The influence of the tropical troposphere on the QBO in model simulations

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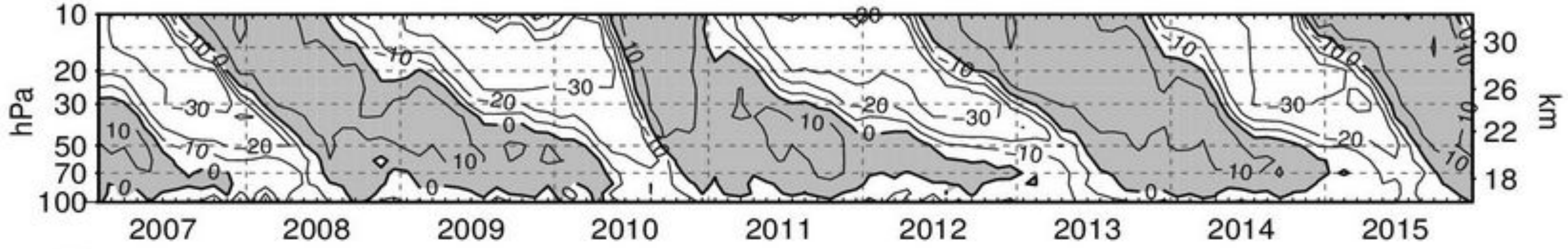
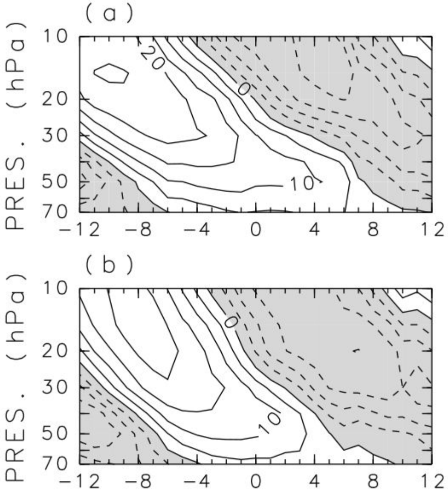
The quasi-biennial oscillation



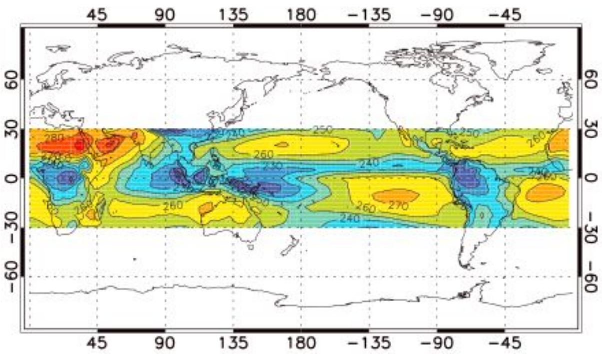
- The quasi-biennial oscillation (QBO) is the periodic alternation of easterly and westerly zonal wind in the tropical stratosphere (figure based on FUB data)
- The inter-cycle variability can be large, due to changes in the wave forcing, influenced by different factors, such as the El Niño - Southern Oscillation (ENSO) phenomenon (Taguchi, JGR, 2010).
- Here we discuss how climate models represent the interaction between ENSO and the QBO (please see Christiansen et al. GRL 2016 and Serva et al., CD, 2020 for more details).

The relationship with ENSO

In (a) the equatorial stratospheric zonal wind during La Niña, in (b) during El Niño. Reproduced from Taguchi, JGR, 2010.

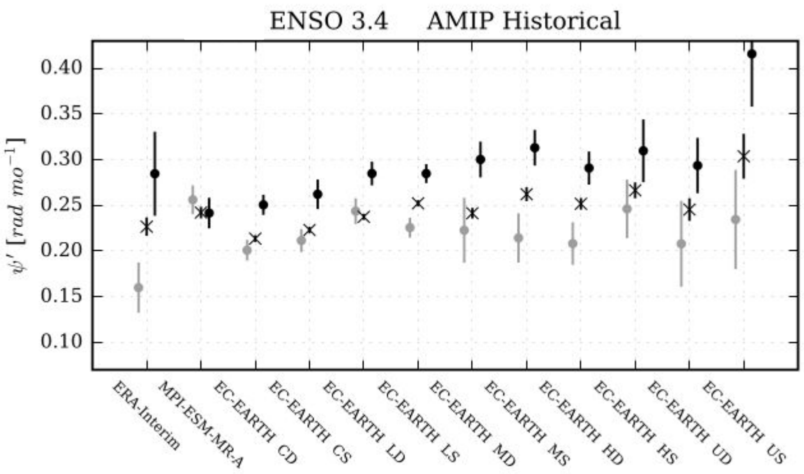


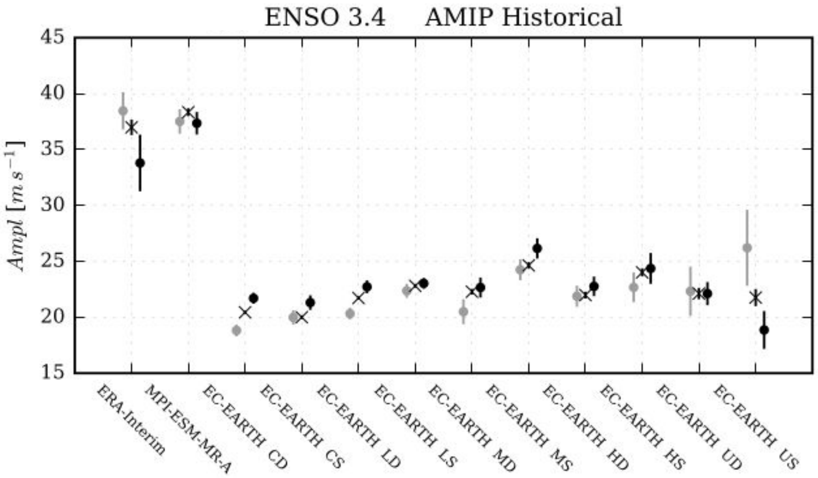
An OLR composite during El Niño events. The convection is deeper during La Niña, however the observational record is fairly short. Reproduced from Geller et al., JGRA, 2016.



- Several observational studies (e.g., Taguchi, JGR, 2010) noted that the QBO propagation is faster (slower) and its amplitude smaller (larger) during warm (cold) events.
- Some authors hypothesized a tropical ocean-stratosphere connection through the changes in the waves excited by convection (Geller et al., JGRA, 2016)

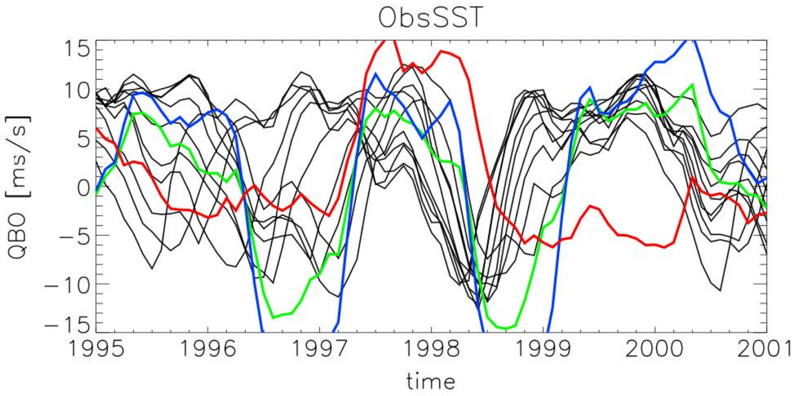
A compact view of the QBO/ENSO interaction

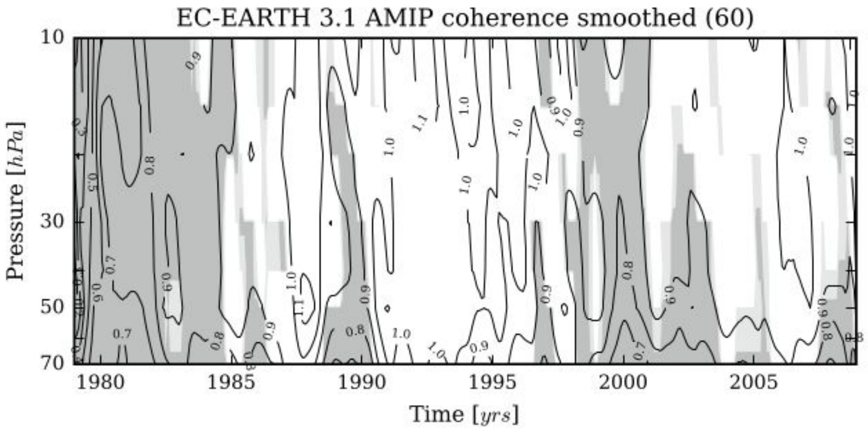




- Following Wallace et al., JAS, 1993, the QBO can be described in terms of amplitude (m/s) and descent rate (rad/month). Black: warm ENSO months, grey: cold ENSO months. Crosses: climatological averages.
- In AMIP-like simulations, the phase speed response benefits of increased horizontal resolution (left plot); the amplitude (right) is instead not much responsive. More details in Serva et al., CD, 2020.

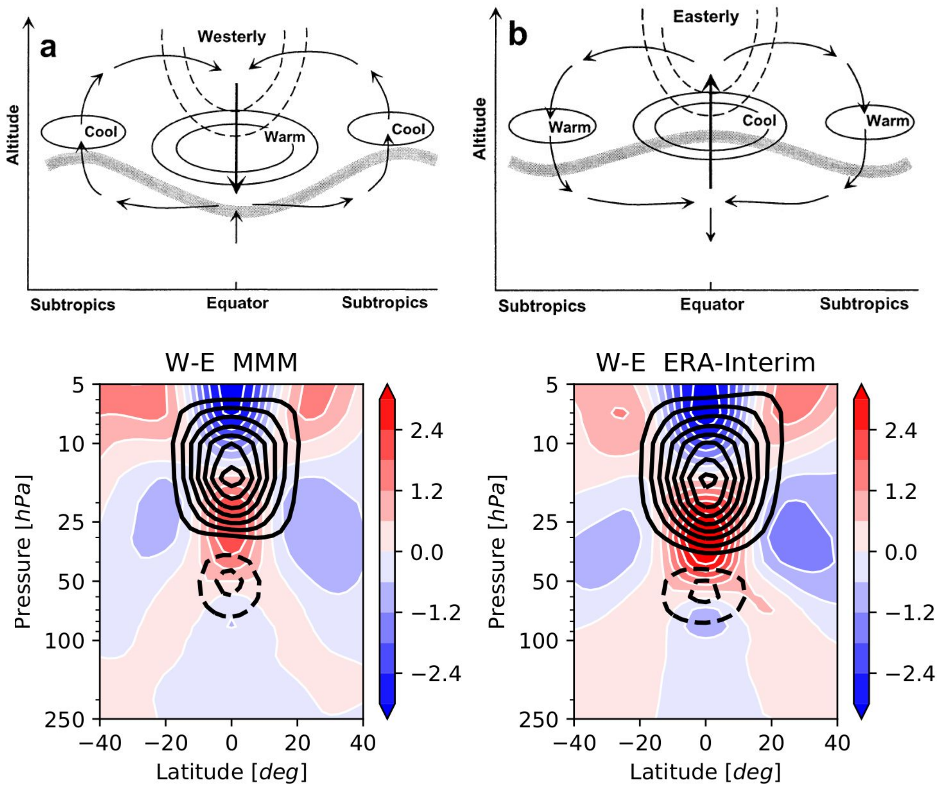
The modelled ENSO pacemaker





- Here we see how the 1997/98 ENSO event regulates the phase of the QBO in free-running EC-EARTH simulations.
- In the left plot, the QBO wind turns to westerly in 10 simulations with observed SSTs (Christiansen et al, GRL, 2016). (Red: ENSO, blue & green: obs, black: model simulations)
- The locking can be given as the normalized spread (right plot), which is small near the initialization and warm ENSO events (Serva et al., CD, 2020)

What happens at the tropopause?



Top: sketch of the tropopause and circulation response in the two QBO phases (from Collimore et al., JC, 2003). Bottom: west-east wind difference (lines, C.I. 5 m/s) and temperature response (shadings, K) from QBOi simulations

- We have seen how models reproduce the observed ENSO-QBO relationship
- This can be important for extended range forecasts of the stratosphere and vertical transport
- New climate simulations (QBOi, CMIP) will be analyzed to understand how the vertical coupling in the tropics is represented