The Interdecadal Pacific Oscillation and mid-stratospheric tropical ozone trends

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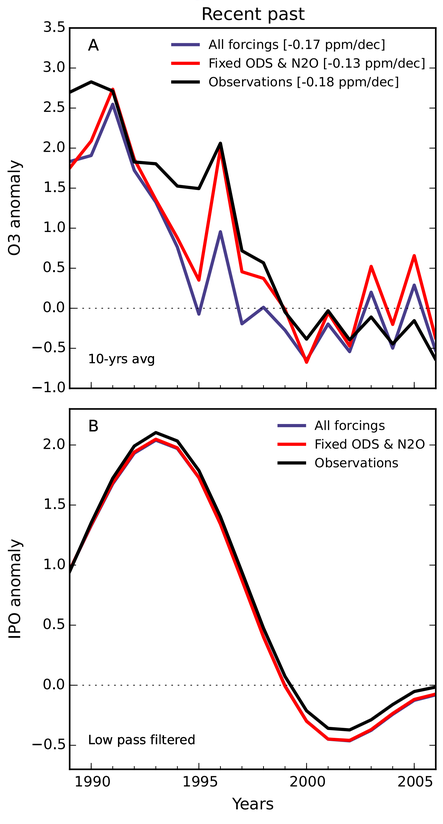
Introduction

In recent years, the global ozone layer has started to show the first signs of recovery, but puzzlingly tropical mid-stratospheric ozone has decreased since the beginning of the 90s. This is a key region of the stratosphere where most ozone is produced. Here we use observational estimates and model simulations to show for the first time how multidecadal internal climate variability – in Pacific Ocean sea surface temperatures, the Interdecadal Pacific Oscillation (IPO) – has an impact in mid-stratospheric tropical ozone.

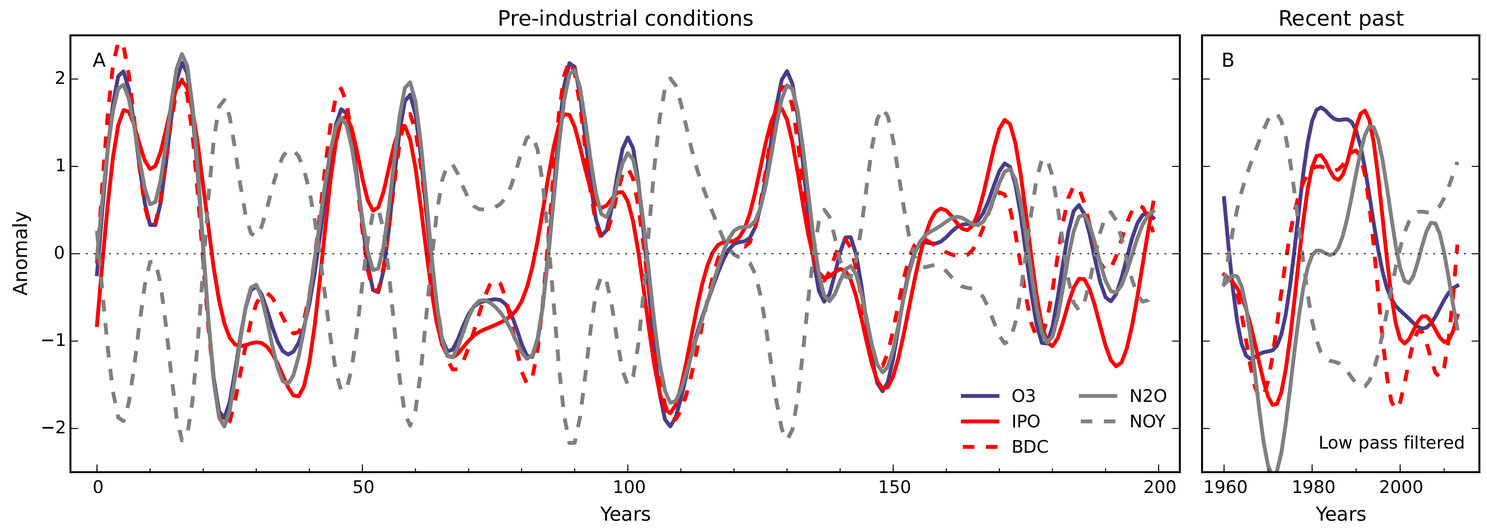
Recent ozone changes and the IPO



Simulated mid-stratospheric tropical ozone anomalies show a sharp decrease for the 1990-2000 period and persistently low levels since ~2000 (A), which is in very good agreement with observations and largely unrelated to forced signals (i.e. ozone depleting substances and N_2O emissions).

This is coincident with a shift from a positive to negative phase of the IPO (B). Sea surface temperatures can affect dynamics in the stratosphere and these results suggest a link.

Model simulations show how the IPO and tropical ozone levels might be related



A long simulation including only internally generated variability (A) and a simulation of the recent past (B) show that the IPO is associated with the general circulation in the stratosphere - the Brewer-Dobson circulation (BDC). Changes in the BDC modulate ozone loss in the tropical middle stratosphere via NO_y chemistry.

IPO (+) → BDC (+) → loss chem. (-) → O3 (+)

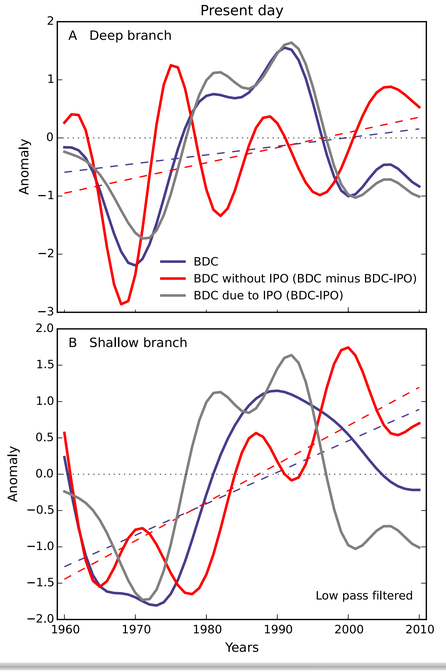
IPO (-) → BDC (-) → loss chem. (+) → O3 (-)

Multidecadal and naturally occuring variability in the Brewer-Dobson circulation

Changes in the BDC are highly uncertain - i.e. observational estimates are derived from indirect measurements - and conflicting results are often found.

The BDC variability from a simulation of the recent past is associated with the phase of the IPO in both the deep (A) and shallow (B) branches.

These results suggest that multidecadal internal climate variability, when taken into account, may help investigate observational trends in the BDC due to increasing greenhouse gases concentrations.



Conclusions

The IPO is associated with multidecadal variability in the stratosphere for both dynamics and composition, and can account for the observed trends in mid-stratospheric tropical ozone.

Understanding internally generated multidecadal variability in mid-stratospheric tropical ozone is crucial to distinguish between forced and unforced signals and better describe ozone recovery.

Natural variability at decadal time scale may help better understand observational trends in the BDC with regard to the chosen period.