A COMPARISON OF SIMULATED AEROSOL OPTICAL DEPTH AND SATELLITE DERIVED DATA FOR MILAN AREA, JUNE 2001

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ABSTRACT:

We study scale issues using the mesoscale Transport Atmospheric Pollutants Model (TAPOM) at three horizontal resolutions (5x5km, 10x10km and 20x20km) through calculations of aerosol optical depth (AOD) and other aerosol properties for the Milan, Italy area during June 2001. A qualitative and quantitative comparison of the AOD calculations is made with AERONET, MISR and MODIS. Calculated AOD values are in good agreement with sunphotometer data and satellite data for dry, clear days, especially at the 5x5km and 10x10km resolutions. Significant differences are found between remote sensing instruments for the same parameter, area and time frame. Remote sensing products become unreliable for days when cirrus clouds are observed and are not straightforward to use for comparison with models.

Key words: mesoscale modelling, aerosols, aerosol optical depth, satellite and sunphotometer data

REFERENCES

1. Introduction

Aerosol modelling to date has focused on two different scales: the urban-regional scale with special attention to health aspects, and the larger continental and global scales focusing on large scale pollution, radiative forcing, eutrophication and acidification in aquatic and terrestrial ecosystems.

One outstanding issue is the limited accuracy of the current generation of C-AGCMs (Chemistry-Atmospheric-General Circulation models) to describe aerosol formation, burden, and removal on regional scales. This problem has three aspects. First, how does aerosol formation and removal depend on model physics and spatial resolution? Second, how to compare measurements that represent scales smaller than the larger scale model? Third, how to interpret the large discrepancies between measurements and models, which results from these scale differences?

Aerosol formation processes are known to be non-linearly dependent on the concentrations of precursor gases and meteorological parameters such as temperature, humidity and vertical mixing. Therefore, model physics and spatial resolution could be important in determining the aerosol formation and the resulting optical properties.

In this paper, the model results together with AERONET, MISR and MODIS AOD are presented for Ispra June 2001.

We focus on measurements of Aerosol Optical Depth (AOD). AOD provides information on size and concentration of particles in a given atmospheric column, the impact on visibility and the role on radiation budget (climate change).

To understand the role of ‘model resolution’ on aerosol formation we study AOD for three resolutions (5x5 km, 10x10 km and 20x20 km) and compare the results with remote sensing data.

We study the Po-Valley for a relatively dry month (June 2001). The Po-valley is one of the most polluted areas in Europe. It is a high densely populated area and is one of the most industrialized regions of Italy.

2. Method
The regional scale model TAPOM (Transport of Atmospheric Pollutants model) is used to model air quality over the Lombardy area for June 2001. Fig. 1, presents the geographical position of the model domain and the Lombardy region (I). The model is driven by the off-line meteorological model MM5. Specific emission inventories are used, as well as boundary and initial conditions.

For qualitative and quantitative model comparison, several data sets of remote sensing instruments are used:
- sunphotometer data of the AERONET Ispra station,
- MISR (Multi-angle Imaging Spectro Radiometer) data,
- MODIS (Moderate Resolution Imaging Spectro radiometer) data.

Irradiance data measured by a pyranometer, is used to determine the presence of clouds, thin cirrus clouds and clear dry days. Based on this information, days are chosen for model comparison with the remote sensing products. AOD retrieval by AERONET, MISR and MODIS are available for days when no clouds were present. Aerosol concentrations measured at the EMEP station in Ispra (Italy) are used for validation of the aerosol concentrations calculated by the model.

3. AOD ISPRA Italy, June 2001
In Figure 2 we present the AOD profile for Ispra (Italy) for the three different model resolutions, 5x5km, 10x10km and 20x20km.

The three different model resolution performs well for the clear dry days (indicated with arrows) in respect to the sunphotometer, MISR and MODIS data. When cirrus clouds are observed the remote sensing instruments tends to overestimate the AOD (indicated with the horizontal dashed bar). The dashed circles indicate the days when it had rained. The model calculates unrealistic AOD values when the relative humidity (RH) exceeds 90%, during rain events, indicated with dashed circles.

In Figure 3 the model AOD (5x5km) versus AERONET for June 2001 is presented. No correlation is found taking all data, whereas a correlation of 0.66 is found for clear dry days. Note that even in that cases the model AID seems underestimate with a factor of 2.

In Table I the correlation factors of the model comparison (5x5, 10x10 and 20x20km) versus AERONET for clear dry days are given.

<table>
<thead>
<tr>
<th>Model resolution</th>
<th>Correlation Model vs AERONET for clear dry days Ispra June 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>5x5km</td>
<td>0.662</td>
</tr>
<tr>
<td>10x10km</td>
<td>0.628</td>
</tr>
<tr>
<td>20x20km</td>
<td>0.649</td>
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</tbody>
</table>

4 Conclusions.
Studying the dependency of aerosol formation on spatial resolution by using an off-line mesoscale model, satellite products from MISR and MODIS and AERONET data, the following conclusions can be made:

1) Looking at the Ispra site, we find a good match for the clear dry days between the calculated AOD for the three resolutions and the measured AOD by the sunphotometer.

2) Increasing the RH leads to an increase of aerosol water formation and therefore a higher AOD values. In some cases the model calculates AOD unrealistically high, due to the strong increase of the relative humidity over ca. 90%.
3) For days when haze and or cirrus clouds are observed, the discrepancy between the model AOD and the satellite products and sunphotometer AOD increases, as the satellite and sunphotometer data becomes unreliable when cirrus clouds and haze are observed. In some cases large discrepancies of the AOD and cloud cover fractions are found between MISR and MODIS. Therefore it makes it difficult to compare model results with remote sensing data products for days when haze and / or cirrus clouds are observed.

4) We were not able to identify a significant improvement of model results at finer resolution compared to coarser resolution, satellite products and sunphotometer data.

5) One month of satellite products, sunphotometer data is not sufficient to make a good comparison from time scale point of view, as cloud cover prevents the satellites and sunphotometers to have proper aerosol retrieval.

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MISR data were obtained from the NASA Langley Research Center Atmospheric Sciences Data Center. MODIS data used in this study were acquired as part of the NASA's Earth Science Enterprise. The algorithms were developed by the MODIS Science Teams. The data were processed by the MODIS Adaptive Processing System (MODAPS) and Goddard Distributed Active Archive Center (DAAC), and are archived and distributed by the Goddard DAAC.

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Figure 2: AOD model 5x5km, 10x10km, 20x20km resolution, AERONET, MISR and MODIS, Ispra June 2001. In Figure 1 clear dry days are indicated with arrows, the horizontal dashed bar indicates the presence of thin cirrus clouds, determined with pyranometer data. The dashed circles present the days when it rained and high relative humidity values are found, circa 90%.

Figure 3: AERONET AOD June 2001 Ispra versus model AOD 5x5km. Figure 3a encompasses all the available AERONET data for June 2001. Figure 3b encompasses only the data for the dry clear days.