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 Artic 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 ~1° 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/

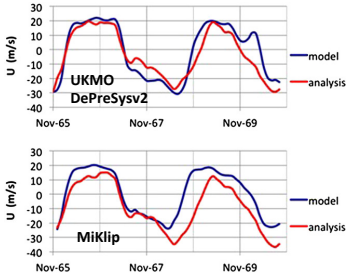
Goals

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

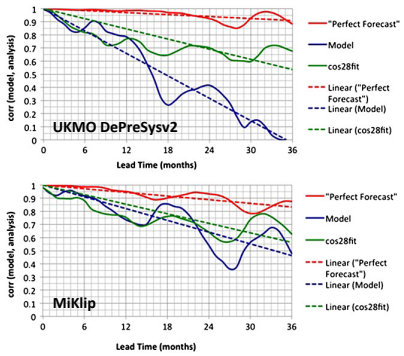
Hindcast Summary

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



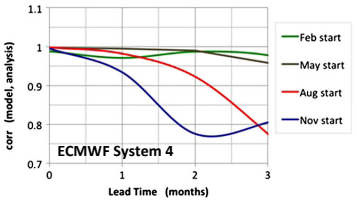
Predictability of the QBO



- 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

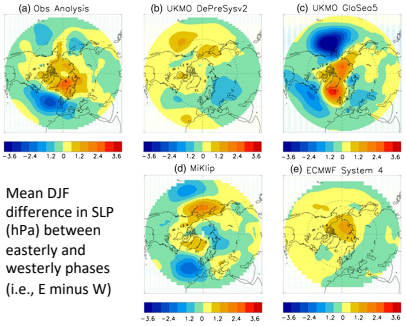
- Split forecasts into W and E categories based on phase at model initialization
- Difference in skill were small but starting in the westerly phases with impending easterlies a year later showed slightly lower skill

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



Mean DJF difference in SLP (hPa) between easterly and westerly phases (i.e., E minus W)

- 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 Artic and lower pressure at midlatitudes) but amplitudes differ from observed