Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 6, 2273-2319, 2006
www.atmos-chem-phys.net/6/2273/2006/

Interactive chemistry in the Laboratoire de Météorologie Dynamique general circulation model: model description and impact analysis of biogenic hydrocarbons on tropospheric chemistry

G. A. Folberth[1,*], D. A. Hauglustaine[1], J. Lathière[1], and F. Brocheton[2]
[1]Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-sur-Yvette, France
[2]Centre National de Recherches Météorologiques (CNRM), Météo France, Toulouse, France
[*]now at: School of Earth and Ocean Science (SEOS), University of Victoria, Victoria, Canada

Abstract. We present a description and evaluation of LMDz-INCA, a global three-dimensional chemistry-climate model, pertaining to its recently developed NMHC version. In this substantially extended version of the model a comprehensive representation of the photochemistry of non-methane hydrocarbons (NMHC) and volatile organic compounds (VOC) from biogenic, anthropogenic, and biomass-burning sources has been included. The tropospheric annual mean methane (9.2 years) and methylchloroform (5.5 years) chemical lifetimes are well within the range of previous modelling studies and are in excellent agreement with estimates established by means of global observations. The model provides a reasonable simulation of the horizontal and vertical distribution and seasonal cycle of CO and key non-methane VOC, such as acetone, methanol, and formaldehyde as compared to observational data from several ground stations and aircraft campaigns. LMDz-INCA in the NMHC version reproduces tropospheric ozone concentrations fairly well throughout most of the troposphere. The model is applied in several sensitivity studies of the biosphere-atmosphere photochemical feedback. The impact of surface emissions of isoprene, acetone, and methanol is studied. These experiments show a substantial impact of isoprene on tropospheric ozone and carbon monoxide concentrations revealing an increase in surface O_3 and CO levels of up to 30 ppbv and 60 ppbv, respectively. Isoprene also appears to significantly impact the global OH distribution resulting in a decrease of the global mean tropospheric OH concentration by approximately 0.7×10^5 molecules cm^{-3} or roughly 8% and an increase in the global mean tropospheric methane lifetime by approximately seven months. A global mean ozone net radiative forcing due to the isoprene induced increase in the tropospheric ozone burden of 0.09 W m^{-2} is found. The key role of isoprene photooxidation in the global tropospheric redistribution of NO_x is demonstrated. LMDz-INCA calculates an increase of PAN surface mixing ratios ranging from 75 to 750 pptv and 10 to 250 pptv during northern hemispheric summer and winter, respectively. Acetone and methanol are found to play a significant role in the upper troposphere/lower stratosphere (UT/LS) budget of peroxy

radicals. Calculations with LMDz-INCA show an increase in HO_x concentrations region of 8 to 15% and 10 to 15% due to methanol and acetone biogenic surface emissions, respectively. The model has been used to estimate the global tropospheric CO budget. A global CO source of 3019 Tg CO yr^{-1} is estimated. This source divides into a primary source of 1533 Tg CO yr^{-1} and secondary source of 1489 Tg CO yr^{-1} deriving from VOC photooxidation. Global VOC-to-CO conversion efficiencies of 90% for methane and between 20 and 45% for individual VOC are calculated by LMDz-INCA.

Final Revised Paper (PDF, 12509 KB) Discussion Paper (ACPD)

Citation: Folberth, G. A., Hauglustaine, D. A., Lathière, J., and Brocheton, F.: Interactive chemistry in the Laboratoire de Météorologie Dynamique general circulation model: model description and impact analysis of biogenic hydrocarbons on tropospheric chemistry, Atmos. Chem. Phys., 6, 2273-2319, 2006. Bibtex EndNote Reference Manager