Simulating Climate Change in the Stratosphere

Presented by Pu Lin
The stratosphere: A unique component of the climate system

- Additional validation for basic theories.
- Significant influence on weather and climate in the troposphere and at the surface.
  - Radiation balance is sensitive to changes in trace gases such as ozone and stratospheric water vapor.
  - Dynamical coupling between the stratosphere and the troposphere.
  - Composition changes from stratosphere-troposphere exchange.

Credit: UCAR
Changes in the Heating Rate at the tropical tropopause from 4xCO2

- GFDL AM3 is capable of simulating the relevant dynamic, radiative, chemical and thermodynamic processes.
- A detailed heat budget is achieved by combining GCM output and the corresponding off-line radiative transfer model.
- A quantitative investigation of the mechanisms.
ΔT at 60°S-90°S 100 hPa as ozone depletes from 1960 level to 2000 level

Delayed southern polar vortex breakdown, a common model bias, implies an overestimation of the response to ozone depletion.
Stratospheric ozone recovery: Elevated volcanic aerosols increase ozone in a low halogen world

Global mean annual mean stratospheric ozone column relative to 1980

- Volcanic aerosols induce uncertainties in future stratospheric ozone projections and expected recovery dates.
- Accurate representation of stratospheric aerosols is necessary.
Summary

• GFDL models are capable of simulating the essential radiative, dynamic and chemical processes in the stratosphere.

• Heat budget analysis reveals that the direct radiative effect of $CO_2$ increase is a major contributor to the tropical tropopause warming.

• The simulated response to ozone depletion depends on the zonal wind climatology.

• Future projections of ozone is modulated by volcanic aerosols.
Future outlook:
High resolution, non-hydrostatic simulations open new doors

Equatorial zonal wind simulated with different model configurations

AM4.0 L33

L71, non-hydro, no CG drag

AM4.0 L63 modified CG drag

Observation

Courtesy of Lucas Harris