COMBINED USE OF SPACE-BORNE OBSERVATIONS OF NO2 AND REGIONAL CTM MODELS FOR AIR QUALITY MONITORING IN NORTHERN ITALY

Petritoli A\textsuperscript{1}.\textsuperscript{1}, E. Palazzi\textsuperscript{1}, G. Giovanelli\textsuperscript{1}, W. Di Nicolantonio\textsuperscript{2}, G. Ballista\textsuperscript{2}, C. Carnevale\textsuperscript{3}, G. Finzi\textsuperscript{3}, E. Pisoni\textsuperscript{3}, M. L. Volta\textsuperscript{3}

\textsuperscript{1}Institute of Atmospheric Science and Climate, ISAC-CNR, Italy
\textsuperscript{2}Carlo Gavazzi Space at ISAC-CNR, Italy
\textsuperscript{3}Department of Electronics for Automation, University of Brescia, Italy
Real time gaseous and PM forecast

Sustainable emission scenarios assessment

Monitoring
PM and gaseous pollutants ($O_3$, $NO_2$, $SO_2$, HCHO) monitoring

Forecast
Real time gaseous and PM forecast
• Basic idea:
  – To merge satellite data column measurement of NO$_2$ and CTM simulated column, in order to provide a consistent NO$_2$ ground level concentration map.

• Methodology:
  – Satellite data retrieved NO$_2$ column
  – CTM simulated NO$_2$ column
  – Merging of the two dataset
  – Ground level concentration map
Methodology: Satellite data

- **SCIAMACHY** (SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY) is a passive remote sensing spectrometer observing backscattered, reflected, transmitted or emitted radiation from the atmosphere and Earth's surface.
- The instrument flies on board **ENVISAT** which was launched on 1 March 2002.
• **SCIAMACHY** retrieved NO2 column:
  – Nadir observation of NO2 slant column using DOAS (Differential Optical Absorption Spectroscopy) technique
  – Stratospheric contribution is removed using clean air values

• Features of **SCIAMACHY** data:
  – 30x60 km²
  – Overpass time at 10:30 local time
  – Limitation due to cloud presence in the instrumental field of view
Methodology: GAMES simulation system

- **Land use Topography**
- **MM5 output**
- **Emission inventories**
- **Temporal Profiles**
- **VOC speciation Profiles**

**Meterological Pre-processor**
- 3D wind and temperature fields
- Turbulence and Boundary Layer parameters

**TCAM**
- Boundary and Initial condition
- Emission Fields

**System Evaluation Tool**
- Continental model output
- Initial and Boundary condition Pre-processors

**Emission Model**
- Emission Fields
- 3D concentration fields
Methodology: GAMES simulation system

- **GAMES** simulation features:
  - Domain: the Po Valley (640 x 480 km)
  - Spatial resolution of 10 x 10 km (64 x 48 cells)
  - Emission model: CTN-ACE Italian modelling intercomparison project
  - Meteorological model: MM5

- Merging with **SCIAMACHY**:
  - only concentrations at satellite passing hours have been used.
Methodology: merging the two data

- The NO2 tropospheric column from satellite and its error are estimated using DOAS technique.
- Similar quantities are obtained from the model by integrating the vertical profile to get the tropospheric columns (using data that match the satellite ground pixel).
- A corrected column is then calculated as a weighted average between satellite and model columns.
- The NO2 profile is properly scaled.
- The ground level concentration map is the final output.
Methodology: merging the two data
Case study application: 20th November 2004

Ground level map

GAMES

SCIAMACHY

Ground level map
Case study application: 28th January 2004

GAMES

SCIAMACHY

Ground level map
Validation of results

- Comparison with ARPA ground measurements:

<table>
<thead>
<tr>
<th>ARPA NO2 (ug/m^3)</th>
<th>Ground level TCAM NO2 (ug/m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

ARPA NO2 (ug/m^3)

Ground level TCAM NO2 (ug/m^3)

GAMES ground level NO2

Final ground level NO2
Conclusions

• A method for merging SCIAMACHY with GAMES:
  – fast (suitable to be used for NRT monitoring);
  – giving good results in terms of validation of the ground level NO2 concentrations;
  – perspective use with sensors (like OMI) overcoming the spatial scale limitations of SCIAMACHY

• Considering the high maintenance costs of ground instrumentations, this synergy seems a promising way to follow for air quality monitoring.
The authors would like to thank:

- ARPA Emilia Romagna and ARPA Lombardia for providing in situ measurements;
- CETEMPS (University of L’Aquila) for the initial and boundary conditions from CHIMERE simulations.

The research has been developed in the framework of the scientific project **QUITSAT** ([http://www.quitsat.it](http://www.quitsat.it)), sponsored and funded by the Italian Space Agency (ASI).