Climate sensitivity of different organic aerosol schemes over the Mediterranean basin

Arineh Cholakian (LISA/INERIS), Matthias Beekmann (LISA/CNRS), Augustin Colette (INERIS), Isabelle Coll (LISA/UPEC)
Introduction/Questions

Climate change → important impacts on air quality
Pollutants → major climate forcing agents
Mitigating climate change ↔ impacts on air quality
PMs → one of the most important factors for air quality
OM in the mediterranean → important part of the PM

Questions:
- What are the effects of climate change
  - On future PM$_{10}$/PM$_{2.5}$ concentration
  - On different components of PM$_{10}$/PM$_{2.5}$?
  - On these factors if organic simulation scheme is changed?

RCP → Representative Concentration Pathways

RCPs
- RCP2.6 : radiative forcing till 2100 fixed to 2.6 W.m$^{-2}$
- RCP4.5 : radiative forcing till 2100 fixed to 4.5 W.m$^{-2}$
- RCP8.5 : radiative forcing till 2100 fixed to 8.5 W.m$^{2}$

PM1 Cap Corse
July-august 2013
Modeling framework for climate impact study

**Global Climate Model (GCM)**
- Meteorological input
- Boundary conditions

**Regional Climate Model (RCM)**
- Meteorological input
- Boundary conditions

<table>
<thead>
<tr>
<th>Name</th>
<th>Global Climate Model</th>
<th>Global Chemical transport Model</th>
<th>Regional Climate Model</th>
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<th>Anthropogenic emissions</th>
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<th>Organic aerosol scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP2.6 (2030-2100)</td>
<td>IPSL-CM5A-MR</td>
<td>LMDZ-INCA</td>
<td>WRF RCP2.6</td>
<td>CHIMERE</td>
<td>ECLIPSE-CLE 2010</td>
<td>MEGAN-v4.02</td>
<td>CHIMERE Standard scheme</td>
</tr>
<tr>
<td>RCP4.5 (2030-2100)</td>
<td>IPSL-CM5A-MR</td>
<td>LMDZ-INCA</td>
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RCP → Representative Concentration Pathways
The **Chimere** chemistry-transport model

- **input data**
  - Emissions: ECLIPSE, MEGAN
  - Boundary Conditions: INCA
  - Meteorology: WRF, L-IPSL Labex

- **domain**
  - Domain horizontal resolution: 0.5°

- **configuration**

- **Concentration for different altitudes/species**
  - Vertical levels: 9 (997 – 500 mb)
Climate effects on $\text{PM}_{10}/\text{PM}_{2.5}$

- Decreasing trend of PM for RCP8.5, Increasing trend for RCP2.6, constant trend for RCP4.5
- Compared to historical average:
  - All scenarios show a decrease
Climate effects: PM$_{10}$ different components

- Increase in Salt, Biogenic SOA, sulfates
- Decrease in nitrates, dust

Distribution of PM$_{10}$ in different scenarios stays quite similar
Climate effects: PM$_{10}$ BSOA

- Compared to historic simulations: Increase in all scenarios
- Significant trend line for RCP4.5 and RCP8.5
- Non-significant for RCP2.6
Climate effects: PM$_{10}$ BSOA

Average on whole domain

BSOA (µg/m$^3$)

C$_5$H$_8$ (molecules/cm$^2$)

temperature (k)

BSOA (µg/m$^3$)
### Climate effects: Sub-domains

#### Average on whole domain

<table>
<thead>
<tr>
<th>Component</th>
<th>Hist</th>
<th>RCP2.6</th>
<th>RCP4.5</th>
<th>RCP8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>11.57</td>
<td>11.57</td>
<td>11.42</td>
<td>11.26</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
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<tr>
<td>BC</td>
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<td>POA</td>
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<td>SO4</td>
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<td>NO3</td>
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<tr>
<td>Dust</td>
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<tr>
<td>NH4</td>
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<td>BSOA</td>
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<tr>
<td>ASOA</td>
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#### Mediterranean average

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<tbody>
<tr>
<td>Salt</td>
<td>17.26</td>
<td>17.38</td>
<td>16.77</td>
<td>16.69</td>
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<td>Other</td>
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# Modeling framework for scheme impact study

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<td></td>
<td>VBS with anthropogenic aging</td>
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<td>Historic (coldest 5 years)</td>
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<td>WRF historic</td>
<td>ECLIPSE-CLE 2010</td>
<td>CHIMERE 2014-b</td>
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<td>Modified VBS</td>
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<tr>
<td>RCP8.5 (hottest 5 years)</td>
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<td>WRF RCP8.5</td>
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**RCP** → Representative Concentration Pathways  
**VBS** → Volatility Basis Set
Scheme effects: monthly differences between schemes

OA (µg.m⁻³)

- CHIMERE standard scheme
- Standard VBS scheme
- Modified VBS scheme with anthropogenic ageing

% change for each month

RCP8.5 simulations
Average for whole domain
Conclusions/perspectives

• Climate effects:
  • $\text{PM}_{10}/\text{PM}_{2.5}$ decrease compared to historical simulations, but trends show an increase for RCP2.6, a decrease for RCP8.5 and constant trend for RCP4.5.
  • BSOA increases with temperature increase, while nitrates decrease.
  • Seasalt increases as a result of wind increase in the model
  • The mediterranean area shows higher dust and salt particle concentrations, while lower BSOA and nitrates concentrations.

• Scheme effects
  • The monthly changes in BSOA averages change intensely with scheme change

• Perspectives:
  • High resolution simulations are to be done on the mediterranean coasts of France to see the effects of emission/land use changes on population.
Thank you for your attention!

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Introduction/Questions
Used SOA schemes

**CHIMERE standard scheme**

- Emissions
- Semi-volatile in gaseous phase
- Particles
- Non-volatile SOA

- Functionalization
- Gaz/particle distribution
- Fragmentation
- Non-volatile SOA formation

VBS standard
  + anthropogenic ageing
  + biogenic ageing
  + fragmentation
  + non-volatile SOA formation

3 schemes are compared:
  1. CHIMERE standard scheme
  2. VBS scheme without BSOA ageing
  3. Modified VBS scheme

Robinson et al 2009
Shrivastava et al 2015

Pun et seigneur 2006
Climate effects: Sub-domains

- All → average on whole domain
- Eur → average on Europe, land-sea mask
- Med → average on Mediterranean, land-sea mask
  - Fr → France
  - MedW → average on western Mediterranean
  - MedE → average on eastern Mediterranean
Scheme effects: Sampling protocol for years

Historic

Temperature (k)

R=0.77

RCP8.5

Temperature (k)

R=0.84
Climate effects: PM$_{10}$ BSOA for subdomains
Salt changes