Seasonal Forecasting of the Quasi-Biennial Oscillation

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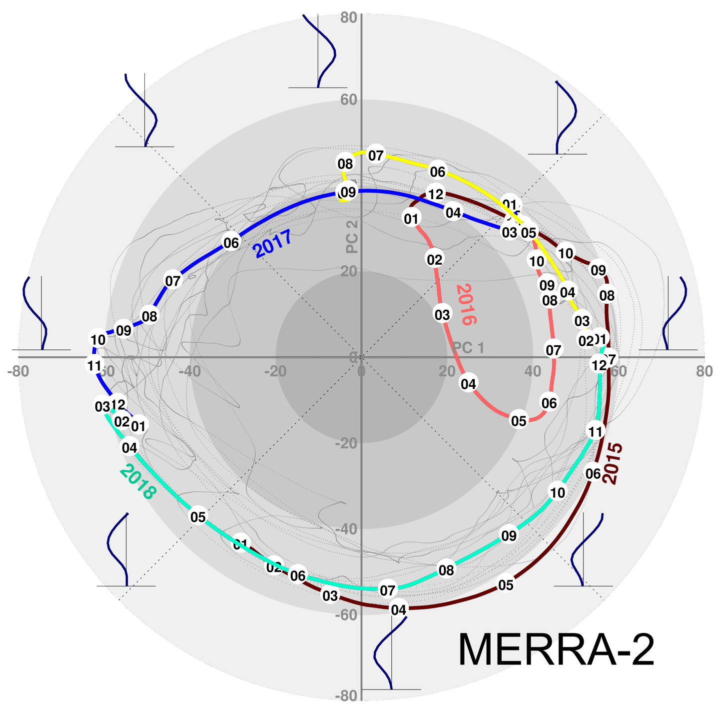
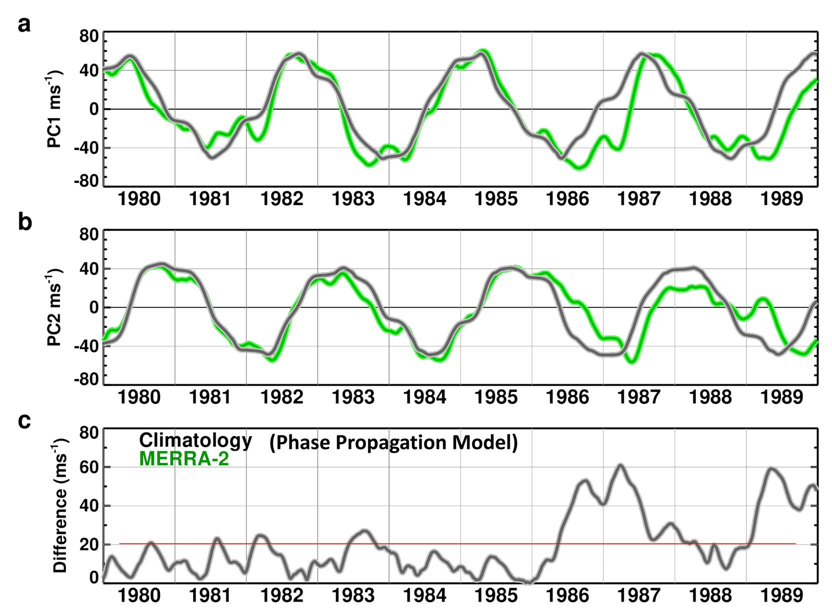
Id #49
Stratospheric predictability and impact on the troposphere

Background

QBO EOFs

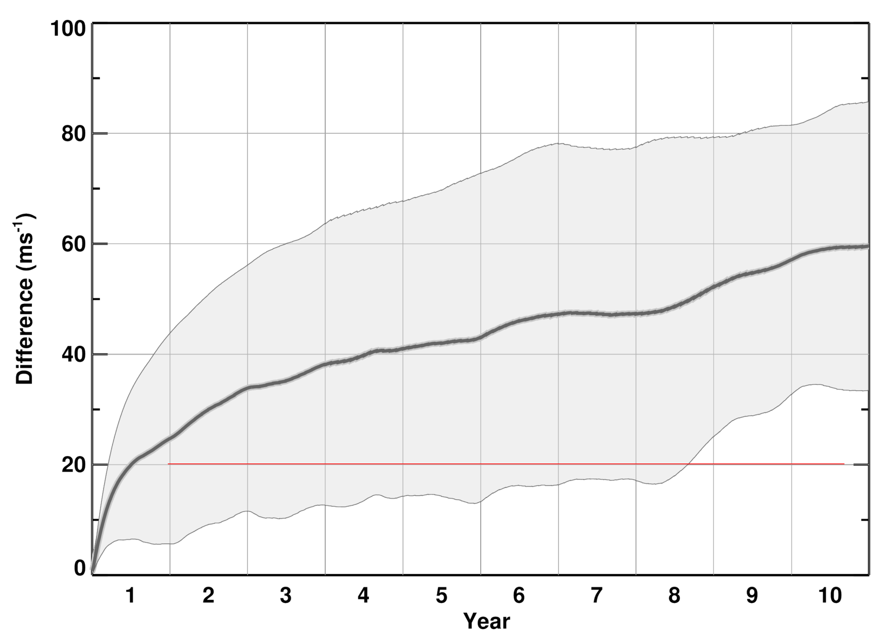


Phase Propagation Model EOF



Vector differences less than 20 m/s have EOF components that match well.

Phase Propagation Model 10 Year Forecasts



Averaged difference error (heavy gray curve) and standard deviation (light gray curves) between QBO phase propagation model initialized monthly from 1980 to 2018 and MERRA-2.

EOF Equations

$$U(z,t)=\sum_{k=1}^{14} PC_k(t)\cdot EOF_k(z)$$

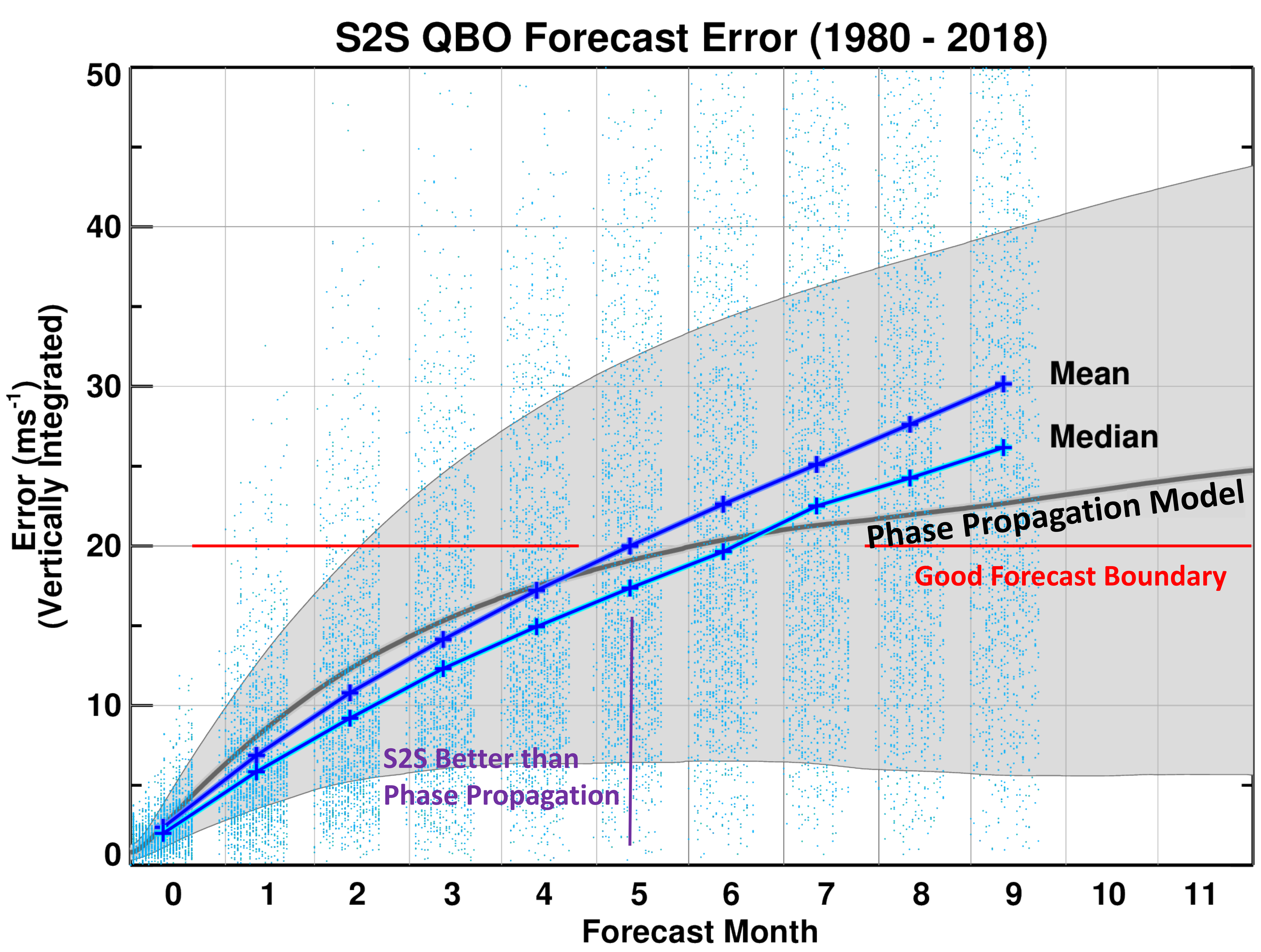
$$PC_k(t)=\sum_{m=1}^{14} U(z_m,t)\cdot EOF_k(z_m)$$

$$Amplitude=\sqrt{PC_1^2+PC_2^2}$$

$$Phase=\arctan(PC_2/PC_1)$$

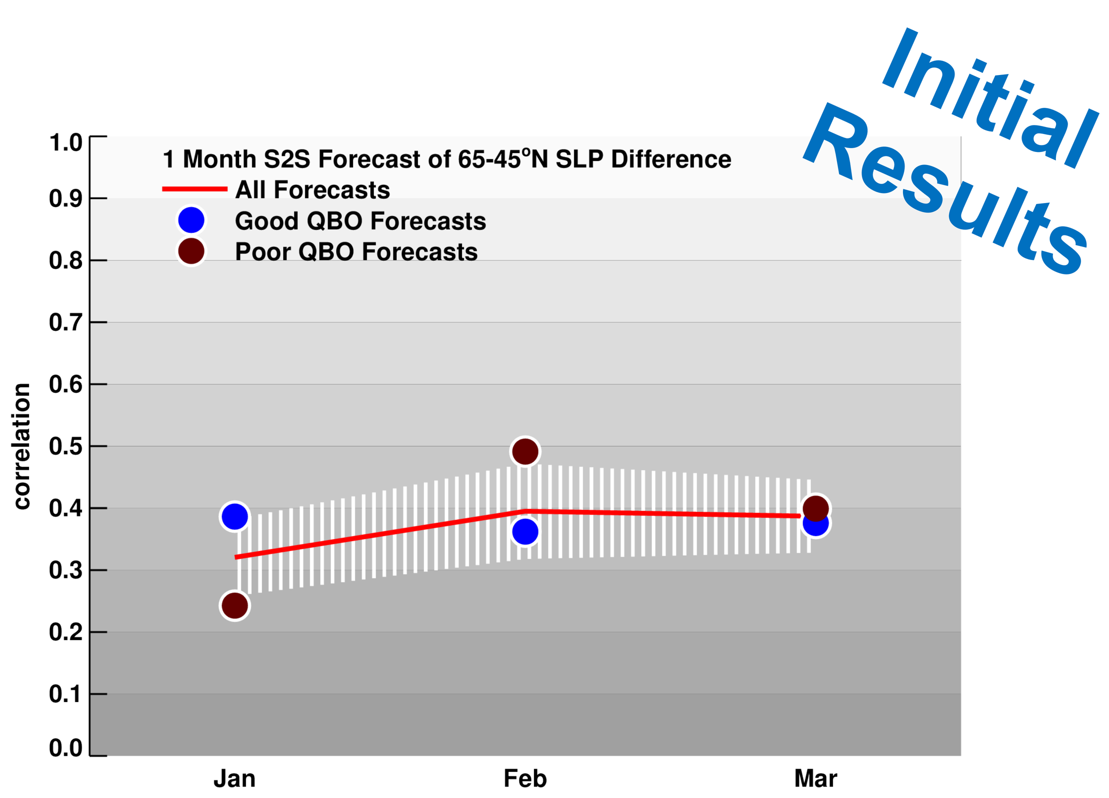
Results

The Seasonal Forecasts of the QBO Showed Skill out to 5 Months



S2S forecast vector amplitude error (m/s) based on 1,835 9-month forecasts from 1980-2018: monthly mean (dark blue), monthly median (light blue) values, and individual monthly forecast values (light blue points). Also shown are the mean (dark gray) and standard deviation region (light gray) of the phase propagation model. Note that the zero labeled month is less than a full month as the S2S initialization starts before the start of the first full month.

Good QBO Forecasts were not Correlated with Improved NAO Forecasts

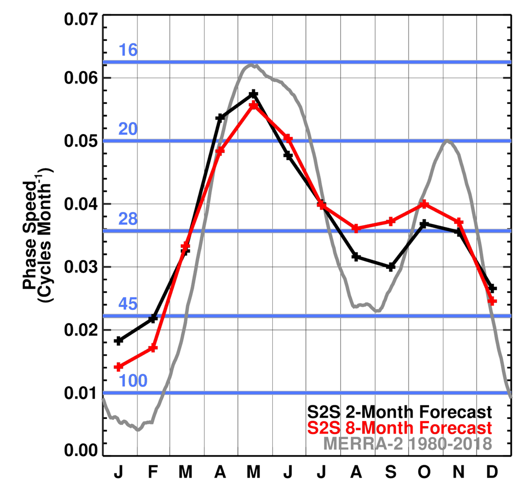


The correlation between MERRA-2 analyses and one month S2S retrospective forecasts of the sea level pressure difference between (0^{o}E, 65^{o}N) and (0^{o}E, 45^{o}N) valid for January, February, and March (red curve). The blue and brown filled circles show the correlation sorted by S2S QBO one month forecast errors below and above the median value respectively. The vertical white lines cover the standard deviation when half of the S2S forecasts are randomly selected.

Details

Phase Propagation Model

Model seasonal slowing of QBO descent



$$\omega = a_0+\sum_{k=1}^{kmax}\left[a_k\cos(k\omega_a t)+b_k\sin(k\omega_a t)\right]$$

The first two harmonics capture most of the QBO seasonal frequency variation

Integrate frequency to get the phase as a function of time:

$$\phi(t)=\phi_0+a_0(t-t_0)+\sum_{k=1}^{kmax}\frac{1}{k\omega_a}\left[a_k\sin(k\omega_a t)-b_k\cos(k\omega_a t)\right]\Big|_{t_0}^{t}$$

Model QBO EOF amplitude variation as a function of the QBO phase:

$$A_{EOF}=c_0+\sum_{k=1}^{kmax}\left[c_k\cos(k\phi)+d_k\sin(k\phi)\right]$$

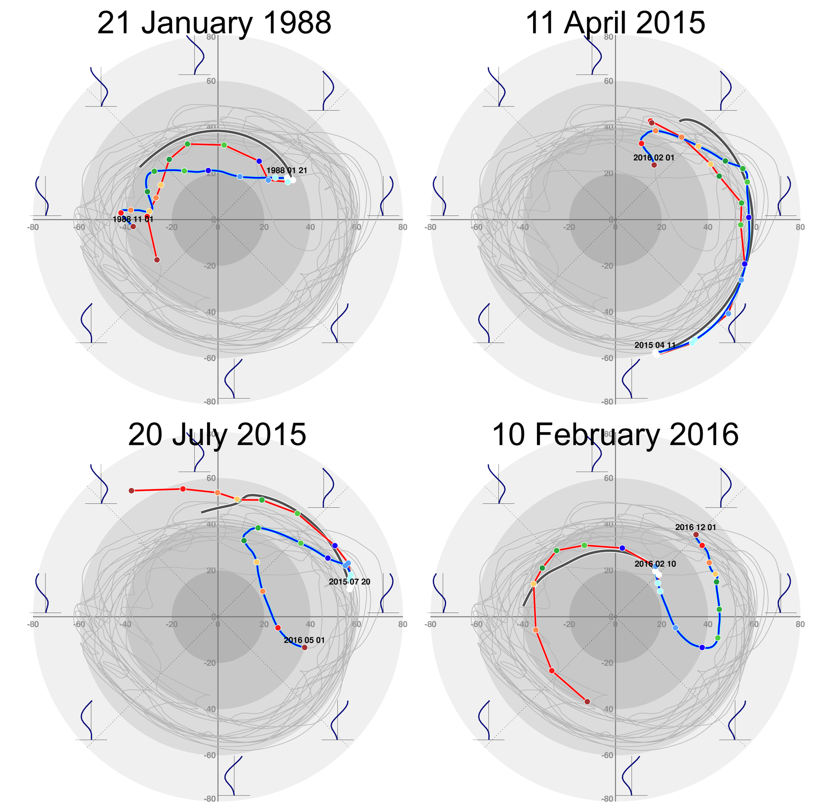
The first two harmonics capture most of the QBO cycle amplitude variation

Allow the initial amplitude to decay to the EOF amplitude:

$$A(t)=(A_0-A_{EOF})e^{-(t-t_0)/T}+A_{EOF}$$

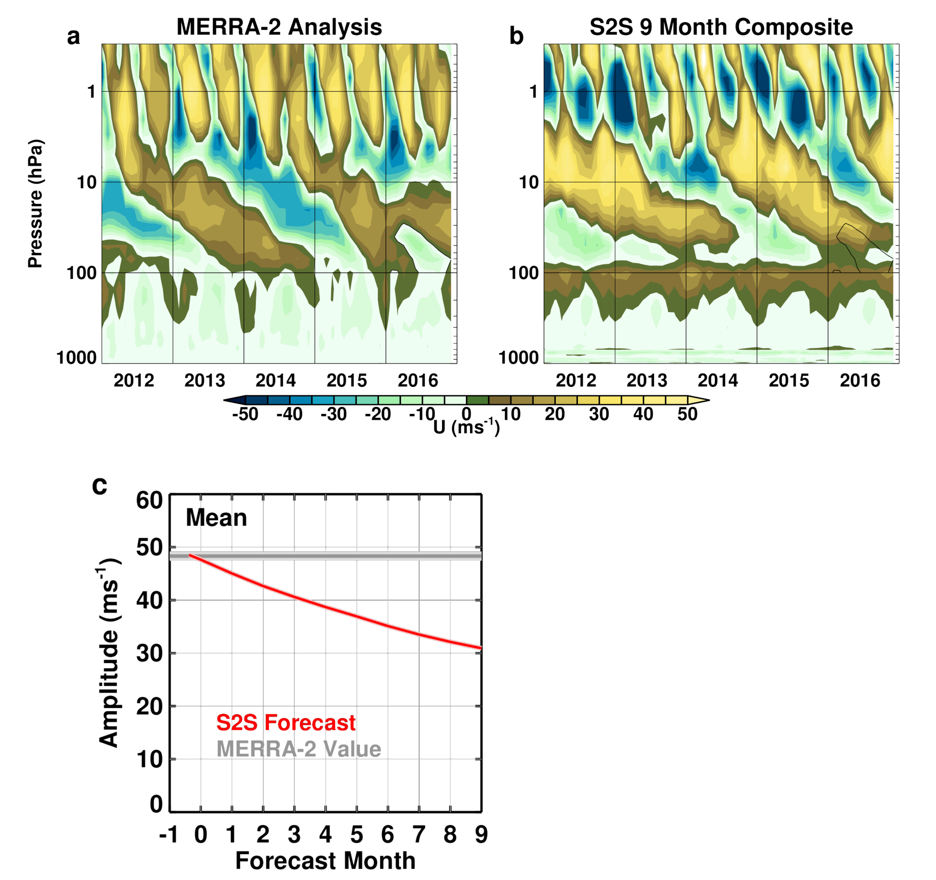
For this study the decay time scale was taken as one year

Sample Forecasts



MERRA-2 analyses, S2S retrospective forecasts, and **phase propagation model**

Model Bias



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