AIR QUALITY FORECASTING OVER ITALY FOR THE WEB SERVICE LAMIAARIA.IT

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Outline

• LaMiaAria modeling system
• Nested domains
• Model configurations
• The Dust model
• Emissions
• Results and case studies
• Future work
LaMiaAria Modeling System Structure

- Meteorology (WRF)
- Meteorology-Chemistry Interface Processor (MCIP)
- Emission Processing System (SMOKE)
- Chemistry Transport Model (CMAQ)
- Post-Processing (AQM®)
<table>
<thead>
<tr>
<th><strong>LaMiaAria MODELING SYSTEM DESCRIPTION</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Meteorological driver</strong></td>
</tr>
<tr>
<td><strong>Chemistry</strong></td>
</tr>
</tbody>
</table>
| **PM representation** | • sectional approach, 2 emissions bins (fine/coarse)  
• 3 modal log-normal size distribution for transport and deposition  
• Advection, diffusion and dry & wet deposition |
| **Emissions** | Different methodology and data sources for the different scales |
| **Domain specifics** | • 54 km grid covering Europe and North Africa  
• 18 km grid covering central Europe  
• 6 km grid covering Italy |
## Nested Domains

<table>
<thead>
<tr>
<th>Domain</th>
<th>Coverage</th>
<th>Spatial resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain1</td>
<td>Europe + North Africa</td>
<td>54 km (77 X 111)</td>
</tr>
<tr>
<td>Domain2</td>
<td>intermediate</td>
<td>18 km (84 X 78)</td>
</tr>
<tr>
<td>Domain3</td>
<td>Italy</td>
<td>6 km (177 X 213)</td>
</tr>
</tbody>
</table>
Current operational CMAQ forecast still uses static profile lateral boundary condition (LBC).

The initial conditions (IC) for CMAQ are set from the previous forecast cycle.

ADOPTED SCHEMES:

- Yamartino global mass-conserving scheme to calculate horizontal and vertical advection
- Diffusion coefficient based on local wind deformation
- Calculate vertical diffusion using the Asymmetric Convective Model version 2
- Deactivate plume in grid model
- 2nd generation CMAQ aerosol deposition velocity routine
- RADM-based cloud processor that uses the asymmetric convective model to compute convective mixing
- Aerosol module: the 3rd generation modal CMAQ aerosol model (AERO 3/AERO5)
ADOPTED SCHEMES:

- NCEP/GFS data
- No grid analysis nudging
- No observation nudging
- Reisner mixed phase
- Kain-fritsch cumulus parameterization (54 and 18 km grid)
- YSU PBL scheme (Hong and Noh)
- Shortwave atmospheric radiation scheme: CLOUD (Dudhia)
- Longwave atmospheric radiation scheme: RRTM
- Shallow convective scheme
- Multi-layer soil model
- Surface layer model: Monin-Obukhov similarity theory

Nested Domains

D54  80 x 114
D18  94 x 91
D6   193 x 216

Vertical Layers

27 sigma pressure
THE DUST MODEL

The algorithm used to assess surface dust flux is based on the Dust Entrainment and Deposition model (DEAD, Zender, 2002). The flux of dust, expressed in Kg/m²s, released in the atmosphere and then transported by CMAQ (in 2 bins fine/coarse fractioned following D’Almeida [1987] size distribution) is given by:

\[ F = \alpha Q(u_*, u_{*t}) \cdot A_m \cdot T \cdot S \]

- **S** Erodibility factor (to reveal Hot Spots) [Ginoux, 2001]
- **T** Tunable Factor
- **A_m** Bare soil fraction [Zender, 2003]
- **\alpha** = \( f(\text{soil texture}) = 100 \exp[(13.4 M_{\text{clay}} - 6.0) \ln 10] \)
- **Q** = \( Q(u_*, u_{*t}) = \text{const} \cdot u_{*t}^3 [1 - (u_{*t}/u_*)^2] [1 + u_{*t}/u_*] \)
- **u_* = (\tau/\rho)^{1/2}** Friction Velocity
- **u_{*t} = f(D, Re_{*t}, \rho_p) \cdot F_c** Threshold Friction Velocity [Iversen & White, 1982]
For the 54 and 18 km grid, the contributions of the anthropogenic sources (road transport, non road transport, industry, agricultural sources, etc.) are implemented using the last available version of:

- European Monitoring and Evaluation Programme (EMEP) emission database;
- Emission Database for Global Atmospheric Research (EDGAR), excluded particulate matter, for north African areas;
- European Pollutant Emission Register (EPER) for industrial point sources.

The spatial disaggregation is evaluated according to the methodology of the surrogate variables, using geographic data in a GIS platform (primary traffic, CORINE land cover by European Environment Agency) related to the emissions sources.
The inventory of emissions for the Italian national territory (6 km grid) is carried out using the National Emission Inventory provided by the Institute for Environmental Protection and Research (ISPRA), according to the CORINAIR classification.

The municipal spatial disaggregation is carried out from the emissive data on a provincial base according to the methodology of the proxy (or surrogate) variables.
Model validation and calibration

AQM® AirMatch is the system module daily intercomparing model predictions with the publicly available data from the official regional EPA (ARPA) monitoring networks.

**hourly means**
- 136 monitoring stations

**daily means**
- 391 monitoring stations
some hourly matching
Ponzone (Al, 14 May 2009) for PM10, Cremona (15 June 2009) for NO2, Alessandria (20 June 2009) and Acqui Terme (8 May 2009) for O3.
Model validation: Fractional Bias

(114 stations)  (83 stations)  (53 stations)
Results

European directive for modeling uncertainty

\[
EVA = 100 \frac{\text{MAX}(C_{\text{pred}} - C_{\text{obs}})}{LM}
\]

LM: European AQ Standard (Target value for O3)
EVA with values exceeding the regulatory target (50%) depicted in red
Summer Ozone results

24-h Max for O₃ in 83 stations.

Analyzed Period:  
July 1ˢᵗ 2009  
September 30ᵗʰ 2009

Summer O₃ daily-max modeled values are  
96.4% inside the range ±30%  
and 86.7% inside ±20%
02/19/2010: Saharan Dust Outbreak

PM10 (µg/m³)

0-25  25-50  51-62.5  62.5-75  75-87.5  87.5-250  >250

h 11.00 AM, MODIS AOD

Rilevamento della qualità dell’aria nel Comune di Palermo
Sintesi dei dati validi rilevati: venerdì 19 febbraio 2010

<table>
<thead>
<tr>
<th>Station</th>
<th>PM10 (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boccadifalco</td>
<td>92</td>
</tr>
<tr>
<td>Indipendenza</td>
<td>133</td>
</tr>
<tr>
<td>Giulio Cesare</td>
<td>153</td>
</tr>
<tr>
<td>Castelnuovo</td>
<td>143</td>
</tr>
<tr>
<td>Torrelunga</td>
<td>136</td>
</tr>
<tr>
<td>Belgio</td>
<td>129</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station</th>
<th>PM10 (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Librino</td>
<td>110</td>
</tr>
<tr>
<td>P.za A.Moro</td>
<td>136</td>
</tr>
<tr>
<td>Viale V.Veneto</td>
<td>119</td>
</tr>
<tr>
<td>P.za Stesicoro</td>
<td>139</td>
</tr>
</tbody>
</table>
02/28/2009: Industrial and traffic air pollution event in Po Valley

PM10 (µg/m³)

- 0-25
- 25-50
- 51-62,5
- 62,5-75
- 75-87,5
- 87,5-250
- >250

h 11.00 AM, MODIS AOD
02/28/2009: Industrial and traffic air pollution event in Piemonte and Lombardia region

PM10 (µg/m³)

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<thead>
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<th>Station</th>
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<tbody>
<tr>
<td>Milano</td>
<td>123</td>
</tr>
<tr>
<td>Bergamo</td>
<td>122</td>
</tr>
<tr>
<td>Brescia</td>
<td>127</td>
</tr>
<tr>
<td>Varese</td>
<td>39</td>
</tr>
<tr>
<td>Bormio</td>
<td>24</td>
</tr>
</tbody>
</table>

PM10 (µg/m³) distribution:

- 0-25
- 25-50
- 51-62,5
- 62,5-75
- 75-87,5
- 87,5-250
- >250
07/24/2009: Industrial plants in Puglia

PM10 (µg/m³)

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</tr>
</thead>
<tbody>
<tr>
<td>Statte</td>
<td>52</td>
</tr>
<tr>
<td>Casa Circondarire</td>
<td>52</td>
</tr>
<tr>
<td>Paolo VI</td>
<td>66</td>
</tr>
<tr>
<td>Via Archimede</td>
<td>48</td>
</tr>
<tr>
<td>Via Machiavelli</td>
<td>54</td>
</tr>
</tbody>
</table>

h 11.00 AM, MODIS AOD
Le previsioni dell’inquinamento atmosferico in Italia

La qualità dell’aria è:
- Eccellente/Acceptabile
- Mediocre
- Insalubre per gruppi sensibili
- Insalubre
- Molto insalubre
- Pericolosa

Selezione l’indice di qualità:
- Indice generale
- Ozono - O₃
- Polvere sottili - PM₁₀
- Biossido di azoto - NO₂
- Biossido di zolfo - SO₂
- Monossido di carbonio - CO

La spedizione è gratis!
Region maps

**Inquinamento atmosferico in Lombardia**

- **Venerdi, 12 Marzo**
- **Avvertenza**

**Inquinamento atmosferico in Toscana**

- **Venerdi, 12 Marzo**
- **Avvertenza**

**Inquinamento atmosferico in Campania**

- **Venerdi, 12 Marzo**
- **Avvertenza**

**Inquinamento atmosferico in Sardegna**

- **Venerdi, 12 Marzo**
- **Avvertenza**
Future works

**Short-term**

* Global CTM BC: INCA model
* Postprocessing, i.e., bias correction (e.g., KF-based algorithm)

**Medium-term:**

* Probabilistic prediction system based on ensemble data assimilation
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Thank you for your attention

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