

Solar Impact on Climate: Is it Important?



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Solar Impact on Climate: Is it Important?

The latest report from the **IPCC** consider only changes in **solar irradiance** as a possibility, and estimate solar forcing from 1880 to present to be 0.05 W/m^2 .

In this picture Solar influence on climate change is completely negligible.

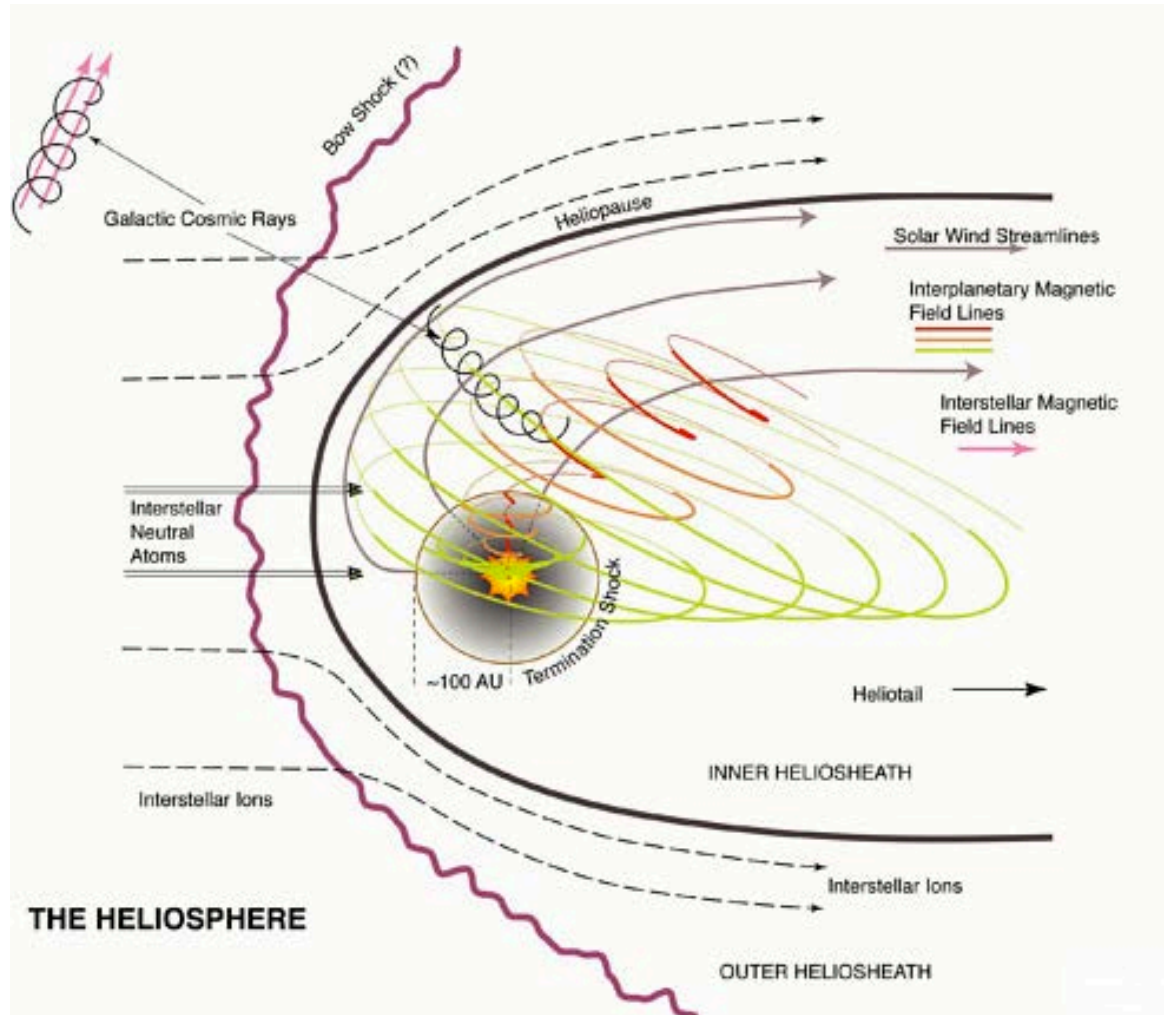
(Forcing from CO_2 is estimated to 1.7 W/m^2)

Further the latest IPCC 1.5 report suggest that all the temperature increase since 1880 is anthropogenic

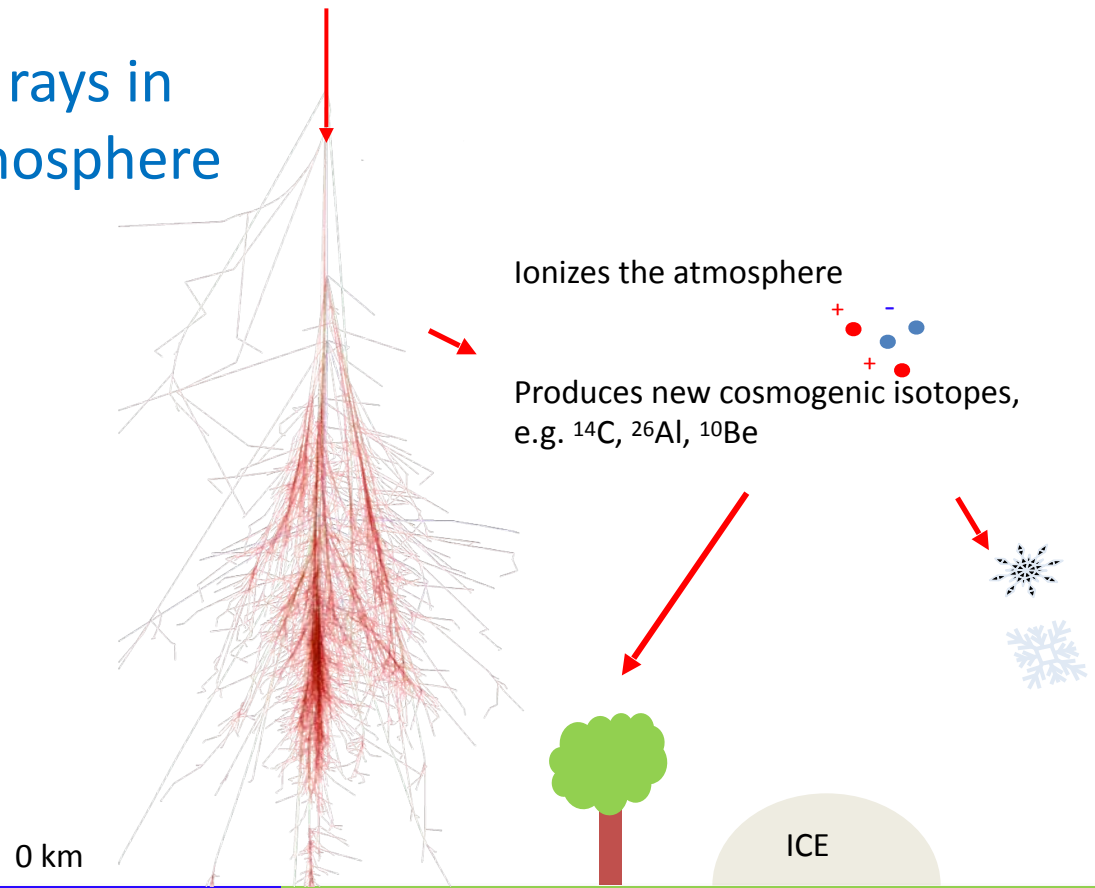
Super Nova



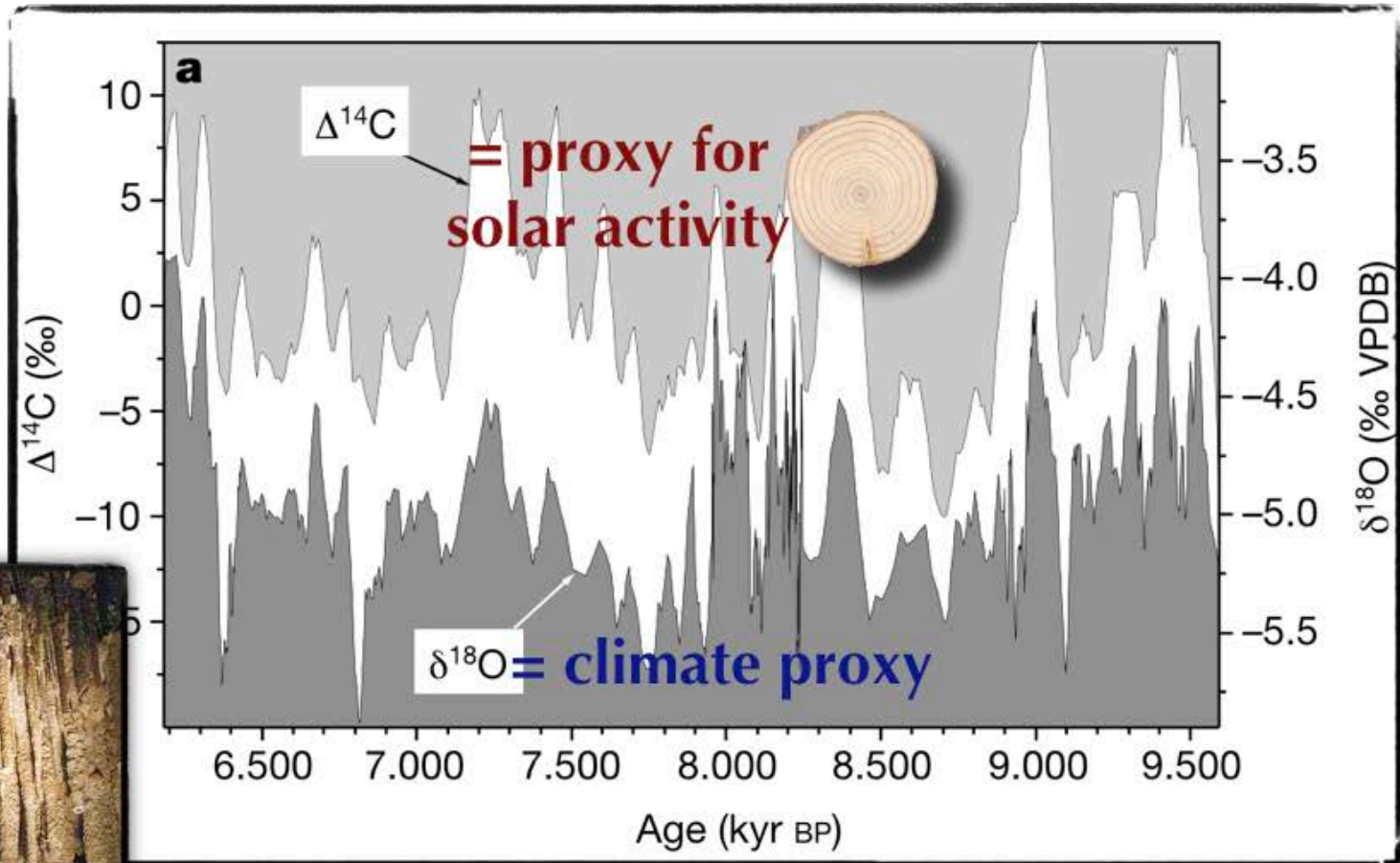
Heliosphere, Cosmic Rays and Solar Activity



Cosmic rays in the atmosphere

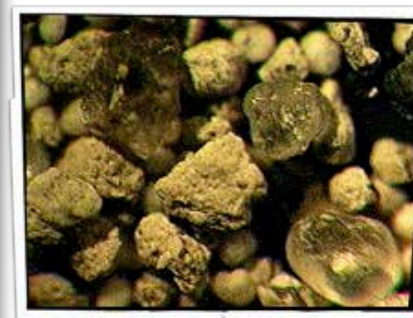
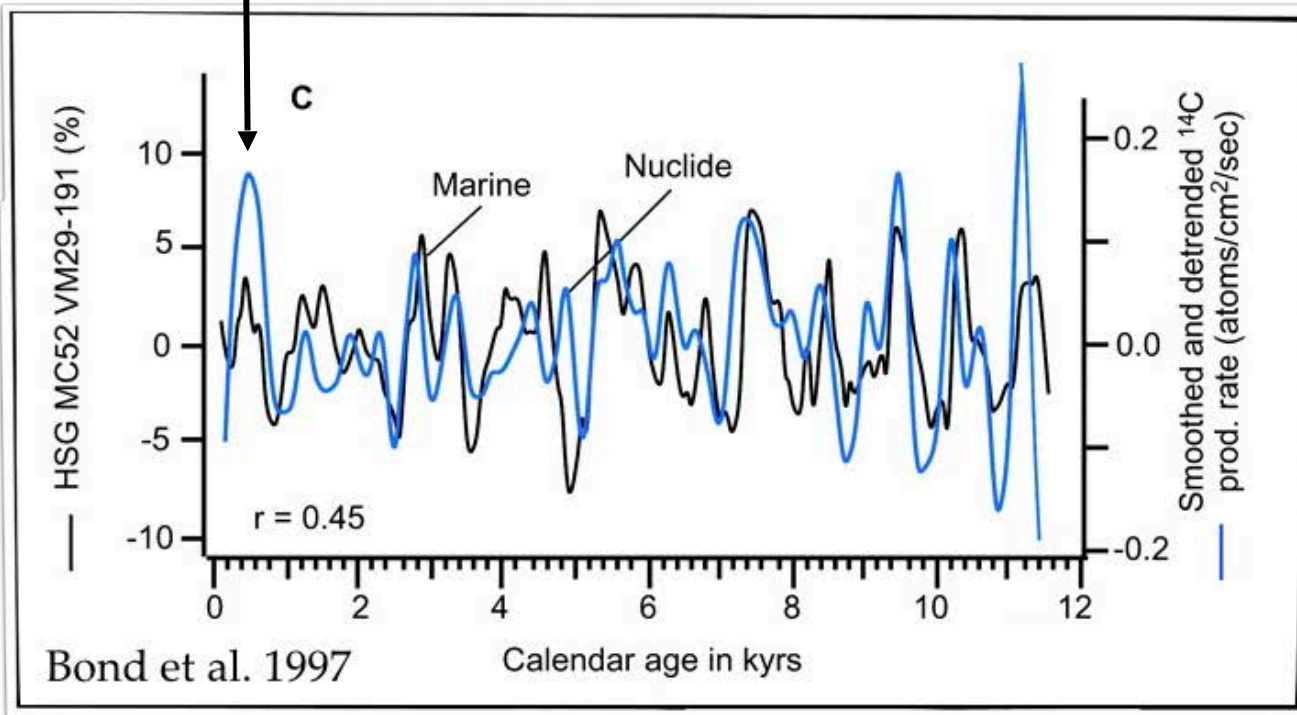


The link over several millennia



The link over several millennia

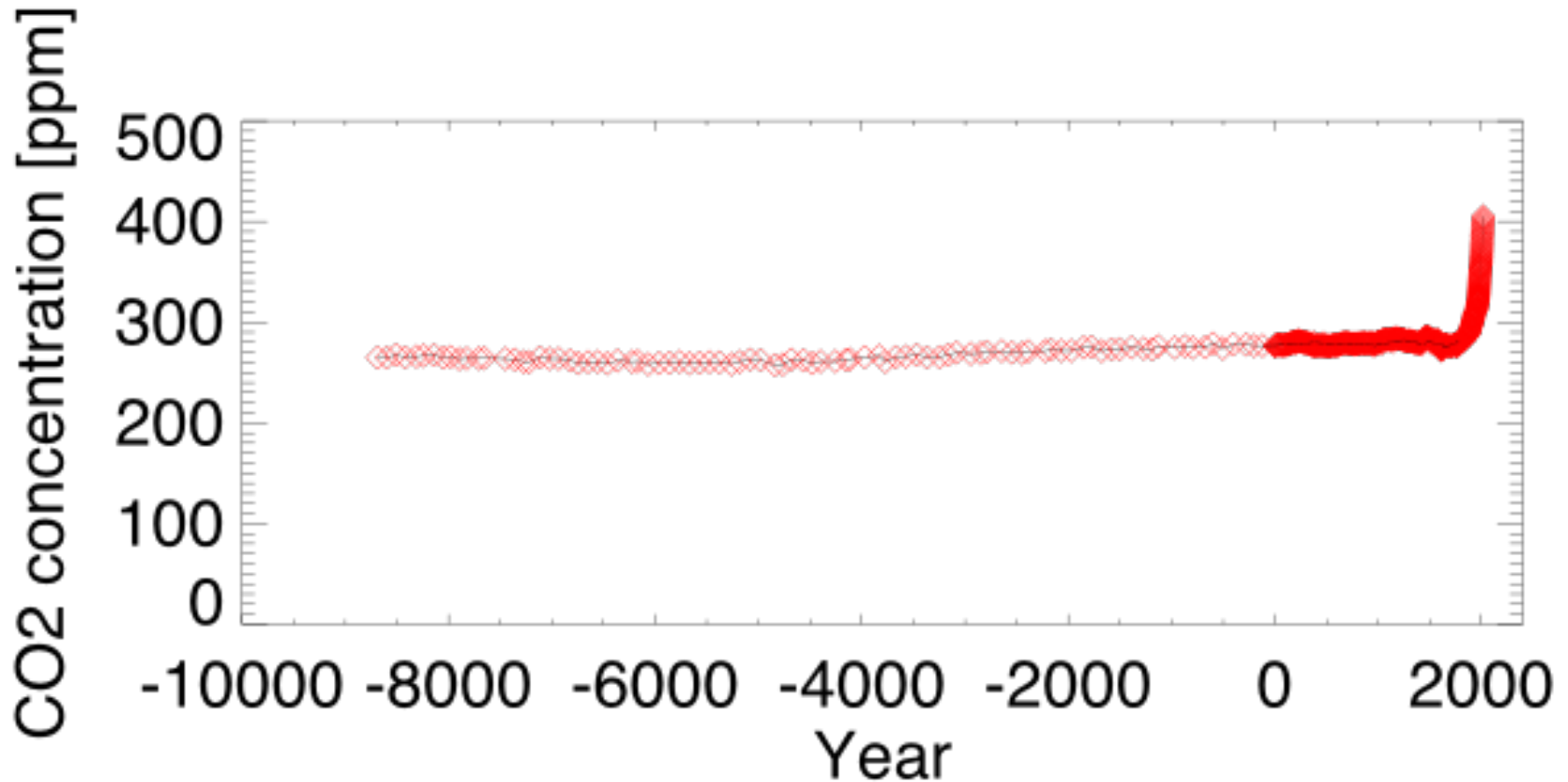
Little Ice Age



Present

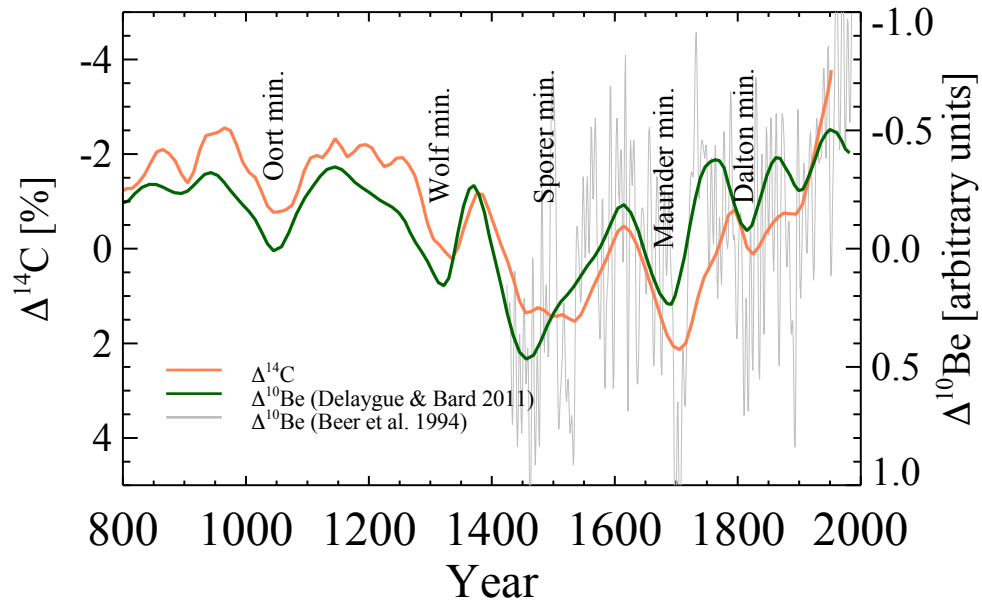
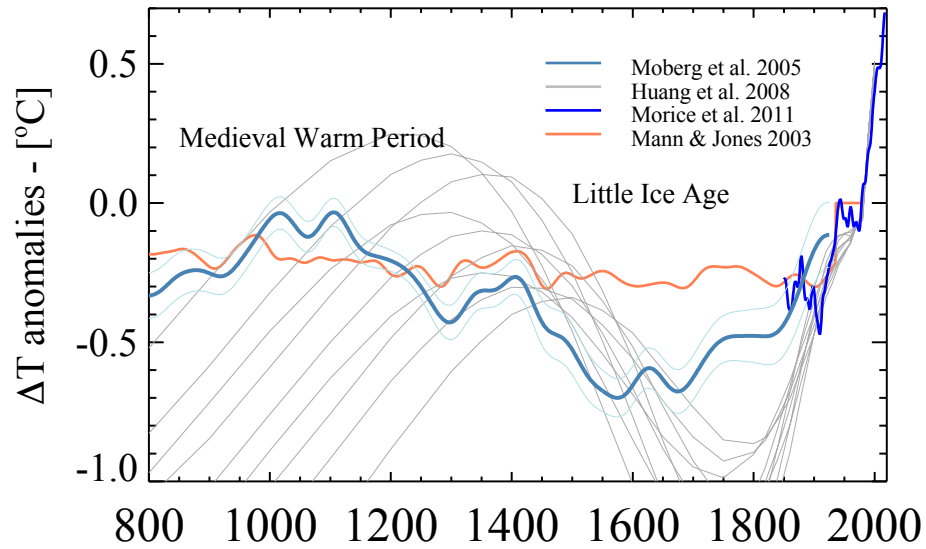


CO₂ concentrations during the last 10.000 years



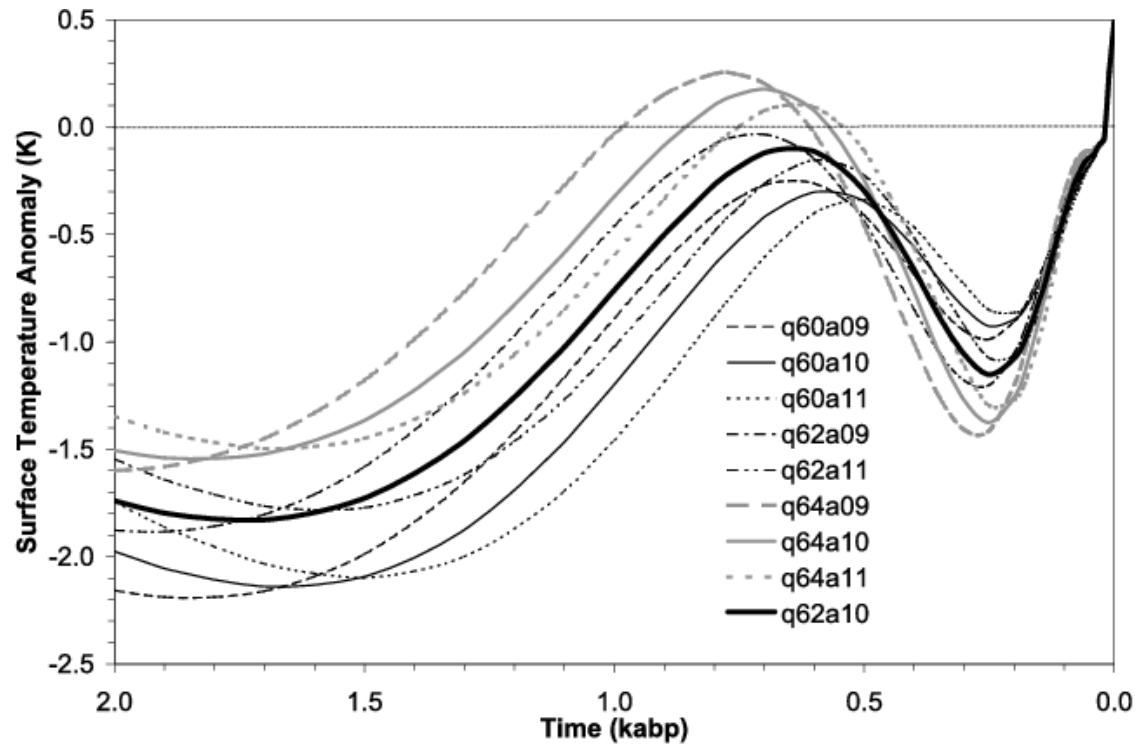
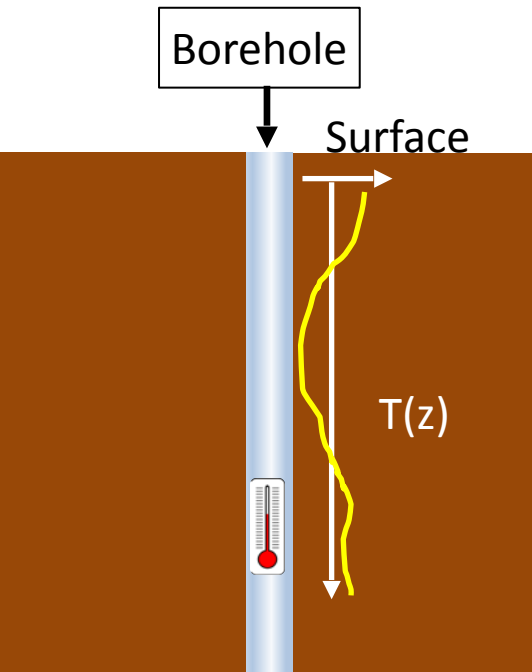
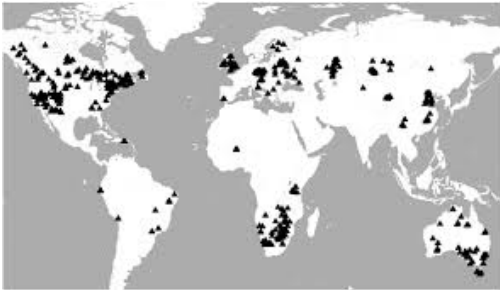
It suggest that CO₂ cannot have influenced climate during the last 10.000 year.
Only during the last part of the 20th century is there is a significant change

Climate and changes in solar activity AD 800 - 2000



Global climate change from borehole temperatures

Measurements from all continents



S. P. Huang, H. N. Pollack, and P.-Y. Shen, 2008

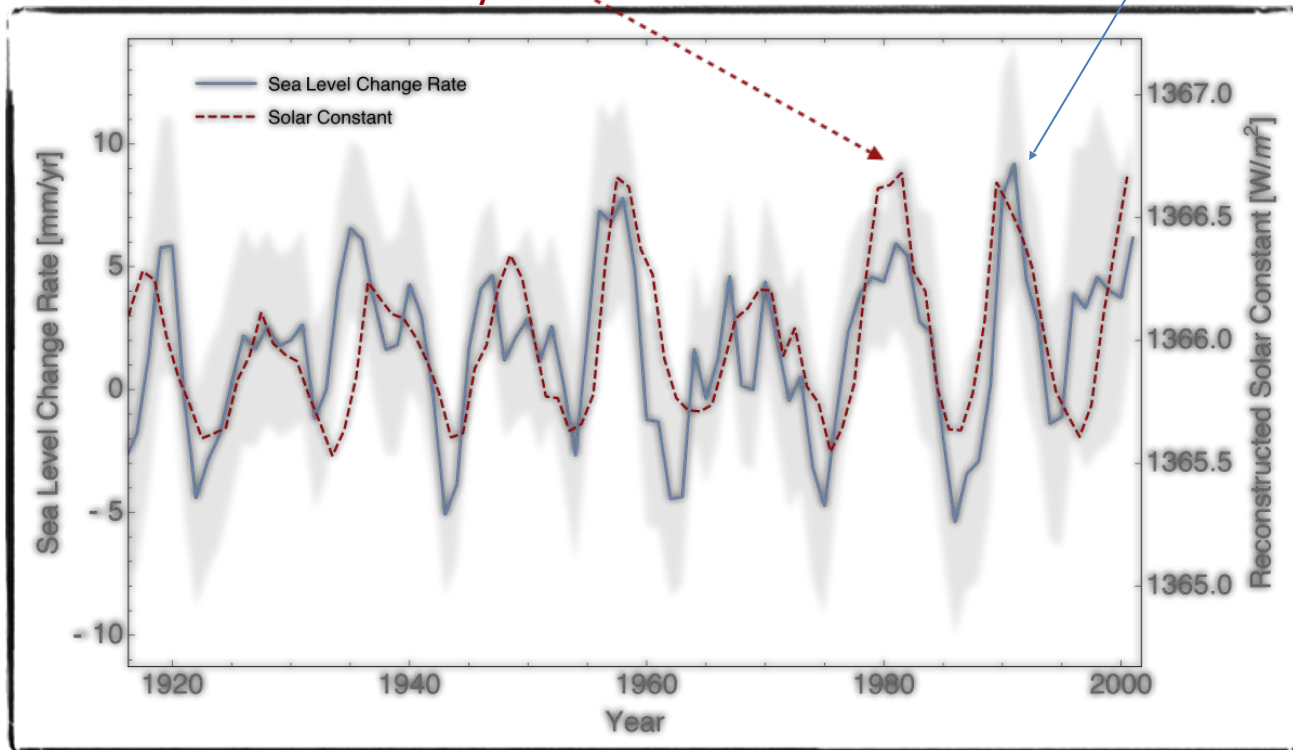
Quantifying the Solar Link over the 11-year Cycle



Solar Activity

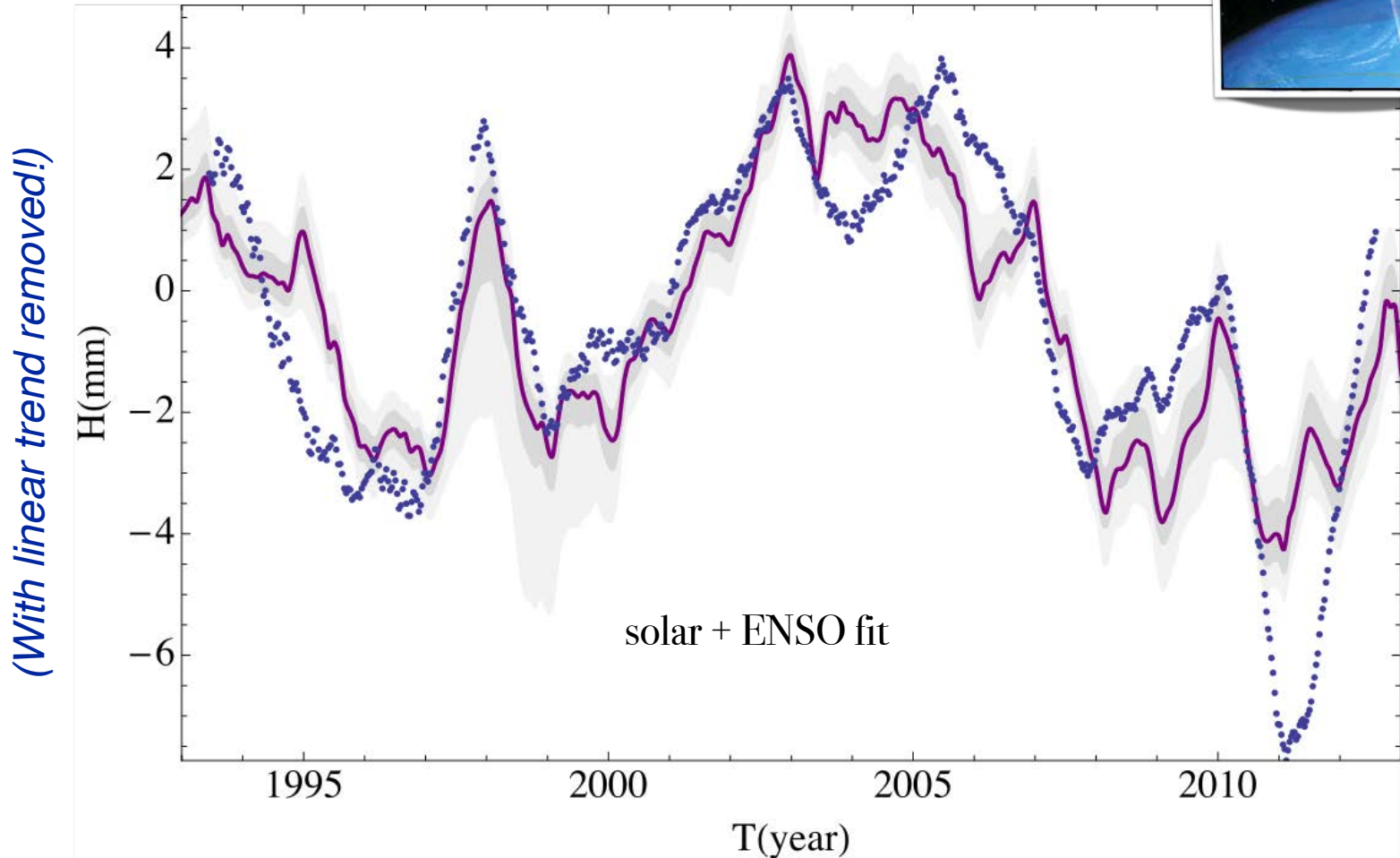


Sea Level Change Rate

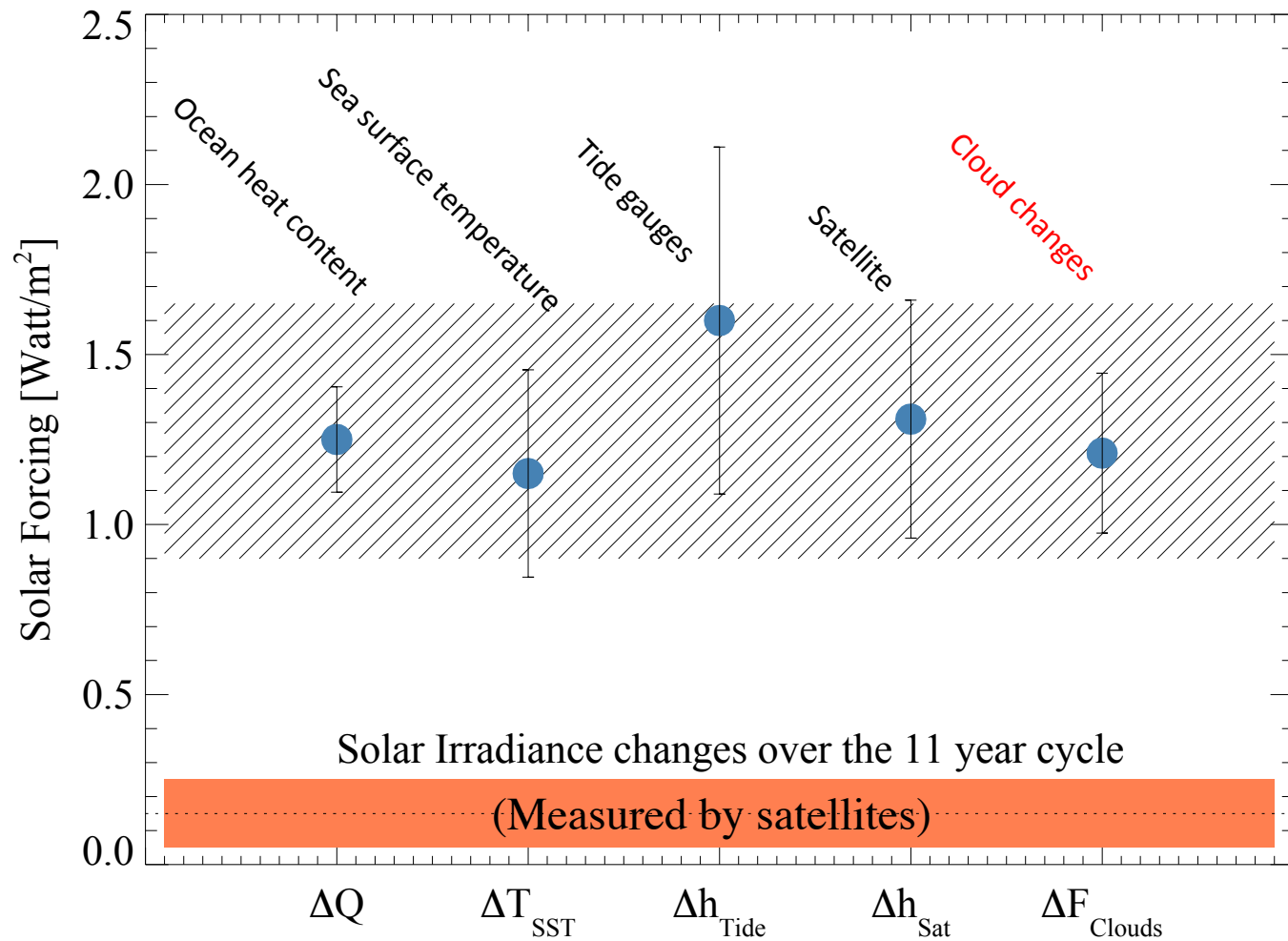


Using the oceans as a calorimeter

Satellite Altimetry



Forcing of climate over the 11-years solar period



Something is amplifying Solar activity. Clouds are a candidate



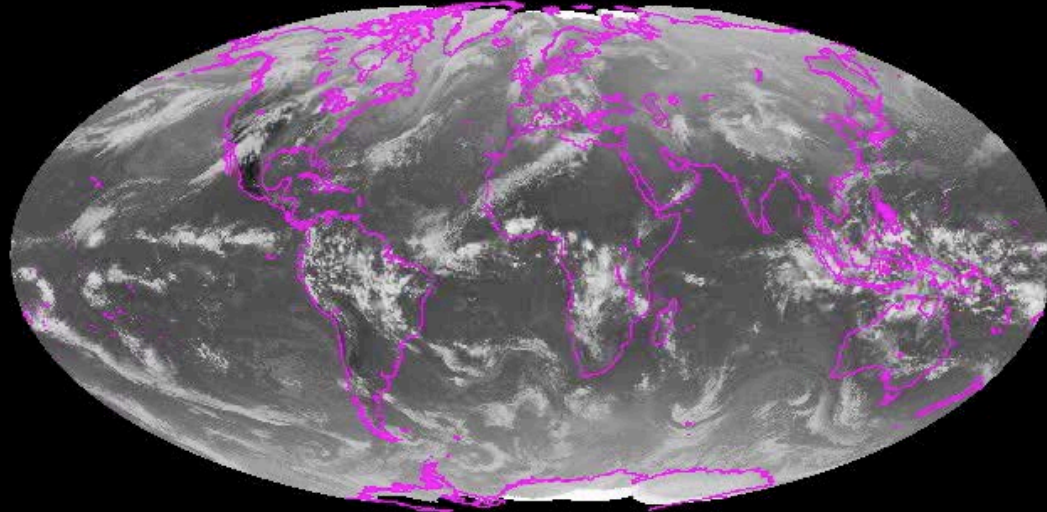
Summary

A significant impact of solar activity on climate is apparent

- Large changes in global climate varying in agreement with solar activity (1-2°C) during the last 10.000 years.
- CO₂ **cannot** explain these variation over most of this period.
- Solar activity is **amplified** so that the forcing is almost 10 times larger than from solar irradiance alone (over the 11-years period forcing 1.0-1.5 W/m² is determined from the energy entering the oceans)

How can cosmic rays influence climate?

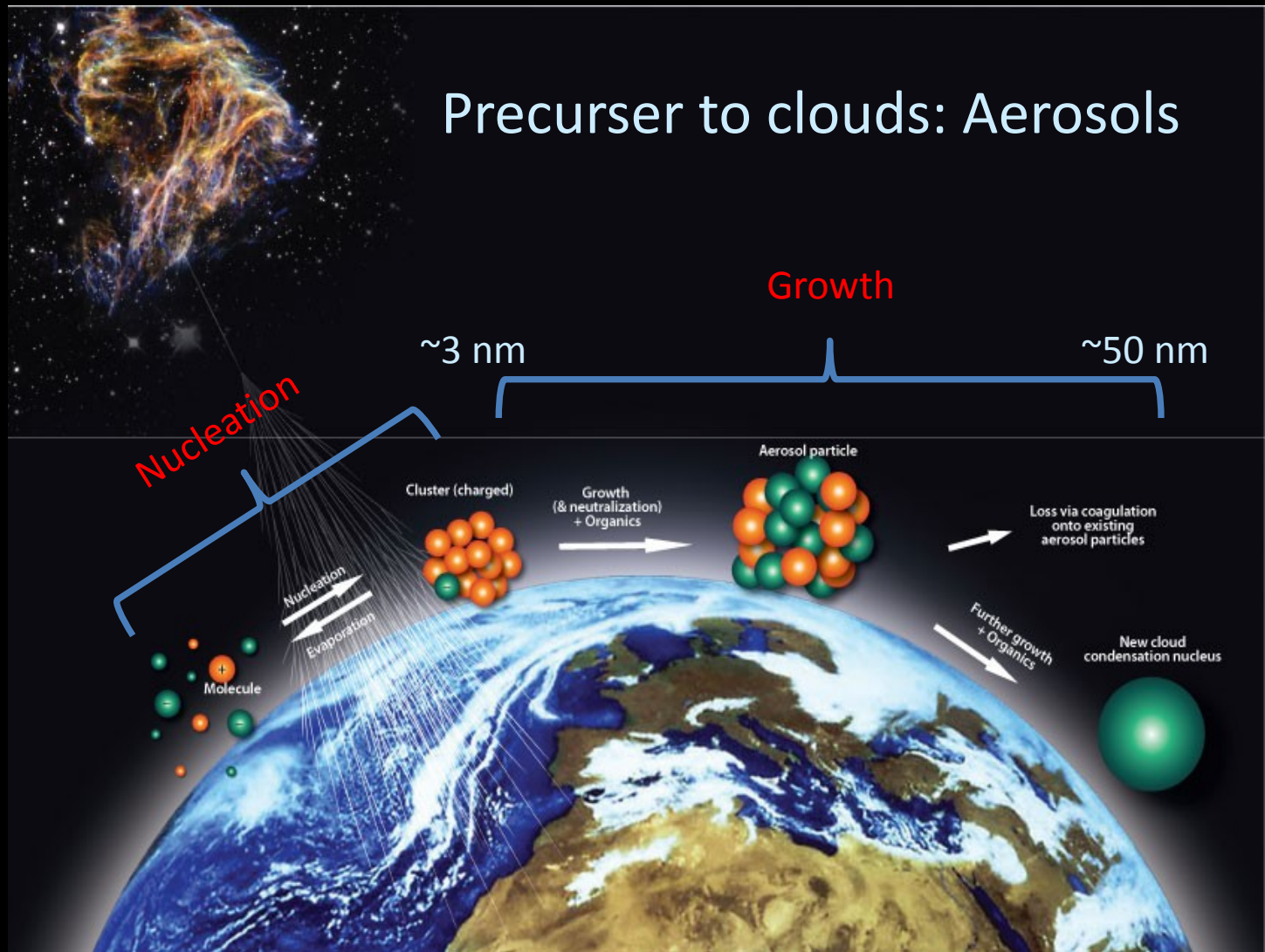
INFRARED COMPOSITE FROM 21 MAR 07 AT 21:00 UTC (SSEC:UW-MADISON)



1 INFRARED COMPOSITE FROM 21 MAR 07 AT 21:00 UTC (SSEC:UW-MADISON) 10/10/07

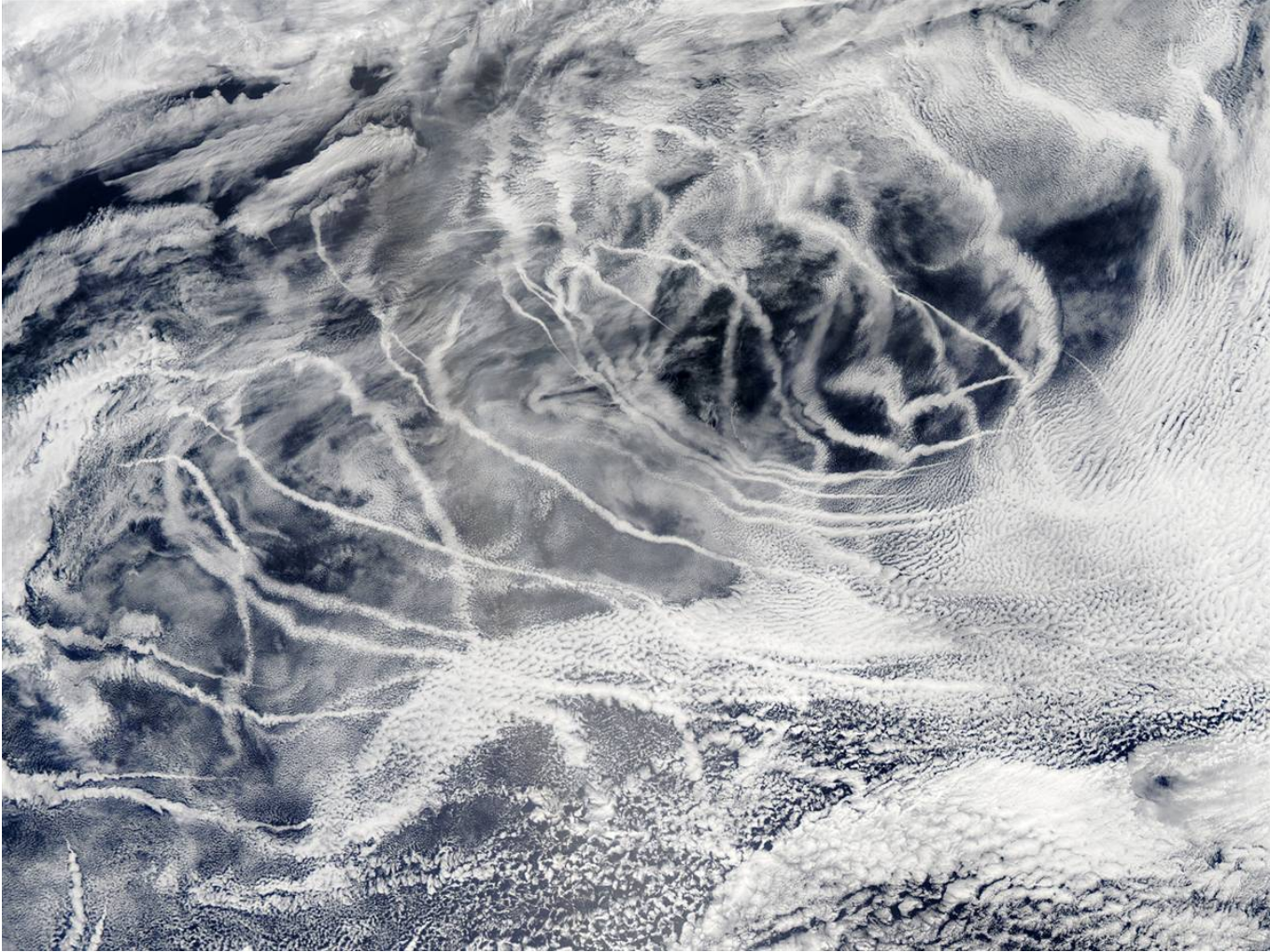
Net effect of clouds is to cool the Earth by about 30 W/m^2

Precursor to clouds: Aerosols



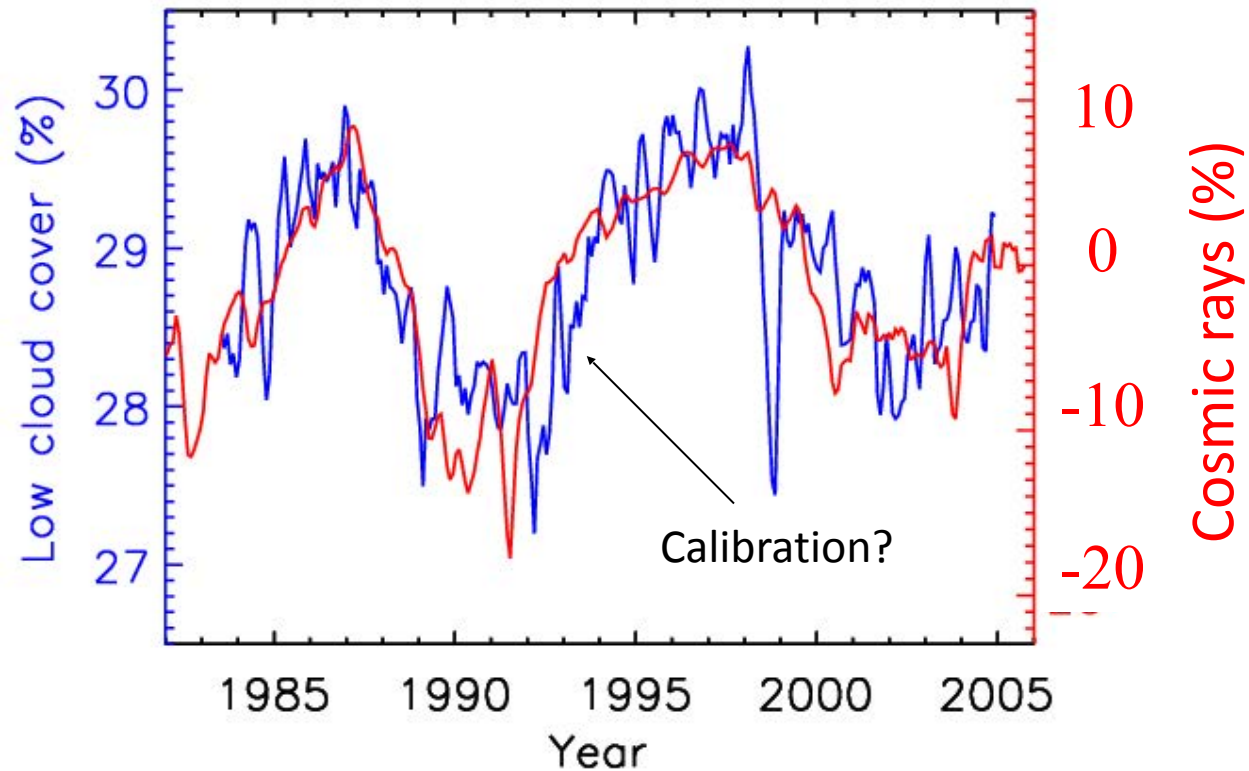
Aerosols and microphysics of clouds

Satellite observations of ship tracks



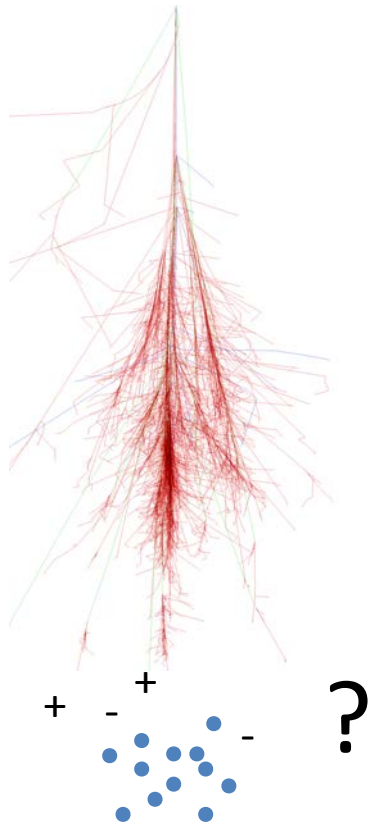
Link between Low Cloud Cover and Galactic Cosmic Rays? Solar cycle variation

ISCCP IR Low cloud data

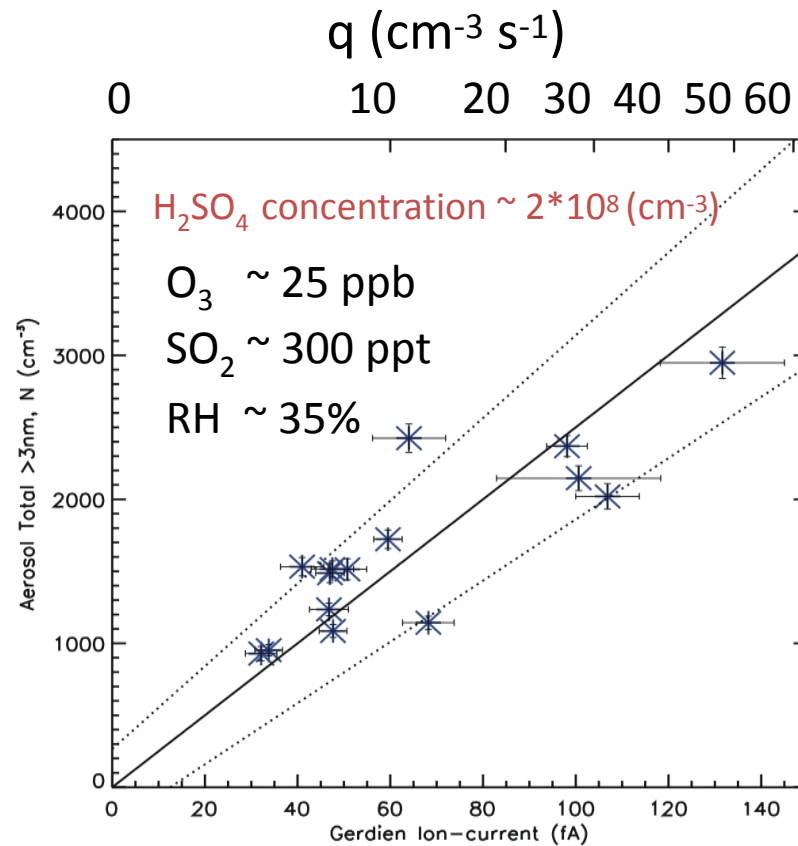


Svensmark & Friis-Christensen, JASTP 1997, Svensmark, PRL 1998, Marsh & Svensmark, PRL, 2000. (update 2005)

Experimental Work 2004 - 2007



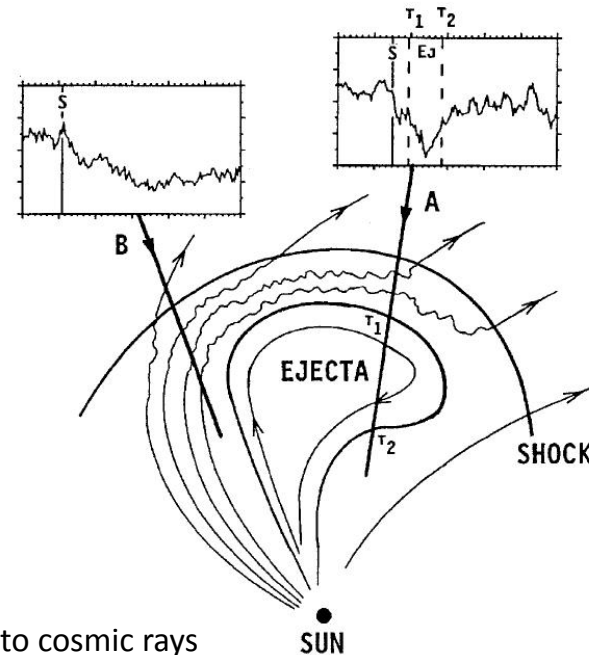
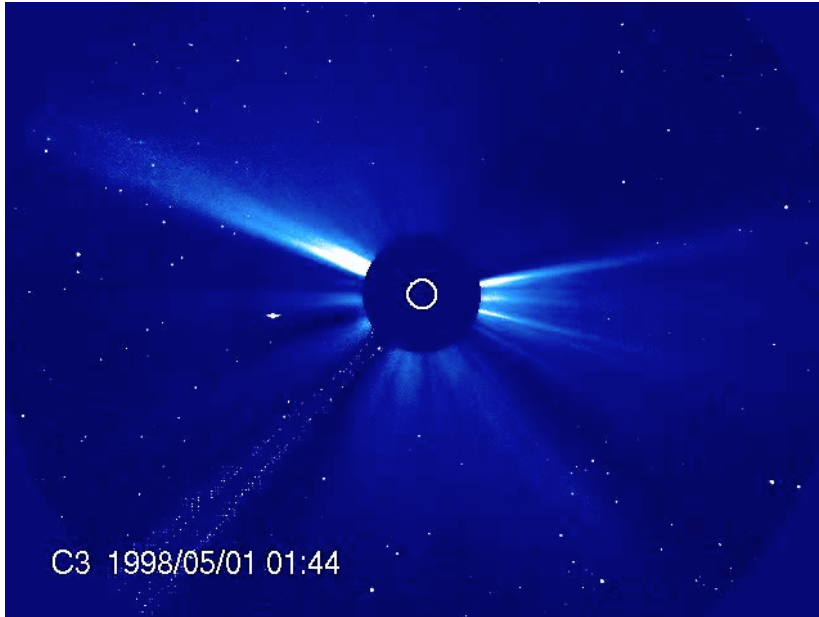
1-2 nm stable aerosols



Svensmark et al. Proc. R. Soc. A (2007) 463, 385–396

Coronal Mass Ejections

Natural experiments for testing the GCR-atmosphere link



We can observe the whole link from solar activity to cosmic rays to aerosols to clouds in the real atmosphere

AERONET, SSM/I, MODIS and ISCCP data for 5 strongest Forbush decreases

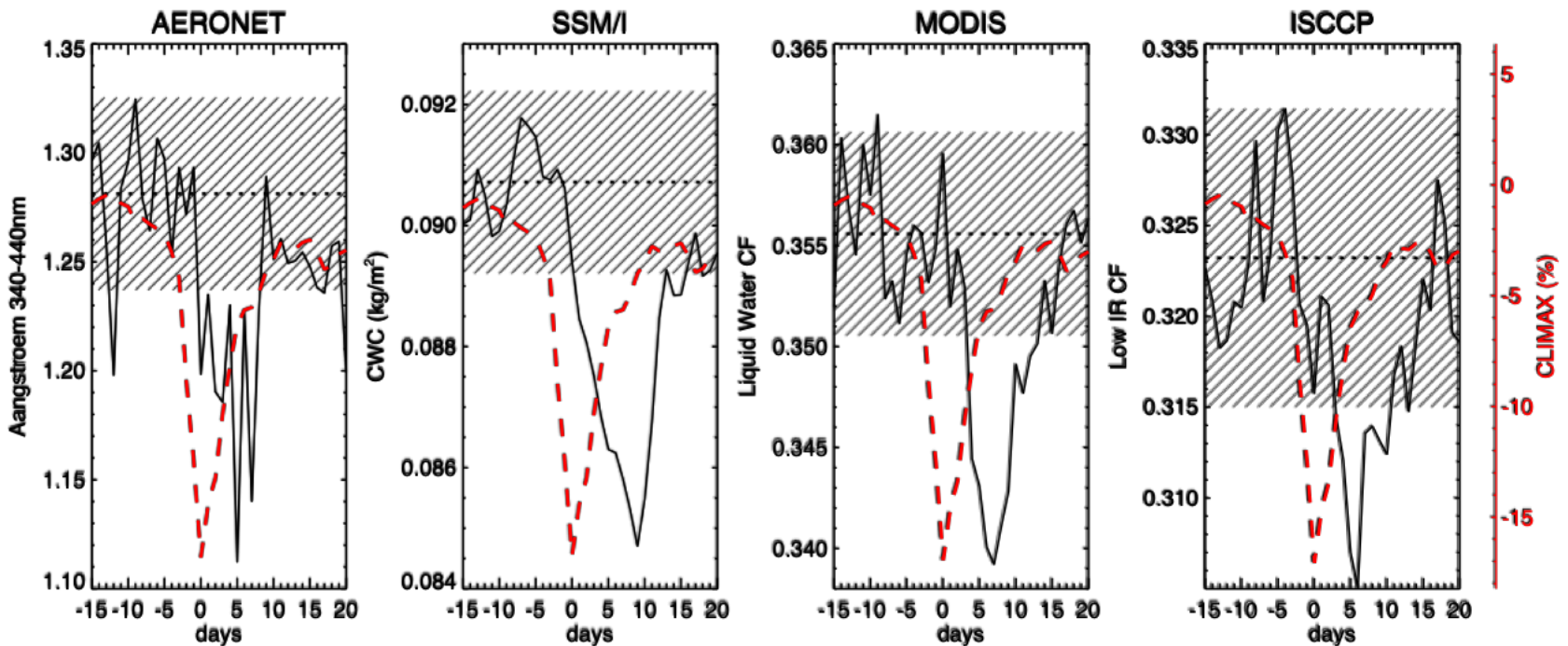
Aerosols

Clouds

Liquid water

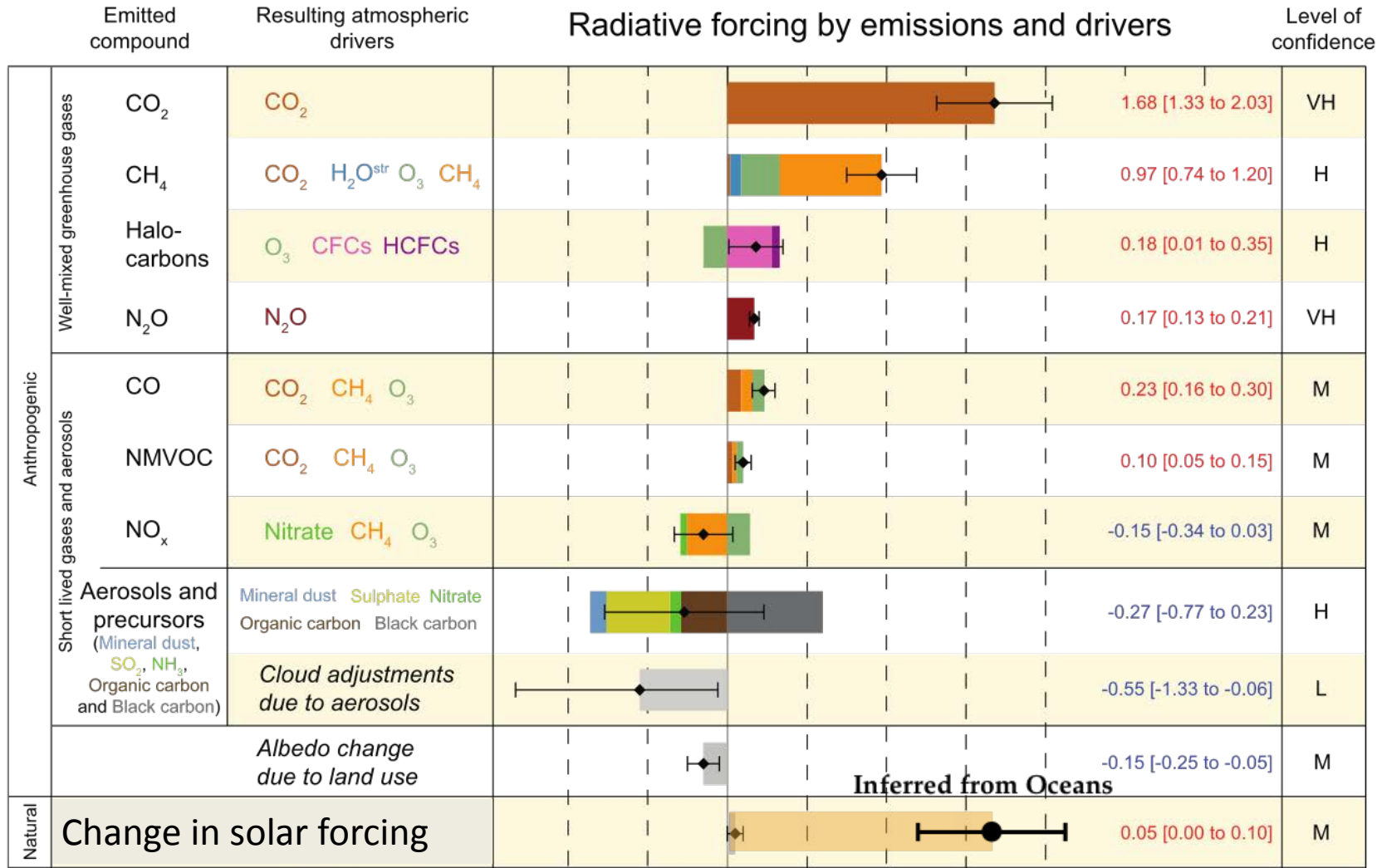
Liquid cloud fraction

Low Clouds



IPCC 5AR forcing graph

Solar forcing $F_{IPCC} = 0.05 \text{ W/m}^2$



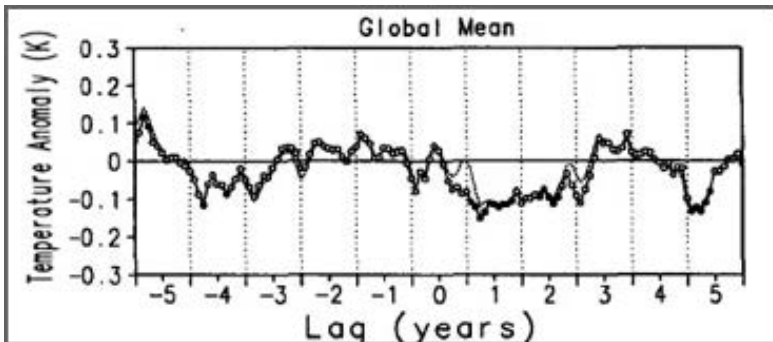
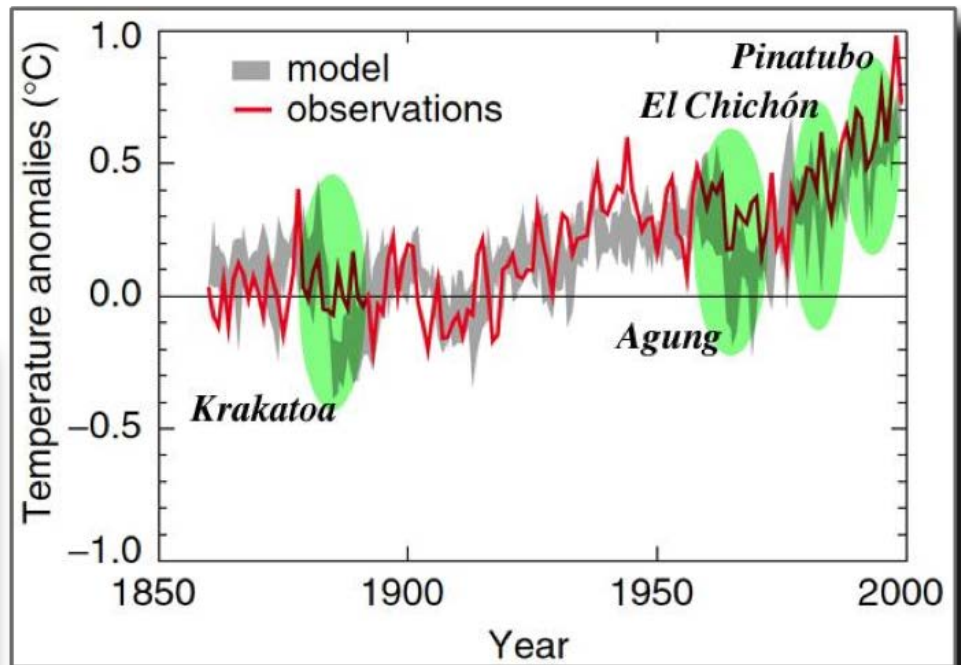
Since Maunder Minimum

Evidence that climate sensitivity is small

- *Computer model response to volcanoes is too large!*



Robock and Mau 1995

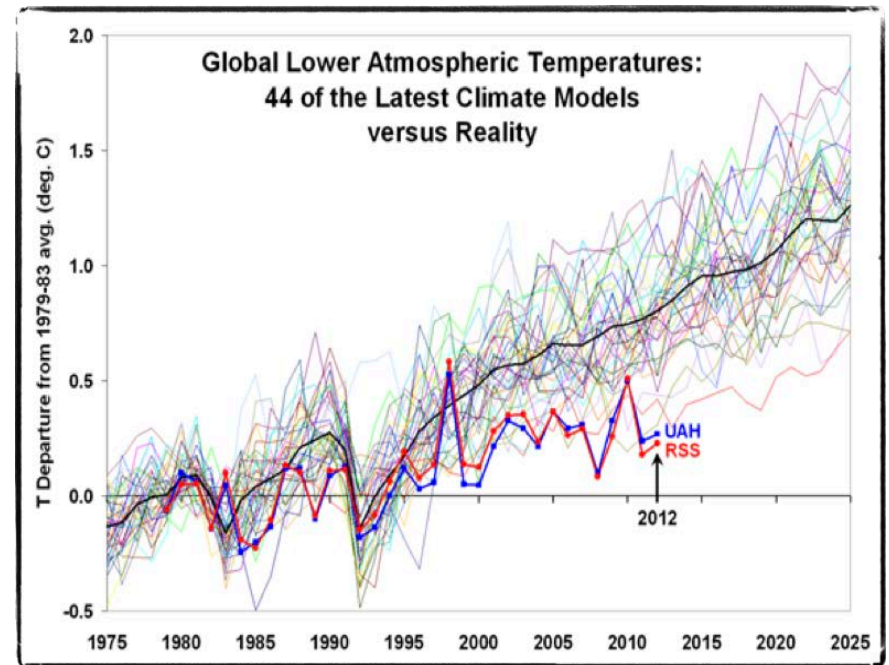
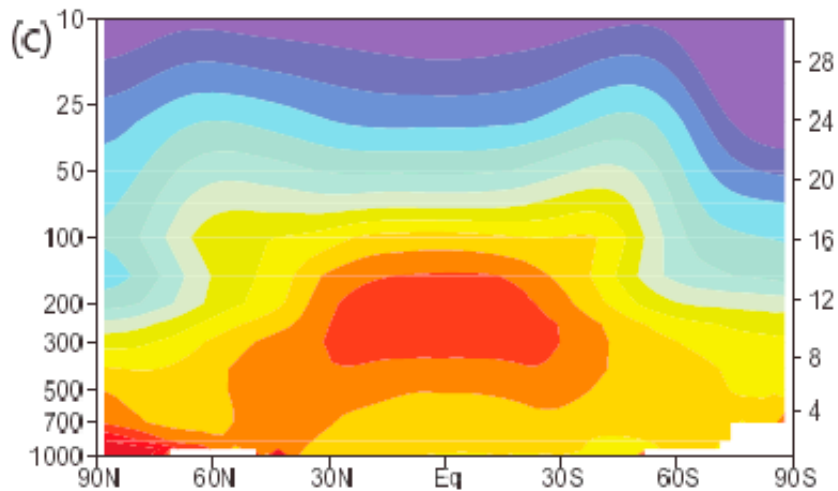


Model predictions: Decrease of 0.3-0.5°C.

Reality: Decrease of 0.1°C on average

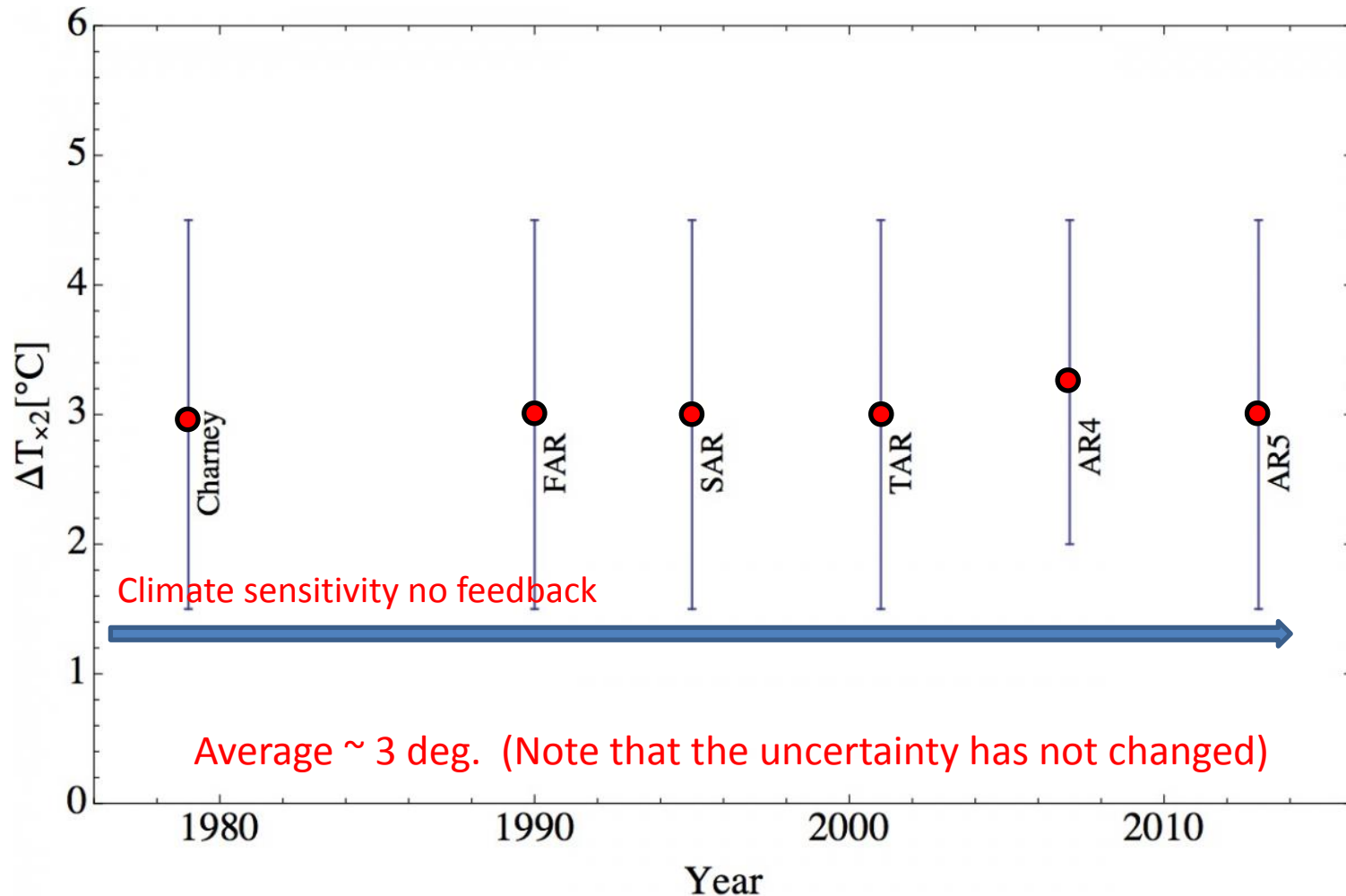
Evidence that climate sensitivity is small

Greenhouse models predicts a hot spot where temperatures increase faster than the surface

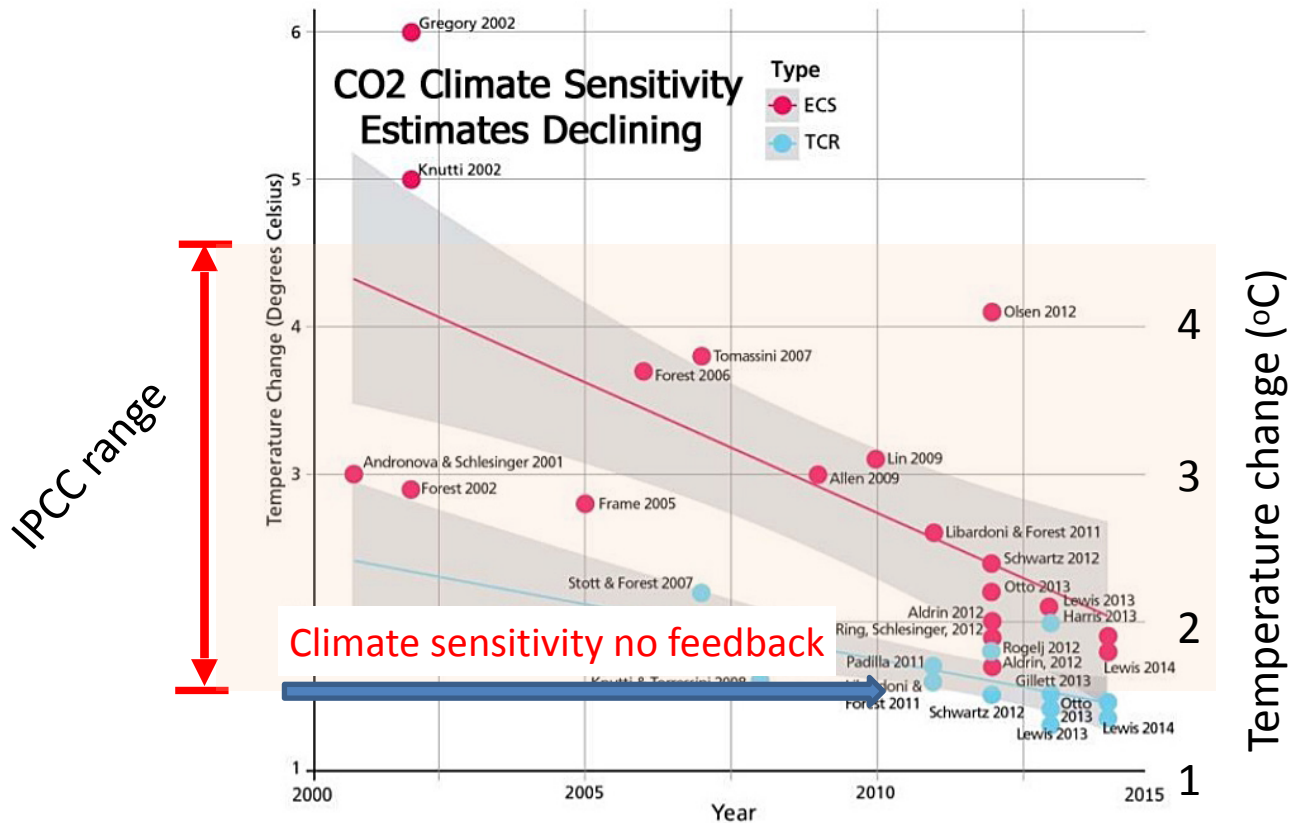


Estimates Climate sensitivity from various reports (Charney and IPCC reports)

How much will the temperature increase if CO₂ is doubled?



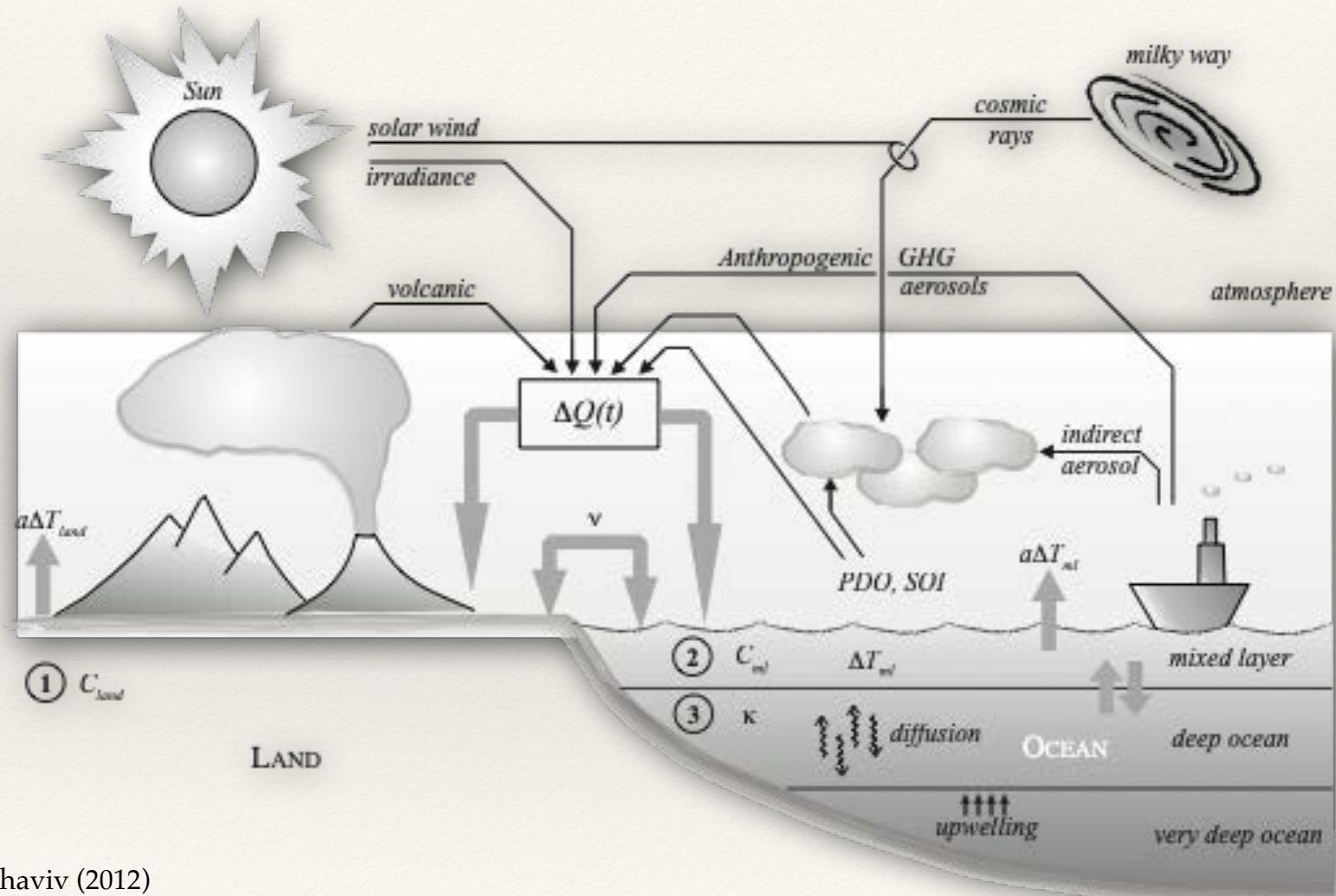
Empirical estimates of climate sensitivity



(figure as shown in Scafetta et al., 2017)

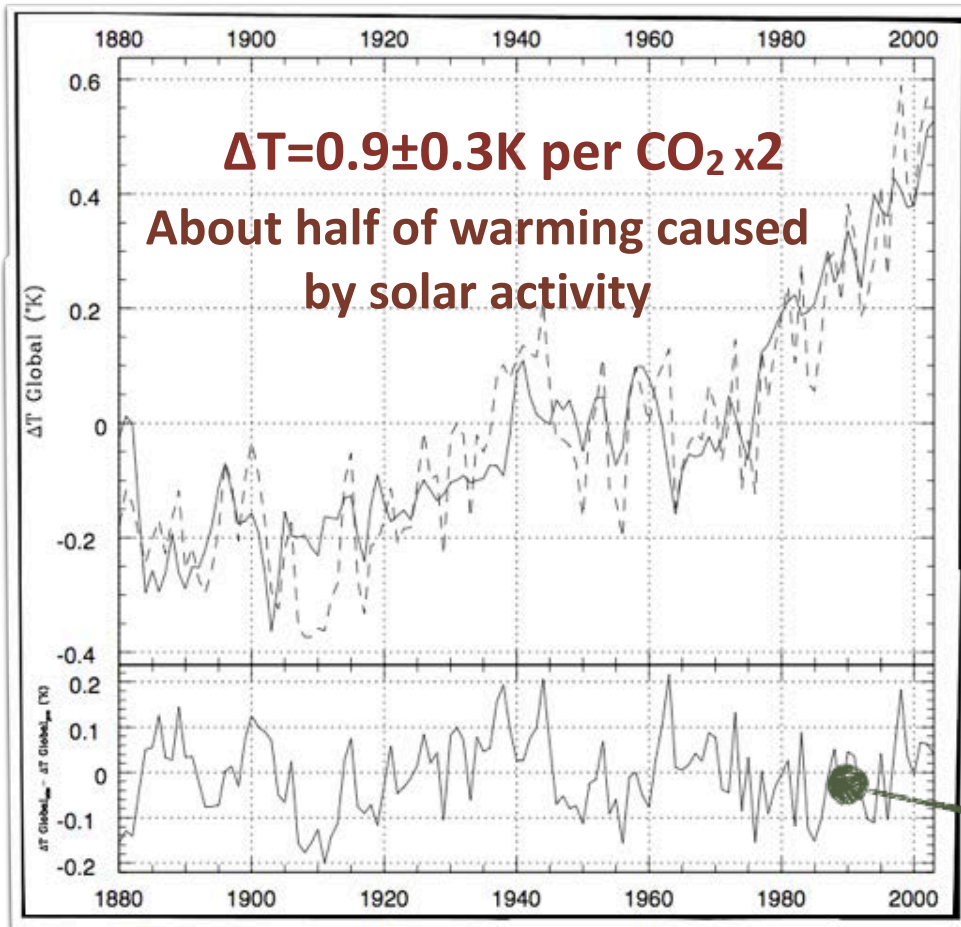
Figure 7. Compilation of published transient climate response (TCR) and equilibrium climate sensitivity (ECS) values to atmospheric CO₂ doubling. (Adapted from Figure 1

Basic Climate Model

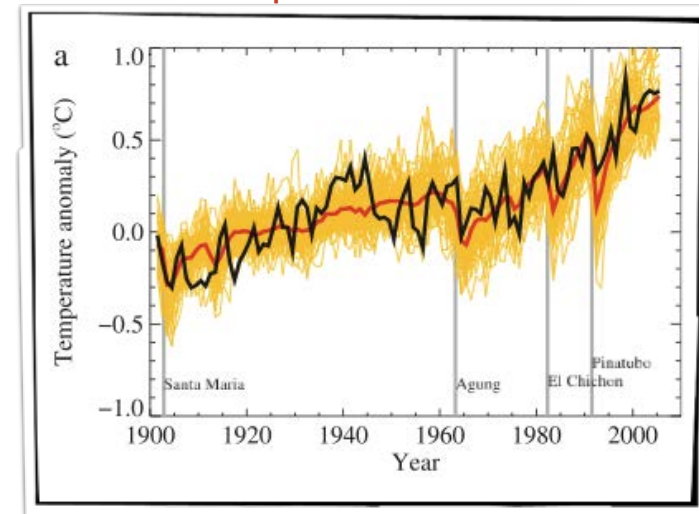


20th century warming

Best fit (i.e., after parameter optimization)

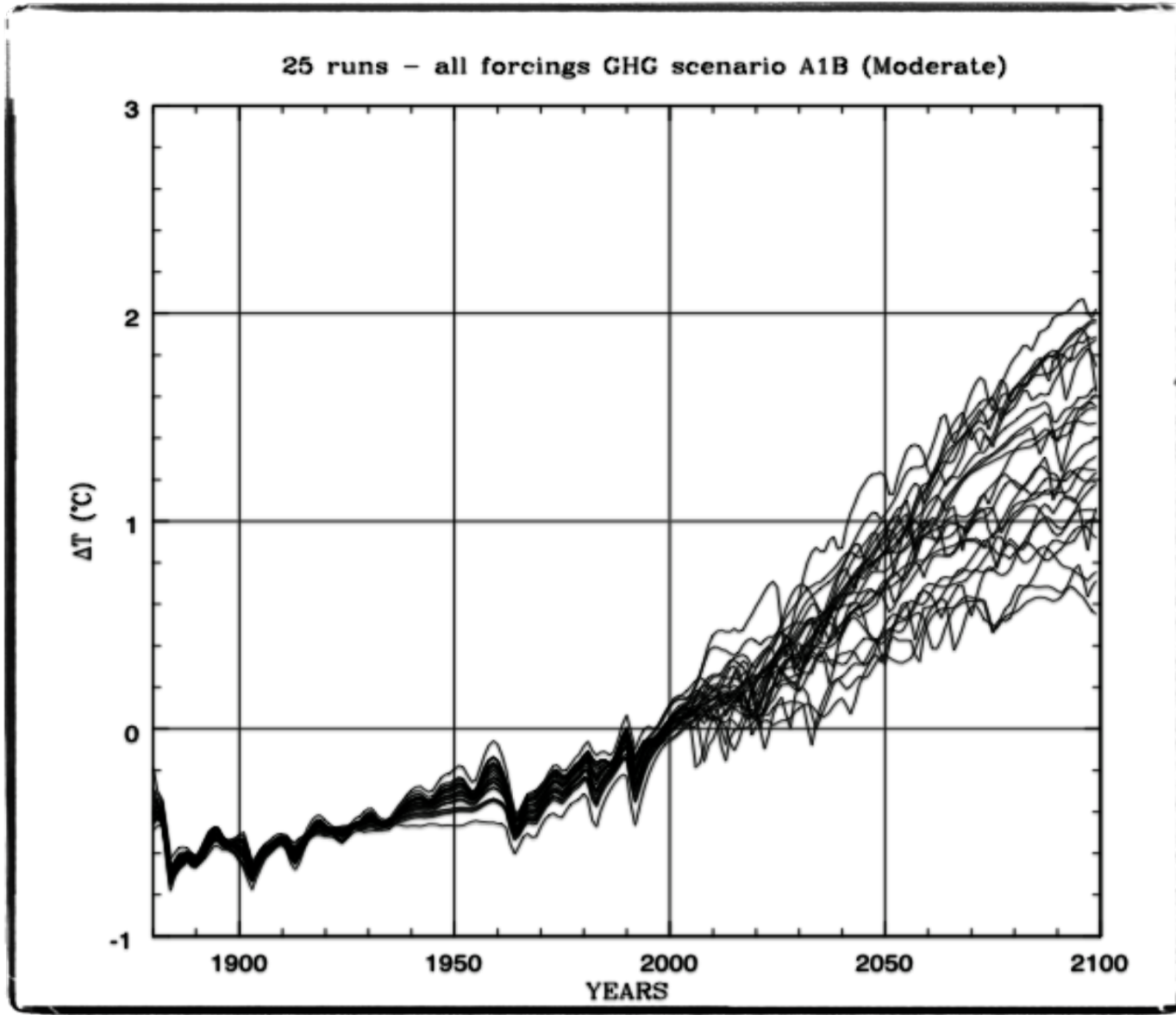


Comparison: IPCC-AR4

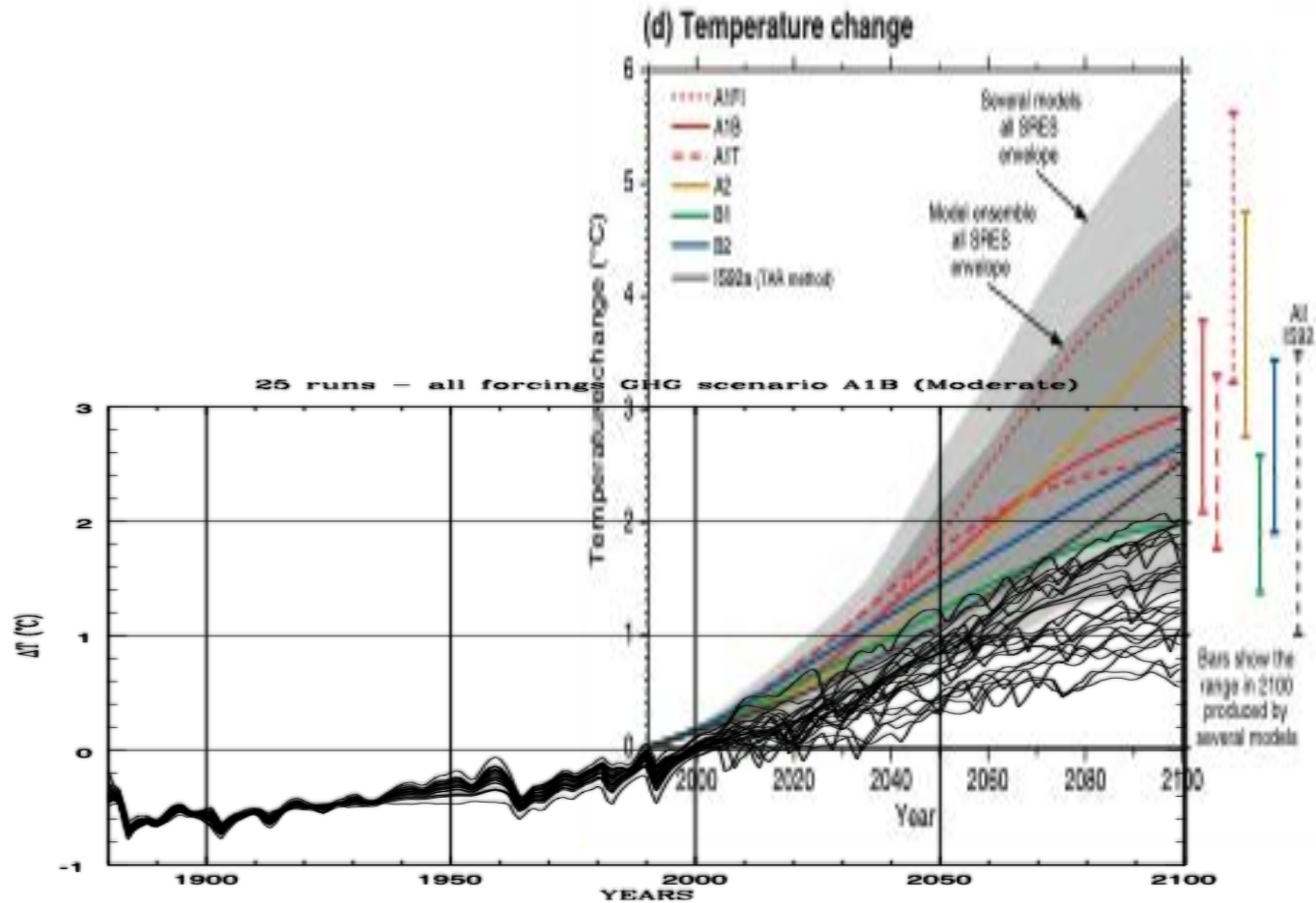


Residual more than twice smaller than with GCMs (without solar amplification)

21st century temperature increase



21st century temperature increase



Conclusion

- ❖ Actual evidence points to a strong solar climate link and a low climate sensitivity.
- ❖ Today we know how the physics behind the link (but in fact, it is totally irrelevant - solar activity should be taken seriously but is ignored!)