Investigation of nitrate simulations from AeroCom multi-models constrained by various measurements

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Background and Motivation.

Nitrate is an important atmospheric aerosol component and impacts on air quality, climate, and ecosystem. Nitrate will be more important in the future climate study owing to projected growth of future population and energy use. It has been concluded that aerosol nitrate has to be included to the current suite of aerosol types (sulfate, BC, OC, dust and sea salt) in the next generation of climate models by the NARSTO final report [http://www.narsto.org/sites/narsto-dev.ornl.gov/files/AerosolProcesses_Final.pdf]. Nevertheless, unlike the other major atmospheric aerosol components, the simulation of aerosol nitrate from AeroCom models has not yet been extensively evaluated. This work attempts to strengthen the nitrate evaluation and will investigate it from three aspects:

1. Address the diversity of the nitrate simulation by the AeroCom multi-models and diagnose the driving process for the diversity;
2. Explore the uncertainty of the model nitrate simulations constrained against various measurements from ground station networks, aircraft campaigns, and satellite retrievals;
3. Investigate how the formation of nitrate changes in different models in response to the perturbation on key precursors and factors that determine the nitrate formation.

Experiments.

Baseline simulation: This experiment should be done in an ammonia-nitrate-sulphate system. A full year simulation for 2008 is required. All models will use the same pre-defined emission data for gas and aerosol tracers as could as possible. The emissions from anthropogenic, aircraft, and ship are obtained from the recently developed HTAP v2 database that provides high spatial resolution monthly emission [http://edgar.jrc.ec.europa.eu/htap_v2/index.php?SECURE=123]. For the tracers that are included in ozone chemistry but are not provided by HTAP v2, they should be obtained from CMIP5 RCP85 with a linear interpolation between 2005 and 2010 [http://tntcat.iiasa.ac.at:8787/RcpDb/dsd?Action=htmlpage&page=download]. Biomass burning emissions are the emissions of GFED3 in 2008 [http://www.globalfiredata.org/Data/index.html]. Participant groups provide their own NO lightning and DMS emissions since they are calculated based on models' meteorological fields. Please add NH3 emission from ocean from this protocol [http://nansen.ipsl.jussieu.fr/AEROCOM/protocol.html]. The emission is reformatted based on the compilation of GEIA emission inventory.

All participant models shall use or nudge meteorological data for 2008. Please allow one-year spin up for the baseline simulation.

The year 2008 is chose due to the availability of measurements over the period: 1. Both North America and Europe start to measure surface ammonia in 2007 by setting up ground station networks (e.g. AMoN for USA and NitroEurope for Europe); 2. There are several surface and aircraft campaigns carried out during 2008 (e.g. ARCTAS, POLARCAT, START08/PreHIPPO, YAK-AEROSIB, and ship-based campaign ICEALOT).

Perturbation experiments: To investigate how the formation of nitrate changes in different models in response to more emissions of NH3, less emissions of NOx, SO2, and dust, and higher temperature and RH that may happen in the future, we design the following 6 perturbation experiments. Participating in these perturbation experiments is encouraged, but is subject to the resources of the participants.

1. Increase NH3 emission by 20%
2. Decrease NOx emission by 20%
3. Decrease SO2 emission by 20%
4. Decrease dust emission by 20%
5. Increase T by 1.5 K
6. Increase RH with RH+(100-RH)x10% (RH in percentage)

Diagnostics

Document: Model documentation should include a brief description of the model and any references (limit: one page). Please include brief notes on: How you treat NO lightning and DMS emissions, the module/methodology of HNO3 partitioning between gas and aerosol phases, the mechanism of dust and sea salt in the formation of nitrate aerosol. Please also note which model mode for your simulation: GCM or CTM.

Results: Participating modelling groups will provide a full year simulation results for 2008. A detailed description for the diagnostics is listed in the following table. The common output for model features and meteorological fields (e.g. 3D pressure field, temperature, RH, and precipitation) will be provided at the AeroCom website [http://nansen.ipsl.jussieu.fr/AEROCOM/protocol.html]. If possible, please provide nitrate concentration, dry and wet depositions, and chemistry production in fine mode and coarse mode separately.

2-D monthly fields	
Emission	NOx, NH3, SO2, SO4, DMS
2-D daily fields	
Meteorology	Precipitation
Dry Deposition, Wet Deposition, Surface Concentration, Load	NH3, NH4, NOx, HNO3, N2O5, NO3[a] (nitrate), PAN, NOy (including nitrate), SO2, DMS, SO4
Optical field	AOD (nitrate)

3-D monthly fields	
Meteorology	Temperature, Specific Humidity, Air Mass, Pressure
Chemistry prod/loss	NO3[a], SO4 (gas), SO4 (aqu)
3-D daily fields	
Concentration	NH3, NH4, NO, NO2, HNO3, N2O5, NO3[a] (nitrate), PAN, SO2, SO4

[a] if possible, please provide nitrate concentration, dry and wet depositions, and chemistry production in fine mode and coarse mode separately.

Timetable (tentative)

09.2013 – discuss and refine the experiment plan at the AeroCom meeting
01.2014 – finalize the experiment plan
06.2014 - submit model results to AeroCom server
09.2014 – preliminary results for the annual AeroCom meeting
02.2014 – Final deadline for the nitrate experiment
05.2015 – Submission of manuscript