Climate responses to 11-year and lower frequency solar variations in the Last Millennium Ensemble

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Simultaneous regression of TOA SOLIN onto global average SOLIN time series
Experiments & Methodology

- Analyses shown based on Last Millennium Ensemble (LME) solar only simulations
- 4 + 2 LF solar enhanced (x2.5) only simulations
- Mechanism connecting solar variations to climate: The “bottom-up” mechanism – changes in SOLIN effect Earth’s energy balance
- Today: A few maps of regression coefficients showing the surface climate response and a hypothesis
DJF surface temperature (°C/Wm⁻²) and near surface wind, HF

Complex, global surface temperature and wind response

- Tropical Pacific and Indian Ocean
- Extra-tropical Pacific/IPO like
- North America/PNA like
- African Sahel/Sahra and Arabian Peninsula
- Arctic and Siberia
- Peak-to-peak response ~ ± 0.14 °C in high latitudes

- Sig. 95% 2-side t-test stippled
- 6 ensemble members x 1050 years = Approx. 600 solar cycles
Complex, global surface temperature and wind response

Working Hypothesis: (1) HF solar variations drive LH & SH flux anomalies that modulate the amplitude of the climatological precipitation in the tropics. (2) This response is strongly amplified by Bjerknes feedback and (3) drives mid-latitude circulation responses, resulting in complex, global patterns.

- Sig. 95% 2-side t-test stippled
- 6 ensemble members x 1050 years = Approx. 600 solar cycles
DJF precipitation (mm day⁻¹/Wm⁻²) and near surface wind, HF

Precipitation responses located throughout the tropics

- Shifts and enhancements to the climatological patterns in the tropics:
  - Tropical Pacific and Indian Basins
  - Tropical Atlantic Basin
- Complex pattern in the extratropical Pacific
- Weak but extensive drying south Atlantic to southwest Asia
(Circumstantial) evidence of wavetrains connecting tropical precipitation to mid-latitude SLP

- North & South Pacific Low/Highs
- PNA like pattern across NA
- High/Low across Europe
- Southern Indian Ocean Low/High

More substantial evidence from TOGA simulations?
Global warming with polar amplification and a very weak wind responses

Enhanced warming over land compared to over the ocean, otherwise fairly zonally symmetric

Peak-to-peak response
~ ± 0.10 °C (for standard forcing)
Some next steps....

• Look into why response to LF & HF forcing are so different

• Some analysis of the tropical ocean response

• Possibly SOM simulations to see the response without ocean dynamics

• Possibly TOGA simulations to see if any and how much of the mid-latitude circulation response is driven by the tropical precipitation
Patterns evolves smoothly into opposite signed anomalies over ~5 years with amplitude in phase with forcing
DJF Surface Temperature (°C/Wm$^{-2}$) and near surface Wind Responses

A number of interesting responses across the globe

- Tropical Pacific and Indian Ocean
- Extra-tropical Pacific
- North America
- African Sahel and Arabian Peninsula
- Arctic and Siberia

- Sig. 95% 2-side t-test stippled
- 6 ensemble members x 1050 years = Approx. 600 solar cycles
- Maximum amplitude only a few 1/10’s of °C