Present day and historical response to solar forcing in the fully coupled chemistry-climate GISS ModelE

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Annual average temperature change between the late 17th and late 18th Century

Proxy based reconstruction, 3 decade average

How can we test a model’s dynamic response?
First winter response

11 historical eruptions

Model E/III

Model II

[Shindell et al., JGR, 2004]
Volcanic response, AR4 models

Figure 5: Regression coefficient of the leading EOF of ensemble mean NH SLP upon ensemble mean SLP averaged over the December-March low-latitude volcanic eruptions, with and without volcanic forcing, respectively, and blue and light-blue indicates the values for individual models with and without volcanic forcing.
Solar Induced Annual Temperature changes

-0.32 W/m$^2$ forcing (Maunder Min. vs late 18th Century)

GiSS Model II

Solar reduction leads to reduced westerlies, similar mechanism to volcanic response
Persists for many years, and summer and winter additive, unlike volcanoes

[Shindell et al., Science, 2001]
New simulations with full chemistry in GISS Model E/III

<table>
<thead>
<tr>
<th>Run</th>
<th>Composition</th>
<th>Ocean</th>
<th>Length (yrs)</th>
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<td>Prescribed</td>
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<td>Present-day</td>
<td>Mixed-layer</td>
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<td>Preindustrial</td>
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<tr>
<td>F Q-flux</td>
<td>Future (A1B)</td>
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<tr>
<td>PI coupled</td>
<td>Preindustrial</td>
<td>HYCOM</td>
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</tbody>
</table>
Ozone response to solar cycle

SBUV

GISS

SAGE

GSFC 2D
Chlorine monoxide (%)
Water (%)
Surface Temperature Response to Reduced Irradiance

Model II
-0.32 W/m²

Model E
PI coup.
-0.14 W/m²

Lagged Proxy Corr.
Conclusions

Global annual average dT dependent upon composition (PI>PD) and ocean dynamic response (coupled<Q-flux)

Decadal to centennial timescale regional climate changes attributable partially to solar via forced NAM/AO/NAO and SAM shifts (spatial patterns independent of calibration!)

Stratosphere-troposphere dynamics important to regional response, therefore ozone and hence UV important - demonstrated influence of stratospheric perturbations on annular modes! Long-term response sensitive to ocean dynamics...
Modeled vs ‘observed’ T

NMC/CPC
1.8

MSU4 /SSU
.6
Zonal wind response

Nov

Dec

Jan

Feb