

# Volcanic and Solar Forcing in CCSM4

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# Goals Volcanic Aerosol

- Implement Volcanics in RRTMG
- Fix broken implementation CAM-RT 3.5+
- Merge assumptions CAM / WACCM
  - CAM-climate: Aerosol radiative forcing
    - Move to evolving aerosol size distribution
  - WACCM-chemistry: evolving Surface Area Density
    - Radiation consistent with chemistry: evolving size
- Fix tropopause “leak”

# Status

## Baseline solution: (CAM-RT / RRTMG):

- Single size distribution radiation (successful for CAM and WACCM)
- Interface works for CAM and WACCM
- Tropopause fix in place (lat-function)

## Improved version (if RRTMG selected):

- Evolving aerosol effective radius, fixed width of log-normal size distribution
- Optics table for evolving size
- Determine tropopause (instantaneous)

# Status (ready for CCSM testing)

## Baseline solution: (CAM-RT / RRTMG):

- Single size distribution (successful for CAM and WACCM)
- Interface works for CAM and WACCM
- Tropopause fix in place (lat-function)
- Simulations with prescribed SSTs

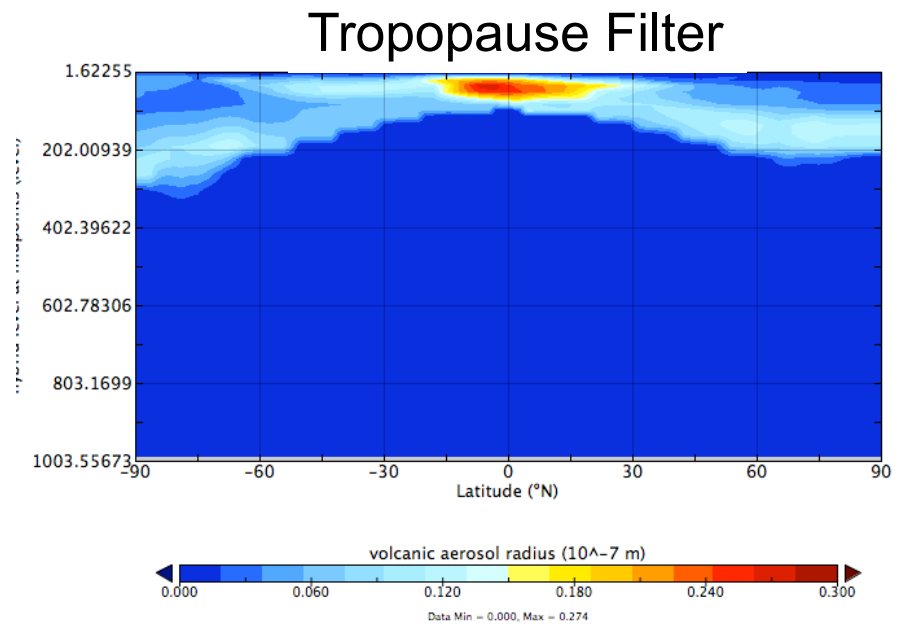
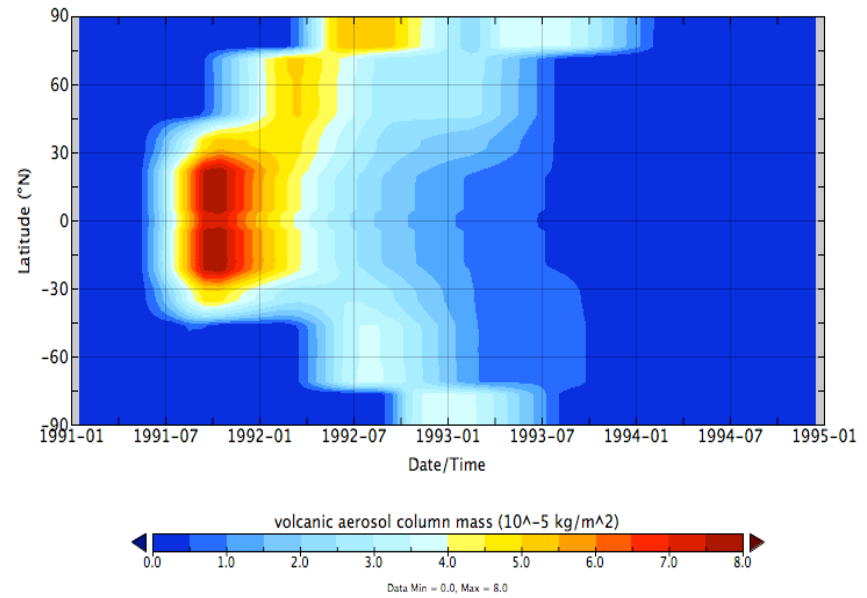
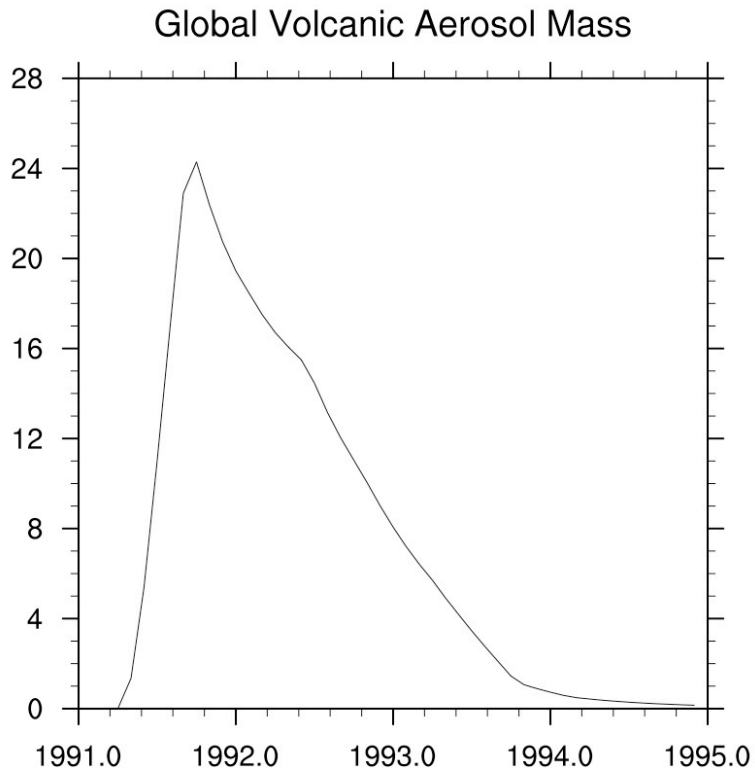
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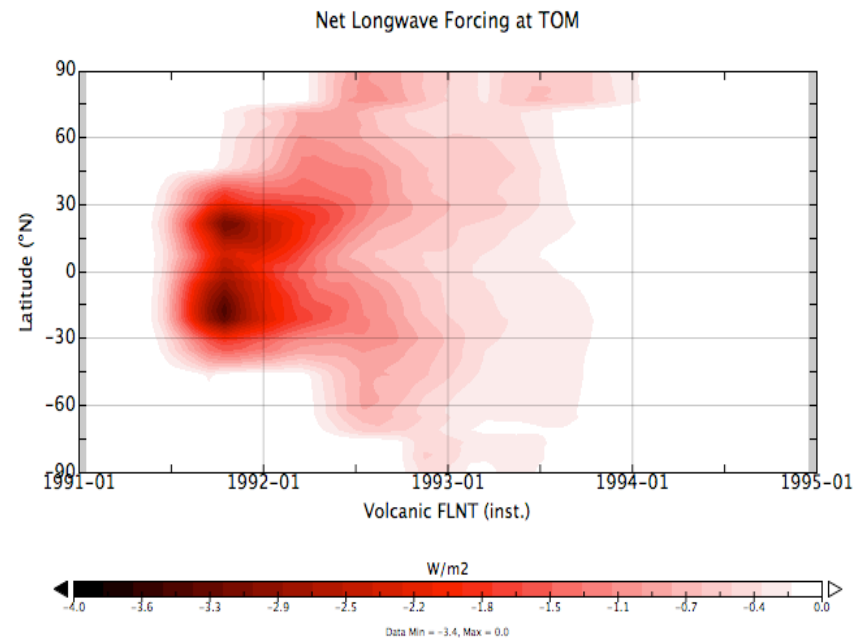
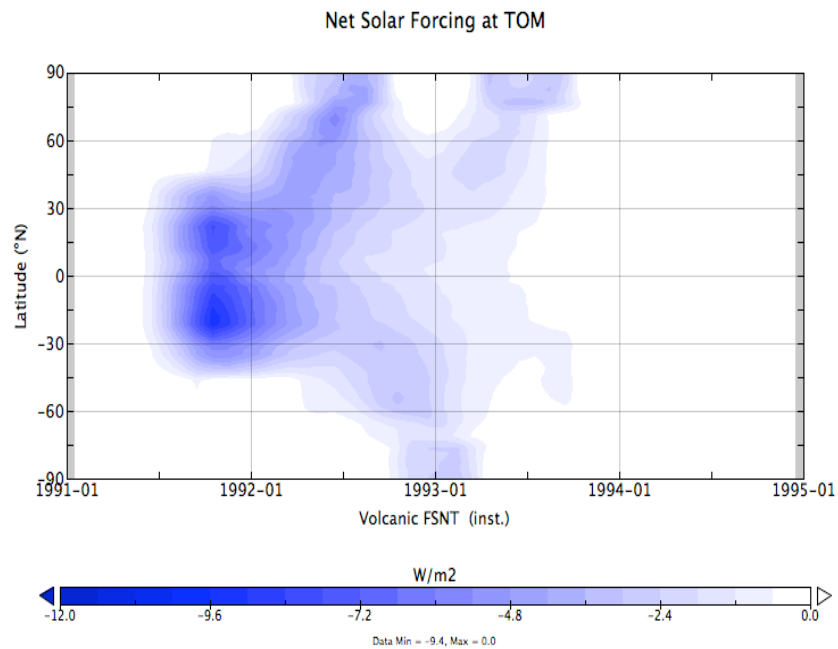


# Pinatubo Aerosol Mass

## Column Mass

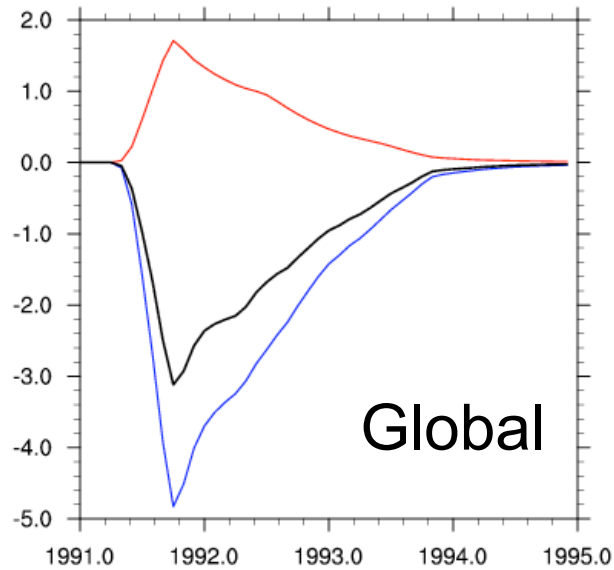


# TOM Zonal Rad Perturbations

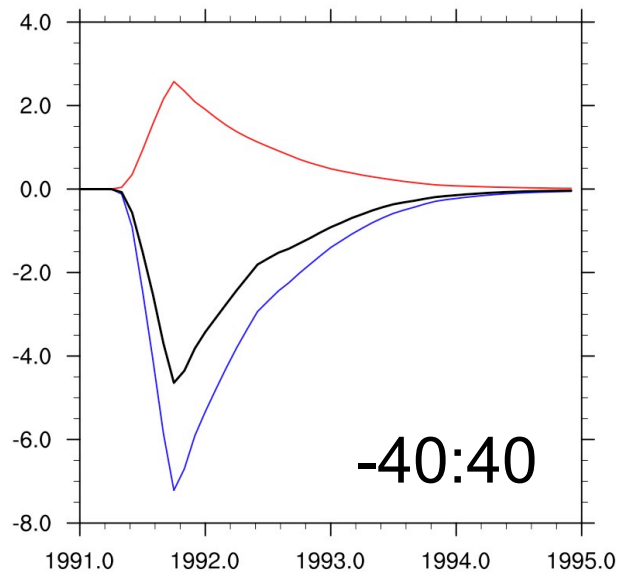


- SW peak  $\sim -9.4 \text{ W/m}^2$
- LW peak  $\sim -3.4 \text{ W/m}^2$

Pintubo Radiation: SW (Blue), LW (Red) and Total (Black)

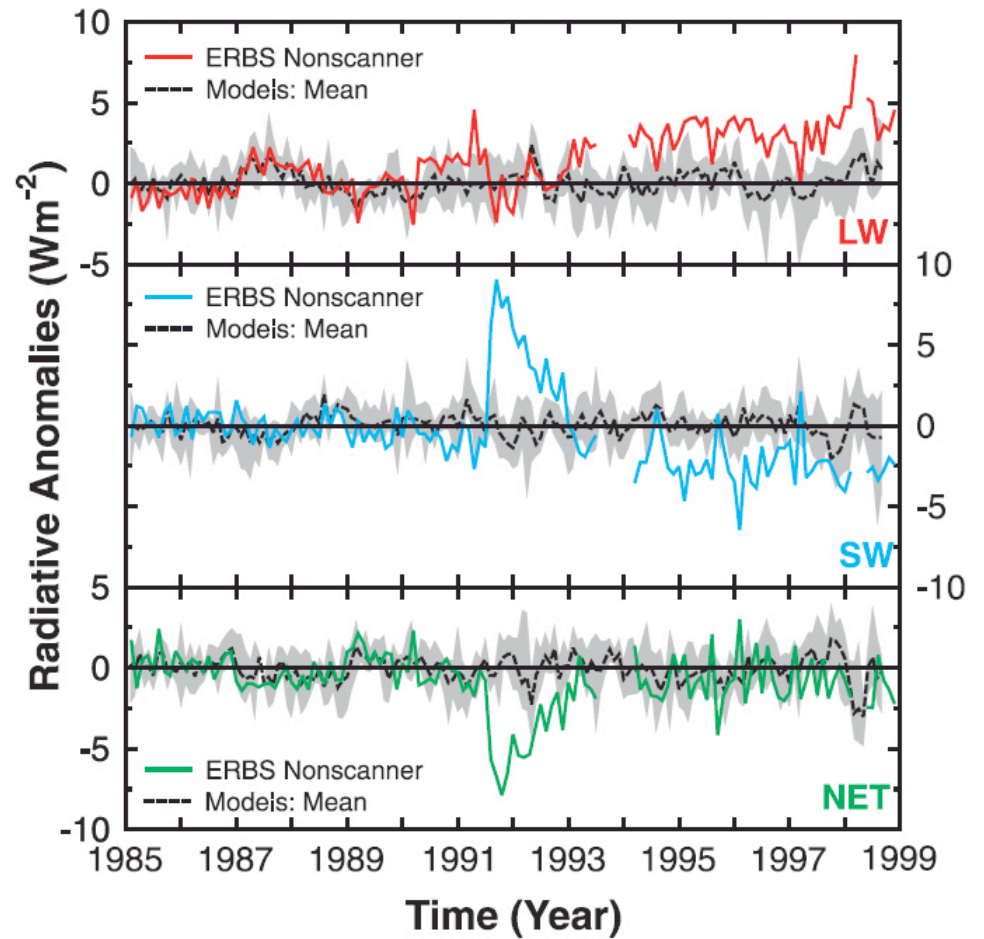


Pintubo Radiation (40N-40S)

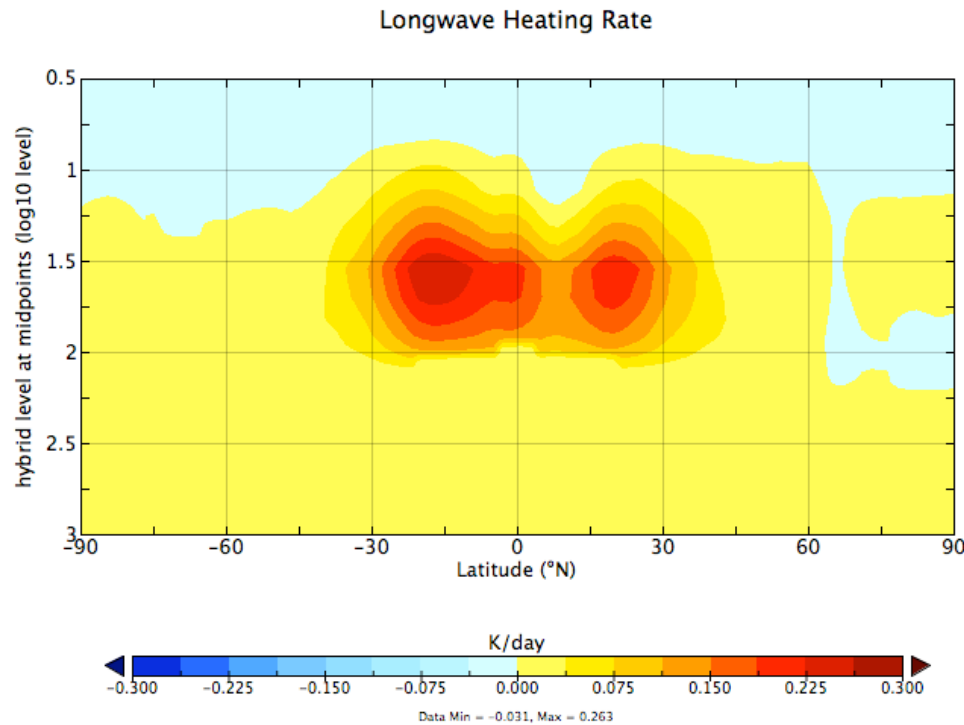


# Radiative Forcing

## RRTMG vs ERBS

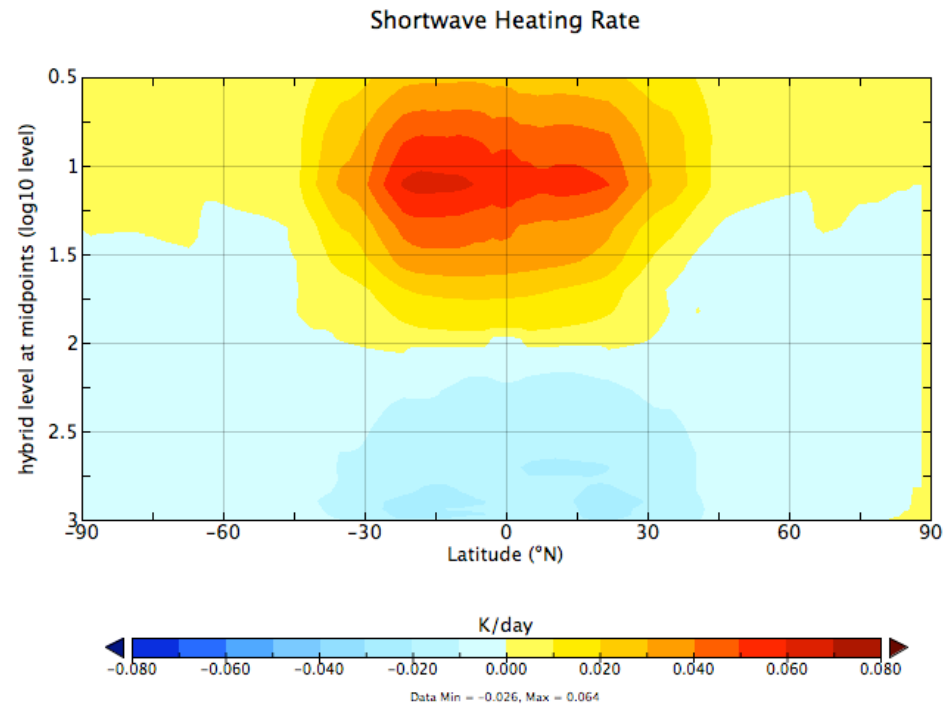


# Volcanic Heating Rates (K/day)

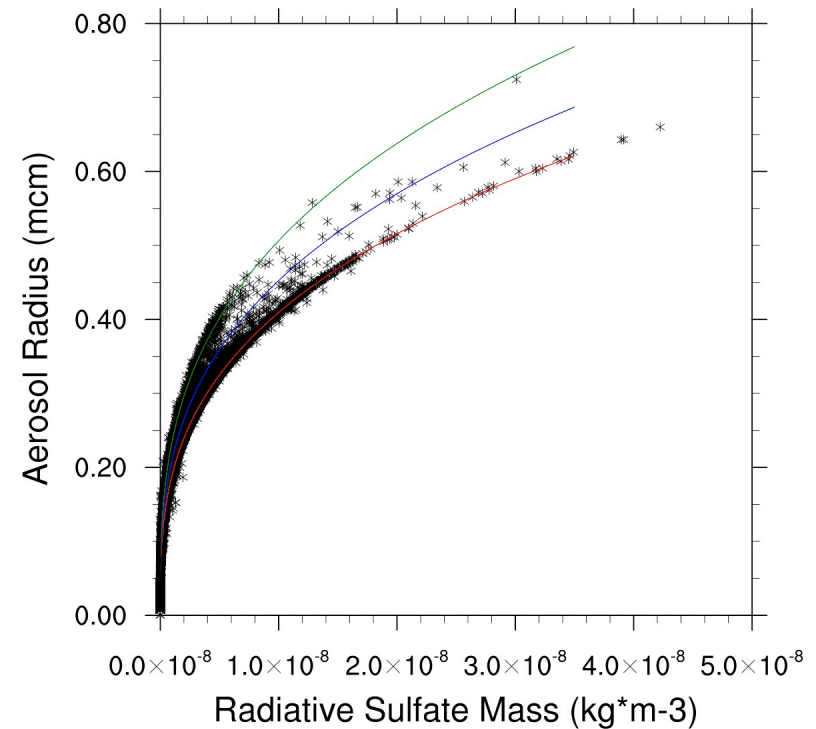
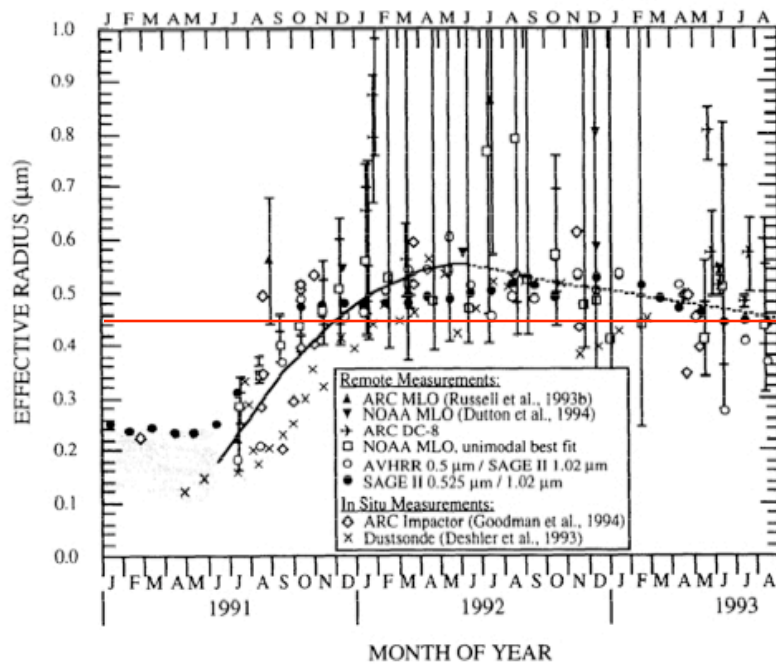


Currently LW >> SW heating

- based on wide distribution
- Narrower width will reduce this issue



# Prognostic Volcanic Aerosol Radii

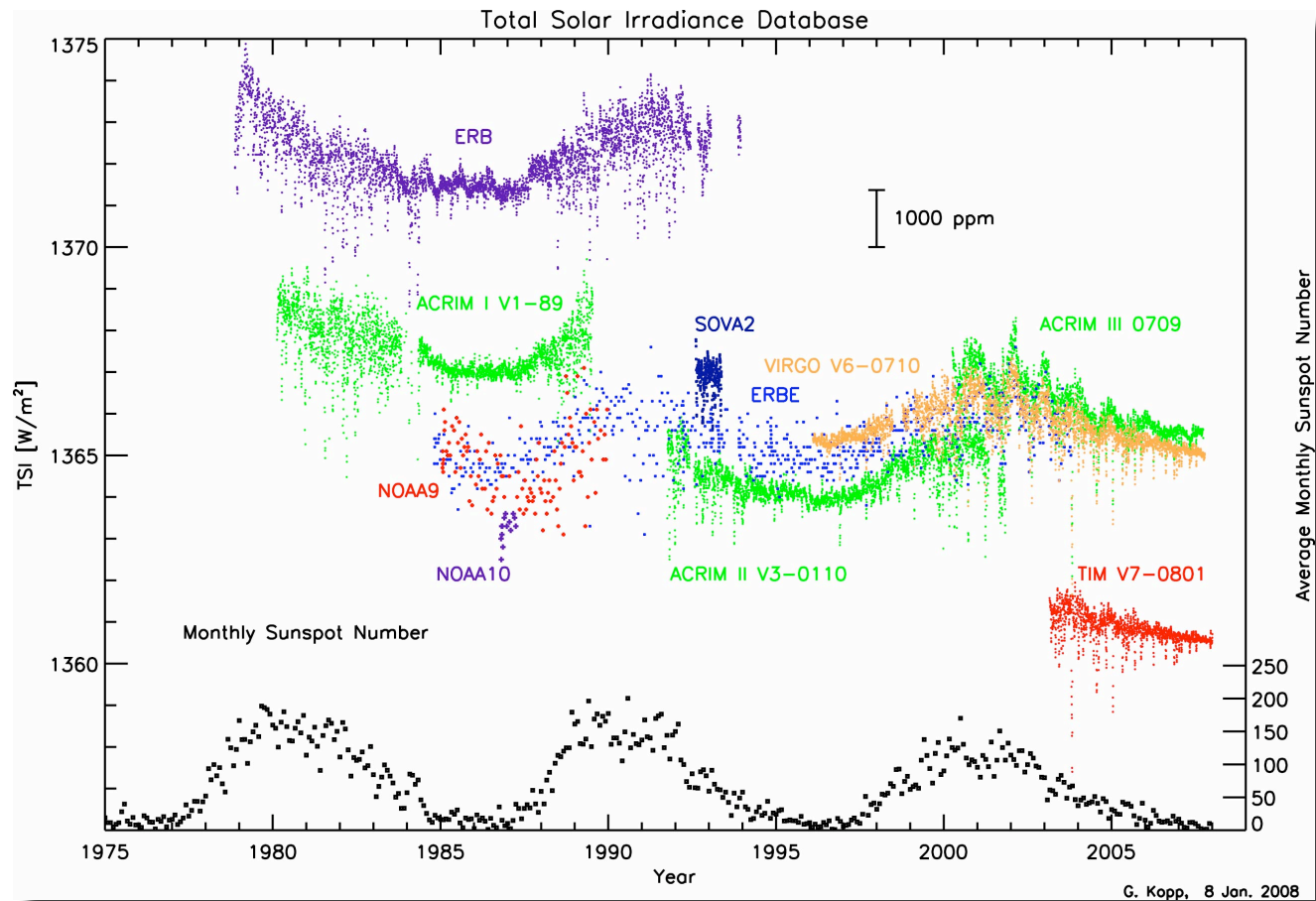


Russell: Observed aerosol show evolution

Simple Mass-concentration driven parameterization (calibrated against SAGE-derived particles in WACCM)

# Observations Total Solar Irradiance

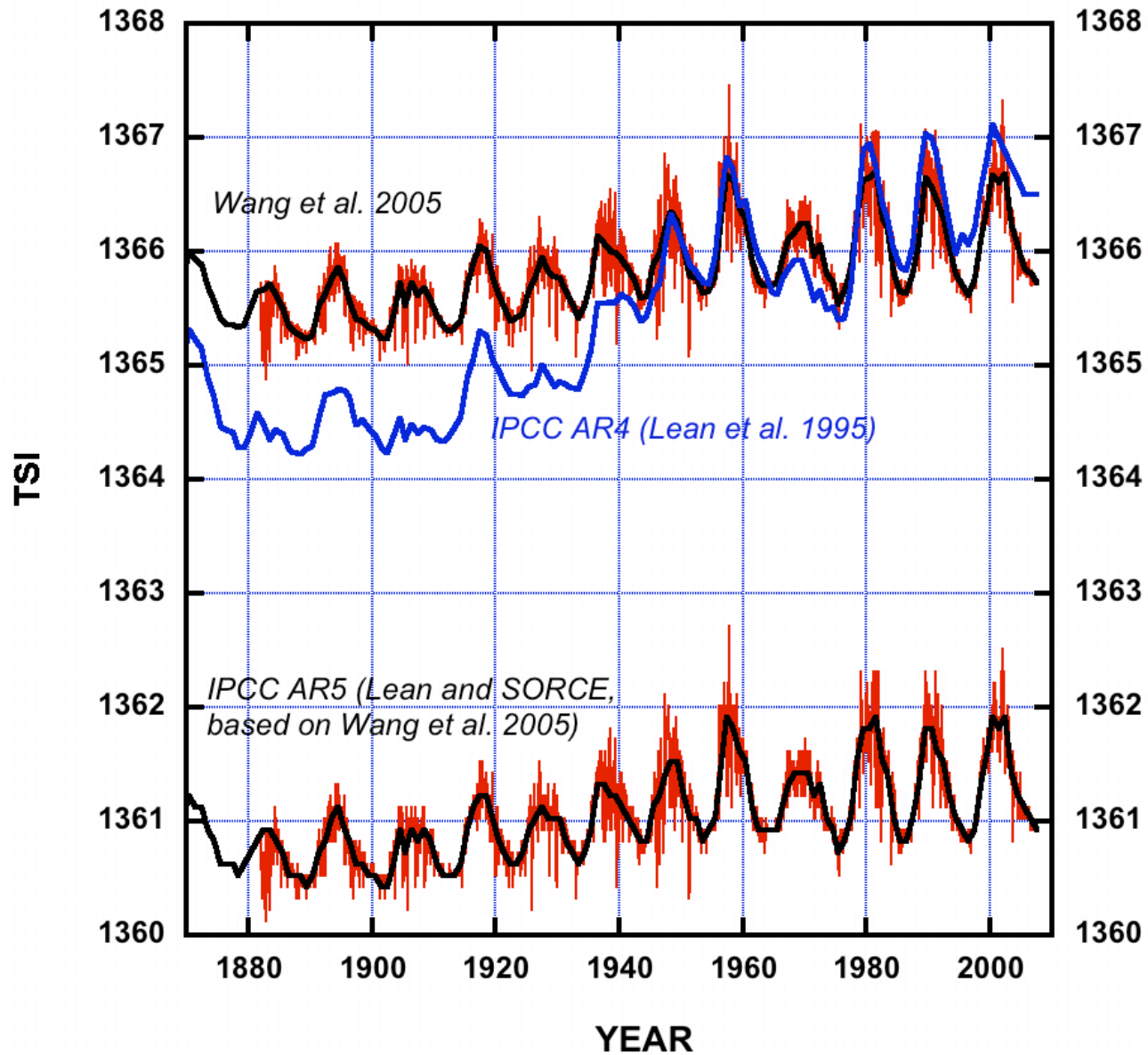
New TSI Level:  $1361 \text{ Wm}^{-2}$



Curtsey: G. Kopp, LASP

# Total Solar Irradiance

## TSI-level and trends



Smaller Trend!

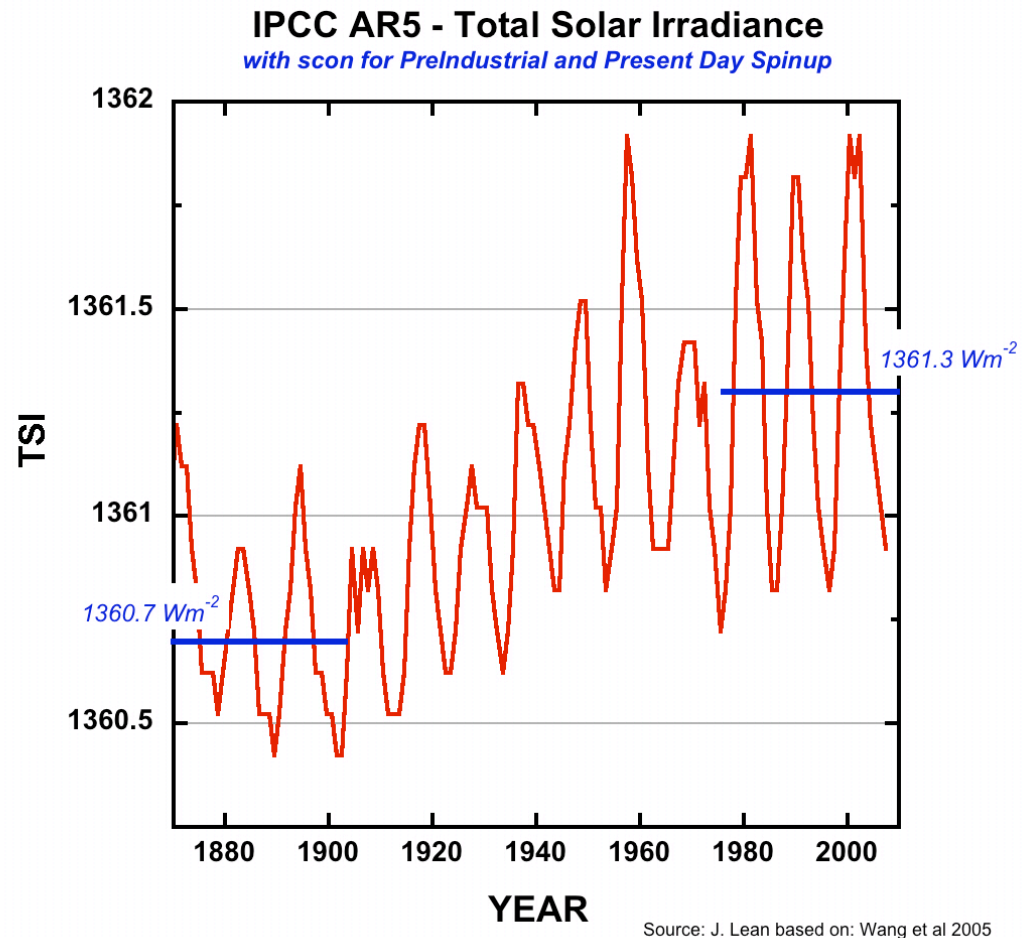
New TSI Level



# SCON (TSI) for CCSM4 spinups?

Suggested TSI ( $W/m^2$ )

- Single spinup: 1361
- Present: 1361.3
- PreInd: 1360.7





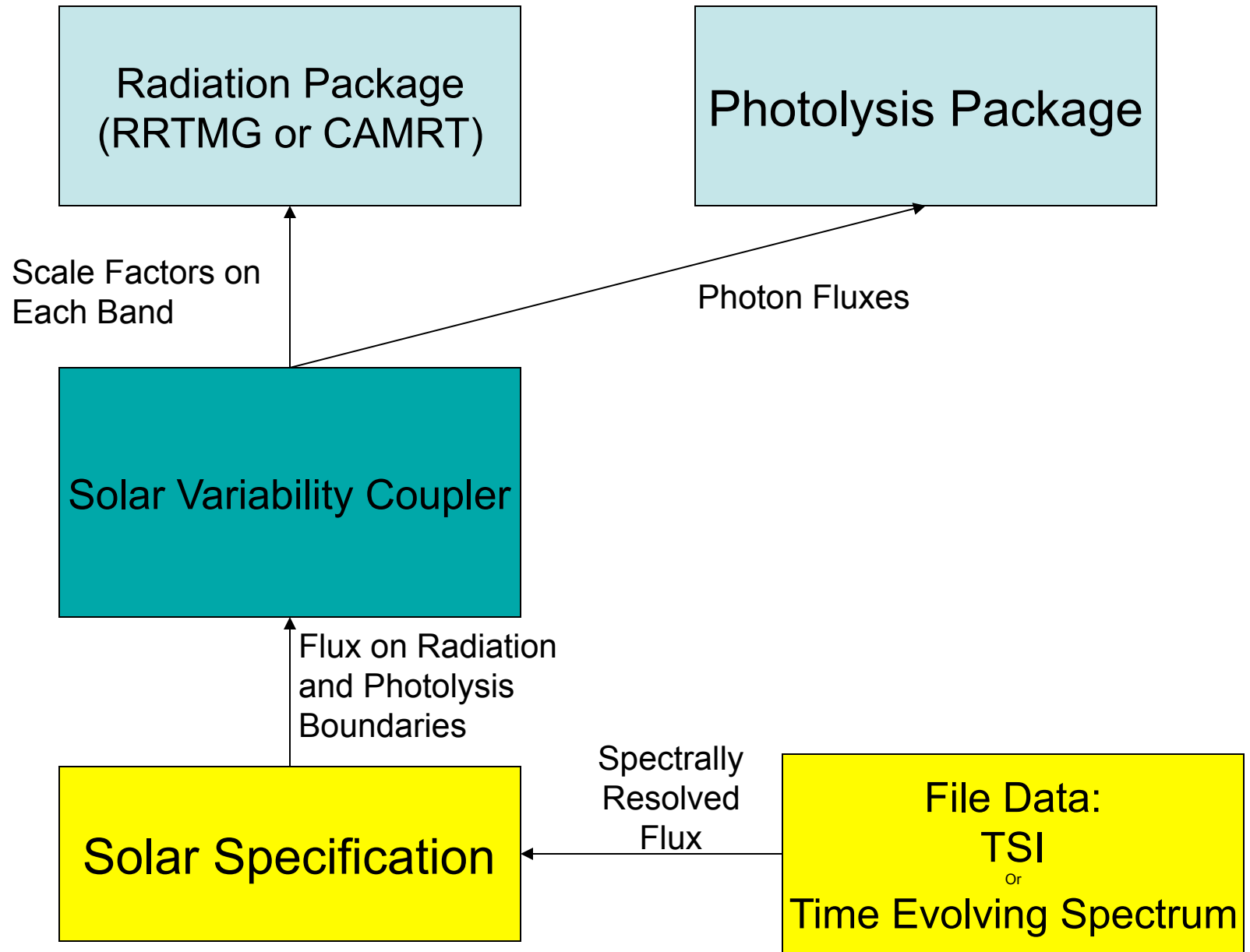
# Options to include Solar Forcing

- Status Quo: TSI change without spectral range
- Advanced: TSI+spectral but no ozone feedback
- Most realistic: TSI+spectral change and modulated ozone climatology based on WACCM predicted.

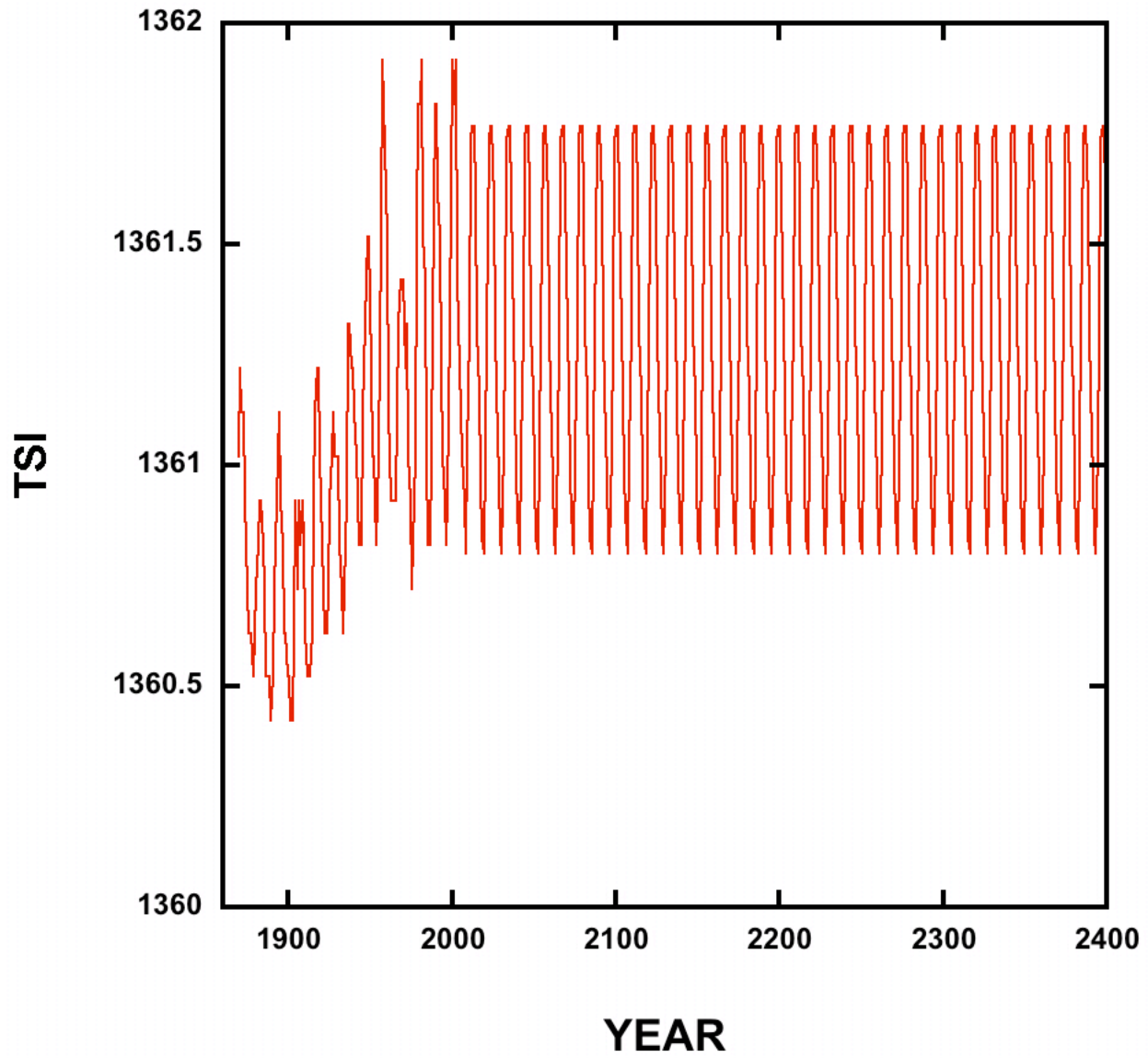
# Options to include Solar Forcing ready for CCSM testing

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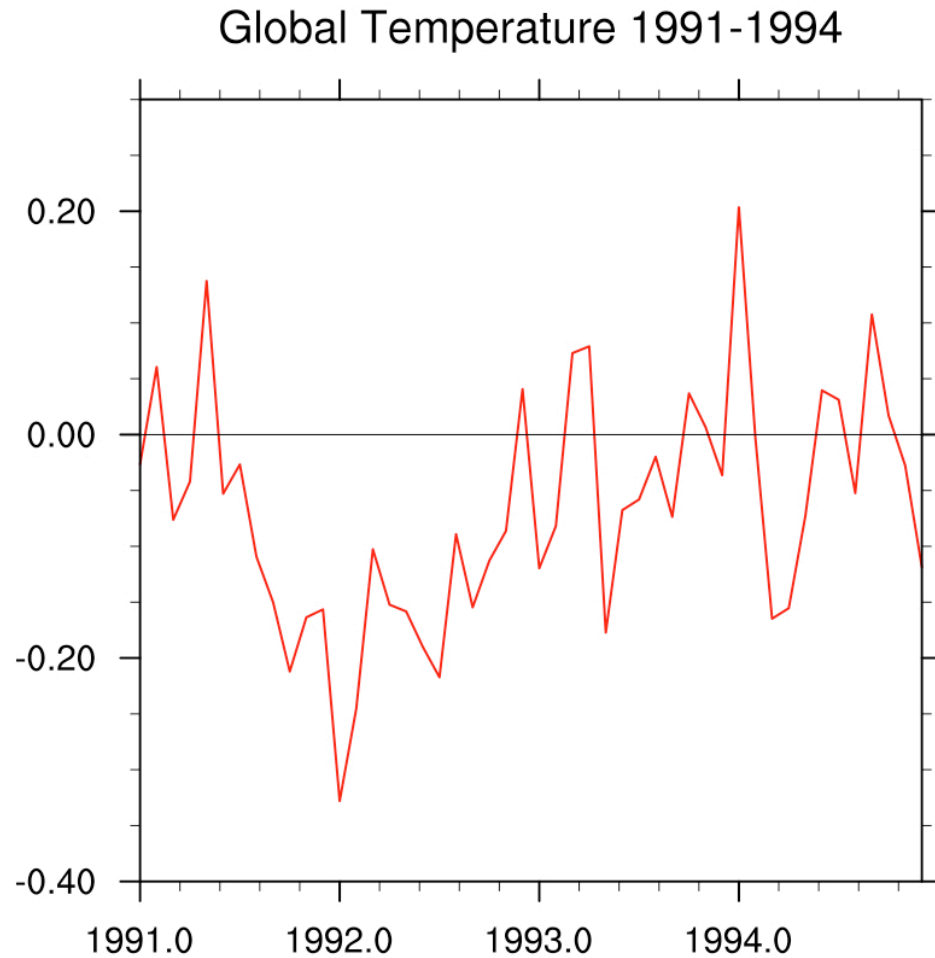


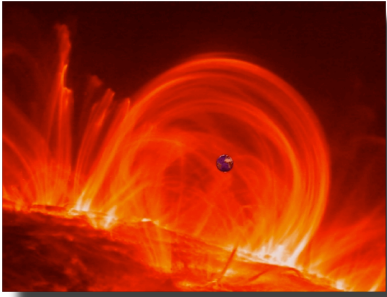
# Total Solar Irradiance for CCSM4 for 1860-2400





# Surface Temperature (Run with observed SSTs)



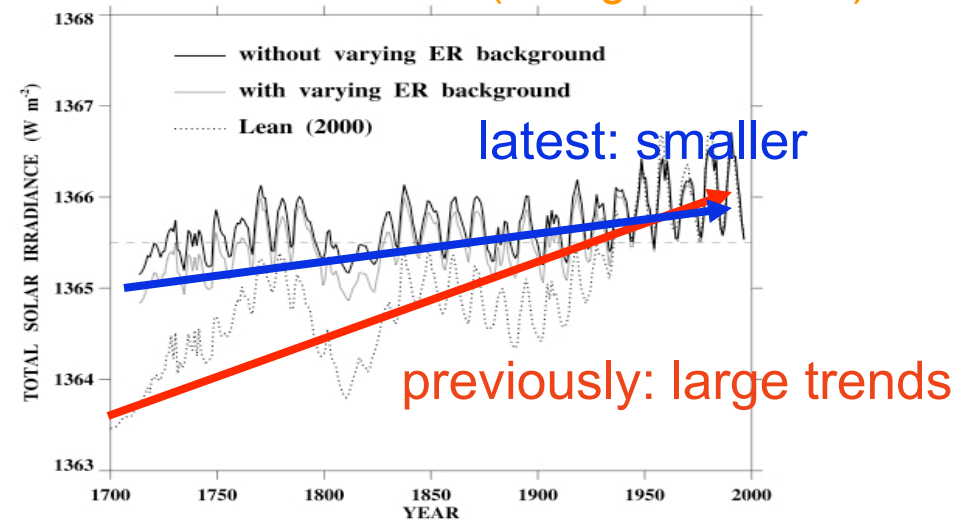


# Uncertain Scaling (but not phase) Models and $^{10}\text{Be}$ derived solar variability

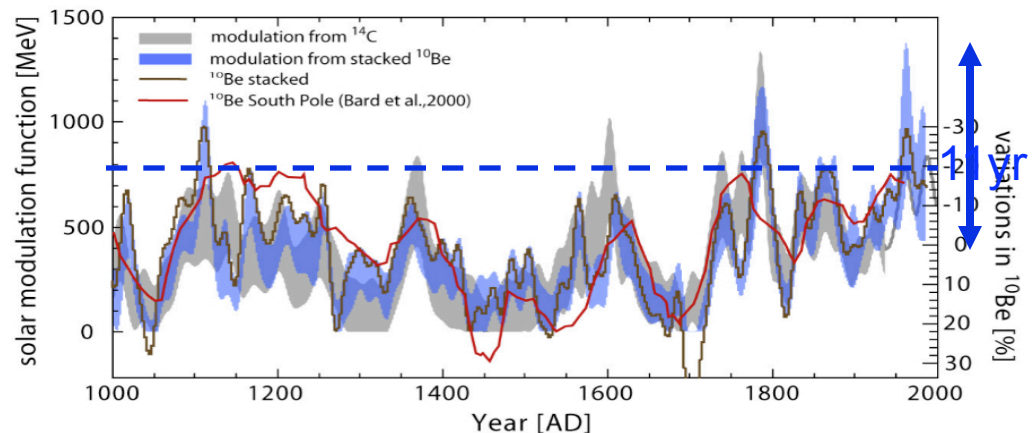
11-year cycle (measured from space:  
e.g. ACRIM, SORCE)

Century-scale:  
 $^{10}\text{Be}$  only slightly larger than  
11-year cycle? (Wang et al. 2005,  
Muscheler et al., 2007...)

## Solar Irradiance Models (Wang et al.2005)



## $^{10}\text{Be}$ Reconstructions (Muscheler et al. 2007)





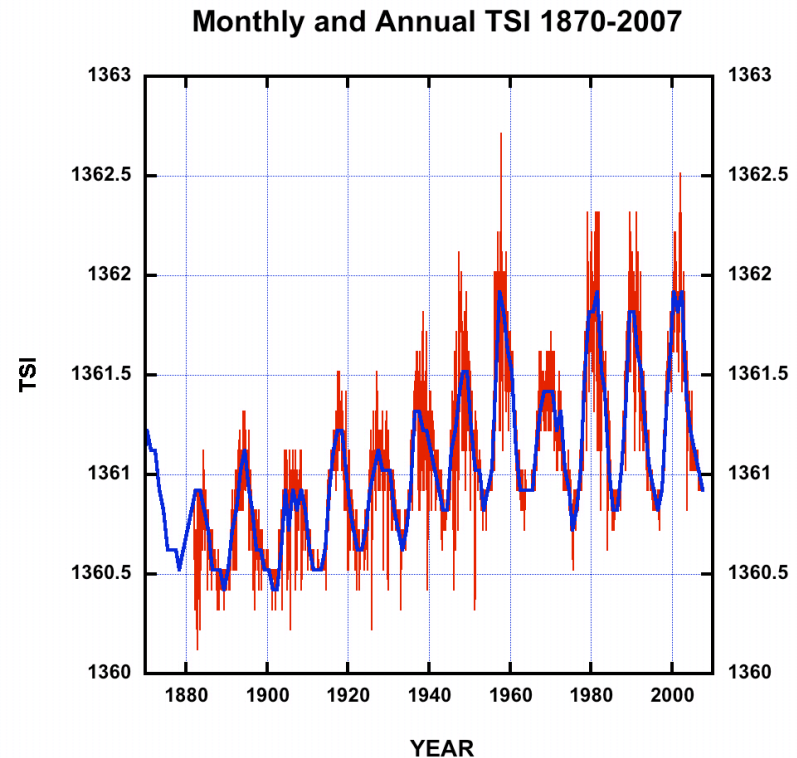
# Temporal Resolution of TSI

Standard IPCC:

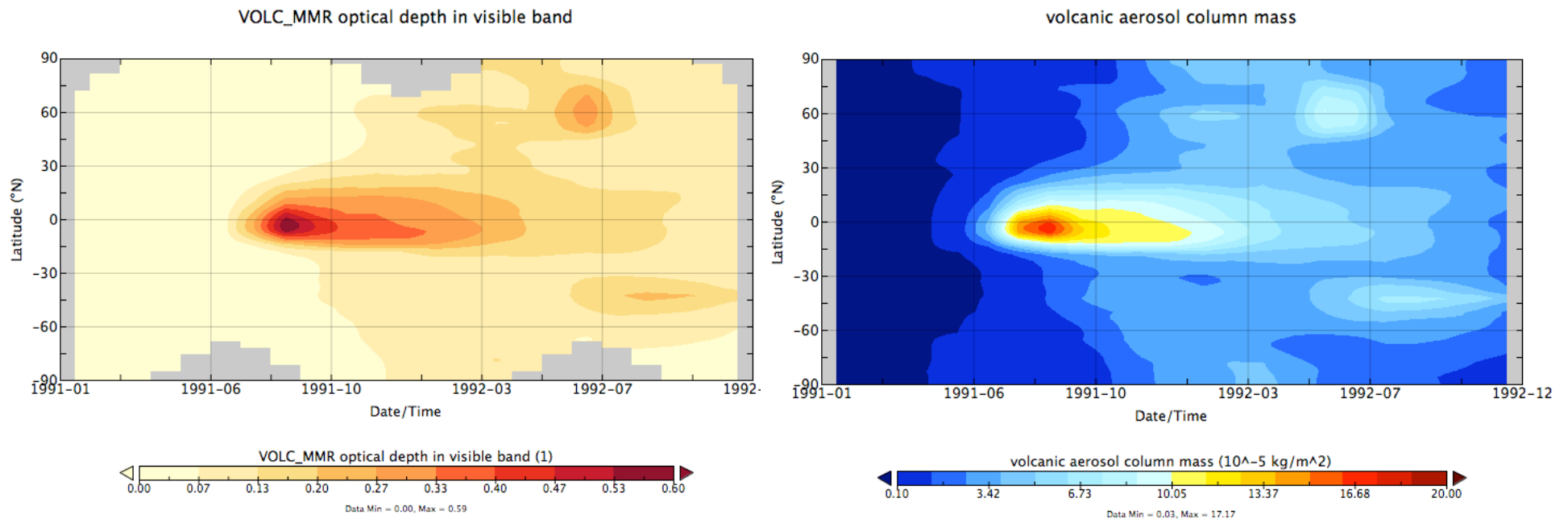
- TSI annual (AR4)
- TSI annual smaller trend (AR5)

Capability:

- Monthly solar irradiance
- Time varying solar spectrum
- Coupled/param. ozone



# Volcanic Visible Optical Depth and Column Loading

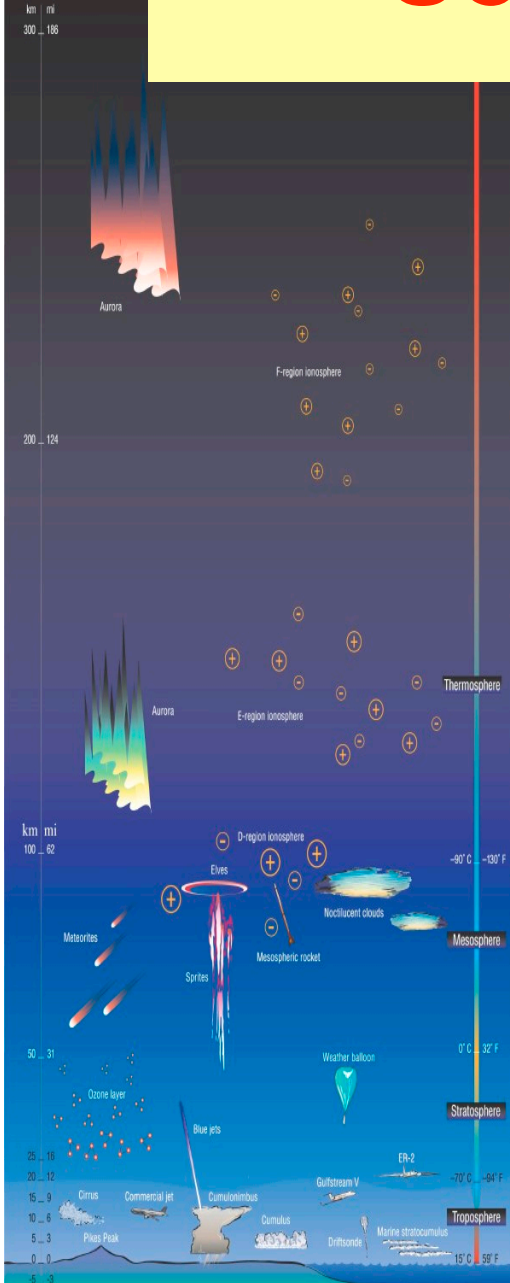


Overall pattern: Ok

Mid-high-latitudes: looks good

Tropics: too much mass -> optically too thick

# Solar Forcing in CCSM



**TSI\_only**  
*AR4*  
*feedback*

**Spectral\_only**  
*pure solar cycle*

**Spec+TSI**  
*solar input*

**Spectral TSI + Ozone**  
*solar +*

