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Mass-conserving tracer transport modelling on a reduced latitude-longitude grid with NIES-TM

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Abstract. The need to perform long-term simulations with reasonable accuracy has led to the development of mass-conservative and efficient numerical methods for solving the transport equation in forward and inverse models. We designed and implemented a flux-form (Eulerian) tracer transport algorithm in the National Institute for Environmental Studies Transport Model (NIES TM), which is used for simulating diurnal and synoptic-scale variations of tropospheric long-lived constituents, as well as their seasonal and inter-annual variability. Implementation of the flux-form method requires the mass conservative wind fields. However, the model is off-line and is driven by datasets from a global atmospheric model or data assimilation system, in which vertically integrated mass changes are not in balance with the surface pressure tendency and mass conservation is not achieved. To rectify the mass-imbalance, a flux-correction method is employed. To avoid a singularity near the poles, caused by the small grid size arising from the meridional convergence problem, the proposed model uses a reduced latitude–longitude grid scheme, in which the grid size is doubled several times approaching the poles. This approach overcomes the Courant condition in the Polar Regions, maintains a reasonably high integration time-step, and ensures adequate model performance during simulations. To assess the model performance, we performed global transport simulations for SF_6, ^{222}Rn, and CO_2. The results were compared with observations available from the World Data Centre for Greenhouse Gases, GLOBALVIEW, and the Hateruma monitoring station, Japan. Overall, the results show that the proposed flux-form version of NIES TM can produce tropospheric tracer transport more realistically than previously possible. The reasons for this improvement are discussed.

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