ECLIPSE project – WP2: Modelling Atmospheric Distribution, Deposition and Air Quality

Objectives

The overall goal of this work package is Perform and analyse an ensemble of reference and perturbation simulations to provide the atmospheric distribution of short-lived species and air quality indices for present and future atmosphere and an uncertainty estimate for source-receptor relationships.

O2.1 – Simulate present day and future atmospheric distribution of short-lived species and air quality indices based on new ECLIPSE reference and scenario emissions with an ensemble of models.
O2.2 – Assess the models' accuracy in reproducing global and seasonal changes in the atmospheric composition by comparison to observations of gases and aerosols in 2008-2009.
O2.3 – Perform additional perturbation simulations to isolate emissions from case-study regions and rest of world to evaluate the sensitivity of atmospheric composition changes to the various emission sectors, including shipping, and regional splits.
O2.4 – Evaluate how regional scale emission changes (including emission height) affect species lifetimes, chemical ageing of air masses and atmospheric mixing and long range transport.
O2.5 – Assess inter-model differences in burden and surface concentrations to establish an uncertainty estimate for source-receptor relationships.
O2.6 – Understand how the different models place plumes containing high concentrations of short-lived climate forcers with respect to clouds in the same model and in meteorological analyses.

Description of work

WP 2 will perform multi-model simulations for the years 2008 and 2009 as well as multiple emission perturbation scenarios to provide modelled global atmospheric distributions of SLCFs, analyse inter-model differences and evaluate model uncertainties associated with the seasonal behaviour of the SLCFs. This WP will receive information on emissions from WP 1 and on processes importance and uncertainties from WP 3. It will provide input to WP 3, WP 4 and WP 7 as well as to international model comparison exercises like AEROCOM.

T2.1 – Simulation of atmospheric distributions (NILU, contributors: CICERO, MET.NO, METOFFICE, ULEI, FORTH)
The emissions prepared in WP 1 will be used in state-of-the-art global climate models (HadGEM, ECHAM, Nor-ESM) and chemistry-transport models (EMEP, TM4-ECPL, and OsloCTM2), identical with those used in WP 4 for the forcing matrix calculation, to simulate the atmospheric distributions of black carbon and co-emitted species or precursors, such as nitrate, sulphate and organic matter and also, ozone and its precursors for the years 2008 and 2009 and for 2030. For black carbon also the

deposition on snow and sea ice will be calculated. For 2008-2009, the climate models will run in nudged mode to represent the observed meteorology. Additional multi-model simulations will be performed for 2030 with base line emissions from WP 1 and fixed sea-surface temperature to calculate future global distributions of SLCF and air quality indices for WP 7.

T2.2 – Validation of overall model performance (MET.NO, contributors: NILU, FORTH, UPMC)
The model results will be reformatted according to CMIP5 and AEROCOM standards and will be made available via a project database to the science community. Visualization of model fields will be done via a public web interface as used for AEROCOM. The new model results will be documented with respect to their relation to previous work done by the involved groups towards AR5 and HTAP. The simulated seasonal behaviour of SLCFs over source (Europe, China) and receptor (Arctic) regions that can affect the quality of radiative forcing calculations will be evaluated against observation data. The 2-year global model runs will be compared to available surface monitoring data (datasets compiled and employed also in WP 3 e.g., EMEP network, ABC, EUSAAR, EUCAARI, CITYZEN, available Arctic station data from Barrow, Alert, Summit and Zeppelin), vertical profile data (lidar, MOZAIC) and satellite data (e.g. MODIS, CALIPSO). An annual cycle of CALIPSO derived aerosol/ cloud distributions versus altitude, will be produced by UPMC, and will be used to validate vertical aerosol and cloud distributions in the models. Information about aerosol properties, also derived from CALIPSO data, such as back-scatter or depolarisation ratios (see Adam de Villiers et al., 2010) will also be compared to model output. Continuous observational datasets will be used for the task that will assess model abilities in terms of horizontal and vertical distributions of ozone, aerosols and their precursors, as a function of season.

T2.3 – Emission perturbation simulations (CICERO, contributors: MET.NO, METOFFICE, ULEI, FORTH)
Through perturbations of the reference emission dataset, multi-model simulations for the years 2008-2009 will be carried out such that resulting burdens (and forcings) as well as surface air pollutant concentrations can be attributed, on a seasonal basis, to source regions identified as study cases in WP 1. Additional simulations will investigate the sensitivity of SLCF lifetimes and distributions to the regional-split, seasonality and injection height of the emissions and to the individual emission sectors, including shipping, Air quality standards such as PM and ozone exceedances will be computed along with the above mentioned set of simulations.

T2.4 – Lifetime response to emission changes (responsible: FORTH, using also model results from T2.1 and T2.3)
The simulations performed in T2.1 and T2.3 will be analysed to document the combined influence on burdens of uncertainties in co-emitted species, photo-oxidant limitations, aerosol ageing and aerosol mixing state. The sensitivity to emission injection heights will be investigated with additional simulations. The impact of these changes to species lifetimes and their long range transport fluxes for the selected regions will be calculated.

T2.5 – Uncertainty in emission-forcing relationships due to processes during transport (responsible: MET.NO, contributors: NILU, CICERO, METO, METOFFICE, ULEI, FORTH)
Inter-model differences in burdens and surface concentrations from simulations performed in T2.1 and T2.3 will be analysed to better translate such differences into an uncertainty in the contribution from chemical and meteorological processes to overall emission-forcing relationships.

T2.6 – Vertical position of pollution plumes (responsible: NILU, using model results from Task T2.1)
Radiative forcing of SLCFs depends critically on the vertical position of a SLCF plume with respect to clouds. For instance, the effect of absorbing material (e.g., BC) will be enhanced if the pollution plume is located above a cloud but reduced if the plume is located underneath a cloud. In reality, pollution will often be taken up systematically by clouds and thus be co-located, at least for certain types of clouds and locations (e.g., Eckhardt et al., 2004). The placement of short-lived climate forcers with respect to clouds will be investigated for the different models, using information on cloud position taken both from the respective models as well as from meteorological analyses (ECMWF). The Lagrangian particle dispersion model FLEXPART (Stohl et al., 2005), which has more accurate transport properties than Eulerian models (Rastigejev et al, 2010), will be used as a reference against which the other models are compared to. Implications for radiative forcing calculations in the various models will be discussed.