Met Office

Representation and predictability of the QBO and its teleconnections

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Observed Quasi-Biennial Oscillation

Zonal wind oscillation



Free University Berlin

QBO most regular low frequency climate variability after seasonal cycle Surface signal in observations, several hPa, potentially important....

Simulation of the QBO





Takahashi et al, 1999 First simulation in 3D climate model W'lys stronger than E'lys Low diffusion and high ppn in troposphere Scaife et al, 2000

First simulation in 3D climate model with parametrized NOGWs

Good asymmetry

Weak amplitude near tropopause



Richter et al, 2020

Multiple models now have a QBO

What drives the modelled QBO?



We often tune our constant sources to get the right period but this removes the climate variability in GW sources

Predictability of the QBO



Example *forecasts* of the QBO

Predictions track analysed oscillations for a couple of years at least

The QBO is likely the most predictable source of interannual variability in the atmosphere

Scaife et al, 2014

Predictability of the QBO



Very high skill a few months ahead, predictability extends to 3 years at least

Due mainly to regular periodicity, 'perfect model' predictability even higher

More predictable than ENSO

An outstanding issue:



Despite high correlation skill, latest systems still show a decline of amplitude

This problem is worst in the lower stratosphere

Surprises: QBO disruption



Freak events in 2016 & 2019 caused unexpected flips These only occur during westerly QBO phases Here is what predictions looked like at the time....

The 2016 disruption was not predicted



Observed teleconnection



The tropospheric teleconnection has stood the test of time

Teleconnection in seasonal forecasts

Obs Analysis



Obs teleconnection for E-W Models very varied Why not always reproduced? Variability or model problem? UKMO DePreSysv2



-3.6 -2.4 1.2 0 1.2 2.4 3.6





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UKMO GloSea5



-3.6 -2.4 1.2 0 1.2 2.4 3.6





Scaife et al., 2014

Impacts on surface prediction







NNR1

Marshall and Scaife 2009

Lonaitude (dea

Lower stratospheric geopotential height signals do correspond to surface temperature signals in reforecasts Providing the atmosphere is initialised with the correct QBO phase, there are detectable (but too weak) impacts on the NAO in reforecasts

Boer and Hamilton 2008

500 hPa Geopotential Height

Correlation with index

80

60

40

20

0



O'Reilly et al 2019

There is a modest but worthwhile correlation with unpredicted tropospheric variability

Tropospheric teleconnections: beyond H-T?



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FIG. 3. Zonal mean anomalous (a) OLR in the chronically convective regions (W m-2); (b) HRC (counts × 10); (c) tropopause pressure, 1958-2001 (hPa); (d) absolute values of 50-200-hPa zonal wind shear, 1958-2001 (m s-1). Solid lines are for the QBO west phase; dashed lines are for the east phase.

Collimore et al 2003





Yamazaki et al 2020

Apparent influences on tropical convection

Mainly West Pacific? Are these robust?

If they are, then there is potential for further extratropical impact...

Tropospheric teleconnections: beyond H-T?



Models do not reproduce the relationship between QBO and MJO Model error or non-robust effect?

Observations show winter correlations between the QBO and MJO amplitude EQBO -> stronger MJO activity, perhaps due to cooling of tropopause and enhanced convective activity

Summary

A growing number of models now simulate the QBO via parametrized GWs with non-zero phase speeds

The QBO presents an atmospheric source of long range predictability

It offers predictability of surface climate on multiyear timescales

Why is the oscillation too weak near the tropopause?

GW sources coupled in some models – tropical rainfall predictable but does this lead to improved predictions?

Why are teleconnections to surface climate (AO/NAO) too weak in models?

Are other teleconnection routes genuine or just sampling noise?

See this new review: Long-Range Prediction and The Stratosphere, Atm. Chem. Phys., 2022

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