INSITU project within AeroCom Phase III:
Description and Model Output Request

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Introduction

The following document outlines the INSITU project- a comparative analysis project within AeroCom Phase III that is aimed at using in-situ dry surface measurements of aerosol optical properties to evaluate the AeroCom suite of aerosol models. The current project plan has three tiers- (I) Evaluation of climatologies and covariance of dry aerosol optical properties in the models and measurements, (II) Analysis of long-term aerosol optical property trends in models and observations, and (III) Comparison of hygroscopicity of aerosol properties in the models and measurements. Each tier is described in detail below, followed by specific model output requests for each tier.

TIER I: Comparisons of Dry Aerosol Climatologies and Covariance

The objective of the dry aerosol comparisons project is to evaluate the performance of multiple AeroCom aerosol models using in-situ surface aerosol optical property measurement climatologies in a way that will inform improvements to model aerosol modules. In general, the in-situ optical measurements are made at low relative humidity (RH < 40%), which is why the model output is requested for dry conditions. Long-term, hourly in-situ surface measurements provide a valuable look at diurnal and monthly aerosol variability, while the suite of observations from monitoring networks give insight into atmospheric processes, sources and transport that may or may not be well represented in the models.

There is currently a very limited number of models that have submitted daily, dry aerosol optical property output suitable for comparison with the in-situ measurements. Furthermore, the model output request for TIER I includes *hourly dry* extinction and absorption at 3 wavelengths, asymmetry parameter, and vertical profiles of all variables at station locations. Since many of the in-situ data sets available for the project are from mountaintop sites, which make free troposphere measurements during certain times of the day, the simulated hourly profiles of dry aerosol parameters are needed to properly make use of in-situ mountain measurements and can be used to assess model output of free troposphere aerosol. Additionally, the simulated hourly profile data can be compared to the in-situ measurement profiles (at Bondville, Illinois and Southern Great Plains, Oklahoma) obtained during from long-term aircraft campaigns (hundreds of in-situ aerosol optical property profiles were obtained above these two instrumented ground sites over the course of several years).

TIER I Outcomes

- Two publications: the first would evaluate how well models are reproducing both observed aerosol optical properties (bias) and temporal variability at specific locations, while the second paper would explore how well the models are capturing aerosol processes and co-variance of parameters observed at monitoring sites
- Benchmark dataset of in-situ surface measurements for use by modelers in evaluating their runs
- Proposal of specific model runs (e.g., perturbed removal processes) to be used in future, more in-depth, comparisons between surface aerosol observations and models.

TIER II: Dry Aerosol Comparisons - Long-term trends

Identifying trends in atmospheric constituents is necessary in order to understand how regional and global cycles may be changing, as well as for validating emissions inventories and testing model simulations on different time scales. Trend analyses can be used to determine the effectiveness of past emission abatement strategies and to predict the effectiveness of future regulatory controls. Many surface in-situ observatories have been making continuous aerosol optical property measurements for more than a decade. The long-term, surface in-situ data has previously been used to evaluate trends in dry aerosol scattering and absorption (i.e., Collaud Coen et al., Atmos. Chem. Phys., 2013). The project proposed here enables us to expand that previous analysis, which focused only on in-situ data, to see how well models simulate the trends observed for in-situ measurements. The number of sites for which a trend analysis can be done (10+ years of data are required) has increased significantly since the publication of the 2013 paper.

TIER II Outcomes

- Publication describing comparisons of in-situ and modelled trends
- Development of benchmark in-situ trend data set expanded from that produced by the Collaud Coen et al. 2013 paper (more sites, longer time series)
- Use results to suggest model perturbation experiments that may produce better predictions of aerosol trends

TIER III: Evaluation of hygroscopicity of aerosol optical properties

Aerosol optical properties are strongly dependent on ambient humidity. Depending on their composition and the ambient humidity, atmospheric particles will take up varying amounts of water, thereby altering their optical properties. This humidity dependence thus has important implications for aerosol radiative forcing. Although most long-term, surface in-situ optical property measurements are made at low RH (<40%), a few sites (approximately 15) have made measurements of aerosol scattering as a function of RH over time periods ranging from months to years. Here we propose to compare model output with these high-quality, long-term, in-situ measurements of aerosol hygroscopicity in order to determine how well model simulations represent the observations of aerosol water uptake. Additionally, we hope to characterize differences between model simulated and observed ambient RH. A long term goal of this project is

to propose hygroscopic growth correction schemes for aerosol scattering as a function of location based on model aerosol characteristics (i.e., aerosol chemistry). This will be particularly useful for locations where measurements of relevant parameters such as aerosol chemistry are unavailable. An added benefit is that this may enable us to better tie long-term surface dry aerosol optical data to ambient aerosol measurements such as lidar profiles and column measurements (e.g., AOD).

TIER III Outcomes

- Publication describing comparisons of in-situ and model hygroscopicity climatologies in terms of magnitude of hygroscopic growth and variability
- Development of benchmark in-situ data set describing temporal variability of scattering aerosol hygroscopicity as observed by in-situ measurements on a variety of time scales
- Use results to suggest model perturbation experiments that may produce better predictions of aerosol hygroscopicity

TECHNICAL MODEL OUTPUT REQUEST for INSITU AeroCom phase III

Output requests are organized by analysis proposed for each tier.

TIER I: Model output request for dry, in-situ optical parameter evaluation at ambient T,P

***Variables**:*

- Dry (0%RH) aerosol extinction @ 550, 440, 870 nm,
- Dry (0%RH) aerosol absorption @ 550, 440, 870 nm
- Dry (0%RH) asymmetry parameter
- Dry (0%RH) fine mode (< 1 um diameter) aerosol extinction and absorption @ 550 nm
- Temperature, Pressure, Specific humidity (alternatively relative humidity)
- Aerosol Optical Depth @550 nm
- Chemical composition as mass mixing ratio profiles

Station dimensional output and frequency:

- 3D: *Hourly* profiles @ModelLevels @Station locations (see station list attached) of the variables requested (see htap format requirements for station output, e.g., use stationid as dimension, lat, lon f(stationid)) - Python script to extract profile data from hourly/daily 3D fields will be available on the AeroCom website
- 2D: *hourly* mean, surface level of all parameters
- Note: Frequency requirement relaxations- daily station and monthly station and field output is allowed, but not recommended

***Years of simulation/emissions**:*

- 2010 (alternatives that are not recommended: 2006, 2008, 2012, 2000)

Variable names:

- <VariableName>: ec550dryaer, abs550dryaer, ec440dryaer, abs440dryaer, ec870dryaer, abs870dryaer, ec550drylt1aer, abs550drylt1aer, asydryaer, temp, hus, pres
  <VerticalCoordinateType>: “Surface”, “ModelLevelAtStations”
  <Period>: ”2010”
  <Frequency>: “hourly”, “daily” (not recommended alternatives: “3hourly”,”monthly”)

Timeline:

- **TIER I** submissions: as soon as possible, best before 31st July 2015. Preliminary data analysis will be done with data available in AeroCom database until the end of July 2015.

TIER II: Model output requests for trend analysis of dry, in-situ optical properties at ambient T,P

***Variables**:* (Same as Tier I)

- Dry (0%RH) aerosol extinction @ 550, 440, 870 nm,
- Dry (0%RH) aerosol absorption @ 550, 440, 870 nm
- Dry (0%RH) asymmetry parameter
- Dry (0%RH) fine mode (< 1 um diameter) aerosol extinction @ 550 nm
- Temperature, Pressure, Specific humidity (alternatively relative humidity)
- Aerosol Optical Depth @550 nm
- Chemical composition as mass mixing ratio profiles

***Station dimensional output and frequency*:**

- 3D: *Daily and monthly* profiles @ModelLevels @Station locations (see station list attached) of the variables requested (see htap format requirements for station output, e.g., use stationid as dimension, lat, lon f(stationid)) - Python script to extract profile data from daily/monthly 3D fields will be available on the AeroCom website
- 2D: *Daily and monthly* mean, surface level of all parameters

Years of simulation/emissions:

- Hindcast simulation 2000-2014, daily and monthly only (not hourly), using HTAP emissions

***Variable names*:**

- <VariableName>: ec550dryaer, abs550dryaer, ec440dryaer, abs440dryaer, ec870dryaer, abs870dryaer, asydryaer, temp, hus, pres
  <VerticalCoordinateType>: "Surface", "ModelLevelAtStations"
  <Period>: "2000-2014"
  <Frequency>: "daily", "monthly"

Timeline:

- **TIER II** submissions: together with Tier I or until the end of October 2015.

TIER III: Model output request for hygroscopicity of aerosol scattering analysis at ambient T,P

***Variables**:*

- 550 nm aerosol extinction @ 40%, 55%, 65%, 75%, 85% RH + ambient
- 550 nm aerosol absorption @ 40%, 55%, 65%, 75%, 85% RH + ambient
- AOD speciated (including H_2O)

***Station dimensional output and frequency*:**

- 3D: *Hourly* profiles @ModelLevels @Station locations (see station list attached) of the variables requested (see htap format requirements for station output, e.g., use stationid as dimension, lat, lon f(stationid)) - Python script to extract profile data from daily/monthly 3D fields will be available on the AeroCom website
- 2D: *Hourly* mean, surface level of all parameters

Years of simulation/emissions:

- 2010 (if modellers could output 2000-2014 (i.e., during Tier II output generation), that would be optimal)

***Variable names*:**

- <VariableName>: ec550rh40aer, abs550rh40aer, ec550rh60aer, abs550rh60aer, ec550rh80aer, abs550rh80aer
  <VerticalCoordinateType>: "Surface", "ModelLevelAtStations"

<Period>: ”2010”
<Frequency>: “hourly”

Timeline:

- **TIER III** submissions: together with Tier I or Tier II or until the end of December 2015

All TIERS

Format: netCDF, see htap format description

File names:

aerocom3_<ModelName>_<ExperimentName>_<VariableName>_<VerticalCoordinateType>_<Period>_<Frequency>.nc

Experiment name: <ExperimentName>: “INSITU”

Data submission procedure:

Via scp or ftp to aerocom-users.met.no server (see AeroCom wiki)

Synergy with other AeroCom experiments:

Simulations for other model intercomparisons (HTAP, nitrate, BB experiments…) may be used to provide the specific output requested here. In particular the annual Aerocom_A3_CTRL simulation (suggested at the last AeroCom workshop), with basic output of variables characterizing budgets, optical depth and aerosol surface concentration, its composition and deposition is recommended to be submitted at the same time.