

# Sensitivity of Last Millennium climate to low- and medium-amplitude solar variability

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# Model Simulations

- CESM1 (CAM5)
  - Atm and Land at 2°
  - Ocn and Ice at 1°
- Span 850 – 2005 A.D.
- Four solar only forcing runs and control from the LME (orange in table) - Low
- Solar only forced using PMIP3 VSK (Schmidt et al., 2011; Vieira et al. 2010 ); other forcing held constant
- Performed 2 additional simulations in which we increased SSI to investigate sensitivity - Medium

## CESM1(CAM5) LAST MILLENNIUM ENSEMBLE COMMUNITY PROJECT DIAGNOSTICS

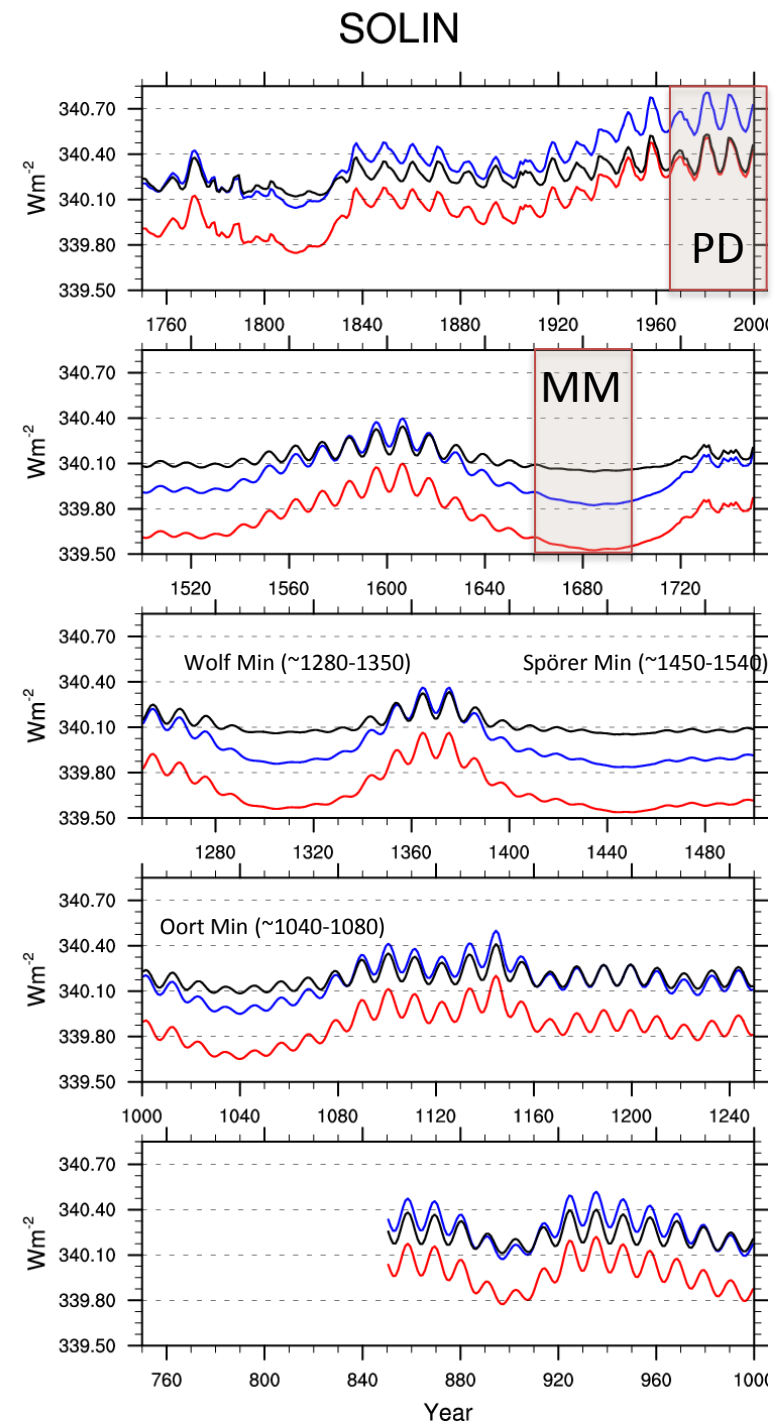
The climate simulated by each member is documented by the new [Climate Variability Diagnostics Package \(CVDP\)](#). This diagnostics package calculates a variety of climate metrics not covered by the individual component diagnostic packages.

### SIMULATION DETAILS AND DIAGNOSTICS

Brief Description	Case Details	Diagnostics					Length of Run Diagnostics	
<b>1850 2° Pre-Industrial Control</b> Case Name: b.e11.B1850C5CN.F19_g16.008	<a href="#">Details</a>	Years 981-1000	Atm	Ice	Land ts.008	Ocean	Ocean Timeseries	Atm Timeseries
<b>850AD 2° Control</b> Case Name: b.e11.B1850C5CN.F19_g16.0850cntl.001	<a href="#">Details</a>	Years 850 - 2005	Atm	Ice 1101- 1150 ts.850- 2005	Land v1850cntl PD-MCA ts.cntl	Ocean	Ocean Timeseries	Atm Timeseries
<b>Full Forcing Ensemble Members #1-#10</b> Case Names: b.e11.BLMTRC5CN.F19_g16.00X Note: #1 missing atm years 850-1699	<a href="#">Details</a>	Years 850 - 2005	Atm 001	Ice 001 ts.001 ts.002 ts.004	Land MCA.001 PD- MCA.001 obs.001 ts.001 ts.002 ts.004	Ocean 001	Ocean timeseries 001 002	Atm Timeseries
<b>Volcanic Only Ensemble Members #1-#5</b> Case Names: b.e11.BLMTRC5CN.F19_g16.VOLC_GRA.00X	<a href="#">Details</a>	Years 850 - 2005	Atm 001	Ice 001 ts.001 ts.002	Land MCA.001 PD- MCA.001 ts.001	Ocean 001	Ocean timeseries 001 002	Atm Timeseries
<b>Solar Only Ensemble Members #1, #3-#5</b> Case Names: b.e11.BLMTRC5CN.F19_g16.SSI_VSK_L.00X	<a href="#">Details</a>	Years 850 - 2005	Atm 001	Ice 001 ts.001 ts.003 ts.004	Land MCA.001 PD- MCA.001 ts.001 ts.003 ts.004	Ocean 001	Ocean timeseries 001 003	Atm Timeseries
<b>Orbital Only Ensemble Members #1-#3</b> Case Names: b.e11.BLMTRC5CN.F19_g16.ORBITAL.00X	<a href="#">Details</a>	Years 850 - 2005	Atm 001	Ice 001 ts.001 ts.002	Land MCA.001* PD- MCA.001 ts.001 ts.002	Ocean 001	Ocean timeseries 001 002	Atm Timeseries
<b>GHG Only Ensemble Members #1-#3</b> Case Names: b.e11.BLMTRC5CN.GHG.00X	<a href="#">Details</a>	Years 850 - 2005	Atm	Ice 001 ts.001 ts.002	Land MCA.001 ts.001 ts.002	Ocean	Ocean timeseries 001 002	Atm Timeseries
<b>Landuse/Landcover Only Ensemble Members #1-#3</b> Case Names: b.e11.BLMTRC5CN.F19_g16.LULC_HurtPongratz.00X	<a href="#">Details</a>	Years 850 - 2005	Atm 001	Ice 001 ts.001 ts.002	Land MCA.001 ts.001 ts.002	Ocean 001	Ocean timeseries 001 002	Atm Timeseries
<b>Ozone_Aerosols Only Ensemble Members #1-#2</b> Case Names: b.e11.BLMTRC5CN.F19_g16.OZONE_AER.00X	<a href="#">Details</a>	Years 1850 - 2005	Atm 001	Ice 001 ts.001 ts.002	Land MCA.001 ts.001 ts.002	Ocean 001	Ocean timeseries 001 002	Atm Timeseries

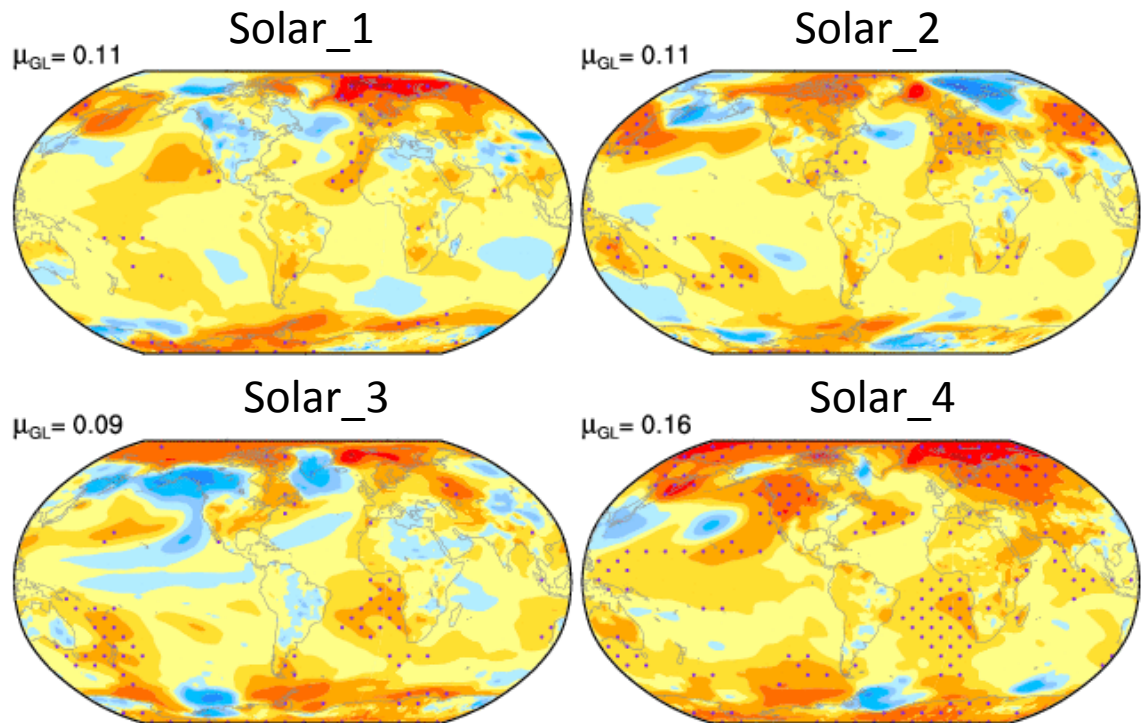
# TOA insolation from all solar simulations

- Four solar only simulations used SSI resulting in TOA insolation shown in black
- Two additional experiments: increase PD (1965-2005) minus MM (1640 – 1700;  $\Delta$ PD-MM) difference x 2.5:  $0.32\text{Wm}^{-2}$  to  $0.80\text{Wm}^{-2}$
- Used two methods :
  - 1) PD remain values the same - this reduces the overall time mean
  - 2) The overall time mean remains the same - the PD values do not line up

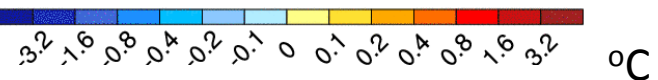


# $T_{2m}$ Solar only (Low)

*Some broad scale similarities with many regional differences*



*Differences between simulations suggest it will be difficult to detect regional signal in proxies*



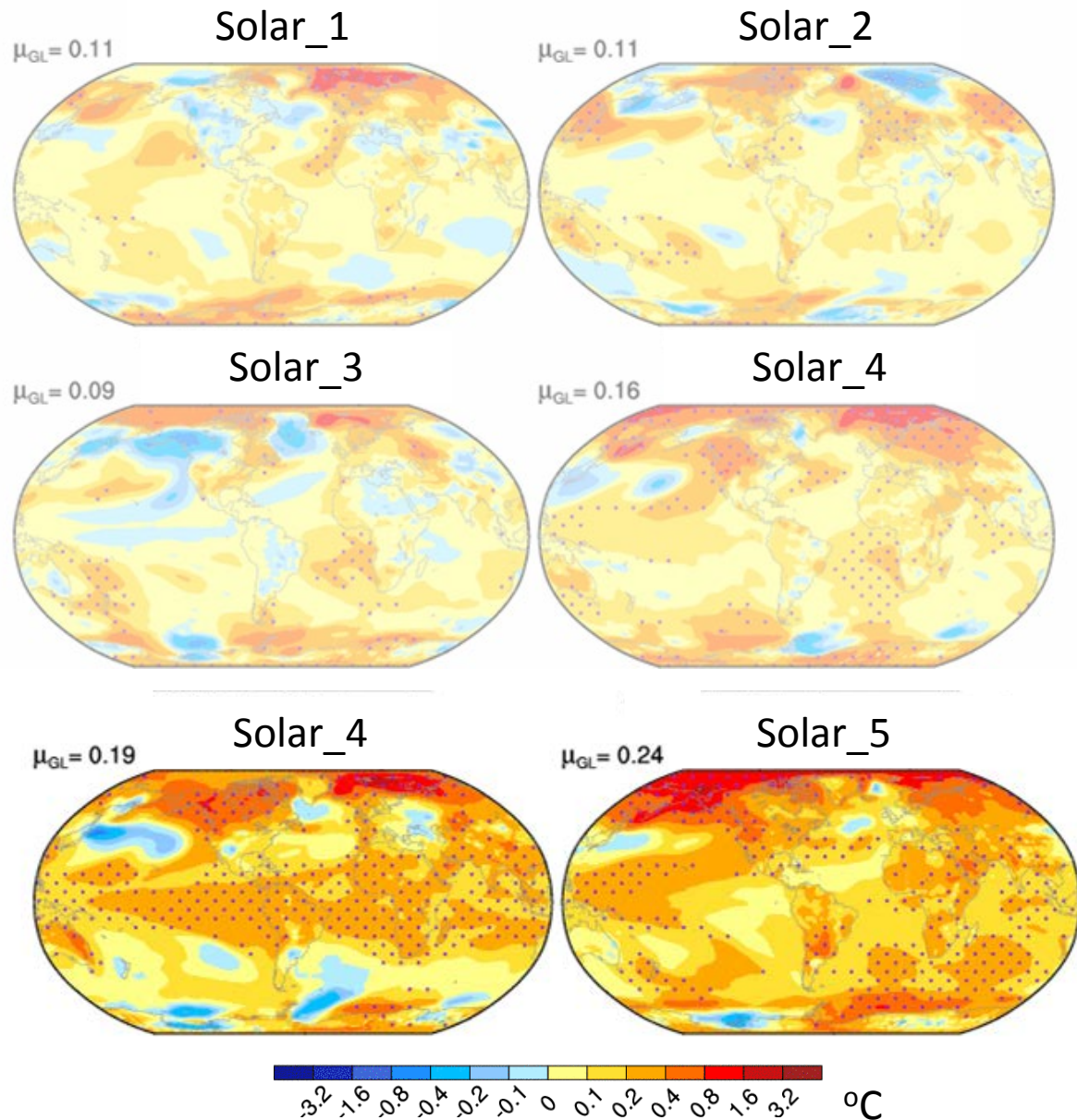
- Extended PD minus MM: 1955-2005 minus 1660-1710
- Stippling: significance at 95%
- Global means on left
- Removed linear trend based on control
- Non-linear contour interval



# $T_{2m}$ Solar only & medium solar

*Stronger forcing ->  
significant tropical  
responses...*

*... but tropical Pacific  
patterns differ  
considerably*

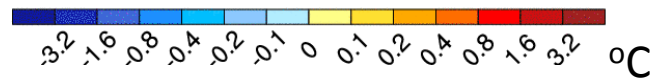
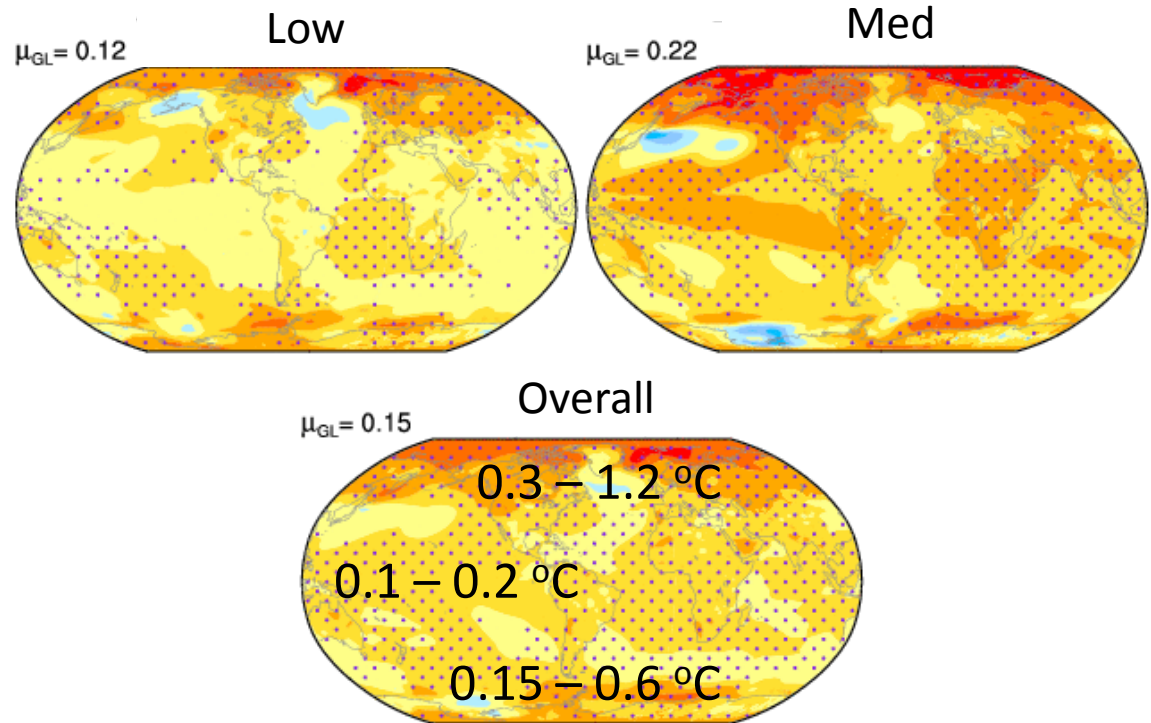


# $T_{2m}$ Solar Ensemble Averages

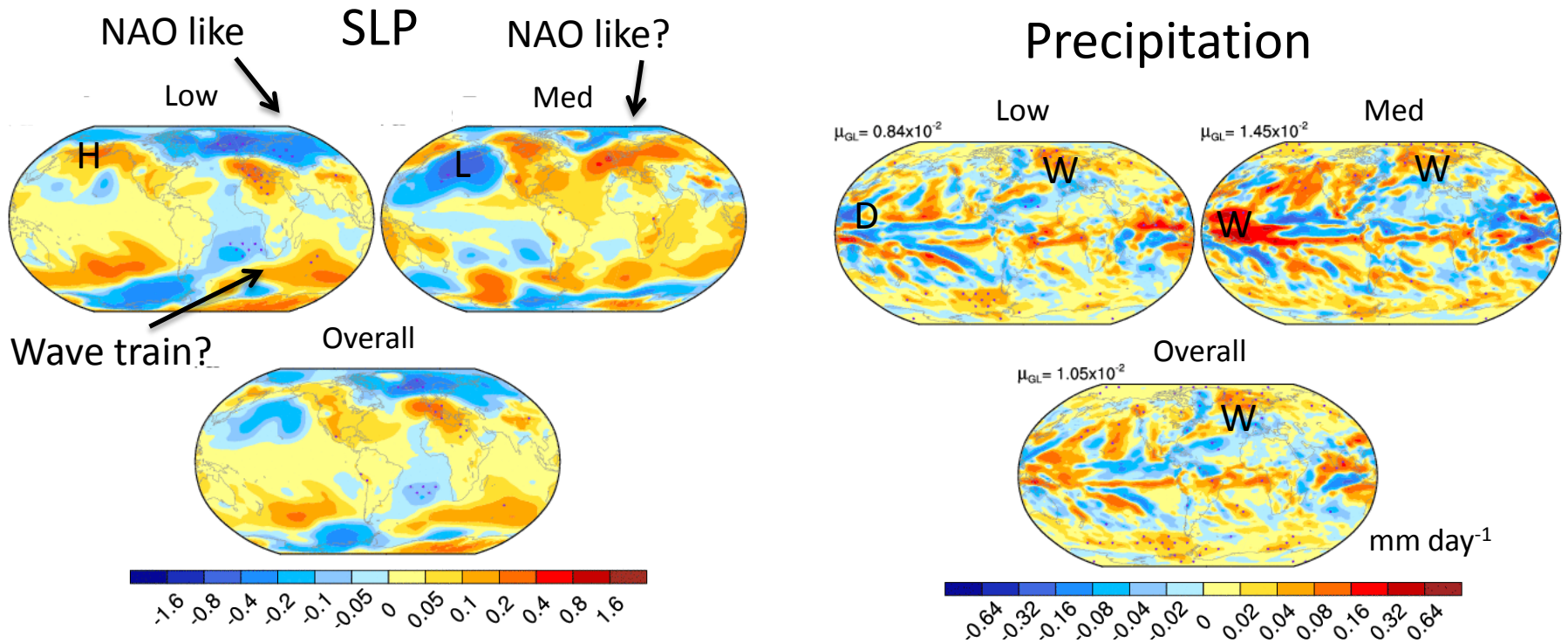
*Relatively small sample size yields extensive significant response in  $T_{2m}$*

*Global warming with polar amplification*

*Do low/med differences suggest non-linear effects?*



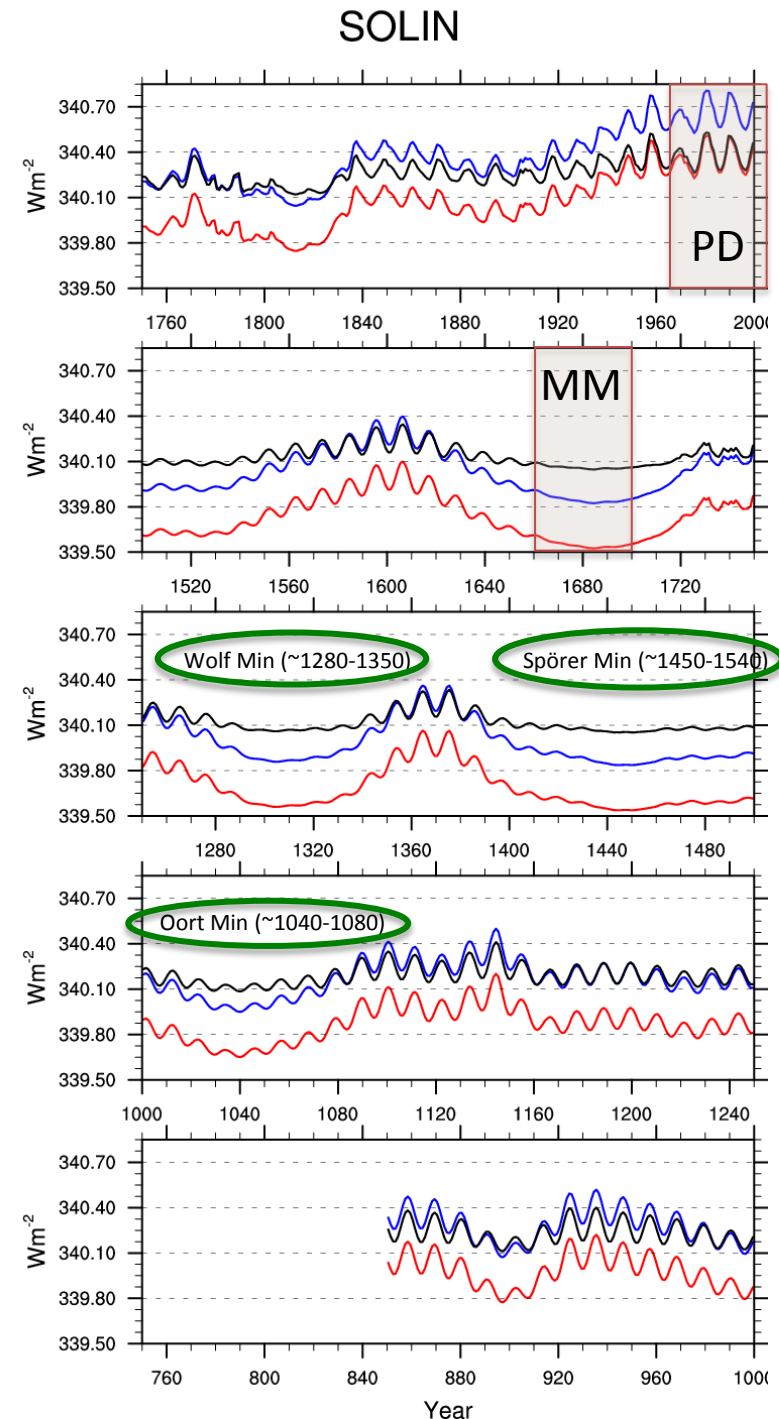
# Solar Ensemble Averages



*More samples might help to reveal additional significant circulation and precipitation responses*

# Current thoughts on paths forward...

- Analyze the other three Grand Minima periods – does compositing make sense?
- Explore possible differences in tropical responses low vs. medium forcing





$\Delta T_{REFHT}$  ( $^{\circ}C$ ) sig: 95% 1955 to 2005 minus 1660 to 1710

