Shedding new light on the radiative impacts of ozone depleting substances

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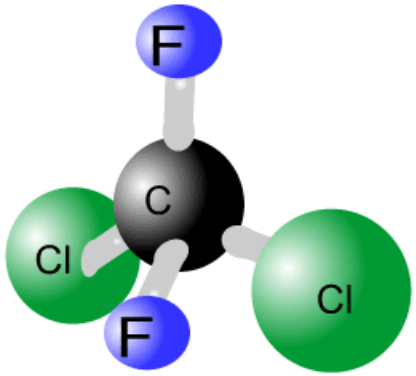
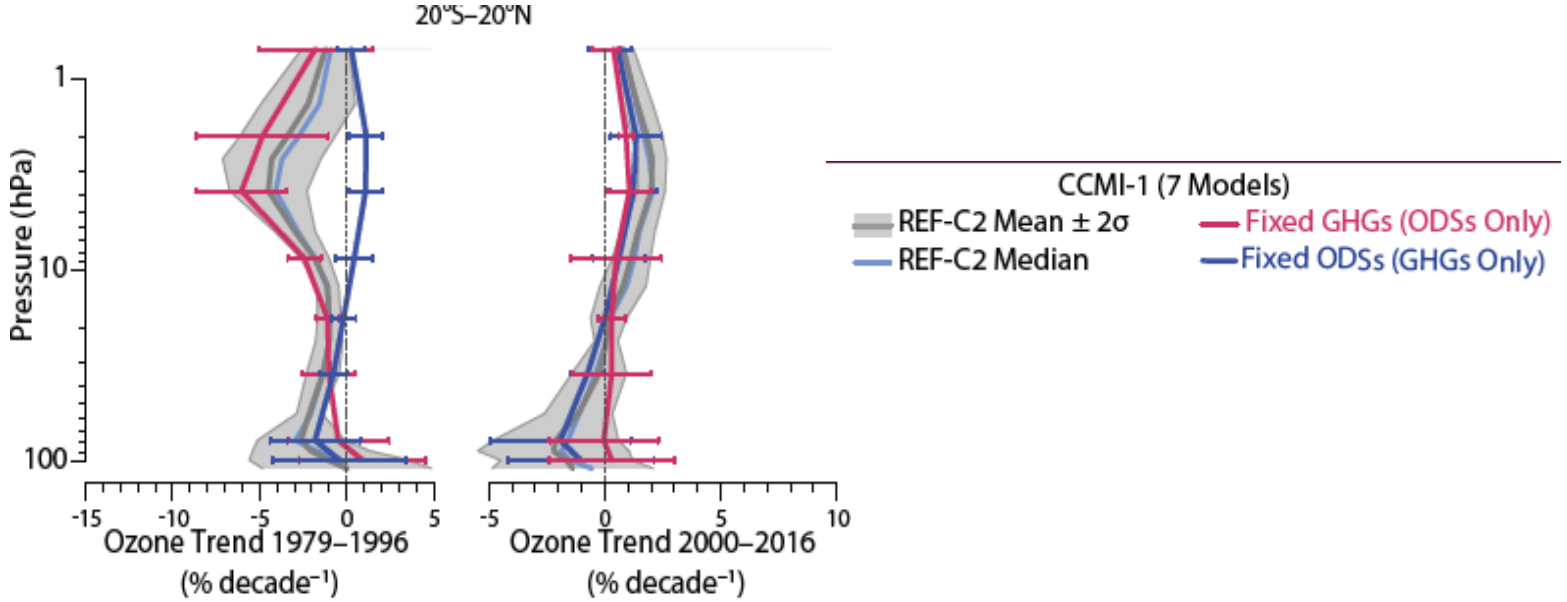


Introduction

- Ozone depleting substances (ODS) are the primary cause of global ozone trends in observational record



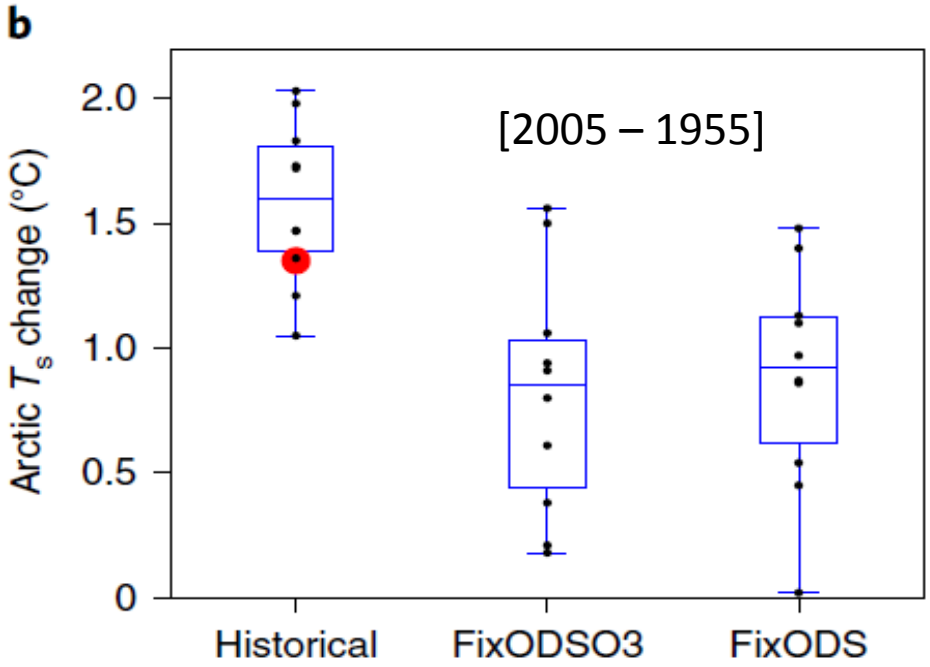
- ODS are also known to be major greenhouse gases (IPCC-AR5)

  20-year GWP (CFC11) = 7000

  100-year GWP (CFC11) = 5300

Motivation

- However, their impacts that are independent of ozone depletion have received less attention
- Recent evidence suggests large role of ODS in contributing to climate change (up to 50% of Arctic Amplification)



Observations

Polvani et al.,
Nat.Clim.Change 2020

Objectives

- Overarching question:

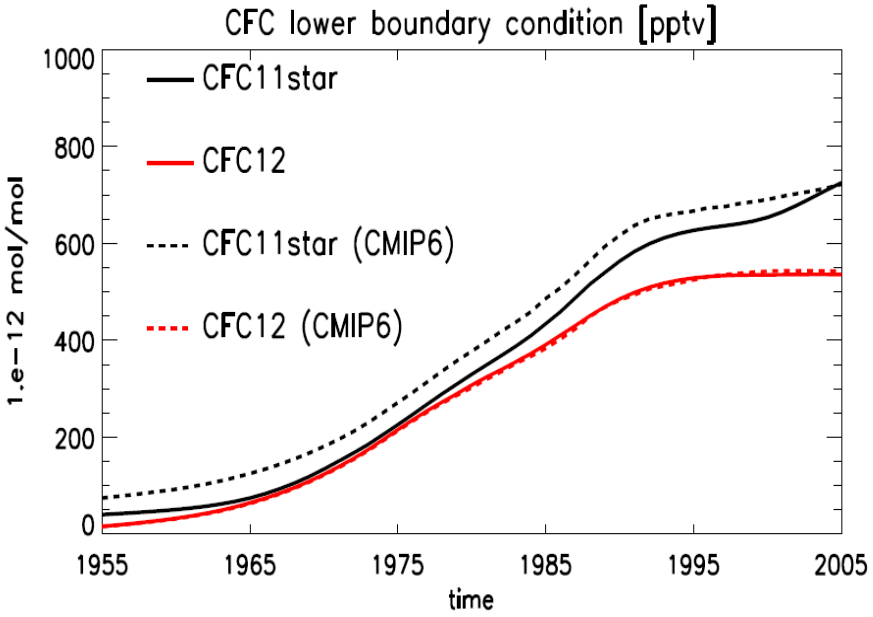
  What creates the large climate efficacy of ODS?

Methods:

– Investigate radiative effect of ODS in offline calculations from CESM-PORT (3-D radiative transfer code) and explore the role of stratospheric adjustments (FDH approximation)

– Compare ODS with other major forcing agents over 2000-1960 (CH4, CO2, N2O, ozone)

Results

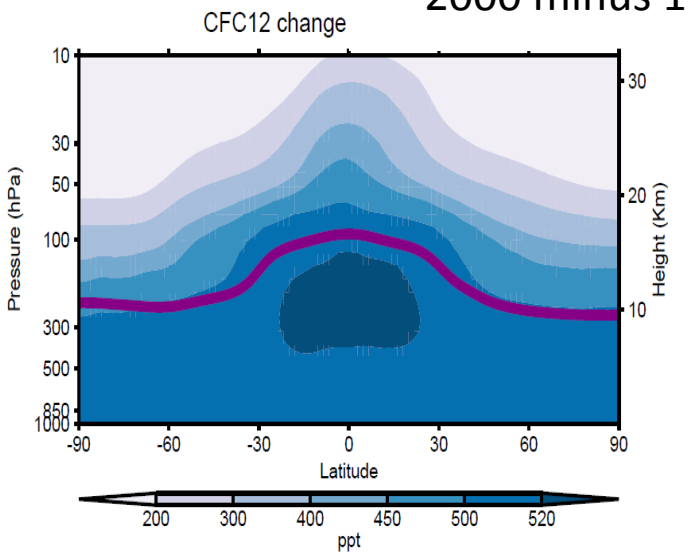


"CFC11STAR" = CFC11 + CFC113 + CCl4 + CH3CCl3 + HCFC22 + CF2ClBr + CF3Br

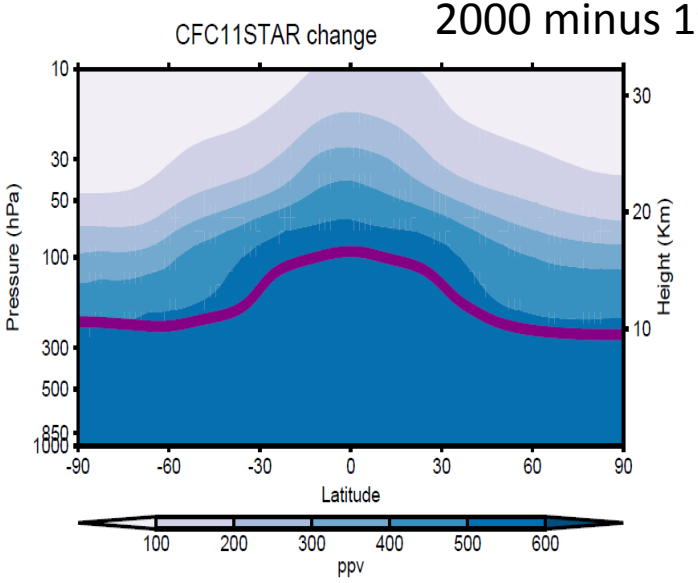
ODS uniform in the troposphere, and quickly decrease in the stratosphere (photolysis)

→ does the distribution of ODS matter for **radiative forcing?**

2000 minus 1960



2000 minus 1960



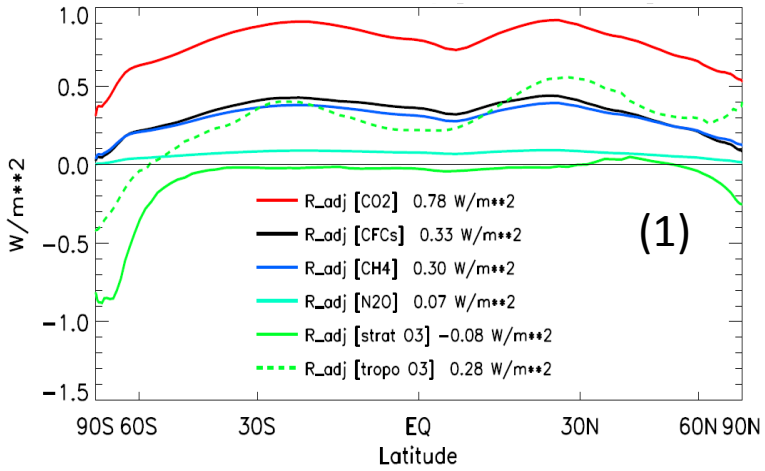
Results

- ODS (CFCs) are second major GHG forcing over 1960-2000 period, and show similar structure as other major GHGs, such as CO2 and CH4 (1)

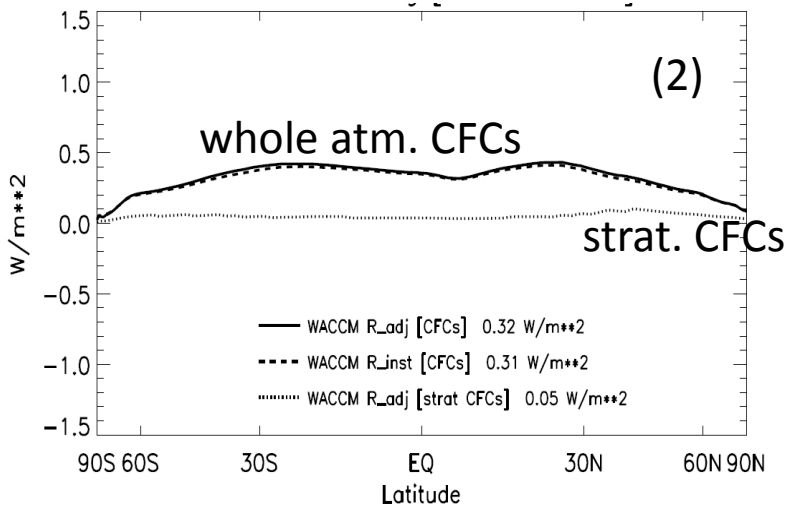
- Majority (>80%) of radiative forcing of created by tropospheric distribution of ODS (2)

- Stratospheric temperature adjustment only contributes to less than 5% of the forcing (2)

TOA radiative forcing (2000 – 1960)



TOA radiative forcing (2000 – 1960)



Ongoing work

- Exploring the effects of ODS on stratospheric temperature

  → ODS behave **differently** from any other major GHG (they warm the stratosphere!)

- Exploring the relationship between spatial structure of the forcing and the "climate efficacy"

  → ODS behave **like any major** GHG (largest forcing in tropics, smallest in polar regions)