

The basic effect of cloud/circulation coupling on tropical SSTs

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*from Li, Thompson, Olonscheck (JCL in review)
thanks also to Thorsten Mauritsen*

interactive clouds -> enhanced ENSO variability

LETTERS

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Amplification of El Niño by cloud longwave coupling to atmospheric circulation

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***interactive clouds ->
higher frequency ENSO variability***

Cloud Radiative Feedbacks and El Niño–Southern Oscillation

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Two experiments (from MPI)

- 1. Control simulation run on a coupled AOGCM with interactive clouds**
 - 2. Simulation run with “scrambled” cloud radiative effects (cloud “locking”)**
- (MPI-ESM1.2-LR with preindustrial forcing)**

Scrambling methodology

Clouds are scrambled by reordering the year of the cloud fields at every 2 hour radiation call. EG:

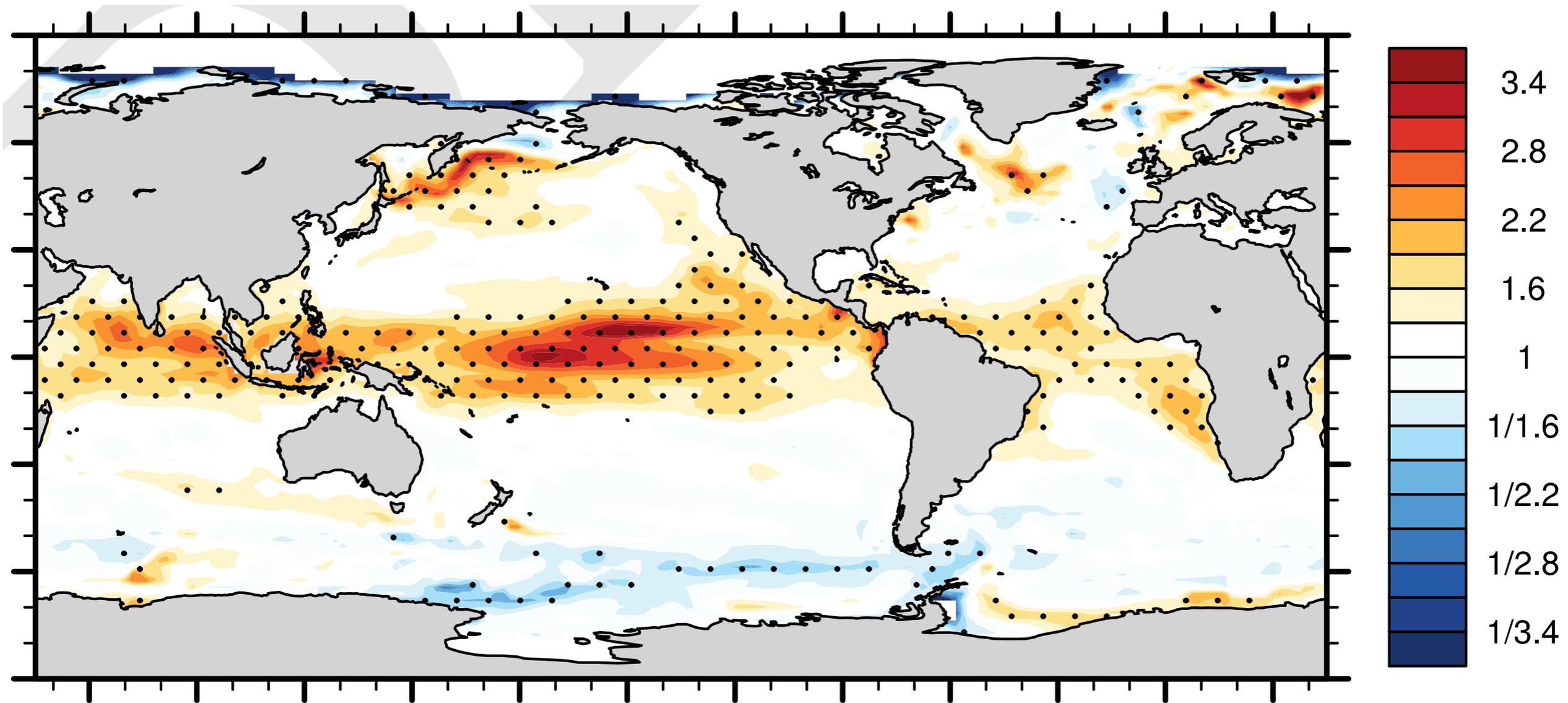
Control run	Scrambled run
00Z, Jan 1, Year 1	00Z, Jan 1, Year 100
02Z, Jan 1, Year 1	02Z, Jan 1, Year 24
04Z, Jan 1, Year 1	04Z, Jan 1, Year 176
06Z, Jan 1, Year 1	06Z, Jan 1, Year 87

Method preserves the mean diurnal and seasonal cycles of the cloud fields.

The differences between the control (interactive) and scrambled (locked) runs are due entirely from the effects of clouds on the circulation

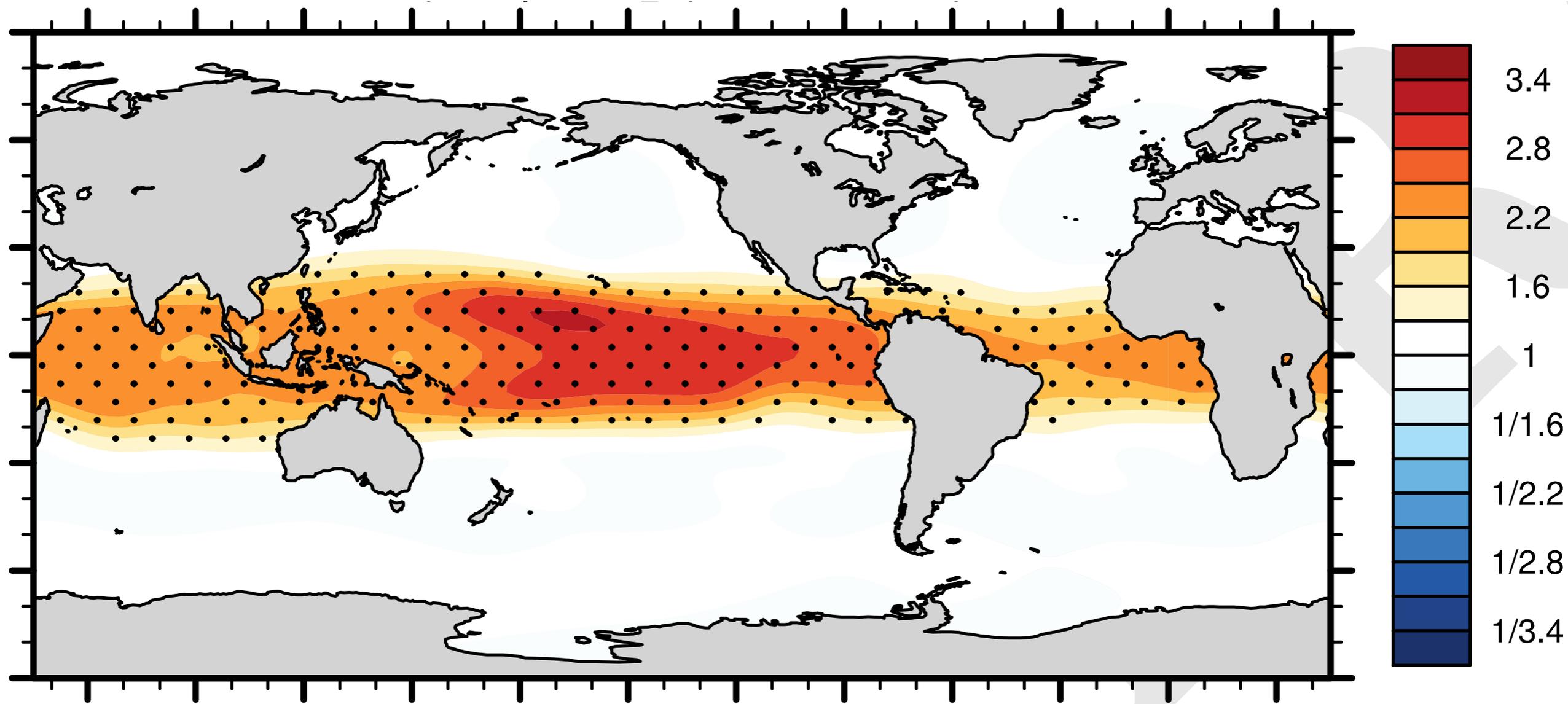
Effects on monthly-mean SST variance

$$\frac{s^2_{\text{interactive}}}{s^2_{\text{locked}}}$$

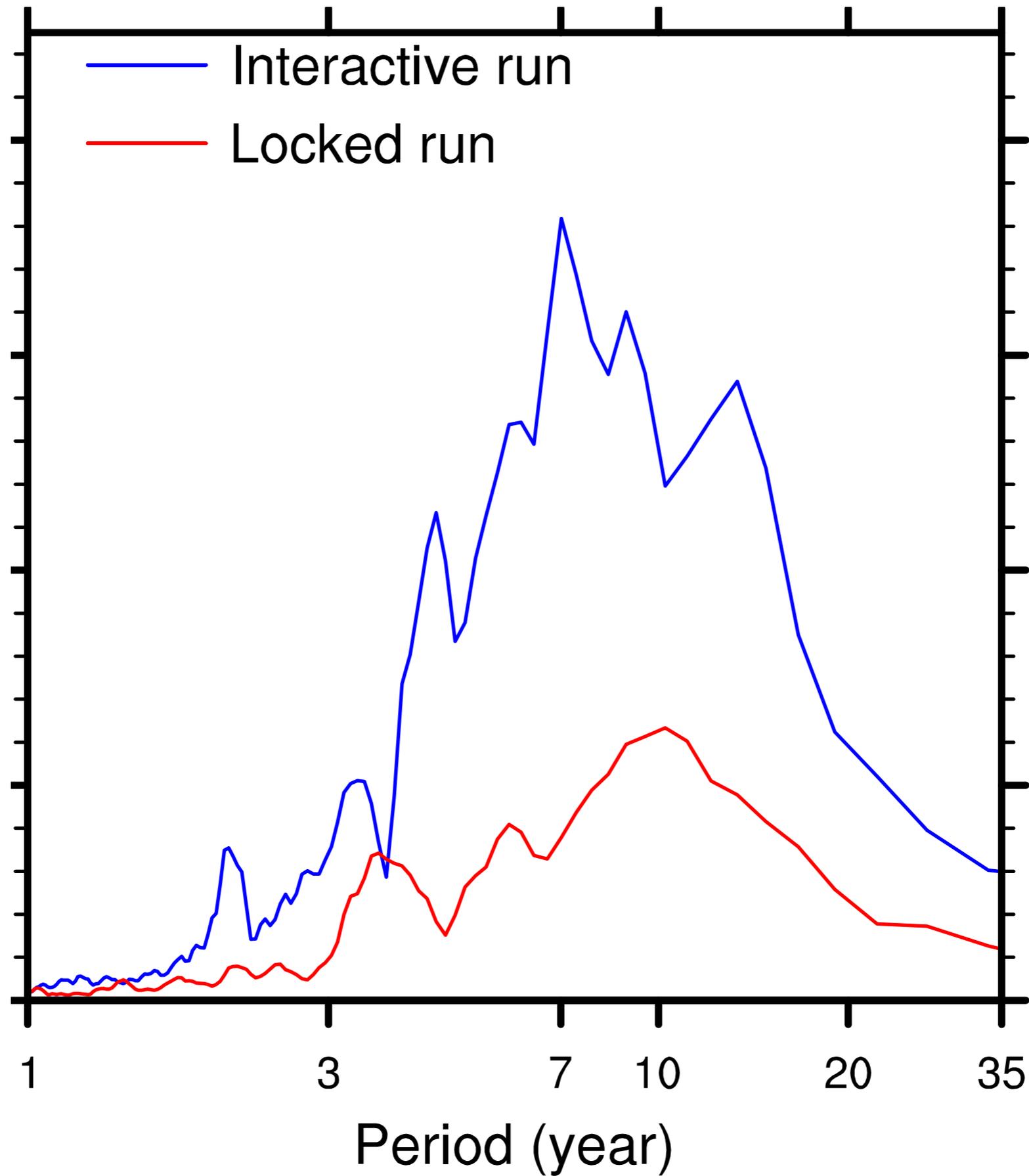


Effects on monthly-mean Z150 variance

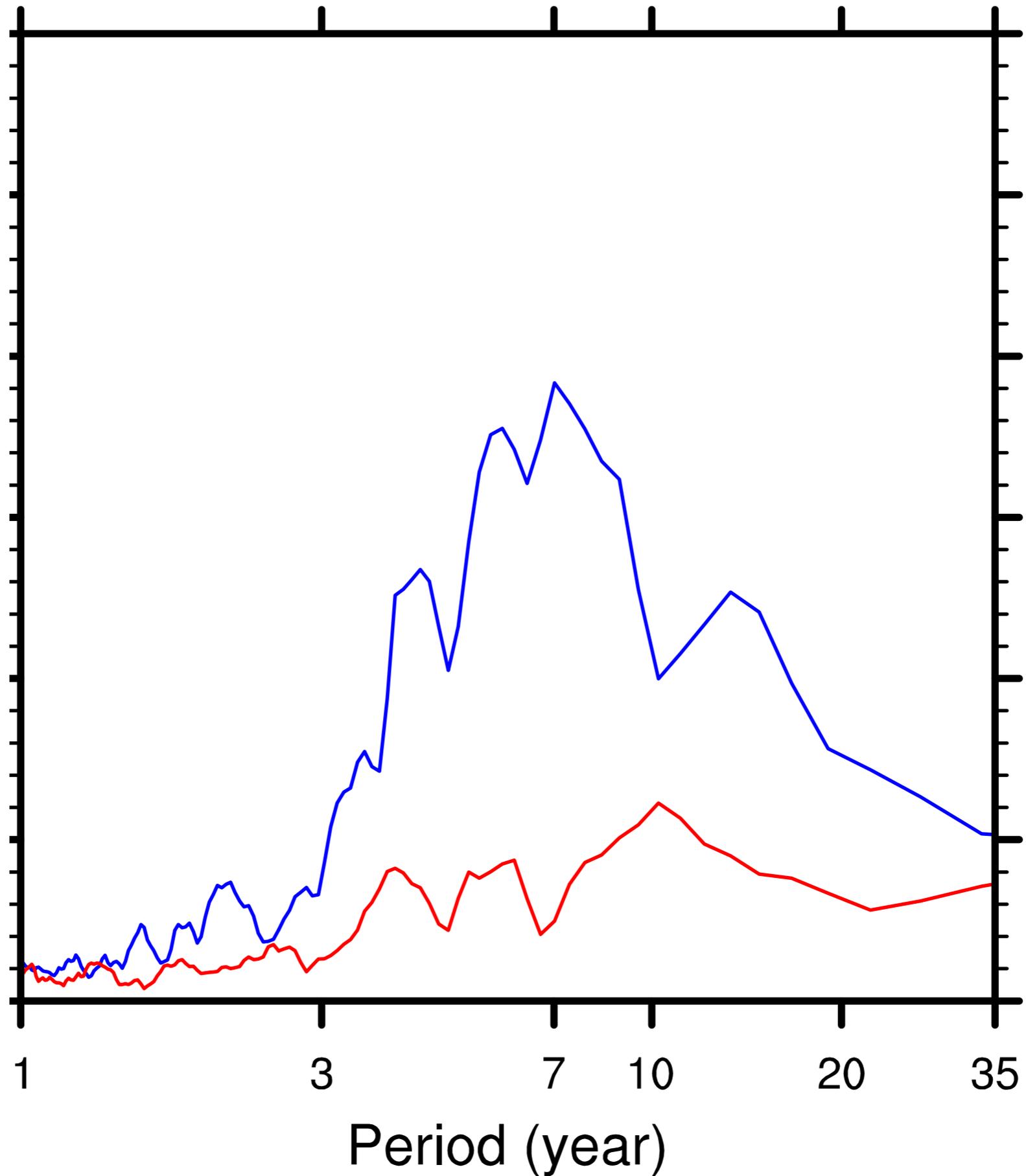
$$\frac{s^2_{\text{interactive}}}{s^2_{\text{locked}}}$$



Power spectra of SSTs in Nino3.4

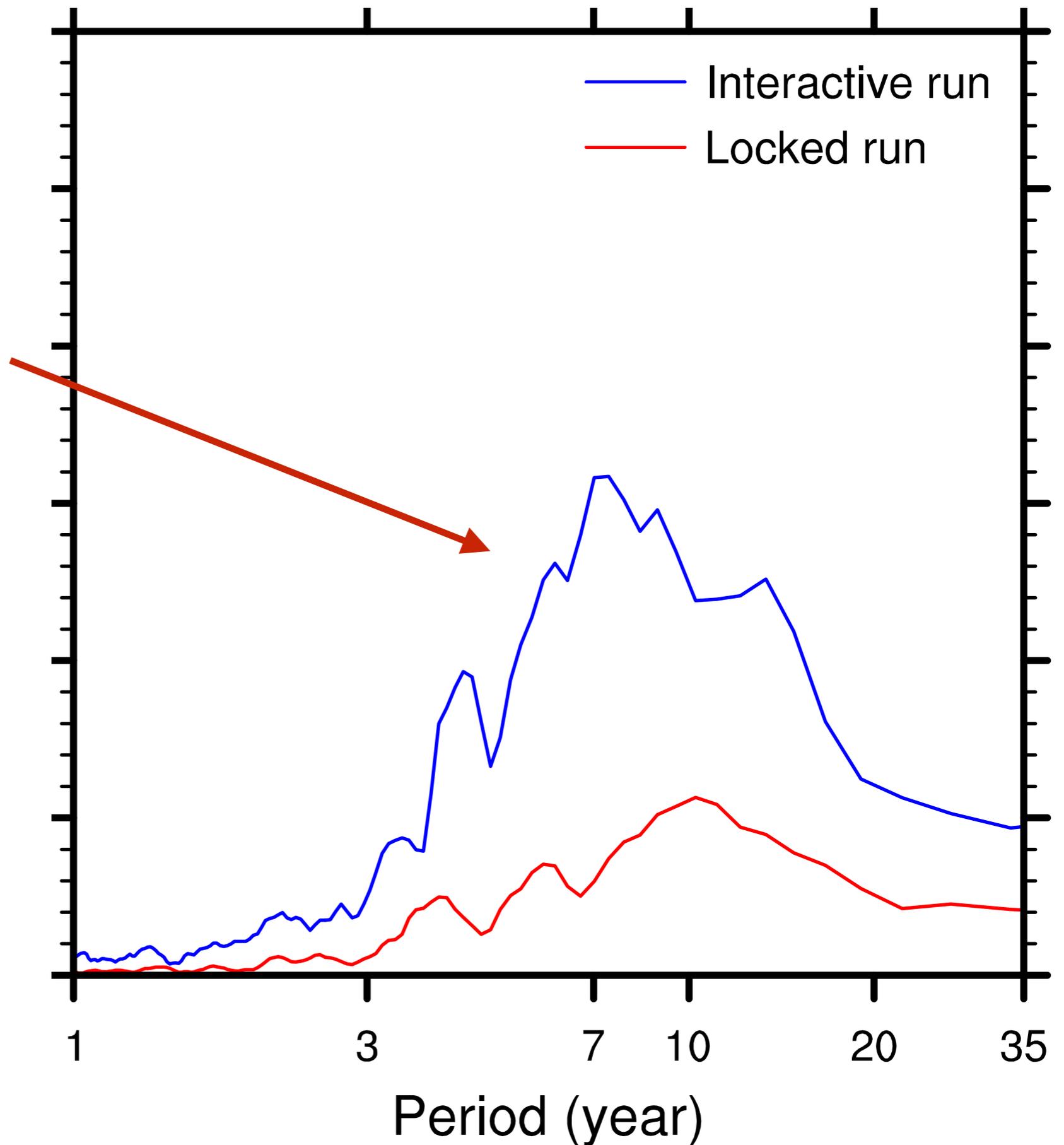


in the tropical Indian ocean



averaged over the tropics

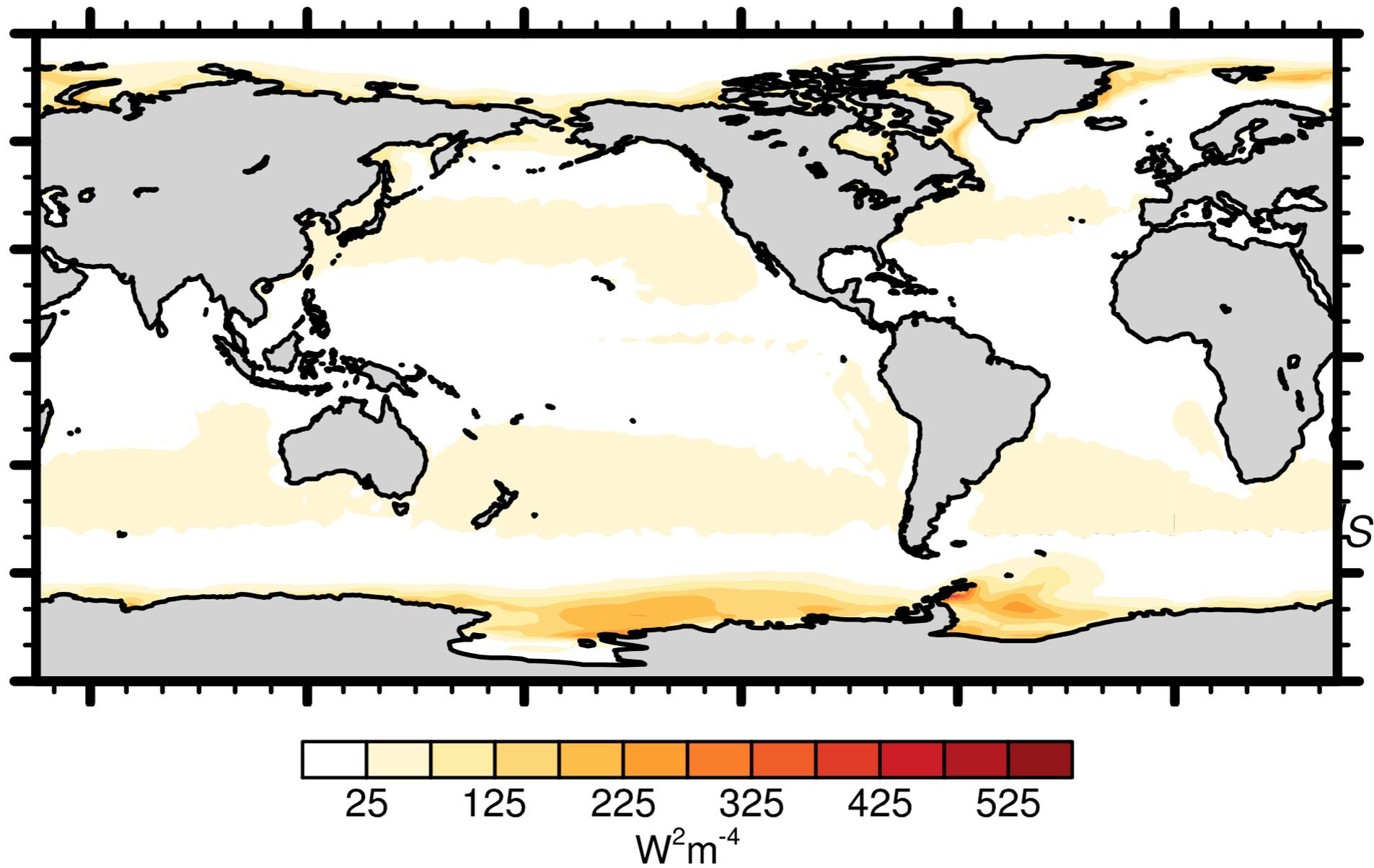
Large increases in tropical SST variance from days - decades.



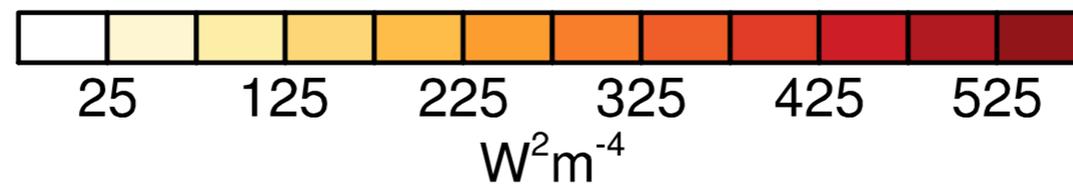
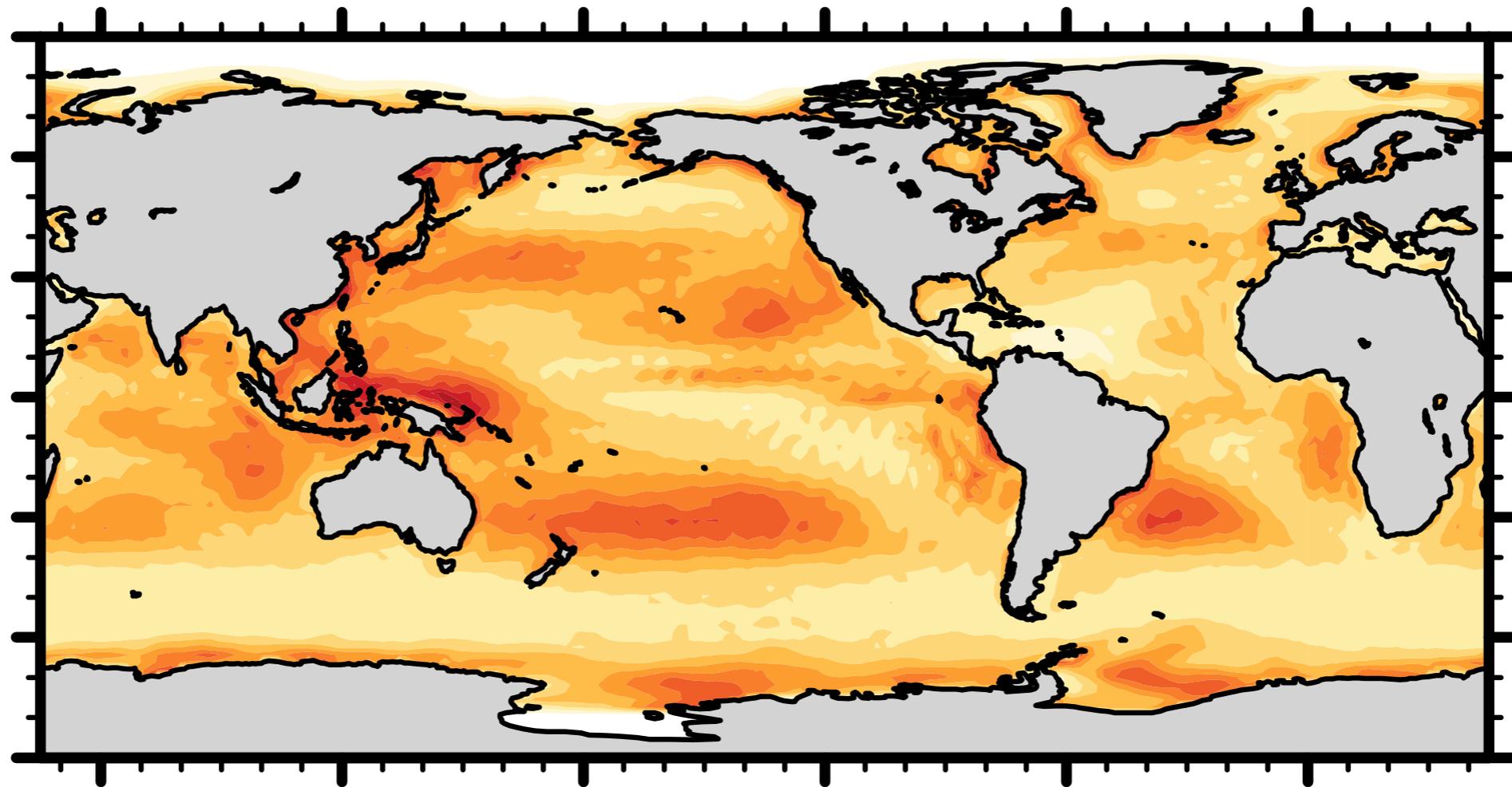
Why?

$$C_o \frac{\partial T}{\partial t} = \boxed{Q_{SW}} + Q_{LW} + Q_{LH} + Q_{SH} + Q_{residual}$$

***Variance of shortwave cloud radiative effects:
Locked clouds***



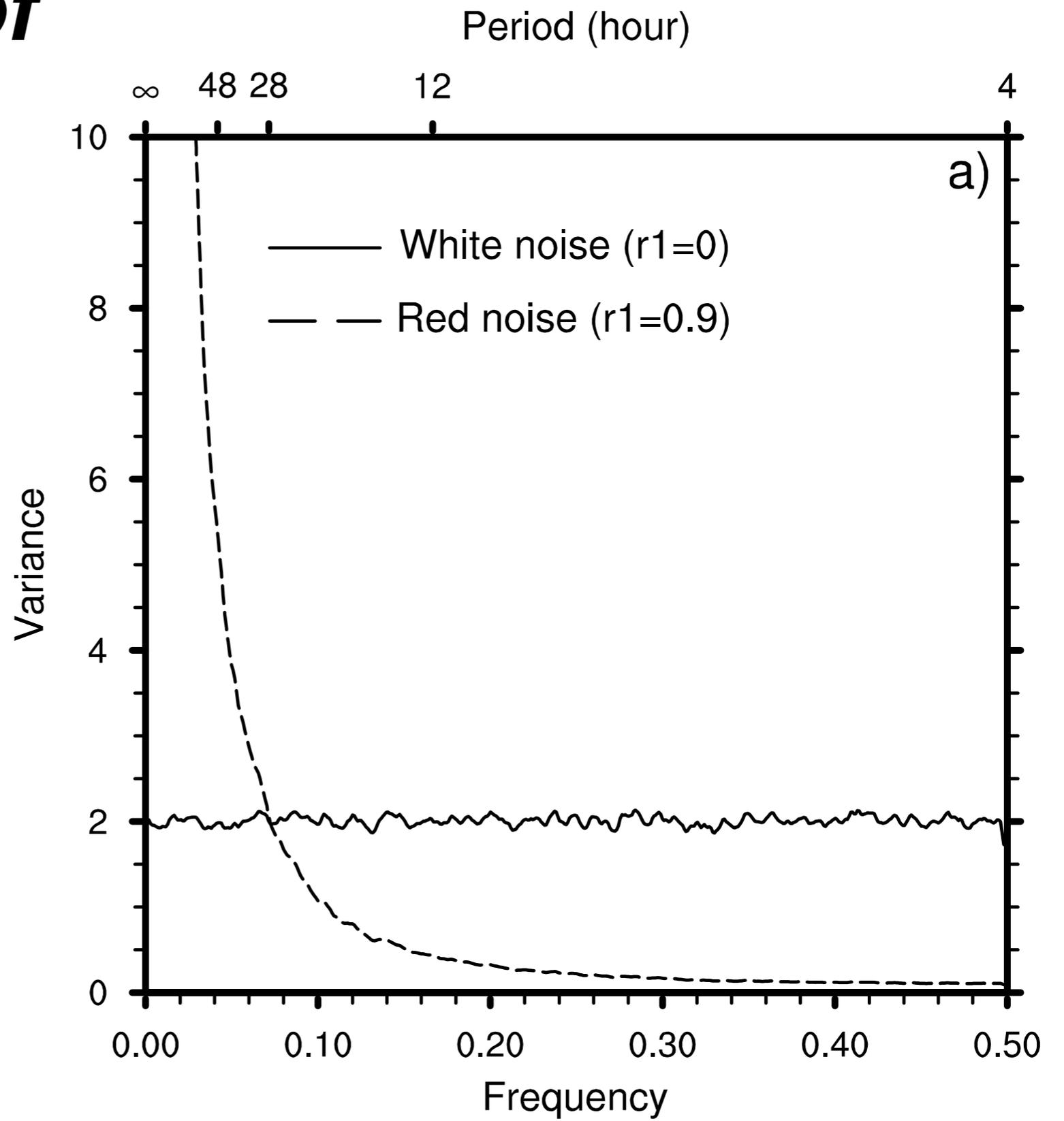
***Variance of shortwave cloud radiative effects:
Interactive clouds***



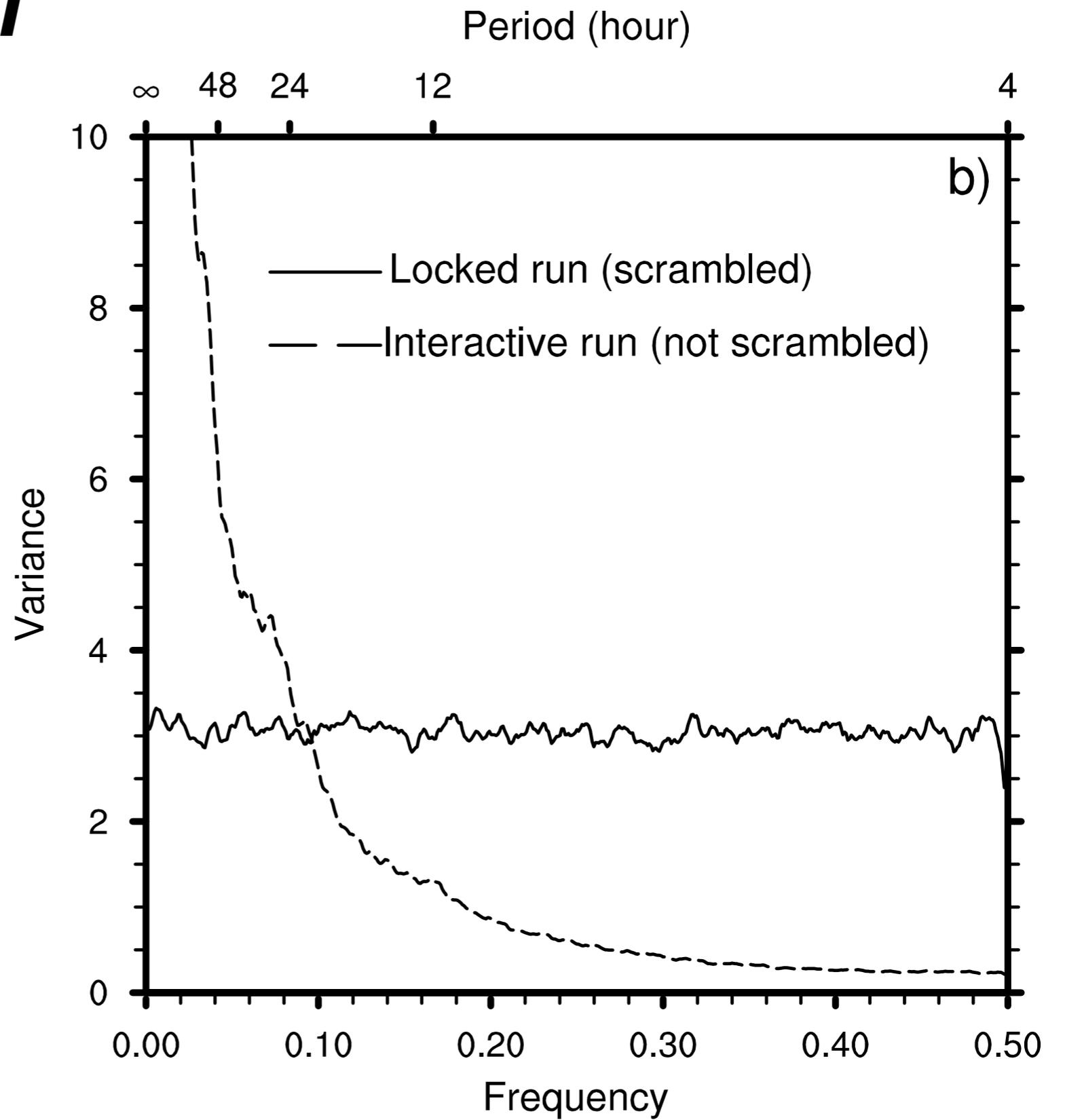
Why does the variance in SW CRE increase?

- 1. Interactive clouds have memory:
Their autocorrelation is $\sim r=0.9$ when
sampled on two hourly intervals.**
- 2. The memory comes from the
circulation. And it has a strong
effect on the variance of clouds and
their radiative effects.**

Power spectra of random time series

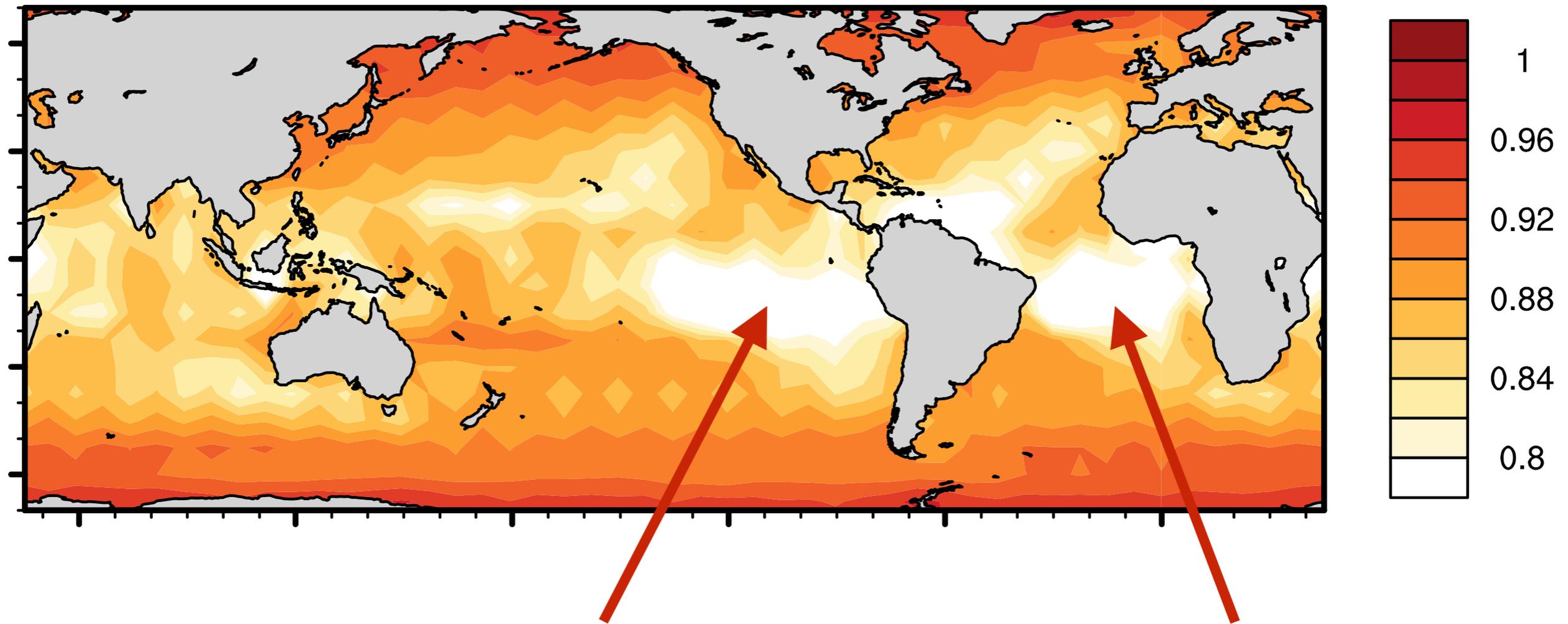


***Power spectra of
cloud fraction
from the two
simulations***

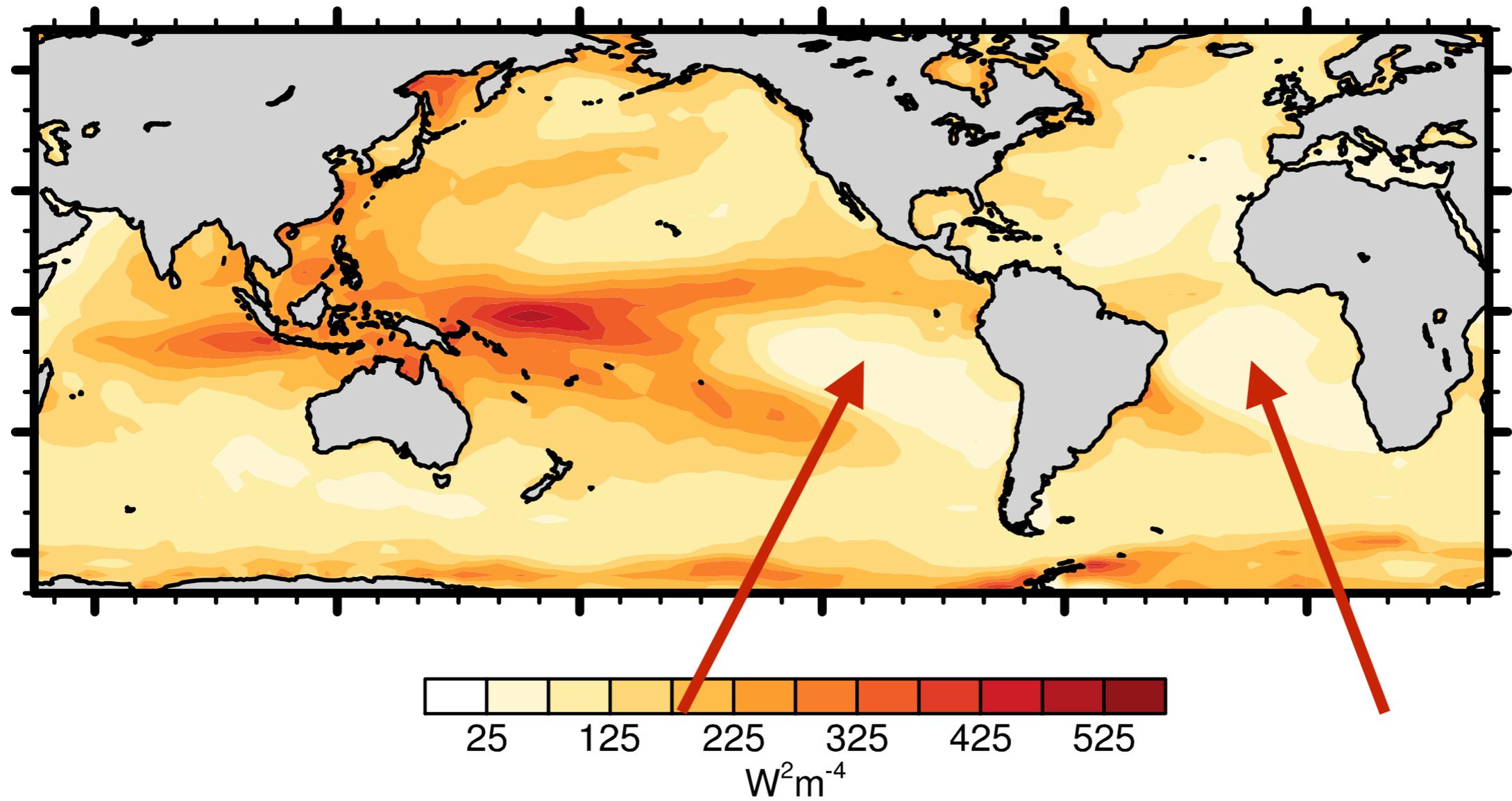


Testing with observations (ERA5)

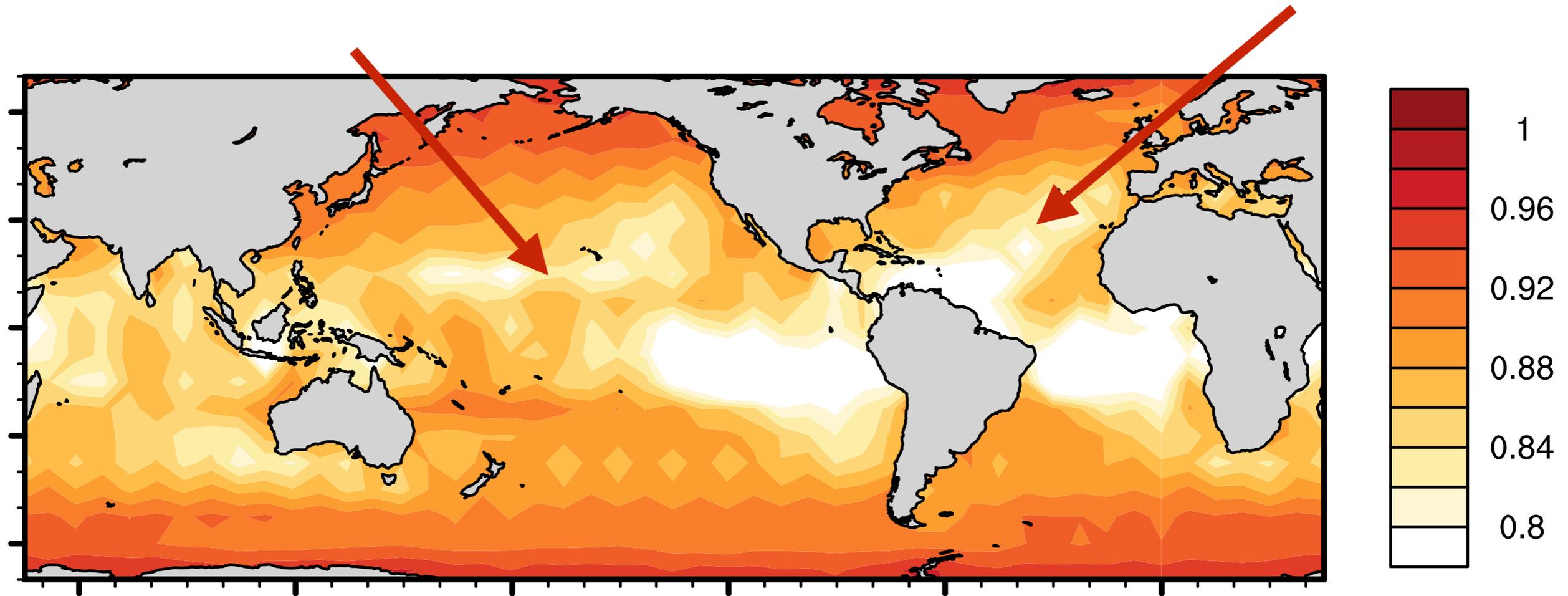
two-hour lag correlation of SW flux



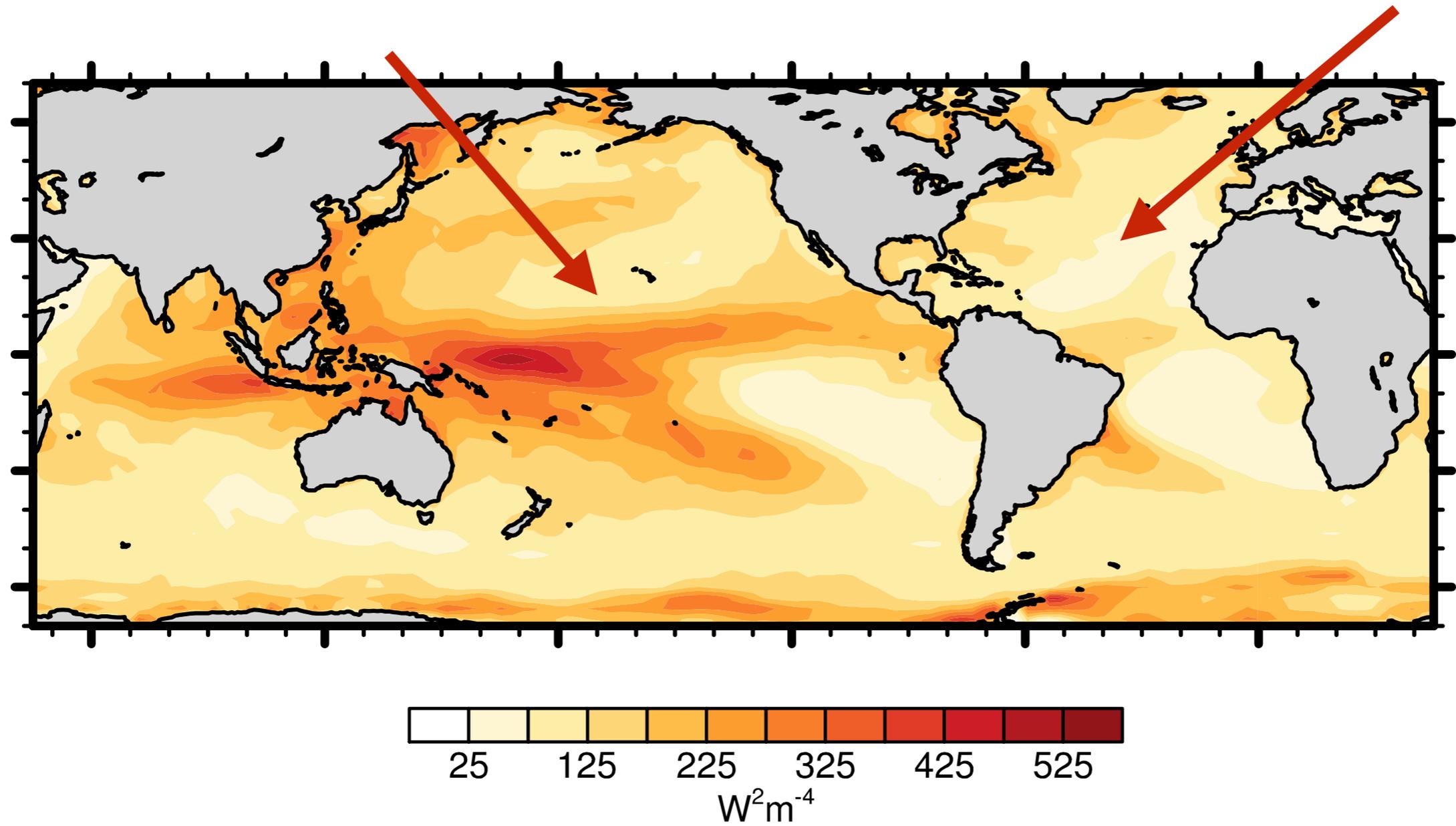
variance of monthly mean SW flux



two-hour lag correlation of SW flux



variance of monthly mean SW flux



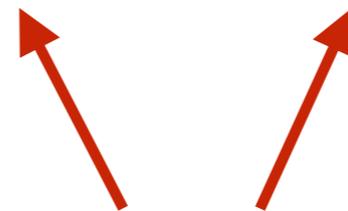
and so...

**Cloud/circulation coupling
acts to “reddden” clouds and
their shortwave radiative
effects.**

The reddening leads to increases in the variance of shortwave CRE - and thus SSTs - on timescales from days to decades.

***The effect is most pronounced
in the tropics***

$$C_o \frac{\partial T}{\partial t} = Q_{SW} + Q_{LW} + Q_{LH} + Q_{SH} + Q_{residual}$$



***turbulent heat fluxes are dominant
in extratropics***

cloud/circulation coupling has a pronounced effect on the amplitude of decadal variability

***spectra of
tropical SSTs
with interactive
clouds***

***decoupled
clouds***

