Understanding the contribution from fires on atmospheric composition over the Euro-Mediterranean region

Solène Turquety¹, Palmira Messina¹, Stavros Stromatas¹, Géraldine Réa¹, Laurent Menut¹, Myrto Valari¹, Maya George², Yasmina R'honi³, Pierre-Francois Coheur³, Cathy Clerbaux²,³, Bertrand Bessagnet⁴, Augustin Colette⁴

(1) LMD-IPSL, UPMC – Paris 6, CNRS, Ecole Polytechnique
(2) LATMOS-ISPL, CNRS, UPMC – Paris 6
(3) Spectroscopie de l'Atmosphere, Université Libre de Bruxelles, Brussels
(4) INERIS, France
Understanding and quantifying impacts on air quality

APIFLAME project (www.lmd.polytechnique.fr/apiflame)
Analysis and Prediction of the Impact of Fires on Air Quality in the Mediterranean and Europe

- Emissions?
- Injection height?
- Chemical evolution?
- Ozone production?
- Long-range impact?
- AQ Forecast?

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Fires in the Euro-Mediterranean region

MODIS area burned product
8 years analysis (20 km grid)

Frequency

Duration

Burned area (km²)

Month (2007)

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IASI observations of trace gases

Retrievals ULB/LATMOS from the FORLI algorithm (Hurtmans et al., 2012)

Total CO (2008-2010)

DOFS
IASI observations of trace gases

Retrievals from ULB/LATMOS
Summer 2007: Research (Turquety et al., 2009; Coheur et al., 2009)
After 2008: FORLI algorithm (Hurtmans et al., 2012)

Regional monthly mean

August 2008 – Daytime obs.

CO total

DOFS @ levels < 3km

O3 (0-6km)
Impact on atmospheric composition: approach

Emissions
- Anthropogenic
- Biogenic
- Dust
- Fires

Chemistry-Transport Model
CHIMERE (regional)

Output: concentrations for each species

Validation with observations: Simulate observations

Boundary and initial conditions

Meteo (WRF regional)

T°, sunlight, entrainment, etc.

In the following: WRF-CHIMERE simulation
- 20 km horizontal resolution
- 19 levels up to 200 hPa
- EMEP anthr., MEGAN biog, dust
- MOZART boundary conditions

Trace gases:
- Smoothing with averaging kernels
Aerosols:
- optical properties
- lidar att. backscatter signal
(Stromatas et al., GMD, 2012)
General approach:

\[ E_i = \sum_{\text{fueltype}(f)} A_f \times FC_f \times EF_{i,f} \]

- **MODIS 500 m x 500 m**
  - Area burned (MCD45)
- **USGS landuse**
- **ORCHIDEE**
  - Carbone, hydro & veg
- **Burnt area**
- **Emission factor**
- **Biomass density**
- **Burning efficiency**

Emissions
- Model species
- Model grid

• Emission factors
  - Akagi et al., 2011

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Case study of the Greek fires in 2007

AB summer 2007

Greece - 200708

Eastern Europe - 200708

Burned area (km²)

CO emissions (10^6 g)

Day

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Evaluation based on satellite observations: CO

- Consistent transport pathways
- Fires start too late
- Underestimate when AK applied

Similar results for WRF-Chem IASI comparisons (Hodneborg et al., 2012)
Evaluation based on satellite observations: CO

Plume above the sea, close to fire

After ~1 day

(P. Messina)
Evaluation of emission factors using IASI/METOP

\[ ER_X = \frac{\Delta X}{\Delta CO} \]

<table>
<thead>
<tr>
<th>X</th>
<th>Emiss. Ratio EF(X)/EF(CO)</th>
<th>CHIMERE model plume</th>
<th>IASI retrieval (Coheur et al., 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C\textsubscript{2}H\textsubscript{4}</td>
<td>0.012 (Emiss)</td>
<td>0.011 (fresh plume)</td>
<td>0.005 fresh plume 0.003 transport</td>
</tr>
<tr>
<td>NH\textsubscript{3}</td>
<td>0.015 (Emiss)</td>
<td>0.012 (fresh plume)</td>
<td>0.02 fresh plume 0.013 transport</td>
</tr>
</tbody>
</table>

ER seems too high for C\textsubscript{2}H\textsubscript{4}; C\textsubscript{2}H\textsubscript{4} too low => CO even lower? VEGETATION?

Akagi et al., ACP, 2011

<table>
<thead>
<tr>
<th></th>
<th>Temp. forest</th>
<th>Crop residue</th>
<th>Pasture maint.</th>
<th>Savanna</th>
<th>Chaparrale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>89</td>
<td>102</td>
<td>135</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>NH\textsubscript{3}/CO</td>
<td>0.009</td>
<td>0.02</td>
<td>0.01</td>
<td>0.008</td>
<td>0.015</td>
</tr>
<tr>
<td>C\textsubscript{2}H\textsubscript{4}/CO</td>
<td>0.012</td>
<td>0.014</td>
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<td>0.011</td>
</tr>
</tbody>
</table>

Here, assume (USGS):
- 50% savanna and shrubland
- 32% cropland
- 18% forest

Alves et al., 2011: CO Portuguese fires: 231 ±117 g /kg
Evaluation based on satellite observations: NO₂

25 Aug 2007

CHIMERE x OMI AK

26 Aug 2007

Average tropospheric NO₂ above fires in Greece

NO₂ slightly underestimated; less than CO

⇒ ER NO₂/CO too large in the inventory

→ Consistent transport pathways
→ Fires start too late
→ Underestimate downwind
Evaluation based on satellite observations: aerosols

Comparison to aerosol remote sensing: PARASOL (A-Train) AOD @ 865 nm

PARASOL 27/08

PARASOL 24-28/08

PARASOL-CHIMERE 24-28/08

(S. Stromatas)
• 3 observations of fire plumes
• Main features well simulated
• Values of R' often underestimated
• Simulated plume seems too extended / advected too high
• Emissions underestimated
• Improve injection altitude
• Variability of emissions and of injection altitude?
• Transport model error?

Evaluating vertical transport using CALIOP
Summary and ongoing work

**APIFLAME fire emission inventory in the Euro-Mediterranean area**
- Daily emission inventory for trace gases and aerosols based on MODIS fire observations
- High resolution over Europe – adaptable for any region
- Specific EF for Mediterranean vegetation (chaparral/maquis or scrub)
- Emission profiles using pyroconvection code (Rio et al., 2010)

Emissions estimates (2003-...) will be available through ECCAD soon *(Ether database)*

- NRT version of the emissions (same methodology but with NRT MODIS fire detection)


**Impact on air quality: ongoing work**
- Case study of the 2007 summer:
  - Strong influence on regional PM
  - No clear contribution in ozone observations
- Interannual variability and mapping of regions influenced
Thank you for your attention!

Acknowledgments

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LATMOS /ULB retrieval teams & Ether for IASI L2 data
LOA and ICARE for support in the use of the A-Train data
Fires in the Euro-Mediterranean region

Exemples: 2007 fire activity (MODIS AB veg.)

Portugal

Greece

Eastern Europe

Northern Europe

Legend:
- Forest
- Cropland
- Grassland
- Shrubland
- Savanna
- Wetland
Evaluation based on satellite observations


CHIMERE O3 – Aug 20-30 2007
Impact of fires on daily max

FINN GFED
Emissions CO 08/2007

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