MODIS.

Results consistent with the  $\text{PM}_{10}$  data: differences about 13-20%. During an extreme smoke events differences of AOT between Warsaw and Belsk in a range of **0.11-0.2** (at 500 nm)  
- urban impact increase up to 50%.

Since comparison of the SEVIRI AOD with the sun photometer data shows quite good agreement further study is planned.

$r_2$  0.33 - 0.73  
bias 0.02  
rms 0.04-0.05  
 $\tau_{err}$   $\pm 0.05$

## Acknowledgments

This research has been partly conducted as part of the Polish National Grants No. 1276/B/P01/2010/38 of the Ministry of Science and Higher Education of Poland, 2012/05/E/ST10/01578 of the National Science Centre, both coordinated by IGF UW, and within the framework of the European Social Fund, contract number UDAPOKL.04.01.01-00-072/09-00. We acknowledge Brent Holben for the use of the data from the Belsk AERONET station, and EUMETSAT for the data availability, license number 50001643. The MODIS data used in this study were acquired as part of the NASA's Earth-Sun System Division and archived and distributed by the MODIS Adaptive Processing System (MODAPS). The authors wish to thank D. Westphal and P. Flatau from the Naval Research Laboratory in Monterey for providing NAAPS data.

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