Updating SD-WACCM’s De-NOY Parameterization Improves Simulation of Arctic Ozone Loss Under Extreme Conditions

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With Thanks to Collaborators:
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Motivation: The Extreme Arctic Spring of 2020

- Observations from balloons and satellites of the Arctic 2020 spring saw lowest mixing ratios ever in the heart of the depletion accompanied by extensive denitrification (Manney et al., 2020; Wohltmann et al., 2020; Inness et al., 2020; others)

- Mainly due to a cold, stable polar vortex which allowed the formation of more PSCs than usual and persisted into the spring
Our “World Avoided” Scenario

- We simulate both the real world (RW) using SD-WACCM4 nudged to MERRA2’s meteorological fields and an even more extreme “World Avoided” (WA) without the Montreal Protocol.

- Increase anthropogenic ODS’s at uniform 3.5% per year from 1985 onward in the model except CH$_3$Br which is assumed to be half natural half anthropogenic.

Wilka et al., in review
Accurate Denitrification is Important

• Initially, the TCO depletion and ozone profiles in the RW run weren’t depleting as much as observations

• Reactive nitrogen will bond with chlorine and convert active chlorine back to reservoir form, thus short-circuiting the catalytic ozone depletion cycles

• SD-WACCM wasn’t denitrifying enough early on compared to MLS, and HNO₃ recovered faster in the model than in observations
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No Arctic Ozone Hole in the Real World

- Our RW run compares well with OMI for Total Column measurements
- We don’t find any contiguous area below 220 DU in WACCM, although the higher-resolution satellite finds a few small spots

Wilka et al., in review
A 2020 Arctic Ozone Hole in the World Avoided

- Area of the ozone hole (defined as < 220 DU) in the World Avoided is now 19.71 million km² in 2020
- The Arctic ozone hole would have stretched across the pole and over much of Canada, Greenland, and Russia

Wilka et al., in review
Total Column Ozone in 2020

- The WA minimum Arctic ozone also follows a more Antarctic-like progression throughout the season
- We see a good match with OMI observations over the entire time period

Wilka et al., in review
Ozone Vertical Profiles in 2020

• Looking at vertical profiles again, we also see a shift toward near-total depletion in a broad region of the lower stratosphere (WA) rather than at a few levels (RW)

• Again, a common feature of the Antarctic, which is itself quite saturated and shows more change higher up

Wilka et al., *in review*
Next Steps: Impacts Elsewhere and WACCM6

- Looking at the Antarctic, we don’t seem to be denitrifying too much
- Preliminary comparisons with MIPAS HNO3 distributions indicates our new reference state is better in the SH subpolar latitudes, but more work is needed
- More careful comparisons with obs needed to decided on final NAT param value

Zambri et al., in prep

Wilka et al., in review
Conclusions

• Increasing the denitrification in SD-WACCM4 allows the model to more accurately simulate the conditions of the meteorologically extreme Arctic spring of 2020

• Given this, we have more confidence in the model’s ability to simulate a “World Avoided” which the real world averted through the Montreal Protocol

• This does not appear to degrade the representation of HNO₃ in the Antarctic, but quantification of this and impacts on other regions is ongoing