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Drivers of the tropospheric ozone budget throughout the 21st century in CCMI-1 simulations

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What we did: We analysed tropospheric ozone in SOCOL CCMI simulations from 1960-2100 with evolving (REF-C2) and fixed (SEN-C2-fEmis) ozone precursor emissions. We performed a further non-CCMI simulation which was identical to SEN-C2-fEmis but with CH_4 concentrations held at constant 1960 levels (fCH_4).

Why we did it: Tropospheric ozone is an air pollutant and greenhouse gas. Its future evolution will be influenced by numerous factors including emissions of ozone precursor gases (nitrogen oxides (NO_x=NO+NO_2), CO, CH_4 and non-methane volatile organic compounds (NMVOCs)), as well as climate change and long-range ozone transport within the troposphere.

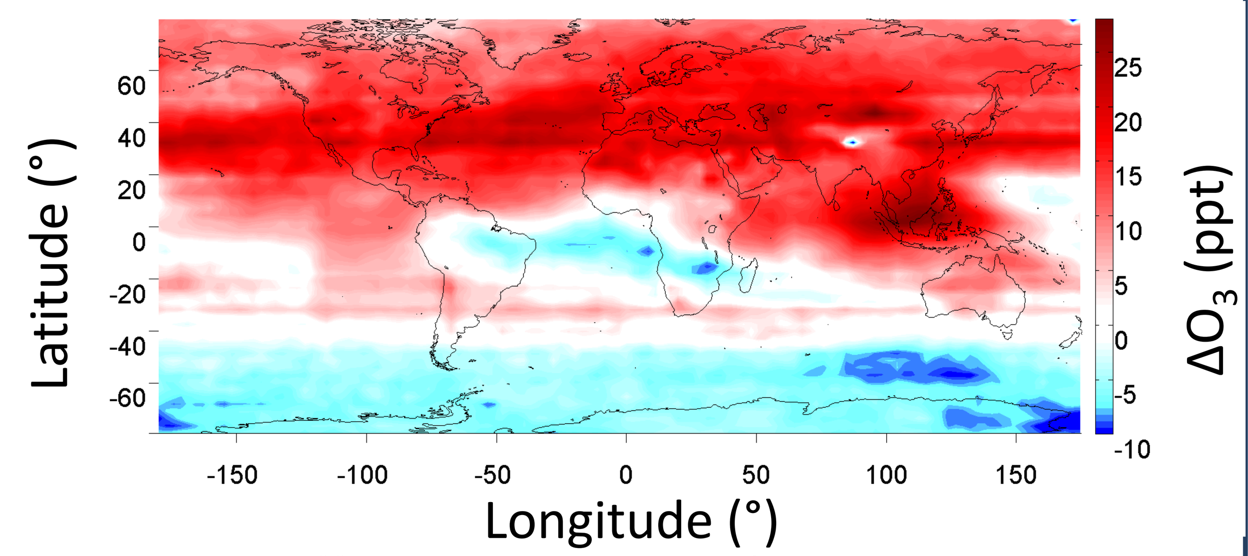

Figure 1: Difference in tropospheric ozone at 500 hPa between SOCOL and observations from TES (SOCOL minus TES).

What do we see? – SOCOL compared with observations and other CCMs:

- SOCOL simulates more Northern Hemisphere tropospheric ozone than indicated by observations (Figure 1) – may be partially related to ozone precursor emissions.
- Because of this positive tropospheric ozone bias, SOCOL simulates decreases in global-mean total column ozone through the second half of the 21st century in the REF-C2 simulation, which is not seen in other CCMs (Figure 2). Decreases in total ozone are caused by decreases in tropospheric, rather than stratospheric ozone (Figure 3a-b).

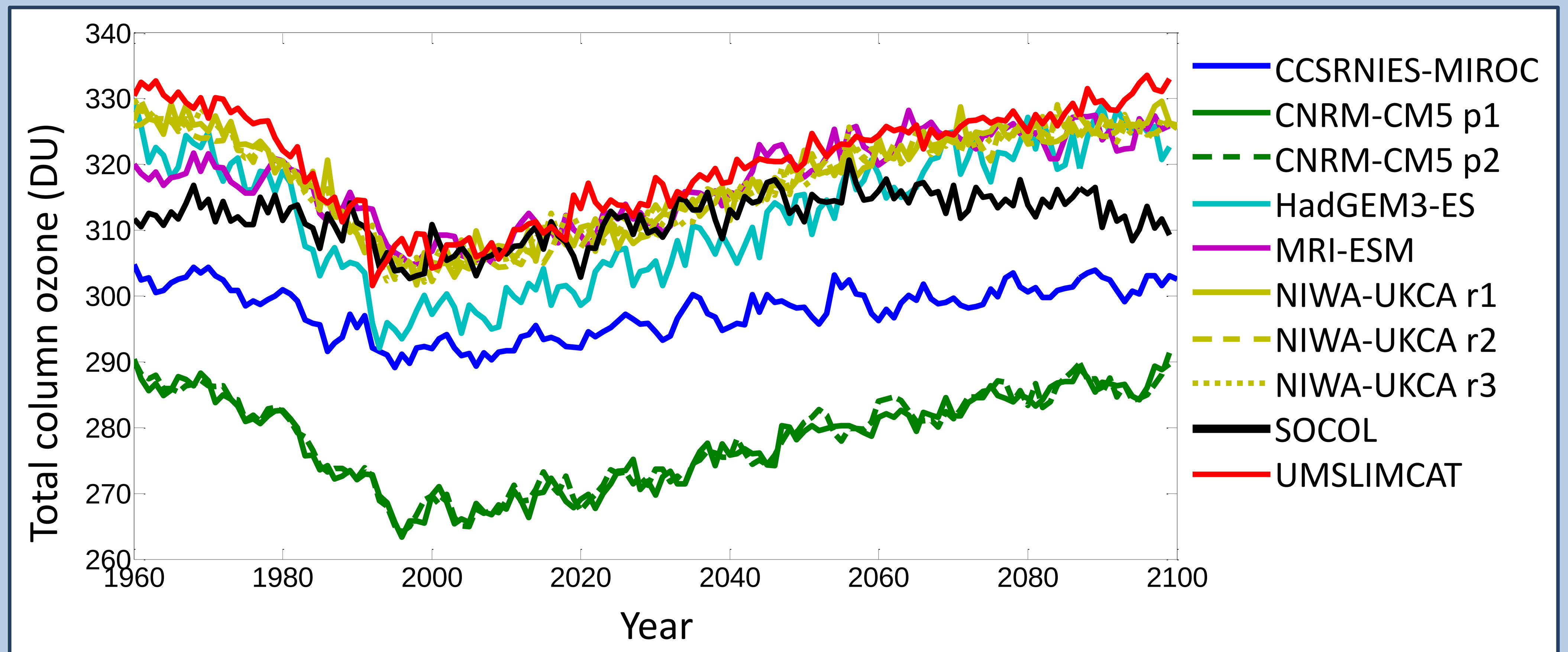

Figure 2: Global-mean total column ozone in CCMI REF-C2 simulations.

What do we see? – Tropospheric ozone projections

- At northern midlatitudes in the REF-C2 simulation, we see a 70-year period between 1990-2060 during which ozone abundances are constantly elevated (Figure 3b) despite reductions in NO_x, NMVOCs and CO in the early 21st century (Figure 3c-d).
- Reductions in NO_x, NMVOCs and CO in the early 21st century are mostly centered over Europe and North America, and here local reductions in ozone are observed (Figure 4). However, large increases in precursor gas emissions from Asia, combined with ozone's ability to be transported on inter-continental scales within the troposphere, lead to constantly elevated ozone abundances at the hemispheric level (Figure 3b).

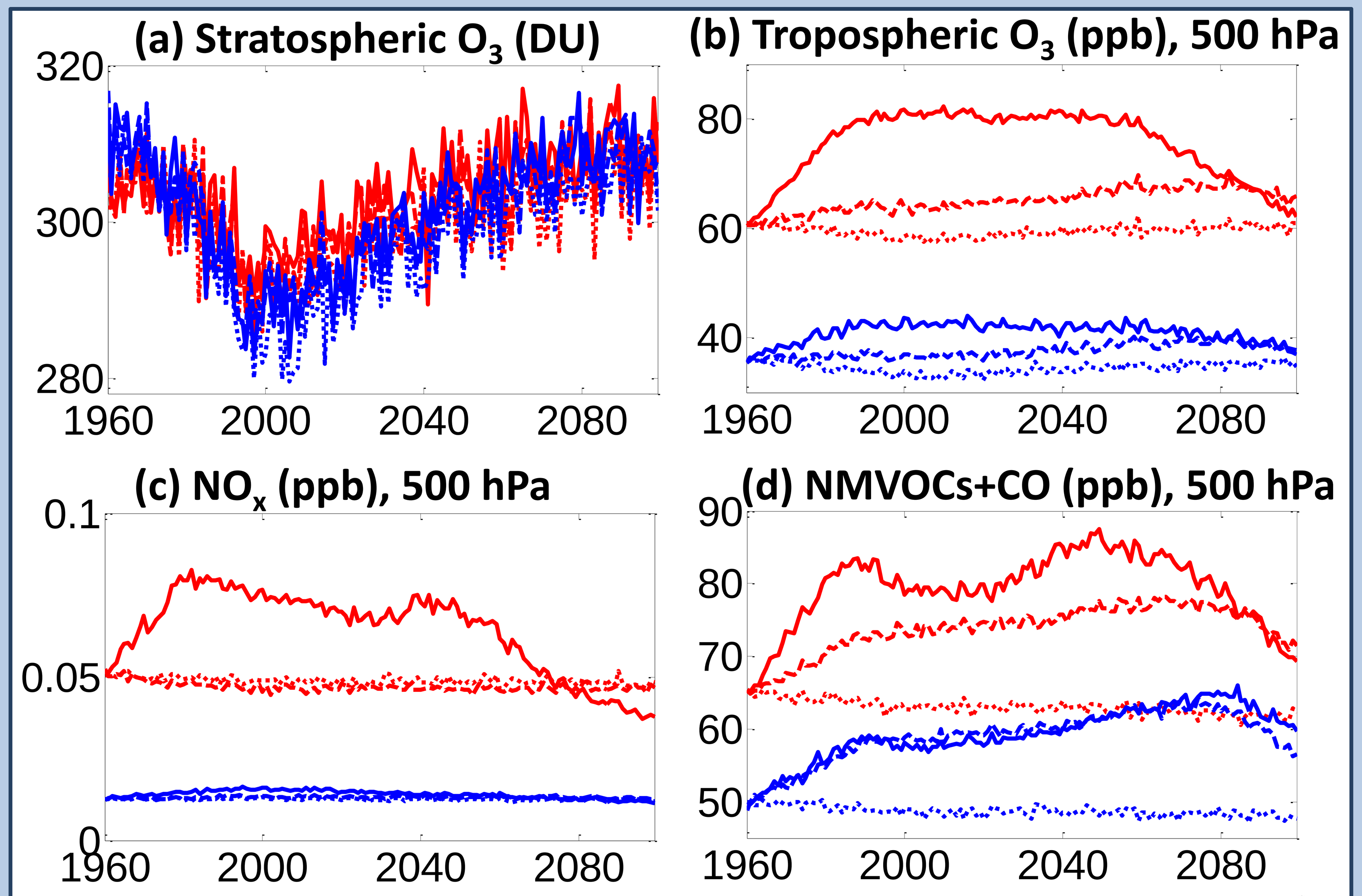

Figure 3. Evolution of chemical species in SOCOL.

- Tropospheric ozone increases between 1960-2100 in the fEmis simulation (Figure 3a), despite constant emissions of ozone precursor gases (Figure 3c-d). This is because CH_4 concentrations were not held constant in the fEmis simulation. Ozone remains at constant 1960 levels in the fCH_4 simulation (Figure 3b).
- Controlling CH_4 emissions is more effective in controlling NMVOC+CO concentrations in the troposphere, than controlling NMVOC+CO emissions themselves (Figure 3d).

Key messages:

- Anthropogenic NO_x emissions have the largest influence on tropospheric ozone in our simulations (which are based on a single climate scenario, RCP 6.0). CH_4 has the second largest influence, which is approximately one-third that of anthropogenic NO_x emissions.
- CH_4 concentrations must be held constant to properly examine the effects of precursor gases on tropospheric ozone, however this is not prescribed for the CCMI SEN-C2-fEmis simulation as we are interested in CH_4's climate impact.
- Changing regional emissions patterns influence the hemispheric signal in tropospheric ozone, therefore global air pollution policies have a significant role to play in determining the evolution and distribution of tropospheric ozone through the 21st century.

See also: Revell *et al.* [2015], ACP, 15, 5887–5902, doi:10.5194/acp-15-5887-2015.

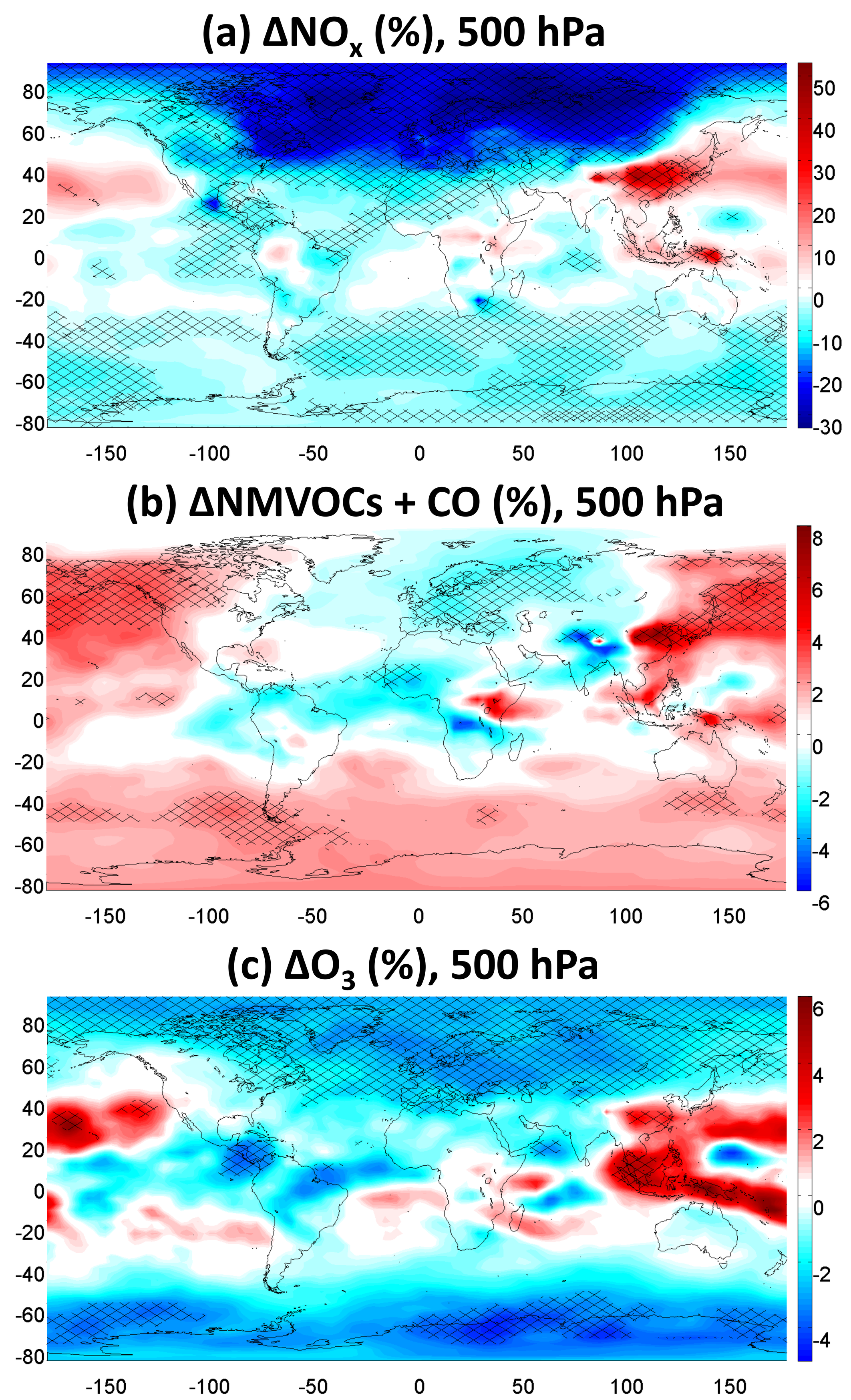

Figure 4: Change in ozone and its precursors between the 2000s and 2020s decades (2020s minus 2000s) in SOCOL's REF-C2 simulation.