A strengthened teleconnection of the quasi-biennial oscillation and tropical easterly jet in the past decades in E3SMv1

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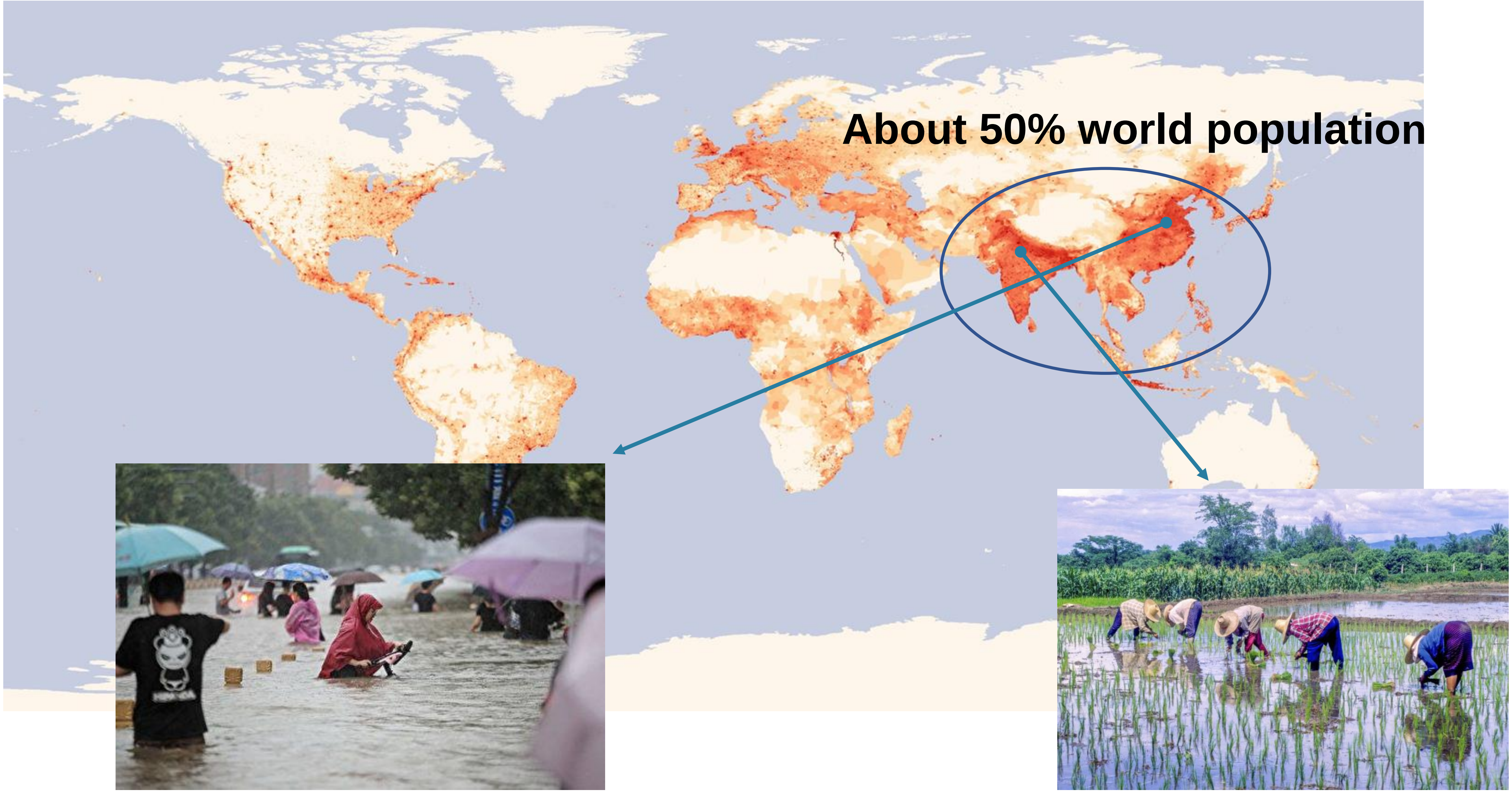
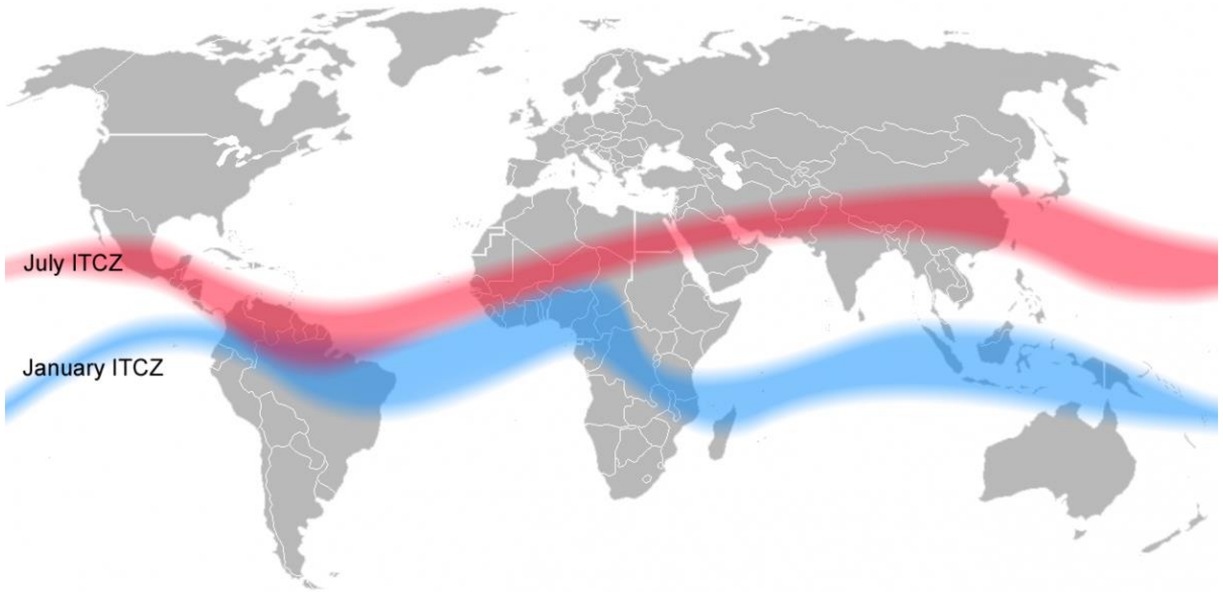
1. Introduction

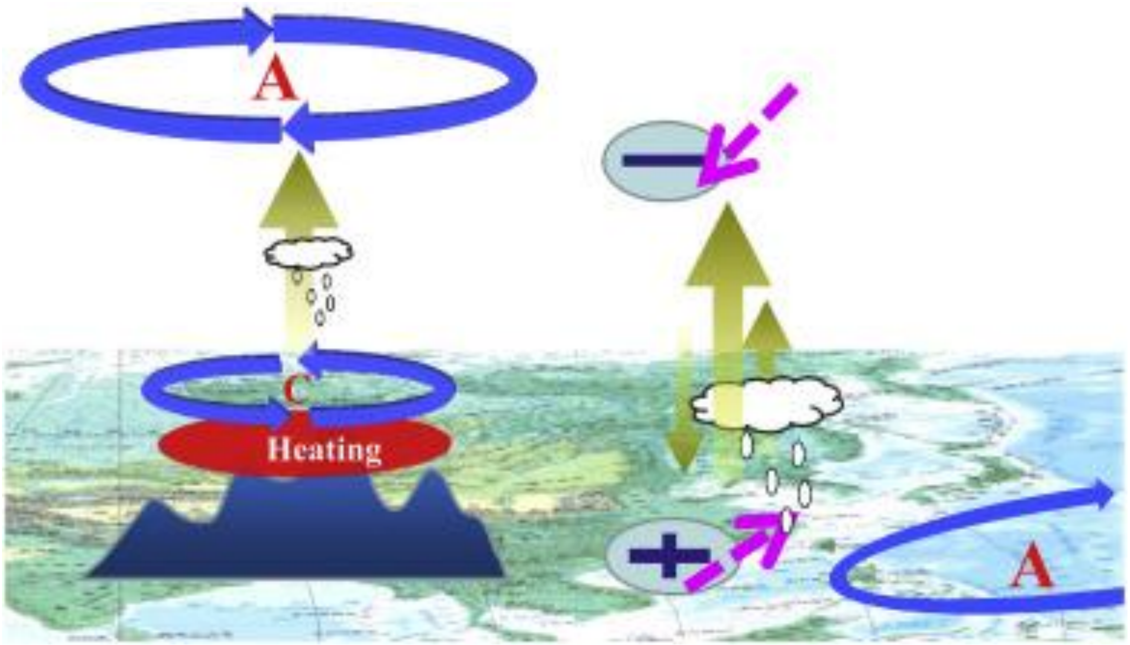
Global population density



Seasonal movement of ITCZ



Land-sea contrast and heating of Tibet

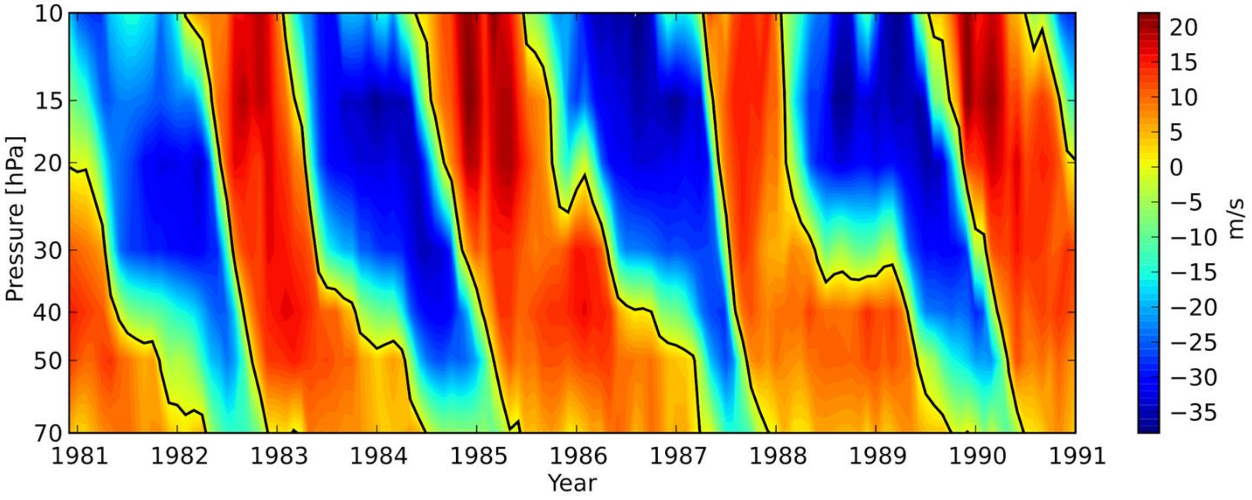


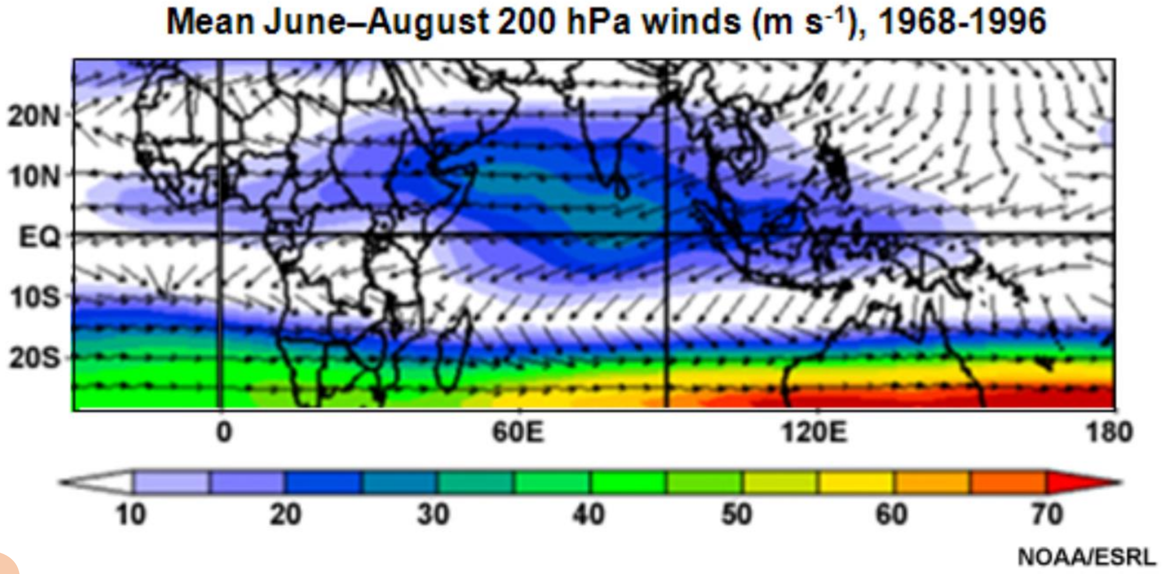
(Ge et al. 2019)

Quasi-Biennial Oscillation (QBO)

Tropical easterly jet (TEJ)

Zonal mean zonal wind in the stratosphere





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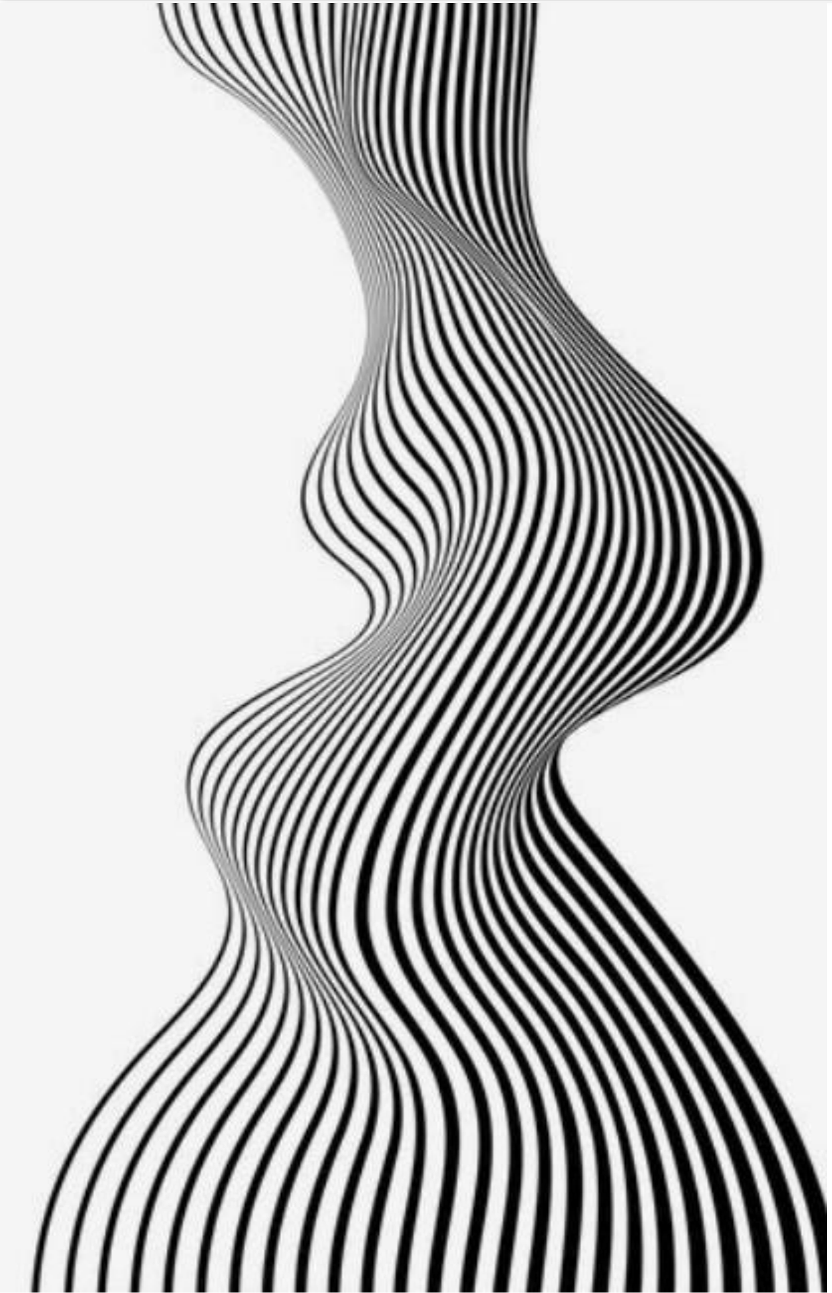
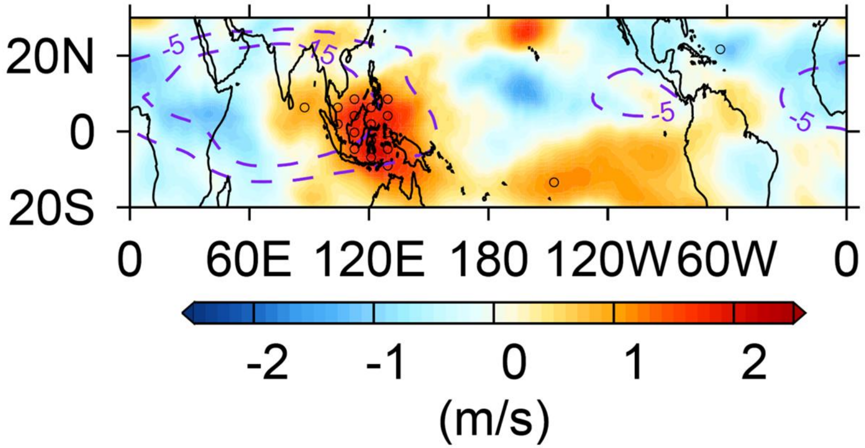
2. Reanalysis data



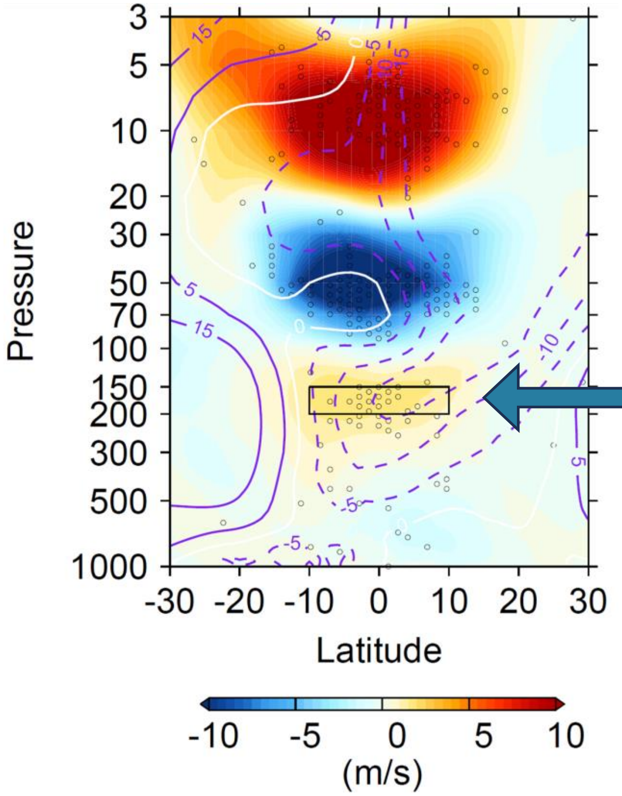
The Influence of the Stratospheric QBO on the Tropical Easterly Jet in ERA5

Impact of QBO on the tropical easterly jet

Easterly QBO: zonal wind at 150 hPa



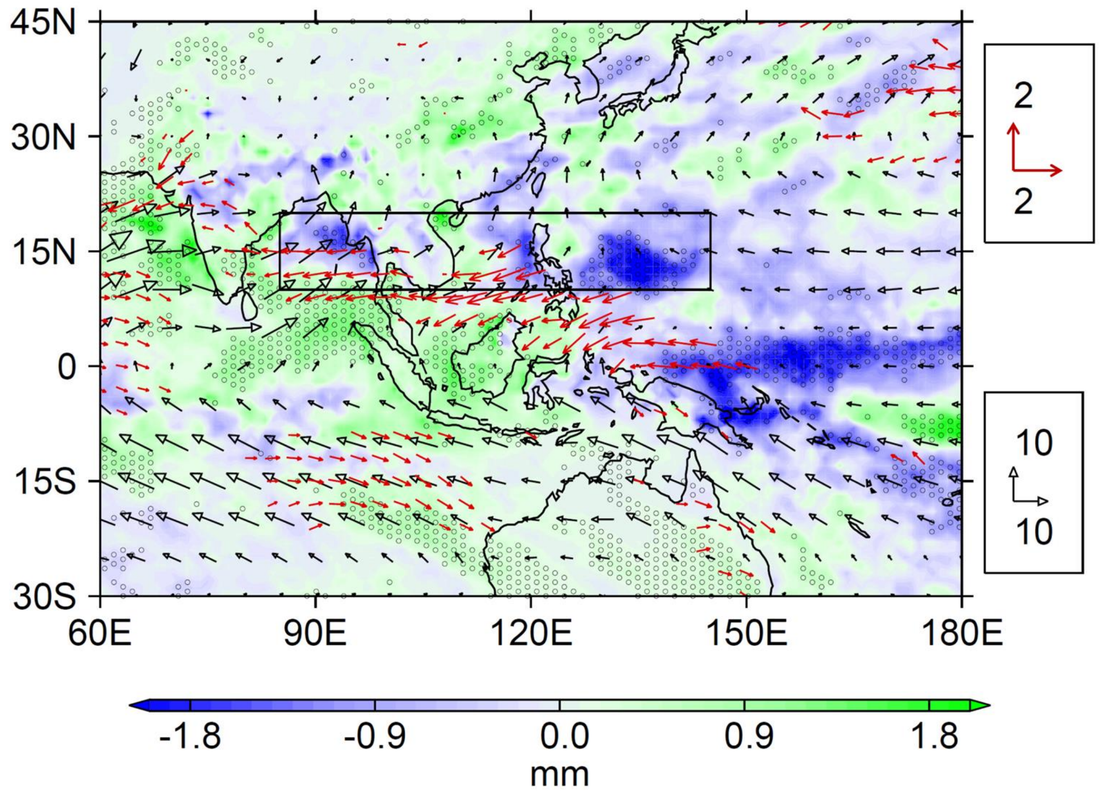
EQBO: zonal wind vertical section at 120E



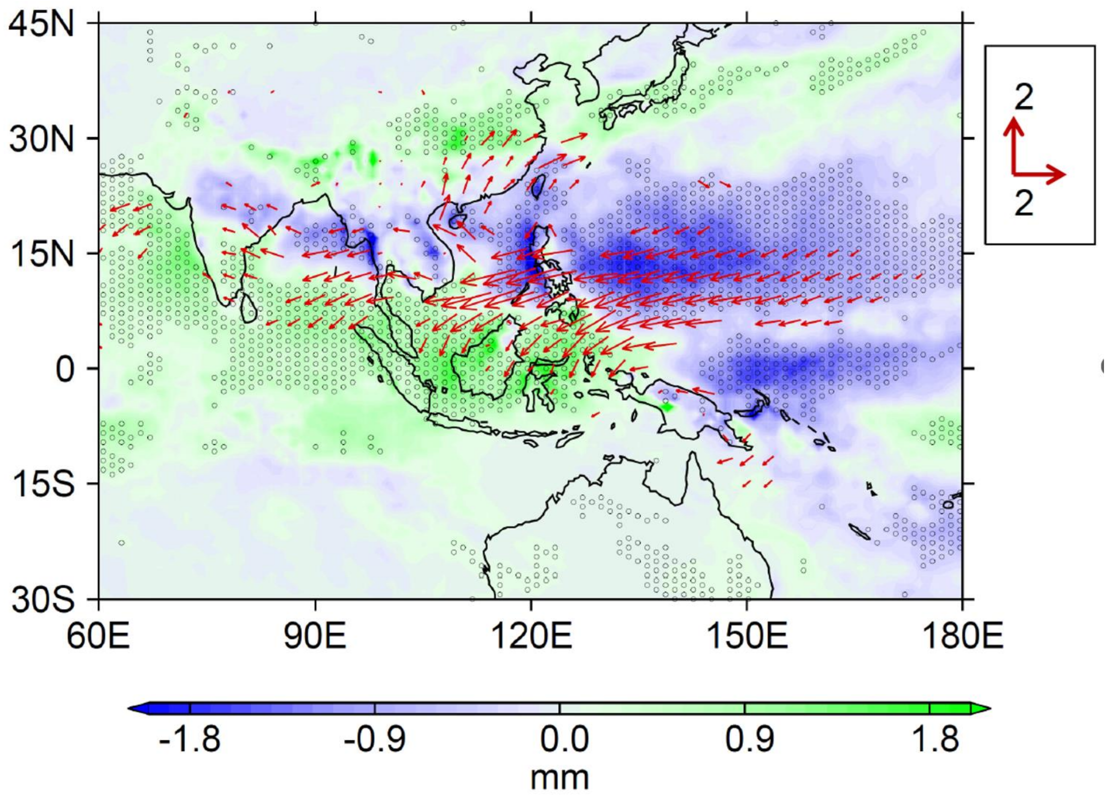
decreased 11%

Purple contour lines is climatology of tropical easterly jet

Precipitation and wind anomalies correspond to EQBO

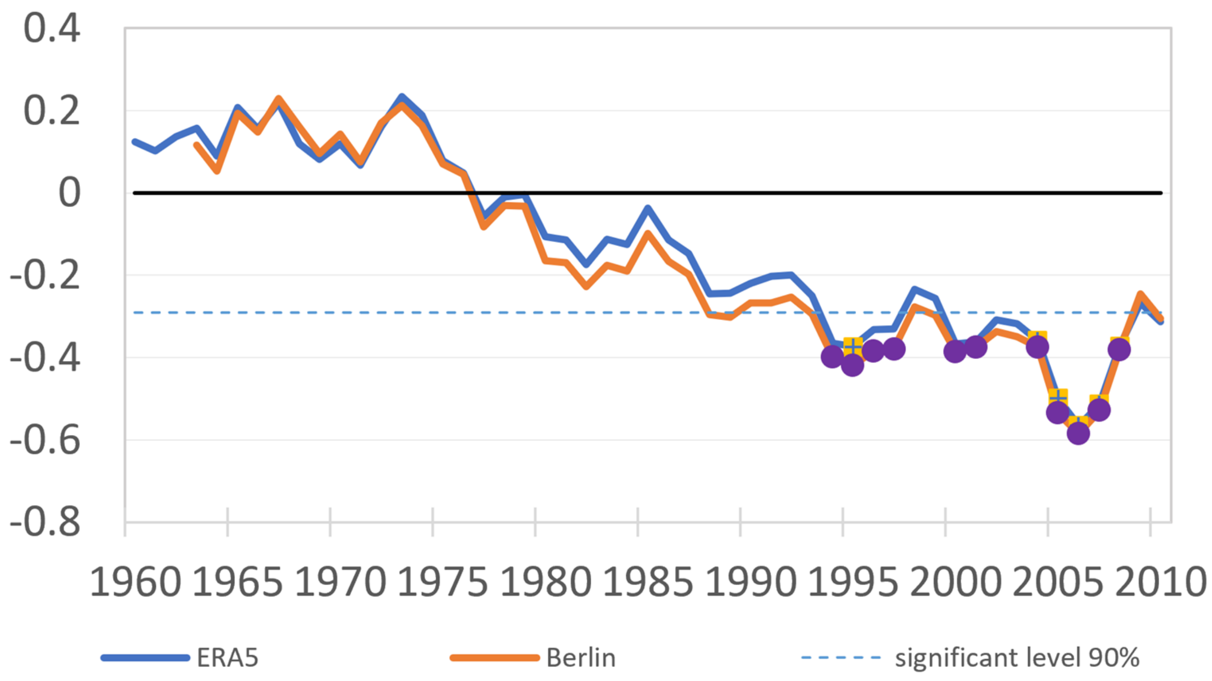


Precipitation and wind anomalies correspond to the weakened TEJ

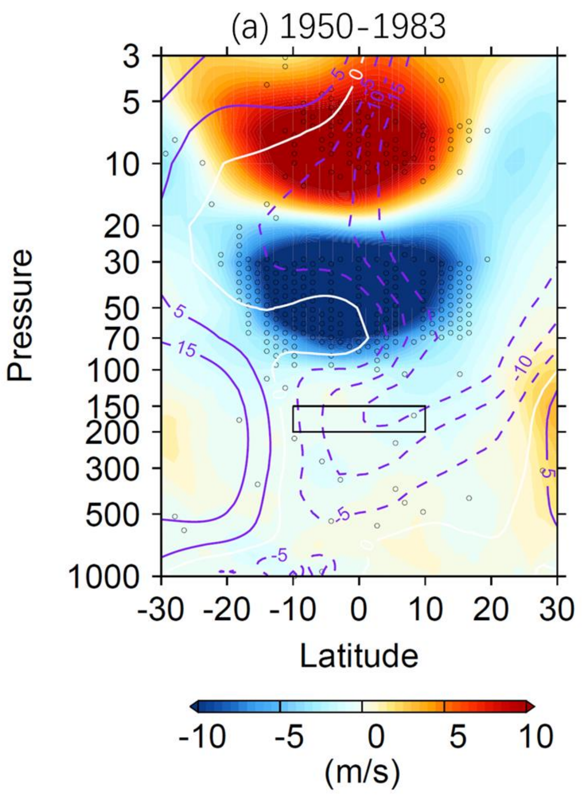


The long-term change in the teleconnection between QBO and TEJ

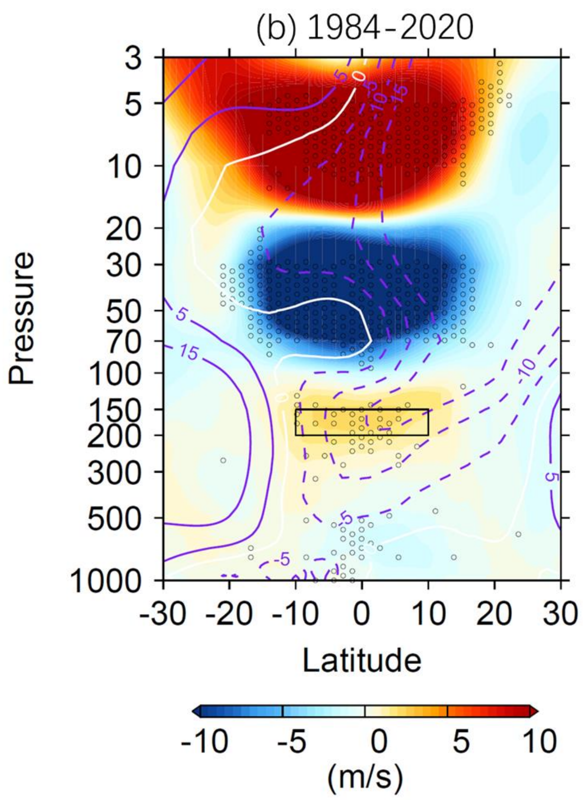
21-year running coefficient between QBO and TEJ indices



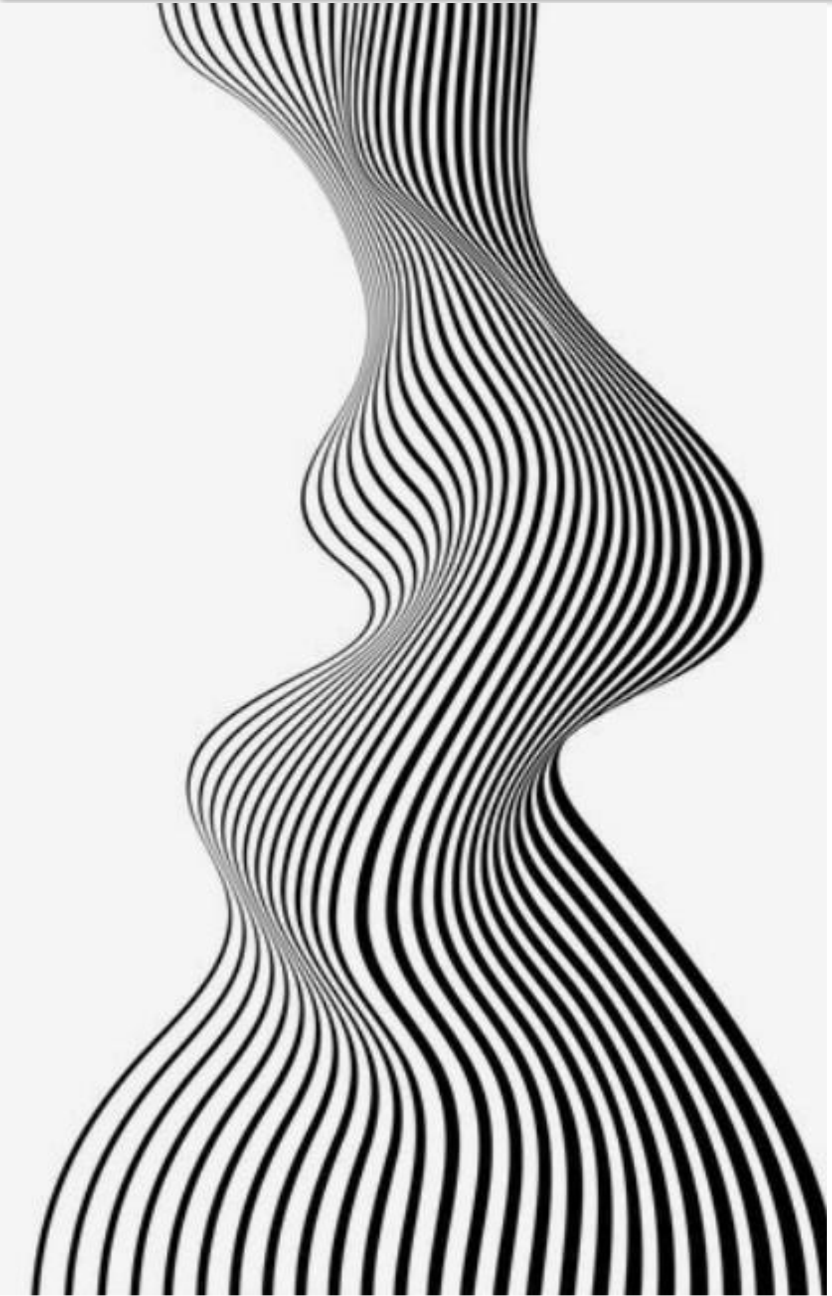
Teleconnection before 1980s



Teleconnection after 1980s



3. E3SMv1 output



Model introduction:

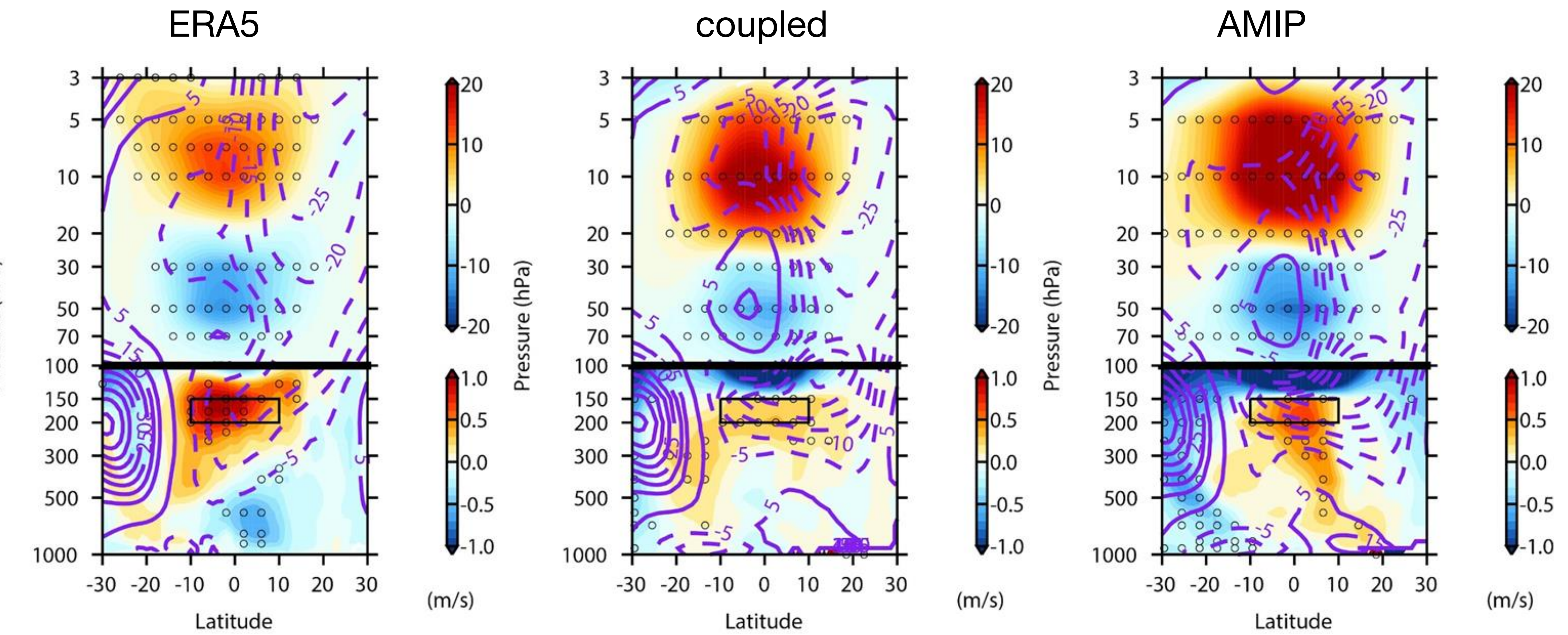
E3SMv1 is a global model developed by DOE, based on CESM developed by NCAR, it can generate QBO internally rather than using prescribed QBO phases

Data:

5 ensemble members of a fully coupled historical simulation (coupled-historical, 1950-2014)

3 ensemble members of Atmospheric Model Intercomparison Project run with prescribed observed SST (AMIP-historical, 1950-2014)

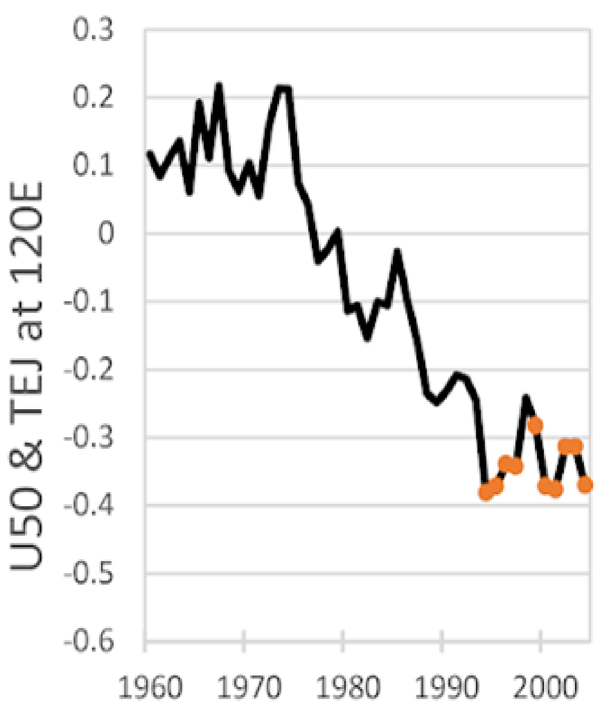
TEJ anomalies correspond to EQBO after 1980



3. E3SMv1 output *The strengthening QBO-TEJ teleconnection in last decades*

21-year running correlation coefficient QBO and TEJ intensity

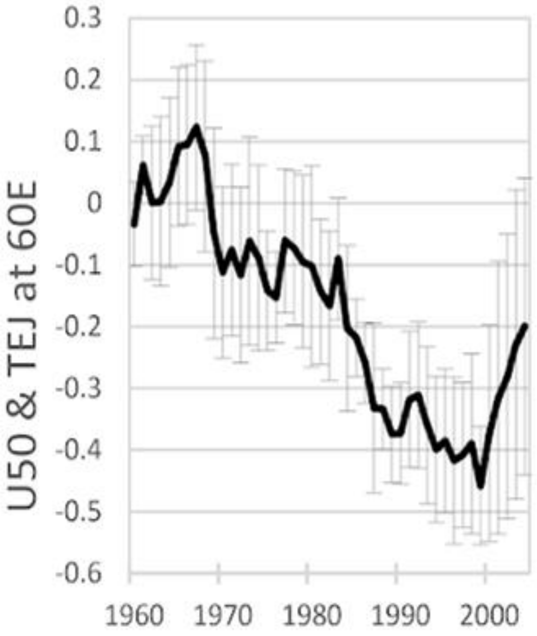
ERA5



coupled

Not Significant strengthening

AMIP



Significant strengthening

3. E3SMv1 output

The long-term change in the background field

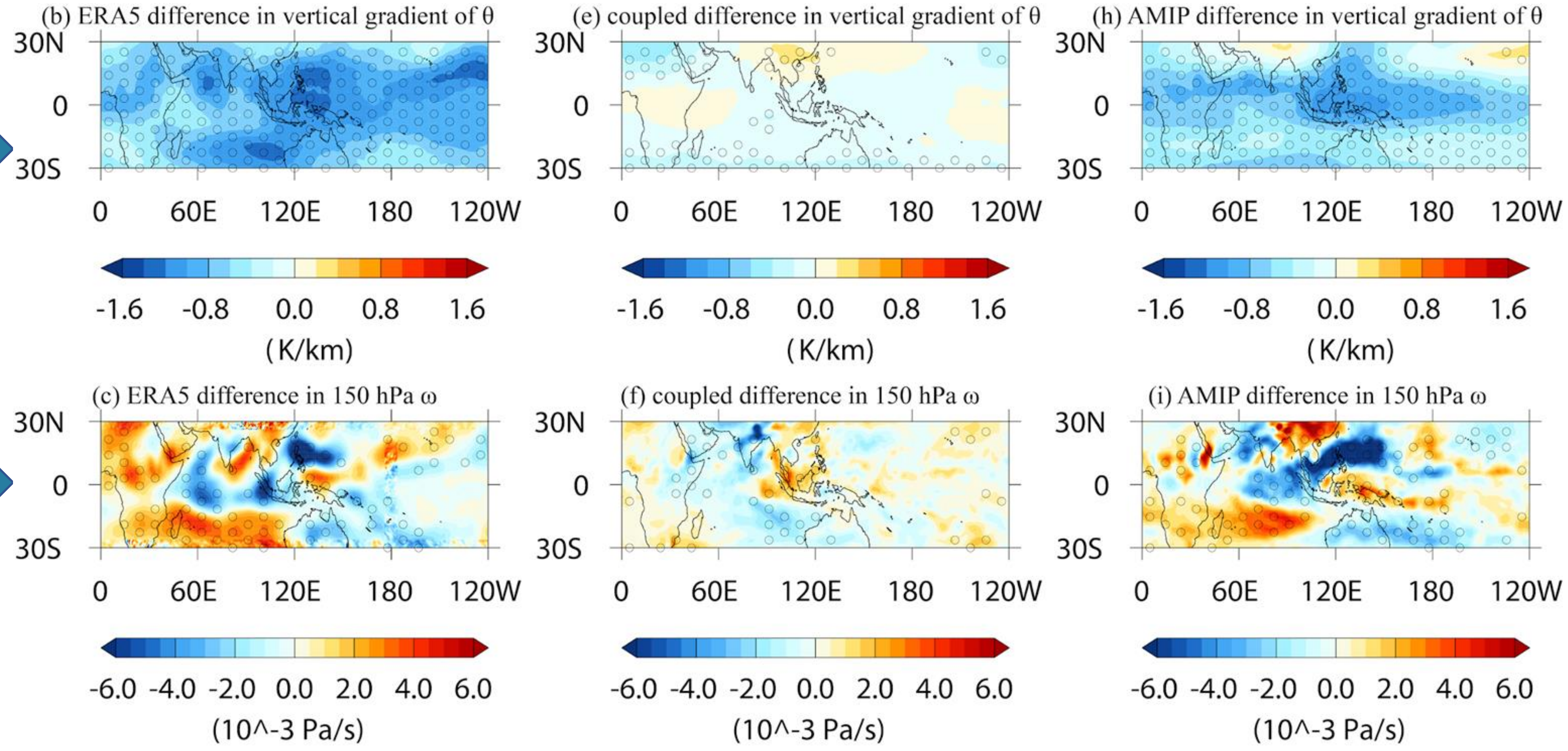
Not Significant strengthening

Significant strengthening

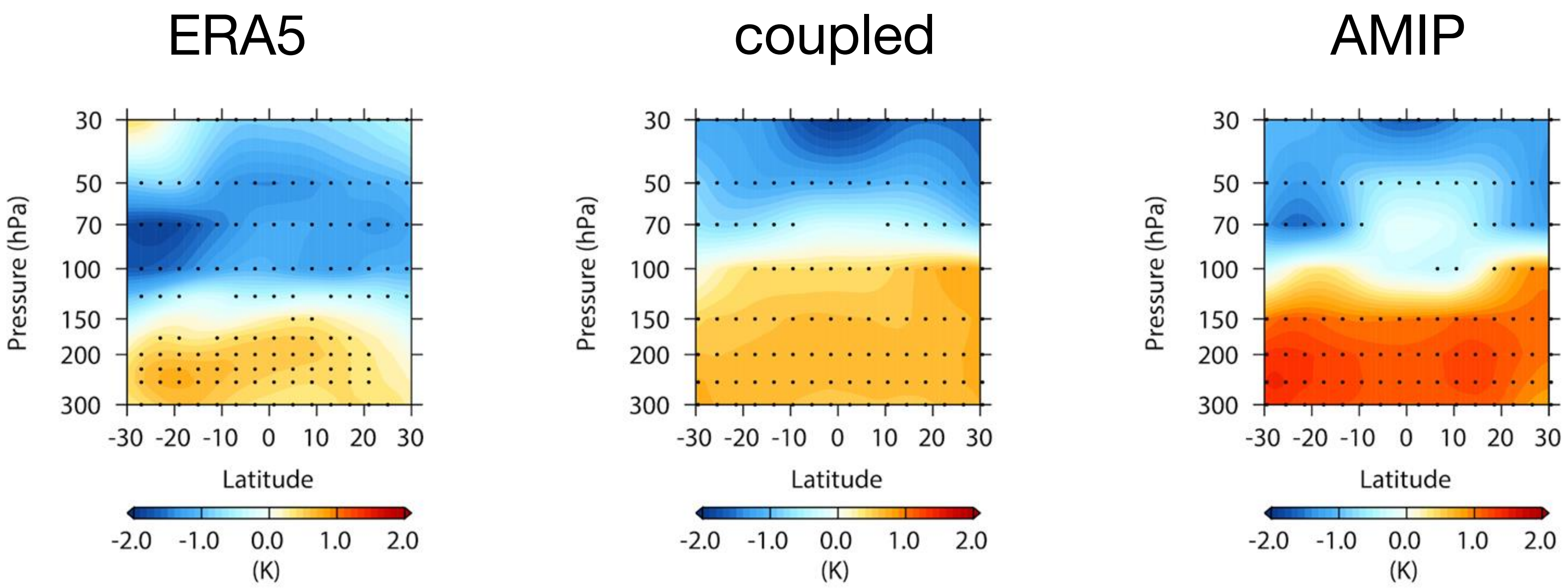
ERA5 coupled AMIP

Differences in 150 hPa stability (1980-2014 minus 1950-1979)

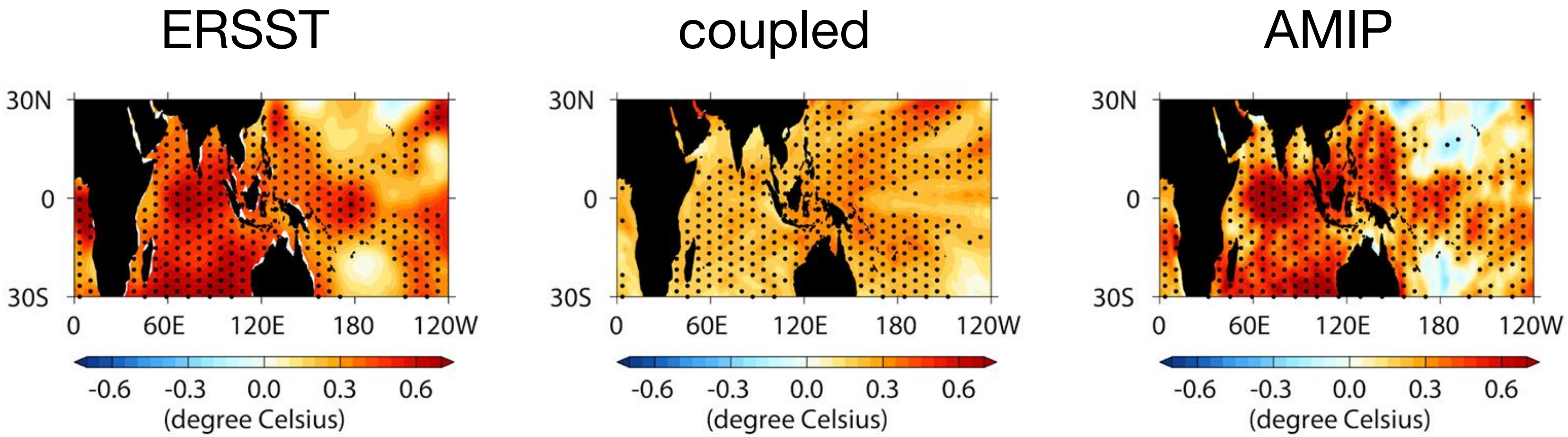
Differences in convection (1980-2014 minus 1950-1979)



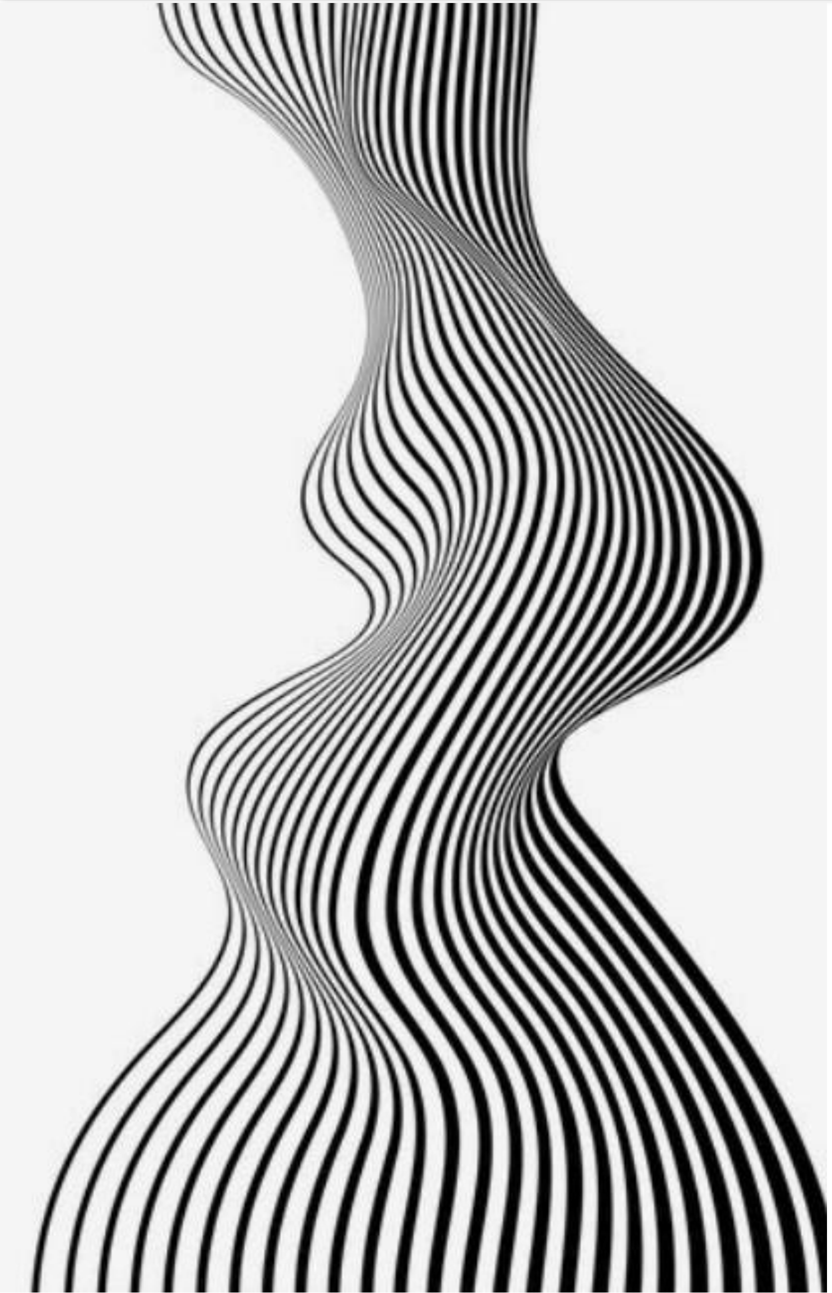
Differences in temperature profile (1980-2014 minus 1950-1979)



Differences in sea surface temperature (1980-2014 minus 1950-1979)



4. Takeaway messages



a. TEJ is weakened over the Maritime Continent during easterly QBO since the 1980s. E3SMv1 produces a weakened/strengthened tropical easterly jet during the easterly/westerly QBO.

b. The correlation between QBO and tropical easterly jet is stronger in the recent past than pre-1980 in ERA5 and AMIP-historical.

c. The warming of the Indian Ocean played a vital role in causing the strengthened teleconnection between the QBO and TEJ.

References
Li, Y., S. Huang, and Z. Wen (2022), The Influence of the Stratospheric Quasi-Biennial Oscillation on the Tropical Easterly Jet Over the Maritime Continent, Geophysical Research Letters, 49(16), e2022GL098940.
Li, Y., Richter, J. H., Chen, C.-C., & Tang, Q. (2023). A strengthened teleconnection of the quasi-biennial oscillation and tropical easterly jet in the past decades in E3SMv1. Geophysical Research Letters, 50, e2023GL104517.

Thanks

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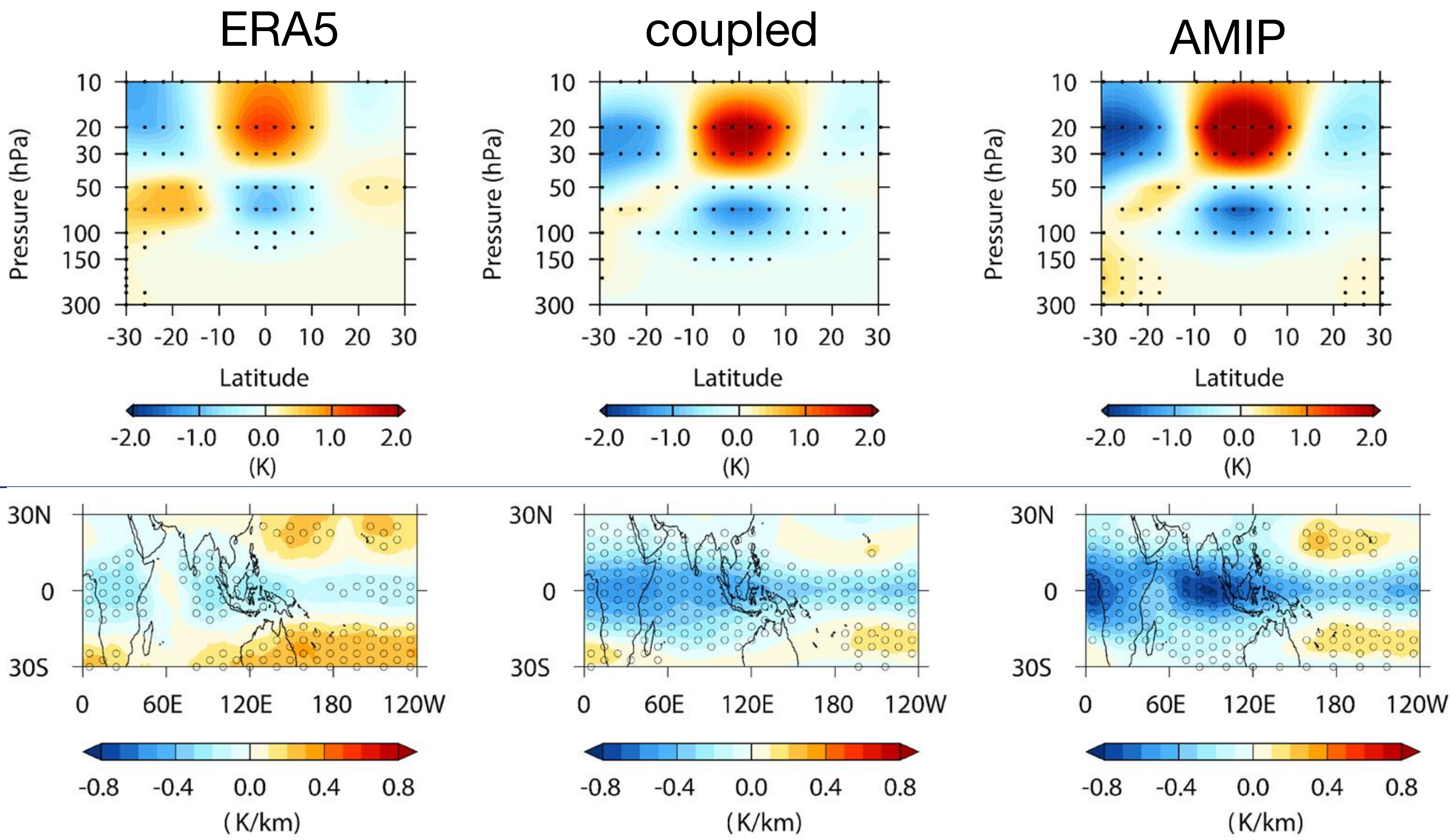
Key factors that impact QBO-TEJ teleconnections

Temperature profile regressed to EQBO

150 hPa stability regressed to the EQBO



QBO modulates Temperature in the upper troposphere → **QBO modulates stability in the upper troposphere** → **Stability modulates convection and TEJ**

Regress the meteorological variables (Y) onto the normalized QBO index (X_1) and Nino3.4 index (X_2) by using a multivariate regression model, solved by an ordinary least-squares method.

$$Y(t) = X_0 + X_1(t)\beta_1 + X_2(t)\beta_2 + \varepsilon$$

(a) (b)

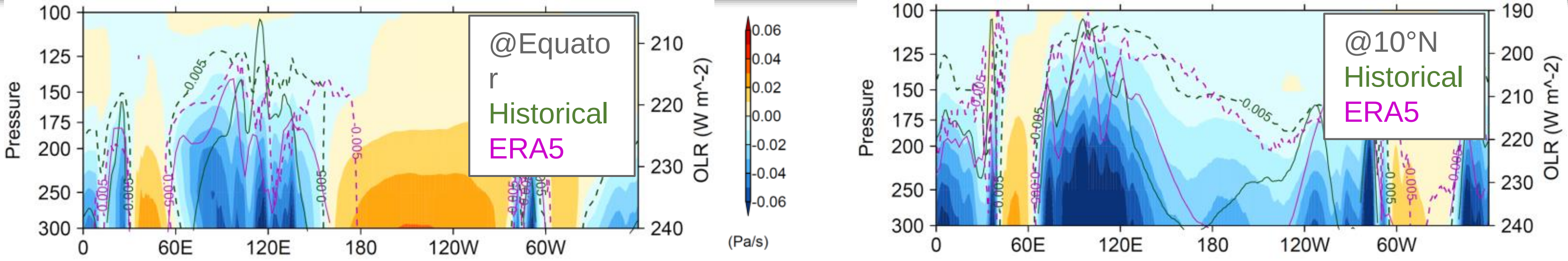
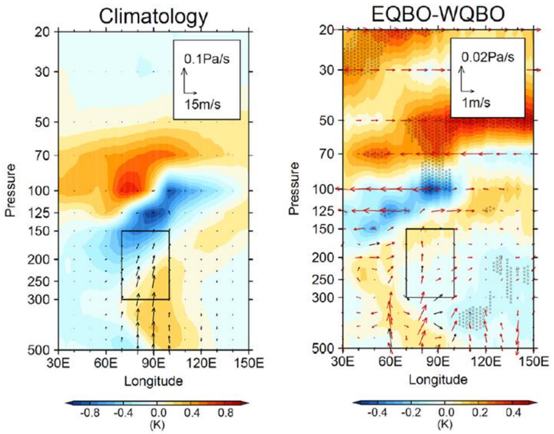
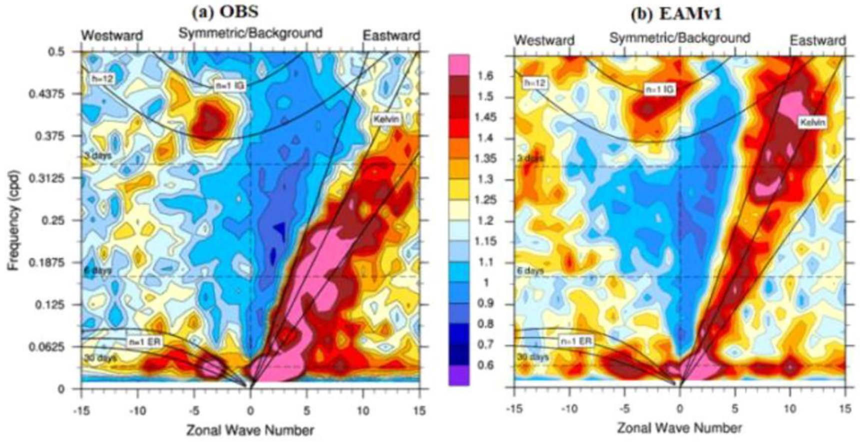


Figure 9. The climatological profiles of ω (shading, historical simulations) and OLR (green solid lines for historical and purple solid lines for ERA5) at the (a) equator and (b) 10°N. The green dashed lines of -0.005 Pa·s-1 is for historical simulations and the purple dashed lines for ERA5. The diagnosis are calculated in the period of 1980-2014.

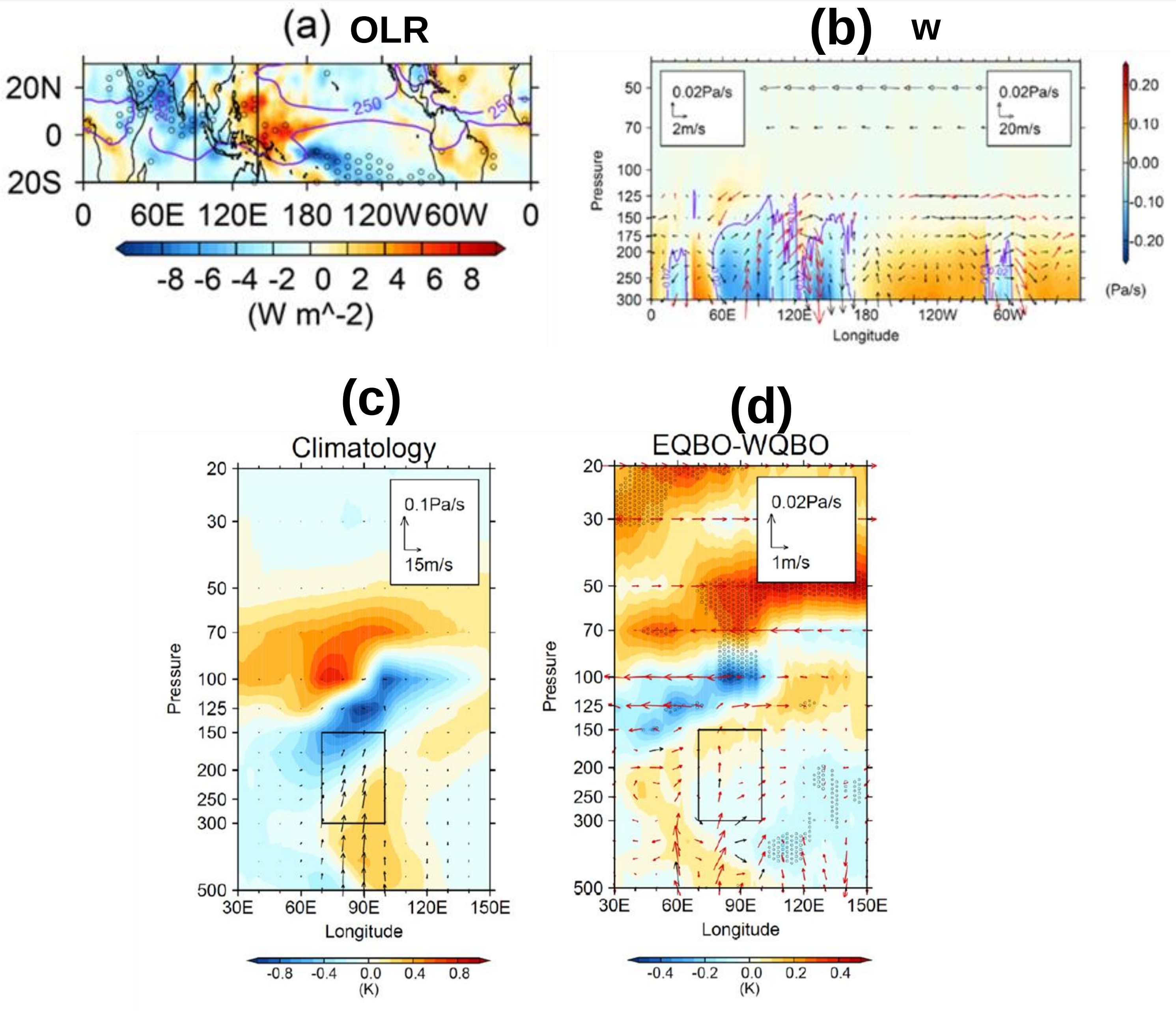




Effects of Organized Convection Parameterization on the MJO and Precipitation in E3SMv1. Part I: Mesoscale Heating

C.-C. Chen, J. H. Richter, C. Liu, M. W. Moncrieff, Q. Tang, W. Lin, S. Xie, P. J. Rasch

Symmetric component of frequency-wavenumber power spectra of precipitation based on methodology of heeler and Kiladis (1999) for: (a) Tropical rainfall measuring mission (TRMM), (b) baseline EAMv1 simulation



Mechanism

Figure 4. Differences (shading) in (a) OLR (purple line for 250 W·m-2 of climatology) between EQBO and WQBO. (b) Differences (vectors) in the zonal and vertical velocity along the equator between EQBO and WQBO. Red vectors are significant at the 95% confidence level under the Monte Carlo test. Climatology of ω along the equator is shown with shading. (c) The regression of JJA equatorial temperatures (shading), and zonal and vertical winds (vectors) onto the normalized daily time series of ω averaged in the box region (70°E-100°E, 150-300 hPa). (d) The differences in the regression of temperatures and winds onto the normalized daily time series of ω between EQBO and WQBO