MIROC4.0 based atmospheric chemistry-transport model (MIROC4-ACTM): Improved dynamical features for greenhouse gases modelling

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The major greenhouse gases with anthropogenic sources, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have long atmospheric residence time of about 100, 10 and 120 years, respectively, once emitted from the Earth's surface. Thus atmospheric transport plays an important role for their concentration distributions in troposphere, stratosphere and above. The concentration simulations by Atmospheric chemistry-transport models (ACTMs) of these greenhouse gases heavily rely upon the quality of model transport in the whole atmosphere. Here we show that the Model for Interdisciplinary Research On Climate Earth System Model (MIROC, version 4.0)-based ACTM simulates the ‘age of air’ as a diagnostic for atmospheric transport in good agreement with those expected from the measured sulphur hexafluoride (SF_6) and CO_2 in troposphere and stratosphere, respectively. The MIROC-ACTM follows hybrid coordinate system in vertical (terrain following pressure-sigma in the altitudes near the Earth’s surface and gradually changing to pressure in the stratosphere).

The MIROC4-ACTM produces “age-of-air” up to about 5 years in the tropical upper stratosphere (at about 1 hPa) and 6 years in the polar middle stratosphere (at about 10 hPa). Our comparisons of MIROC4-ACTM with the simulations using pure sigma-pressure vertical coordinate (AGCM5.7b-ACTM) suggest that the former is characterized by slower convective transport in the troposphere and much lesser meridional diffusive transport in the stratosphere. The MIROC4-ACTM simulations produce better agreement with SF_6 observations at the surface sites and aircraft campaigns (e.g., HIPPO), compared to those using the ACGM5.7b-ACTM.

The MIROC4-ACTM is being developed for inverse modelling of long-lived gases for reducing bias in estimated emissions caused by uncertainties in model transport. These advancement in MIROC4-ACTM system also produces key improvements that are required for ingesting columnar CO_2 and CH_4 measurements from Greenhouse gases observing satellite (GOSAT) and other remote sensing instruments in an inverse modelling system. The stratospheric transport was not a cause of major concerns for utilizing in situ observations from the tropospheric altitudes in inversion systems, which however is not the case for columnar data.

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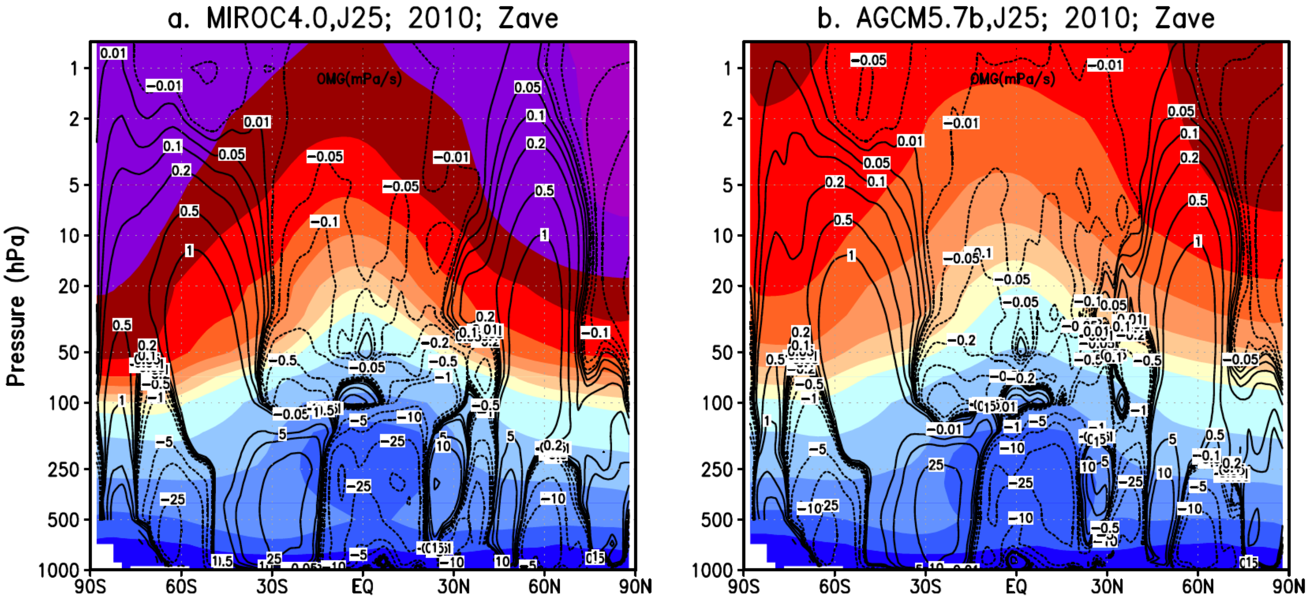
Keywords: Greenhouse gases modelling, Interhemispheric transport, Stratosphere-troposphere exchange


a. MIROC4.0,J25; 2010; Zave
b. AGCM5.7b,J25; 2010; Zave
OMG(mPa/s)
Pressure (hPa)
1
2
5
10
20
50
100
250
500
1000
90S
60S
30S
EQ
30N
60N
90N