GISS Models
David Rind (in absentia)

- From Surface to Mesopause (~85km)
- Variable vertical and horizontal resolution
  - from 23 to 150 layers
  - 4°x5°, 2°x2.5°, .... eventually 1°x1°
- Variable Ocean
  - mixed layer with specified heat transports
  - fully dynamic 3D model
- Atmospheric Chemistry
  - linearized ozone/methane routines
  - chemical family advection (HOx, NOx, ClOx, SOx)
GISS Model Processes

1. Solar Radiation
2. Radiation
3. Longwave Gases (H2O, CO2, CH4, O3, CFCS, etc.)
4. Cloud Cover
5. Shortwave Aerosols (Strat, Trop)
6. Dynamics (Numerics)
7. Rainfall (Convective, Large-Scale)
8. Convection
9. Atmospheric Boundary Layer Turbulence
10. Land Surface (Vegetation)
11. Land Surface (Soils)
12. Ocean
13. Sea Ice
Studies of Climate Response to Changes in Total Solar Irradiance

• How have solar variations contributed to climate change over the last 1000 years? 100 years?
• How have they contributed between 1900 and 1950?
• What component of the warming since 1950 is associated with solar variations?
• How are they likely to influence observations over the next few decades?
Studies of Climate and Weather Variability Forced by Spectral Irradiance Changes

- Requires models with on-line atmospheric chemistry (solar impact amplified by stratospheric ozone response)
- Possibly acting through influence on atmospheric dynamics (planetary waves, storm tracks, tropical circulation patterns)
- Requires full stratosphere
- Investigate need for finer vertical/horizontal resolution

## GISS GCM Simulations: 1950-2005

<table>
<thead>
<tr>
<th>Run</th>
<th>Resolution</th>
<th>Forcing</th>
<th>Ozone</th>
<th>Ocean</th>
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<tbody>
<tr>
<td>1</td>
<td>4x5, 23 layer</td>
<td>solar (monthly mean spectra)</td>
<td>non-interactive</td>
<td>Q-flux, no diffusion (thru bottom of mixed layer)</td>
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<tr>
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<td>Linoz</td>
<td>Q-flux, no diffusion</td>
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<td>Linoz</td>
<td>Q-flux, no diffusion</td>
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<tr>
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<td>solar, trace gases, volcanic aerosols</td>
<td>non-interactive</td>
<td>Q-flux, no diffusion</td>
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<td>5</td>
<td>4x5, 53 layer</td>
<td>solar, trace gases, trop. + volcanic aerosols, trop + strat. Ozone</td>
<td>non-interactive</td>
<td>Q-flux with and without diffusion (thru bottom of mixed layer)</td>
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<td>solar</td>
<td>Linoz</td>
<td>observed SSTs</td>
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<td>Linoz</td>
<td>observed SSTs</td>
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<td>solar</td>
<td>Linoz</td>
<td>observed SSTs</td>
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</tbody>
</table>
TEMPERATURE  SOLAR HEATING  OZONE

DECEMBER-JANUARY-FEBRUARY: Solar Max-Solar Min
Observed Natural and Anthropogenic Sources of Climate Change

Volcanic aerosols

El Nino

La Nina

http://data.giss.nasa.gov/

GISS Land+Ocean Global Temperature

model: ENSO+VOL, r = 0.48

CO₂

tropospheric aerosols

greenhouse gases

industrial aerosols

model: SUN+ANTH, r = 0.70
Solar Cycle Signals in Earth’s Atmosphere

**SURFACE**
0 km

- TOTAL SOLAR IRRADIANCE
- GHG TREND
- ENSO MEI INDEX
- AEROSOL OPTICAL DEPTH
- GISS SURFACE

**MIDDLE TROPOSPHERE**
8 km

- SOLAR IRRADIANCE
- ENSO MEI INDEX
- AEROSOL OPTICAL DEPTH
- MSU MT

**LOWER STRATOSPHERE**
20 km

- SOLAR UV IRRADIANCE
- CFC TREND
- ENSO MEI INDEX
- AEROSOL OPTICAL DEPTH
- MSU

**Temperature Anomaly (K)**

**Highlights**
- Solar increase → warming
- CO₂ increase → warming
- Volcanoes → cooling
- Solar increase → warming
- CO₂ & CFC increase → cooling
- Volcanoes → warming
The Ozone Layer:

GSFC TOMS Total Ozone Sep 16, 2001

Total Ozone 50S-50N ~ 280 DU

Recent Variations

Nimbus 7 solar upper photosphere/chromosphere

UV radiation: 200-295 nm

1996-06-16

TOMS TOTAL OZONE 50S-50N (deseasonalized)

Ozone Anomaly (DU)

2000-02-25

SOLAR UV IRRADIANCE

CFC-12

VOLCANIC AEROSOLS

QBO: 30 mb zonal wind index

Ozone Anomaly (DU)

observed, modeled, r=0.89

+1.2%

+ 2.2%

+ 4%

+ +