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Data assimilation of satellite retrieved ozone, carbon monoxide and nitrogen dioxide with ECMWF's Composition-IFS

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Daily global analyses and 5-day forecasts are generated in the context of the European Monitoring Atmospheric Composition and Climate (MACC) project using an extended version of the Integrated Forecasting System (IFS) of the European Centre for Medium Range Weather Forecasts (ECMWF). IFS now includes modules for chemistry, deposition and emission of reactive gases, aerosols, and greenhouse gases, and the 4-dimensional variational data assimilation scheme makes use of multiple satellite observations of atmospheric composition in addition to meteorological observations. This paper describes the data assimilation setup of the new Composition-IFS (C-IFS) with respect to reactive gases and validates analysis fields of ozone (O_3), carbon monoxide (CO), and nitrogen dioxide (NO_2) for the year 2008 against independent observations and a control run without data assimilation. The largest improvement in CO by assimilation of MOPITT CO columns is seen in the lower troposphere of the Northern Hemisphere (NH) Extratropics during winter, and during the South African biomass burning season. The assimilation of several O_3 total column and stratospheric profile retrievals greatly improves the total column, stratospheric and upper tropospheric O_3 analysis fields relative to the control run. The impact on lower tropospheric ozone, which comes from the residual of the total column and stratospheric profile O_3 data, is smaller, but nevertheless there is some improvement particularly in the NH during winter and spring. The impact of the assimilation of OMI tropospheric NO_2 columns is small because of the short lifetime of NO_2, suggesting that NO_2 observations would be better used to adjust emissions instead of initial conditions. The results further indicate that the quality of the tropospheric analyses and of the stratospheric ozone analysis obtained with the C-IFS system has improved compared to the previous 'coupled' model system of MACC.