**Documentation on the Boundary Conditions provided by MET Norway to EDIII Trend exercise**

The boundary conditions (BCs) supplied for the EDIII study are a simplified version of those used in the standard EMEP MSC-W model. The values are loosely based upon climatological data (except from those for natural particles). The most important gaseous BC compounds are certainly O3, CO and CH4, and these values are believed to be well founded. BCs for other gaseous and particulate compounds are much more uncertain. In principle results from global 3-D models could have been used, but this would introduce very complex and likely equally uncertain BCs into the EDII exercise. The values documented below aim rather to be simple and transparent.

The BCs are provided as monthly mean 3D fields of the following species:

* Gases: O3, PAN, CO, CH4
* Aerosols (fine < 2.5 um, coarse 2.5 – 10 um) :

fine SO4 (“SO4”)

fine NO3 (“NO3\_F”)

coarse NO3 (“NO3\_C”)

fine NH4 (“NH4”)

sea salt fine (“SEASALT\_F”)

coarse (“SEASALT\_C”)

mineral dust fine (“DUST\_WB\_F”)

mineral dust coarse(“DUST\_WB\_C”)

UNITS: volume mixing ratios. Note: dust molecular weight = 200 g/mol

GRID: Identical to the ERA/WRF meteorological data grid

Horizontal - rotated spherical

Vertical - 31 layers

IMPLEMENTATION:

No temporal interpolation between the months

BCs BRIEF DESCRIPTION:

The parameters used to prescribe the seasonal cycle are provided in Table 1 (cf Eqn 74 in Simpson et al., 2012).

The vertical distribution of most species are characterized with the scale-heights Hz (e-fold decrease of the surface concentrations) and other parameters as specified in Table 1 (cf Eqns (75), ibid). The main simplification from Simpson et al 2012 is that the latitudinal variations (Table S22, ibid) were omitted. These variations were based upon old literature, and recent work has shown that these variations have little impact on model results.

Table 1 Adapted from Table S21 (Supplement, Simpson et al., 2012)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Component | χ mean  ppb | dmax  days | Δχ  ppb | Hz  km | χ min v  ppb | Annual  Trend |
| CO | 125.0 | 75.0 | 35.0 | 25.0 | 70.0 | no |
| PAN | 0.20 | 120 | 0.15 | ∞ | 0.20 | yes |
| SO4 | 0.15 | 180 | 0.00 | ∞ | 0.05 | yes |
| NO3 fine | 0.07 | 15 | 0.03 | 1.6 | 0.025 | yes |
| NO3 coarse | 0.07 | 15 | 0.00 | 1.6 | 0.025 | yes |
| NH4 | 0.15 | 180 | 0.00 | 1.6 | 0.05 | yes |
| Sea salt fine | 0.2 | 15 | 0.05 | 1.6 | 0.01 | no |
| Sea salt coarse | 1.5 | 15 | 0.25 | 1.6 | 0.01 | no |

χ mean - the annual mean surface concentration, Δχ - the amplitude of the cycle, dmax - the day number of χ maximum; Hz - the scale-heights of vertical distribution. For trends, see below.

For Ozone, BCs have zonal, monthly and vertical variation and annual trend (see below)

For Sea salt, BCs over land are set to 0.001 \* BCs over sea

Mineral Dust – monthly 3D fields from EMEP global run for 2012

Constant BCs (no 3-D or monthly variations) are set for:

CH4 - 1870 ppb

H2 - 600 ppb

REFERENCES / NOTES

**Ozone**

For BCs, we make use of Logan's climatological data (Logan, JGR, 1999).

These climatological values are modified each month to ensure that they match concentrations observed in clean westerly Atlantic air masses as measured at Mace Head on the coast of Ireland. This `Mace Head correction' is calculated using IE31 O3 data and trajectory sectors (based on ECMWF met) for respective years, as described in Simpson et al., 2012.

**PAN**

Trends are based on NOx emission trend in North America (see SIA below)

**CH4**

The following values are set: 1780 ppb in 1990, 1820 ppb in 2000, and 1870 ppb in 2010. For other year, interpolation is applied. Values from Simpson et al. (2012), Table 6.2 for 1990, and from CDIAC (Mace Head) data for 2000. 2010 also from Mace Head

**SIA**

For SO4 and NO3, the trends for 1980-2003 are derived from the trend in EPA emissions for North America of SO2 and NOx.

For NH4, the trends are derived as 2/3\*SO4 + 1/3\*NOx

Support for SO2 can be found in Hicks, Artz, Meyer and Hosker (2002) in Figure 7 (Eastern US) which show 'close' correspondence between national emissions and concentration trend.

The trend-factors look like this:

**SO2 NOx NH4**

SIAfac (1990, 0.890, 0.943, 0.920)

SIAfac (2000, 0.631, 0.835, 1.046)

SIAfac (2010, 0.292, 0.543, 0.925)

The reference value for SO2 and SO4 is 0.15 ppb in 1980 (for both), loosely based upon a number of studies (Table S21 in Simpson et al. 2012 gives references). For example, Warneck (1999, Fig. 10.6) showed SO2 concentrations being around 0.1-0.5 ug/m3 (STP, ca. 0.04-0.2 ppb) over marine areas. Observations at Valentia Observatory on the west coast of Ireland show ca. 1 ug/m3 for both SO2 and SO4 around 1980 (although certainly influenced by polluted sources). In earlier EMEP studies a scale height of 1.6 km was used for SO2 and SO4, but model studies suggest that SO4 should show little vertical variation with height.

Warneck, Chemistry of the Natural Atmosphere, 2nd edition, 1999; Academic Press. (Fig 10-6)

References for NO3 fine & coarse and NH4:

BCs are based on ACE-2 measurements. Lots of conflicting measurements exist, from NH4/SO4=2 to NH4/SO4=0.5 Thus, a 'mean' value of NH4/SO4=1 is therefore selected. Otherwise NH4 is assumed to act as SO4.

Fine NO3 is assumed to act as SO4, but with 1/2 concentrations and seasonal var.

Coarse NO3 is assumed to act like sea salt in the vertical, with decreasing concentrations with height, and has approximately same concentration levels as fine NO3.

Reference for Sea Salt

A constant value over ocean has been selected, loosely based on EMEP global runs and on Na+ verification with EMEP observations.