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Minimizing the wintertime low bias of Northern Hemisphere carbon monoxide in global model simulations

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Carbon monoxide (CO) is a product of incomplete combustion and is also produced from oxidation of volatile organic compounds (VOC) in the atmosphere. It is of interest as an indirect greenhouse gas and an air pollutant causing health effects and is thus subject to emission restrictions. CO acts as a major sink for the OH radical and as a precursor for tropospheric ozone and affects the oxidizing capacity of the atmosphere as well as regional air quality. Despite the developments in the global modelling of chemistry and of the parameterization of the physical processes, CO concentrations remain underestimated during NH winter by most state-of-the-art chemical transport models. The resulting model bias can in principle originate from either an underestimation of CO sources or an overestimation of its sinks. We address both the role of sources and sinks with a series of MOZART chemistry transport model sensitivity simulations for the year 2008 and compare our results to observational data from ground-based stations, satellite observations, and from MOZAIC tropospheric profile measurements on passenger aircraft.

Our base case simulation using the MACCity emission inventory (Granier et al. 2011) underestimates the near-surface Northern Hemispheric CO mixing ratios by more than 20 ppb from December to April with a maximal bias of 40 ppb in January. The bias is strongest for the European region (up to 75 ppb in January). From our sensitivity studies the mismatch between observed and modelled atmospheric CO concentrations can be explained by a combination of the following emission inventory shortcuts: (i) missing anthropogenic wintertime CO emissions from traffic or other combustion processes, (ii) missing anthropogenic VOC emissions, (iii) an exaggerated downward trend in the RCP8.5 scenario underlying the MACCity inventory, (iv) a lack of knowledge about the seasonality of emissions. Deficiencies in the parameterization of the dry deposition velocities can also lead to underestimations of Northern Hemisphere wintertime CO concentrations which are in the same order than those from the current emission inventories. A methane lifetime of 9.7 yr for our basic model and 9.8 yr for the optimized simulation agrees well with current estimates of global OH, but we cannot fully exclude a potential effect from errors in the geographical and seasonal distribution of OH concentrations on the modelled CO.

References:
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