Evaluation and Intercomparison of Modeled Atmospheric Deposition over North America and Europe: An Overview of Phase 4 of the Air Quality Model Evaluation International Initiative

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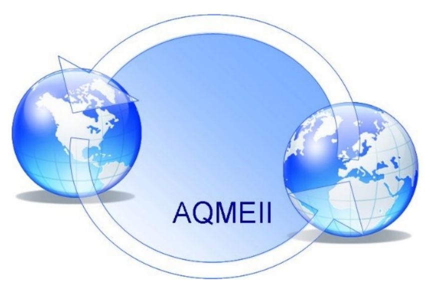
Background



- Under the leadership of the Joint Research Centre and U.S. EPA, the Air Quality Model Evaluation International Initiative (AQMEII) has brought together 37 modeling groups from 17 countries in North America and Europe since its inception in 2009 (Rao et al., 2011).
- AQMEII coordinates research projects and model inter-comparisons to advance evaluation practices and inform model development.
- Most analyses have focused on meteorological variables, trace gases and fine particulates.

Objectives of AQMEII Phase 4

- Quantify the performance and variability of dry and wet deposition fields simulated by multiple state-of-science regional air quality models.
- Document deposition schemes and key parameters used in these models.
- Perform box model simulations to quantify the impacts of different deposition schemes and parameters on simulated dry deposition.
- Investigate methods for using simulated meteorological, concentration, and deposition fields from multiple models in conjunction with available observations to estimate maps of total deposition and critical load exceedances.

Details of Planned AQMEII Phase 4 Activities

3D Air Quality Model Simulations

Annual Simulations

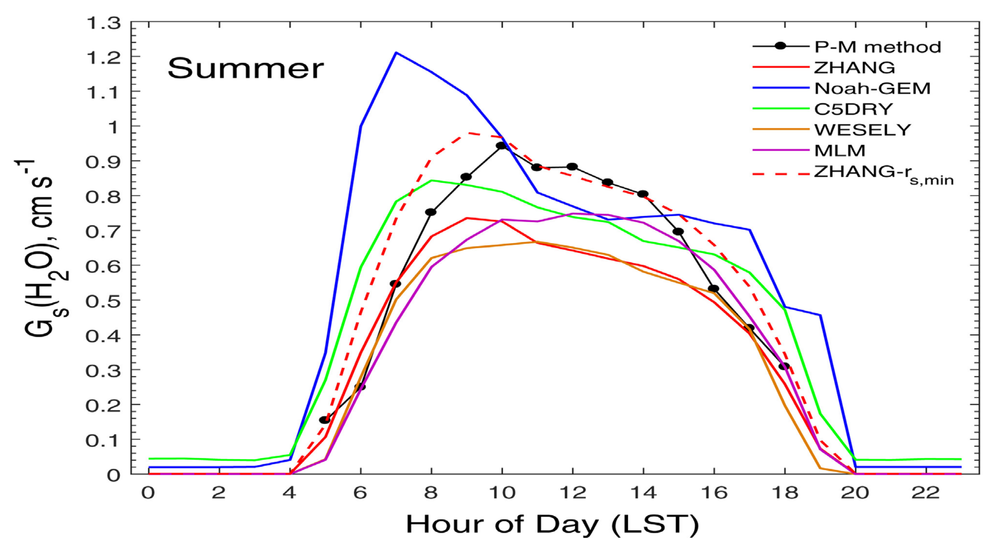
- North America: 2010 and 2016.
- Europe: 2009 and 2010.
- Common emission and boundary condition inputs.
- Target horizontal resolution: 0.125 x 0.125 degrees.
- Questions to be addressed:
  - How do simulated deposition fields for specific land use types differ between modeling systems?
  - What are the key drivers of these differences?
  - How well do these models' simulated deposition fields agree with observations?

Simulations Under Idealized Meteorological Conditions

- How does simulated dry deposition velocity vary across land cover types and between models under common meteorological conditions at all grid points?
- What are the effects of three key factors (day vs. night, summer vs. winter, and dry vs. wet conditions) on simulated dry deposition velocity?
- How do inter-model differences under standardized conditions compare to differences under modeled ambient conditions?

Box Model Simulations

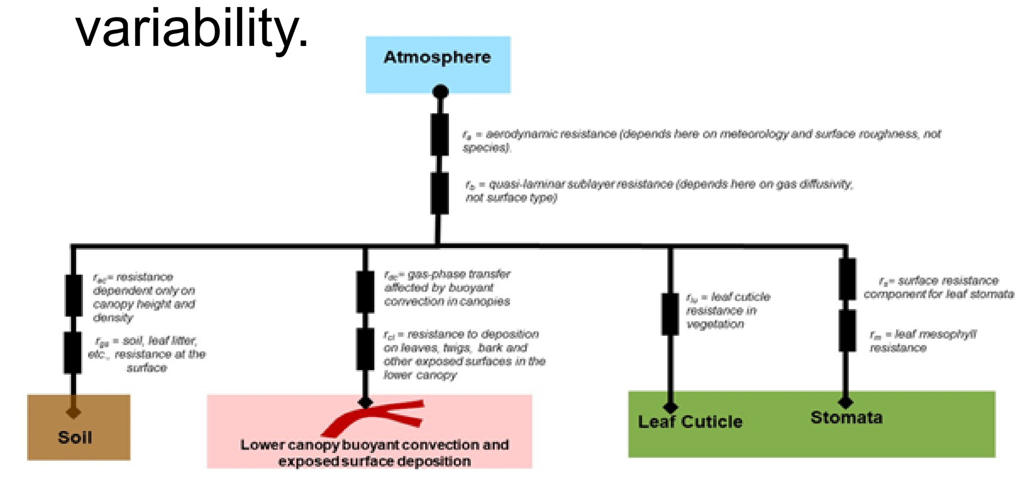
- To be performed for several field measurement sites
- How and why do current dry deposition models differ under identical environmental conditions?
- How well do these models predict measured deposition velocity?



Illustrative example of planned analyses: Evaluation of averaged diurnal cycles of stomatal conductance (Gs) for water vapor at Borden Forest (Wu et al., 2018)

Intercomparison of Dry Deposition Pathways

- Details of resistance-based dry deposition schemes vary across models.
- Despite these differences, common deposition pathways may be compared using the concept of ***effective conductance:***
  - contribution of a given depositional pathway to the deposition velocity.
  - tool for determining which deposition pathways for surface resistance drive net deposition, as well as inter-model, spatial, and temporal variability.



$$E_{SOIL} = \left(\frac{(r_{ac}+r_{gs})^{-1}}{(r_s+r_m)^{-1}+(r_{lu})^{-1}+(r_{dc}+r_{cl})^{-1}+(r_{ac}+r_{gs})^{-1}}\right)V_d$$

$$E_{LCAN} = \left(\frac{(r_{dc}+r_{cl})^{-1}}{(r_s+r_m)^{-1}+(r_{lu})^{-1}+(r_{dc}+r_{cl})^{-1}+(r_{ac}+r_{gs})^{-1}}\right)V_d$$

$$E_{CUT} = \left(\frac{(r_{lu})^{-1}}{(r_s+r_m)^{-1}+(r_{lu})^{-1}+(r_{dc}+r_{cl})^{-1}+(r_{ac}+r_{gs})^{-1}}\right)V_d$$

$$E_{STOM} = \left(\frac{(r_s+r_m)^{-1}}{(r_s+r_m)^{-1}+(r_{lu})^{-1}+(r_{dc}+r_{cl})^{-1}+(r_{ac}+r_{gs})^{-1}}\right)V_d$$

Effective conductances of the soil, lower canopy, cuticle and stomata branches for Wesely (1989). The exact formulation differs between models due to different implementations of the resistance framework, but the terms can meaningfully be compared across models.

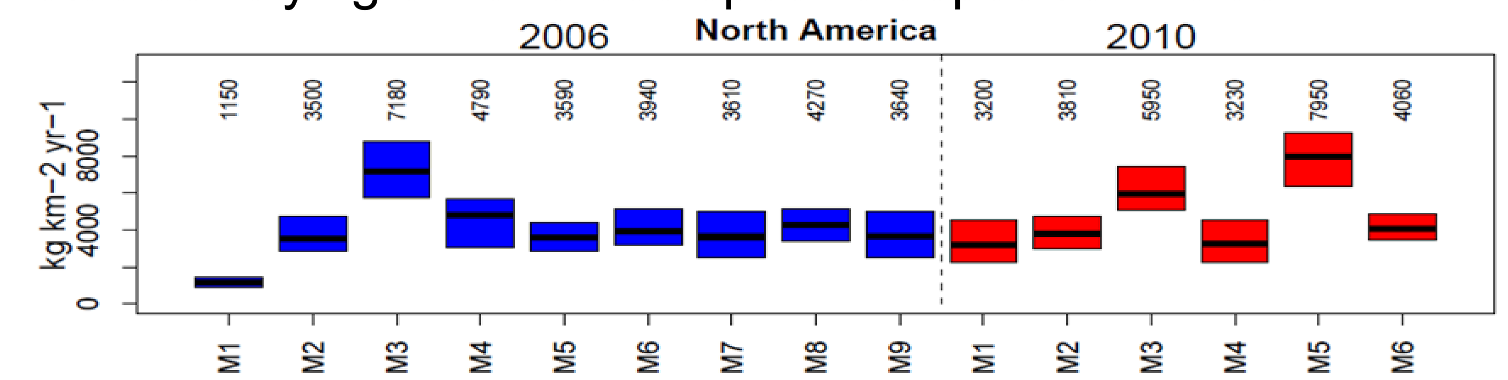
Harmonization of Land Use

- Every model uses its own land use scheme for the simulations.
- A common 16-class scheme has been devised to lump the individual model classes for reporting and analysis purposes.

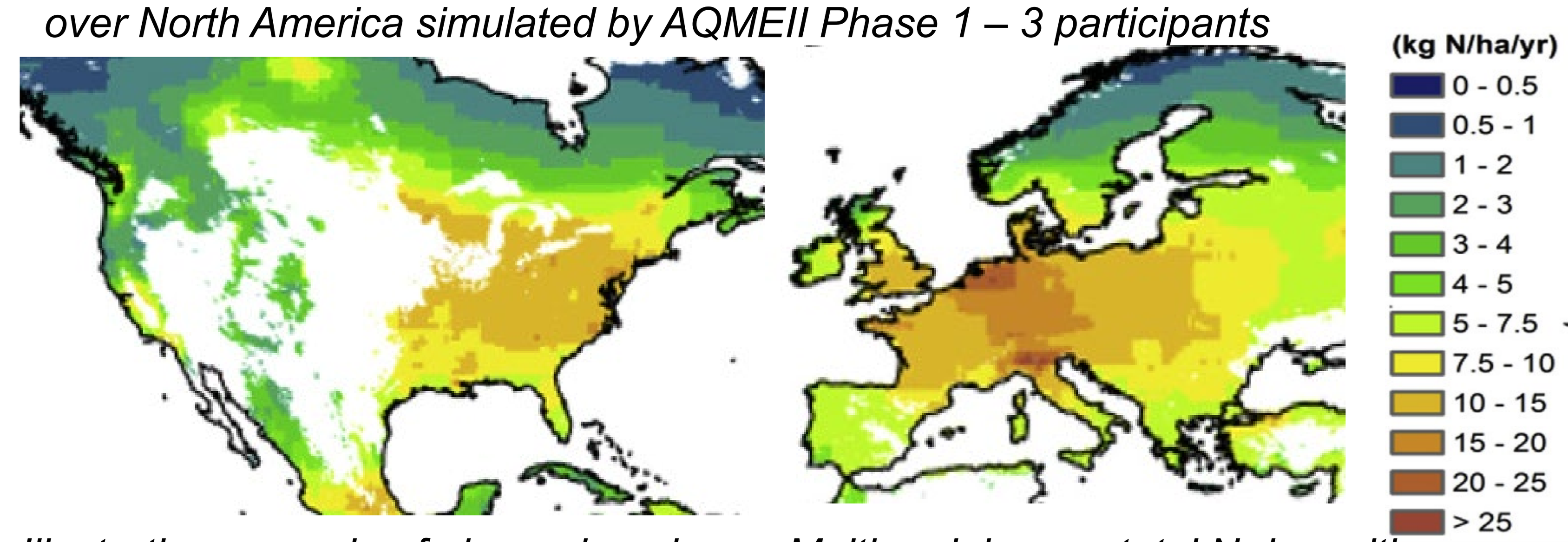
1 Water
2 Developed / Urban
3 Barren
4 Evergreen needleleaf forest
5 Deciduous needleleaf forest
6 Evergreen broadleaf forest
7 Deciduous broadleaf forest
8 Mixed forest
9 Shrubland
10 Herbaceous
11 Planted/Cultivated
12 Grassland
13 Savanna
14 Wetlands
15 Tundra
16 Snow and Ice

Planned Analyses and Uses of AQMEII Phase 4 Data Sets

- The activity is aimed both at improving the representation of deposition in regional-scale models and at supporting impact studies relying on land-use specific deposition fields.



Illustrative example of planned analyses: Annual total ozone dry deposition flux over North America simulated by AQMEII Phase 1 – 3 participants



Illustrative example of planned analyses: Multimodel mean total N deposition (kgN ha^{-1} yr^{-1}) on grid cells with a forest cover >5% (Schwede et al., 2018)

How to Get Involved: Participants and Tentative Timeline

- **Fall 2018:** Call for participation.
  - Positive response from 20+ modeling groups.
- **Summer 2019:**
  - Distribution of boundary condition and emission datasets.
  - Distribution of information about expected variables, output formats, database organization, etc.
- **Fall 2019**
  - Begin simulations.
- **Spring 2020:** Begin data submission for analysis.
- **Summer 2020:** Analysis of model simulations.
- **Late Spring 2021:** Submission of articles to a special issue.
- **Interested in participating? Contact Christian Hogrefe (hogrefe.christian@epa.gov)**

Rao et al., 2011: Bulletin of the Amer. Met. Soc. 92 (1):23-30, doi:10.1175/2010BAMS3069.1
Schwede et al., 2018: Environ Pollut. 243(Pt B):1287-1301. doi: 10.1016/j.envpol.2018.09.084
Wesely et al., 1989: Atmos., Env., 23(6), 1293-1304, doi:10.1016/0004-6981(89)90153-4
Wu et al., 2018: J. Adv. Mod. Earth Syst., doi:10.1029/2017MS001231