Overview of gaps to be discussed in White Paper on ‘Integrated meteorology & chemistry models’

Alexander Baklanov
WMO Research Department
and the EuMetChem team
Some key general gaps and needs

- Multi-scale: downstream service => Urban, Copernicus
- Emissions: number conc, biogenic emis, dust, sea, SOA, ...
- Fit for purpose approach:
- Gap between observations and models: requirements from both sides
- Data assimilation
- Interacting meteorology-chemistry, atmosphere-ecosystem, air-water/ocean processes
- New generation of models for atmospheric composition in changing climate, AQ and CWF
Abstract:
Online coupled meteorology atmospheric chemistry models have undergone a rapid evolution in recent years. Although mainly developed by the air quality modelling community, these models are also of interest for numerical weather prediction and climate modelling as they can consider not only the effects of meteorology on air quality, but also the potentially important effects of atmospheric composition on weather. Two ways of online coupling can be distinguished: online integrated and online access coupling. Online integrated models simulate meteorology and chemistry over the same grid in one model using one main timestep for integration. Online access models use independent meteorology and chemistry modules that might even have different grids, but exchange meteorology and chemistry data on a regular and frequent basis. This paper offers a review of the current research status of online coupled meteorology and atmospheric chemistry modelling, a survey of processes relevant to the interactions between atmospheric physics, dynamics and composition; and highlights selected scientific issues and emerging challenges that require proper consideration to improve the reliability and usability of these models for the three scientific communities: (i) air quality, (ii) numerical meteorology modelling (including weather prediction) and (iii) climate modelling. It presents a synthesis of scientific progress and provides recommendations for future research directions and priorities in the development, application and evaluation of online coupled models.
‘Integrated Meteorology Chemistry Models: Challenges, gaps, needs and future directions’

*White Paper Structure (draft 1):*

1. Introduction into coupled meteorology-chemistry modelling
2. Potential direct impact and feedback processes relevant in meteorology chemistry coupling
3. Major challenges and needs
   3.1 Interacting processes and feedback mechanisms
   3.2 Numerical and computational aspects
   3.3 Data assimilation
   3.4 Evaluation of methodologies and data
4. Future directions, perspectives and recommendations
   4.1 Emissions and depositions
   4.2 Model formulations
   4.3 Real-time application
   4.4 Model evaluation
Online coupled regional meteorology chemistry models in Europe: current status and prospects


¹Danish Meteorological Institute, Copenhagen, Denmark
²Meteorological Institute, University of Hamburg, Hamburg, Germany
³Karlsruhe Institute of Technology, Garmisch-Partenkirchen, Germany
⁴Barcelona Supercomputing Center, Barcelona, Spain
⁵Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland
⁶Paul Scherrer Institute, Villigen, Switzerland
⁷Center for Global and Regional Environmental Research, University of Iowa, USA
The overall objective is to set up a multi-disciplinary forum for online integrated air quality/meteorology modelling and to elaborate an European strategy for an integrated ACT/NWP-CLIM modelling capability/framework.

Benefits for the Society
This European action (involving also key American experts) will enable the EU to develop world class capabilities in integrated ACT/NWP-RCM modelling systems, including research, education and forecasting. More than 40 teams from 19 European COST countries, as well as ECMWF, JRC, WMO, US EPA, NOAA, etc. are already involved in the Action. In detail the action will contribute to:

- a better forecasting of severe weather events and their consequences (forest fires, dust storms, flooding, volcano eruption, etc.)
- the Action aims towards a new generation of online integrated Atmospheric Chemical Transport (ACT) and Meteorology modelling systems (NWP and RCM) using two-way interactions between different atmospheric processes including chemistry, clouds, radiation, boundary layer, emissions, meteorology and climate (Fig. 1). The Action intends to consider at least two application areas of integrated modelling:
  1. improved numerical weather prediction (NWP) and chemical weather forecasting (CWF) with short-term feedbacks of aerosols and chemistry on meteorological variables,
  2. two-way interactions between atmospheric pollutions / composition and climate variability / change.

The action covers four working groups:
WG1 Strategy and framework for online integrated modelling (coordinated by Peter Suppan and Jose M. Baldasano),
WG2 Interactions, parameterisations and feedback mechanisms (coordinated by Michael Gauss and Alberto Maurizi),
WG3 Chemical data assimilation in integrated models (coordinated by Christian Seigneur and Hendrik Elbern),
WG4 Evaluation, validation, and applications (coordinated by Dominic Brunner and
COST Action ES1004 EuMetChem

23 COST countries
4 COST neighbour countries
2 COST partner countries
3 EU institutions
18 online models analysed =>

- Strategy and framework for online integrated modelling
  - 17 experts (P. Suppan, J.M. Baltasano, G. Grell).
- Interactions, parameterisations and feedback mechanisms
  - 22 experts (M. Gauss, A. Maurizi, Y. Zhang).
- Chemical data assimilation in integrated models
  - 13 experts (Ch. Seigner, H. Elbern, G. Carmichael).
- Evaluation, validation, and applications

(Duration: 02.2011 ... 02.2015)

Time scale: episodes / multiple episodes

Spatial scale

Base map: © 2004-2009 schulbilder.org
Meteorological, chemical and biological processes relevant for health effects and meteorological, chemical and biological weather

- Meteorological processes
  - Impacted by physical atmospheric variables.
- Chemical processes
  - Impacted by chemical variables.
- Biological processes
  - Impacted by bioaerosols (e.g. pollen, fungal spores).

\[\Rightarrow\] Interaction of all processes
\[\Rightarrow\] Towards Integrated Models

Based on Klein et al. (2012)
Advantages of On-line & Off-line modeling

**On-line coupling**
- Only one grid;
- No interpolation in space
- No time interpolation
- Possibility to consider aerosol forcing mechanisms
- All 3D met. variables are available
  No restriction in variability, no mass consistency concerns
- Possibility of feedbacks from meteorology to emission and chemical composition
- Does not need meteo- pre/post-processors
- Physical parameterizations are the same; No inconsistencies
- Harmonised advection schemes for all variables (meteo and chemical)
- Maybe more suitable for ensembles

**Off-line**
- Easier to use for the inverse modelling and adjoint problem;
- Independence of atmospheric pollution model runs (interpretation of results independent of meteorological model computations);
- More flexible grid construction and generation for ACT models,
- Suitable for emission scenarios analysis and air quality management.
- Possibility of independent parameterizations;
- Low computational cost (if NWP data are already available and no need to run meteorological model);
- Maybe more suitable for ensembles and operational activities;

_Baklanov & Korsholm, 2007_
Atmosphere Interactions:
Gases, Aerosols, Chemistry, Transport, Radiation, Climate

Motivation for Climate modeling: large uncertainty of short-lived climate forcers

IPCC (2007)
Greenhouse Gas Forcing: 3.01 $\text{w m}^{-2}$
Aerosol Direct Forcing: -0.5 $\text{w m}^{-2}$
Aerosol Indirect Forcing: -0.7 $\text{w m}^{-2}$ (?)

Temperature $\rightarrow$ chemistry $\rightarrow$ concentrations $\rightarrow$ radiative processes $\rightarrow$ temperature
Aerosol $\rightarrow$ radiation $\rightarrow$ photolysis $\rightarrow$ chemistry
Temperature gradients $\rightarrow$ turbulence $\rightarrow$ surface concentrations, boundary layer outflow/inflow
Aerosol $\rightarrow$ cloud optical depth through influence of droplet number on mean droplet size $\rightarrow$ initiation of precipitation
Aerosol absorption of sunlight $\rightarrow$ cloud liquid water $\rightarrow$ cloud optical depth

After Y. Zhang, Copenhagen, 2007
Importance and Representation of Aerosol-chemistry-meteorology interactions for NWP, CWF and Climate models

Table 1 List of meteorology-chemistry interactions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature → reaction rates</td>
</tr>
<tr>
<td>2</td>
<td>Radiation → reaction rates</td>
</tr>
<tr>
<td>3</td>
<td>Temperature → biogenic emissions</td>
</tr>
<tr>
<td>4</td>
<td>Radiation → photosynthesis → biogenic emission</td>
</tr>
<tr>
<td>5</td>
<td>Temperature → volatility of species</td>
</tr>
<tr>
<td>6</td>
<td>Temperature → aerosol dynamics</td>
</tr>
<tr>
<td>7</td>
<td>Liquid water → wet scavenging, concentrations</td>
</tr>
<tr>
<td>8</td>
<td>Temperature &amp; humidity → gas/particle partition</td>
</tr>
<tr>
<td>9</td>
<td>Precipitation (frequency/intensity) → concentration</td>
</tr>
<tr>
<td>10</td>
<td>Soil moisture → dust emissions</td>
</tr>
<tr>
<td>11</td>
<td>Soil moisture → dry deposition (biosphere and soil)</td>
</tr>
<tr>
<td>12</td>
<td>Wind speed → dust &amp; sea salt emissions</td>
</tr>
<tr>
<td>13</td>
<td>Temperature vertical gradients → vertical diffusion</td>
</tr>
<tr>
<td>14</td>
<td>Lighting → NOX emissions</td>
</tr>
<tr>
<td>15</td>
<td>Water vapour → OH radicals → ozone</td>
</tr>
<tr>
<td>16</td>
<td>Aerosols → SW scattering/absorption, LW absorption</td>
</tr>
<tr>
<td>17</td>
<td>Radiatively active gases → radiation</td>
</tr>
<tr>
<td>18</td>
<td>Aerosol → haze</td>
</tr>
<tr>
<td>19</td>
<td>Soot deposition → ice albedo</td>
</tr>
<tr>
<td>20</td>
<td>Aerosol → cloud droplet/crystals → cloud O.D.</td>
</tr>
<tr>
<td>21</td>
<td>Aerosol → cloud morphology (e.g., reflectance)</td>
</tr>
<tr>
<td>22</td>
<td>Aerosol → precipitation (initiation, intensity)</td>
</tr>
<tr>
<td>23</td>
<td>Climate change → forest fire emissions</td>
</tr>
<tr>
<td>24</td>
<td>Changes in land surface → BVOC emissions</td>
</tr>
</tbody>
</table>

Figure 1 COST ES1004 expert survey results

Baklanov et al., ACP, 2014
Kong et al., AQC, 2014
# Relevance of better knowledge on properties to improve simulation of meteorological, chemical, biological variables

<table>
<thead>
<tr>
<th>Properties (clouds, aerosols)</th>
<th>For variables in</th>
<th>For applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cloud properties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Droplet number concentrations, size distribution,</td>
<td>X</td>
<td>(X)</td>
</tr>
<tr>
<td>• <strong>Cloud fraction</strong>,</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• <strong>Liquid water content, optical depths</strong></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Aerosol properties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Number, aerosol mass, size distribution</td>
<td>(X)</td>
<td>X</td>
</tr>
<tr>
<td>• Composition, phase, hygroscopicity, mixing state,</td>
<td>(X)</td>
<td>X</td>
</tr>
<tr>
<td>• Optical depths</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

EuMetChem: Baklanov, Schlünzen et al.
Relevance of better knowledge on specific processes to improve simulation of meteorological, chemical, biological variables

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Cloud processes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Microphysics, dynamics,</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• In-cloud and below-cloud scavenging,</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Aqueous-phase chemistry</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Aerosol processes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Chemistry</td>
<td>(X)</td>
<td>X</td>
<td></td>
<td>(X)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Thermodynamics</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Dynamics</td>
<td>(X)</td>
<td>X</td>
<td></td>
<td>(X)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Representation of aerosol–radiation–cloud–chemistry interactions (improve indirect estimates of aerosol effect)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

EuMetChem: Baklanov, Schlünzen et al.
Relevance of better process descriptions to improve simulation of meteorological, chemical, biological variables

<table>
<thead>
<tr>
<th>Process (emissions)</th>
<th>For variables in</th>
<th>For applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteorology-dependent emission processes to be described more accurately:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Biogenic</td>
<td>(X)</td>
<td>X</td>
</tr>
<tr>
<td>• Sea spray</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>• Windblown dust</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>• Lightning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthropogenic emission data in urgent need for improvement:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Ships</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>• Wild fires</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>• Volcanic eruptions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Heat fluxes sources needing better knowledge:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Wild fires</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• Volcanic eruptions</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

EuMetChem: Baklanov, Schlünzen et al.
Model formulation and implementation aspects to improve simulations of meteorological, chemical, biological variables

<table>
<thead>
<tr>
<th>Model formulation and implementation</th>
<th>For variables in</th>
<th>For applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of coupling between meteorology and chemistry models needs to be high enough to (at least) properly consider effects of mesoscale events (land-sea breeze, etc.).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data assimilation methodology for meteorological and chemical data that avoids antagonistic effects and over-specification due to interactions between meteorological and chemical variables</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Consistency in processes ensures one single atmosphere is simulated (to achieve by improving collaboration of communities)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Online access modelling to be transferred to online integration of met., chem., biol., to avoid double work</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

EuMetChem: Baklanov, Schlünzen et al.
Our parametrisation/understanding of aerosol–radiation–cloud–chemistry interactions is still incomplete and further research on the model representations of these interactions is needed.

Key aerosol properties (size distribution, phase, hygroscopicity, mixing state and optical depths) and processes (chemistry, thermodynamics for SOA and dynamics) need to be better represented for AQ simulations.

Cloud properties (droplet number concentrations, size distribution, optical depths), processes (microphysics, dynamics, wet scavenging, aqueous phase chemistry) and cloud–aerosol interactions for all types of clouds (in particular for convective and ice clouds) need to be better represented.

A major challenge for most online models is the adequate treatment of indirect aerosol effects. Its implementation with affordable computational requirements and evaluation against laboratory/field data would greatly facilitate this transition.

As more meteorological and chemical variables are assimilated into a model, one must be cautious about possible diminishing returns and possible antagonistic effects due to the interactions between meteorological variables and chemical concentrations. Consequently, the development of optimal methods for data assimilation is warranted.
Modelling recommendations for simulation of meteorological, chemical, biological variables

<table>
<thead>
<tr>
<th>Modelling recommendations</th>
<th>For variables in</th>
<th>For applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerosol/chemistry transport and interactions to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Identify shortcomings in transport schemes,</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Improve assimilation of meteorological satellite data (better through a better representation of gases, aerosols, radiative transfer)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Extend forecasts to AQ in weather time scale</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Meteorology impacts acting online to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduce interpolation efforts and increase accuracy</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Improve meteorology-dependent processes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Improve cloud-connected processes</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

EuMetChem: Baklanov, Schlünzen et al.
Online coupling for (i) NWP and MetM, (ii) AQ and CWF, (iii) Climate and Earth System modelling

- Relative importance of online integration and of the priorities, requirements and level of details necessary for representing different processes and feedbacks can greatly vary for these related communities.
- NWP might not depend on detailed chemical processes but considering the cloud and radiative effects of aerosols can be important for fog, visibility and precipitation forecasting.
- For climate modelling, feedbacks from GHGs and aerosols become extremely important. However in some cases (e.g., for long-lived GHGs on global scale), fully online integration of full-scale chemistry and aerosol dynamics is not critically needed.
- For chemical weather forecasting and prediction of atmospheric composition in a changing climate, the online integration definitely improves AQ and chemical atmospheric composition projections.
- Different targets with respect to temporal as well as spatial scales, but also to processes under focus.
- For AQ forecasting, the key issue is usually the ground-level concentration of pollutants, whereas for weather and climate studies model skill is typically based on screen level temperature, wind speed and precipitation.
- However, several applications are likely to benefit from online modelling though they do not clearly fall under one of these four above mentioned main communities, e.g.: bio-weather forecasting, volcano eruption or forest fires plumes, pollen warnings, dust storms, oil/gas fires, assessing geo-engineering techniques that involve changes in the radiation balance, nuclear war, nuclear accidental releases, etc.
## Recommendations for model evaluation of coupled meteorology, chemistry, biology models

<table>
<thead>
<tr>
<th>Recommendations for evaluating models</th>
<th>For variables in</th>
<th>For applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>International test-bed for model evaluation of urban- and mesoscale models (AQMEII...+)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>To be additionally evaluated:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Shortwave and longwave radiation,</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• Photolytic rate of NO₂,</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• AOD, COT, CCN</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• Cloud droplet number concentration</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• Precipitation</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Additional measurements needed for evaluations:

• Radiative forcing,
• PBL height or vertical mixing,
• Photolytic rates of NO₂,
• AOD, COT, CCN
• Long-term measurement data sets (incl. met. variables, aerosol and cloud properties, biol. variables)

EuMetChem: Baklanov, Schlünzen et al.
WMO Supported Aerosol and Weather Prediction Research

Forecast Models

18 UTC, 7 May 2002 30-hr forecast

NASA A-Train MODIS  CALIPSO &
Geostationary Satellite IR Obs

European PM10

GALION
Surface-based LIDAR

GAW/AERONET/SKYNET
Surface-based AOD

Presentation of the Barcelona Dust Forecast Centre, AEMET, Madrid, Spain, June 10th, 2014
Conclusions

• Online modelling approach is a prospective way for future *single-atmosphere* modelling systems with advantages for applications at all time scales of NWP, AQ and climate models.

• Not necessarily one integrated online modelling approach/system is best for all communities.
  
  ✓ Parameters of one sphere do not singly depend on processes of that very sphere and vice versa (e.g. wet deposition depends on aerosol and cloud formation).
  
  ✓ We need improved understanding of several processes but also of some parameters.
  
  ✓ Data assimilation in online models still to be developed to avoid over-specification and antagonistic effects.
  
  ✓ Model evaluation for online models needs more (process) data and long-term measurements – and a test-bed.
‘Integrated Meteorology Chemistry Models: Challenges, gaps, needs and future directions’

White Paper Structure (draft 1):

1. Introduction into coupled meteorology-chemistry modelling

2. Potential direct impact and feedback processes relevant in meteorology chemistry coupling

3. Major challenges and needs
   3.1 Interacting processes and feedback mechanisms
   3.2 Numerical and computational aspects
   3.3 Data assimilation
   3.4 Evaluation of methodologies and data

4. Future directions, perspectives and recommendations
   4.1 Emissions and depositions
   4.2 Model formulations
   4.3 Real-time application
   4.4 Model evaluation
‘White Paper’ further work

• Existing experience in different international programs/projects and national centers: EuMetChem, WMO GURME, WGNE CCWG, WCRP, AQMEII, ICAP, IGBP, IGAC, …

• 3 communities: NWP, AQ and Climate: Needs, requirements and applications; Science questions from all 3 communities; What is the significant problem to meet these 3 communities?

• Suggestions for further steps and recommendations: links with GAW&WWRP priorities; integrated urban weather, environment & climate service; multi-scale: chain global-regional-urban (MACC extension); regional centers

• Requirements for data: observations and modelling, data assimilation and near-real-time data access; models evaluation

• Focus on aerosols and their interactions with meteorological/ climate and chemical processes (the main gap)
Coupled Met-Chem Models Applications:

- Urban Integrated Services
- Sand and Dust Storm Warning Systems
- Wildfire atmospheric pollution and effects
- Volcano ash forecasting, warning and effects
- High Impact Weather and Disaster Risk
- Effects of Short-Lived Climate Forcers
- Weather modification and geo-engineering
- …
Connections between Megacities, Air Quality and Climate

- Science - nonlinear interactions and feedbacks between urban land cover, emissions, chemistry, meteorology and climate
- Multiple spatial and temporal scales
- Complex mixture of pollutants from large sources
- Scales from urban to global
- Interacting effects of urban features and emissions
- FUMAPEX Integrated UAQIFS: in 6 EU cities

see: Nature, 455, 142-143 (2008)
Conference: ‘Coupled Chemistry-Meteorology Modelling (CCMM): status and relevance for numerical weather prediction, atmospheric pollution and climate research

WMO, Geneva, 9-11 February 2015

Main sessions:
- Coupled Chemistry-Meteorology Modelling (CCMM): approaches and requirements
- Key processes of Chemistry-Meteorology interactions and their descriptions
- Aerosol effects on meteorological processes and NWP
- CCMM for air quality and atmospheric composition
- Inputs from CCMM to climate research community
- Model validation and evaluation
- Data requirements, use of observations and data assimilation
- Outlook and future challenges

Organizers and co-organisers:
EuMetChem COST ES1004, WMO WGNE, GURME and WCRP WGCM, MACC, US EPA, JRC, AQMEII
Special Issue of Atmospheric Chemistry & Physics (ACP) and Geoscientific Model Development (GMD) Journals:
‘Coupled Chemistry-Meteorology Modelling: status and relevance for NWP, atmospheric pollution and climate communities’
Editors: A. Baklanov, S. Freitas, B. Vogel, ...

To be open in August 2014 and be open until August 2015

Key Issues:
• Coupled Modelling: approaches and requirements
• Aerosol effects on meteorological processes
• Online coupling for air quality and atmospheric composition
• Coupling modelling in climate research
• Model evaluation and data assimilation
• Requirements and future challenges

WWOSC relevant papers are invited to be submitted!
Thank You!

COST ES1004 EuMetChem: http://eumetchem.info
WMO GAW and WWRP: www.wmo.int
MEGAPOLI: http://megapoli.info
EuMetChem AQMEII wiki-page: http://aqmeii-eu.wikidot.com/
AQMEII: http://aqmeii.jrc.ec.europa.eu/

Contact: abaklanov@wmo.int
References / Overview:


