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Trends in ozone concentration caused by emissions from fossil fuel combustion and natural sources

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Ozone is the third most important greenhouse gas perturbed by human activity, next to carbon dioxide (CO2) and methane (CH4). Ozone is produced due to photochemical reaction of NOx in a rapid photochemical equilibrium. Enhanced NOx (=NO+NO2) emissions from anthropogenic sources in general lead to enhanced tropospheric ozone production.
In this study transient simulations with a fully coupled chemistry-climate model ECHAM4/CHEM for the period 1960-2020 are analysed to determine trends in ozone changes and to identify individual contributions from major sources, e.g. fossil fuel burning, soil emissions.
These transient simulations comprise external influences on dynamics and chemistry from sea-surface temperatures, greenhouse gases, anthropogenic and natural emissions, Quasi-Biennial-Oscillations, volcanoes, solar cycle, and CFCs.
In the presented study NOx and ozone contributions are calculated by tagging of NOy (Grewe et al., 2004) allowing to efficiently determine individual contributions to the overall ozone development within one single simulation. Temporal development of ozone concentrations and its precursors will be presented. Regional trends will be presented in order to emphasize effects of non-linear chemistry in regions with different economic characteristics.
Due to the fact that there is an upward trend in ozone precursor NOx originating from different sources simulations show a strong increasing trend in tropospheric ozone abundance. In particular industry and air traffic emissions have shown a rapid increase in NOx emission since 1960 and an ongoing increase in the next decades is projected. Hence, further ozone increase in the troposphere is expected.
By contrast the ozone amount in the stratosphere has decreased from 1970 to 2000 due to emission of CFCs. Our model simulations include this development, allowing to assess the competition and compensation of the tropospheric and stratospheric impact on tropospheric ozone at times of contradicting contributions from these two spheres.
In order to explain observed trends in ozone changes ozone production efficiency is assessed in order to investigate non-linear ozone production in different regions and levels. Additionally radiative forcing from individual Nox emission sources was calculated and will be presented, which allows further insight into the climatological relevance of the various sources.