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GEM-AQ, an on-line global multiscale chemical weather modelling system: model description and evaluation of gas phase chemistry processes

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Abstract. Tropospheric chemistry and air quality processes were implemented on-line in the Global Environmental Multiscale weather prediction model. The integrated model, GEM-AQ, was developed as a platform to investigate chemical weather at scales from global to urban. The current chemical mechanism is comprised of 50 gas-phase species, 116 chemical and 19 photolysis reactions, and is complemented by a sectional aerosol module with 5 aerosols types. All tracers are advected using the semi-Lagrangian scheme native to GEM. The vertical transport includes parameterized subgrid-scale turbulence and large scale deep convection. Dry deposition is included as a flux boundary condition in the vertical diffusion equation. Wet deposition of gas-phase species is treated in a simplified way, and only below-cloud scavenging is considered. The emissions used include yearly-averaged anthropogenic, and monthly-averaged biogenic, ocean, soil, and biomass burning emission fluxes, as well as NO_x from lightning. In order to evaluate the ability to simulate seasonal variations and regional distributions of trace gases such as ozone, nitrogen dioxide and carbon monoxide, the model was run for a period of five years (2001–2005) on a global uniform 1.5°×1.5° horizontal resolution domain and 28 hybrid levels extending up to 10 hPa. Model results were compared with observations from satellites, aircraft measurement campaigns and balloon sondes. We find that GEM-AQ is able to capture the spatial details of the chemical fields in the middle and lower troposphere. The modelled ozone consistently shows good agreement with observations, except over tropical oceans. The comparison of carbon monoxide and nitrogen dioxide with satellite measurements emphasizes the need for more accurate, year-specific emissions fluxes for biomass burning and anthropogenic sources. Other species also compare well with available observations.

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