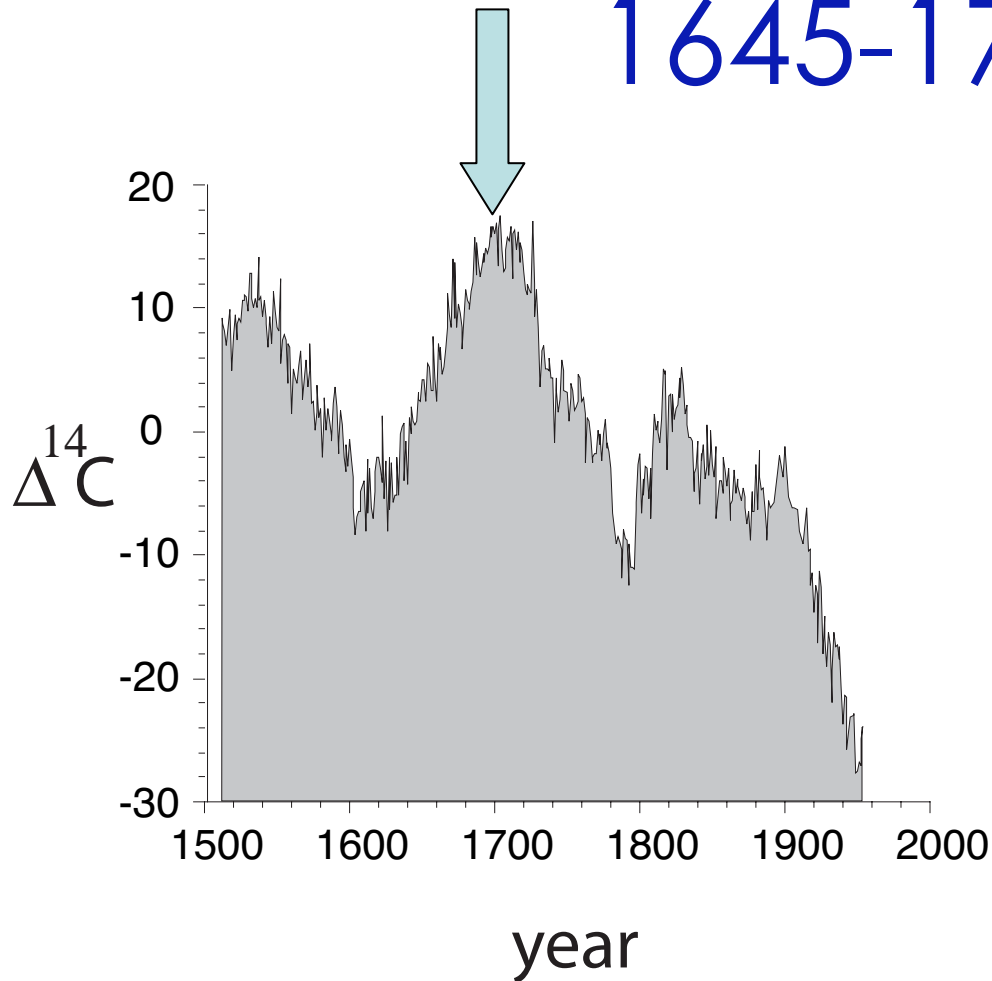


Solar Influence on Surface Air Temperature During the Maunder Minimum

J. Feynman, A. Ruzmaikin (JPL, Caltech),
X. Jiang, D. Noone and Y. Yung (Caltech)

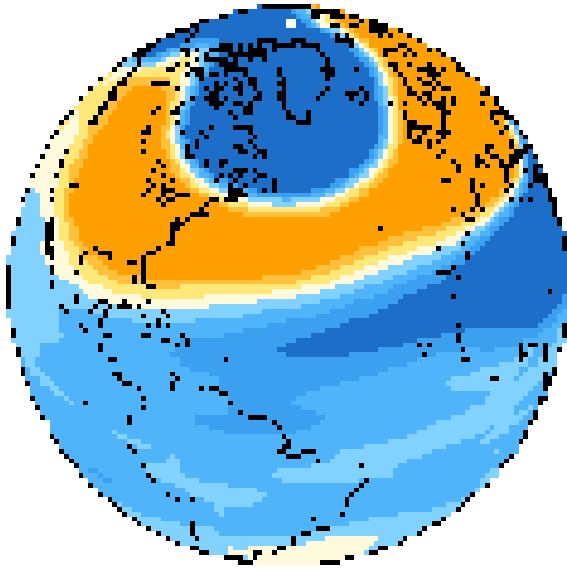
Maunder Minimum

1645-1715



- MM in cosmic ray flux.
- Also seen in aurora & sunspots
- Mean northern hemisphere relative ΔT about $0.1\text{ }^{\circ}\text{C}$ (Mann et al.)

North Annular Mode

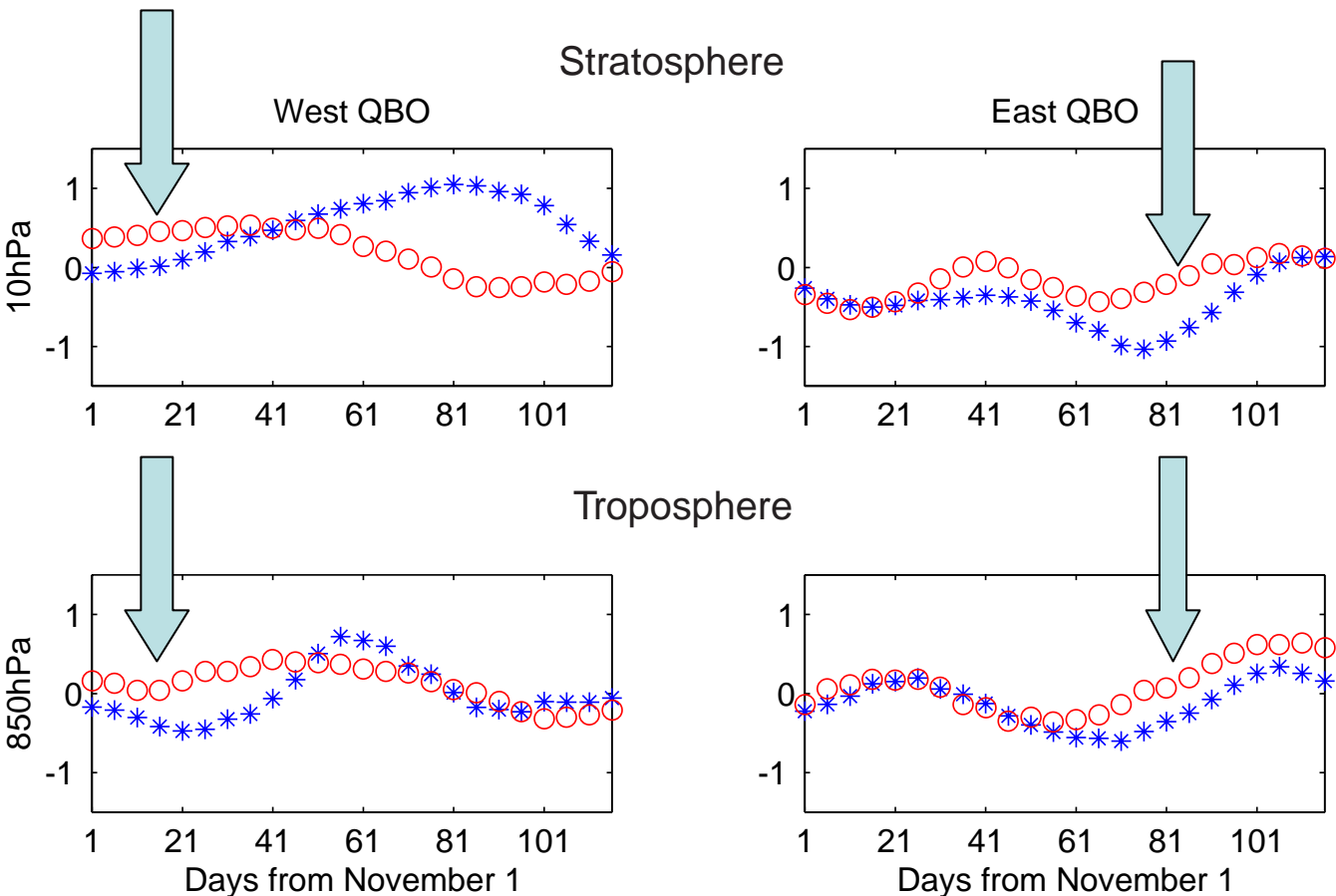


- Pattern of wintertime climate anomalies with two states, 1) high pressure at pole and a band of lower at lower latitudes .2) the other way round
- Account for 23% of variability at sea level

Thompson & Wallace (98)

Baldwin & Dunkerton (99)

Solar Influence on the North Annular Mode



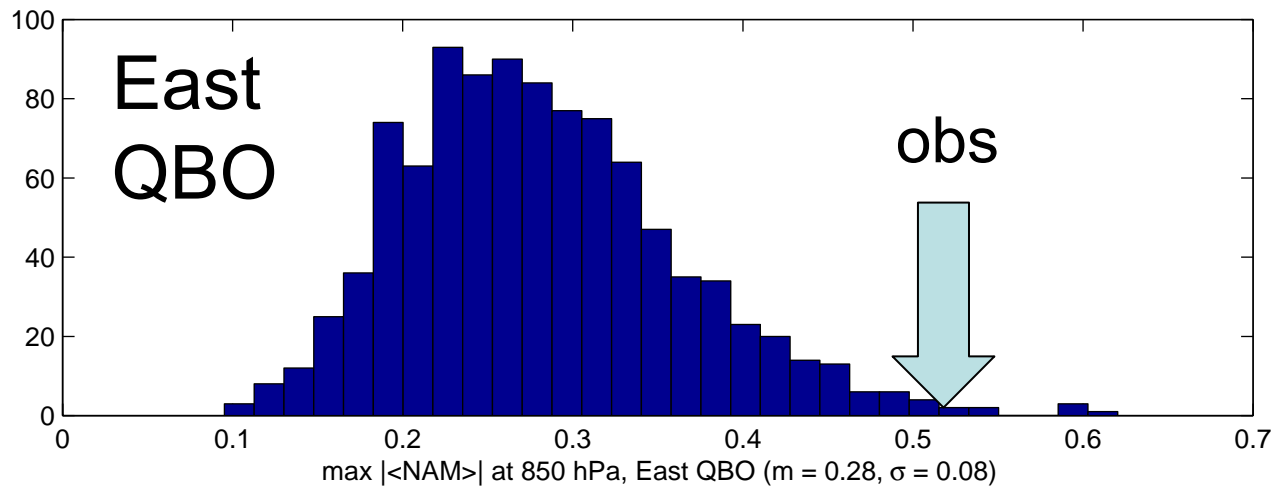
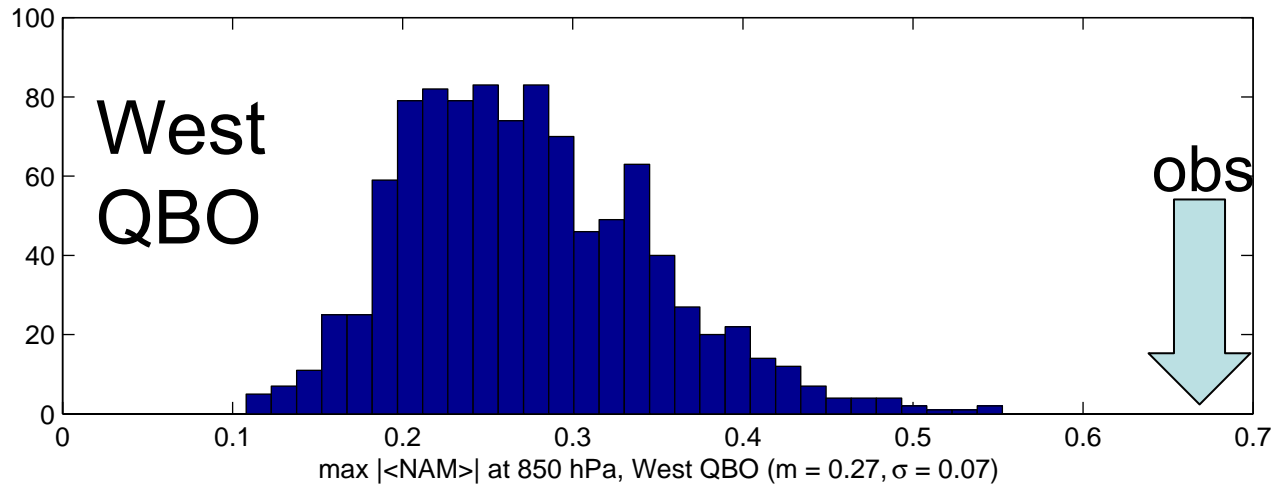
In early (late) winter for West (East) QBO UV effect on NAM is not damped between 10hPa and 850hPa

NAM index is persistently low in troposphere during Maunder Minimum

Ruzmaikin & Feynman(02)

High UV flux - circles, Low UV flux - asterisks

Test of statistical significance (troposphere)



Distribution of
1,000
realizations of
max $|\langle \text{NAM} \rangle|$
for randomized
data at 850 hPa

Approach

- Tropospheric NAM index is more negative at solar min than at solar max (R & F, 02)
- Use NCEP data to isolate ΔT pattern due to NAM (minimize contribution of other EOF modes)
- Compare with pattern of sensitivity of temperature to solar forcing (Waple et al.)

Isolate ΔT pattern, due to ΔNAM

Observed potential height is

$$PH = \sum PC_n EOF_n$$

- 1) Form composite of 10 months when $\langle NAM \rangle$ has highest positive values; form T_h composite

$$\sum PC_1 EOF_1 \gg \sum PC_m EOF_m \quad m > 1$$

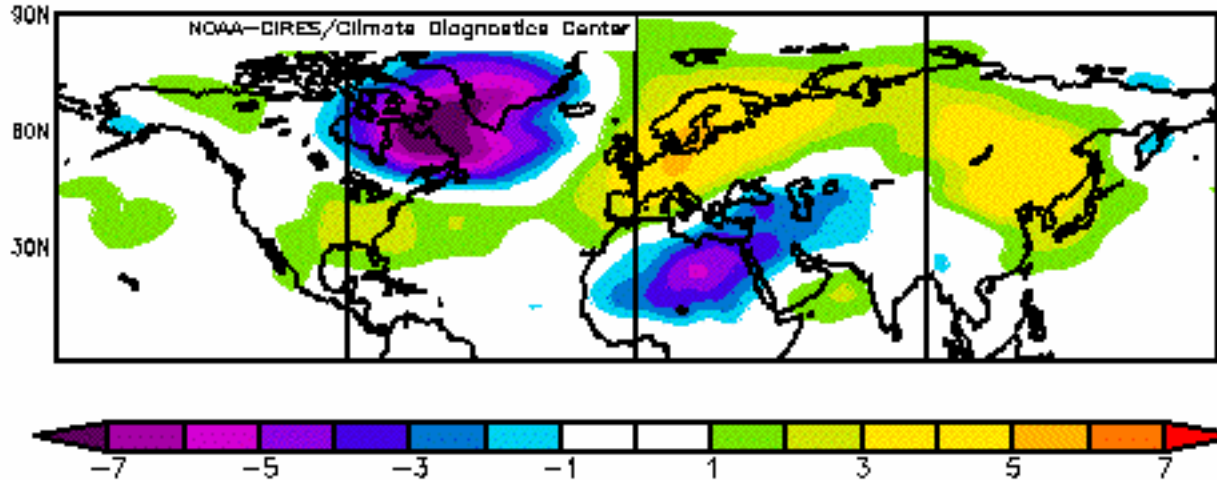
- 2) Repeat for $\langle NAM \rangle$ most negative, form T_s

- 3) $\Delta T = T_h$ minus T_s

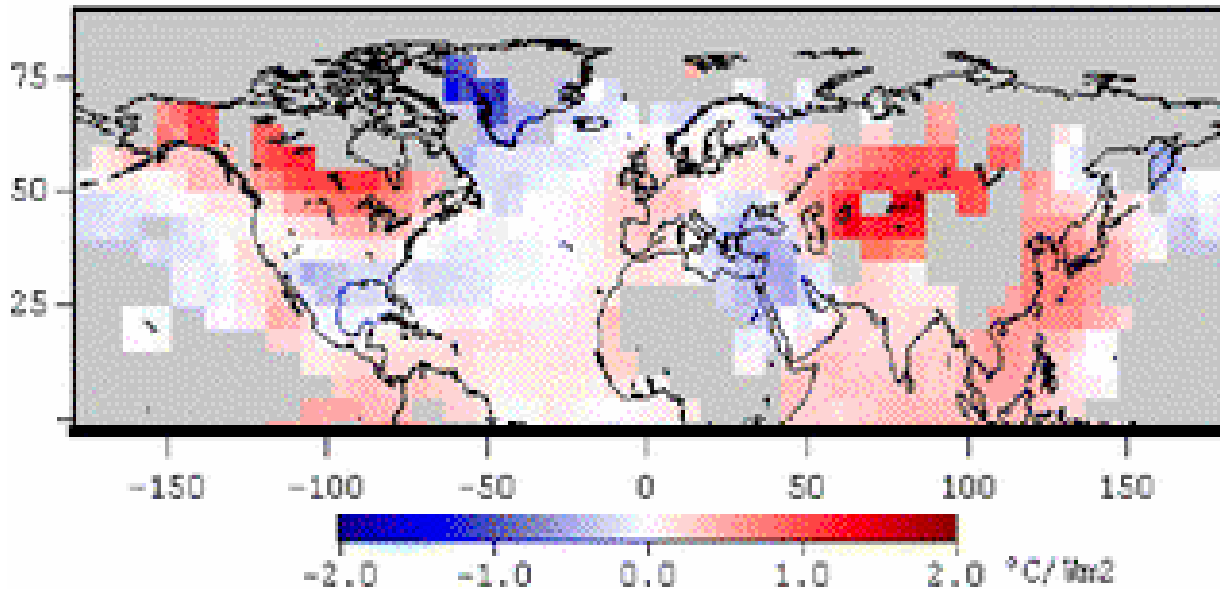
NAM Temperature Anomaly

NCEP/NCAR Reanalysis

850mb air (C) Composite Anomaly 1968-1996 Feb



Modern ΔT
Solar Max
Minus Min

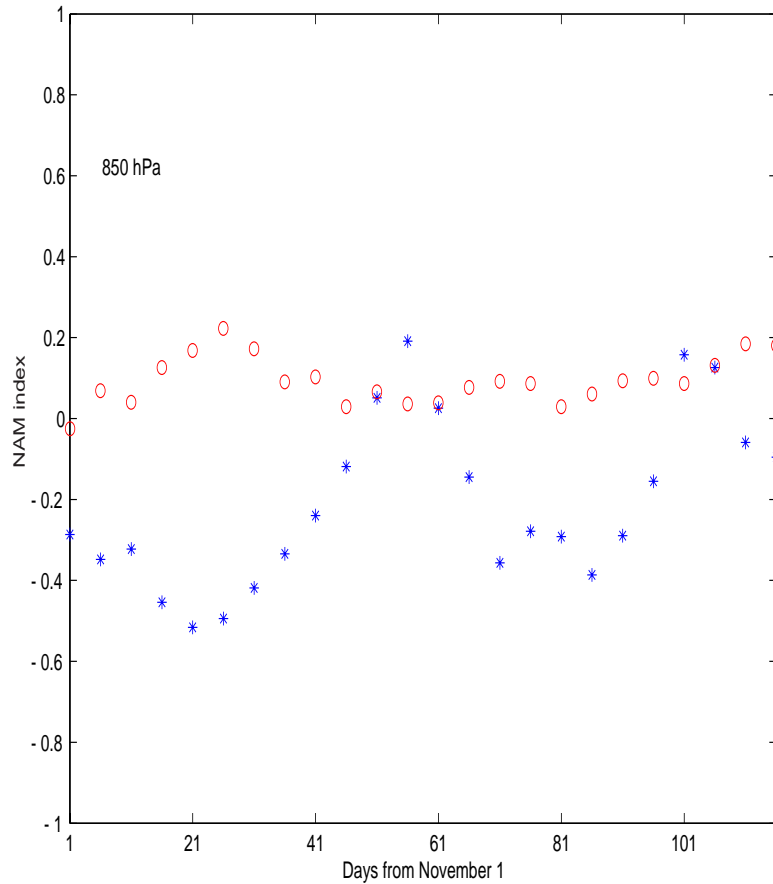


Irradiance
Sensitivity
Waple et al. 2002

Conclusion

A major part of the Northern Hemisphere temperature changes driven by the Sun can be attributed to effect of solar changes on the NAM mode of atmospheric variability.

Maunder Minimum NAM



- Modern maximum

- Maunder minimum

(using Lean
et al. 1995)