SAMIRA - SAtellite based Monitoring Initiative for Regional Air quality

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Summary

We present a new project entitled Satellite based Monitoring Initiative for Regional Air quality (SAMIRA), which is to be funded by ESA. The three year project will start 20 May 2016. It aims at improving regional and local air quality monitoring through synergetic use of data from present and upcoming earth observation satellites, traditionally used in situ air quality monitoring networks and output from chemical transport models. Through collaborative efforts in four countries, namely Romania, Poland, the Czech Republic and Norway, all with existing air quality problems, SAMIRA intends to support the involved institutions and associated users in their national monitoring and reporting mandates as well as to generate novel research in this area.

SEVIRI AOD retrieval

The SAMIRA project will develop a near real-time retrieval of aerosol optical depth (AOD) from the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) instrument onboard of the geostationary Meteosat Second Generation (MSG) platform. Building on existing work by Zawadzka and Markowicz (2014), the AOD product will be provide up-to-date AOD information over the territories of Poland, Romania, the Czech Republic, as well as southern Norway and Sweden.

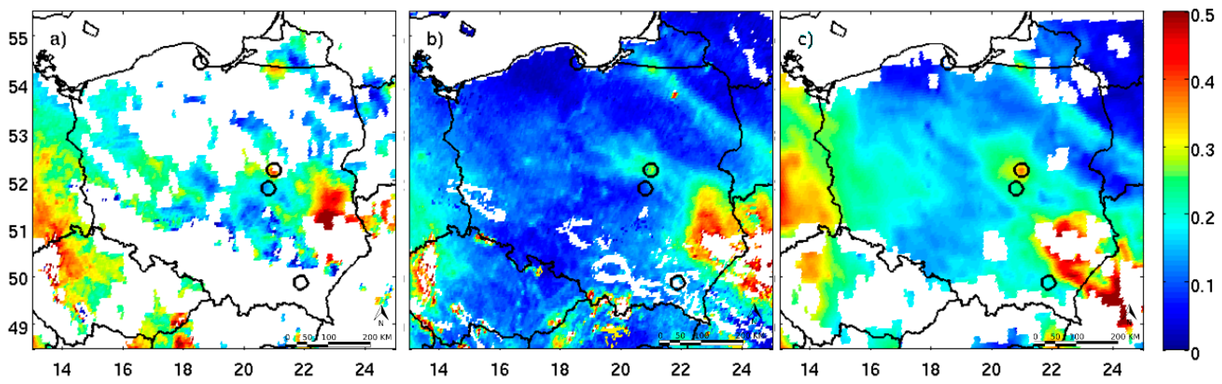

Figure 1: SEVIRI-derived AOD over Poland on 4 April 2009 . Successive plots correspond to (a) one-channel method AOD; (b) two-channel method AOD; (c) MODIS AOD. From Zawadzka and Markowicz (2014)

AOD to PM conversion

One of the goals of SAMIRA is to generate column and near-surface hourly $PM_{2.5}$ and PM_{10} maps for the study areas from SEVIRI-AOD and modelled data. WRF-Chem aerosol species will be grouped to reconstruct the aerosol components defined in GADS, for which microphysical parameters are available. T-Matrix computation will be applied to calculate the mass-to-extinction conversion factors for a wide range of aerosol classes in various humidity conditions and mass proportions. The mass-to-extinction conversion factor LUT's will then be used to calculate the column $PM_{2.5}$ and PM_{10} from the SEVIRI-AOD.

Data fusion

The objective of this task is to combine in-situ measurement data, chemistry transport model data and Earth Observation data using data fusion techniques based on geostatistics. The methodology will be demonstrated for two domains - for the Czech Republic (with CAMx) and for the major part of Europe (using WRF-Chem). After initial tests with historical data, the technique will be applied in a near-real time system to provide up-to-date air quality maps for select areas in Europe.

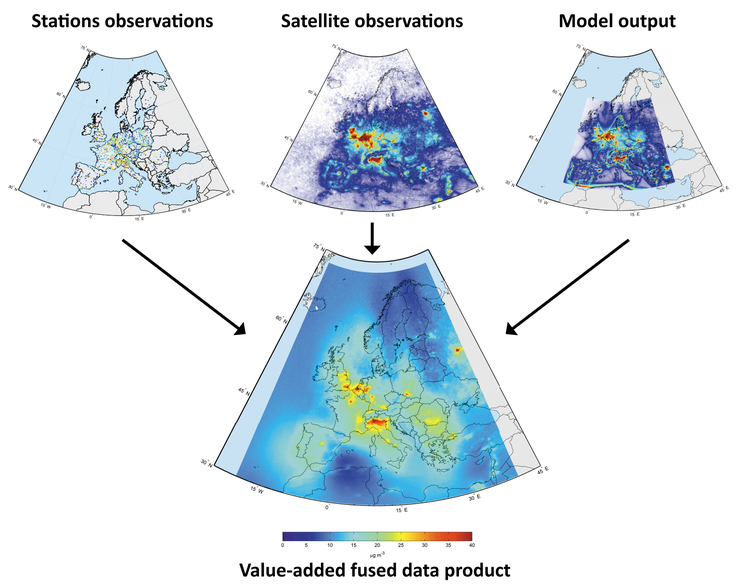

Figure 2: The concept of data fusion as applied in SAMIRA. Information from the three main data sources of air quality are combined to provide a best-guess field of concentrations.

Downscaling of satellite data for air quality

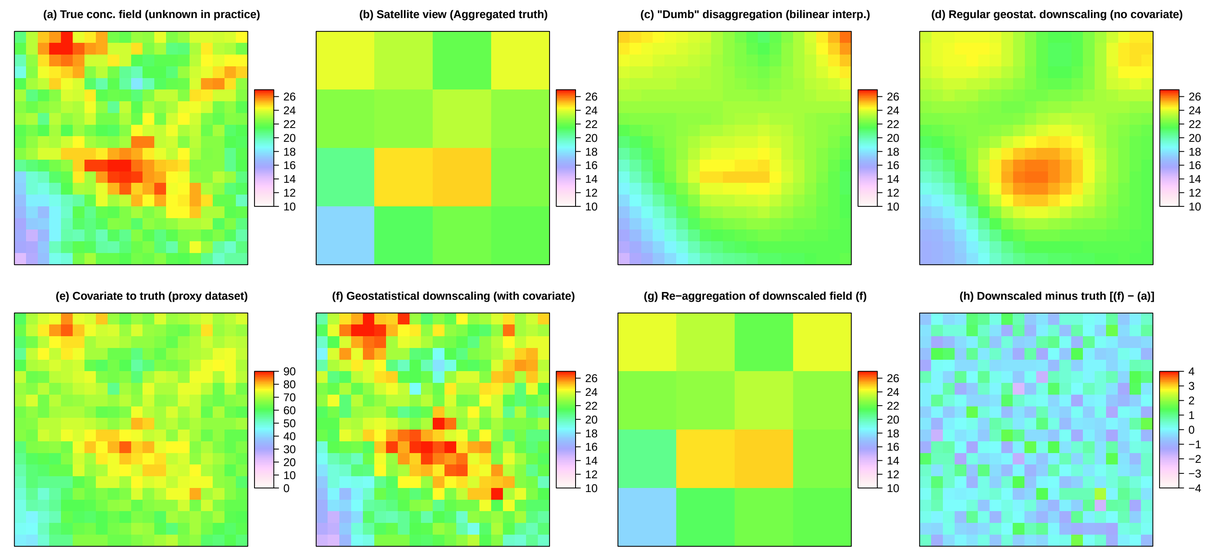

Figure 3: Demonstration of geostatistical downscaling using a simulated dataset. The method used in SAMIRA downscales a satellite product of air quality (Panel b) using area-to-point kriging and a proxy dataset which is assumed to have similar spatial patterns as the truth (Panel e). The result of the downscaling can be seen in Panel (f).

To make their coarse spatial resolution more suitable for local applications, satellite data of air quality is downscaled within SAMIRA with the help of high-resolution CTM output and geostatistical techniques. Area-to-point spatial interpolation (Kyriakidis, 2004) with regression against a proxy dataset will be used. We aim at demonstrating the methodology for NO_2, SO_2 and AOD/PM, if possible. We will focus on a set of study sites that include the capitals of the four studied countries (Bucharest, Warsaw, Prague, and Oslo) and regions of special interest that are traditionally severely affected by air pollution.

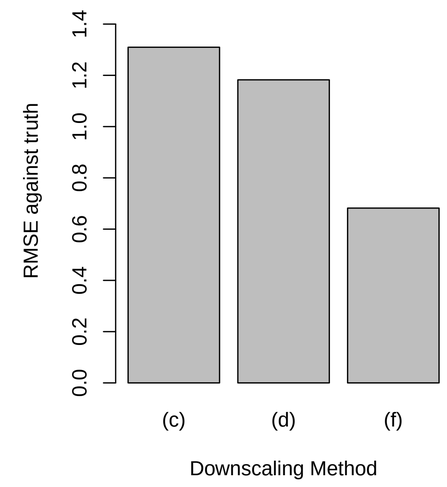

Figure 4: RMSE of all pixels for each downscaling method against truth field.

Validation

SAMIRA aims to provide a robust and independent validation of all products. The validation will be carried out against specific measurement datasets that were not included in the development of the product.

Data assimilation

SAMIRA will develop a pre-operational PM air quality forecast system capable to produce high-resolution $PM_{2.5}$ and PM_{10} forecasts over the Czech Republic, Norway, Poland and Romania. Initially the system will assimilate in-situ information of PM into the WRF-Chem model. The open architecture will allow a straightforward extension to assimilating satellite AOD.

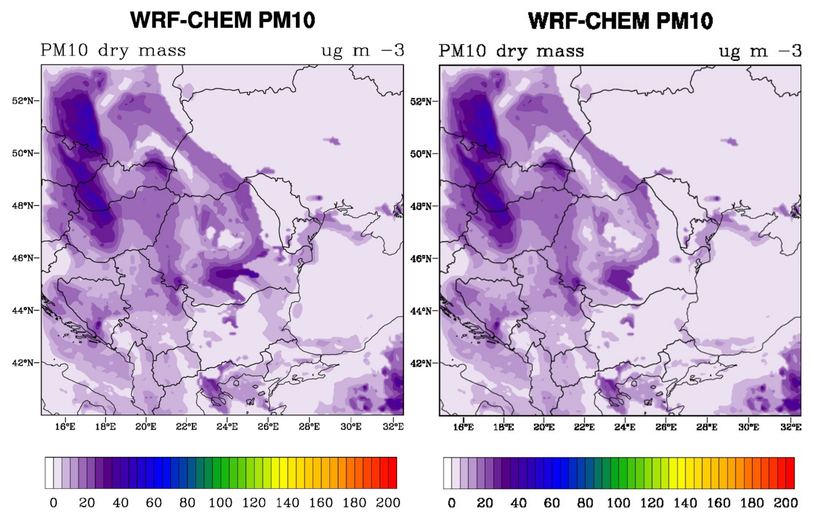

Figure 5: WRF-Chem forecast of PM_{10} for 25th of June 2013 in the region of Bulgaria, with (left panel) and without (right panel) in-situ data assimilation of station observations.

References

Kyriakidis P. C. (2004). A geostatistical framework for area-to-point spatial interpolation. Geographical Analysis, 36(3), 259-289.

Zawadzka, O. and Markowicz, K. (2014). Retrieval of Aerosol Optical Depth from Optimal Interpolation Approach Applied to SEVIRI Data. Remote Sensing, 6(8), 7182-7211.