Geophysical Research Abstracts
Vol. 13, EGU2011-6939, 2011
EGU General Assembly 2011

Sensitivity of radiative forcing to aerosol vertical distribution

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Aerosols in the earth's atmosphere affect the radiation balance of the planet. The radiative forcing (RF) induced by a given aerosol burden depends on the vertical aerosol density profile, aerosol optical properties, cloud distribution, as well as on the surface albedo and height of the land surface. Using a radiative transfer model applied on a high resolution three-dimensional field, we have studied the RF induced by introducing prescribed aerosol concentration at various atmospheric pressure levels. Densities of sulphate (SO4), black carbon (BC) and biomass burning (BIO) aerosols have been prescribed, and we calculate RFs globally and for regions associated with high aerosol content. Meteorological data for the year 2006 was used to give realistic cloud distribution input to the calculations, together with aerosol fields from the Oslo-CTM2 global chemical transport model.

We show that local and global average radiative forcing normalized to aerosol burden (NRF) are highly dependent on both vertical location and cloud conditions. Global NRF for BC for realistic cloud cover ranges from almost zero at sea level to 4000 W/g at the upper troposphere and lower stratosphere, consistent with results from other groups. NRF for SO4, while negative and smaller in magnitude, changes by about 20% in the same altitude range. For BIO the NRF is negative near sea level, but changes sign around 800mb and stays positive above this level in global calculations, but has a substantial regional dependence. For clear-sky conditions we find similar results for BC and SO4, while BIO then yields a negative NRF contribution at all altitudes.