 Investigating the Missing Solar Cycle Signal in Polar Mesospheric Clouds

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OBJECTIVE
This investigation looks to determine if PMCs are influenced by the solar cycle or if PMCs are influenced by other underlying trends.

Polar Mesospheric Clouds (PMCs) are ice clouds formed in the mesosphere during polar summer hemispheric months. PMCs are used to study mesospheric conditions due to having high sensitivity to temperature and water vapor. Solar Backscatter Ultraviolet (SBUV) satellite data set is used to observe long-term variability in PMCs. SBUV indicates a strong anti-correlation of the cloud occurrence with the 11-year solar cycle (SC) until 2004 when the SC signal appears to diminish. We use attribution studies from NCAR’s Whole Atmosphere Community Climate Model (WACCM) to investigate and quantify the Sun’s influence on the decadal variability observed in the mesosphere.

BACKGROUND INTEGRATION

PMCs-Why they are important

- PMCs are sensitive to their local environment. Any small changes to temperature or water vapor from dynamics or vertical coupling will be observed in the cloud characteristics.
- PMCs are excellent tracers of vertical coupling from the lower atmosphere.
- Ice water content of PMCs are excellent tracers of vertical coupling from the lower atmosphere.
- PMCs are only 1 km thick that form in the mesosphere near 85 km during hemispheric summer months in the 50- to 90-degree latitudes.
- PMCs are used to study mesospheric conditions due to having high sensitivity to temperature and water vapor.
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REFERENCES
Hervig, M. E., & Stevens, M. H. (2014). Interpreting the PMC are excellent tracers of vertical coupling from the lower atmosphere.

CONCLUSIONS

- PMCs-Solar cycle variability in observations

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Satellite observations of PMCs are compared to Lyman Alpha to illustrate the anti-correlation of PMC variability with the 11-year solar cycle (SC). The SBUV dataset is the longest satellite data record of PMCs. PMCs are anti-correlated with the SC since Lyman alpha is an effective destroyer of water vapor. PMC brightness and occurrence is decreased during solar maximum and increases during solar minimum.

RESULTS

WACCM-PMC Model Runs

Whole Atmosphere Community Climate Model (WACCM)

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<td>WACCM-PMC</td>
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 attribution study shows Sun affects decadal variation of PMCs by 25%. FR-WACCM shows that after 2004, solar cycle in PMCs, temperature and water vapor diminished (<25%) which can help explain what SBUV is observing.

Future work will continue to investigate diminished solar signal focusing on vertical coupling of lower to upper atmosphere.

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RECOMMENDATIONS

- Whole Atmosphere Community Climate Model (WACCM)

- Attribution Study: Solar varying vs Solar Constant Min

- Free Running WACCM: Solar Varying vs Solar Constant Minimum

- Free Running WACCM: SBUV observations (black) with Lyman alpha (dashed red) to indicate solar cycle.

- Time series of the modeled monthly mean IWC for 80- to 85-km July averages at 78%.

- Temperature time series shows a compilation of multiple satellite data sets normalized to portray temperature anomalies over time. There is a distinct temperature variability indicative of a solar cycle signal before 2004, then slightly diminishes after 2004.

- Water vapor time series shows a compilation of different satellite data sets normalized to portray water vapor anomalies over time. There is a distinct water vapor variability indicative of a solar cycle signal before 2004 and completely diminishes after 2004.

- Time series of monthly mean anomalies for 80 to 85 km using July averages for H2O and T at 68%.

- PMC - Water vapor, and Temperature Comparison: Solar Varying vs Solar Constant Minimum

- WACCM using solar minimum as a constant (green) vs FR-WACCM using solar forcing (blue) with Lyman alpha (dashed red) to indicate solar cycle.

- Time series of the modeled monthly mean IWC for 80- to 85-km July averages at 78%.

- WACCM-PRE: Using FR-WACCM(blue) compared to using a minimum solar constant model run(green) with Lyman alpha(dashed yellow) to indicate solar cycle.

- Time series of the modeled monthly mean water vapor, IWC, and T for 80- to 85-km July averages at 78%.

- WACCM-PRE: PMC, Water Vapor, and Temperature Comparison: Solar Varying vs Solar Constant Minimum

- Figure W1: Using FR-WACCM(blue) compared to using a minimum solar constant model run(green) with Lyman alpha(dashed yellow) to indicate solar cycle.

- Time series of the modeled monthly mean water vapor, IWC, and T for 80- to 85-km July averages at 78%.

- Figure W3: Using FR-WACCM(blue) compared to using a minimum solar constant model run(green) with Lyman alpha(dashed yellow) to indicate solar cycle.

- Time series of the modeled monthly mean water vapor, IWC, and T for 80- to 85-km July averages at 78%.