Solar Forcing of Industrial Era Climate Change

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Thanks for collaboration and funding to Gavin Schmidt (GISS) & Dong Wu (GSFC)
Short-term RF from the Sun

IPCC AR5, Ch 8, 2013
Long-term RF from the Sun

IPCC AR5, Ch 8, 2013
RF Summary

IPCC AR5, Ch 8, 2013
Based on plage network (dashed) or on white-light facula (solid)

Foukal, Astrophys. J, in press
Historical Climate

IPCC AR5, Ch 5, 2013
AR5: Solar Impacts (global)

- Sensitivity to solar comparable in models to other forcing agents

IPCC AR5, Ch 10, 2013
AR5 Main Conclusions: Solar

- Overall small forcing during recent centuries; low confidence in quantification
- Contributor to early 20th century warming, though too small to explain fully
- Large impact inconsistent with observations over last 1000 yr
- Decreasing in recent decades, when warming most rapid
- May play a larger role in regional temperature changes via altered circulation
AR5: Solar Impacts (regional)

- All contain so-called ‘bottom-up’ mechanisms
- Small influence in Indo-Pacific, no clear AO/NAO impact
- Many do not fully represent ‘top-down’ mechanisms

IPCC AR5, Ch 10, 2013
Stratosphere-Troposphere Coupling Observations

Reichler et al., NGeo, 2012
Stratosphere-Troposphere Coupling: Models

Left column: GFDL model
Right column: CMIP5 models

Reichler et al., NGeo, 2012
Solar Induced Temperature changes
Observations (top) & Model (bottom)

Shindell et al., Science, 2001
Model Evaluation

Mann et al., Science, 2009
Model Evaluation

Mann et al., Science, 2009
No Interactive Chemistry

With Interactive Chemistry

Solar cycle response of temperature (Lag 0)

GISS CMIP5 runs
Interactive Chemistry

GISS CMIP5 runs
Interactive Chemistry

GISS CMIP5 runs
Interactive Chemistry

GISS CMIP5 runs
Stratospheric Response

Temperature (°C)

1860 1880 1900 1920 1940 1960 1980 2000

Ozone column (DU)

Temperature
- E2-H
- E2-R with offline ozone
- E2-R
- Observed temperature

Forcing
- Solar
- Volcanic

Shindell et al., ACP, 2013
Surface Response

Dashed: non-interactive
Solid: interactive chemistry

GISS CMIP5 runs
Surface Response

**NH Annual Temperature**

- TCADI R
- TCADI H
- NINT R
- NINT H

5–95% significance

**SH Annual Temperature**

- TCADI R
- TCADI H
- NINT R
- NINT H

5–95% significance

GISS CMIP5 runs
Surface Response

Both high latitude responses appear only in simulations with interactive chemistry

GISS CMIP5 runs
Conclusions

• Additional modeling needed with coupled ocean-atmosphere-composition (i.e. computationally expensive!)

• Mechanisms of solar-climate regional impacts being identified, not yet robustly present in climate models

• Top-down and bottom-up may not be so distinct

• Not easy to tell from observations what are the actual regional responses to solar forcing