WP6- NA6: WP "Integration, outreach, and sustainability"
Deliverable D6.22:

Report on Higher level data product: Radiative forcing benchmark dataset

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SUMMARY

Providing a benchmark dataset for the evaluation of parameters characteristic for the calculation of aerosol radiative forcing would help constraining model based forcing estimates. Radiative forcing is constituted of various components (direct, semi-direct and indirect effects) combined in an effective radiative forcing as described in the latest IPCC report. One particular evaluation can be made with ACTRIS surface aerosol parameters: Optical aerosol parameters can be measured and can constrain the direct aerosol effect estimated from models. Parameters such as aerosol scattering coefficients, absorption coefficients, their wavelengths dependence, profiles of extinction coefficients and column integrated aerosol optical depth constitute basic parameters in radiative transfer calculations, in particular in the shortwave part of the solar spectrum. Constraining forcing estimates from concentrations would be more difficult, because the computation of radiative effects requires assumptions on the optical model to convert mass to scattering and absorption coefficients.

Several important steps are made within ACTRIS to make the optical aerosol data available to better constrain modelled radiative forcing. Revised and applied quality control measures are described elsewhere in the corresponding work packages 3 and 18. The preparation, visualization and testing of vertical profiles of aerosol extinction has been reported in deliverable D6.21 (Climatology of vertical distribution of key parameters over Europe). Deliverable 6.16 describes the trend data sets available to test temporal evolution of optical parameters and aerosol number concentrations over the last decades. For the latter ACTRIS secondary data sets have been compiled of aerosol optical properties (Collaud Coen et al. 2013) and of aerosol number concentration (Asmi et al. 2013). The data sets are found via the ACTRIS data portal (http://actris.nilu.no/Content/Resources/Products/).

This deliverable describes two products developed in ACTRIS to constrain and evaluate models with respect to aerosol optical parameters:

a) a joint benchmark visualization of the ACTRIS aerosol optical parameters and their usage for the evaluation of AeroCom phase II model results ;

b) a benchmark model evaluation protocol established to make use of the ACTRIS aerosol in-situ optical properties, sent out to the international modelling community, which will be associated by a compilation of available data.

Joint benchmark visualization of ACTRIS aerosol optical parameters and usage for AeroCom model evaluation

Optical aerosol parameters from ACTRIS cover aerosol absorption, scattering, extinction, column integrated optical depth and absorption optical depth, and for all of them their wavelength dependence. A range of instruments had been used to obtain the measurements (aethalometer, nephelometer, filter absorption photometer, sun tracking filter radiometer, sun photometer). A particular parameter plotted is the humidity in nephelometers, which allows to check whether dry or ambient scattering coefficients where measured. These measurements are in principal accessible via the ACTRIS data portal, in the EBAS database at NILU and via Aeronet, the database hosted by NASA, including also the European ACTRIS component of sun photometer data.

These data are all incorporated via the AeroCom tools for joint visualization and are compared with selected recent aerosol model results. These are available via the ACTRIS portal:
http://actris.nilu.no/Content/Resources/AeroCom/AerosolForcing/

Another path to the ACTRIS/AeroCom web interface:
http://aerocom.met.no/cgi-bin/aerocom/surfobs_annualrs.pl?PROJECT=ACTRIS&MODELLIST=FORCING-BENCHMARK

The traceability of the measurement data exposed via the AeroCom web interface to EBAS has been significantly improved by adding metadata from EBAS to the time series plots (including instrument type, network and PI name, original parameter name, revision number of EBAS data extract). A particular problem is the data incompleteness both on the model and data side. Model evaluation depends on both data and model availability. The AeroCom phase II experiments had simulated mainly the years 2006-2008, while observations increase in number in the latest years. The web interface offers therefore also a data subset category “OBSERVATIONS-ONLY” which provides the user a full overview of which years, stations and parameters in principal are available for comparison. A second possibility is the preparation of a climatological average from measurements, which allows the user to compare any simulated year.

An overview of the technical features and frequently asked questions on the web interface can be found in annex I.

Model evaluation protocol for in-situ aerosol optical properties

Evaluating AeroCom models with in-situ aerosol optical properties from GAW/NOAA/ACTRIS and other super sites has been a plan since the early workshops in AeroCom. With the support of ACTRIS NOAA-ESRL, MetNo and NILU join efforts to make this happen. The ultimate goal is to improve the predictive capability of global climate models. There is a unique opportunity in using in-situ surface optical property measurements for model evaluation since they are well calibrated, independent observations that are referenced to physical standards, thanks to ACTRIS and NOAA work. The in-situ surface data enable the evaluation of climatological values, temporal/spatial biases and parameter covariance. Additionally, subsets of the in-situ surface data offer the opportunity to assess simulations of long term trends in aerosol optical properties and aerosol hygroscopicity.

An analysis of the AeroCom model database shows potential for a preliminary analysis, but there are clearly model data missing with respect to dry aerosol optical properties as well as additional output (in terms of dimensions, frequency and added parameters) which are needed for the proposed analyses. The INSITU-Opt project invites thus modellers to consider augmenting model diagnostics and submit the output to the AeroCom database. In parallel observations will be collected into a new dataset. Intended deliverables will be several (2-4) joint science papers and a benchmark, in-situ dataset available for future analyses. The annex II describes the proposed projects and the corresponding three-tiered request for model data.

TIER I: Model output request for dry, in-situ optical parameter evaluation
TIER II: Model output request for trend analysis of dry, in-situ optical properties
TIER III: Model output request for hygroscopicity of aerosol scattering evaluation

A benchmark model evaluation project has been discussed, developed and sent out in March 2015 to the AeroCom modelling community. Annex II reports the details of the “INSITU-OPT project: Description and Model Output Request”.

Annex I

Frequently asked questions on technical functionality of ACTRIS/AeroCom Web Interface

Which observational data are used?

Observational data stem from ACTRIS, EMEP, GAW, NOAA, AERONET, PHOTONS, SKYNET, NDACC, ESA, NASA and other networks. The data source can be found on Time Series and Profile plots. If several networks are used for a parameter, a menu pops up showing the reference networks.
PIs, instruments, institutions are shown on time series and profile plots based on metadata information provided through EBAS, EARLINET, EMEP. Suggestions to complete these are very welcome !!
The "OBSERVATIONS-ONLY" Category in the Dataset Menu can be used to see (almost) all observations currently available for model-data comparisons.

Which version of the data?

We use irregular updates. EBAS/EMEP/ACTRIS/EARLINET data are updated every 1-3 months. Aeronet data approxiamtely every year, except AERONET-NRT data (monthly). Not all plots are renewed at all times. You can check for the revision date on time series plots, see lower left below graph (Rev. YYYYMMDD), which represents the date when the data were updated. See also the "image created YYYY.MM.DD HH.MM" tag, which indicates when a particular plot was created.

Which stations are used?

An overview can be gathered from the SITELOCATION plot
Example and Time series plots Example

Standard statistics?

Visible on the SCATTERLOG plot Example) and in SCORE pot Example

Can I share with colleague? Report Error?

To share what you see on the aerocom webinterface with a colleague, click on mail-share button upper right, (should open an email with URL link) or click on Button "Show URL link to current", below images, and copy link from popup window appearing. Use this also to report errors to Michael.

Scroll through all options?

Select a menu and use left/right arrows on keyboard.

All Models / Stations for year XXXX?

Below the images there is a "Filter Models/Stations on year:" menu, which can be used to preselect the models or station time series plots to those from a given year.

Compare models synchron?

Use 2/4/6 panels, push "SYNCHRONISE PANEL" Example

Display two model versions

using two panels, use "synchronise panels" button to see corresponding images Example

Meaning of the variables

Long description is visible by hovering over menu ite, and - if the info text (appearing above image when hovering over image) is not hidden Example

Which year is used?

The year in the menu refers to the observations year used and generally to the meteorology of that year. Year may be different in the model wrt to emissions. Also a model simulation of year x maybe be compared to year y in observations. A different year for the model shows up in eg y-axis of SCATTERLOG file. Note that 9999 is used for a climatology for either model or observations, typically comprising 5-10 years.

What means RMSspatial/temporal?

For daily data analysis, RMS is split into the “spatial” RMS, calculated from monthly/seasonal/yearly averages and the “temporal” RMS, which is the residual (RMS^2temp=RMS^2-RMS^2spatial)

ANNEX II

INSITU-OPT project: Description and Model Output Request

A cooperation between ACTRIS/NOAA/AeroCom

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Introduction

The following document outlines the INSITU-OPT 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-OPT
Output requests are organized by analysis proposed for each tier.

FOR All TIERS
Format: netCDF, following the htap format description and requirements
http://iek8wikis.iek.fz-juelich.de/HTAPWiki/WP2.2#A1._HTAP2_experiments_and_output_variables

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

Experiment name: <ExperimentName>: “INSITU-OPT” or “A3_CTRL”

Data submission procedure:
Via scp to aerocom-users.met.no server
(see AeroCom wiki: https://wiki.met.no/aerocom/data_submission)

Synergy with other AeroCom experiments:
Simulations for other model experiments/intercomparisons (HTAP, nitrate, BB experiments…) may be used/reused to provide the specific output requested here. Emissions are not prescribed, but the latest HTAP emissions for 2010 are recommended (http://iek8wikis.iek.fz-juelich.de/HTAPWiki/WP1.1). 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.

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)
- Chemical composition as mass mixing ratio profiles
- Aerosol Optical Depth @550 nm

Station dimensional output and frequency:

- 3D: *Hourly* vertical profiles @ModelLevels @Station locations (see station list attached) of all variables (except AOD) (see htap format requirements for station output, e.g., use stationid as dimension, lat, lon f(stationid)
- 2D global: *Daily* mean, surface level of all parameters
- Note: Frequency requirement relaxations – eg daily @ station and monthly @ station and as field output is allowed, but not recommended

Years of simulation/emissions*:*

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

Variable names:

- <VariableName>: ec550dryaer, abs550dryaer, ec440dryaer, abs440dryaer, ec870dryaer, abs870dryaer, asydryaer, ec550drylt1aer, abs550drylt1aer, temp, pres, hus, mmrso4, mmrno3, mmrss, mmrdust, mmroa, od550aer
  <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 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

The following is a list of monitoring stations with dry surface absorption and scattering measurements available for comparison to aerosol models. A Python script will be available to modelers to sample global model runs at these specific station locations.

Questions?
Contact Betsy Andrews (betsy.andrews@noaa.gov)

Station	Country	EBAS Code	GAW code	Lat.	Lon.
Anmyeon-do	Korea	KR0100R	AMY	36.540000	126.330000
Annaberg-Buchholz	Germany	DE0061B	0.000000	50.570000	13.000000
Appalachian State U.	USA	US3446C	APP	36.213000	-81.692000
Aspvreten	Sweden	SE0012R	APT	58.805780	17.388370
Barrow	USA	US0008R	BRW	71.323010	-156.611470
BEO Moussala	Bulgaria	BG0001R	BEO	42.179200	23.585600
Birkenes	Norway	NO0002R	BIR	58.388330	8.251940
Bondville	USA	US0035R	BND	40.050000	-88.366670
Bukit Kototabang	Indonesia	ID1013R	BKT	-0.201940	100.318050
Bösel	Germany	DE0056R	0.000000	52.998060	7.942500
Cabauw	Netherlands	NL0011R	CES	51.971000	4.927000
Cape Cod	USA	US0042R	PVC	42.070000	-70.200000
Cape Grim	Australia	AU0002G	CGO	-40.682220	144.688340
Cape Point	S. Africa	ZA0001G	CPT	-34.353480	18.489680
Cape San Juan	Puerto Rico	PR0100C	CPR	18.381070	-65.617750
Chacaltaya	Bolivia	BO0001R	CHC	-16.200000	-68.100000
Danum Valley	Malaysia	MY1053R	DMV	4.981390	117.843610
Demokritos	Greece	GR0100B	DEM	37.995000	23.816000
East Trout Lake	Canada	CA0102R	ETL	54.350100	-104.983400
Egbert	Canada	CA0011R	EGB	44.230000	-79.783330
El Arenosillo	Spain	ES0100R	ARN	37.104000	-6.734200
El Tololo	Chile	CL0001R	TLL	-30.172540	-70.799230
Finokalia	Greece	GR0002R	FIN	35.337800	25.669400
Gosan	Korea	KR0101R	GSN	33.280000	126.170000
Graciosa	Azores, Portugal	PT0007R	GRW	39.080000	-28.030000
Granada	Spain	ES0020U	UGR	37.163890	-3.605000
Hesselbach	Germany	DE0070R	FKB	48.540000	8.400000
Hohenpeissenberg	Germany	DE0043G	HPB	47.801500	11.009620
Hyytiälä	Finland	FI0050R	HYY	61.847380	24.294780
Ispra	Italy	IT0004R	IPR	45.803000	8.627000
Izaña	Spain (Tenerife)	ES0018G	IZA	28.309000	-16.499400
Jungfraujoch	Switzerland	CH0001G	JFJ	46.547490	7.985090
K-puszta	Hungary	HU0002R	KPS	46.966670	19.583330
Leipzig	Germany	DE0055B	LEI	51.352500	12.434600
Leipzig-West	Germany	DE0068B	0.000000	51.318056	12.297500
Lulin	Taiwan	TW0100R	LLN	23.470000	120.870000
Mace Head	Ireland	IE0031R	MHD	53.325830	-9.899440
Manacapuro	Brazil	BR0101R	MAO-AMF	-3.210000	-60.590000
Manaus	Brazil	BR0100C	MAO	-2.595000	-60.209000
Mauna Loa	USA	US1200R	MLO	19.536230	-155.576160

Melpitz	Germany	DE0044R	MPZ	51.530000	12.930000
Montseny	Spain	ES1778R	MSY	41.766670	2.350000
Mt Cimone	Italy	IT0009R	CMN	44.166670	10.683330
Nepal Climate Observatory	Nepal	NP0001G	PYR	27.957800	86.814900
Nainital	India	IN0003R	PGH	29.360000	79.460000
Neumayer	Antarctica	DE0060G	NMY	-70.666000	-8.266000
Niamey	Niger	NE0002R	NIM	13.470000	2.170000
Pallas	Finland	FI0096G	PAL	67.973610	24.115830
Preila	Lithuania	LT0015R	PLA	55.350000	21.066670
Pt. Reyes	USA	US0098R	PYE	38.091000	-122.957167
Puy de Dôme	France	FR0030R	PUY	45.771900	2.965800
Resolute Bay	Canada	CA0103R	RSL	74.716670	-94.983330
Sable Island	Canada	CA0101R	WSA	43.933330	-60.016670
Schauinsland	Germany	DE0003R	SSL	47.900000	7.916670
Schneefernerhaus	Germany	DE0054R	ZSF	47.416500	10.979640
Shouxian	China	CN0105R	HFE	32.558383	116.781950
SIRTA	France	FR0020R	0.000000	48.708610	2.158890
South Pole	Antarctica	US6004G	SPO	-89.996950	-24.800000
Southern Great Plains	USA	US6002C	SGP	36.600000	-97.500000
Storm Peak	USA	US9050R	SPL	40.455000	-106.744000
Summit	Greenland	DK0025G	SUM	72.580000	-38.480000
Tiksi	Russia	RU0100R	TIK	71.586166	128.918823
Trinidad Head	USA	US6005G	THD	41.054100	-124.151000
Trollhaugen	Antarctica	NO0059G	TRL	-72.011700	2.535100
Vavihill	Sweden	SE0011R	VAV	56.016670	13.150000
Waldhof	Germany	DE0002R	WAL	52.802220	10.759440
Whistler Mountain	Canada	CA0100R	WHI	50.059300	-122.957600
Zeppelin	Norway	NO0042G	ZEP	78.906690	11.889340