Solar Influence on North Atlantic Climate

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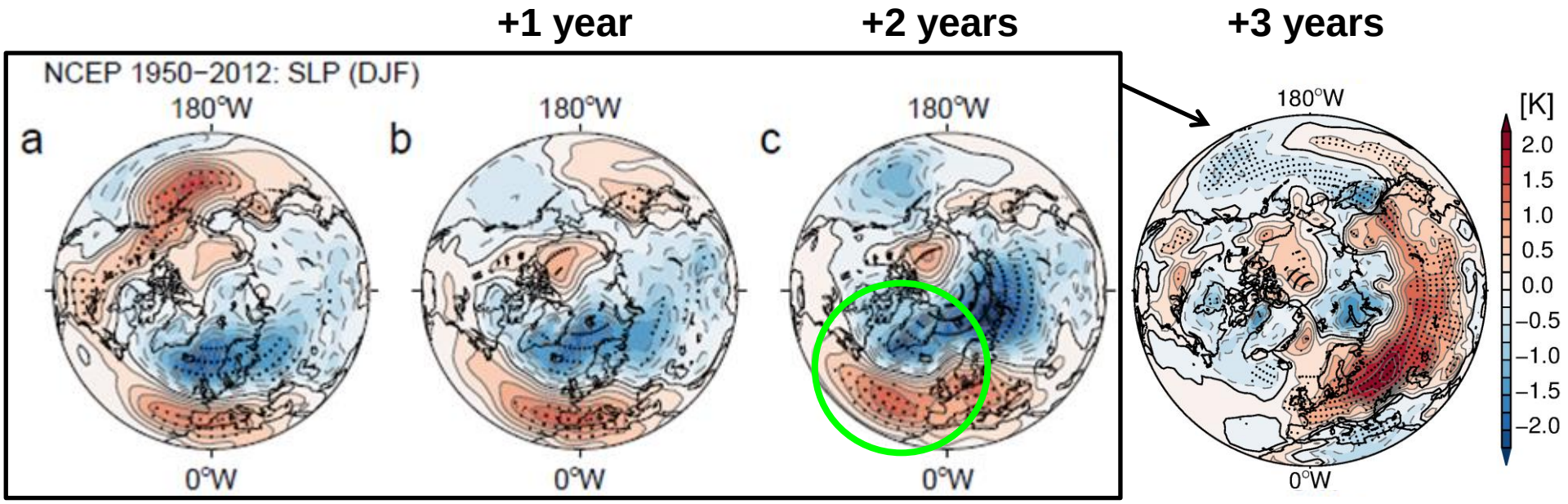
Solar variability influence on regional climate

- What do we observe ? -

Sea level pressure in DJF (Smax – Smin)



(*Thiéblemont et al.*, 2015)

Solar signal projects onto an **AO/NAO-like pattern** (Matthes et al., 2006; Ineson et al., 2011) which amplifies with a **lag of a few years** (Gray et al., 2013; Scaife et al., 2013).

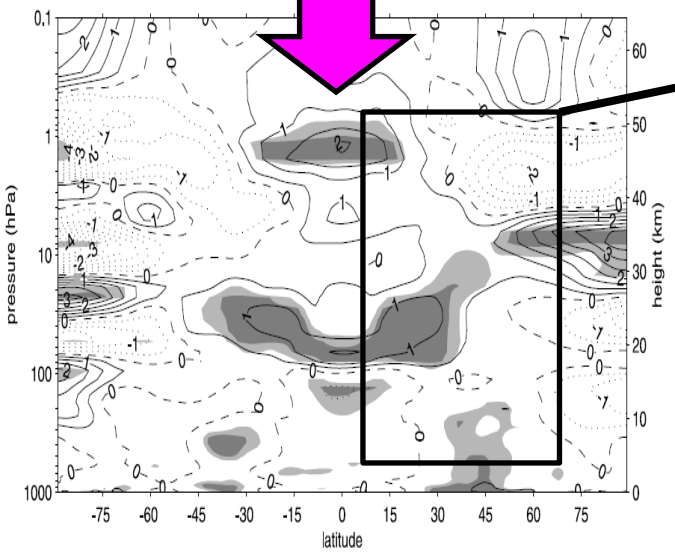
Which mechanisms drive this response ?

Major role of the stratosphere: „Top-down“

Temperature (Smax – Smin)

UV variability (~5%)

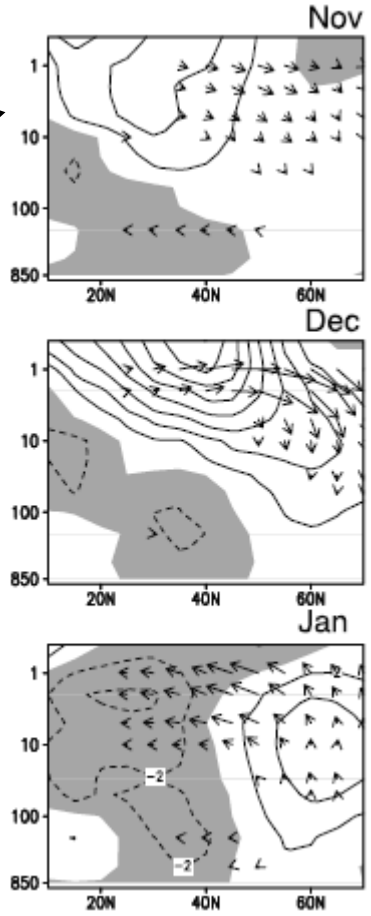
(*Frame and Gray*, 2010)



stratos phere

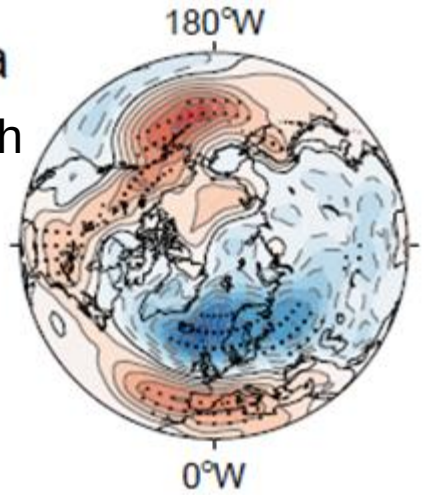
tropos phère

Zonal wind (Smax – Smin)



(*Kodera & Kuroda*, 2002)

Projection on the North annular mode



Does not explain the lagged response

Poleward/downward propagation of the jet anomalies

Importance of ocean-atmosphere interactions

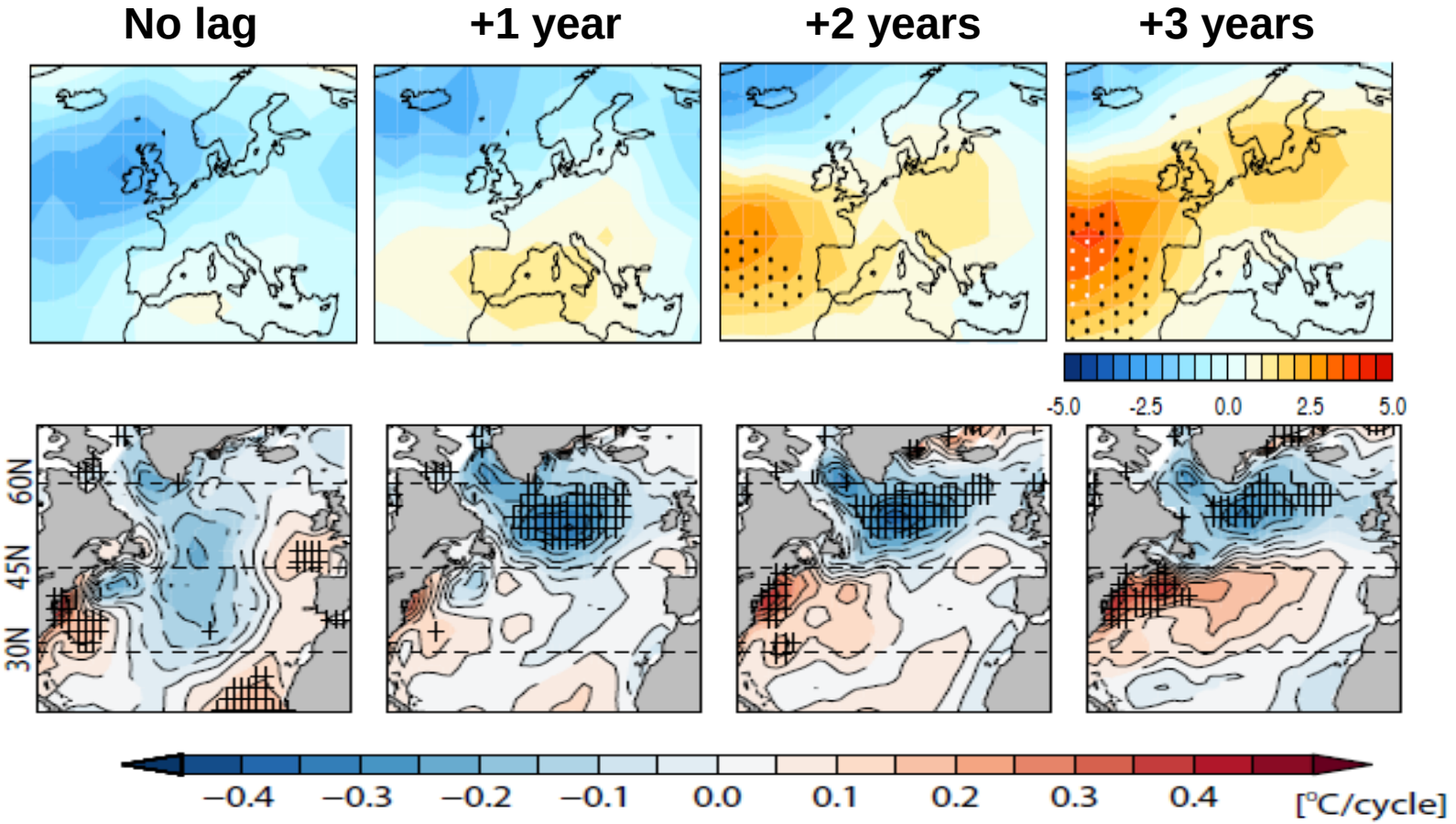
DJF (Smax – Smin) from 1850 to present

(*Gray et* al., 2016)

SLP (hPa)

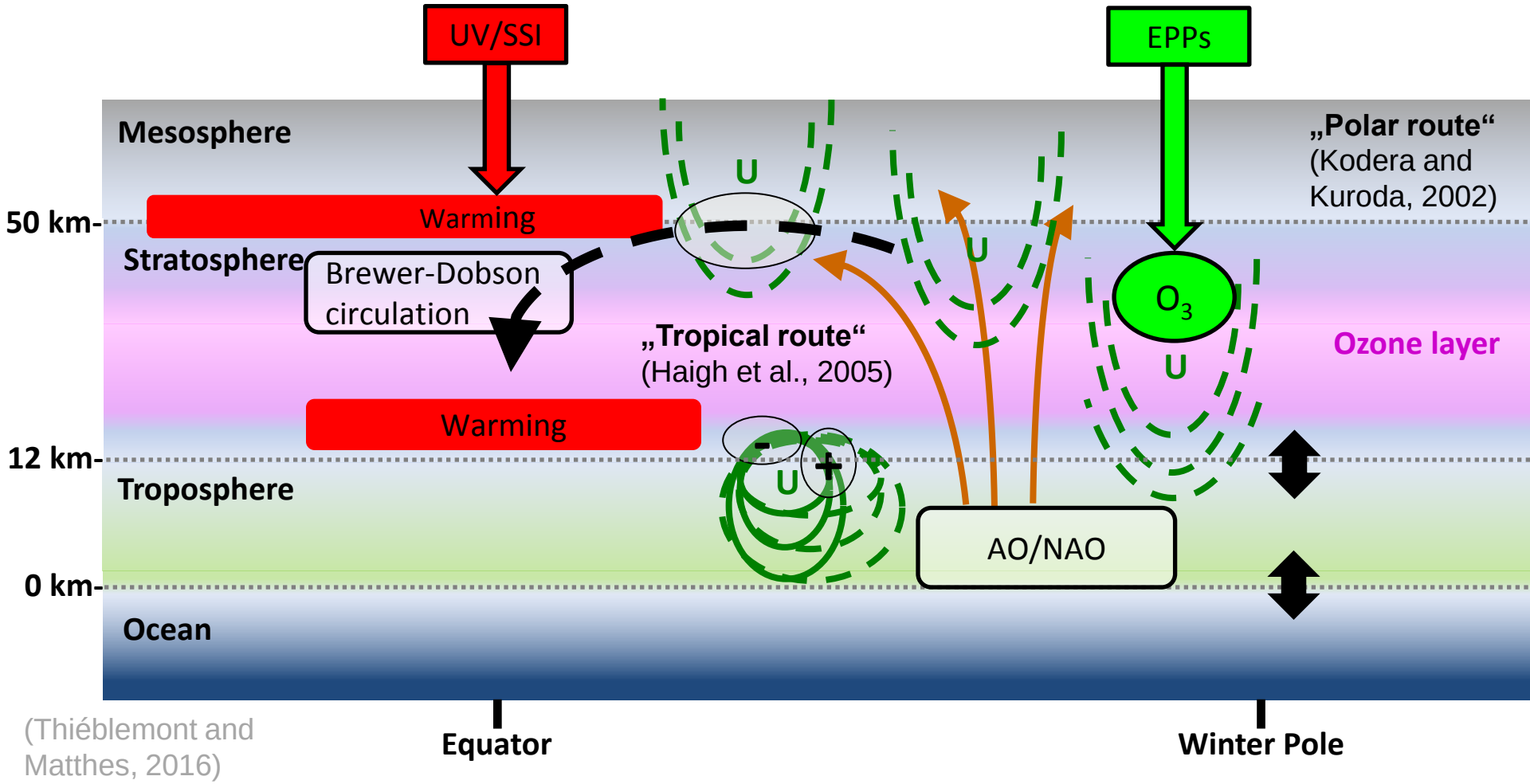
(*Kodera et al*., 2016)

SST (°C)



Ocean memory of the signal and positive feedback on tropospheric circulation ⇔ lagged amplified response (*Scaife et al*., 2013 ; *Gray et al*., 2013, *Andrews et al*., 2015)

Proposed mechanisms



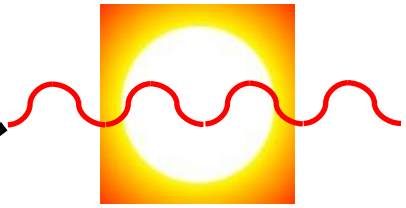
(Thiéblemont and Matthes, 2016)

Complex interactions between different atmospheric layers (from the upper atmosphere to the ocean)!

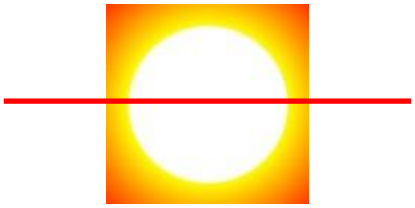
Space **Can climate models reproduce that response ?**

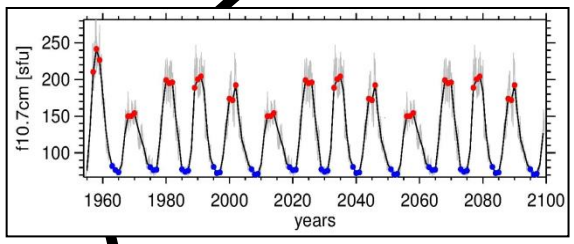
Model response using CESM(WACCM)

2 experiments:

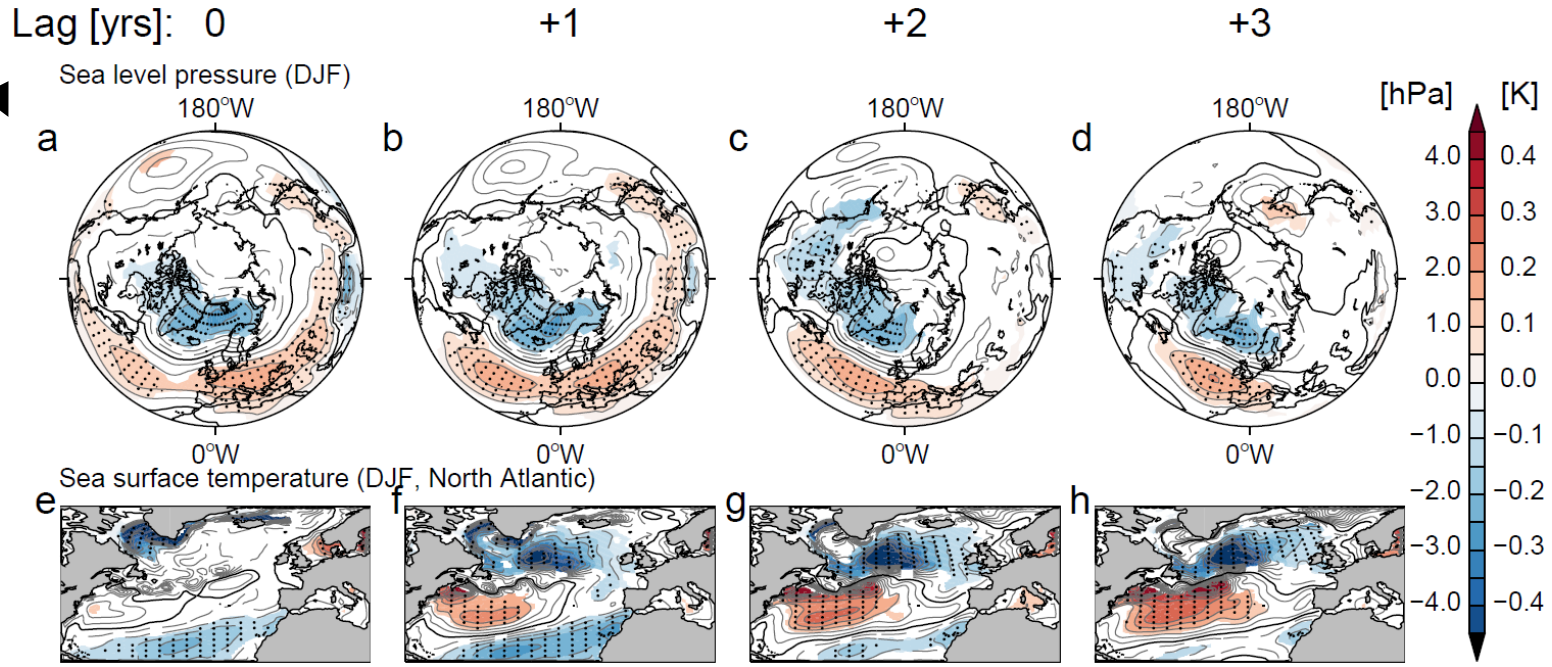


vs.





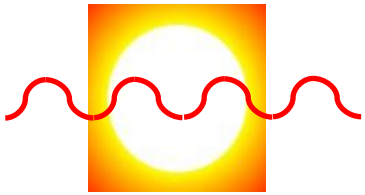
Solar maximum – minimum phases

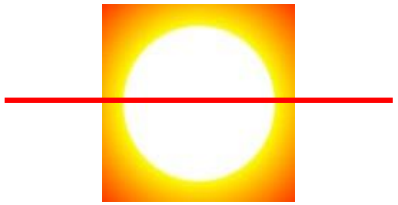


Space Climate

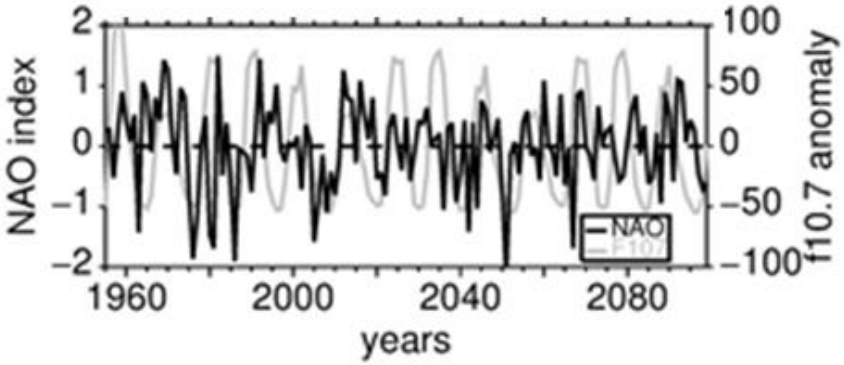
Good agreement with observations

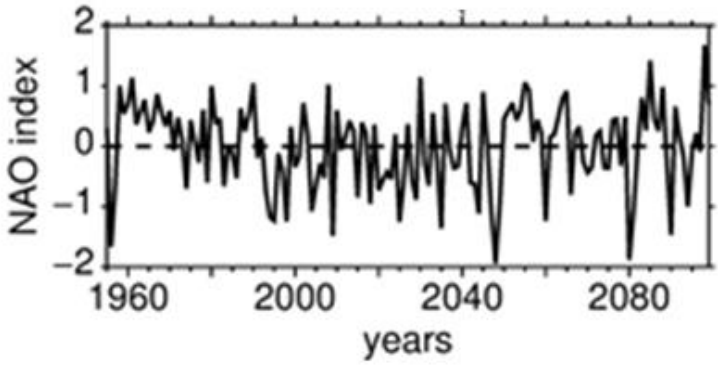
North Atlantic Oscillation variability



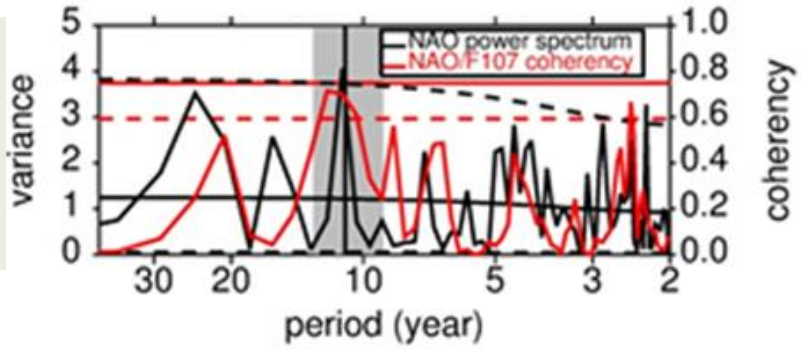


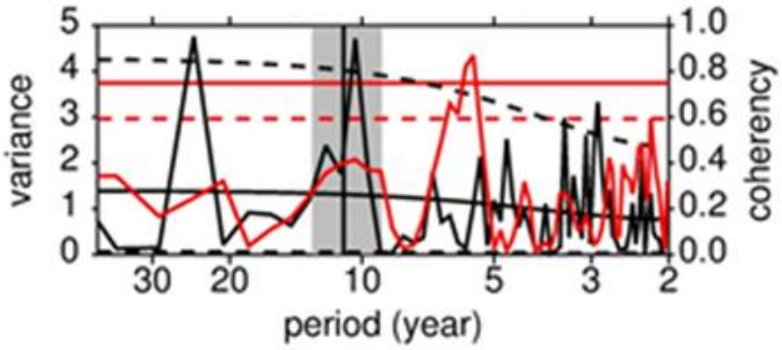
NAO index





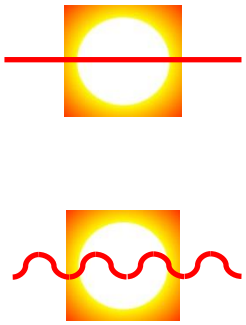
NAO spectra & coherency

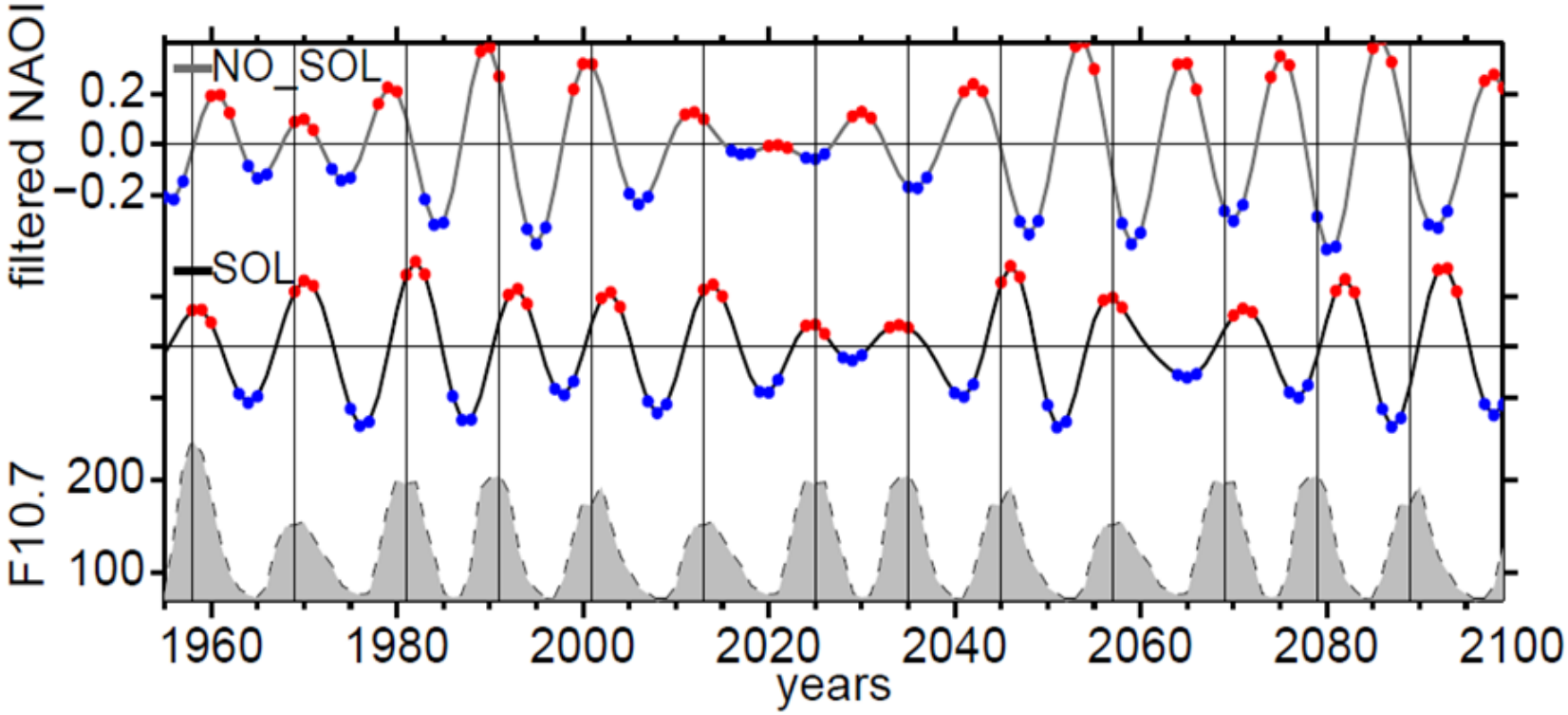




Although not significantly coherent with the solar 11-yr solar cycle, the model **simulates a strong internal quasi-decadal mode** (Czaja, 2003; Park and Latif, 2005)

North Atlantic Oscillation synchronization



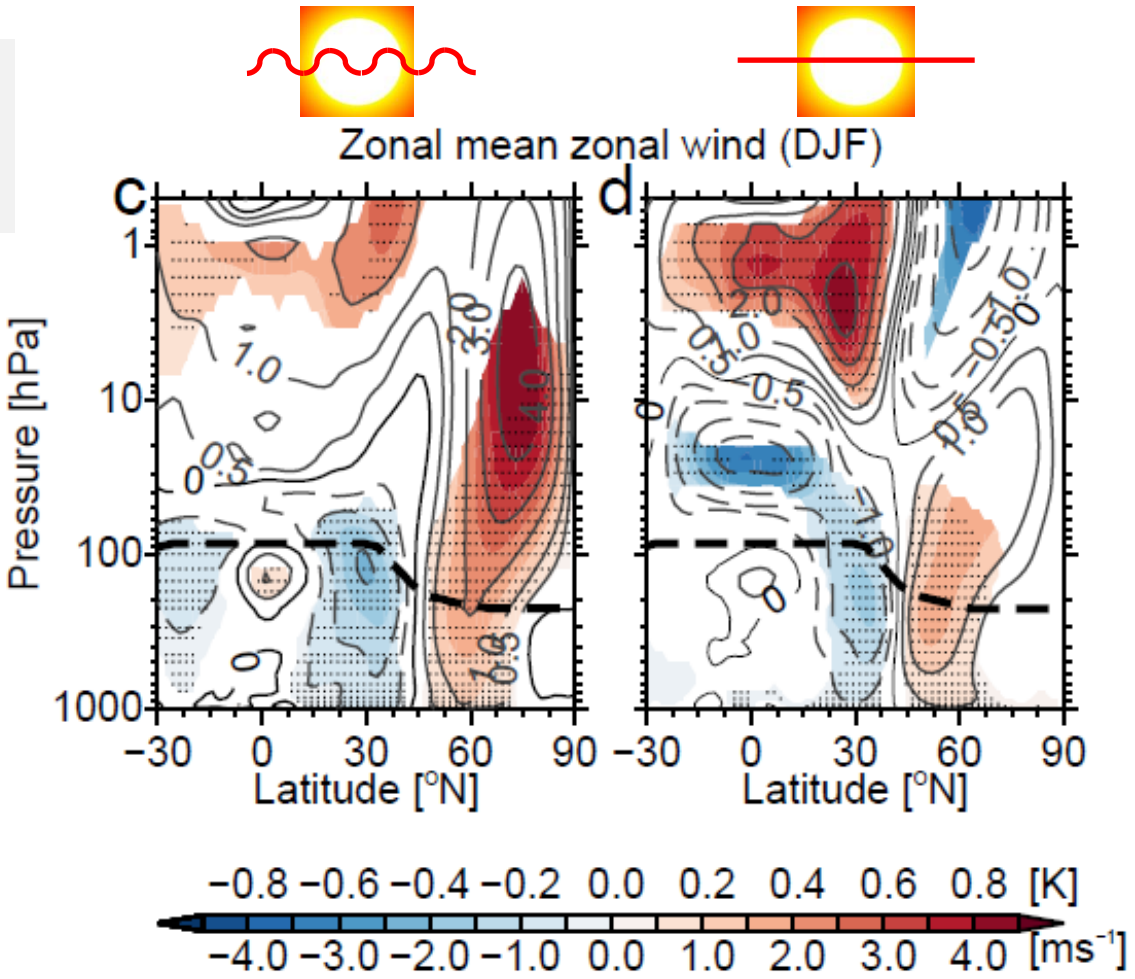


The solar variability seems to **synchronize** an internal quasi-decadal mode.
Mechanisms ?

Stratosphere response

NAO-based composites
Max-Min at lag -1
Zonal mean zonal wind

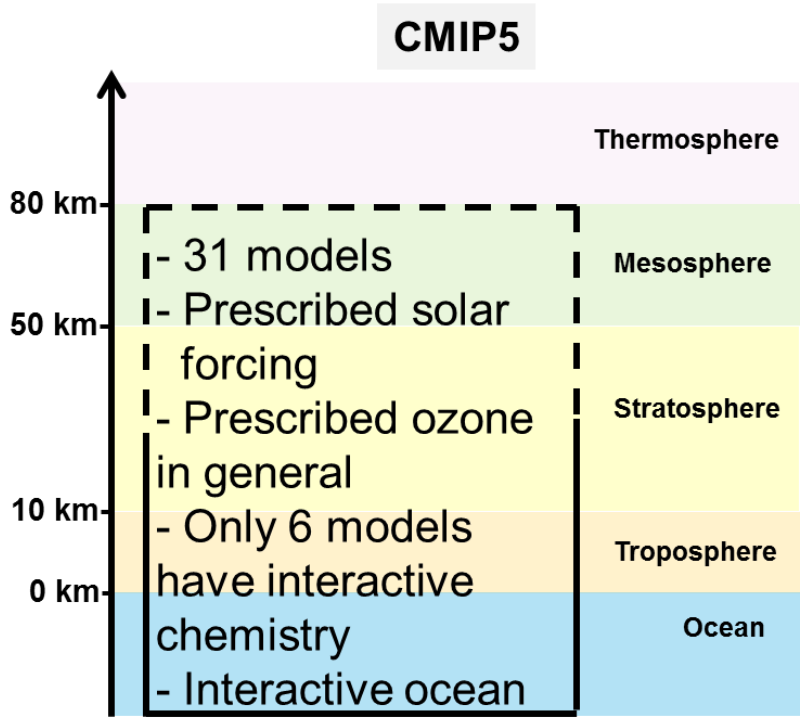
- Same signal in the tropopshere.
- Strong coupling with the stratosphere when solar variability is considered.
- **Synchronization consistent with the „top-down“ mechanism**.



Summary

- It seems that, in our experiments, the solar quasi-decadal variability **synchronizes a NAO intrisic mode of variability** ...
- ... through the „top-down“ mechanism

What about the solar signal in CMIP5 simulations ?

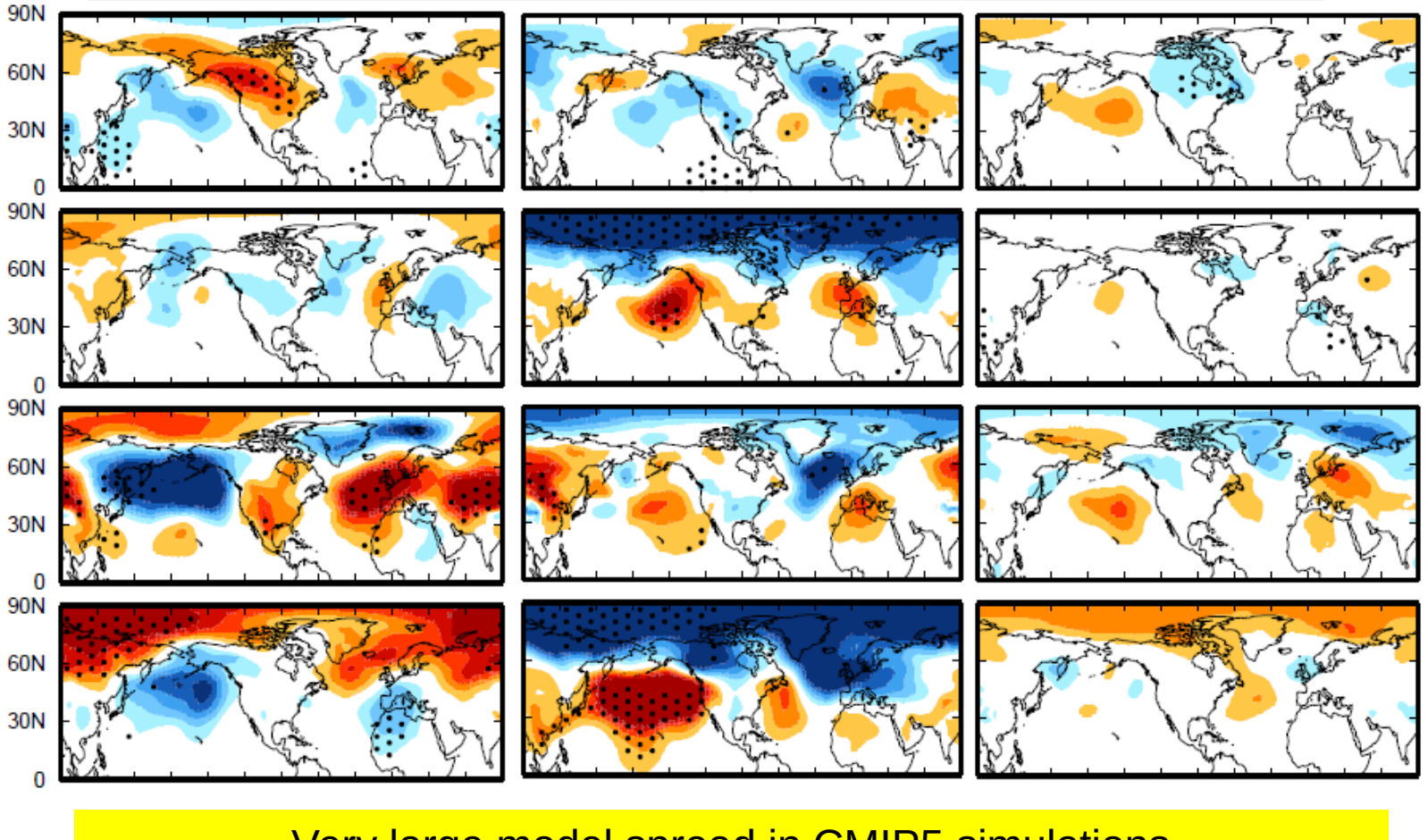


SolarMIP project:
Mitchell et al., Hood et al., Misios et al., QJRMS, 2015

Regional climate response in CMIP5 simulations

Sea level pressure (hPa) response to solar variations

12 randomly selected models



Very large model spread in CMIP5 simulations

Stratosphere response in CMIP5 simulations

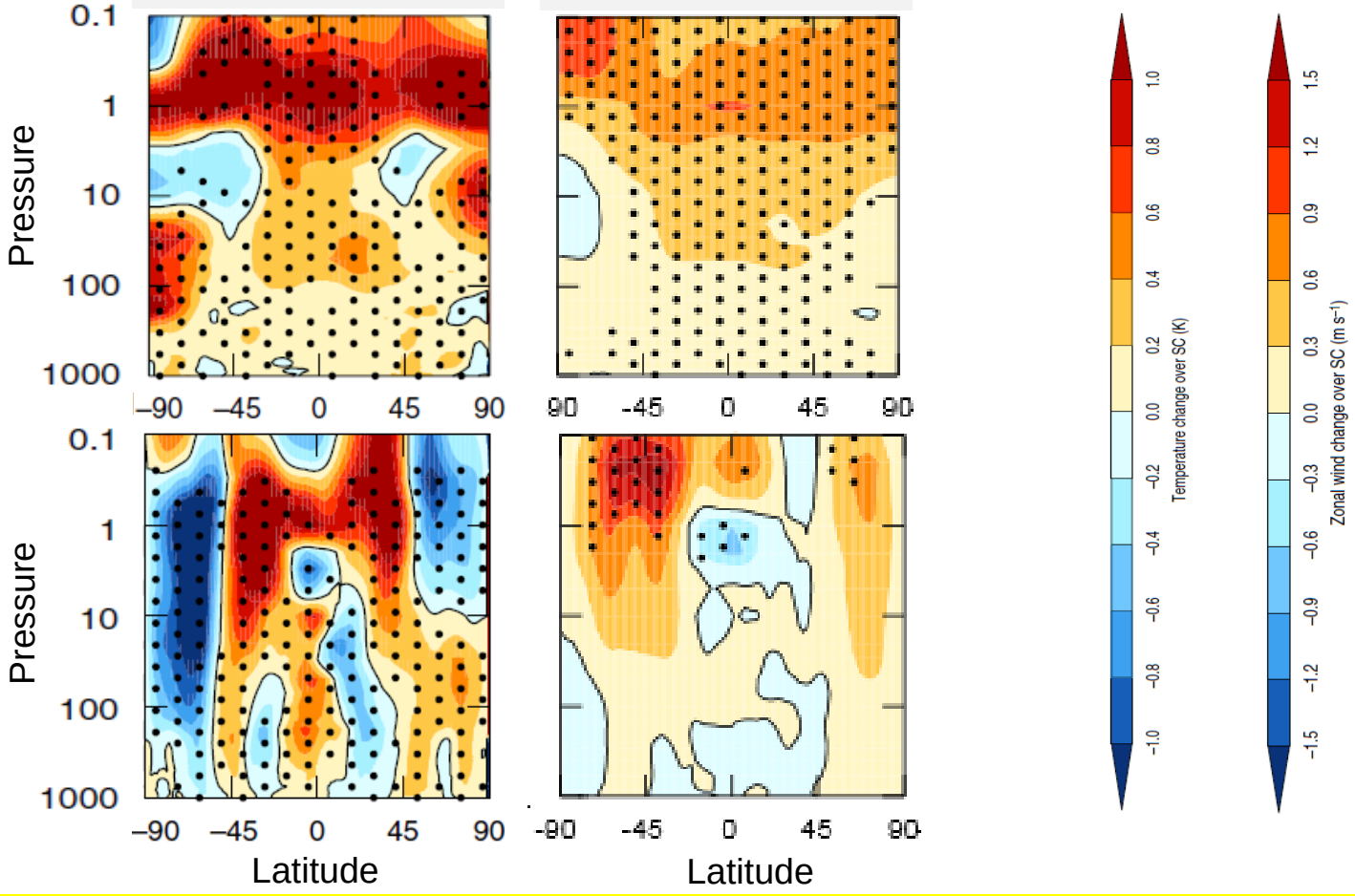
Annual (Smax – Smin)

Observations

Multi Models

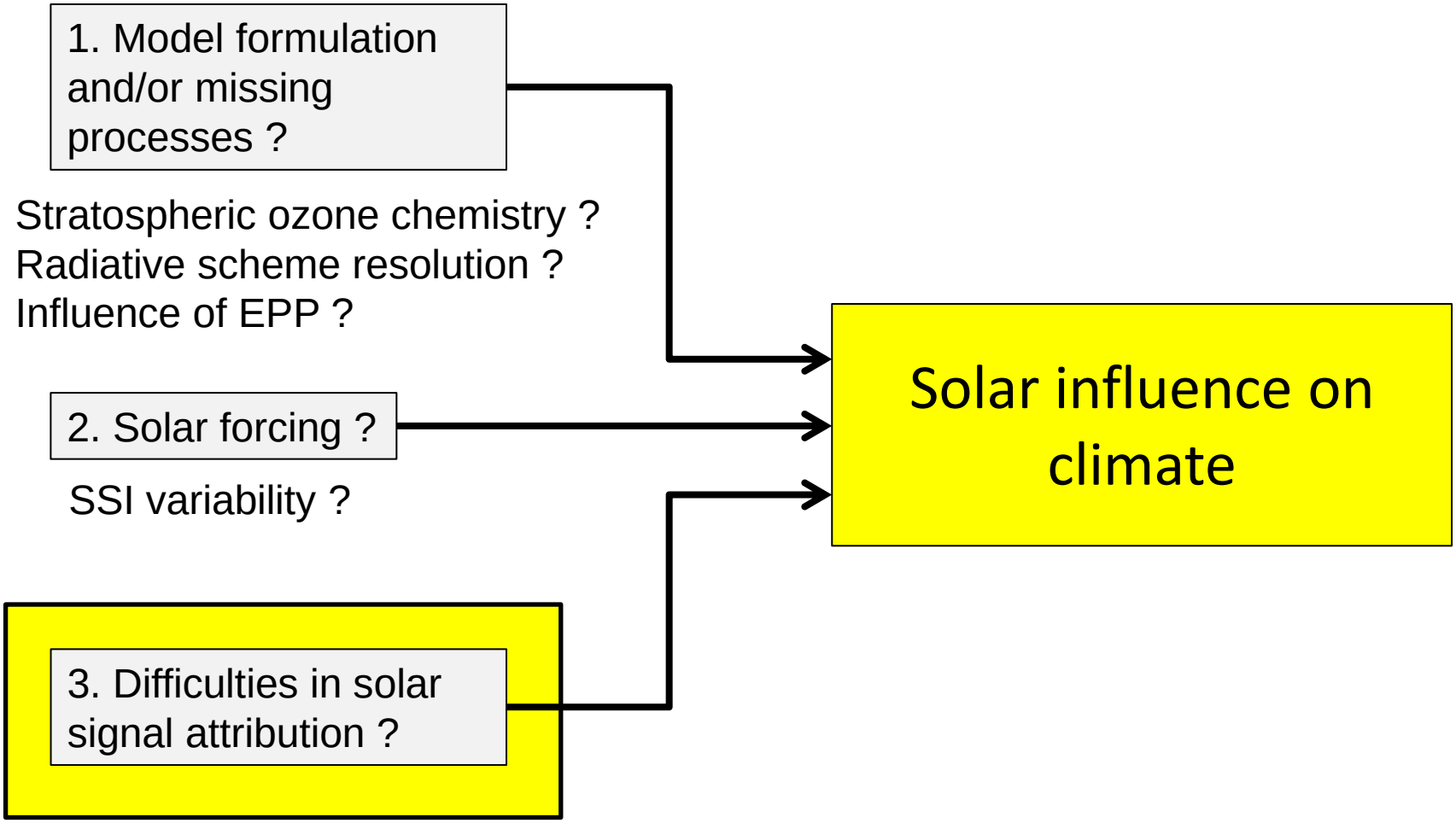
Temp

Zonal wind

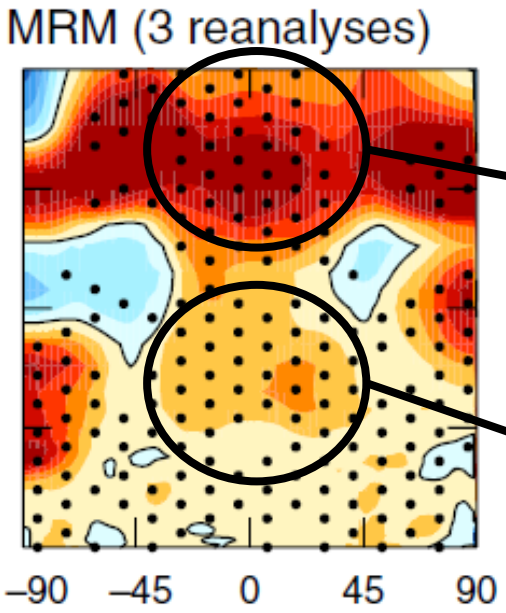


Top-down signal not well reproduced in CMIP5 simulations

Why are solar signals so difficult to simulate/identify ?

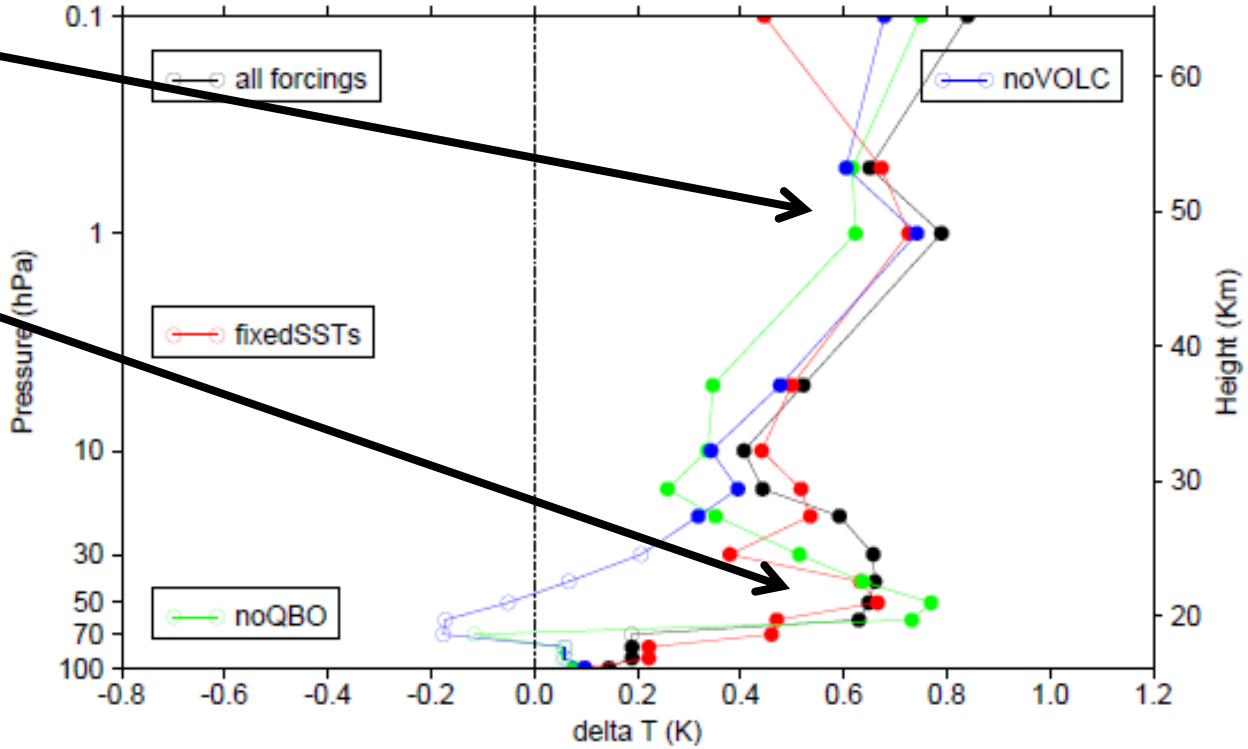


Aliasing signals



11-year solar signal in zonal mean T [25S,25N]

Chiodo et al., *ACP*, 2014



The last major volcanic eruptions coincide with solar maximum !

The secondary temperature signal in lower tropical stratosphere may partly result from an **aliasing with volcanic signal**.

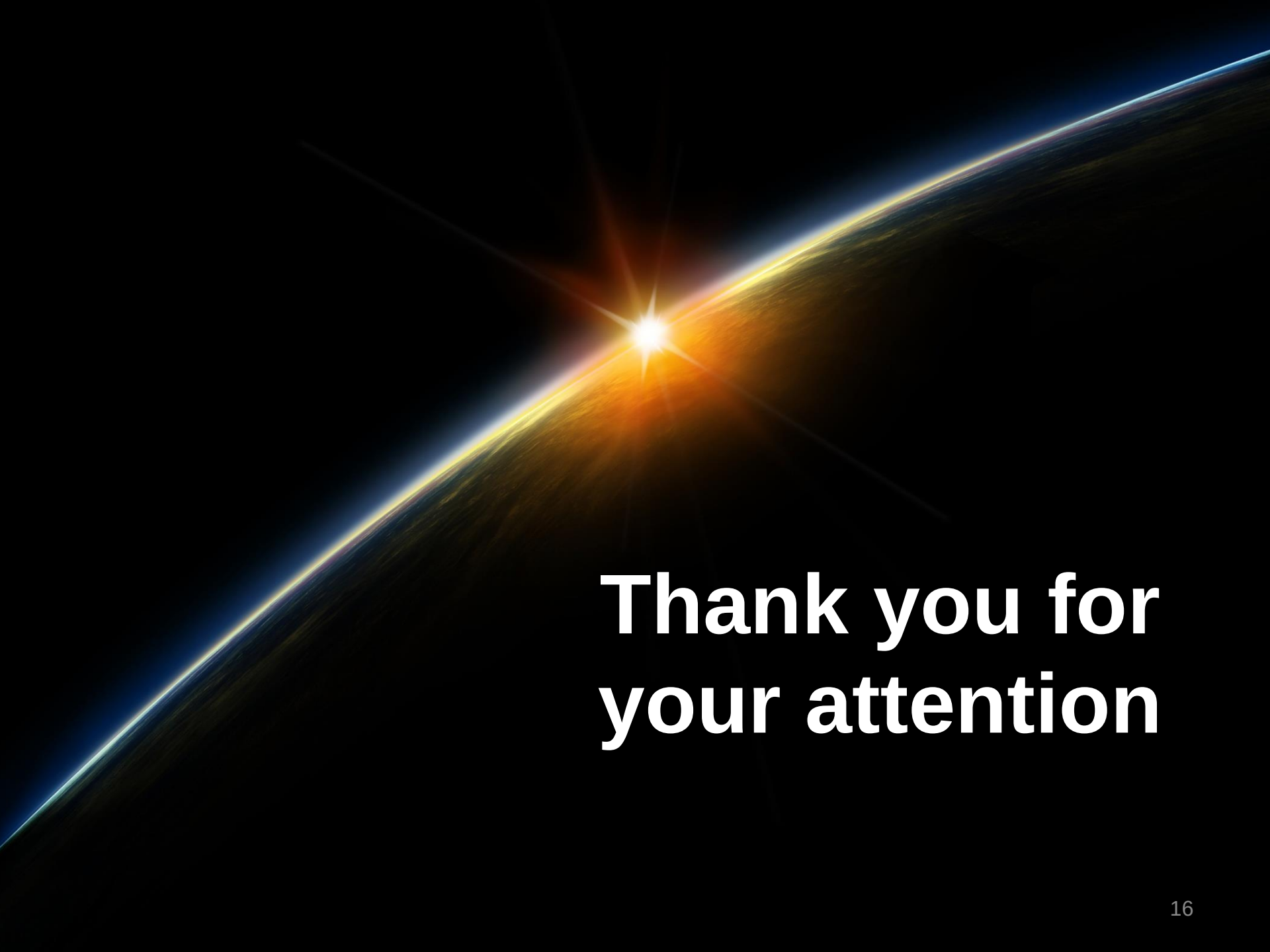
Conclusions

- Increasing evidences that solar irradiance variability projects on **regional climate** (and at different timescales) ⇔ very important to understand **climate natural varia**bi**lity** and **seasonnal-to-decadal prediction**.

- Proposed mechanisms involved **complex couplings** between the different components of the climate system…

- ... but these mechanisms are still far from being well simulated in climate models !

- **What to do ?** ⇔ identification of robust solar signals and quantification, identifying prevalent mechanisms, improve model formulation...


Thank you for
your attention