

Hemispheric Transport Air Pollution (HTAP): Specification of the HTAP2 experiments

Ensuring harmonized modelling

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Abstract

In 2012, the Hemispheric Transport of Air Pollution (HTAP) Task Force launched a cooperative multi-model experiments and analysis (HTAP Phase 2) that is intended to inform the Convention on Long-range Transboundary Air Pollution (LRTAP) and other multi-lateral cooperative efforts, as well as national governments on actions to decrease air pollution and its impacts.

The HTAP Phase 2 modelling experiments have been designed to provide:

- relative contributions of regional and extra-regional sources of air pollution in different regions of the world that will help refine the source/receptor relationships derived from the previous HTAP Phase 1 simulations.
- a basis for model evaluation and process studies to characterize the uncertainty in the estimates of regional and extra-regional contributions and to understand the differences between models.
- input to assessments of the impacts of control strategies on the contribution of regional and extra-regional emissions sources to the exceedance of air quality standards and to impacts on human health, ecosystems, and climate.

The purpose of this report is to gather in a single document the guidance and technical specifications provided from 2012 to end of 2015 by the Joint Research Center (European Commission) to the global modelers participating to HTAP Phase 2, which are currently only partly accessible through the HTAP WIKI pages (Annex 1). It also includes some information on the input to the AQMEII (Air Quality Model Evaluation International Initiative) and MICS (Model Inter-comparison Study for Asia) regional simulations performed in the frame of HTAP2, as well as additional information with respect to the HTAP_v2.2 global emission inventory. This report provides detailed background information to a technical overview paper (Galmarini et al., 2016) in the special issue of the Atmospheric Chemistry and Physics journal, entitled ‘Global and regional assessment of intercontinental transport of air pollution: results from HTAP, AQMEII and MICS.

1 Introduction

The Task Force Hemispheric Transport Air Pollution launched in 2012 a new phase of collaborative experiments, called HTAP2. In order to ensure harmonized simulations, the general specifications of HTAP2 experiments, as well as specific guidance and technical support have been provided from 2012 by the Joint Research Center (European Commission) to the global modelers participating in HTAP2.

Compared to HTAP1, the novel aspects of HTAP2 are:

- a focus on more recent years as a basis for extrapolation (2008-2010), including an updated collection of emission inventories for 2008 and 2010 (“HTAP_v2.2 inventory”).
- a larger number of source/receptor regions.
- the use of regional models and consistent boundary conditions from selected global models for Europe, North America, and Asia to provide higher resolution estimates of the impacts on health, vegetation, and climate, in addition to global models providing world-wide coverage
- the use of sector-based perturbations, along with perturbations by region and individual pollutants, to better understand the impact of potential control strategies
- a focus on capacity building and strengthening regional expertise
- an increased focus on model evaluation.

This report provides detailed background information to a technical overview paper (Galmarini et al., 2016) in the special issue of the Atmospheric Chemistry and Physics journal, entitled ‘Global and regional assessment of intercontinental transport of air pollution: results from HTAP, AQMEII and MICS.

2 Specification of HTAP2 experiments

The set-up of the model simulations has been chosen such that a set of core simulations will give direct answers to Question 1: ‘What is the Response in a given region to Extra-Regional Emission Reduction?’ Additional simulations will address Question 2: ‘How can we attribute this extra-regional response to various individual regional contributions?’

In a mathematical formulation, the answer to Question 1 can be expressed as the RERER metric (Response to Extra-Regional Emission Reduction) for a specific region as follows :

$$RERER = \frac{\Sigma R(\text{foreign_regions})}{\Sigma R(\text{all_regions})} = \frac{R(\text{global}) - R(\text{region})}{R(\text{global})}$$

with R, the concentration response to 20% emission decrease

To calculate RERER for a particular region, 3 simulations are needed: a) a base (unperturbed) global simulation, b) a global perturbation simulation, and c) a regional perturbation simulation. Once the RERER is defined for a given region, further perturbation simulations can be used to address Question 2, attributing the extra-regional response to other geographic source regions.

The RERER equation is later repeated? Why

2.1 Simulation period and meteorology

The simulation period of interest is 2008-2010. If possible, the simulations for the whole three year period were to be provided. However, if resources are limited, the highest priority is 2010, followed by 2008, and then 2009. The models should use meteorological data representative of the respective year (e.g. driven or constrained by one of the global analysis products, as is most convenient to the modelling group). There may be scope for GCM studies constrained by sea-surface-temperature alone, for a somewhat longer period (2005-2010) to better analyse the role of inter-annual variability. No concrete experiments have been planned at this point. All simulations should include a spin-up time of 6 months prior to the period of interest.

2.2 Emission inputs

2.2.1 HTAP_v2.2 anthropogenic emissions

The JRC EDGAR Team, in collaboration with US EPA, EMEP, CEIP, TNO, the MICS-Asia Scientific Community and REAS experts, has compiled a composite of regional emission inventories with monthly grid maps that includes EDGARv4.3 gap filling. The so-called HTAP_v2.2 database (Janssens-Maenhout et al., 2015), which is input to regional and global modelling experiments, has the following characteristics:

- Years 2008 and 2010, yearly and newly also monthly resolution
- Components: SO₂, NO_x, NMVOC, CH₄, CO, NH₃, PM₁₀, PM_{2.5}, BC, and OC at sector-specific level.
- Global geo-coverage with spatial resolution of 0.1degree x 0.1 degree.

Participation in the HTAP2 exercise requires mandatory use of these datasets.

The data, available under http://edgar.jrc.ec.europa.eu/htap_v2/index.php, are divided into the following sectors: “Energy” (or Electricity Generation), “Industry”, “Transport”, “Ships”, “Air” (aviation), Agriculture, and Residential. Annual gridded values are provided for each pollutant from each sector. Monthly gridded values are provided for some sectors. We refer to them as emission mosaics because the estimates for different regions of the world come from different sources. These regional inventories have been pieced together to form a global mosaic (**Figure 1**) that is consistent with inventories being used at the regional scale.

Conversion to HTAP2 output format

In order to allow for a first check of the HTAP model (total) emissions fields (see section 4) on the MetNo server, which holds the HTAP2 database, the HTAP_v2.2 anthropogenic emission files have been converted to the HTAP2 model output format as described in **Annex 2** and illustrated in **Figure 2**.

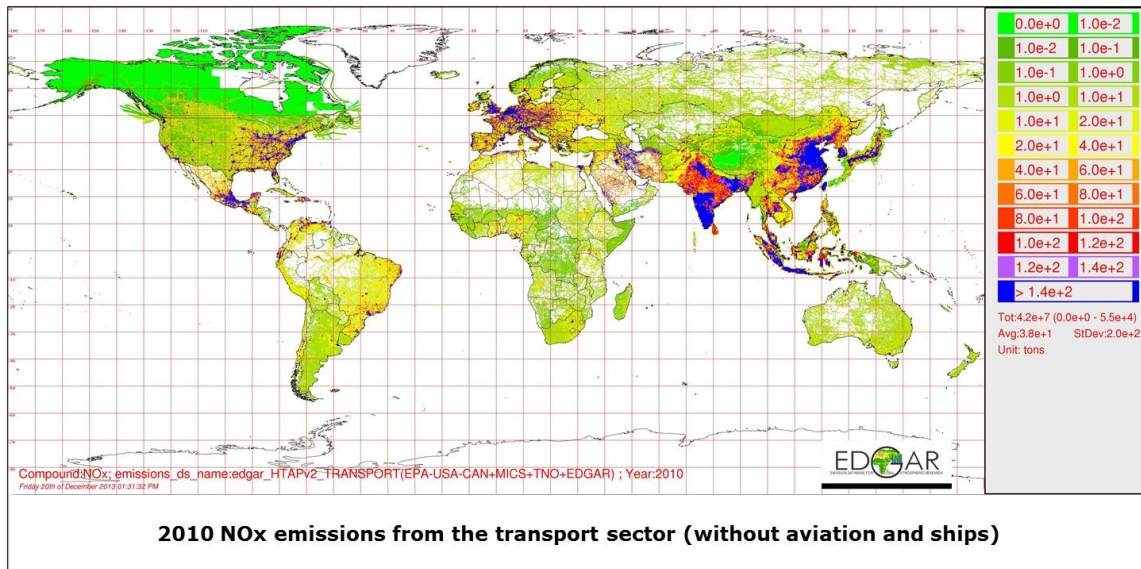


Figure 1: Illustration of HTAP_v2.2 emission mosaics pertaining to NOx emissions from land-based transport.

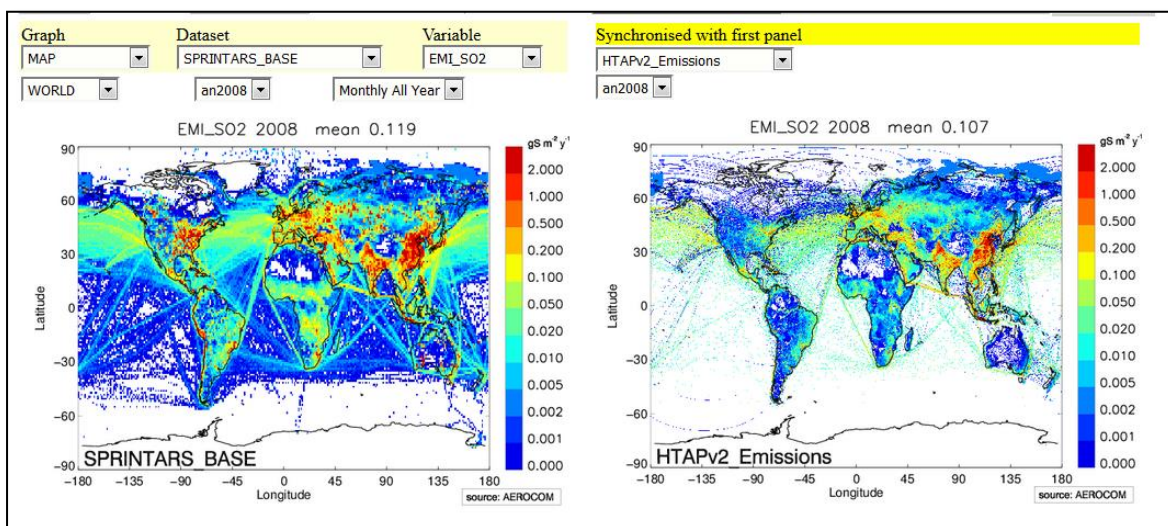


Figure 2: Comparison of HTAP_v2.2 (anthropogenic) and an example of implementation by the SPRINTARS model (total) of 2008 SO₂ emission fields.

2.2.2 HTAP guidance for VOC speciation

The speciation for NMVOC emissions has not been prescribed and modelling groups were encouraged to use the best information that they have available, given the time constraints to set-up the model simulations. Nevertheless, in the specification of the model output (discussed in section 3.5.1), we have requested model information on emissions of the following VOC species:

total NMVOC as C
total NMVOC
ethane
propane

total C₄ and higher
alkanes
ethene
propene

total C₄ and higher
alkenes
ethyne
formaldehyde
acetaldehyde

acetone	total aromatics	total sesquiterpenes
methanol	isoprene	total biogenic VOCs
toluene	total monoterpenes	

We also request volume mixing ratios for the following VOC species:

total NMVOC	total C ₄ and higher	methanol
ethane	alkenes	toluene
propane	formaldehyde	total aromatics
total C ₄ and higher	acetaldehyde	isoprene
alkanes	acetone	alpha-pinene
ethene	glyoxal	total terpenes

HTAP VOC speciation

The HTAP_v2.2 anthropogenic emission files (see section 2.2.1) do not include individual VOC species. To further assist the HTAP modellers, emissions files for individual VOC components have been built by the LATMOS, with the support of MetOffice and the JRC, using the VOCs breakdown that was generated by the TNO (Maarten van het Bolscher, Tinus Pulles) for the RETRO project and for the ACCMIP emission inventory (CMIP5 historical emissions). The original ratios dataset consists of 23 VOCs species. It gives the individual VOCs emission ratios to total NMVOC at a 0.5°x0.5° resolution for 8 anthropic emission sectors. It has been re-gridded to a 0.1°x0.1° resolution and applied to HTAP_v2.2 NMVOC emissions to calculate 2008 and 2010 individual VOCs emissions files. It first required calculating NMVOC global emission data for the different industrial sub-sectors, which are not provided in HTAP_v2.2 dataset.

The 2008 and 2010 HTAP_v2_VOCs_anthro_<species>_<year>_flux_0.1x0.1.nc emissions files for each of the 23 VOCs species are available on the ECCAD2 server (<http://eccad2.sedoo.fr/eccad2/>). More details on the building and specification of the files are provided on the HTAP WIKI (see Annex 1) and summarized in Annex 3.

Other VOC speciation

It is worth to note that **HTAP global VOC speciation is not mandatory** and that individual modelers may have very good reasons to use different distributions.

In addition to HTAP global VOC speciation, **regional VOC speciation** for Asia, Europe and North America are provided on the HTAP WIKI under Work Package 1 (Annex 1).

2.2.3 Methane

Base run (BASE)

In some past inter-comparison exercises, the methane concentrations were fixed in different ways - some fixing over the whole domain, others just fixing in the surface layer. In HTAP2, we explicitly requested the global methane concentrations to be set at 1798 ppb throughout the model domain for the base simulations. However, in case of models with active stratospheric chemistry, running with CH₄=1798 ppb in the stratosphere may create problems (i.e. by influencing H₂O and HO_x at unrealistically high concentrations). In those cases we suggested to fix 1798 ppb throughout the troposphere (and probably into the lower

stratosphere), and not further constraining it in the stratosphere. We further mention that some models, such as AM3, have two independent impact pathways for fixing methane concentration to a constant level: one for tropospheric chemistry and the other for radiation. In that case, fixed CH₄ of 1798 ppb only affects tropospheric concentrations.

Perturbation runs

For CH₄ two perturbation studies are requested: A high priority is assigned to the simulation of an increase in methane concentrations where global concentrations are set at 2121 ppb throughout the domain. A lower priority is assigned to the simulation of a methane decrease to 1562 ppb throughout the domain. These perturbation studies are further discussed in section 2.3.

2.2.4 Non-Anthropogenic

Biomass burning emissions have not been prescribed, but it was recommended that groups use GFED3 data (Van der Werf et al., 2010), which are available at daily and 3-hour intervals (see <http://globalfiredata.org/>).

Biogenic NMVOCs, soil and lightning NO_x, dust, and sea salt emissions have not been prescribed; modelling groups are encouraged to use the best information that they have available. Detailed output about PM, its components and size will be requested.

For wind-driven DMS emissions from ocean water, it is recommended that the climatology of ocean surface DMS concentrations described in Lana et al. (2011) be used as the basis for calculations. The use of other parameterisation should be indicated.

For volcano emissions, it is recommended that groups use the estimates produced by Diehl for AeroCom (Diehl, 2013). These estimates for 2008-2010 can be accessed at <http://aerocom.met.no/download/emissions/HTAP/>.

2.2.5 Passive Tracers

To help diagnose the differences between models and isolate different transport processes, we are requesting that models also include two passive tracers: vmrcodirect50d and vmrcodirect25d. These tracers should be emitted in the same quantity as total anthropogenic CO emissions (not including fires) and decay exponentially with uniform fixed mean lifetimes (or e-folding times) of 25 and 50 days, respectively (as in CCMI). Note that the emissions of vmrcodirect50d and vmrcodirect25d should be perturbed in the ALL and CO experiments discussed below in section 2.3.

2.2.6 Mercury

For the mercury, no specific recommendations were made. For example, the EDGARv4 global gridded anthropogenic mercury emissions for 2008 (Muntean et al. 2014) and the AMAP/UNEP global emissions inventory for 2010 (AMAP/UNEP, 2013; <http://www.amap.no/mercury-emissions>) can be used.

2.3 Emission Perturbation Experiments

In addition to the base 2008-2010 simulations, we are asking each modelling group to perform emission perturbation experiments to help attribute estimated concentrations, deposition, and derived impacts to sources and estimate source/receptor relationships. **Figure 3** lists a large number of possible perturbation experiments; all except the methane

perturbation experiments involve a 20% decrease in anthropogenic emissions similar to HTAP1. The emission decreases are specified for combinations of pollutants, regions, and sectors.

It is not mandatory that all models perform all of the possible experiments. The relative priorities assigned by the TF HTAP co-chairs are shown in **Figure 3** and are discussed further below. Each modelling group should balance these priorities with their own research interests in deciding which simulations to perform. Our hope is that most modellers will perform the highest priority perturbation experiments as well as a few of the lower priority experiments based on their own interests, helping to fill in a sparse matrix of results.

2.3.1 Global Perturbations

The first priority after the base simulations (BASE) is a 20% decrease of all anthropogenic emissions globally (GLOALL), but methane at the base concentration of 1798 ppb. The results of BASE and GLOALL will provide important reference points to allow us to compare across the ensemble of models participating in the experiments. Note that the emissions of the artificial tracers vmrcodirect50d and vmrcodirect25d tracers should be perturbed along with the emissions of CO in the ALL experiments.

2.3.2 Methane Perturbations

To capture the impact of changing methane emissions in a one year simulation, it is necessary to perturb the methane concentration instead of the emissions. The recommended perturbations are intended to cover the range of the RCP (Representative Concentration Pathways) scenarios used by IPCC for 2030. The highest priority is assigned to an increase of global CH₄ concentration to 2121 ppb_v (representative of RCP8.5). The next priority is assigned to a decrease of global CH₄ concentration to 1562 ppb_v (representative of RCP2.6).

Table 1: BASE and Methane Perturbation runs

Simulation	Global CH ₄ Concentration (ppbv)	Representative of
BASE	1798	2010 based on IPCC AR5
CH4INC	2121	2030 under RCP 8.5
CH4DEC	1562	2030 under RCP2.6

Priorities for HTAP2 Simulations

Base BASE
Increase CH4 Conc CH4INC
Decrease CH4 Conc CH4DEC

2008	2009	2010
1		1
		1

Highest Priority 1
Next Priority
Lower Priority

Region of Emissions Perturbation

Global	GLO			1			1			1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										</
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PM = Other Particulate Matter (BC, OC, PM10, PM2.5)

TRN = Ground Transport Sector; PIN = Power and Industry Sectors; RES = Residential Sector; OTH = Other Sectors (Ships, Aviation, Agriculture); FIR = Fire

DST = Dust * For dust, some models should divide the NAF source into separate source regions for the Sahara (091+092, in the Tier2 regions) and Sahel (093).

Figure 3. Priorities for HTAP2 emission perturbation experiments. Note that vmrcodirect50d and vmrcodirect25d should be perturbed as CO.

2.3.3 Source Region Perturbations

In HTAP1 (HTAP, 2010), a set of 4 rectangular regions approximating North America, Europe, South Asia, and East Asia was used for the model perturbations studies. In HTAP2, a two-tiered system of regions has been defined primarily along national boundaries. The first tier consists of the 16 regions and the second tier consists of 60 sub-regions. These regions provide a common set of possible source and/or receptor regions for all experiments.

- The regions are described on the HTAP WIKI (see Annex 1) and in **Annex 4**.
- Masks in netCDF format (outputNC_20130411_1550.rar) are also provided on the HTAP WIKI under Work Package 2.1. We note that the dataset has a 'reversed' projection compared to the HTAP emissions, (longitudes and latitudes starting South instead of North). This should not be a problem if the software correctly uses attribute information.

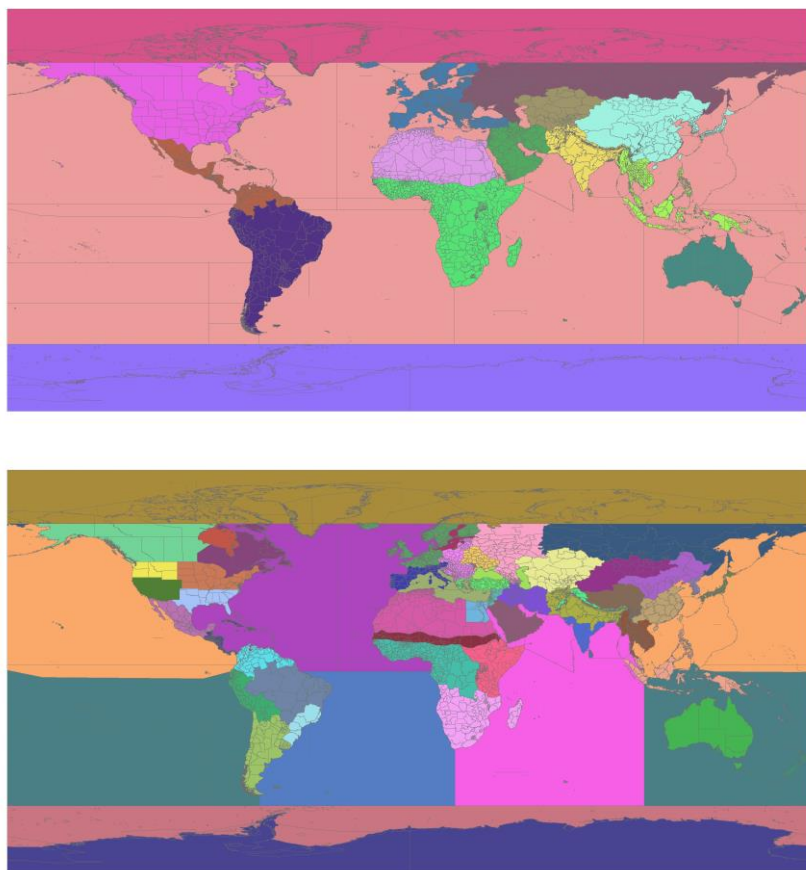


Figure 4: The 16 Tier 1 regions (up) and 60 Tier 2 regions (bottom) defined for HTAP2.

After the global and methane perturbations, the next priorities are perturbations by Tier 1 regions. Six of the Tier 1 regions have been designated as higher priority than the others. These are: North America (NAM), Europe (EUR), South Asia (SAS), East Asia (EAS), Middle East (MDE), and Russia/Belarus/Ukraine (RBU).

With the BASE and GLOALL results and the results from perturbing all anthropogenic emissions in one other region (e.g. NAMALL for North America), we can calculate the following metric, labeled the Response to Extra-Regional Emission Reductions (RERER).

$$RERER_{NAM} = \frac{\Delta C_{NAMALL}(extraregional_anthro_emissions)}{\Delta C_{NAMALL}(all_anthro_emissions)} = \frac{(C_{BASE} - C_{GLOALL}) - (C_{BASE} - C_{NAMALL})}{(C_{BASE} - C_{GLOALL})}$$

Similar to the RAIR metric used in HTAP1, the RERER metric will enable us to make a variety of comparisons across models and regions and provide a comparative measure of the value of global cooperation to different regions. RERER can be used for surface concentrations, depositions, column quantities, and derived impacts. This is probably one time too much?

Individual Pollutant Perturbations

In addition to decreasing all anthropogenic emissions simultaneously, perturbations can be applied to individual pollutants. These perturbations can be applied globally (e.g., GLONOX for global NO_x perturbation) or in individual regions (e.g., NAMNOX for the North American NO_x perturbation). These experiments are particularly useful for evaluating the individual pollutant contributions and for estimating the impacts of some source types that are dominated by these pollutants. With these purposes in mind and guided by earlier HTAP1 results, the highest priority has been assigned to perturbation experiments for NO_x and CO (and the vmrcodirect50d and vmrcodirect25d tracers, which should be perturbed using the CO emissions). The next level of priority has been assigned to individual perturbations of SO₂, NMVOC, and NH₃. Perturbations of direct PM (BC, OC, PM₁₀, PM_{2.5} together) have been assigned lower priority, as we expect to be able to derive the sensitivities from the higher-priority experiments.

Individual Sector Perturbations

Similar to perturbing individual pollutants, one can also perturb the emissions from an individual economic or activity sector. Figure 5 presents the sectorial attribution for each of the pollutants in the 2008 HTAP_v2.2 emission mosaics. Sectorial perturbation experiments take into account the large differences in the horizontal and vertical spatial distribution and temporal distribution of emissions and the pollutant mixtures co-emitted from each sector.

Sectorial perturbation experiments would not reproduce the effect of control strategies that significantly change the spatial distribution or component mix of pollutants from a given sector. However, given the large differences in the spatial distribution and pollutant mix from different sectors, these sectorial experiments are expected to more closely reproduce the effect of actual mitigation policies on emissions than would uniform perturbations of individual pollutants. These sectorial perturbation experiments will also explore a different way of calculating source-receptor relationships that was not explored in HTAP1.

The highest priority has been assigned to decreasing emissions globally from i) the ground transportation sector (TRN), which corresponds to the HTAP_v2.2 “Transport” sector and does not include shipping or aviation, ii) the power (energy/electricity generation) and industry sectors (PIN), which include HTAP_v2.2 “Energy” and “Industry” sectors, iii) the residential sector (RES), corresponding to the HTAP_v2.2 “Residential” sector, and iv) large scale forest and savannah fires (FIR), as defined by GFED, in particular for the experiments jointly performed with AEROCOM. A lower priority is assigned to simulations that decrease emissions from these sectors on a regional basis from the highest priority regions. Note that the regions of most interest for fires (North America (NAM), Russia (RBU), Southeast Asia (SEA), Southern Africa (SAF), and South America (SAM)) are different from those for the other sectors.

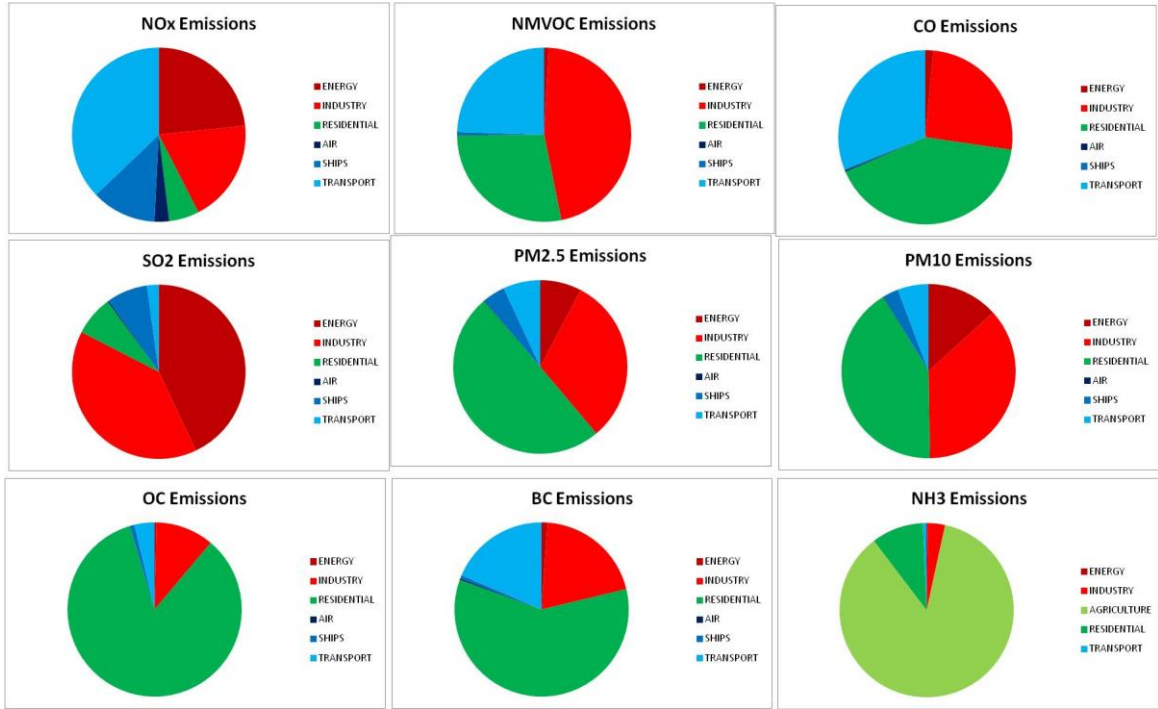


Figure 5. HTAP2_v2.2 2008 anthropogenic emissions estimates divided by sector[Janssens-Maenhout et al, 2015]

The lowest priority is assigned to simulations that decrease emissions from the remaining sectors, which are including shipping, aviation, and agriculture. The effects of these sectors are already captured in the ALL perturbations. However, if groups are interested and have appropriate model configurations, it would be interesting to have perturbation simulations of the shipping and aviation sectors, as these have very different spatial distributions (and separate policy regimes) than the other land-based sectors.

For aerosol models, the highest priority is assigned to both global and regional perturbations of dust emissions. Note that the highest priority is assigned to the source regions North America (NAM), East Asia (EAS), Russia (RBU), Middle East (MDE), Central Asia (CAS), and North Africa (NAF), with possible further experiments pin-pointing the role of emissions from the Sahel region (which can be separated out using the Tier 2 regional definitions).

2.4 Boundary Conditions for Regional Simulations

2.4.1 Linking of global and regional model simulations

One of the new aspects of HTAP2 experiments is the linking of global and regional model simulations. By conducting common experiments, we hope to be able to examine the effects of a) the finer spatial and temporal resolution of regional models and b) different process represented in global and regional models. To “nest” the regional simulations within the global simulations, we need outputs from one or more global models to be used as boundary conditions for the regional models’ domains (Figure 6).

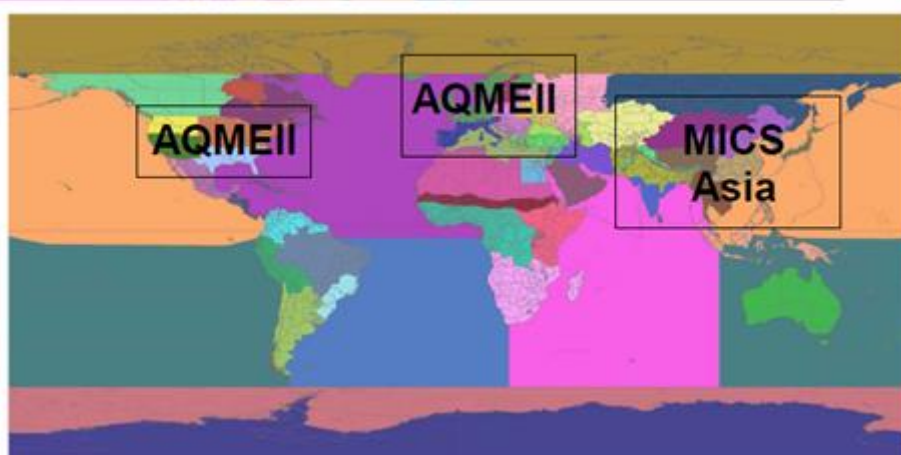


Figure 6: Domains of the regional model simulations

Each of the emissions perturbation experiments with the global models will create a new set of boundary conditions that can be applied at the regional scale. This nesting is depicted graphically in Figure 7. It shows an example where the source region (in this case, East Asia) is fully included within the regional model domain.

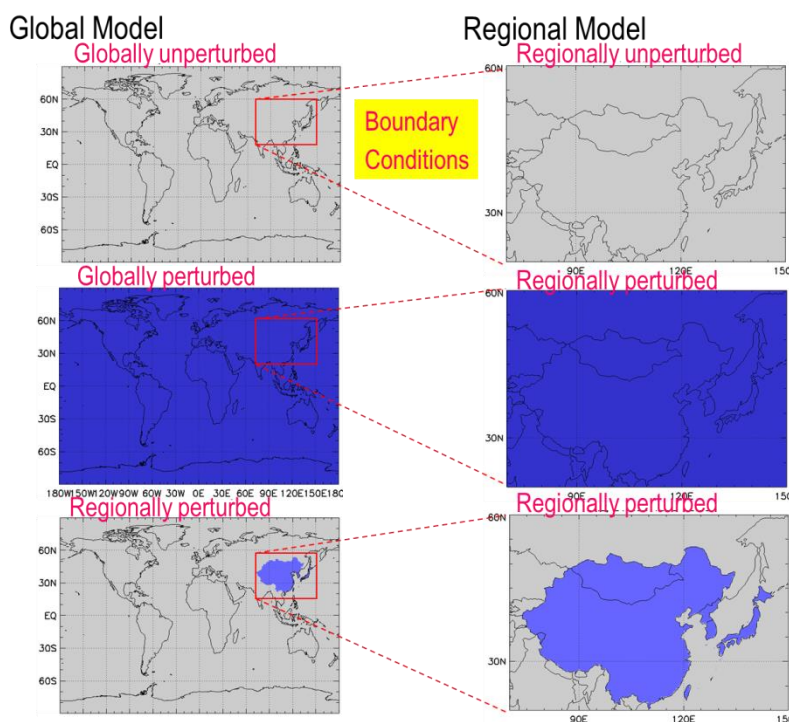


Figure 7: Example set of experiments, with both global and regional model (in this case a regional model over East Asia, red box), where the regional source perturbation is East Asia (blue shading), and is wholly within the regional model domain. Note that the magnitude of the emission perturbation in region of consideration is identical.

We note here, that regional modellers may consider performing additional experiments, such as evaluating the contribution from specific extra-regional emission perturbations (i.e., simulating EUR with boundary conditions from a global simulation with perturbed NAM

emissions). This is not a priority for HTAP regional modelling, since the global model ensembles will provide this information as well. Some regional model domain boundaries may straddle source regions (i.e. the source region will not be completely within or outside the regional model domain). This is not envisaged to be a common problem, as most regional models attempt to define their domains such that the model's boundaries are away from high emissions regions.

2.4.2 Specification and access to the HTAP Boundary Conditions

Global simulations have been performed by 4 groups to provide boundary conditions for regional modeling, as summarized in the Table below. The minimum set of simulations requested from the IFS CB05 MACC, GEOS-Chem and GFDL AM3 models is: BASE, CH4INC, GLOALL, NAMALL, EURALL, EASALL, for 2008 and 2010 (3 hourly outputs). Additional Boundary Conditions (BASE simulations from the CHASER model; 3 hourly and daily outputs) are available for the MICS Asia III regional simulations.

Table 2: 2008, 2009 and 2010 HTAP Global Runs for Regional Boundary Conditions

Model	Spatial Resolution	Temporal Resolution	Simulations	Estimated Size of Dataset
IFS CB05 MACC (ECMWF)	1.125°x1.125° (T159) 54 levels	3 hourly	BASE GLOALL CH4INC NAMALL EURALL EASALL SASALL	11000Gb
GFDL/AM3	~1°x1° 48 levels	3 hourly	BASE GLOALL CH4INC NAMALL EURALL EASALL	4000 Gb
GEOS-Chem	2.5°x2° 47 levels	3 hourly	BASE GLOALL CH4INC NAMALL EURALL EASALL	11000Gb
CHASER	2.8°x2.8° 32 levels	3 hourly Daily	BASE BASE	274 Gb 36 Gb

Table 3: Regional Boundary Conditions - Models and Spatial domains

Model	North America	Europe	Asia	Global	Type of Boundaries
IFS CB05 MACC	[15°-78°N; 185°E- 325°E]	[16°-77°N; 56°W-80°E]	[20°S-65°N; 40°-165°E]	-	rectangular domain
GFDL AM3	-	-	-	X	rectangular domain
GEOS- Chem	-	-	-	X	political boundaries from HTAP masks
CHASER	-	-	-	X	rectangular domain

Table 4: Boundary Conditions - Components (Aerosols ; Gas ; Physics) and VOC speciation

Model	Resolution	Number of output diagnostics (see documentation for more details)	Units (Gas and Aerosol)
IFS CB05 MACC	1.125°x 1.125° 54 levels	Gas: 24 ; Aerosol: 13 ; Physics: 2	kg/kg (Gas and Aerosol)
GFDL AM3	~1°x 1° 48 levels	Gas : 10 ; Aerosol: 6 ; Physics: 2	vmr (Gas) ; mmr (Aerosol)
GEOS- Chem	2.5°x 2° 47 levels	Gas: 48; Aerosol: 15 ; Physics: 4	ppb _v or ppbC (Gas and Aerosol)
CHASER	2.8°x 2.8° 32 levels	Gas: 21; Aerosol: 8 ; Physics: 3	m ³ /m ³ (Gas) kg/m ³ (Aerosol)

Documentation of the Boundary Conditions data sets

In order to assist the regional modellers, the Boundary Conditions (BC) specifications are further documented on HTAP WIKI Work-package 2.3 as follows:

- List of BC diagnostics: HTAP2_BC_Variables_Table.xls.
- IFS CB05 MACC model : MACC_Boundary_Condition_for-HTAP.doc
- GEOS-Chem model: README_GEOS-Chem.pdf
- GFDL AM3 model: AM3-HTAP2_MODEL_DESCRIPTION.doc
- CHASER model:CHASER_BC_documentation.pdf

Access to the Boundary Conditions data sets

The BC data listed in the Tables above can be accessed for each model as follows:

IFS CB05 MACC

The BC for 2008 and 2010 are downloadable from ftp dissemination.ecmwf.int in the sub-directory structure /DATA/MACC-HTAP/\$SCENARIO/\$YEAR/\$DOMAIN.

For each scenario, year and domain (EU, NA, AS), there are 4 monthly files: AER_, GRG_, GRG_voc and PS, which contain the aerosol, reactive gases, VOCs and surface pressure data for one month, respectively (e.g.: GRG_voc_20100601_20100630_CH4INC_EU.nc).

Contact: Johannes.Flemming@ecmwf.int

GEOS-Chem

To access the data from [ftp presto.snu.ac.kr](ftp://presto.snu.ac.kr) (under /pub/SNU_GEOS_Chem_v9.1.3/), an email has to be sent to Rokjin Park asking for an id and password. To read directly the tsYYYYMMDD.bpch binary punch v 2.0 files (standard output format of the GEOS-CHEM model) or convert to other file formats (such as HDF, netCDF, or ASCII), IDL routines are available as part of the GAMAP software (<http://acmg.seas.harvard.edu/gamap/doc/> ; see for instance bpch2n.pro). Please note that you will need to also download the diaginfo.dat and tracerinfo.dat files from the same SNU_GEOS_Chem_v9.1.3 folder that contains the .bpch files to make it work.

Contact: Rokjin Park (rjpark@snu.ac.kr)

GFDL AM3

The files (netCDF) are on <http://data1.gfdl.noaa.gov/nomads/forms/HTAP2/> GFDL data portal. An username and a password are required for data access when clicking "getdata".

Contact : Meiyun Lin (meiyun.lin@noaa.gov).

CHASER

The CHASER outputs of HTAP2 2008-2010 simulations for MICS-Asia-III regional simulations are archived on the MICS server in China.

Contact: Kengo Sudo (kengo@nagoya-u.jp)

2.5 Specification of the global model outputs

2.5.1 Definition of HTAP2 variables

The list of requested model outputs was built from several interactions between HTAP co-chairs and modellers, on the basis of HTAP2 specific objectives and previous MIPs output diagnostics. It is designed to provide more detailed information for the model evaluation, as well as for the assessment of the intercontinental transport and the impacts of air pollution. In addition to outputs onto the original model grids, the modellers are requested to provide specific diagnostics at given locations.

HTAP2 variables

The requested model outputs are listed in the HTAP2_variables.xlsx EXCEL file located on the HTAP WIKI Work Package 2.2 (see also the HTAP2 CMOR Tables in section 3.1).

HTAP2_variables.xlsx consists of six different worksheets that correspond to the 5 following different data types, defined primarily by the vertical dimension of the data:

- Surface
- Column
- ModelLevel
- SurfaceAtStations with separate lists for Aerosols and Gases)
- ModelLevelAtStations

The frequency of the outputs includes time invariant, hourly, daily, monthly, as well as instantaneous outputs at satellite overpass times.

Table 5: Number of (priority 1) “standard” HTAP2 variables as of December 2013.

	Gridded outputs			Outputs at stations		Totals
	Surface	Column	ModelLevel	Surface (A+G)	ModelLevel	
Invariant	19 (13)	-	-	-	-	19 (13)
Hourly	20 (9)	-	-	72 (58)	17 (16)	109 (83)
Daily	71 (55)	21 (21)	-	-	31 (20)	123 (96)
Monthly	128 (93)	-	100 (86)	-	-	228 (179)
Sat. times	-	-	19 (19)	-	-	19 (19)
Totals	238 (170)	21 (21)	119 (105)	72 (58)	48 (36)	498 (390)

Each of the 6 data-type worksheet is divided into two parts (see Figure 8):

- Time and Coordinates (shaded in green)

At the top of the sheet for each type is a list of the time and spatial coordinates that should be contained in each file of that type. For the ModelLevel and ModelLevelAtStations, four different options are provided for defining the model’s vertical coordinate system (one has to be selected). For the SurfAtStations and ModelLevelAtStations, the station locations (longitude, latitude, and altitude) are provided in separate lists for gas (G) and (A) aerosol observations (see section 2.5.3).

- Output Variables (shaded in yellow ; one file per variable per year is requested)

Following the coordinates is a list of variables, marked by a bright yellow header, for each of which an output file should be generated for each year’s worth of output. Data frequency can be time invariant, hourly, daily, monthly, as well as instantaneous outputs at satellite overpass time (10:00, 13:30, 21:30 and 01:30 local times), as specified in each worksheet.

	A	B	C	D	E	F	G	H	I	J	K	L
	HTAP Name	Variable Long Name (Description)	CF standard name (already existing) else proposed	Variable type	Unit	Minimum	Maximum	Dimensions	Frequency	PRIORITY	Comments	Obligatory CF comment in NetCDF variable file
1												
2	Time and Coordinates = needed in each output file. See http://iek8wikis.iek.fz-juelich.de/HTAPWiki/HTAP-2-data-submission for details											
3	time	Time	time	coordinate	days since	-8000	8000	time		1		
4	time_bnds	bounds coordinates for time	time	variables	days since	-8000	8000	(time,2)		1		
5	lon	Center coordinates for longitude	longitude	coordinate	degrees_east	-180	180	lon	timeinvariant	1		
6	lon_bnds	bounds coordinates for longitude	longitude	variables	degrees_east	-180	180	lon,2	timeinvariant	1		
7	lat	Center coordinates for latitude	latitude	coordinate	degrees_north	-90	90	lat	timeinvariant	1		
8	lat_bnds	bounds coordinates for latitude	latitude	variables	degrees_north	-90	90	lat,2	timeinvariant	1		
9												
10	HTAP Variable Name (one per output file)	Variable Long Name (Description)	CF standard name (already existing) else proposed	Variable type	Unit	Minimum	Maximum	Dimensions	Frequency	PRIORITY	Comments	Obligatory CF comment in NetCDF variable file
11	HTAP Variables = One File per Output Variable Per Year (note obligatory comments in last column to be included in file)											
12	Landcover and vegetation information											
13	growveg_bnds	Growing season start and end date	time	LandVegetation	days since	-8000	8000	lat, lon, 2	timeinvariant	1		
14	areacella	Grid-cell area	cell area	LandVegetation	m2	100000	1E+12	lat, lon	timeinvariant	1		

Figure 8: Screenshot of the HTAP2 variables file (surface gridded data worksheet)

Priority

The requested outputs were chosen and prioritized based on discussions in TF HTAP meetings and expert judgement on the potential use of the datasets (“Priority = 1” stands for high priority and “Priority = 2” for lower priority or for specific application). We realize that not all models can provide all requested outputs. In practice, scientists will consider a model suitable for inclusion in a specific analysis/publication when the provided model data are available, complete, and correct (see also the proposition for revised priorities below).

Updating

Many additions and updates were made from June 2014 to the HTAP2 list of outputs. They have been regularly documented in a specific **ReadMe spreadsheet** of the HTAP2_variables.xls. Among the main updates are:

- Following the request from HTAP and ACCMIP modelers, a brief description of the purpose of each diagnostic has been added to HTAP2_variables.xlsx (Column K).
- Following the addition of GMOS and AeroCom diagnostics in September and October 2014, “Standard HTAP2 variables” are identified in Column O of each sheet.

A repeated theme from the participating modelling groups at the HTAP meeting in Boulder (May 2015) was that the list of output variables is overwhelming and that it would be useful to identify a smaller number of priority outputs. A new column A has been added to the HTAP2_variables_150526.xls spreadsheet to this aim. The priority values that have changed are highlighted with an orange background. Who is interested in commenting about these revised priorities should contact the HTAP co-chairs so that they can note that and communicate it to the rest of the community.

2.5.2 HTAP2 CF Standard Names

The model outputs must be submitted to the MetNo Server as netCDF-CF compliant files (see section 3). The JRC has been in charge of providing (when exist) or proposing the CF standard names for all HTAP2 diagnostics. A total of 102 new standard names were submitted to the CF steering committee in December 2013.

- 20 CF standard_names for emission fields
- 31 CF standard_names for deposition
- 25 CF standard_names for mass mixing ratio of aerosols
- 7 CF standard_names for volume mixing ratio of gases
- 19 CF standard_names for other gaseous and aerosol variables.

All the CF Standard Names and Definitions defined in the frame of HTAP 2 are now part of the last version of the **CF Convention** (v28, 07 January 2015) and can be found under: <http://cfeditor.ceda.ac.uk/proposals/1?status=all&namefilter=&proposerfilter=koffi&descfilter=&unitfilter=&yearfilter=&commentfilter=&filter+and+display=Filter>

Note that part but not all additional variables from GMOS and AeroCom communities are included (the missing ones concern specific diagnostics for Mercury and for AeroCom biomass burning and NO₃ experiments).

2.5.3 HTAP2 stations lists

In order to compare the HTAP2 model outputs to observational datasets, **HTAP2 stations' lists** were compiled from the collection, merging, updating and correction of various datasets from Air Quality Monitoring networks in Europe and North America (AQMEII, AeroCom, CALNEX, GAW, EMEP, EANET, ABC, JMA, IAGOS, SHADOZ, IAGOS, ..). Many of these stations are also part of the AQMEII2-3 compilation), supplemented with other stations in other parts of world, including GAW sites, research sites in Asia, etc.

Two sets of stations' lists were initially defined in the frame of HTAP2: the short lists (where global model outputs were requested) and the long lists (mainly for regional model evaluation purpose). Based on the discussion at the HTAP meeting in Boulder (May 2015), it has been decided to ask all models to provide data for the entire lists of stations. They are provided both in EXCEL and CSV formats, together with the maps (.jpeg and as Google Earth .kmz files) of the stations' location (Figure 9) under HTAP WP2.2 WIKI page (Annex 1).

It is important to note that:

- **Three different files** have to be used for Surface gases (4128 stations), Surface aerosols (2068 Stations) and Profile (240 stations for both gas and aerosol) outputs.
- **No cross-verification has been made** if actual measurements were available for 2010 (2008), which means that in some cases the model station data can not be used for comparison. Thus, care must be taken in comparing the model outputs to the observational data.
- Further information on the model evaluation and available observation data is provided under HTAP WIKI Theme 3 page (Annex 1).

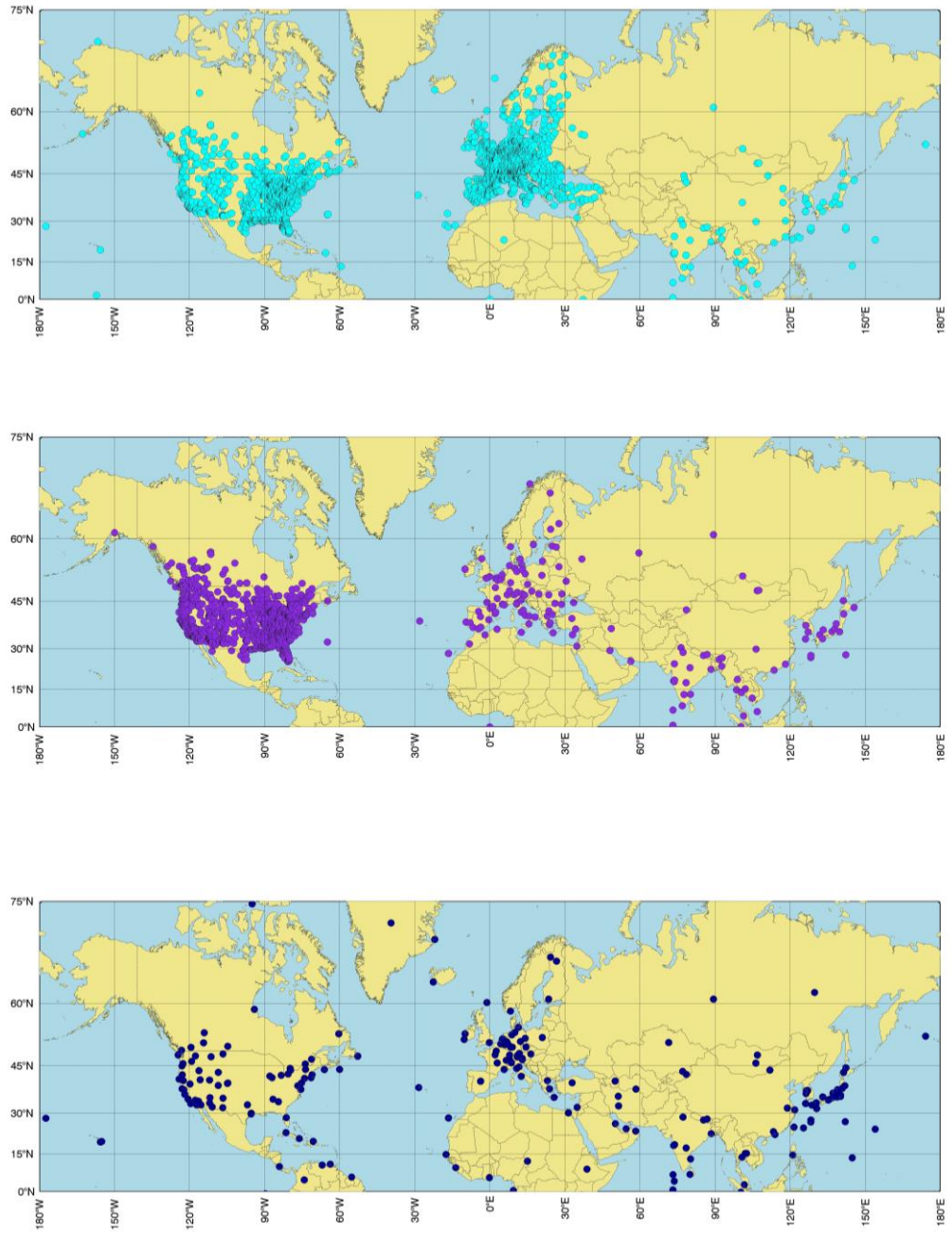


Figure 9: Location of the stations where surface gas (4128 stations; top), surface aerosol (2068 stations; middle) and Profile (240 stations; bottom) model outputs are requested.

3. Data submission and follow-up support

3.1 Data submission

The HTAP2 model database is hold by MetNo. Instructions for the file naming convention, the data upload, and the model documentation are found under HTAP2 data submission page: <http://iek8wikis.iek.fz-juelich.de/HTAPWiki/HTAP-2-data-submission>

Any submission of data to the MetNo server requires the 10 following steps:

- 1) format data to agreed netCDF htap standards, cf compliant
- 2) adjust filenames
- 3) check format with cf compliance checker, correct and check again
- 4) obtain account on htap server to access ftp and/or aerocom-users server
- 5) transfer data to the ftp server at the Norwegian Meteorological Institute
- 6) notify metno and JRC that - and what data - have been submitted
- 7) Where the data on htap data server can be found
- 8) update errors on submission log on htap wiki page
- 9) submit/update simulation status and model documentation
- 10) First screening of the model outputs

3.1.1 HTAP Naming Convention

Each requested output variable is to be provided in a separate file containing all time steps for a single year to make it easier to use simple commands and automated tools to manage the data and perform analyses. The model output data must be submitted to the MetNo server in the CF-compliant netCDF format with file names based on the **HTAP2 naming convention**:

htap2_<ModelName>_<ExperimentName>_<Realisation>_<VariableName>_
<VerticalCoordinateType>_<Period_Frequency>.nc

<ModelName> should be chosen such that model name, model version, and possibly the institution can be identified. No underscore () is allowed in <ModelName>, use (-) instead. Restrict <ModelName> to max 20 characters.

<ExperimentName> = will either be BASE, CH4INC, CH4DEC, or, for the various emissions perturbation runs, will be 5-6 letters (3 indicating the region of perturbation and 2-3 indicating the pollutants or sector decreased) based on the experiment matrix in Figure 3. For example, GLOALL is used to indicate a 20% decrease in anthropogenic emissions globally; NAMNOX is used to indicate a 20% decrease in anthropogenic NO_x emissions from North America; and SEACO is used to indicate a 20% decrease in anthropogenic CO (and CO passive tracers) from South East Asia.

<VariableName> = are the HTAP variable *short* names in the requested output spreadsheet discussed in section 7 above. An example of an variable *short* name is: vmro3

<VerticalCoordinateType> = Surface, Column, ModelLevel, SurfaceAtStations, or ModelLevelAtStations

<Period> = 2008, 2009, or 2010

<Frequency> = timeinvariant, hourly, daily, monthly, sat1000, sat1330, sat2200, sat0130

3.1.2 HTAP2 CF Format and CMOR Tables

The CF-compliance implies that sufficient attributes, coordinates and coordinate describing variables are included in each file to describe metadata needed to understand grid representation, units and origin of the data.

Formatting can be achieved with CMOR (<http://www-pcmdi.llnl.gov/software-portal/cmor/>) and NCO (<http://nco.sourceforge.net/nco.html>) tools. For using the **CF compliance checker** installed at the MetNo server (<http://aerocom-test.met.no/upload>), it was required to build HTAP-2 CMOR Tables- which can also be used by models to generate formatted output, including meta-data information.

Seven HTAP2 CMOR Tables have been built from HTAP2_variables.xls file (see section 2.5.1). The original EXCEL spreadsheets have been re-organized, as a function of the time resolution, as follows:

- Gridded time invariant outputs at surface: HTAP2_Table_fixed_v3.txt,
- Gridded outputs at satellite overpass time: HTAP2_Table_satellite_v3.txt,
- Gridded hourly outputs: HTAP2_Table_hourly_v3.txt,
- Gridded daily variables: HTAP2_Table_daily_v3.txt,
- Gridded monthly outputs: HTAP2_Table_monthly_v3.txt,
- Hourly outputs at stations: HTAP2_Table_hourly_station_v3.txt,
- Daily outputs at stations: HTAP2_Table_daily_station_v3.txt.

In addition to general information (CMOR and CF versions, table_id, base URL, required global attributes, and list of experiments), the HTAP CMOR Tables, which are available on the HTAP WIKI WP 2.2 (Annex 1), contain the definition of the axis (dimensions) and variables, as well as the variables attributes and comments, to be added to the NetCDF-CF output.

The Tables also include part but not all additional variables from GMOS and AeroCom communities (see 2.5.2). To further assist the HTAP modellers, **examples of HTAP2 NetCDF-CF model files** (EMEP regional model) are also provided by MetNo, on both HTAP WP2.2 and HTAP-2-data-submission WIKI pages.

3.2 Model run survey and documentation

3.2.1 Global model runs

- **Participating modelers** are requested to fill out the **EPA online-forms** on the model documentation and the simulation status (<http://www.htap.org/survey/index.cfm>). To facilitate the analysis of the results and minimize additional requests for information, it is important that the documentation is provided at the time of submission of the output data. As regards the submission procedure (see 3.1), the modelers are also responsible for the **communication to MetNo** of new submissions and major updates to their model outputs.
- **Model analysers** are responsible for frequently verifying changes in the model submissions (e.g. before submitting a paper). In case of doubt, we recommend to directly contact the modellers.
- **The JRC** assisted MetNo and EPA in the HTAP2 run submission and survey by:
 - updating the relevant information on the HTAP WIKI

- being the JRC contact point to the global modelers for the data submissions. The JRC is more specifically in charge of answering questions related to the specification and format of the model outputs, whereas the MetNo provides support on the use of the CF checker (see 4.1.2).
- checking the status of progress of HTAP2 global model simulations together with the MetNo Partner and providing a “HTAP2 Status Summary Table” (Annex 5), on HTAP WIKI, which documents the data submissions, updates, error corrections and the modellers’ contacts.

More detailed information on the different submissions, updates and corrections for the different models is also provided in the readme ASCII file located in each experiment folder of the different models on the MetNo server:

i.e.: /metno/htap/HTAP-PHASE-II/<ModelName_experiment>/readme

- **The AeroCom Visualization Tool** on the MetNo server allows for a first screening of the HTAP2 global outputs (see Figure 10), under:

http://aerocom.met.no/cgi-bin/aerocom/surfobs_annualrs.pl?PROJECT=HTAP&MODELLIST

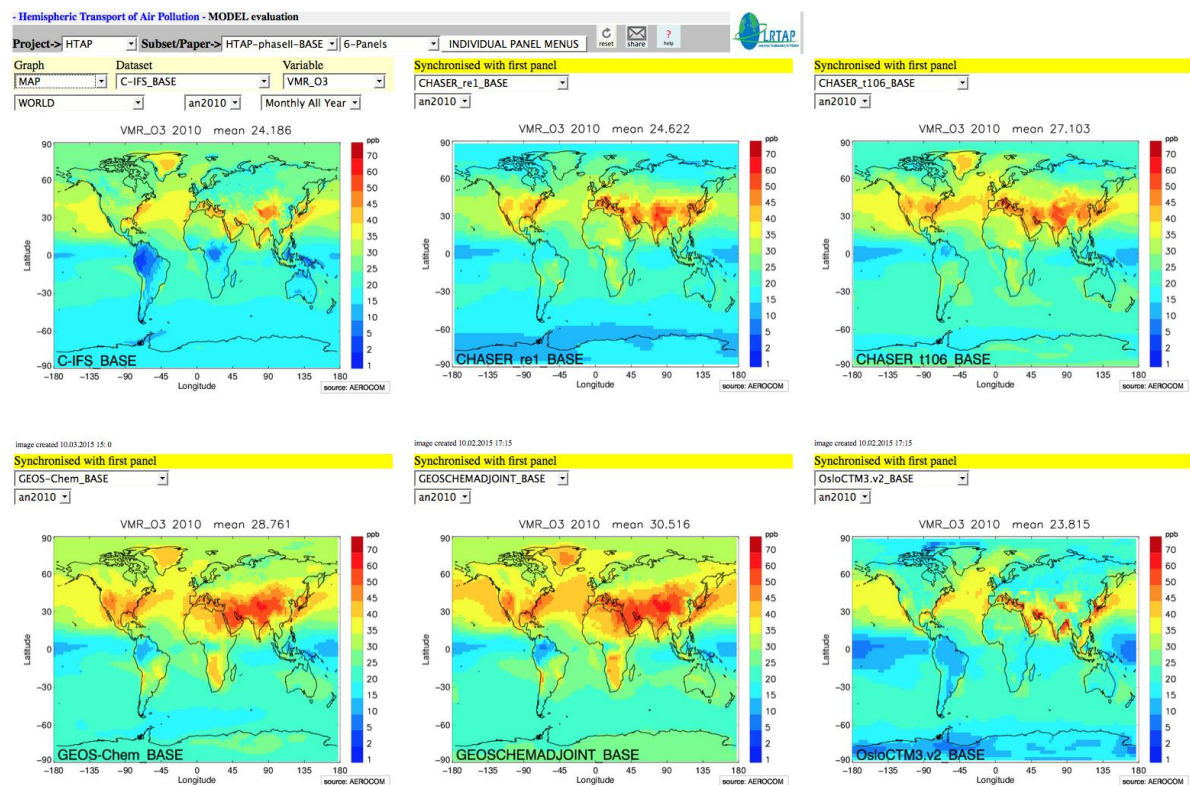


Figure 10: Quick-look comparison of the 2010 mean annual surface ozone distribution (ppb_v) from different HTAP2 global models

Status of the HTAP2 global model runs

The first publishing of HTAP2 modelling specification was achieved in December 2013. Additions and updates have been performed from June 2014 to October 2014. Global simulations have begun in June 2014 and results were still received at the time of the writing.

The status as of 27/01/2016 (**Annex 5**) was the following:

- 17 models delivered the BASE run outputs
- 11 models delivered the BASE run outputs at stations
- 4 models delivered outputs from perturbation runs per pollutant
- 5 models delivered outputs from perturbation runs per sector

3.2.2 Regional model runs

The regional AQMEII-HTAP and MICS-HTAP modelling exercises (see section 2.4.) focus on the following questions:

- How well do regional and global models simulate air quality at various space and time scales over North America, Europe and Asia?
- How sensitive are estimated source/receptor relationships to grid resolution?

Boundary conditions for regional models, together with the documentation are available since summer 2014. The Regional simulations began in September 2014 and are also still running. It is worth noting that the specification, status and analysis of the regional simulations, which are under the responsibility of the AQMEII and MICS modelling communities, following their own modelling protocol, are not documented in the present report.

4 Model-Observation evaluation

4.1 On-line analyses

Starting from within the UNECE CLRTAP EMEP framework, the most readily available observational data for us to access is the EMEP (and other datasets) stored in EBAS at NILU (ebas.nilu.no). Michael Schulz and his team at MetNo have worked with the NILU to import a number of observational data sets into the AeroCom/HTAP2 server and to build visualization tools to allow the modellers to do model performance analyses online at:

http://aerocom.met.no/cgi-bin/aerocom/surfobs_annualrs.pl?PROJECT=HTAP&MODELLIST=HTAP-phaseII

We note that the data available on the site are only a subset of the requested data in HTAP2.

4.2 Data sets for off-line analyses

To facilitate off-line evaluation with observations, we are also making two compilations of observational data also available on the AeroCom/HTAP2 server (*aerocom-users.met.no:/metno/htap/HTAP-PHASE-II/HTAP2-ObservationalDataset*):

- The first is an extract of observations from the EBAS database at NILU for 2008 and 2010. It consists primarily of EMEP data and other sources of rural stations in the European domain. EBAS only includes data from sites that are considered representative of regional concentrations of air pollution. It does not include urban, near-source locations.
- The second (AQMEII2-3) is an extract of the observations from the ENSEMBLE database at JRC for 2010 that was compiled for use in AQMEII Phase 2 and Phase 3. This database includes observational data for the European and North American domains of AQMEII. Note that these data include a wide range of sites from rural to urban locations, not all of which may be relevant for model evaluation, particularly for global models with relatively coarse resolution. Ozone data have been made available and other species and parameters will follow.

5 Conclusion and perspectives

Guidance and technical specifications have been provided to the HTAP2 modelers to ensure harmonized simulations. While the HTAP Phase 2 modelling experiments are still running, first analyses have been already performed. An ACP special issue (Dentener et al., 2016) is currently open to all publications that provide answers to the HTAP2 scientific questions (see Section 2). Are especially welcomed publications i) evaluating the joint HTAP2, AQMEII and MICS modelling experiments, ii) developing new methodologies to assess intercontinental transport of air pollution, or iii) describing and evaluating observational and emission data sets used in HTAP2 experiments and their relevance for hemispheric transport of air pollution. The present report has to be considered as a background document of the forthcoming HTAP2 technical note (Galmarini et al., 2016) of the ACP special issue, which will emphasize the coordination, harmonization and data handling issues, so as to minimize the description of the simulations' set up in the papers of the contributing authors and leave more space to their results.

6 References

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7 List of abbreviations and definitions

ABC: Atmospheric Brown Cloud

ACCMIP: Atmospheric Chemistry and Climate Model Intercomparison Project

ACP: Atmospheric Chemistry and Physics (Copernicus Publications Journal)

AeroCom: Aerosol Comparisons between Observations and Models

AQMEII: Air Quality Model Evaluation International Initiative

CalNEX: California Research at the Nexus of Air Quality and Climate Change

CCMI: Chemistry-Climate Model Initiative

CEIP: Centre on Emission Inventories and Projections

CF: Climate and Forecast

CMOR: Climate Model Output Rewriter

DMS: Dimethyl Sulfide

EANET: Acid Deposition Monitoring Network in East Asia Data

EBAS: Database for Atmospheric Composition Research

EC: European Commission

ECCAD: Emissions of atmospheric Compounds & Compilation of Ancillary Data

ECMWF: European Centre for Medium-Range Weather Forecasts

EDGAR: Emission Database for Global Atmospheric Research

EMEP: European Monitoring and Evaluation Programme

EPA: Environmental Protection Agency (U.S.)

GAMAP: Global Atmospheric Model Analysis Package

GAW: Global Atmosphere Watch

GFDL: Geophysical Fluid Dynamics Laboratory

GFED: Global Fire Emissions Database

GMOS: Global Mercury Observation System

HTAP: Hemispheric Transport of Air pollution

IAGOS: In-Service Aircraft for a Global Observing System

IPCC: Intergovernmental Panel on Climate Change

IPSL: Institut Paul Simon Laplace

JMA: Japan Meteorological Agency

JRC: Joint Research Centre (European Commission)

LATMOS: Laboratoire Atmosphères, Milieux, Observations Spatiales)

LRTAP: Long-range Transboundary Air Pollution

MetNo: MET Norway (Norwegian Meteorological Institute)

MICS-Asia: Model Intercomparison Study for Asia

MIPs: Model Inter-comparison Projects
NCO: NetCDF Operators
NetCDF: network Common Data Form
NILU: Norsk institutt for luftforskning (Norwegian Institute for Air Research)
NMVOC: Non Methane Volatile Organic Compound
NOAA: National Oceanic and Atmospheric Administration
PM: Particulate Matter
ppb: part per billion
RCP: Representative Concentration Pathways
REAS: Regional Emission Inventory in Asia
RETRO: REanalysis of the TROpospheric chemical composition
SHADOZ: Southern Hemisphere ADditional OZonesondes
SNU: Seoul National University
TF: Task Force
TNO: Netherlands Organisation for Applied Scientific Research
UNECE: United Nations Economic Commission for Europe
UK: United Kingdom
US: United States of America
vmr: volume mixing ratio
VOC: Volatile Organic Compound

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10.1 Annex 1: HTAP WIKI and other links

The HTAP wiki (<http://iek8wikis.iek.fz-juelich.de/HTAPWiki/>) is intended to facilitate the exchange of information between all TF HTAP participants.

- Anyone can view the wiki and download files without an account.
- To edit, e.g., to add comment on the discussion pages, it is needed to establish an account on: <http://www.htap.org/> > “About TF HTAP” > “Wiki Instructions”. A short guide on how to use this Wiki is also provided there.

The HTAP WIKI structure (http://iek8wikis.iek.fz-juelich.de/HTAPWiki/*) follows the TF HTAP Work Plan 2012-2016, as follows:

- *=WP1: Theme 1: Emissions inventories and Projections
- *=WP2: Theme 2: Source Apportionment and Source/Receptor Analysis
- *=WP3: Theme 3: Model-Observation Evaluation and Process Diagnosis
- *=WP4: Theme 4: Assessment of Health, Ecosystem, and Climate Impacts
- *=WP5: Theme 5: Assessment of Climate Change Impact on Pollution
- *=WP6: Theme 6: Expansion of the Data Network and Analysis Tool

The information and associated files reported the different *sections* of this report and archived at the JRC are accessible under WP1, WP2 and WP3 WIKI pages as follows:

WP1: Links to HTAP2 input emissions and associated information (*Section 3.2*)

WP2.1: Common set of source and receptor regions (*Section 3.3.3*)

WP2.2: Specification of the simulation experiments and output variables (*Section 3.5*)

WP2.3: Boundary Conditions for Regional Simulations (*Section 3.4*)

WP2.4: Model run survey and documentation (*Section 4.2*)

WP3: Model-Observation Evaluation (*Section 5*)

More general information is provided under :

HTAP: www.htap.org

HTAP_v2.2 data: http://edgar.jrc.ec.europa.eu/htap_v2/

AeroCom: <http://aerocom.met.no/>

AQMEII: <http://aqmeii.jrc.ec.europa.eu/>

MICS-Asia: <http://gains.iiasa.ac.at/index.php/gains-asia/262-mics-asia>.

10.2 Annex 2: Conversion of HTAP_v2.2 emission files to HTAP format

The JRC EDGAR Team has compiled a composite of anthropogenic regional emission inventories with monthly grid maps that includes EDGARv4.3 gap filling. The so-called HTAP_v2.2 database consists of monthly and annual emission files for 9 (sub)sectors and 9 species as described in Table A1.1. They have been converted to monthly variables files as reported in Table A1.2.

10.2.1 HTAP_v2.2 emission files by sector (original files)

- File naming: edgar-HTAP_<specie>_emi_<sector>_<year>(<M>).0.1x0.1.nc
- Sectors: Energy, Industry, Transport, Residential, Agriculture, Air, Ships
- Unit = Kg. m⁻². s⁻¹
- Format: One time step per file (with M= 1 to 12 for Monthly files)
- File size = 25943000

Table A1.1: HTAP_v2.2 emission files by sector (original files)

HTAP_v2.2 sector	Species	Time resolution	Number of files	Total Size
Energy	BC, CO, NH ₃ , NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Monthly	9*12*2=216	5603688000
Industry	BC, CO, NH ₃ , NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Monthly	9*12*2=216	5603688000
Transport	BC, CO, NH ₃ , NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Monthly	9*12*2=216	5603688000
Residential	BC, CO, NH ₃ , NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Monthly	9*12*2=216	5603688000
Agriculture	NH ₃	Monthly	12*2=24	622632000
Air AIR_LTO	BC, CO, NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Annual	8*2 = 16	415088000
Air AIR_CDS	BC, CO, NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Annual	8*2 = 16	415088000
Air AIR_CRS	BC, CO, NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Annual	8*2 = 16	415088000
Ships	BC, CO, NMVOC, NO _x , OC, PM ₁₀ , PM _{2.5} , SO ₂	Annual	8*2 = 16	415088000
Total			952	24,7 Giga

10.2.2 HTAP_v2.2 emissions converted to HTAP format

In order to allow for a first check of the HTAP model emissions fields by comparing to HTAP_v2.2 input emissions, they have been converted to the HTAP2 format as follows:

- File Naming:
htap2_HTAPv2_BASE_<VariableName>_Surface_<Period>_monthly.nc
- Format: all time steps in one file, i.e. 2 files (2008, 2010) per variables with 12 values
- VariableName: emibc, emico, eminh3, emivoc, eminox, emioc, emipm10, emipm2p5, emiso2
- Period: 2008, 2010
- File size=311064084
- Number of files: 18 (9 variables x 2 years)
- Example of file : htap2_HTAP2v2_BASE_emibc_Surface_2010_monthly.nc

Table A.1.2 : Converted HTAP_v2.2 emissions files (per variable)

HTAP_v2.2 Variable name	HTAP_v2 input sectors	HTAP2 Variable name	N. of input files	Total output size (2 files per variables)
BC	Energy, Industry, Transport, Residential, Air, Ships	emibc	104	622128168
CO	Energy, Industry, Transport, Residential, Air, Ships	emico	104	622128168
NMVOC	Energy, Industry, Transport, Residential, Air, Ships	emivoc	104	622128168
NO _x	Energy, Industry, Transport, Residential, Air, Ships	emiNO _x	104	622128168
OC	Energy, Industry, Transport, Residential, Air, Ships	emioc	104	622128168
PM10	Energy, Industry, Transport, Residential, Air, Ships	emipm10	104	622128168
PM2.5	Energy, Industry, Transport, Residential, Air, Ships	emipm2p5	104	622128168
SO ₂	Energy, Industry, Transport, Residential, Air, Ships	emiso2	104	622128168
NH ₃	Energy, Industry, Transport, Residential, Agriculture	eminh3	120	622128168
Total			952	5,6 Giga

10.3 Annex 3: VOCs speciation for HTAP_v2.2

Global gridded emissions of individual VOCs, which are not provided in HTAP_v2 emission dataset, have been calculated for 23 VOCs species, using the VOCs breakdown that was generated by the TNO for the RETRO project and then used for the ACCMIP emissions and RCPs scenarios. This work was performed through international collaboration between the LATMOS and the Met Office, with the support of the JRC expertise for the adaptation of the breakdown to the HTAP_v2 sectors. The RETRO original ratios dataset gives the individual VOCs emission ratios to total NMVOC at a 0.5°x0.5° resolution for 8 anthropic emission sectors (Section 1). It has been re-gridded to 0.1°x0.1° resolution and applied to HTAP_v2 NMVOC emissions to calculate 2008 and 2010 individual VOCs emissions files. This first required calculating HTAP NMVOC emission data for the different industrial sub-sectors (Section 2), since they are not part of HTAP_v2 emission dataset. Details on the correspondence between HTAP, EDGAR, RETRO and IPCC sectors are provided in Section 3.

The 2008 and 2010 HTAPv2_VOCs_anthro_<species>_<year>_flux_0.1x0.1.nc emissions NetCDF files for each of the VOCs species are available on the ECCAD2 server (<http://eccad2.sedoo.fr/eccad2/>).

10.3.1 RETRO VOCs ratios files

The VOCs breakdown as generated by the TNO (Maarten van het Bolscher, Tinus Pulles) for the RETRO project consist of 23 NetCDF files corresponding to 23 VOCs groups. They give the VOCs emission ratios at 0.5°x0.5° resolution for the following sectors:

- power (pow)
- extraction of fossil fuels (exf)
- transport (tra)
- residential (res)
- industrial combustion and processes (inc)
- solvents (sol)
- agriculture (agr)
- waste disposal (was) : * *not used in HTAP VOCs speciation guidance (see section 2.)*

(Note that the files n°10 and 11 that correspond to isoprene and terpenes species are not provided).

Table A2.1 : RETRO VOCs ratio files

File n°	VOCs species	RETRO sectors							
		pow	res	inc	exf	sol	tra	agr	was*
01	Alcohols	X	X	X		X		X	X
02	Ethane	X	X	X	X		X	X	X
03	Propane	X	X	X	X		X	X	X
04	Butanes	X	X	X	X		X	X	X
05	Pentanes	X	X	X	X		X	X	X
06	hexanes_plus_higher_alkanes	X	X	X	X	X	X	X	X
07	Ethane	X	X	X	X		X	X	X
08	Propene	X	X	X	X		X	X	X
09	Ethyne	X	X	X			X	X	X
12	other_alkenes_and_alkynes	X	X	X	X		X	X	X
13	Benzene	X	X	X	X		X	X	X
14	Toluene	X	X	X	X	X	X	X	X
15	Xylene	X	X	X	X	X	X	X	X
16	Trimethylbenzenes	X	X	X			X		X
17	other_aromatics	X	X	X	X	X	X	X	X
18	Esters					X			X
19	Ethers		X			X		X	X
20	chlorinated_hydrocarbons					X			X
21	Methanol	X	X	X			X	X	X
22	other_alkanals	X	X	X			X	X	X
23	Ketones	X	X	X		X	X	X	X
24	Acids	X	X	X				X	X
25	other_voc	X	X	X		X			X

The original RETRO files have been regridded at 0.1°x0.1° resolution by Gerd Folberth (MetOffice) in order to allow generating the VOC breakdown from HTAP_v2 total NMVOC emissions, as described in section 11.2.2.

10.3.2. HTAP_v2.2 VOCs breakdown

The RETRO ratios are applied to HTAP_v2 total NMVOC emissions files for the five HTAP_v2.2 sectors⁽¹⁾ (Power, Industry, Transport, Residential, Agriculture), for which individual VOC can be calculated, using the correspondence table below (Table A.2.2). HTAP_v2 dataset only provides one industrial sector. The 2008 and 2010 HTAP_v2 industrial emissions files have been split into three sub-industrial sectors by applying the EDGARv4 NMVOC 2008 emission fractions calculated for 3 sub-sectors that match the 'inc', 'exf' and 'sol' RETRO sectors. The corresponding EDGARv4 sub-industrial fractions file, as well as the derived htap_4.1, htap_4.2, htap_4.3 NMVOC 2008 and 2010 emission files, are provided on the HTAP WIKI. More details on the correspondence between HTAP/EDGAR/RETRO and IPCC sectors are provided in footnotes and in section 3.

Table A2.2: VOCs ratio applied to HTAP_v2 NMVOC emissions

HTAP sector ⁽¹⁾	HTAP_v2 sector description (and IPCC source classification)	Corresponding EDGARv4 subsector for NMVOCs (and IPCC classification)	RETRO ratios applied
HTAP_3 Power	Electricity generation (1A1a)	Energy industry (1A1a)	pow (1A1)
HTAP_4 Industry	Energy production other than electricity generation, Industrial processes, solvent production and application (1A1b-c, 1A2, 1B1-2, 2A-B-C-D-G, 3)	HTAP_4 has been split into three sub-sectors as defined below.	
→ htap_4.1 ⁽²⁾	<i>Industrial combustion and processes</i>	<i>Combustion in manufacturing industry (1A2)</i> <i>+ Non-metallic mineral products chemical industry (2A_B_D_E_F_G)</i>	<i>inc (1A2)</i>
→ htap_4.2 ⁽³⁾	<i>Production of fossil fuels, refineries, steel</i>	<i>Transformation, fossil fuel production, refineries (1A1bc_1B_2C1_2C2)</i>	<i>exf (1B2)</i>
→ htap_4.3	<i>Solvents</i>	<i>Solvents production and application (3)</i>	<i>sol (3)</i>
HTAP_5 Transport	Ground transport (1A3b-c-e)	Road Transportation (1A3b)	tra (1A3b)
HTAP_6 Residential ⁽⁴⁾	Buildings heating, cooling, equipment, and waste disposal or incineration (1.A4-5, 6.A-D)	Residential, commercial (1A4) + solid waste disposal (6A_6C)	res (1A4)
HTAP_8 Agriculture	Agriculture and agricultural waste burning (4.A,B,C,D,F,G)	Agricultural waste burning (4F)	agr (4E 5A)

1) No RETRO ratios exist for HTAP_1 (Air) and HTAP_2 (Ships) emission sectors; 2) As for the IPCC AR5 simulations, the 'inc' RETRO ratio is used for both industrial combustion and industrial processes. See: www.atmos-chem-phys-discuss.net/10/4963/2010/ and ftp-ippc.fz-juelich.de/pub/emissions/ancillary_data/IPCC_AR5_Emission_Sectors_v02.xls; 3) In htap_4.2 sub-sector, B2 NMVOCs emissions ('exf' ratios) are largely preponderant. See 'v4.2_NMVOC_2008.csv' from http://edgar.jrc.ec.europa.eu/datasets_list.php?v=42. 4) In HTAP_6 NMVOCs emissions, which include the waste disposal, the 1A4 (residential and commercial) emissions are largely preponderant (93% at global scale from 'v4.2_NMVOC_2008.csv'). Therefore, only the 'res' ratios are applied to calculate the individual VOCs emissions from this sector.

10.3.3. HTAP_v2.2, EDGARv4, LOTOS and IPCC sectors correspondence

Table A.2.3: HTAP_v2 sectors for which the VOC speciation is provided in Table 1.

HTAP sector	HTAP_v2 sector description	IPCC source classification
HTAP_3 Power	Electricity generation	1A1a
HTAP_4 Industry	Energy production other than electricity generation, Industrial processes, solvent production and application	1A1b-c, 1A2 1B1-2 2A-B-C-D-G 3
HTAP_5 Transport	Ground transport	1A3b-c-e
HTAP_6 Residential	Buildings heating, cooling, equipment, and waste disposal or incineration	1.A4-5, 6.A-D
HTAP_8 Agriculture	Agriculture and agricultural waste burning	4.A,B,C,D,F,G

Table A.2.4: EDGARv4 Industry subsectors used to calculate the HTAP_4 sub-sectors

EDGARv4 industry subsectors	IPCC source classification
Energy (electricity generation)	1A1a
Transformation, refineries, fossil fuel production, steel	1A1b 1A1c 1B 2C1 2C2
Combustion in manufacturing industry	1A2
Non-metallic, paper, food, chemical industry	2A 2B 2D 2E 2F 2G
Solvents	3

Table A.2.5: LOTOS sectors (RETRO report) and ratios* applied to HTAP_v2 NMVOC

LOTOS Group	LOTOS Group Description	IPCC source classification
1	Power generation (pow*)	1A1a 1A1b 1A1c
2	Residential, commercial and other (res*)	1A4
3	Industrial combustion (inc*)	1A2
4	Industrial processes (inp)	2
5	Extraction distribution of fossil fuels (exf*)	1B2a
6	Solvent use (sol*)	3
7	Road transport (tra*)	1A3b
8	Other mobile sources (otm)	1A3a 1A3c 1A3d 1A3e
9	Waste treatment and disposal (was)	6C 6D
10	Agriculture and Landuse change (agr*)	4E 5A

10.4 Annex 4: HTAP2 regions

10.4.1 Objective

The objective of this document is to discuss and define a common global mask defining source and receptor regions. These regions are to be used in reporting emissions and scenarios, to calculate source/receptor relationships, to perform impact assessments, and to perform integrated analysis of measurements.

10.4.2 Introduction

The HTAP 2010 report used a set of 4 source regions approximating North America (NA), Europe (EU), South Asia (SA), and East Asia (EA) complemented by a global (GL) source region for the purpose of source-receptor modeling and analysis.

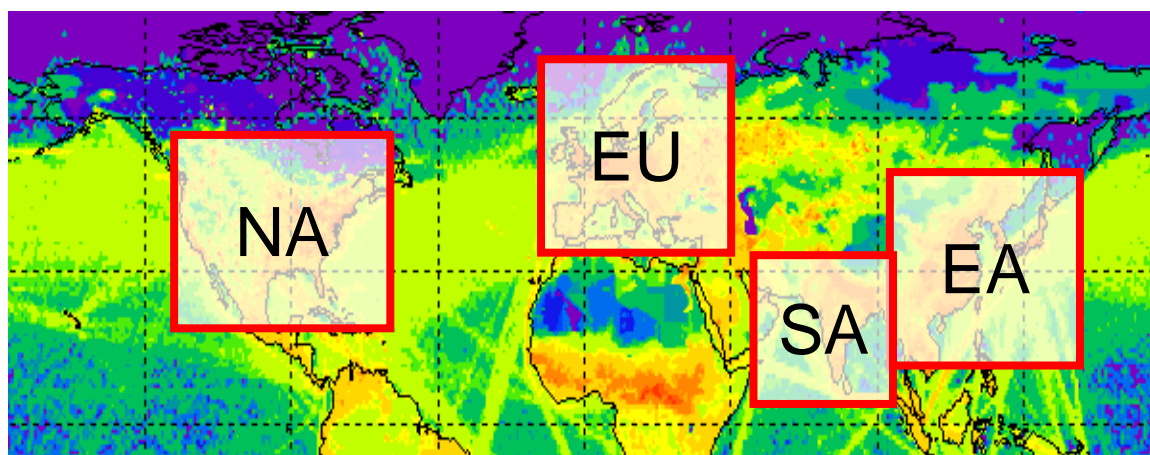


Figure A.4.1: HTAP1 regions

These regions were chosen to get a first overview of impacts of intercontinental transport from major source regions. The region definition was deliberately chosen to be simple, and not too close to resembling individual countries. The 4 regions represented together 60-70 % of anthropogenic emissions, with NA, EU, and EA being about equal size (and as a consequence expected to have about an equal ‘signal’). A number of disadvantages of this particular choice were noted during the HTAP phase 1.

- Initially a global region was not defined, which was needed for a complete attribution of regional signals.
- Especially for receptor studies these large regions were less useful, because of heterogeneity of sub-regions in these larger regions.
- Some important sources (dust; biomass burning) missed adequate regional definition.

During the HTAP meeting in 2012 in Pasadena a first step towards a new HTAP region definition for an updated set of source and receptor regions was presented. The following principles were identified:

- HTAP should keep its focus on the Northern Hemisphere
- 4 (5) source regions do not sufficiently resolve the diversity of source regions.
- HTAP source/receptor calculations may address not only source location, but also differentiate source types, which requires keeping the number of source regions to a manageable number.
- Greater resolution of receptors should be achieved by subdividing the source regions.

- Targeting about 10 source and 20 receptor regions, a set of practical boundaries should be defined for use throughout the HTAP work plan, maximizing the correspondence with regional definitions used on other relevant projects.

These regions were subsequently discussed in 2012 and 2013. During the TF HTAP meeting in March 2013, it was noted that in the tiered approach is not fully consistent with the RERER (Response to Extra-Regional Emission Reduction) metric (see Section 2).

It was considered advisable to use the terminology tiered regions definitions, where Tier 1 regions are both source and receptor, and Tier 2 regions can also be used in particular cases as source regions, and as well be used for analysis purpose beyond the RERER approach.

10.4.3 Tiered Regions.

Below is a proposed two-tiered set of regional definitions. There are 17 Tier 1 regions, which include the whole globe, the oceans, Arctic, Antarctic, and 13 land mass regions. The Arctic and Antarctic are defined roughly as the regions north of 66°N and south of 60°S, respectively. The Tier 1 regions are subdivided into 60 receptor regions. Note that most regions follow national or provincial boundaries. For the purpose of impact assessments, we have also defined a Himalaya receptor region that is comprised of sub-regions of the South, East, and Central Asian Tier 1 regions and where the elevation is greater than 1500m. A mask has been produced in digital form (netCDF) at 0.1°x0.1° resolution, as well as derived maps on 0.5°x0.5° and 1°x1° resolution, attributing a region classification number to the largest area fraction contributed by individual regions. We recommend for emission perturbation experiments to convolute the emissions at the highest possible resolution (i.e. 0.1°x0.1°) to avoid numerical errors occurring when aggregating emissions (as demonstrated in Table A.4.1 and Table A.4.2).

Table A.4.1: HTAP2 regions

	Tier 1		Tier 2	Remark
01	GLO*	World		Not provided as separate mask
02	OCN	Non-arctic/Antarctic Ocean	020 Baltic Sea 021 North Atlantic 022 South Atlantic 023 North Pacific 024 South Pacific 025 Indian Ocean 026 Hudson Bay 027 Mediterranean Sea 028 Black and Caspian Sea	150 Arctic seas are included in the Arctic receptor region 160 Antarctic seas are included in Antarctic receptor as Southern Ocean
03	NAM*	US+Canada (upto 66 N; polar circle)	031 NE US 032 SE US 033 NW US 034 SW US 035 E. Canada 036 W. Canada + Alaska up to 66 N.	Division along state lines. Emissions North of 66 N are marginal.
04	EUR*	Western + Eastern EU+Turkey (upto 66 N polar circle)	041 NW Europe 042 SW Europe (France follows province borders at ca. 46 N). 043 Eastern Europe 044 Greece+Turkey+Cyprus	
05	SAS*	South Asia: India, Nepal, Pakistan, Afghanistan, Bangladesh, Sri Lanka	051 North India +Nepal +Bangladesh +Afghanistan +Pakistan (ex. Himalaya) 052 South India+Sri Lanka 053 Indian Himalaya	Himalaya defined as regions above 1500 m altitude
06	EAS*	East Asia: China, Korea, Japan	061 North East China 062 South East China 063 West China +Mongolia (excl. Himalaya) 064 North/South Korea 065 Japan 066 China/Tibet Himalaya	Himalaya defined as regions above 1500 m altitude
07	SEA	South East Asia	071 Indonesia+Malaysia+Singapore 072 Thailand+Myanmar+Vietnam	
08	PAN	Pacific, Australia+New Zealand	081 Pacific 082 Australia 083 New Zealand	
09	NAF	Northern Africa+Sahara+Sahel	091 Egypt 092 Rest of Northern Africa 093 Sahel	Sahel identified as important dust source region.
10	SAF	Sub Saharan/sub Sahel Africa	101 West and Central Africa: Côte d'Ivoire, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Congo Brazzaville, Democratic Republic of Congo, Equatorial Guinea, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo (excluding Sahel) 102 East Africa: Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Sudan, Rwanda, Uganda, Somalia and Tanzania. 103 Southern Africa: Angola, Botswana, Lesotho, Madagascar, Malawi,	Parts of these countries included in Sahel region.

			Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe	
11	MDE*	Middle East: S. Arabia, Oman, etc, Iran, Iraq	111 Lebanon, Israel, Jordan, Syria. 112 Saudi Arabia; Yemen; Oman; Emirates, Qatar, Bahrein. 113 Iran, Iraq	
12	MCA	Mexico, Central America, Caribbean, Guyanas, Venezuela, Columbia	121 Mexico 122 Central America 123 Caribbean 124 Guyanas, Columbia, Venezuela	
13	SAM	S. America	131 South Brazil 132 Rest of Brazil 133 Uruguay, Paraguay, Argentina, Chile 134 Peru, Ecuador	
14	RBU*	Russia, Belarussia, Ukraine	141 Russia West 142 Russia East 143 Belarussia+Ukraine	
15	CAS	Central Asia	151 Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan	Pamir mountains not included in Himalaya
16	NPO	Arctic Circle (North of 66 N)+Greenland	150 Arctic (includes ocean and all of Greenland)	Defined as Tier 1; but mainly relevant as receptor
17	SPO	Antarctic	160 Antarctic 161 Southern Ocean, south of 60S	Defined as Tier 1; but mainly relevant as receptor

*Regions in bold characters defined as priority regions for TF HTAP Phase 2 simulations.

Table A.4.2: Overview of area (km²) and integrated CO emissions (tons/year) (source EDGAR4.2; <http://edgar.jrc.ec.europa.eu>; including large scale biomass burning) for Tier 1 regions is given on 3 resolutions: 0.1° x0.1°, 0.5° x0.5° and 1° x1°. Aggregation errors can be substantial.

Region Code	Region #	area (Km2) 0.1x0.1	area (Km2) 0.5x0.5	area (Km2) 1x1	CO_emi 2008_tons 0.1x0.1	CO_emi 2008_tons 0.5x0.5	CO_emi 2008_tons 1x1
OCN	2	3.2856E+08	3.2927E+08	3.2925E+08	1.5620E+07	3.2677E+07	4.7830E+07
NAM	3	1.6938E+07	1.6858E+07	1.6895E+07	5.5161E+07	5.3513E+07	4.9229E+07
EUR	4	5.5447E+06	5.4544E+06	5.4931E+06	2.9904E+07	2.8020E+07	2.7444E+07
SAS	5	5.0838E+06	5.1105E+06	5.0583E+06	7.0684E+07	6.9667E+07	6.7818E+07
EAS	6	1.1599E+07	1.1560E+07	1.1556E+07	1.2046E+08	1.1726E+08	1.1659E+08
SEA	7	4.9494E+06	4.7709E+06	4.7650E+06	8.3332E+07	7.9528E+07	7.4480E+07
PAN	8	8.0780E+06	8.0061E+06	7.9943E+06	7.6702E+06	7.5256E+06	6.9458E+06
NAF	9	1.2096E+07	1.2089E+07	1.2094E+07	1.8425E+07	1.8102E+07	1.8524E+07
SAF	10	1.7971E+07	1.7915E+07	1.7943E+07	3.8652E+08	3.8559E+08	3.8447E+08
MDE	11	5.1792E+06	5.1559E+06	5.1571E+06	6.5050E+06	6.3512E+06	6.0994E+06
MCA	12	5.2202E+06	5.1482E+06	5.0861E+06	3.6854E+07	3.4483E+07	3.2904E+07
SAM	13	1.5333E+07	1.5312E+07	1.5315E+07	4.3685E+07	4.1914E+07	4.2204E+07
RBU	14	1.3986E+07	1.3906E+07	1.3901E+07	1.4077E+07	1.4317E+07	1.4400E+07
CAS	15	4.0087E+06	3.9917E+06	4.0257E+06	4.0419E+06	4.0007E+06	4.0101E+06
NPO	16	2.2418E+07	2.2416E+07	2.2414E+07	5.5056E+05	5.4914E+05	5.4477E+05
SPO	17	3.4244E+07	3.4244E+07	3.4244E+07	4.8977E+02	4.8977E+02	4.8977E+02
GLO	1	5.1121E+08	5.1120E+08	5.1119E+08	8.9349E+08	8.9349E+08	8.9349E+08

Table A.4.3: Overview of area (km²) and integrated CO emissions (tons/year) (source EDGAR4.2; <http://edgar.jrc.ec.europa.eu>) for Tier 2 regions is given on 3 resolutions: 0.1° x 0.1°, 0.5° x 0.5° and 1° x 1°. Aggregation errors can be substantial.

region #	area (Km2) 0.1x0.1	area (Km2) 0.5x0.5	area (Km2) 1x1	CO_emi_2008 tons 0.1x0.1	CO_emi_2008 tons 0.5x0.5	CO_emi_2008 tons 1x1
20	3.8321E+05	3.9360E+05	3.8121E+05	2.3275E+05	3.9273E+05	3.3408E+05
21	4.3040E+07	4.3145E+07	4.3140E+07	2.8322E+06	6.4256E+06	1.0997E+07
22	4.0416E+07	4.0489E+07	4.0385E+07	4.7885E+05	2.1991E+06	1.4509E+06
23	8.5074E+07	8.5181E+07	8.5251E+07	6.6960E+06	1.2712E+07	1.7609E+07
24	9.8636E+07	9.8893E+07	9.8714E+07	1.9537E+06	3.7419E+06	6.6461E+06
25	5.6812E+07	5.6910E+07	5.7131E+07	1.8471E+06	4.5467E+06	7.3823E+06
26	8.3524E+05	8.3498E+05	8.4600E+05	8.6687E+02	8.4387E+02	1.3152E+03
27	2.5164E+06	2.5630E+06	2.5397E+06	1.0577E+06	2.2401E+06	2.5297E+06
28	8.4513E+05	8.6183E+05	8.6513E+05	5.2082E+05	4.9261E+05	8.7996E+05
31	2.8764E+06	2.8856E+06	2.8896E+06	2.6097E+07	2.6104E+07	2.2254E+07
32	2.0023E+06	1.9676E+06	2.0206E+06	1.1452E+07	1.0582E+07	1.1380E+07
33	1.2761E+06	1.2830E+06	1.2720E+06	2.1314E+06	2.1604E+06	2.1623E+06
34	1.8190E+06	1.8186E+06	1.8174E+06	9.3441E+06	8.4826E+06	7.2012E+06
35	3.3481E+06	3.3288E+06	3.3174E+06	3.6833E+06	3.7521E+06	3.7712E+06
36	5.6159E+06	5.5744E+06	5.5785E+06	2.4523E+06	2.4317E+06	2.4601E+06
41	1.9855E+06	1.9538E+06	1.9752E+06	1.0143E+07	9.7913E+06	9.5362E+06
42	1.2964E+06	1.2657E+06	1.3106E+06	6.8171E+06	5.6541E+06	6.0817E+06
43	1.3397E+06	1.3331E+06	1.3319E+06	8.3055E+06	8.3218E+06	8.0383E+06
44	9.2303E+05	9.0360E+05	8.7534E+05	4.6383E+06	4.2575E+06	3.7880E+06
51	2.8866E+06	2.9587E+06	2.8557E+06	4.4492E+07	4.4966E+07	4.4304E+07
52	1.3707E+06	1.3576E+06	1.3583E+06	2.3989E+07	2.2853E+07	2.0823E+07
53	8.2655E+05	7.9422E+05	8.4424E+05	2.2030E+06	1.8475E+06	2.6918E+06
61	2.9245E+06	2.9397E+06	2.9635E+06	3.4581E+07	3.3922E+07	3.4456E+07
62	2.5346E+06	2.5218E+06	2.5082E+06	6.8763E+07	6.5432E+07	6.4283E+07
63	3.1728E+06	3.1765E+06	3.1401E+06	2.0900E+06	2.1012E+06	2.0560E+06
64	2.2443E+05	2.1520E+05	2.1319E+05	5.1164E+06	4.6072E+06	2.9397E+06
65	3.7306E+05	3.3927E+05	3.4500E+05	7.3795E+06	6.4352E+06	7.8485E+06
66	2.3698E+06	2.3644E+06	2.3863E+06	2.5286E+06	4.7489E+06	5.0036E+06
71	3.0161E+06	2.8358E+06	2.8482E+06	3.8057E+07	3.4853E+07	3.1957E+07
72	1.9333E+06	1.9348E+06	1.9167E+06	4.5275E+07	4.4617E+07	4.2524E+07
81	8.9484E+04	3.2540E+04	4.7067E+04	3.5444E+04	9.9833E+03	5.5067E+03
82	7.7190E+06	7.7030E+06	7.6802E+06	7.3927E+06	7.2607E+06	6.7015E+06
83	2.6952E+05	2.7055E+05	2.6703E+05	2.4206E+05	2.5484E+05	2.3874E+05
91	9.8800E+05	9.7972E+05	9.7523E+05	2.4022E+06	2.3604E+06	1.9125E+06
92	8.5041E+06	8.5073E+06	8.5045E+06	2.9342E+06	2.9521E+06	2.9257E+06
93	2.6030E+06	2.6019E+06	2.6143E+06	1.3088E+07	1.2789E+07	1.3686E+07
101	6.9112E+06	6.9158E+06	6.8921E+06	2.7499E+08	2.7210E+08	2.6721E+08
102	4.4673E+06	4.4586E+06	4.4498E+06	9.6668E+07	9.8694E+07	1.0131E+08
103	6.5944E+06	6.5408E+06	6.6008E+06	1.4864E+07	1.4797E+07	1.5955E+07

111	3.1452E+05	3.0891E+05	3.0896E+05	8.3965E+05	7.7668E+05	7.4809E+05
112	2.7915E+06	2.7875E+06	2.7870E+06	3.0357E+06	2.8167E+06	2.5819E+06
113	2.0732E+06	2.0595E+06	2.0612E+06	2.6297E+06	2.7578E+06	2.7694E+06
121	1.9587E+06	1.9378E+06	1.9178E+06	1.0743E+07	1.0411E+07	1.0178E+07
122	5.2130E+05	5.1481E+05	5.2998E+05	5.2419E+06	4.9616E+06	4.5772E+06
123	2.3550E+05	2.0328E+05	1.8586E+05	3.1615E+06	2.4654E+06	1.9060E+06
124	2.5046E+06	2.4923E+06	2.4525E+06	1.7707E+07	1.6646E+07	1.6243E+07
131	1.4937E+06	1.4931E+06	1.5134E+06	1.6545E+07	1.5691E+07	1.6338E+07
132	7.0535E+06	7.0452E+06	7.0435E+06	1.1950E+07	1.1329E+07	1.1325E+07
133	4.1235E+06	4.1332E+06	4.1124E+06	1.1817E+07	1.1658E+07	1.1476E+07
134	2.6627E+06	2.6375E+06	2.6461E+06	3.3731E+06	3.2268E+06	3.0646E+06
141	3.6427E+06	3.6297E+06	3.6479E+06	6.9011E+06	6.8930E+06	6.9656E+06
142	9.5349E+06	9.4665E+06	9.4456E+06	3.7073E+06	3.6625E+06	3.6851E+06
143	8.0793E+05	8.0821E+05	8.0735E+05	3.4689E+06	3.7586E+06	3.7495E+06
151	4.0087E+06	3.9917E+06	4.0257E+06	4.0419E+06	4.0007E+06	4.0101E+06
160	2.2418E+07	2.2416E+07	2.2414E+07	5.5056E+05	5.4914E+05	5.4477E+05
170	1.3969E+07	1.4057E+07	1.4044E+07	2.6649E+01	1.3897E+02	1.2622E+02
171	2.0275E+07	2.0187E+07	2.0199E+07	4.6312E+02	3.5079E+02	3.6355E+02
1	5.1121E+08	5.1120E+08	5.1119E+08	8.9349E+08	8.9349E+08	8.9349E+08

10.4.4 Aggregation of regions used in other international projects

a) Global Burden of Disease

For the 2012 Global Burden of Diseases exercise (<http://www.healthdata.org/GBD>) the following 21 world regions have been defined.

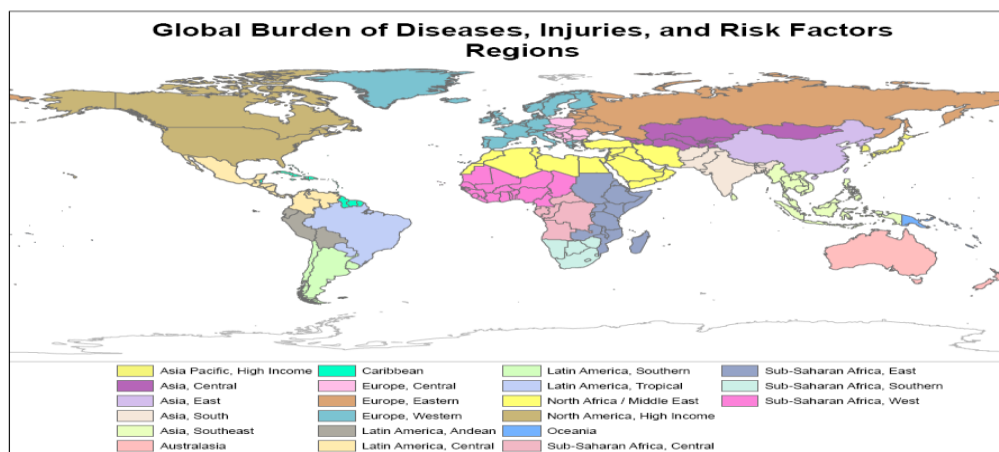


Figure A.4.2 (Murray et al., 2012)

Reference: Murray C.J. , Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010, Lancet. 2012 Dec 15;380(9859):2197-223. doi: 10.1016/S0140-6736(12)61689-4.

b) ECCAD and GFED

http://eccad.sedoo.fr/eccad_extract_interface/JSF/page_login.jsf

ECCAD displays and analyses global emission inventories in either 14 or 26 regions, for biomass burning GFED regions.

GFED region (biomass burning)	ECCAD 26	ECCAD 14
Australia and New Zealand Boreal Asia Boreal North America Central American Central Asia Equatorial Asia Europe Middle East North. Hemisph. Africa North. Hemisph. South America South. Hemisph. Africa South. Hemisph. South America Southeast Asia Temperate North America	Asia-Stan Brazil Canada Central Europe China+ Eastern Africa Greenland India+ Indonesia+ Japan Korea Mexico Middle East Northern Africa Oceania Rest Central America Rest South America Russia+ Southeastern Asia Southern Africa Turkey USA Ukraine+ Western Africa Western Europe	All Africa Canada China + Centrally Planned countries Eastern Europe Former USSR India + South Asia Japan Latin America Middle East OECD Europe Oceania South East Asia USA

c) Representative Concentration Pathways Region definition

<http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=compare>

The RCP database aggregates regions into:

OECD90 = Includes the OECD 90 countries, therefore encompassing the countries included in the regions **Western Europe** (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom), **Northern America** (Canada, United States of America) and **Pacific OECD** (Australia, Fiji, French Polynesia, Guam, Japan, New Caledonia, New Zealand, Samoa, Solomon Islands, Vanuatu) .

REF = Countries from the **Reforming Economies** region (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Malta, Poland, Republic of Moldova, Romania, Russian Federation, Slovakia, Slovenia, Tajikistan, TFYR Macedonia, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia).

ASIA = The countries included in the regions **China** + (China, China Hong Kong SAR, China Macao SAR, Mongolia, Taiwan) , **India** + (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka) and **Rest of Asia** (Brunei Darussalam, Cambodia, Democratic People's Republic of Korea, East Timor, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Papua New Guinea, Philippines, Republic of Korea, Singapore, Thailand, Viet Nam) are aggregated into this region.

MAF = This region includes the **Middle East** (Bahrain, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen) and **African** (Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cote

d'Ivoire, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Democratic Republic of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Togo, Tunisia, Uganda, United Republic of Tanzania, Western Sahara, Zambia, Zimbabwe) countries.

LAM = This region includes the **Latin American** countries (Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Suriname, Trinidad and Tobago, Uruguay, Venezuela).

d) IMAGE region definition

The integrated Assessment Model is one of the more widely used models for impact analysis. It has 26 regions.

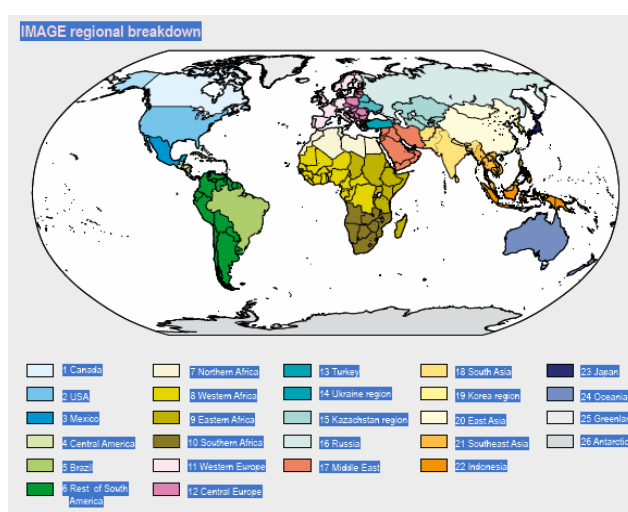


Figure A.4.3: IMAGE regions (Bouwman et al., 2006)

Reference: Bouwman, L., T. Kram, K. Klein-Goldewijk, 2006, Integrated modelling of global environmental change. An overview of IMAGE 2.4, Netherlands Environmental Assessment Agency, Bilthoven.

10.5 Annex 5: HTAP2 Status Summary Table

(as of 26/01/2016)

Models: column 2 (see modelers' contact list page 56)

Years: x =2008; x=2009; X=2010

Experiments Priority

	HTAP2 First Priority
	HTAP2 Second Priority
	Not part of HTAP2 experiments

Diagnostics

ST(A): Aerosol diagnostics at Stations*

ST(G): Gaseous diagnostics at Stations *

G(A): Gridded aerosol diagnostics

G(G): Gridded gaseous diagnostics

AT STATIONS

Group Institution	Model	BASE		CH4INC	CH4DEC	GLOALL		NAMALL	EURALL	EASALL	SASALL	RBUALL	MDEALL	SEAALL	CASALL	NAFALL	MCAALL	SAFALL	SAMALL	PANALL	OCNALL
		ST(A)	ST(G)			ST(A)	ST(G)														
CICERO	OsloCTM3.v2	X*																			
NASA GSFC	GOCARTv5																				
RIAM	SPRINTARS																				
NAGOYA,JAMSTEC,NIES	CHASER_re1	xxX	xxX																		
NAGOYA,JAMSTEC,NIES	CHASER_t106	X	X																		
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X			X	X	X	X												
SSEC-NESDIS	RAQMS	X*	X*																		
SSEC_NESDIS	RAQMS_ASSIM	X*	X*																		
NASA GSFC	GEOS5																				
GEORGIA TECH	REAM**		X**																		
SNU	GEOS-Chem		X																		
SNU	GEOS_Chem_Calnex		X																		
UNIMOD	EMEP_rv4.5																				
UNIMOD	EMEP_rv4.8	X	X																		
ECMWF	C-IFS																				
ECMWF	C-IFS_v2																				
IITM	MOZART-4																				
UTK	HCMQAQ		X																		
NCAR	CAM-chem																				

Since June 2015 we **ask all models to provide data for the entire list of stations (in bold)** for Surface gaz (4128 stations), Surface aerosol (2068 stations) and Profile (240 stations) outputs **instead of the short lists (*)**. ** = regional outputs that do not include all stations.

See HTAP WIKI for more details on the HTAP2 stations lists (see section 2.5.3).

GRIDDED: BASE, CH4 and “ALL” perturbation experiments

Group Institution	Model	BASE		CH4INC	CH4DEC	GLOALL	NAMALL	EURALL	EASALL	SASALL	RBULL	MDEALL	SEAALL	CASALL	NAFALL	MCAALL	SAFALL	SAMALL	PANALL	OCNALL
		G(A)	G(G)																	
CICERO	OsloCTM3.v2	X	X	X	X	X	X	X	X	X	X	X				X		X		
NASA GSFC	GOCARTv5	xX	-			xX	xX	xX	xX	xX	xX	xX								
RIAM	SPRINTARS	xxX	-			X	X	X	X	X	X	X								
NAGOYA,JAMSTEC,NIES	CHASER_re1	xxX	xxX	xX		xX	xX	xX	xX	X	X	X								
NAGOYA,JAMSTEC,NIES	CHASER_t106	X	X	X		X	X	X	X	X										
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X			X	X	X												
SSEC-NESDIS	RAQMS	X	X						X											
SSEC_NESDIS	RAQMS_ASSIM																			
NASA GSFC	GEOS5	X	-			X	X	X	X	X	X	X								
GEORGIA TECH	REAM																			
SNU	GEOS-Chem		xxX			xxX	xxX		xxX											
SNU	GEOS_Chem_Calnex		X																	
UNIMOD	EMEP_rv4.5	X	X																	
UNIMOD	EMEP_rv4.8	xxX	xxX			X	X	X	X	X										X
ECMWF	C-IFS	xX	xX	xX		xX	xX	xX	xX	xX										
ECMWF	C-IFS_v2	X	X			X	X	X	X											
IITM	MOZART-4		x X							X										
UTK	HCMAQ	X	X																	
NCAR	CAM-chem	xxX	xxX			xxX	xxX	xxX	xxX	xxX	xxX	xxX								

AT STATIONS : Perturbation per pollutant

Group Institution	Model	GLONOX	NAMNOX	EURNOX	EASNOX	SASNOX	RBUNOX	MDENOX	GLOCO	NAMCO	EURCO	EASCO	SASCO	RBUCO	MDECO							
CICERO	OsloCTM3.v2																					
NASA GSFC	GOCARTv5																					
RIAM	SPRINTARS																					
NAGOYA,JAMSTEC,NIES	CHASER_re1																					
NAGOYA,JAMSTEC,NIES	CHASER_t106																					
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X	X					X	X	X											
SSEC-NESDIS	RAQMS																					
SSEC-NESDIS	RAQMS_ASSIM																					
NASA GSFC	GEOS5																					
GEORGIA TECH	REAM																					
SNU	GEOS-Chem																					
SNU	GEOS-Chem_Calnex																					
UNIMOD	EMEP_rv4.5																					
UNIMOD	EMEP_rv4.8																					
ECMWF	C-IFS																					
ECMWF	C-IFS_v2																					
IITM	MOZART-4																					
UTK	HCMAQ																					
NCAR	CAM-chem																					
Group Institution	Model	GLOVOC	NAMVOC	EURVOC	EASVOC	SASVOC	RBUVOC	MDEVOC	GLOSO2	NAMSO2	EURSO2	EASSO2	SASSO2	RBUSO2	MDESO2	GLONH3	NAMNH3	EURNH3	EASNH3	SASNH3	RBUNH3	MDENH3
CICERO	OsloCTM3.v2																					
NASA GSFC	GOCARTv5																					
RIAM	SPRINTARS																					
NAGOYA,JAMSTEC,NIES	CHASER_re1																					
NAGOYA,JAMSTEC,NIES	CHASER_t106																					
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X	X					X	X	X					X	X	X				
SSEC-NESDIS	RAQMS																					
SSEC-NESDIS	RAQMS_ASSIM																					
NASA GSFC	GEOS5																					
GEORGIA TECH	REAM																					
SNU	GEOS-Chem																					
SNU	GEOS-Chem_Calnex																					
UNIMOD	EMEP_rv4.5																					
UNIMOD	EMEP_rv4.8																					
ECMWF	C-IFS																					
ECMWF	C-IFS_v2																					
IITM	MOZART-4																					
UTK	HCMAQ																					
NCAR	CAM-chem																					

STATIONS: Perturbations by sector

Group Institution	Model	GLOTRN	NAMTRN	EURTRN	EASTRN	SASTRN	RBUTRN	MDETRN	GLOPIN	NAMPIN	EURPIN	EASPIN	SASPIN	RBUPIN	MDEPIN	GLORES	NAMRES	EURRES	EASRES	SASRES	RBURES	MDERES
CICERO	OsloCTM3.v2																					
NASA GSFC	GOCARTv5																					
RIAM	SPRINTARS																					
NAGOYA,JAMSTEC,NIES	CHASER_re1																					
NAGOYA,JAMSTEC,NIES	CHASER_t106																					
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X	X					X	X	X					X	X	X				
SSEC-NESDIS	RAQMS																					
SSEC-NESDIS	RAQMS_ASSIM																					
NASA GSFC	GEOS5																					
GEORGIA TECH	REAM																					
SNU	GEOS-Chem																					
SNU	GEOS-Chem_Calnex																					
UNIMOD	EMEP_rv4.5																					
UNIMOD	EMEP_rv4.8																					
ECMWF	C-IFS																					
ECMWF	C-IFS_v2																					
IITM	MOZART-4																					
UTK	HCMAQ																					
NCAR	CAM-chem																					
Group Institution	Model	GLOFIR	NAMFIR	RBUFIR	SEAFIR	SAFFIR	SAMFIR	GLODST	EASDST	MDEDST	CASDST	NAFDST	SHLDST	SHRDST								
CICERO	OsloCTM3.v2																					
NASA GSFC	GOCARTv5																					
RIAM	SPRINTARS																					
NAGOYA,JAMSTEC,NIES	CHASER_re1																					
NAGOYA,JAMSTEC,NIES	CHASER_t106																					
Univ.Col. Boulder	GEOSCHEM-ADJOINT																					
SSEC-NESDIS	RAQMS																					
SSEC-NESDIS	RAQMS_ASSIM																					
NASA GSFC	GEOS5																					
GEORGIA TECH	REAM																					
SNU	GEOS-Chem																					
SNU	GEOS-Chem_Calnex																					
UNIMOD	EMEP_rv4.5																					
UNIMOD	EMEP_rv4.8																					
ECMWF	C-IFS																					
ECMWF	C-IFS_v2																					
IITM	MOZART-4																					
UTK	HCMAQ;																					
NCAR	CAM-chem																					

GRIDDED : Perturbations by pollutant

Group Institution	Model	GLONOX	NAMNOX	EURNOX	EASNOX	SASNOX	RBUNOX	MDENOX	GLOCO	NAMCO	EURCO	EASCO	SASCO	RBUCO	MDECO								
CICERO	OsloCTM3.v2	X							X														
NASA GSFC	GOCARTv5																						
RIAM	SPRINTARS																						
NAGOYA,JAMSTEC,NIES	CHASER_re1	X			X				X														
NAGOYA,JAMSTEC,NIES	CHASER_t106	X							X														
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X	X					X	X	X												
SSEC-NESDIS	RAQMS																						
SSEC-NESDIS	RAQMS_ASSIM																						
NASA GSFC	GEOS5																						
GEORGIA TECH	REAM																						
SNU	GEOS-Chem																						
SNU	GEOS-Chem_Calnex																						
UNIMOD	EMEP_rv4.5																						
UNIMOD	EMEP_rv4.8																						
ECMWF	C-IFS																						
ECMWF	C-IFS_v2																						
IITM	MOZART-4																						
UTK	HCMAQ																						
NCAR	CAM-chem																						
Group Institution	Model	GLOVOC	NAMVOC	EURVOC	EASVOC	SASVOC	RBUVOC	MDEVOC	GLOSO2	NAMSO2	EURSO2	EASSO2	SASSO2	RBUSO2	MDES02	GLONH3	NAMNH3	EURNH3	EASNH3	SASNH3	RBUNH3	MDENH3	
CICERO	OsloCTM3.v2	X																					
NASA GSFC	GOCARTv5																						
RIAM	SPRINTARS																						
NAGOYA,JAMSTEC,NIES	CHASER_re1	X			X							X											
NAGOYA,JAMSTEC,NIES	CHASER_t106	X																					
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X	X					X	X	X					X	X	X					
SSEC-NESDIS	RAQMS																						
SSEC-NESDIS	RAQMS_ASSIM																						
NASA GSFC	GEOS5																						
GEORGIA TECH	REAM																						
SNU	GEOS-Chem																						
SNU	GEOS-Chem_Calnex																						
UNIMOD	EMEP_rv4.5																						
UNIMOD	EMEP_rv4.8																						
ECMWF	C-IFS																						
ECMWF	C-IFS_v2																						
IITM	MOZART-4																						
UTK	HCMAQ																						
NCAR	CAM-chem																						

GRIDDED : Perturbations by sector

Group Institution	Model	GLOTRN	NAMTR N	EURTRN	EASTRN	SASTRN	RBUTRN	MDETR N	GLOPIN	NAMPIN	EURPIN	EASPIN	SASPIN	RBUPIN	MDEPIN	GLORES	NAMRE S	EURRES	EASRES	SASRES	RBURES	MDERE S
CICERO	OsloCTM3.v2	X							X							X						
NASA GSFC	GOCARTv5	xX							xX							xX						
RIAM	SPRINTARS	X							X							X						
NAGOYA,JAMSTEC,NIES	CHASER_re1	X							X							X						
NAGOYA,JAMSTEC,NIES	CHASER_t106																					
Univ.Col. Boulder	GEOSCHEM-ADJOINT	X	X	X					X	X	X					X	X	X				
SSEC-NESDIS	RAQMS																					
SSEC-NESDIS	RAQMS_ASSIM																					
NASA GSFC	GEOS5																					
GEORGIA TECH	REAM																					
SNU	GEOS-Chem																					
SNU	GEOS-Chem_Calnex																					
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UNIMOD	EMEP_rv4.8																					
ECMWF	C-IFS																					
ECMWF	C-IFS_v2																					
IITM	MOZART-4																					
UTK	HCMAQ																					
NCAR	CAM-chem																					

Group Institution	Model	GLOFIR	NAMFIR	RBUFIR	SEAFIR	SAFFIR	SAMFIR	GLODST	EASDST	MDEDS T	CASDST	NAFDST	SHLDST	SHRDST
CICERO	OsloCTM3.v2													
NASA GSFC	GOCARTv5	xX							xX	xX	xX	xX		
RIAM	SPRINTARS	X							X	X	X		X	X
NAGOYA,JAMSTEC,NIES	CHASER_re1													
NAGOYA,JAMSTEC,NIES	CHASER_t106													
Univ.Col. Boulder	GEOSCHEM-ADJOINT													
SSEC-NESDIS	RAQMS													
SSEC-NESDIS	RAQMS_ASSIM													
NASA GSFC	GEOS5	X							X	X	X	X		
GEORGIA TECH	REAM													
SNU	GEOS-Chem													
SNU	GEOS-Chem_Calnex													
UNIMOD	EMEP_rv4.5													
UNIMOD	EMEP_rv4.8													
ECMWF	C-IFS													
ECMWF	C-IFS_v2													
IITM	MOZART-4													
UTK	HCMAQ;													
NCAR	CAM-chem													

Modelers' contact list (26/01/2016)

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RIAM	SPRINTARS	<u>Toshihiko Takemura</u>	toshi@riam.kyushu-u.ac.jp
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NAGOYA,JAMSTEC,NIES	CHASER_t106	Kengo Sudo <u>Takashi Sekiya</u>	kengo@nagoya-u.jp tsekiya@nagoya-u.jp
Univ.Col. Boulder	GEOSCHEM-ADJOINT	<u>Daven Henze</u>	daven.henze@colorado.edu"
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SSEC_NESDIS	RAQMS_ASSIM	Brad Pierce <u>Allen Lenzen</u>	Brad.Pierce@noaa.gov allenl@ssec.wisc.edu
NASA GSFC	GEOS5	Huisheng Bian Mian Chin Xiaohua Pan	huisheng.bian@nasa.gov mian.chin@nasa.gov xiaohua.pan@nasa.gov
GEORGIA TECH	REAM		
SNU	GEOS-Chem	<u>Rokjin Park</u>	rjpark@snu.ac.kr
SNU	GEOS_Chem_Calnex	<u>Rokjin Park</u>	rjpark@snu.ac.kr
UNIMOD	EMEP_rv4.5		
UNIMOD	EMEP_rv4.8	<u>Jan Eiof Jonson</u>	j.e.jonson@met.no
ECMWF	C-IFS	<u>Johannes Flemming</u>	Flemming@ecmwf.int
IITM	MOZART-4		
UTK	HCMAQ	Dr. Joshua S Fu <u>Xinyi Dong</u>	jsfu@utk.edu xdong1@utk.edu
NCAR	CAM-chem	Louisa Emmons	emmons@ucar.edu

- See HTAP WIKI <http://iek8wikis.iek.fz-juelich.de/HTAPWiki/WP2.2> for more details on the HTAP2 experiments and variables
- See <http://iek8wikis.iek.fz-juelich.de/HTAPWiki/HTAP-2-data-submission> for details on the 9 submission steps
- See <http://www.htap.org/survey/index.cfm> for the reporting of your model documentation and simulations' status

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