

Predictability of the quasi-biennial oscillation and its northern winter teleconnection on seasonal to decadal timescales

Scaife et al. 2014, *Geophys. Res. Lett.*

Preliminaries

- QBO** → downward propagating shift in mean zonal winds in the equatorial stratosphere from westerly to easterly and back again with a period of approximately 24 to 30 months; one of the few purely atmospheric sources of climate predictability on seasonal to decadal timescales
- Northern winter teleconnection** → here, the Arctic Oscillation (positive phase characterized by anomalously low sea level pressure over the Arctic and anomalously high sea level pressure over the North Pacific and North Atlantic)

- Models of $\sim 1^\circ$ atmospheric resolution require combined forcing of the QBO from resolved waves and the parameterization of nonorographic gravity wave momentum fluxes
- Supplemental figures: <https://awsisco.github.io/qbo-discussion/>

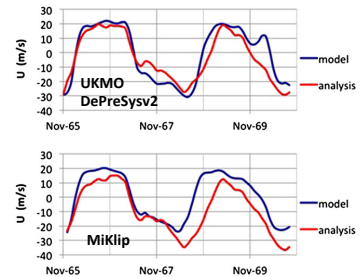
Goals

- 1) Quantify the prediction skill of the QBO in seasonal and decadal ensemble forecasts
- 2) Assess whether the influence of the QBO on extratropical surface winter climate is reproduced in these forecasts

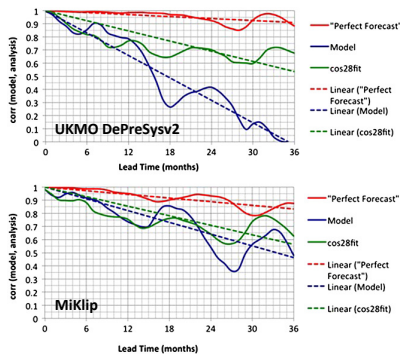
Hindcast Summary

| | | | |
|----------|-----------------|-------------------|------------|
| Seasonal | UKMO GloSea5 | 1996-2009 | 9 members |
| | ECMWF System 4 | 1981-2010 | 51 members |
| Decadal | UKMO DePreSysv2 | 1960-2006 (1 Nov) | 4 members |
| | MiKlip | 1961-2012 (1 Jan) | 5 members |

- Both decadal systems capture the period of the QBO reasonably well
- UKMO better captures the asymmetric amplitude ($E > W$) than MiKlip
- Need a QBO diagnostic to assess predictability → 30 hPa monthly mean zonal wind near the equator



Predictability of the QBO



- 3 methods are used to assess predictability of the QBO:
 1. Compare models to observations
 2. Compare observations to a cosine function with a period of 28 months
 3. Compare individual ensemble members to the mean of the remaining members (this is a perfect model experiment in which the same numerical model produces the forecasts and the data that replaces observations)
- Method 1 (blue) shows correlation scores > 0.8 up to 6 months and > 0.7 up to 12 months
- For UKMO DePreSysv2 forecasts started in early November, the probability of correctly predicting the winter QBO phase is greater than climatology (50%) for the 3 coming winters (not shown)
- Method 2 (green) shows that using a simple statistical model yields skill at least as high as that found in dynamical prediction systems, especially beyond 1 year
- Method 3 (red) removes the effect of model error and has correlation scores > 0.8 out to 3 years ahead → thus, higher forecast skill is achievable if initial condition and model errors are reduced
- However, constant source of parametrized gravity waves from the lower atmosphere is not realistic; the scores for Method 3 may therefore be an overestimate

Sensitivity to the Seasonal Cycle and QBO Phase

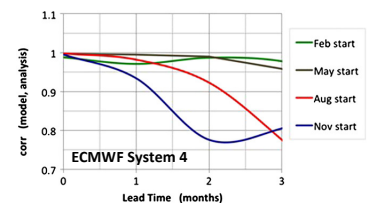
- Westerly phase is weaker in amplitude, propagates down faster; easterly QBO phase in winter exhibits enhanced stalling (i.e., a delayed transition to easterlies between 30 and 50 hPa)

Dependence on phase at initialization

- Split forecasts into W and E categories based on phase at model initialization
- Difference in skill were small but starting in the westerly phases with impending easterlies a year later showed slightly lower skill

Dependence on season of initialization

- Forecasts initialized in winter are less skillful than those initialized in other seasons
- Decrease in skill as winter approaches is consistent with irregular downward QBO propagation



Teleconnections to Boreal Winter Surface Climate

- Westerly QBO → stronger SLP gradients and stronger, northward shifted tropospheric jets
- Easterly QBO → more negative NAO/AO
- UKMO DePreSysv2 (b): small and statistically insignificant differences between E and W phases
- MiKlip and ECMWF System 4 (d and e, respectively): very weak teleconnection signatures
- UKMO GloSea5 (c): sign and spatial pattern is reproduced (high pressure over Arctic and lower pressure at midlatitudes) but amplitudes differ from observed

