Highlights from AQMEII Phase 2 and Next Steps

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AQMEII Phase 2 Overview

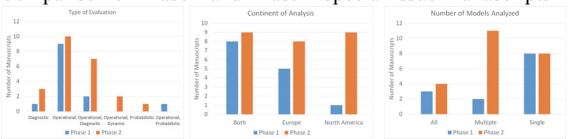
AQMEII Phase 2 Objectives

- Evaluate regional-scale online coupled meteorology / chemistry models
- Employ operational, diagnostic, dynamic and probabilistic evaluation approaches (Dennis et al., 2010)

AQMEII Phase 2 By The Numbers

- 18 groups from 10 countries in North America (NA) and Europe (EU) performed annual continental scale simulations for 2010 (primary focus) and 2006
- 26 manuscripts were submitted to a special issue of Atmospheric Environment

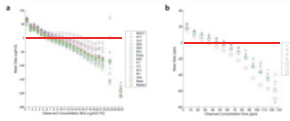
Comparison of Phase 1 and Phase 2 Special Issue Manuscripts



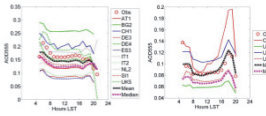
AQMEII Phase 2 Key Findings

- During the summer and during intense emission events (e.g. Russian forest fires of 2010), feedbacks can have a noticeable impact on air quality simulations
- The aerosol indirect effect was usually found to dominate feedbacks compared to the direct effect
- For annual statistics, model-to-model variations in performance are greater than the within-model variations associated with feedbacks
- Analysis results reaffirm the importance of chemical boundary conditions on the performance of regional-scale models

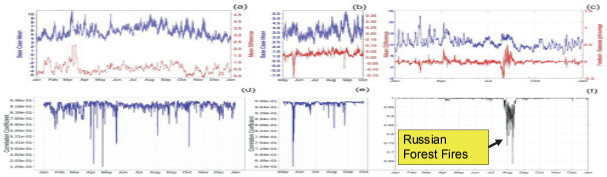
Operational Evaluation and Model-to-Model Comparisons



Mean bias of summertime daily maximum 8-hr O_3 vs. observed concentration bins for the EU (left) and NA (right) domains (Im et al., 2014a)



Diurnal cycle of observed and simulated AOD (555nm) over Europe (left) and North America (right) (Im et al., 2014b)



Grid average non-feedback $PM_{2.5}$ concentrations (blue) and mean feedback – no feedback concentration differences (red), for (a) NA/GEM-MACH (direct+indirect effects), (b) NA/WRF-CMAQ (direct effects only), (c) EU/WRF-CHEM (direct+indirect effects). (d,e,f): Correlation coefficients between feedback and no-feedback simulations for these models. (Makar et al., 2014)

Diagnostic Evaluation

Use the FlexAOD column model to investigate differences in modeled AOD: What is the role of differences in assumptions in the optics calculations vs. differences in profiles of $PM_{2.5}$ composition and mass? (Curci et al., 2014)

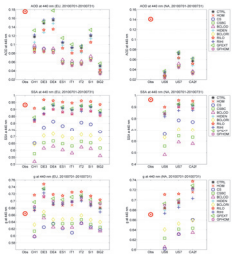
Table 1. Optical properties of aerosol model components used in the FlexAOD calculations.

	Sulfate	Nitrate	BC	POA	SOA	Sea Salt	Dust
r_0 (μm)	0.05(1)	0.085	0.0118	0.12	0.095	0.209	0.31
σ_g	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Density (g/cm³)	1.769(1) 1.8(2)	1.725 1.8	1.8 1.0	1.47 2.0	1.3 1.8	2.2 2.2	2.65 2.6
Refr. Ind. (550 nm)	1.53-i0.0(1) 1.53-i0.006(2) 1.43-i10-6 (3)	1.80-i0.0 1.53-i0.006 1.43-i10-6	1.85-i0.71 1.75-i0.44 1.75-i0.44	1.53-i0.021 1.53-i0.008 1.53-i0.006	1.43-i0.0 1.53-i0.006 1.53-i0.006	1.5-i10-6 1.5-i10-6 1.5-i10-6	1.52-i0.0001 1.53-i0.0055 1.558-i0.0014
Growth Factor	1.64(1) 1.8(2)	1.64 1.8	1.0 1.0	1.0 1.0	1.64 1.6	2.38 2.4	1.0 1.0

(1) ADIENT (Highwood et al., 2009), (2) OPAC/GADS (Hess et al., 1998), (3) GOCART (Chin et al., 2002)

Table 2. Description of the sensitivity tests on aerosol optical properties calculations, performed using model predicted aerosol profiles. The symbol "=" denotes no change with respect to the CTRL simulation.

Simulation Label	Mixing	Core	Density	Refractive Index	Hygroscopic GF
CTRL	EXT	None	ADIENT	ADIENT	OPAC
HOM	HOM	None	ADIENT	ADIENT	OPAC
CS	CS	BC, OC, DUST	ADIENT	ADIENT	OPAC
CSBC	CS	BC	ADIENT	ADIENT	OPAC
BCLOD	CS	BC	OPAC	ADIENT	OPAC
HIDEN	EXT	None	Highest in Table 1	ADIENT	OPAC
BCLORI	CS	BC	ADIENT	OPAC	OPAC
RILO	EXT	None	ADIENT	Real part lowest in Table 1	OPAC
RHI	EXT	None	ADIENT	Real part highest in Table 1	OPAC
GFEXT	EXT	None	ADIENT	ADIENT	CHN
GFHOM	HOM	None	ADIENT	ADIENT	CHN

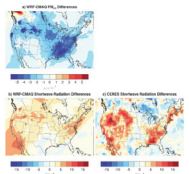


FlexAOD AOD, single scattering albedo (SSA), and asymmetry parameter (g) at 440 nm for EU and NA domains. The observed values averaged over all AERONET observations in July 2010 (red target) are compared to space-time paired simulated values for all sensitivity tests described in Table 2.

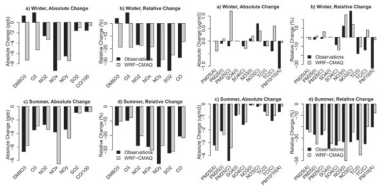
Also see the presentation on indicator ratio comparisons by Campbell et al. (Tuesday, 2 pm)

Dynamic Evaluation

Comparison of observed and modeled changes in AOD, radiation, and pollutant concentrations between 2006 and 2010 (Hogrefe et al., 2010)



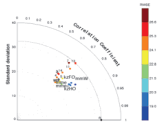
Differences between summer 2010 and 2006 in a) WRF/CMAQ $PM_{2.5}$ b) WRF/CMAQ clear-sky SW radiation. c) CERES satellite clear-sky SW radiation



Observed (black) and simulated (grey) differences in quarterly average concentrations between 2010 and 2006. Letters in parenthesis indicate the monitoring network: A – AQS, I – IMPROVE, C - CSN.

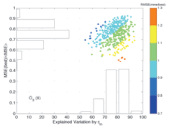
Probabilistic Evaluation

Comparison of EU ozone simulations from individual models against various postprocessing ensemble approaches (Kioutsioukis et al., 2014)



Taylor diagrams for individual models and postprocessing ensemble approaches

Ratio of the median model ensemble (mme) RMSE and the RMSE of the best individual model



Ratio of mme RMSE and best individual model RMSE as function of skill difference and error dependence

See presentation by S. Galmarini (Tuesday, 3:40 pm) for further details

AQMEII Phase 3 – Collaboration with HTAP

Background

- Contribute to the modeling and analysis activities performed under the umbrella of the Task Force on Hemispheric Transport of Air Pollution (TF-HTAP)
- Under TF-HTAP, global models will simulate the impact of emission perturbations in upwind regions on regional and local air quality
- Regional air quality models will be used to perform corresponding simulations over North America and Europe, utilizing boundary conditions from the global models

Questions to be addressed

- In which aspects does model performance over North America and Europe differ between global and regional models?
- How do source/receptor linkages differ between global models and linked global/regional models

Overview of Activity

- Focus year of analysis: 2010 (utilizes emission and observation databases compiled for Phase 2)
- Participating models: coupled and uncoupled – open invitation to Phase 1 and Phase 2 participants as well as the wider community. To date, 19 modeling groups have signed up
- HTAP global models providing temporally-resolved 4D fields to generate boundary conditions to regional scale modeling groups (e.g. AQMEII3 and MICS-ASIA – *see posters by Huang et al. and Lam et al.)*
  - MACC (ECMWF) ← Use as "base case" for AQMEII3
  - AM3 (NOAA GFDL)
  - GEOS-CHEM (Seoul National University)
  - CHASER (Nagoya University)
- HTAP emission scenarios simulated by HTAP global models (not all global models may simulate all scenarios):
  - BASE – models use the EDGAR/HTAP 2010 emission inventory that includes the AQMEII2 / AQMEII3 North American and European emissions
  - GLOALL - all anthropogenic emissions reduced by 20% globally
  - 20% anthropogenic emission reductions in specific source region, e.g. East Asia (EASALL), North America (NAMALL), Europe (EURALL), etc.

References

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