ENSO-Induced Changes in Tropical Stratosphere as Simulated by WACCM

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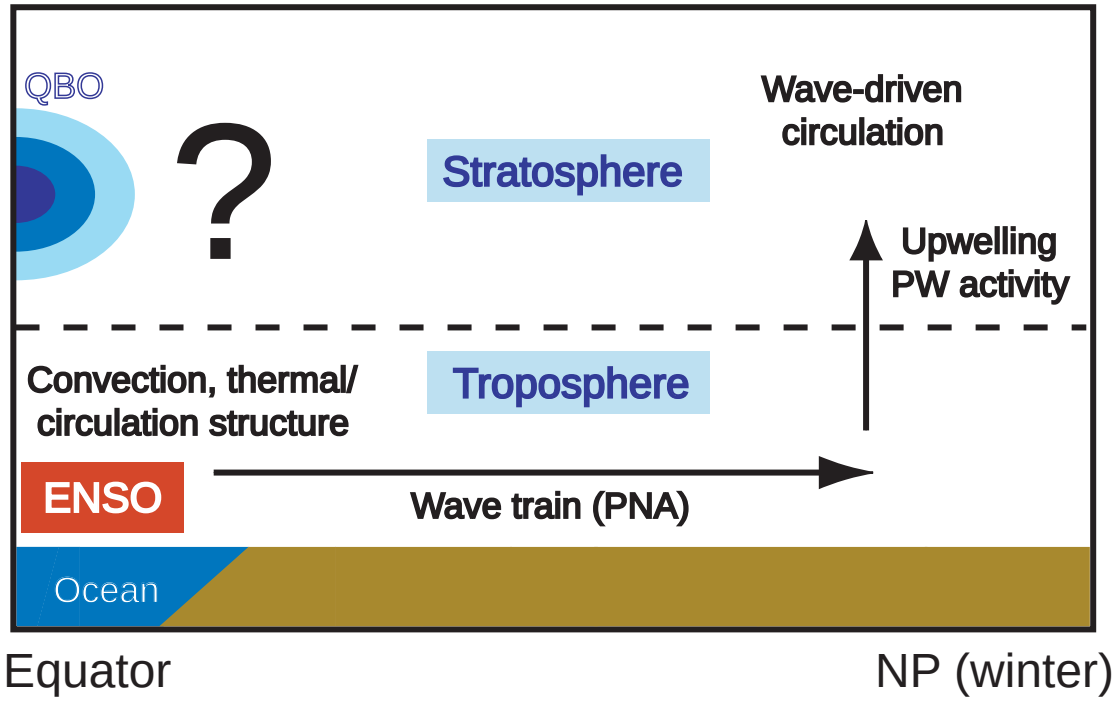
1. Introduction (1)

ENSO (El Nino/Southern Oscillation):

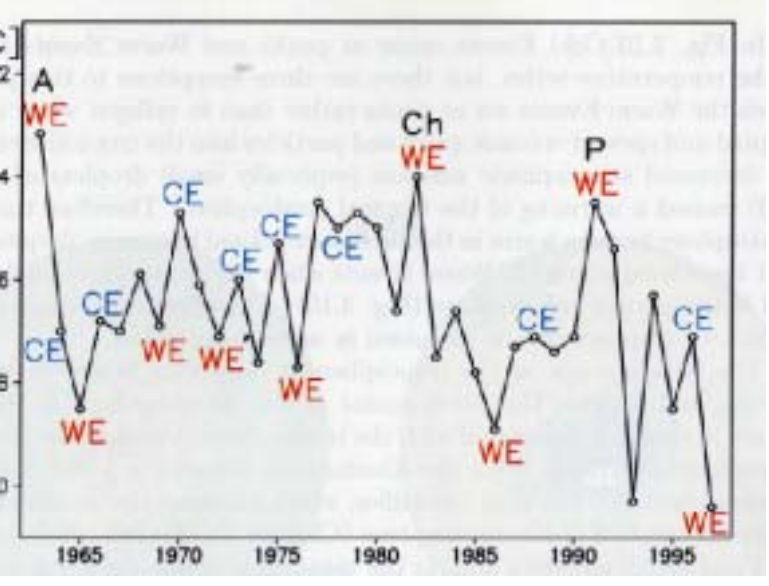
Large(st) source of global climate variability in troposphere and probably also stratosphere



We focus on NH winter, because ENSO tends to have large amplitudes during this season.

1. Introduction (2)

ENSO-related changes in tropical stratosphere revealed by existing studies:



Zonal mean temperature@10N, 30hPa for December (Labitzke & van Loon 2000)

⇒ Warming for La Nina (CE) vs.

Cooling for El Nino (WE)

-May not be conclusive, because statistical reliability and attribution are difficult problems in real world due to QBO, volcanic eruptions, …

-However, the results are supported by model experiments forced with ENSO only (shown below).

1. Introduction (3)

Mechanism(s) for the ENSO-related changes seems unclear.

Labitzke & van Loon (2000) states:

> The SO which plays a large rôle in the troposphere also extends its influence into the stratosphere (Fig. 3.10). The higher equatorial water temperatures in the Pacific Ocean in Warm Events lead to increased convection in the equatorial belt, and the stronger than normal upward motion of the air in the convection zones lifts and cools the tropopause region so that the air in the lower tropical stratosphere becomes abnormally cold in a Warm Event, in contrast to the tropical troposphere which is abnormally warm. In the Cold Events the tropical troposphere is abnormally cold and the lower stratosphere warm (see Box 3.2).

-Is the underlined part the best explanation (alternative possible?)

-Existing results suggest:

wave driving & residual circulation (RMMC) change with ENSO, and then these could drive the thermal changes.

-We examine ENSO-induced changes inc. RMMC/wave driving using existing WACCM simulations forced with ENSO-like SST.

2. WACCM Simulations Used

-Whole Atmosphere Community Climate Model (WACCM, Sassi et al. 2002)

T63, L66 up to about 110 km

-Taguchi & Hartmann (2006, TH) simulations

Two perpetual January runs (3650-day long for each)

ENSO-like SST forcing in tropical Pacific applied:

run COLD for La Nina vs. run WARM for El Nino

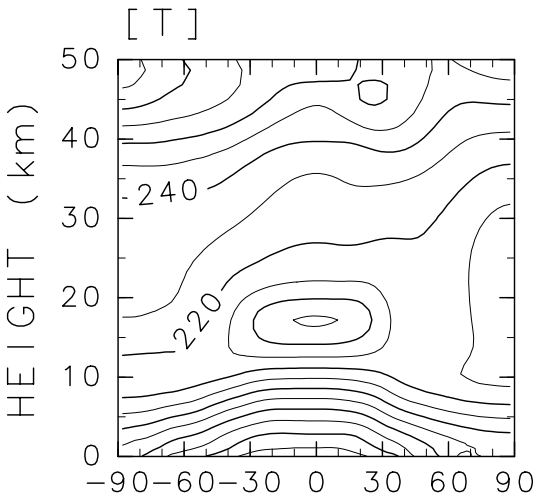
Compare time-mean states

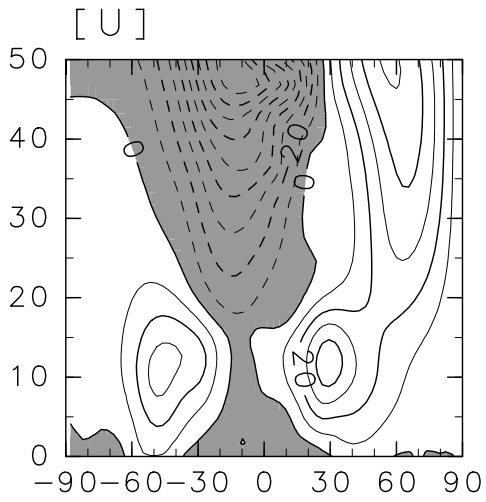
-Sassi et al. (2004) simulation

50-year simulation forced with observed SSTs from 1951-2000

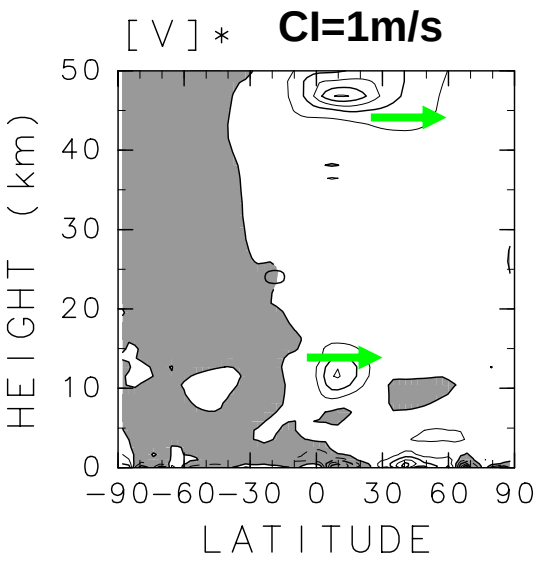
Apply regression analysis for JAN-FEB mean data with "CTI" (SST in eastern tropical Pacific)

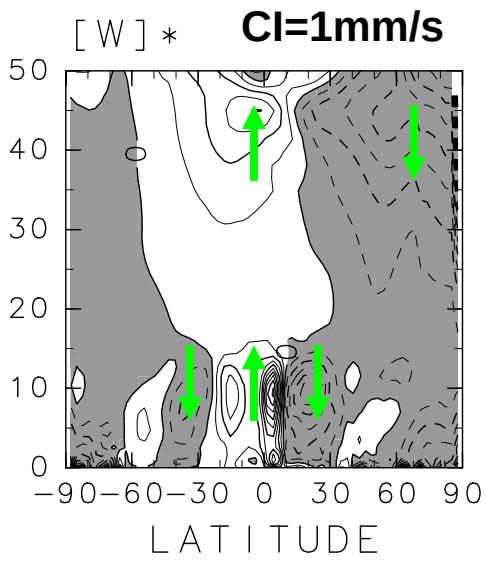
Climatological States (from TH data)

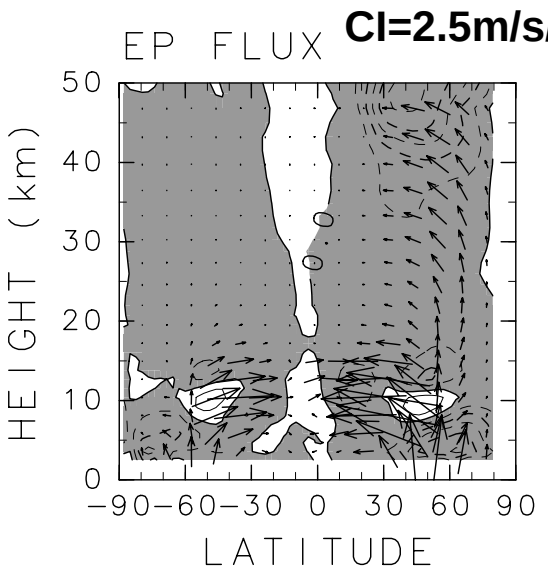




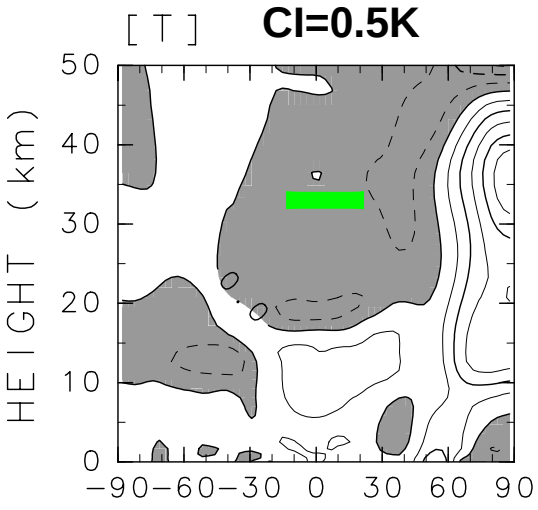
Time mean states averaged for runs COLD & WARM

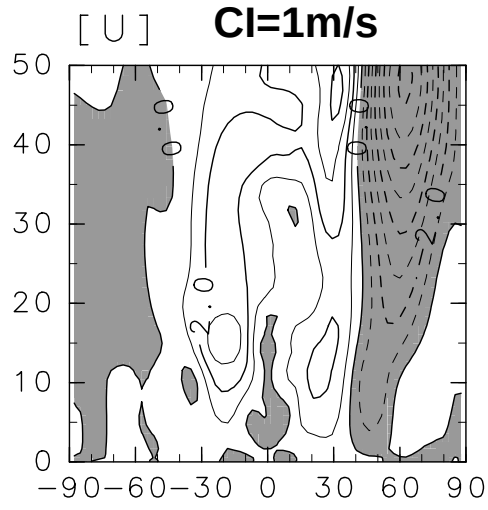






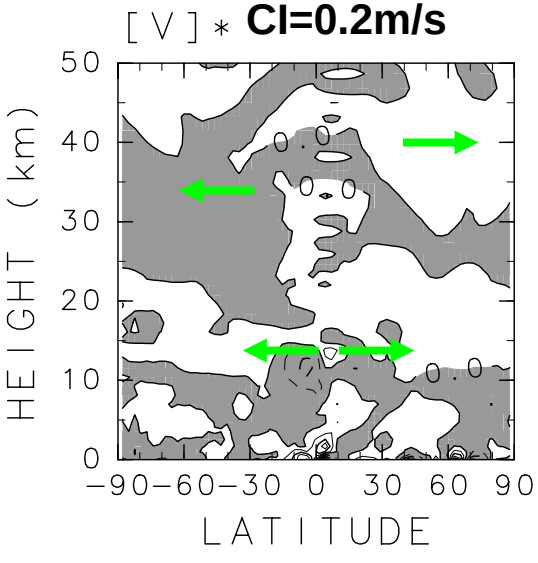
Changes in Climatological States (TH)

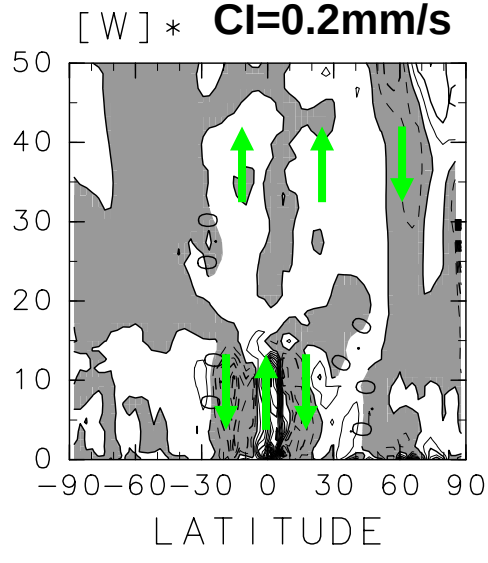


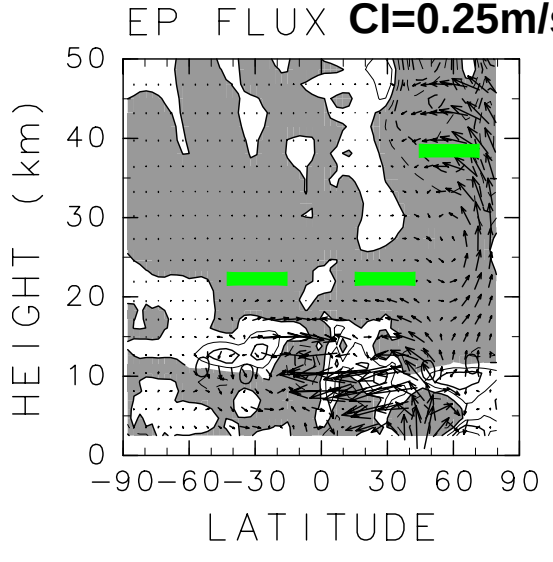


Clim. diff.: WARM − COLD

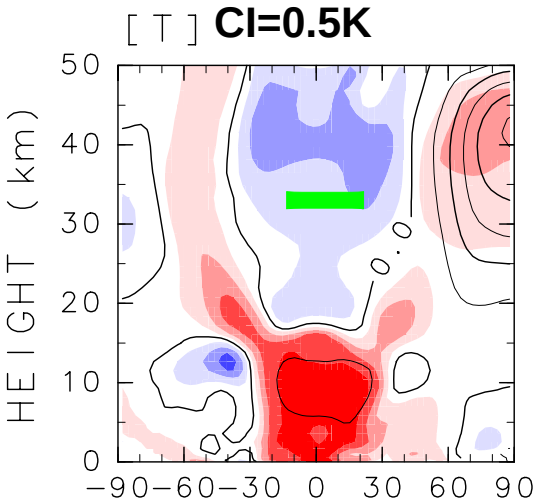
- -Slight cooling in tropical stratosphere
- -Upwelling at both sides of Equator
- -Convergence of EP flux in tropical lower stratosphere

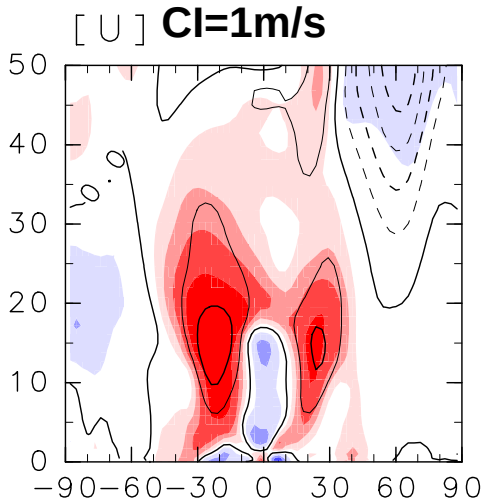






Regression Analysis (Sassi et al. data)

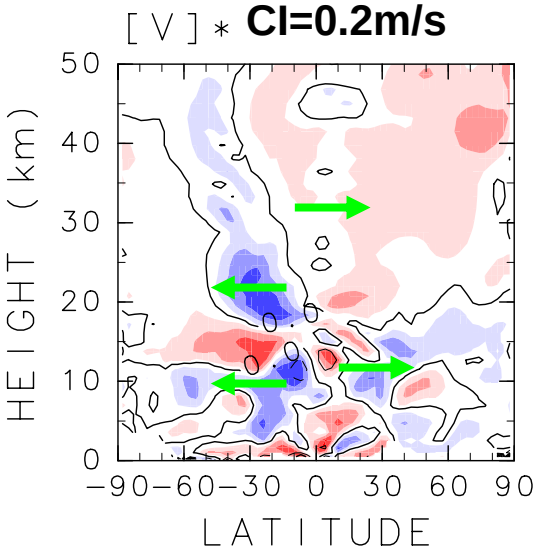


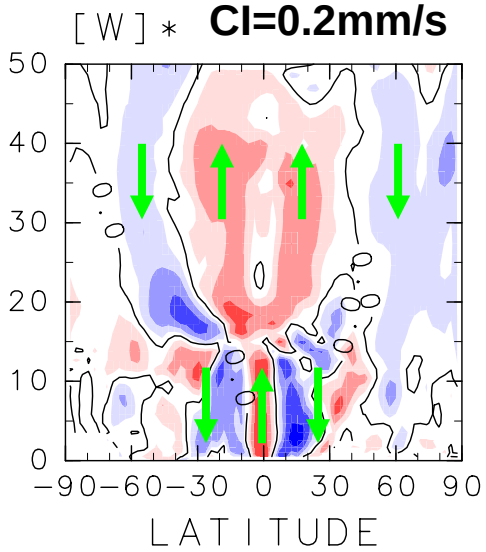


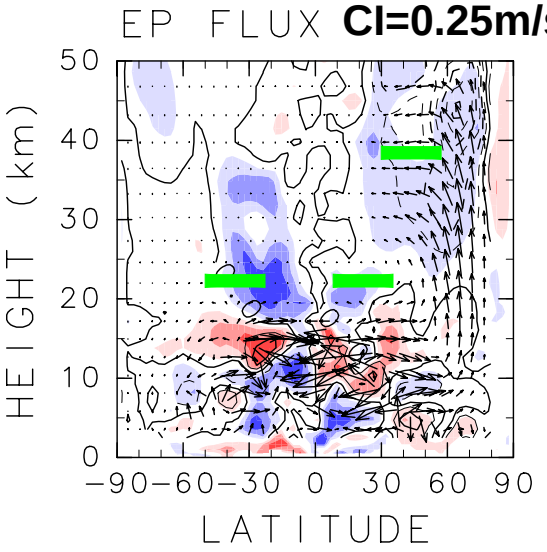
-Share most tropical features with clim. diff.

⇒Extract robust results

-Correlations over ±0.4 support significance.



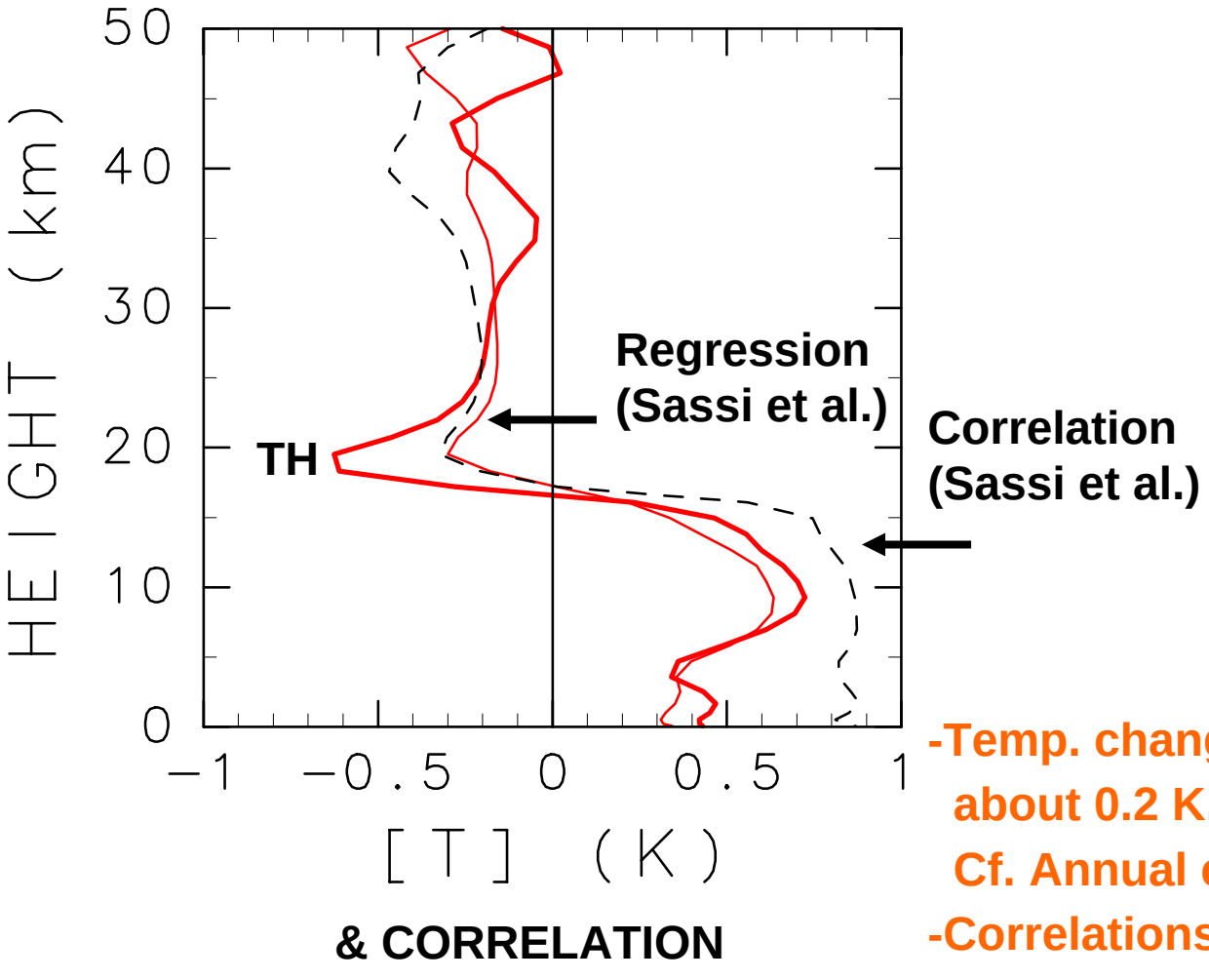




Blue/Red shadings denote correlations over ±0.2.

Profiles of Tropical Temperature Changes

Temperature changes averaged for ±10 °

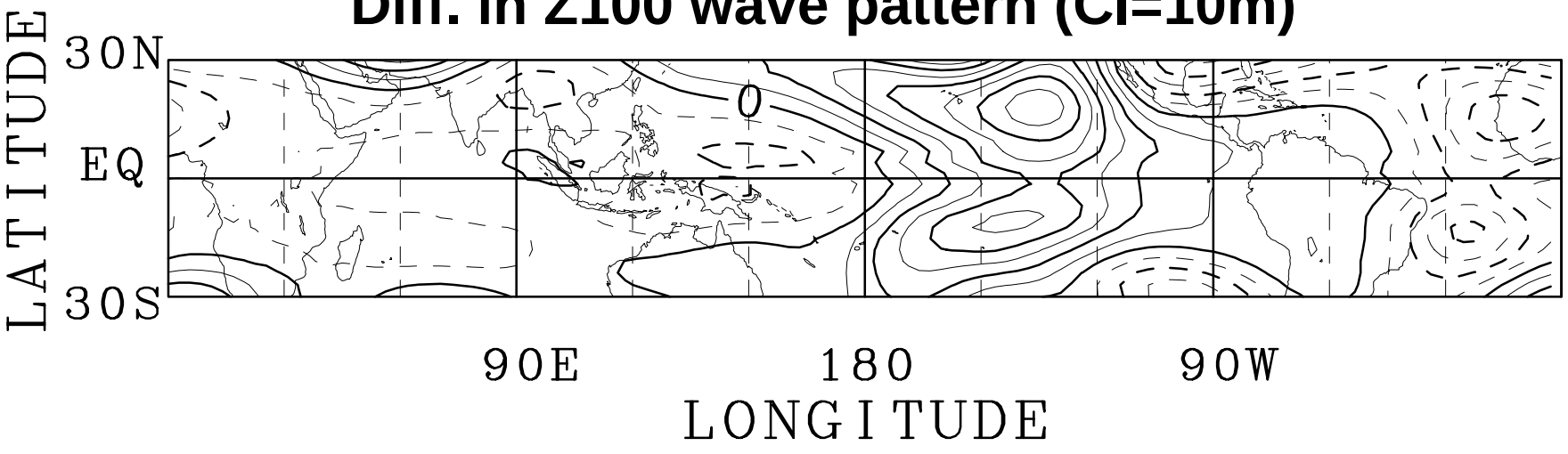


-Temp. changes in stratos are small, about 0.2 K, half of those in tropos. Cf. Annual cycle ~ 8 K

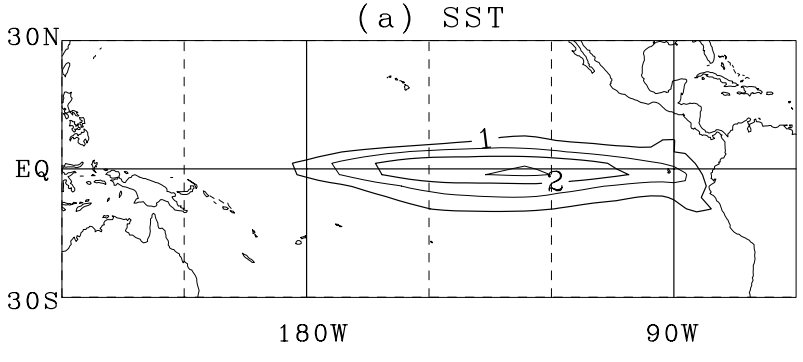
-Correlations will be significant, about -0.3.

Change in Wave Pattern of Z100

Diff. in Z100 wave pattern (CI=10m)



SST diff. (K) applied



Z100 diff. suggests

-Wave response to heating (SST/convection)

-May explain change in EP flux in tropical stratosphere

4. Summary & Discussion

Summary

-Slight cooling in tropical stratosphere for El Nino

-Associated with changes in RMMC:

Upwelling response

-Driven by wave drag changes:

Equatorial wave response forced by heating?

Extratropical “pump” in winter NH

～consistent with increased PW activity in TH

Discussion

-Useful to test/increase understanding of wave-driven RMMC in global tropos/stratosphere

-Changes found here are very small in magnitude, may be masked by dominant QBO signals in the real world