



KIK, 13-11-2006



Zonneactiviteit en klimaat – nieuwe inzichten

Andreas Sterl: Foukal et al., Nature 413 (2006), 161-166:

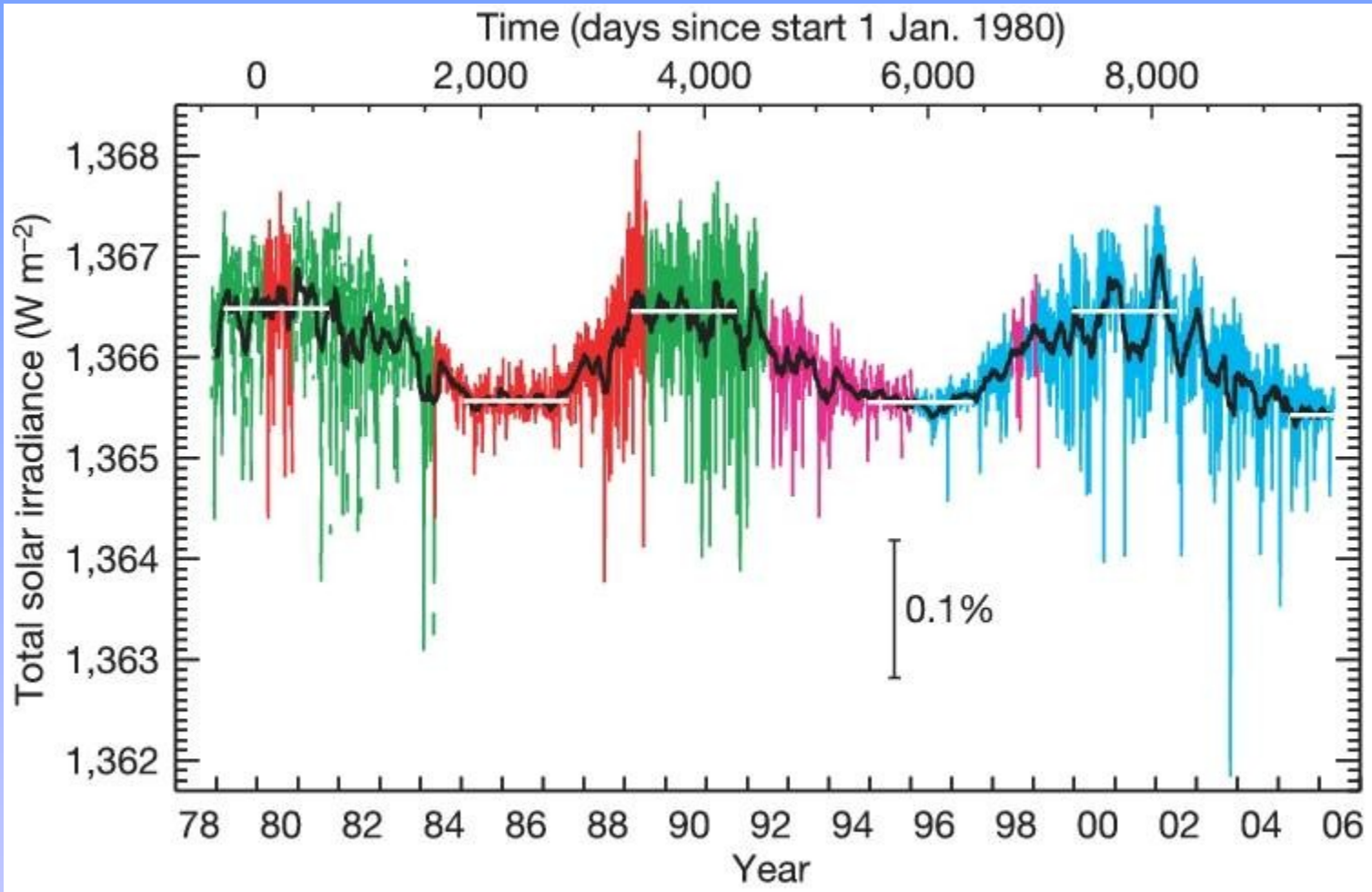
Variations in solar luminosity and their effect on the Earth's climate

**Rob v. Dorland: de Jager, Versteegh, v. Dorland
2006:**

Andreas Sterl, KIK, 13.11.2006

Scientific assessment of solar induced climate

TSI – Total Solar Irradiance



TSI

•••••
1 1-year cycle (sunspot number)

27-day cycle (rotation of Sun)

$TSI(\text{max-sunspot}) > TSI(\text{min-sunspot})$

Amplitude solar cycle $\approx 0.9 \text{ W/m}^2$: $< 0.1\%$

$\lambda \approx 0.7 \text{ K}/(\text{Wm}^{-2})$

albedo = 0.3; geometr. = 0.25

$\Rightarrow \Delta T_{\text{sol-cycl}} = 0.11 \text{ K}$ in **equilibrium**

TSI variations: geometrical:

$\Delta TSI = \Sigma A \Delta(\text{bright}) : EV = 80\%$

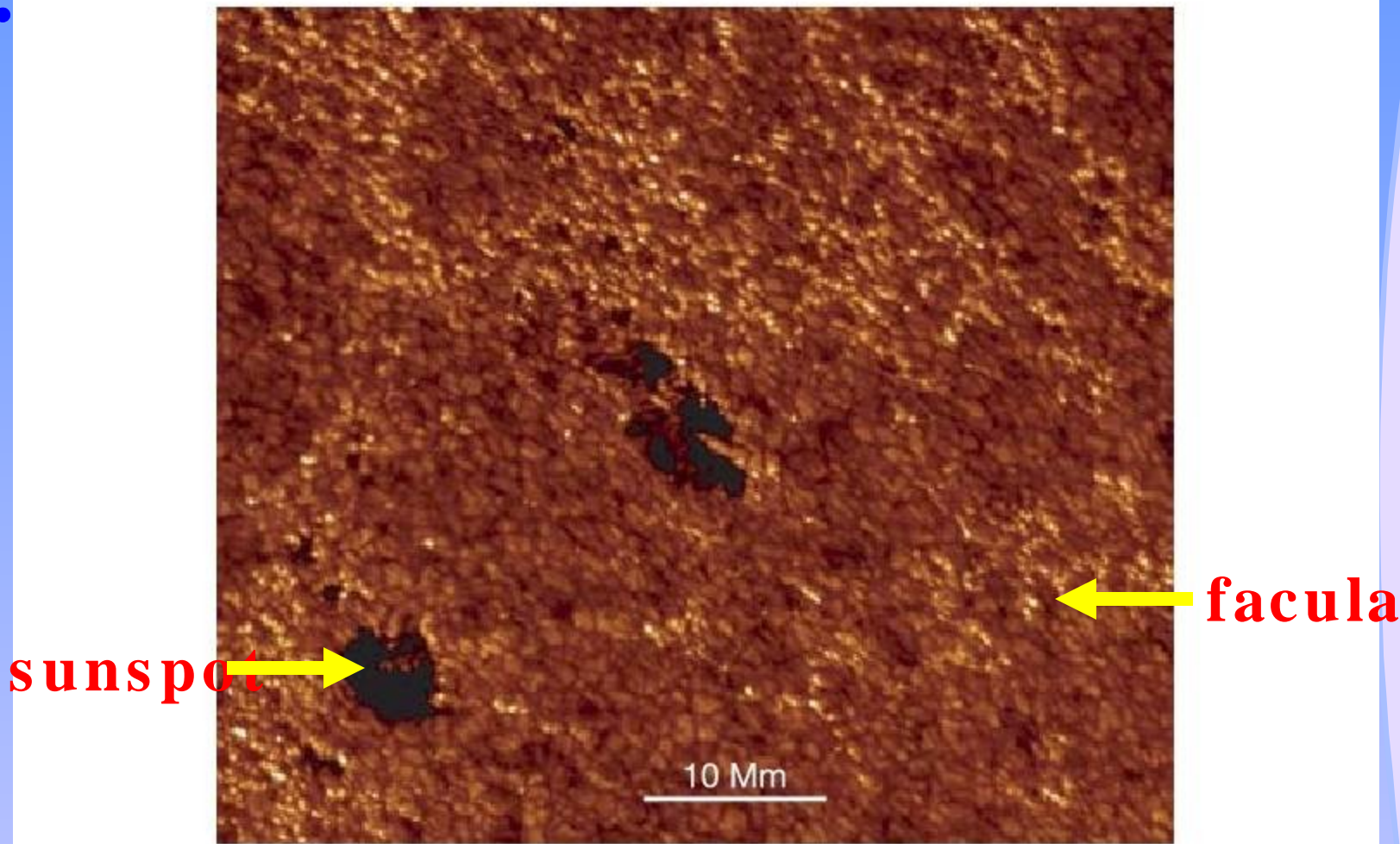
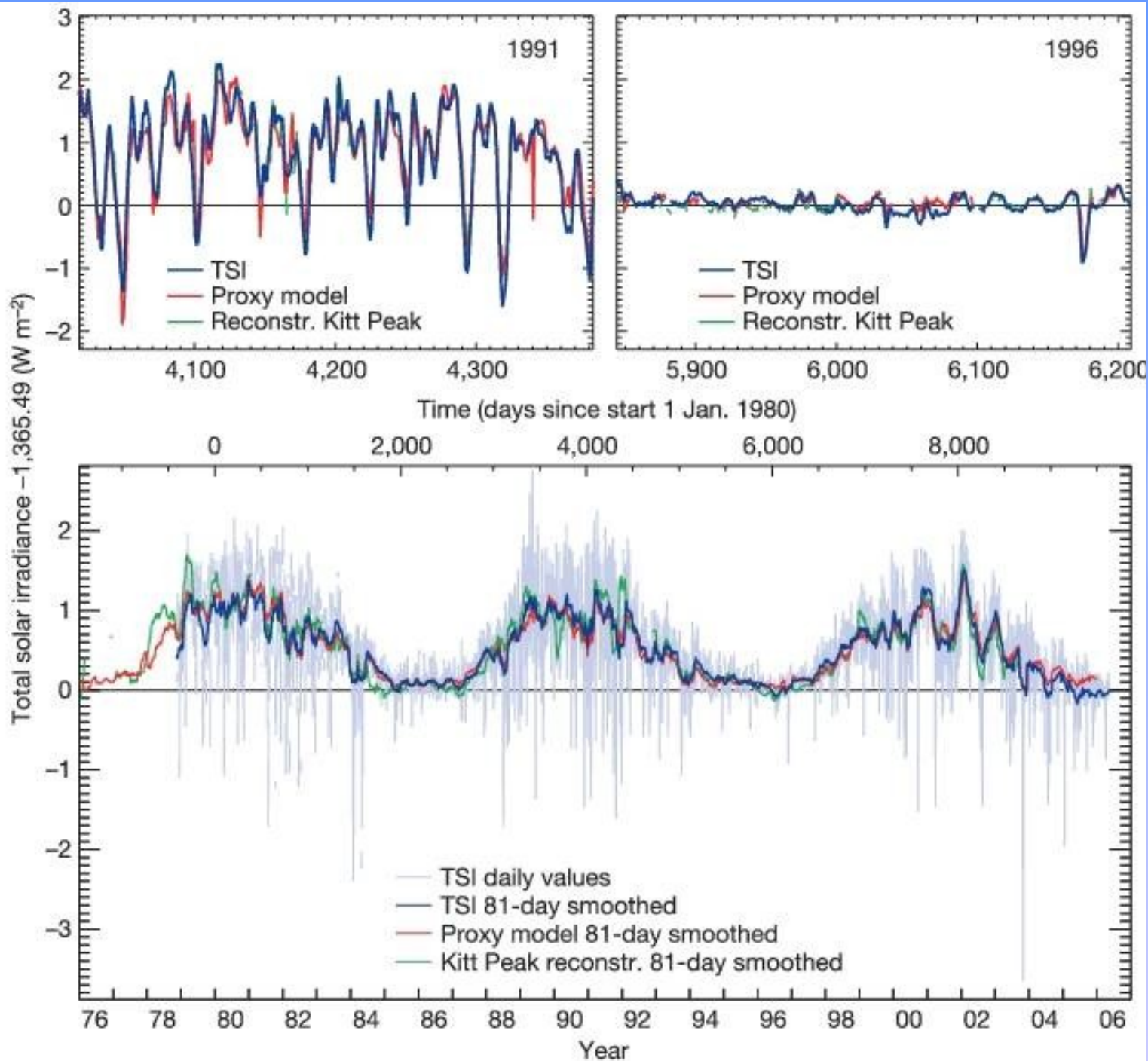


Figure 2 | An image of the solar photosphere (the surface of the solar disk seen in visible light), showing the structures responsible for the TSI variations. The granules, covering most of the area, are the convective flows



Short-term TSI variations

Geometric

Sunspots = thermal plugs

Faculae = thermal leaks

No shunting => large thermal inertia

Others

Deep convection

Diameter changes

=> Ruled out by recent observations

=> TSI variations only from photosphere

Long-term TSI variations

Decadal to centennial

Relation between TSI and proxies other than solar activity
speculative

Lean et al. (1995):

Extrapolate present relationship TSI-solar activity using Be-10
as a proxy

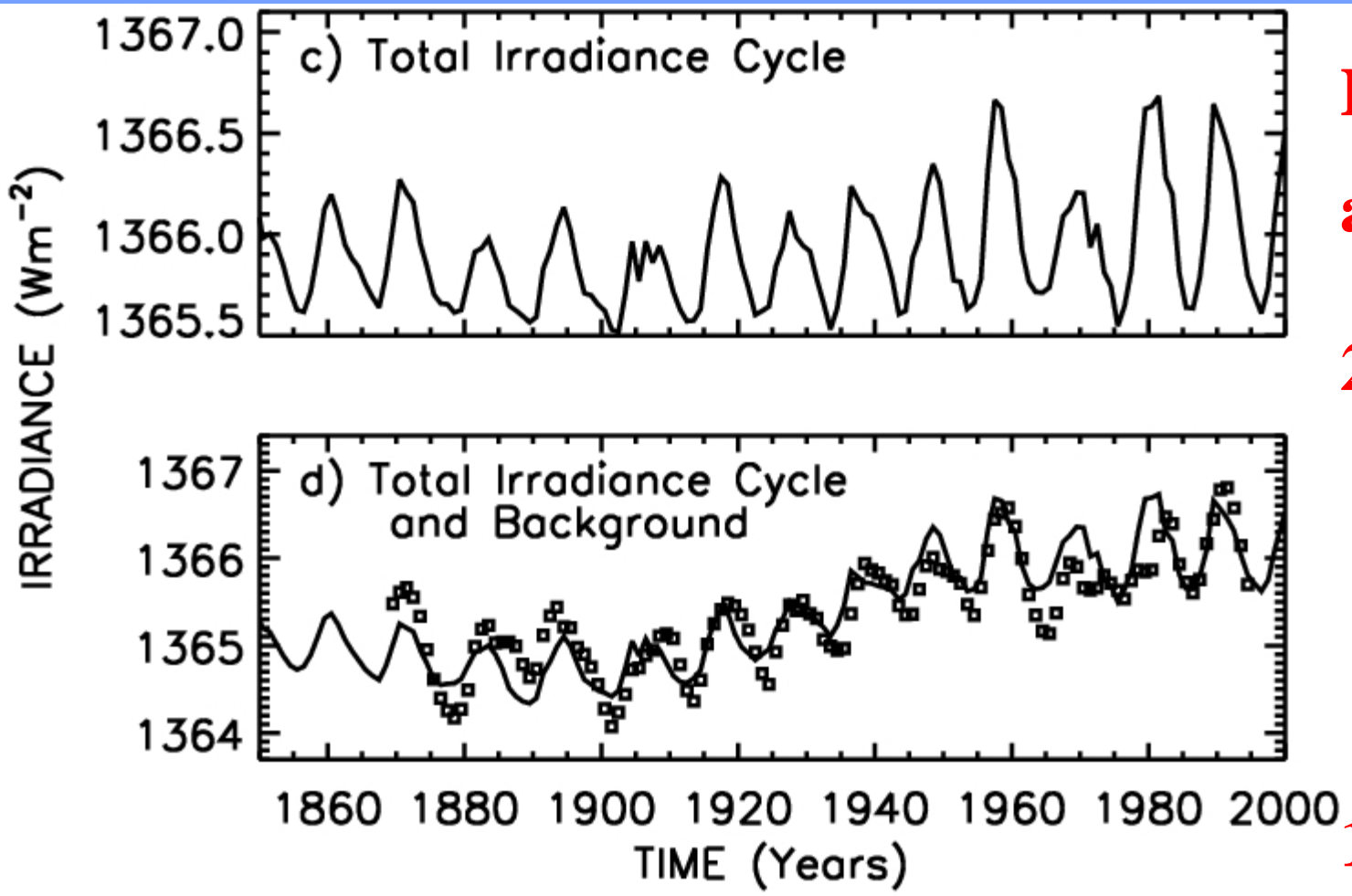
=> low freq. amplitude of >3 times high freq.

Apparent success in modeling climate variations

However: retracted in Lean et al. (2002) because of new
evidence: Be-10 not directly linked to TSI

Millennial

Not known



Lean et al. 2002

1995/2000



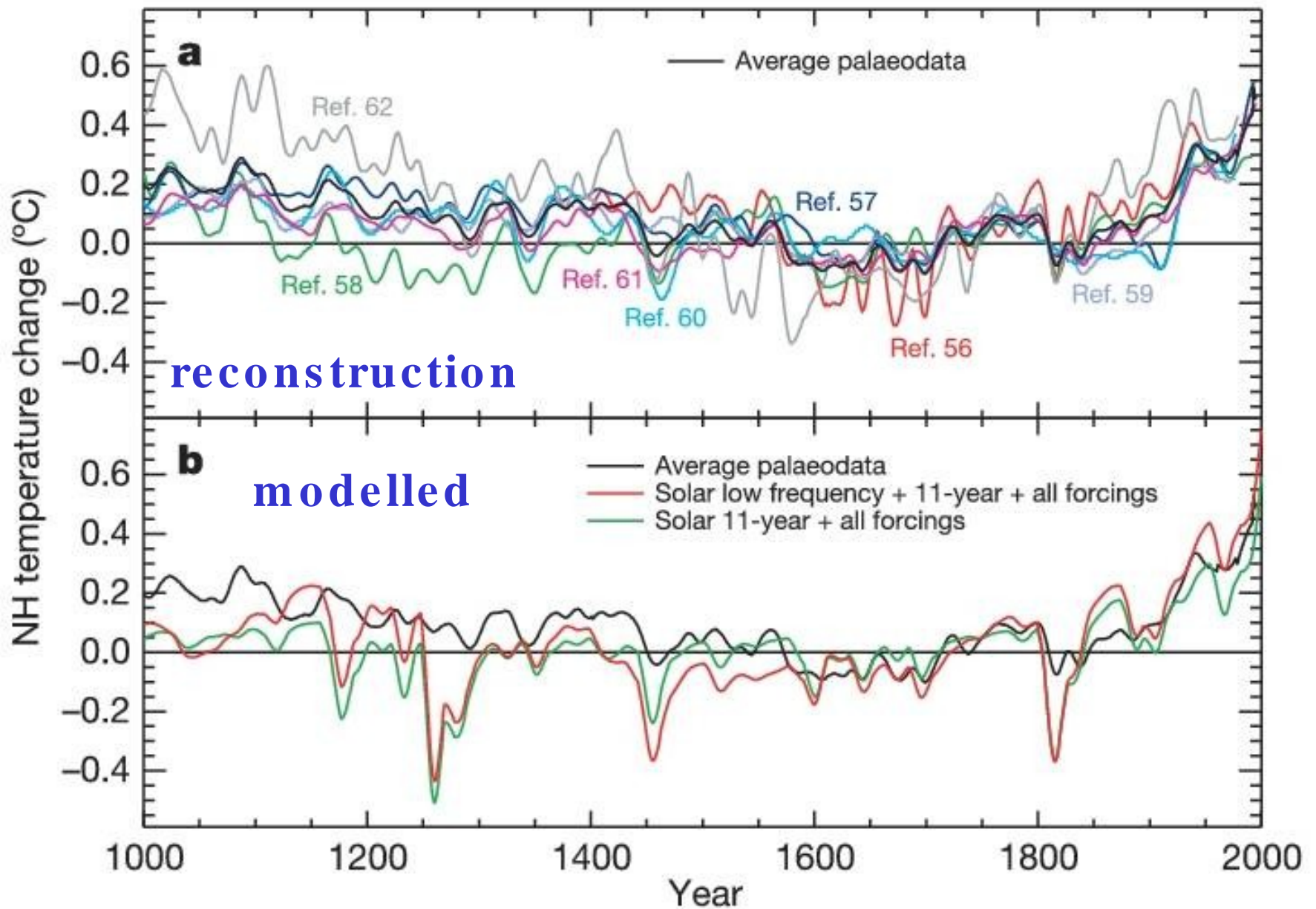


Figure 5 | Northern Hemisphere temperatures compared to model results. a, Variations of Northern Hemisphere (NH) mean temperature

Conclusion: Sun and climate

Indirect mechanisms (e.g., O₃ in stratosphere) not considered, too complex

TSI variations **only** through bright/dark areas

Problems in extending TSI record before 1900:

Back to 1700 only sunspot number (no faculae)

Before 1700 Be-10 reconstruction (indirect)

Even with unrealistic large variations TSI cannot explain reconstructed temperature

Overall, we can find no evidence for solar luminosity variations of sufficient amplitude to drive significant climate variations on centennial, millennial and even million-year timescales.

However ...

Bond et al. (2001) find Sun-climate relation with 1500 years cycle in NATl region (based on Be-10)

Lean et al. (1995 and 2000) are still used in modelling (e.g., Stendel et al., Clim. Dyn. 2006)

Even Hoyt & Schatten (1993) with even larger variations have been used