MONITORING AND ASSESSMENT OF REGIONAL AIR QUALITY IN CHINA USING SPACE OBSERVATIONS (MARCOPOLO)

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ABSTRACT

In this paper we will present the FP7-project 'MarcoPolo'. The main objective of Marco Polo is to improve air quality monitoring, modelling and forecasting over China using satellite data. Within the preceeding DRAGON project AMFIC it was concluded that modelling of air quality are hampered by the rapidly changing emission data due to economic growth in China. In addition, air quality policies could not directly be related to changes in emissions. Therefore, within the MarcoPolo project, the focus will be placed on emission estimates from space and the refinement of these emission estimates by spatial downscaling and by source sector apportionment. A wide range of satellite data will be used from various satellite instruments to derive emission estimates for NO_x, SO_2, PM and biogenic sources. By combining these emission data with known information from the ground, a new emission database for MarcoPolo will be constructed. The improved emission inventory will be input to the regional and local air quality models.

1. INTRODUCTION

Due to the strong economic growth in China in the past decade, air pollution is now a recognized serious issue in China with also global implications. Especially, the Beijing-Tianjin-Hebei region, the Yangtze River and the Pearl River deltas are three regions with serious air pollution and three key areas where air quality policies have gained a lot of attention in China. Up-to-date regional air pollution information and means of emission control for the main pollutants are becoming increasingly important. Unfortunately, regular emission inventories are quickly outdated in these regions.

Within previous DRAGON programmes it was concluded that modelling of air quality, and therefore the forecast capabilities, are hampered by the rapidly changing emissions due to economic growth [1,2]. In addition, the effect of air quality measures (for example during the Olympic Games of 2008 [3]) could not directly be included in air quality modelling.

2. CONCEPT

Within the project MarcoPolo the focus is on updating emission inventories in China. This will be achieved with emission estimates from space and the refinement of these estimates by spatial downscaling and by source sector apportionment. Air pollutants cover both anthropogenic and biogenic sources. A wide range of satellite data will be used: observations of nitrogen dioxide (NO_2), sulphur dioxide (SO_2), formaldehyde (HCHO), tropospheric ozone (O_3), volatile organic compounds (VOCs) and aerosol/particulate matter (PM) from various instruments. Using various state-of-the-art techniques emission estimates will be made for NO_x, SO_2, PM and biogenic sources. By combining these emission data with geophysical information from the ground, a new emission database for China will be constructed. In a next step of the MarcoPolo project, the emission inventory is used as input to regional air quality models. We will provide a monthly update of the emissions based on the latest satellite observations. The new inventory is expected to significantly improve the existing air quality modelling and forecasts. Using the satellite constraint emission inventory we will provide air quality information by running models on meso-scale and urban-scale.

Every step of the described chain from satellite observations to air quality assessments and forecasts will be validated in the project. The satellite observations, emission estimates and the modelling results will be validated using ground-based measurements. If direct validation of emission data is not possible, the validation of concentrations simulated by chemical transport models using the emission data will provide information on the quality of the emission estimates.

As shown in Fig. 1 three groups of end-users of the products are considered: (1) scientists, (2) policy makers and (3) the general public. For each of the end-user groups, different products and a different approach will be utilised. Scientists will be mostly interested in emission and model data and the quality assessment coming from the validation. The policy makers are likely to be interested in the emission totals e.g. per province and the outcome of the air quality assessments. The general public will be provided with air quality forecasts visualised in a comprehensible way. The

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results of MarcoPolo will be disseminated following guidelines established in the EU-China Environmental Governance Programme. In addition, a public dissemination and outreach plan will be elaborated for providing results to the public, scientists and policy makers.

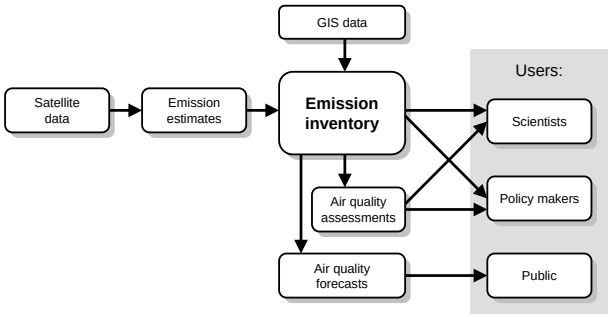

Figure 1. Diagram of the data products generated for the three main user groups in the project

3. OBJECTIVES OF MARCOPOLO

3.1. Air quality research

The main objective of MarcoPolo is to improve air quality monitoring, modelling and forecasting by improving the emission database over East China using satellite data on a monthly basis. As shown in Figure 2 the satellite observations often show a different picture than the modelled air quality based on existing emission inventories [4]. Therefore, a new emission inventory will be constructed by combining Chinese and European expertises. It will be based on recent satellite data and GIS (Geographic Information System) information. We will collect the available atmospheric satellite and in-situ data, and provide the new data as they become available. The air quality monitoring system will be improved where necessary, through (1) developing additional satellite products (e.g. tropospheric ozone) and (2) adding additional in-situ observations (e.g. additional ground instruments). Validation is a key element in assessing the quality of the end-results in the processing chain. Each step in this chain will be validated by inter-comparison with ground-based in situ observations.

3.2. Co-operation

The second objective is the strengthening of the Chinese-European co-operation, for which a foundation has been laid within the earlier AMFIC project in the DRAGON programme of the European Space Agency (ESA) and the Ministry of Science and Technology (MOST). This co-operation will be strengthened with the MarcoPolo project. It is vital for the success of the validation activities and the construction of the emission inventories.

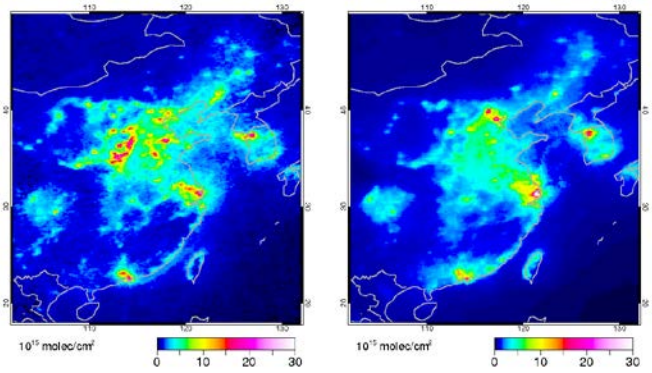

Figure 2. Average satellite (OMI on AURA) observations of tropospheric NO_2 for the summer of 2008 (left), and collocated model simulations by CHIMERE (right).

3.3. Data dissemination

The third objective is the dissemination of the MarcoPolo products to the different identified end-users. The indicators of air quality will be presented to end-users in compliance to international standards and recommendations (e.g. INSPIRE). The generated images of emissions and of air quality assessments and forecasts on the MarcoPolo web site can be interactively customized. The emission inventory will also be made available for the scientific community at the end of the project in 2016.
The satellite data products will be available for scientists and policy makers. The final model assessments will be made available to policy makers and the air quality forecasts are presented to the public.

4. VALIDATION OF THE MODEL USED FOR NOx EMISSION ESTIMATES

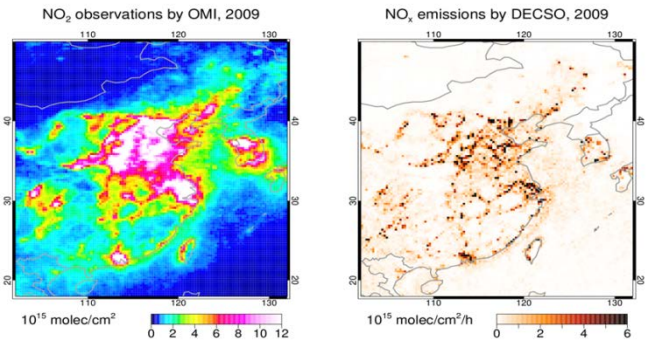

Figure 3. Example of the NOx emission estimates(right) using the DECSO algorithm on OMI observations (left) in the year 2009.

One of the first tasks within MarcoPolo is the evaluation of the existing algorithm for the emission estimates.

KNMI has developed the Daily Emission estimates Constrained by Satellite Observations (DECSO) algorithm [4] for NOx emissions, which has been implemented over China by using the chemical transport model CHIMERE (see Fig. 3). The quality of the derived emission inventory depend heavily on the quality of both the satellite observations and the model simulations. The satellite observations have already been validated in the previous AMFIC project. Recently, we have also studied the performance of the model used in the DECSO algorithm. We compared two versions of CHIMERE, V2013 [5] and V2006, to simulate the air quality over east China in 2010 using two emission inventories, INTEX-B [6] and MEIC.
The two CHIMERE models have been implemented over east China (18-50^{0}N, 102-132^{0}E) with a 0.25x0.25^0 horizontal resolution and 8 vertical layers up to 500hPa.
To study the influence of different models and emission inventories, we have set up different runs over China for January and July 2010 with:

- CHIMERE V2006 using MEIC
- CHIMERE V2013 using MEIC
- CHIMERE V2013 using INTEX-B

The MEIC emission inventory is in general higher than INTEX-B. In MEIC, the agriculture emission sector has been added and also other sectors are updated compared to INTEX-B. We conclude that the MEIC inventory is more realistic than the INTEX-B inventory. Using MEIC can therefore decrease the time to converge to new NOx emissions in DECSO.

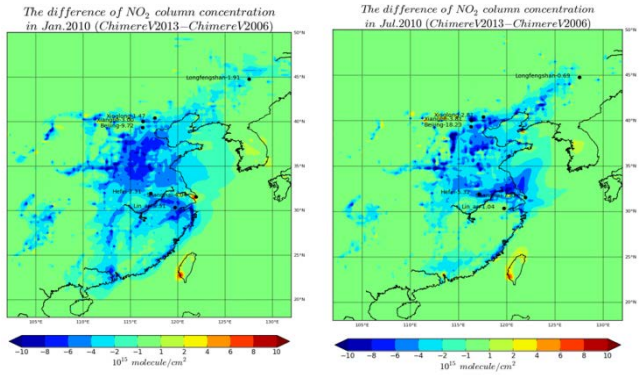

Figure 4. The difference in modelled NO2 concentrations between Chimere V2013 and Chimere V2006 for January 2010 (left) and July 2010 (righ).

As shown in Fig. 4 the modelled NO_2 column concentration of CHIMERE V2013 is lower than that of CHIMERE V2006, especially over the highly polluted regions. This is because CHIMERE V2013 has a new transport scheme and secondary organic aerosol chemistry. In addition, its chemical reaction rates are updated.
For comparison with observations we used OMI satellite observations with a spatial resolution of 24x13 km^2 in nadir till 68x14 km^2 at the swath edges. The overpass time is around 13:30 local time.
To validate the model, we compared the results with OMI satellite measurements. The comparison with the OMI satellite measurements shows that the old CHIMERE overestimates the NO_2 column concentrations, while the new CHIMERE is closer to the observations and performs better than CHIMERE V2006. Therefore, the CHIMERE V2013 model and the MEIC inventory will be implemented in DECSO.

5. CONCUSION

In MarcoPolo, part of DRAGON 3, researchers from China and Europe are studying the sources, transport and trends of air pollution using various observational techniques and models. Within previous progammes DRAGON 1 and 2, atmospheric environmental monitoring over China was addressed by a team of both Chinese and European scientists, most of them again involved in DRAGON 3. A service was constructed of an integrated information system for monitoring and forecasting tropospheric pollutants over China. The system used satellite measurements and modelling to generate consistent air quality information for China. In MarcoPolo we will build on these results to improve air quality monitoring and modelling capabilities.

6. REFERENCES

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