Die Entwicklung der Ozonschicht im Klimawandel

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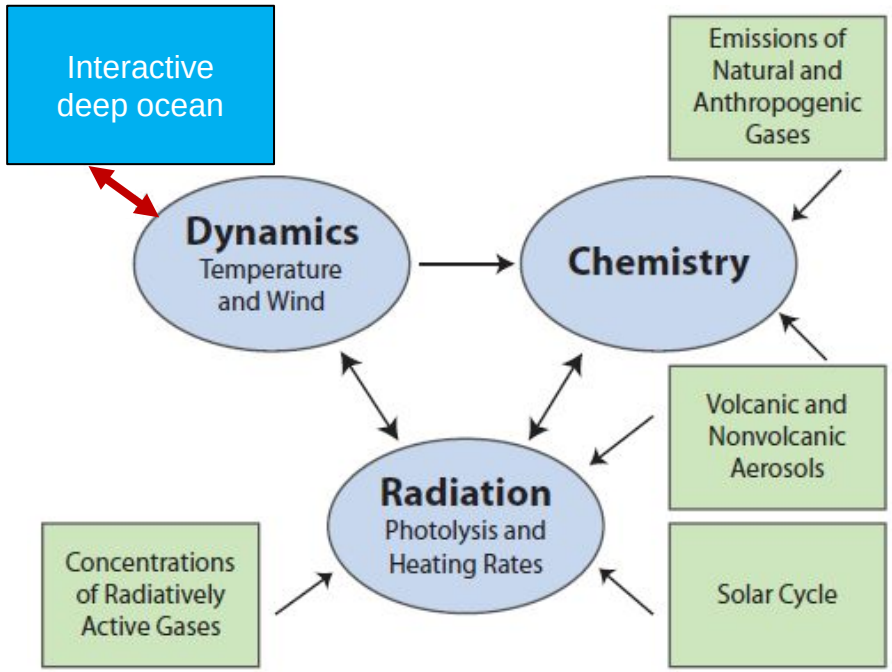
The Chemistry-Climate Model EMAC

European Centre for Medium-Range Weather Forecasts - Hamburg (ECHAM) / Modular Earth Submodel System (MESSy) Atmospheric Chemistry (**EMAC**) model

- is based on ECHAM 5,
- using a full set of stratospheric and tropospheric chemistry;
- resolution: T42/L90 (T42: 2.8° x 2.8°, L90: 0-80 km).

(Detailed description: Jöckel et al., 2016.)



Strategy for CCM simulations

Three types of numerical model simulations covering the middle atmosphere and troposphere have been defined, as recommended by the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI):

(1) A hindcast simulation with specified dynamics, i.e. nudged to observed meteorology from 1979 to 2013 (referred to REF-C1SD),

(2) a free-running hindcast simulation representing the past (from 1950 to 2013; referred to REF-C1), and

(3) a combined hindcast and forecast simulation (from 1950 until 2100; referred to REF-C2 either with fixed ocean temperature (SST and SIC) and with an interactively coupled ocean).

For the EMAC REF-C1SD simulation,

- forcing: 6 hourly ERA-Interim with vertically varying relaxation time constants,
- the middle and upper stratosphere (>30 km) and mesosphere is free running.

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Scientific challenges, questions and tasks regarding stratospheric ozone

- Detection of ozone return/recovery in the next 5 to 10 years due to the regulation of CFCs. It has to be investigated if the recovery of ozone in the upper stratosphere is consistent with our expectations based on Cl_y, temperature, and other factors.
- Prediction of the future evolution of the stratospheric ozone layer in a changing climate, determining the dependence of ozone recovery in space (latitude and altitude) and time, especially investigating the evolution of the ozone layer in polar regions (ozone hole) as well as in the tropics.
- How will ozone concentrations develop depending on the assumed climate scenarios (RCPs: Representative Concentration Pathways), e.g. detecting higher stratospheric ozone values (‘super-recovery’) as an indicator of climate change?

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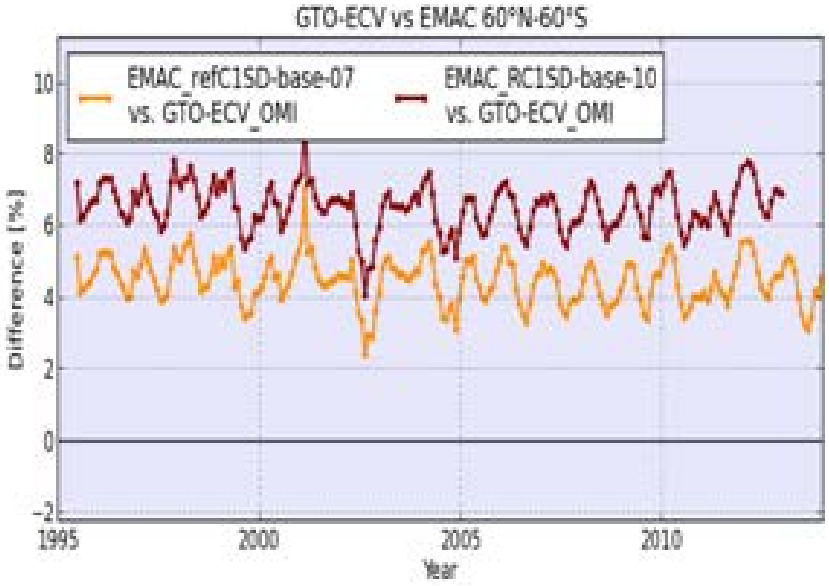
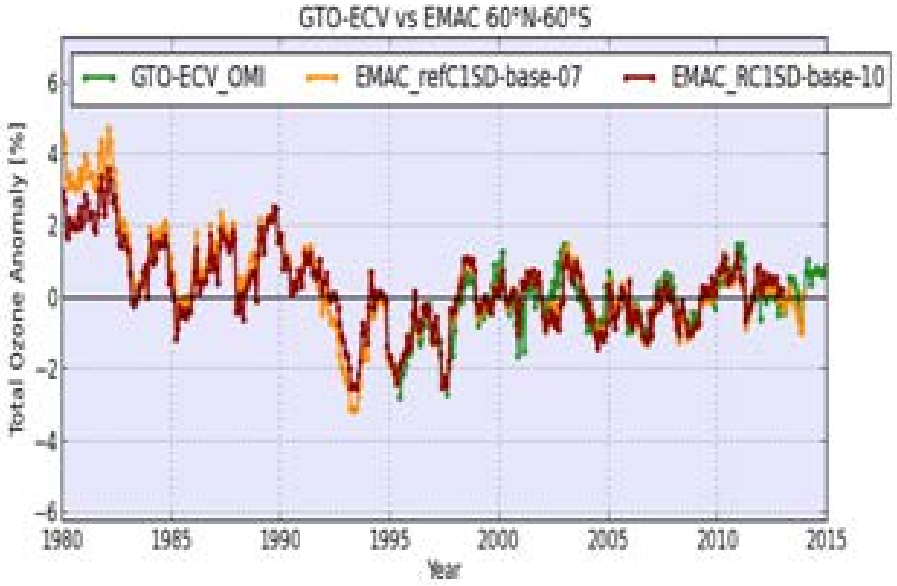
Ozone anomalies (1995-2013): 60°S-60°N

Comparison of satellite-instrument- and model (EMAC) data





Near global mean:

ESA Ozone-cci data set (since 1995) compared with two different RC1SD simulations (red/orange: without/with nudging of the mean temperature)

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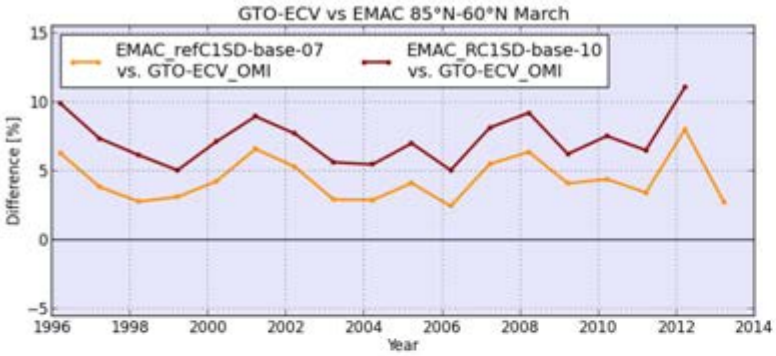
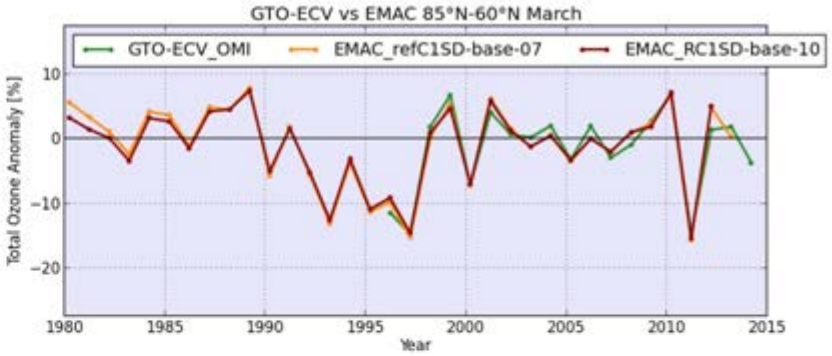
Ozone anomalies (1995-2013): polar regions, spring

Comparison of satellite-instrument- and model (EMAC) data





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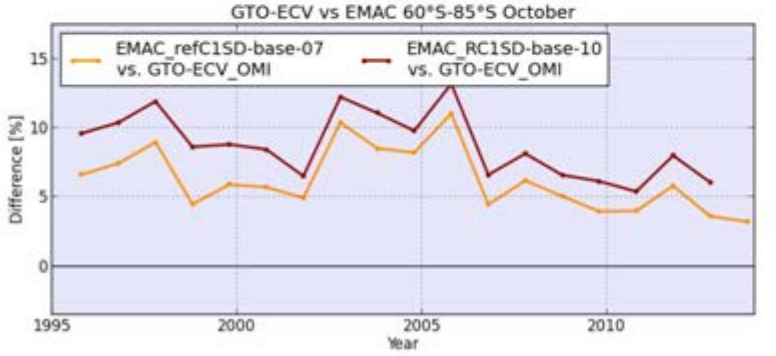

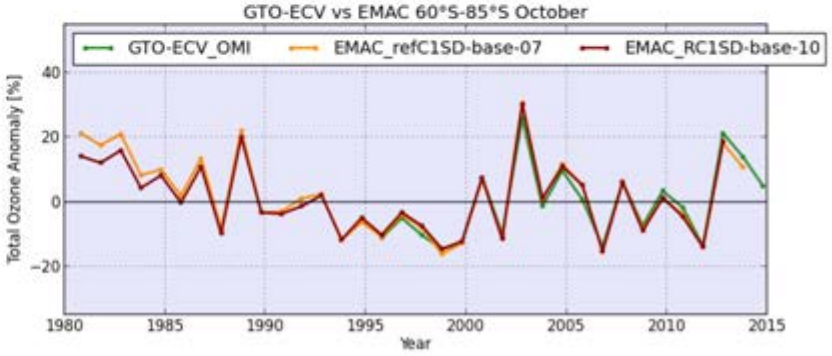

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Ozone anomalies (1960-2100): polar regions

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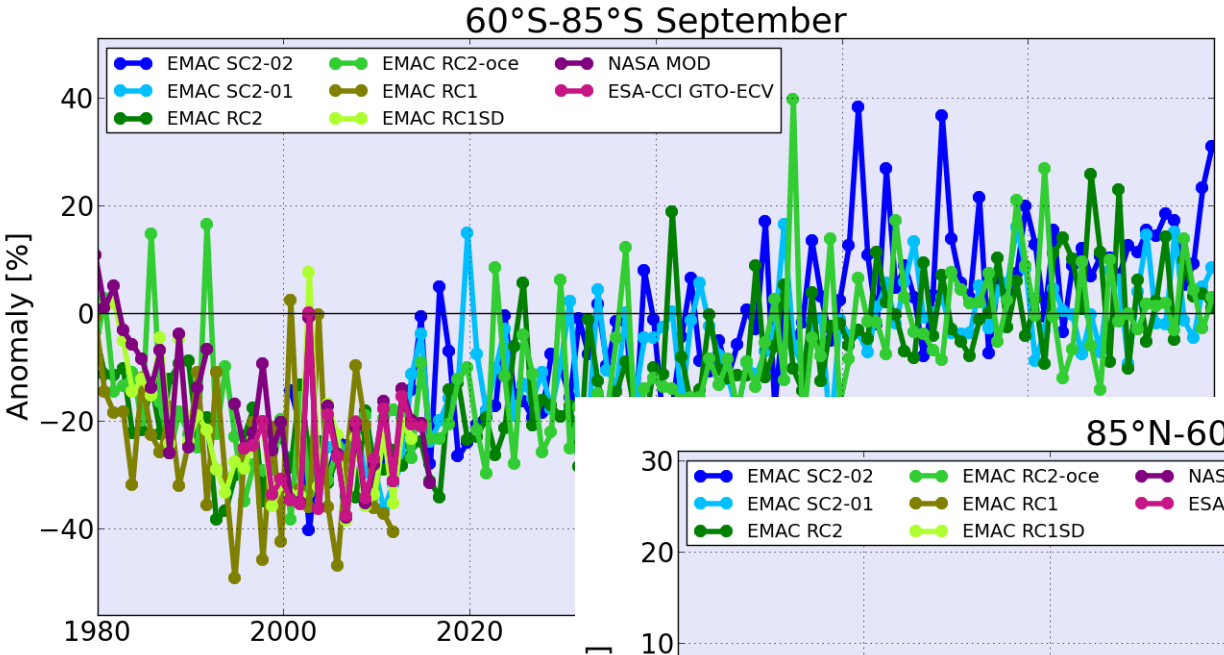
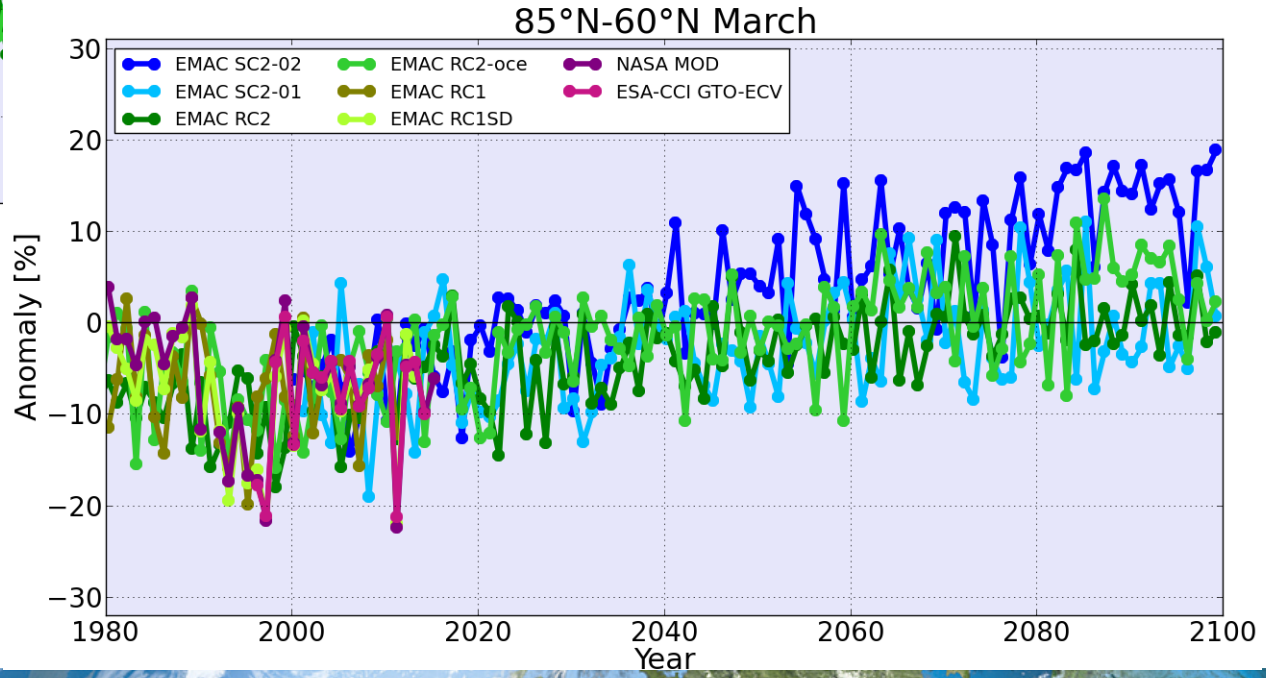


RCP 8.5

all

RCP 6.0



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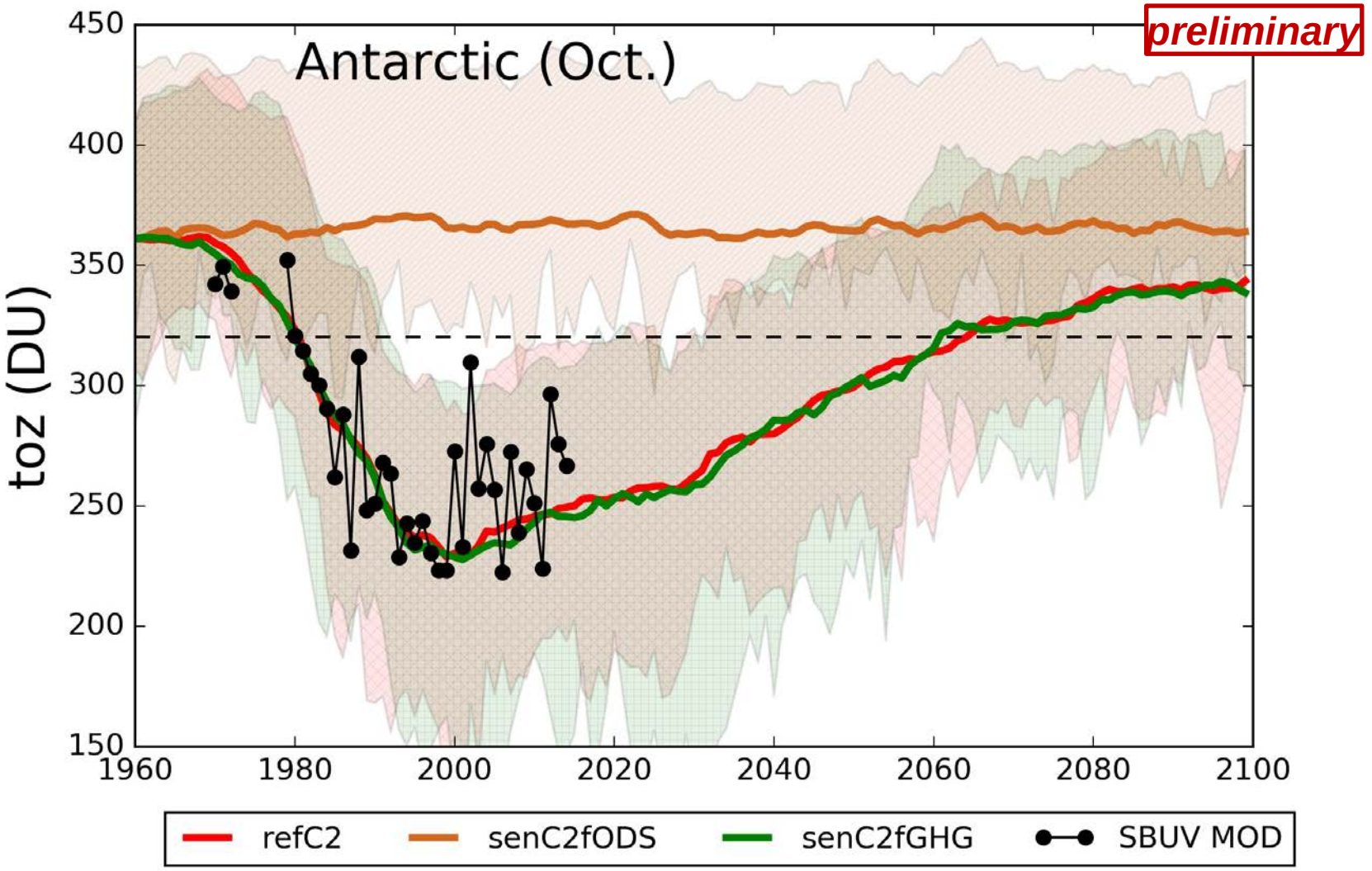
Ozone anomalies (1960-2100): polar regions

Comparison with satellite data and model (MMM) prediction



Dohmse et al., 2018

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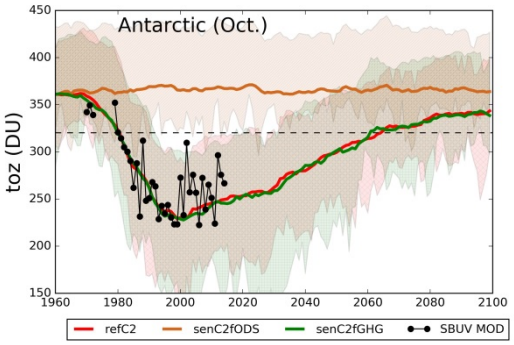

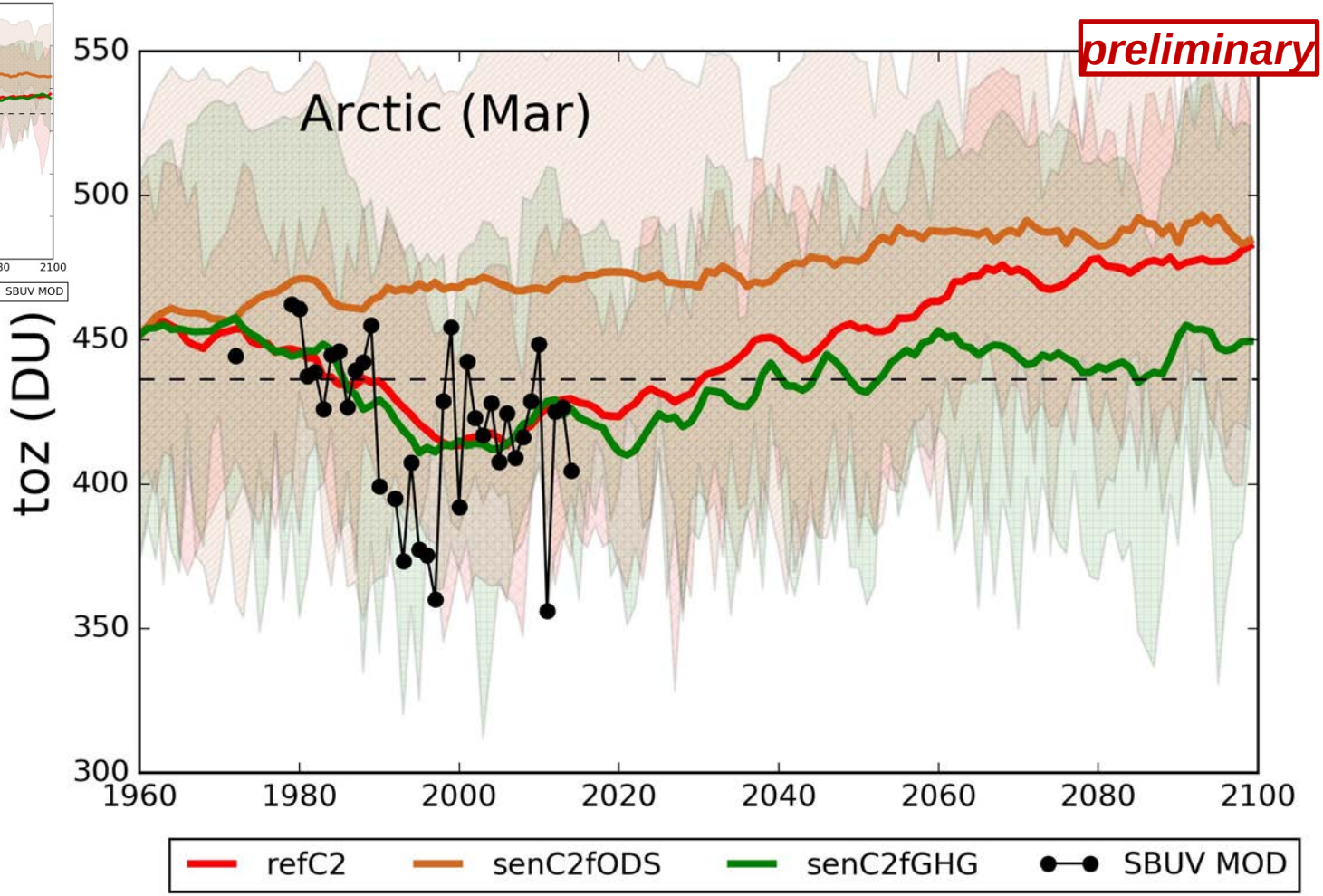

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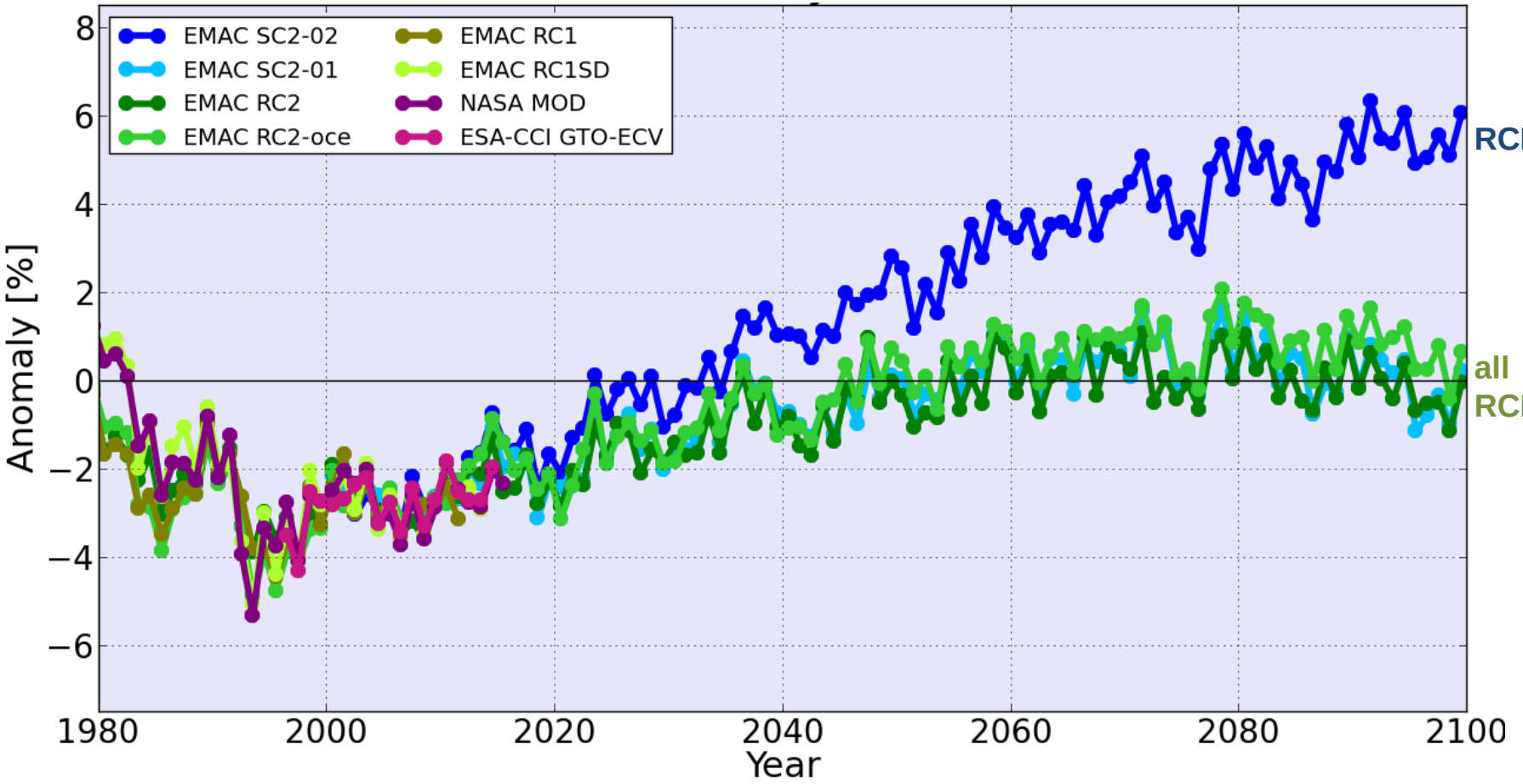

update of Jöckel et al., 2016

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Ozone anomalies (1960-2100): 20°S-20°N

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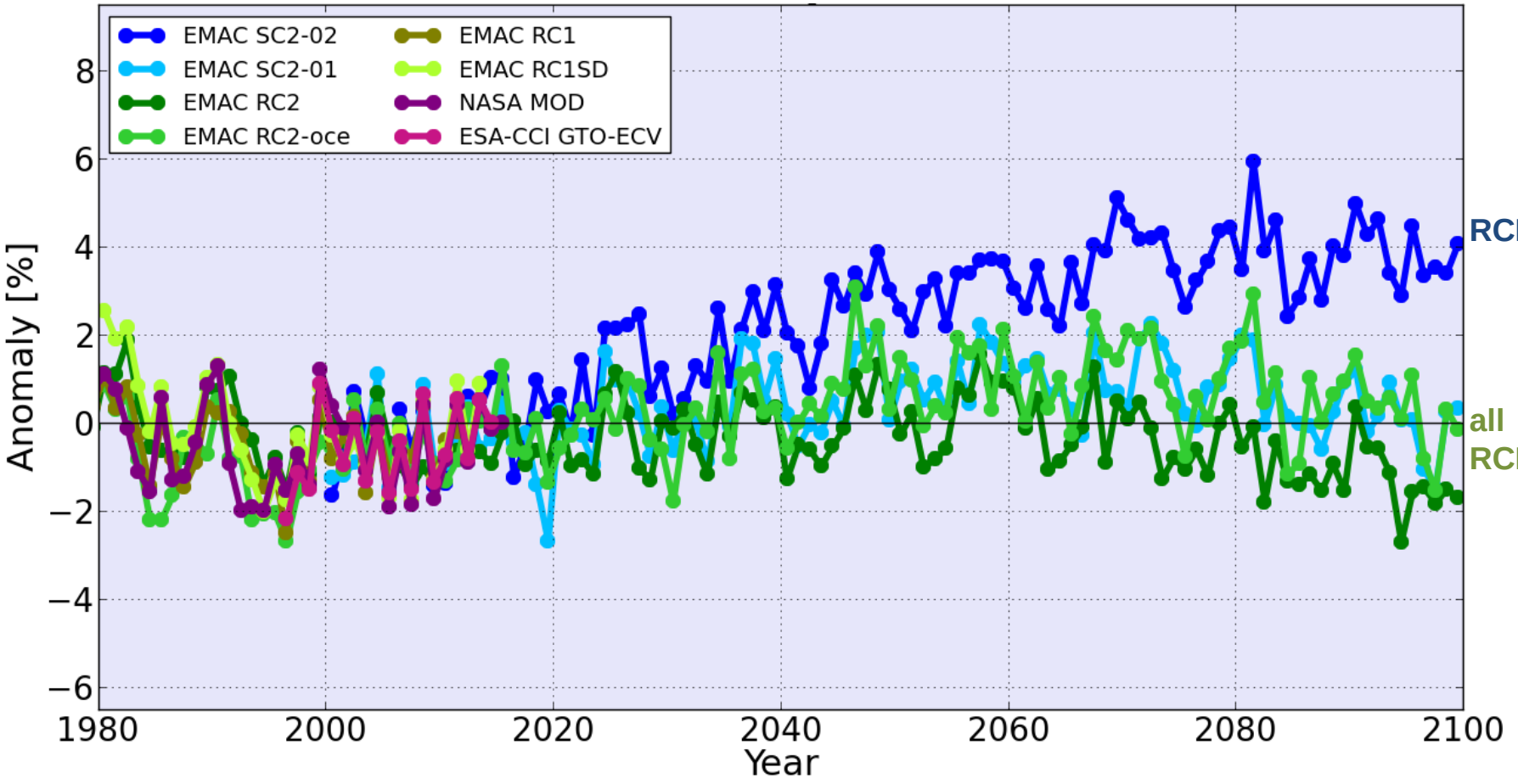

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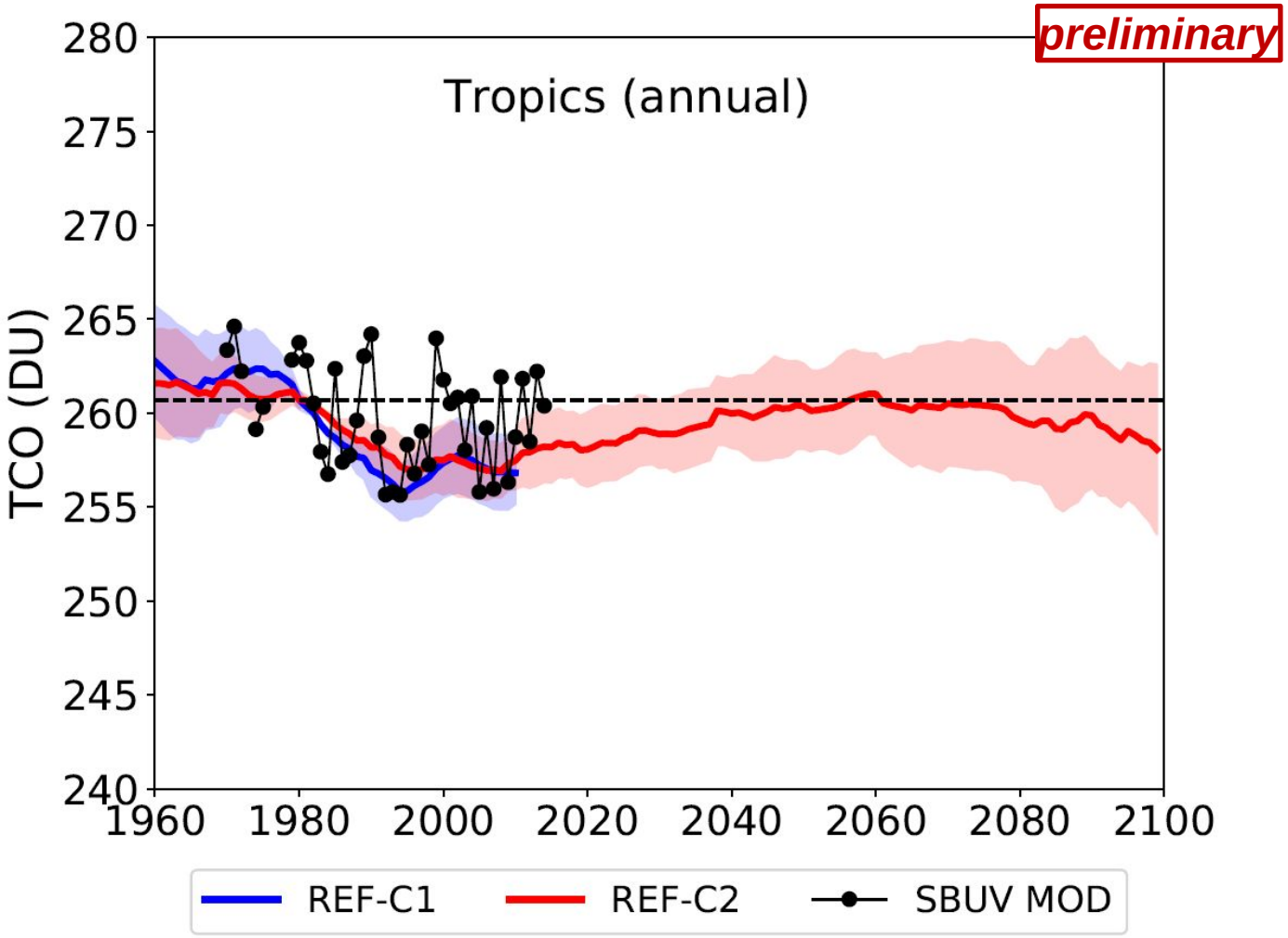
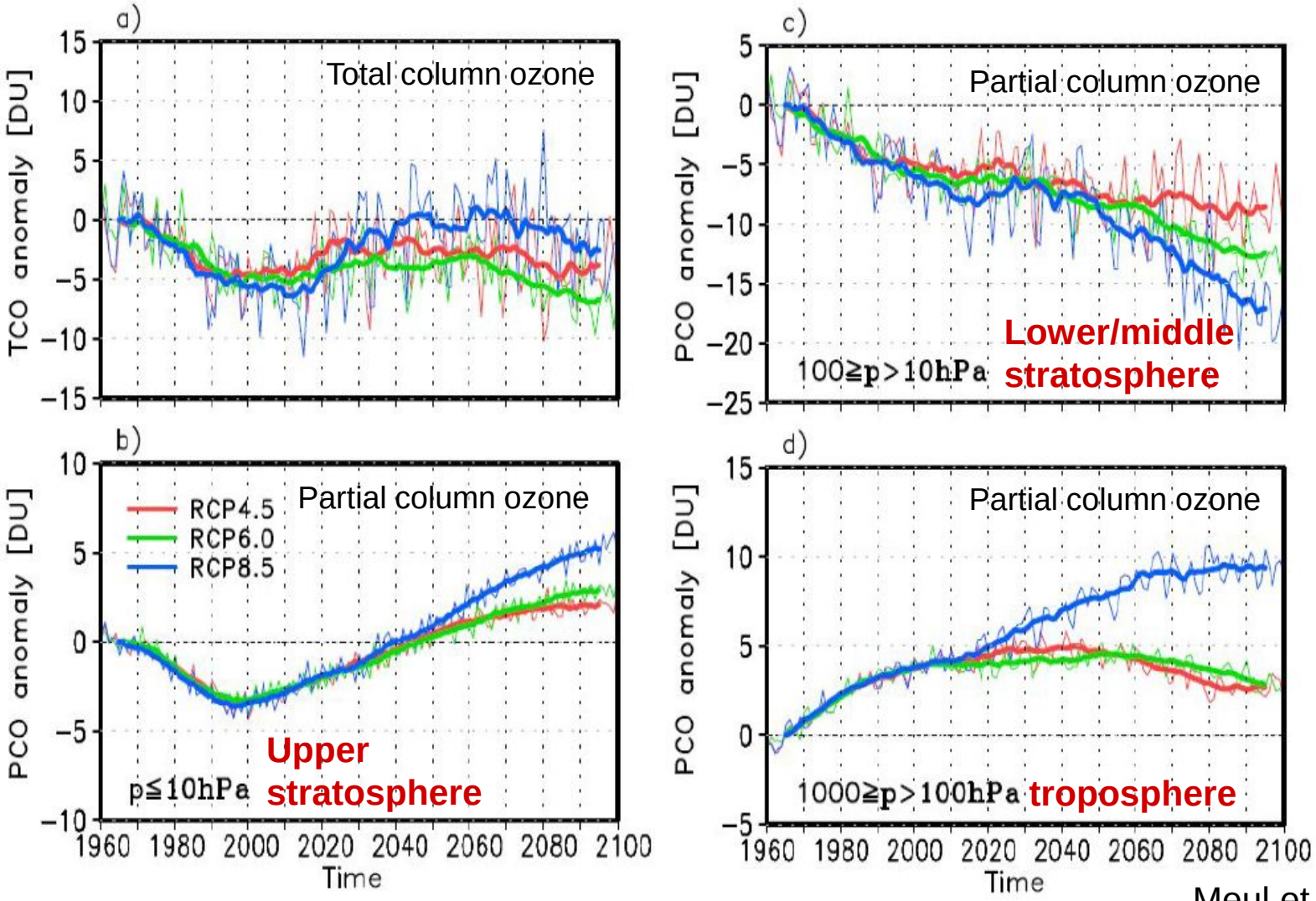


Dohmse et al., 2018

Evolution of the tropical stratospheric ozone layer



Meul et al., 2016

Concluding remarks

Stratospheric ozone

- Regional differences with respect to the timing of full recovery
- Strong impact of climate change, in particular changes of atmospheric circulation and temperature
- Important changes are expected in the tropics (surface UV)