Ozone/Climate Coupling: New Challenges

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1. Polar stratospheric change and surface climate: SAM and NAM

2. How Montreal helped Kyoto, and can help more

Conclusion:
There has never been a better time to invest yourself in stratospheric processes and their role in climate.
The Antarctic ozone hole
Ozone and Climate in the Vortex

A fundamental aspect of temperature, wind, and climate variability in the polar regions

Less ozone -> colder, tighter vortex in stratosphere. Effects on troposphere?

**Stronger vortex:** cold air stays bottled up in the vortex, so the plateau gets colder while the peninsula gets warmer

*Thompson and Solomon Science 2002*
Overall trends very different. Ozone and SAM has affected the air temperatures and circulation patterns in SH summer (and probably fall as well). Is this affecting sea ice? What about ice shelves and SLR?
Arctic and Antarctic sea ice trends

Overall trends very different. Ozone and SAM has affected the air temperatures and circulation patterns in SH summer (and probably fall as well). Is this affecting sea ice? What about ice shelves and SLR?
Arctic and Antarctic sea ice trends for 1980-2000 vs model with data assimilation to capture SAM trends:


Increases in sea ice extent driven by SAM changes 1980-2000 (circulation, ozone?). Model also shows decreases for 1950-1980 (warming, GHG?).
NAM in NH?
Needs a better assessment

SAM in SH
Miller et al. JGR 2005;
IPCC (2007) Ch 10;
Perlwitz et al. (2009)
Changes in the Tropics

- Stratospheric cooling and SST linkage; effect on water vapor, coupling to troposphere?
Link To Water Vapor

Rosenlof, Reid, Dameris, others: SST/convection...

Radiative forcing?
A World of Change: More Rain for Some, Less for Others

- Regional changes (+/-) of up to 20% in average rainfall
- Drying in the subtropics in both hemispheres
- More precip in high latitudes

(2090s: medium emissions scenario; high confidence in stippled areas)

IPCC (2007) Summary for Policymakers
The Meaning In The Stratosphere

The Meaning In The Stratosphere

Figure 1 What climatological features distinguish the tropics? Some of the atmospheric structure, circulation, and hydrological features shown in this schematic diagram of the Earth have moved poleward in recent decades, indicating a widening of the tropical belt and the Hadley circulation.
IPCC (2013): To do better on many aspects of structure/regional behavior, will benefit from a better understanding of the stratosphere.
- Cooling
- less strat H2O
- changes in ozone
- temperature trends
- Shift of storm tracks, regional climates, SAM, NAM
- Drought in subtropics?
How Are We Doing? The Montreal Protocol is On Track In Terms of Phasing Out Global *Production* of CFCs.

The US was a leader in the CFC production phaseout, beginning with a domestic spray-can CFC ban in 1978. All countries have now phased out CFC production.

* Tonnes multiplied by the ozone depleting potential of the considered gas.
GWP-Weighted Emissions

Combined CO\textsubscript{2}-eq from halocarbons:

~7.5 Gt near 1990, about 33\% of that year's CO\textsubscript{2} emissions from global fossil fuel burning.

2002 breakdown:
1.5-1.9 Gt for CFCs;
0.53-0.56 Gt for HCFCs;
0.36 Gt for HFCs
Benefits of Montreal Protocol for Climate

CO₂ emissions

World avoided by the Montreal Protocol?

Reduction to date by Montreal Protocol of ~11 GtCO₂-eq/yr

5-6 times global Kyoto target

Role of ozone depletion cooling due to CFCs? Could reduce this by perhaps a third but....
Montreal Sep 2007 adjustment: HCFC early phase-out

Reduction in future emissions:
- HCFCs ‘transition’ speedup
- 12-15 GtCO$_2$-eq potential reduction if replaced with low-GWP alternatives or reduced through conservation/recycling.
CCSP: Connecting with our national process
SAP 2.4 (2008) NOAA key contributors:
Ravishankara (lead), Montzka, Daniel, Fahey

USA Accessible Banks (CO2-eq)

- CFC
- HCFC
- HFC
- Halons
CCSP: Connecting with our national process
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US Banks: 1.9 Gt CO2-eq in all, about 1 Gt in HCFCs (AC, refrigeration).
Possible future actions to recover/destroy banks would represent several years of ‘Kyoto-equivalent’ for US.
• Climate links in poles and tropics
• NH past?
• SH recovery?

• Decisionmaking about substitutes continuing (HCFCs, HFCs)