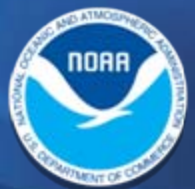


# Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



# Modeling of Atmospheric Chemistry

Presented by  
**Larry Horowitz**

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# Outline

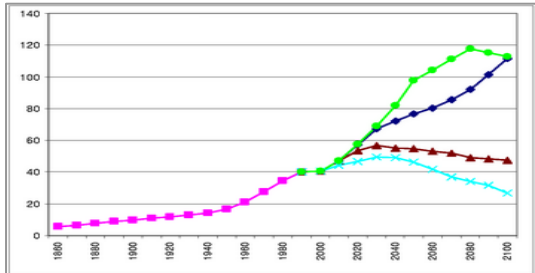
- Sequential coupling of chemistry and climate
  - Methodology
  - Uncertainties
- Synthesizing models and observations
- Stratospheric ozone chemistry
- “Full” coupling of chemistry and climate



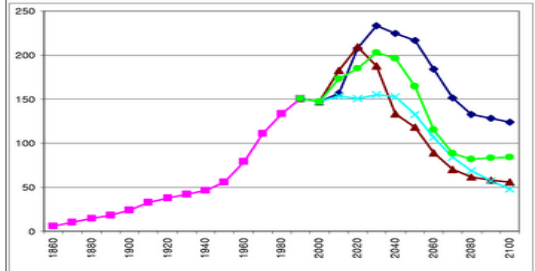
# “Off-line” Coupling of Chemistry and Climate

## Global Emissions

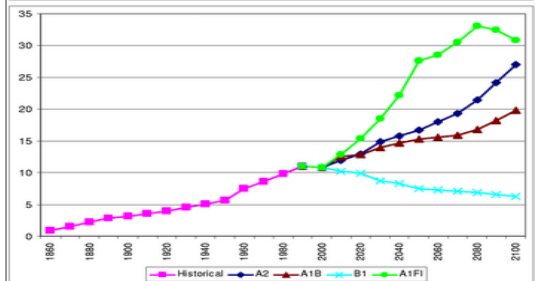
$\text{NO}_x$   
(TgN/yr)



$\text{SO}_2$   
(Tg/yr)



Black Carbon  
(Tg/yr)

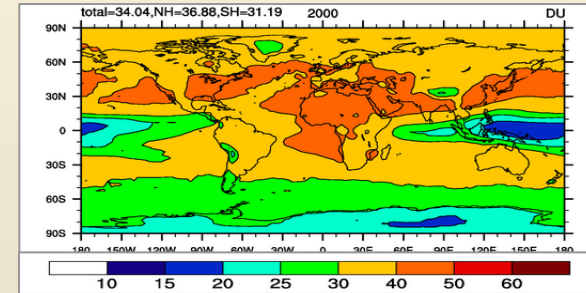


1860 1900 1950 2000 2050 2100

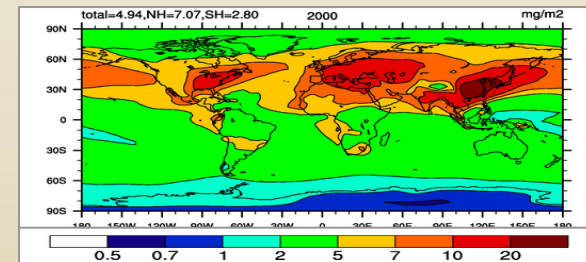
Historical  
A2  
A1B  
B1  
A1FI

## Tropospheric Column (2000)

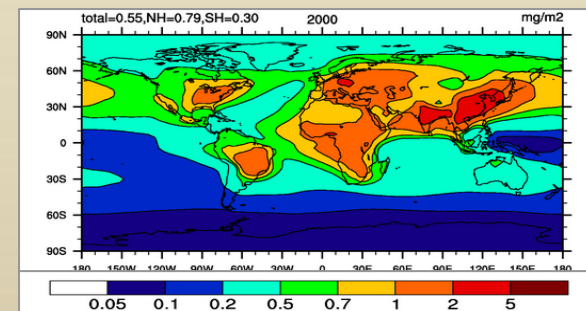
Ozone  
(DU)



Sulfate  
(mg/m<sup>2</sup>)



Black Carbon  
(mg/m<sup>2</sup>)

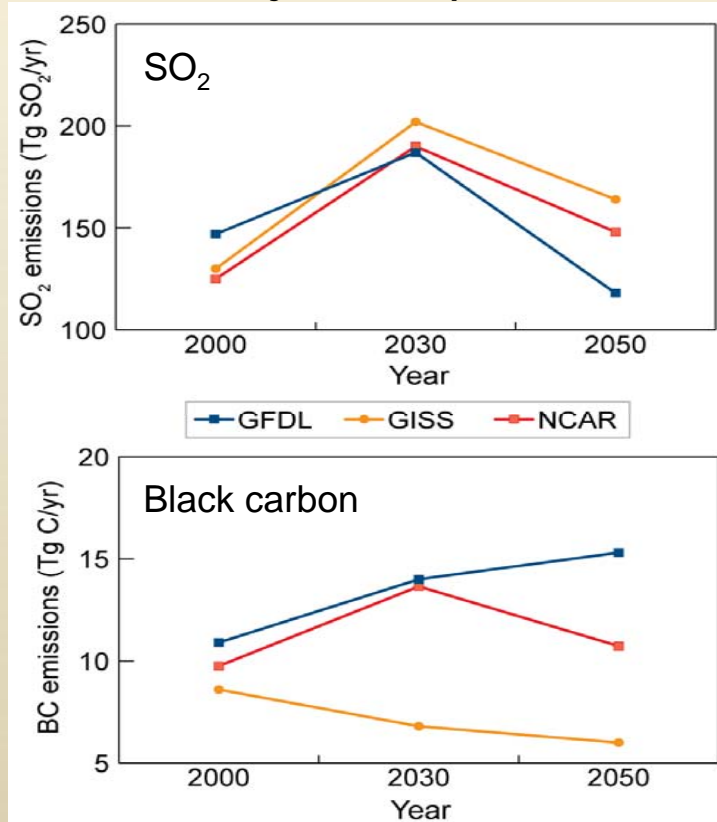


- Concentrations estimated with MOZART CTM (neglecting climate feedbacks)
- Direct radiative forcing in climate model (CM2)

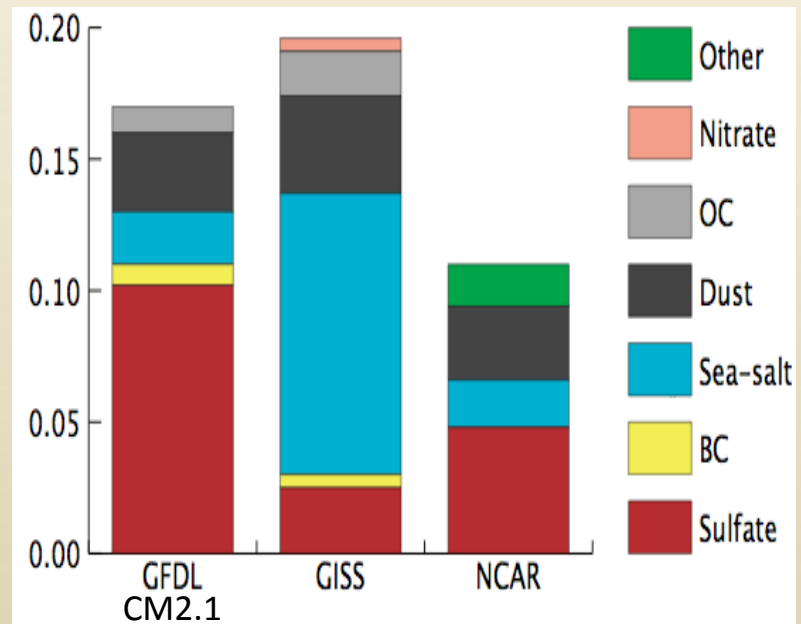
(Horowitz, 2006)

# Multiple Uncertainties in Climate Impact of Aerosols

## Emission Projections (A1B scenario)



## Aerosol Optical Depth



### Methodologies for black carbon:

Scaled to CO emissions

Estimates by D. Streets

Scaled to SO<sub>2</sub> emissions

MOZART

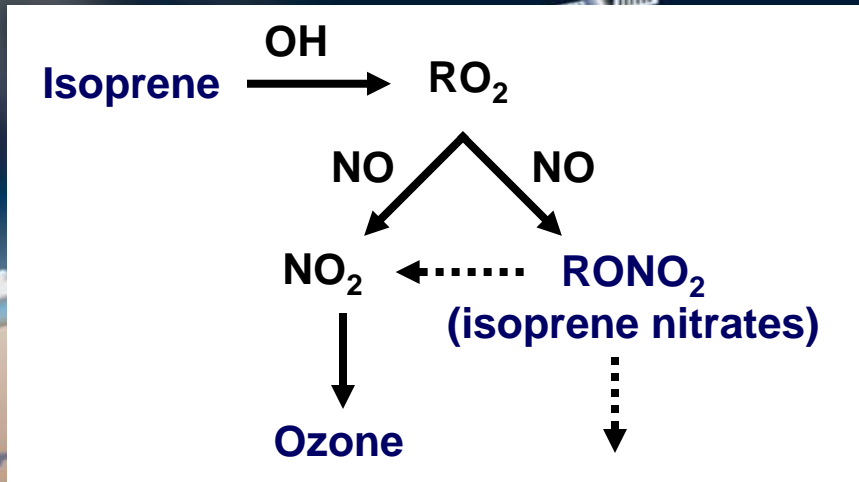
CM2.1

Emissions → Concentrations → Radiation/Climate

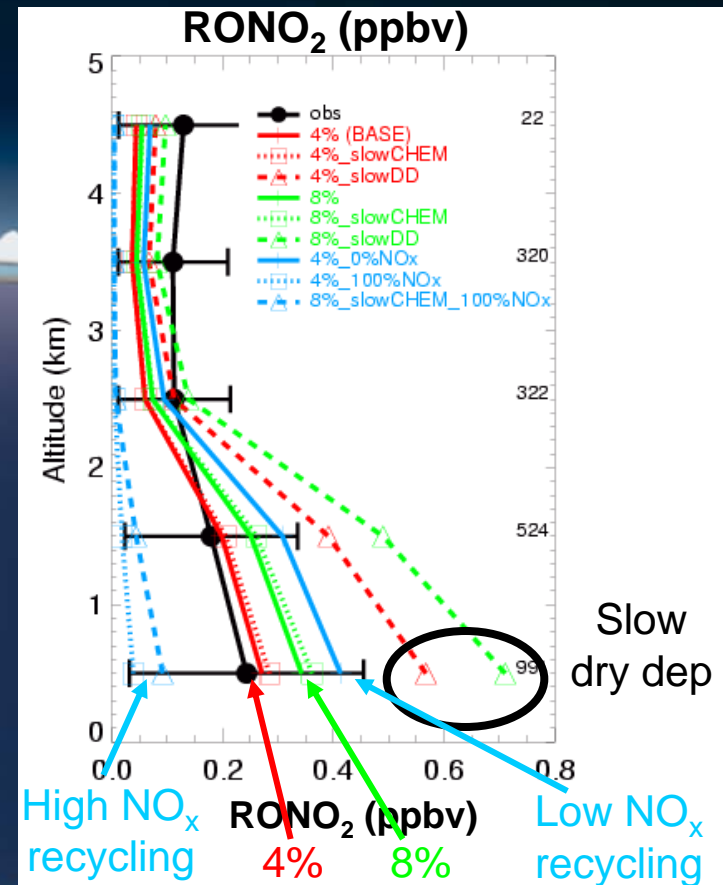


# Synthesizing Models and Field Observations

## ICARTT field campaign, Summer 2004



- Constraints on highly uncertain isoprene chemistry
- Significant implications for ozone concentrations



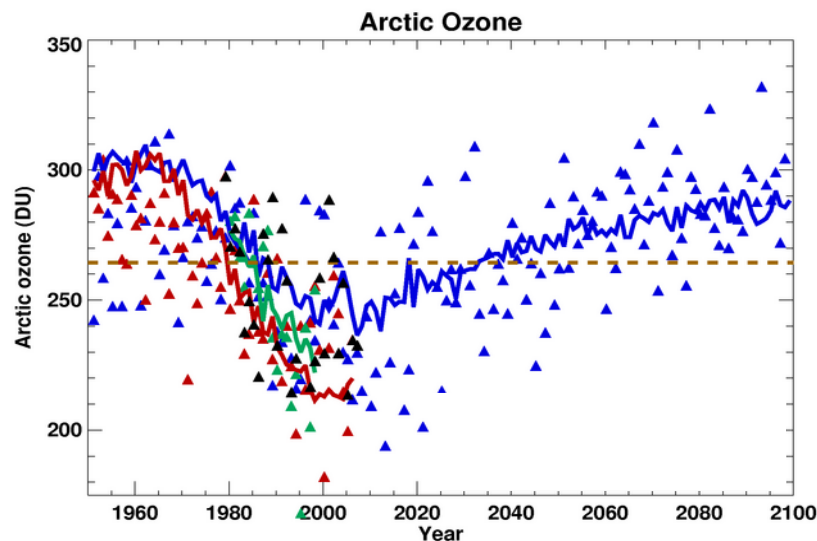
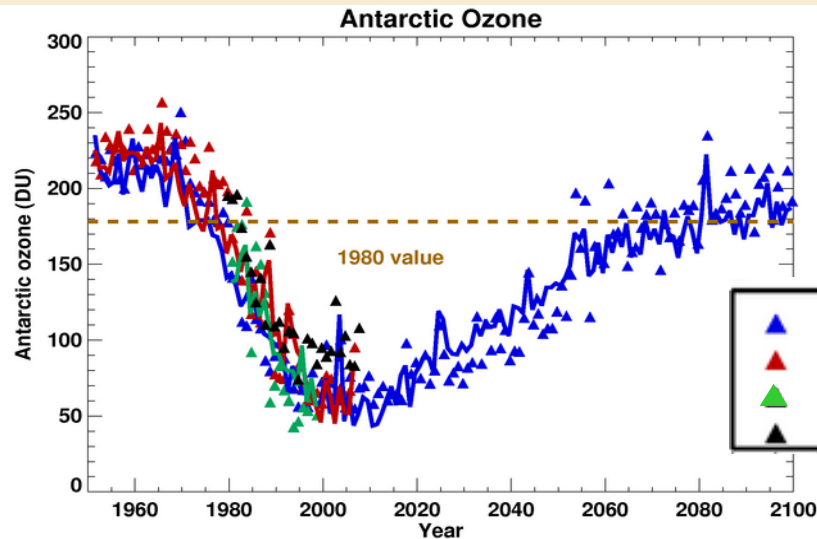
(Horowitz et al., 2007)

# Decline and Recovery of Polar Ozone

## Antarctic

Minimum ozone column (DU) for each spring season

## Arctic



# Recent Developments: Coupled Chemistry-Aerosol-Climate Model

## Aim:

**Develop model to allow investigation into coupled chemistry-climate-air quality issues**

**AM3, the atmospheric component of GFDL's CM3 climate model for IPCC AR5, includes:**

- “On-line” tropospheric and stratospheric chemistry and aerosols
- Wet deposition in large-scale precipitation, convective updrafts, and mesoscale circulations
- Chemical feedbacks on climate through direct and indirect radiative effects



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