Modeling the Interaction of the MJO and the QBO

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Image: Adapted from Hand 2015, Science
Overview

- The MJO-QBO Relationship
- Modeling Approach
- Results & Summary
During QBO easterly phase, boreal winter MJO is more active and lasts longer. Studies also indicate MJO may be more predictable.
Mechanism driving QBO-MJO relationship is difficult to determine from observations

We explore two proposed mechanisms driving QBO-MJO interaction:
- QBO wind anomalies
- QBO-induced temperature anomalies

Fig. 1. Schematic representation of the mean meridional circulation driven by the QBO, after Trepte (1993). Dashed contours indicate isopleths of zonal velocity; solid contours represent anomaly isotherms. The thick, gray lines represent the tropopause. (a) Warm anomaly during descending zonal mean westerly shear; (b) cold anomaly during descending zonal mean easterly shear.
Basic Modeling Approach

- WRF idealized, small domain, cloud-resolving model coupled to large-scale observational forcing
- Forcing data from the “DYNAMO” field campaign which captures 2 MJOs
- Weak temperature gradient (WTG) approximation made instead of specified vertical velocity:
  \[
  \bar{w} \frac{\partial \bar{\theta}}{\partial z} = \frac{\bar{\theta} - \bar{\theta}_{\text{ref}}(z, t)}{\tau}
  \]


Model versus Observations

- Model simulates both observed MJOs, as evident in two periods of ascent.

**Observed Vertical Velocity (m/s)**

**Model Vertical Velocity (m/s)**
Model versus Observations

- Model simulates both observed MJOs, as evident in two periods of higher precipitation.
QBO Temperature Experiments

- Input idealized temperature anomaly consistent with QBOE/W signal
- (1) Control run without temperature anomaly; (2) QBOE with cold anomaly; (3) QBOW with warm anomaly. Wind field is unaltered

QBOE - QBOW Anomaly

![Graph showing temperature anomaly]
QBO Temperature Experiments

- Results show stronger upper level vertical velocity and cloud fraction during QBOE (red), opposite during QBOW (blue)
QBO Temperature Experiments

- QBO changes OLR are of same sign as observations. Changes to precipitation are *not* consistent with observed.

**Daily OLR**

- Ctrl mean: 218.3
- QW mean: 233.1
- QE mean: 194.4

**Daily Precipitation**

- Ctrl mean: 6.96
- QW mean: 6.74
- QE mean: 6.63
QBO Wind Experiments

- Input idealized wind anomalies (red) consistent with QBOE/W signal (blue) from ERA-Interim data. Temperature field unaltered.
QBO Wind Experiments

- Small change in vertical velocity, cloud fraction, also OLR & precip
Summary and Discussion

- The QBO modulates the MJO such that during the easterly QBO, the boreal winter MJO is stronger and more active.

- The QBO may exert its influence on the MJO through temperature anomalies which decrease the static stability and/or modify high cloud properties. The QBO wind anomalies seem to be of less importance.

- Most results from temperature experiments are qualitatively consistent with observations: increase in vertical velocity and cloud fraction and decrease in OLR during QBOE with opposite behavior during QBOW.

- Precipitation results are less conclusive and are being analyzed more.

Thank you!