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Analysis of column-averaged carbon dioxide and methane concentrations simulated by NIES TM

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We performed multi-annual simulations of CO_2 and CH_4 using the National Institute for Environmental Studies (NIES) three-dimensional offline chemical transport model (version NIES-08.1i), driven by JRA-25/JCDAS reanalysis data. This version uses a flexible hybrid sigma–isentropic (σ–θ) vertical coordinate consisting of terrain-following and isentropic levels switched smoothly near the tropopause. Vertical transport in the isentropic part of the grid in the stratosphere was controlled by an air-ascending rate derived from the effective heating rate from JRA-25/JCDAS reanalysis, and was adjusted to fit the observed age of air in the stratosphere.

The model was validated against balloon-borne observations in the stratosphere, aircraft observations in the free-troposphere and continuous surface measurements at GLOBALVIEW sites.

Convolved with scene-dependent instrument averaging kernels, dry-air column-averaged mole fractions of CO_2 (XCO_2) and CH_4 (XCH_4) were calculated from NIES TM tracer distributions and were compared with measurements acquired at the Total Carbon Column Observing Network (TCCON) ground-based high-resolution Fourier Transform Spectrometer (FTS) sites (Bialystok, Bremen, Darwin, Garmisch, Izaña, Lamont, Lauder, Orleans, Park Falls, Sodankylä, Tsukuba, and Wollongong) for the period from January 2009 to January 2011. The model was able to reproduce the seasonal and inter-annual variability of XCO_2 and XCH_4 with correlation coefficients of 0.8–0.9 and 0.4–0.8, respectively. A comparison of modeled data and TCCON observations revealed that the model biases are generally in the range of $\pm 0.2\%$ for XCO_2 and $\pm 0.5\%$ for XCH_4 excluding Sodankylä, where strong biases are found. Thus, the performance of the current model version is sufficient for use in evaluating satellite retrieval algorithms in areas not covered by ground-based FTS sites.