Quasi-biweekly Oscillations during the Boreal Summer

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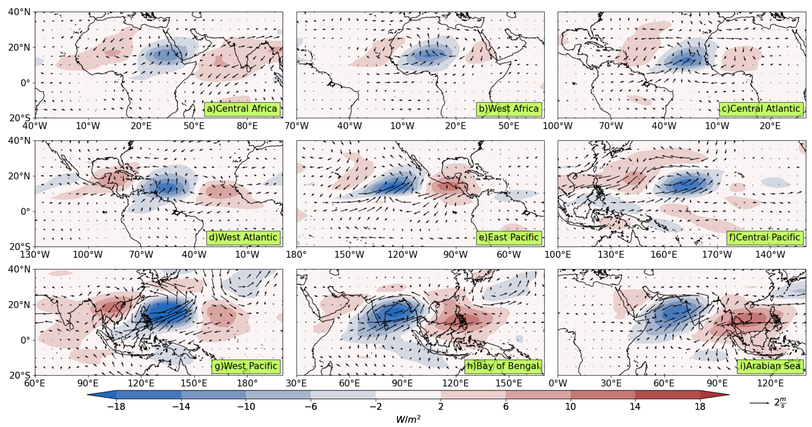
Wind and convection

OLR and 850 hPa horizontal wind on Day 0 (day of active convection).



Seasonal mean of wind and moisture

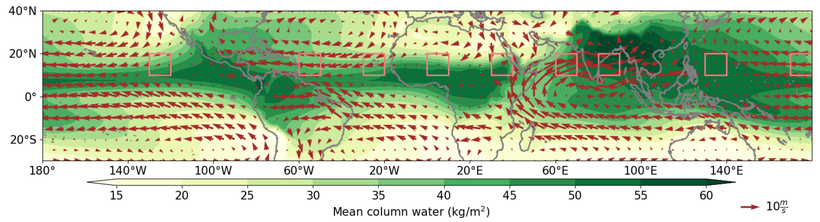


Figure 1. Mean column water and 850 hPa wind in June to September (JJAS).

Vertical structure

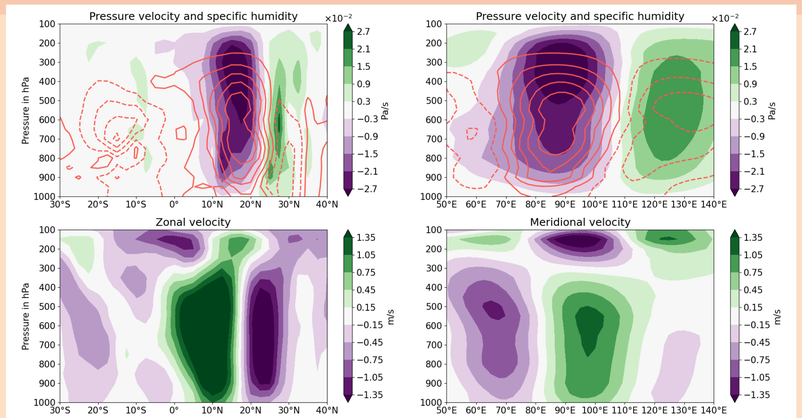


Figure 2. Day 0 in the Bay of Bengal region, contour interval is $8 \times 10^{-5}\,\mathrm{kg/kg}$.

1. Quadrature phase difference between moisture and vorticity in dry regions [2], tiny phase difference in moist regions of South Asia.
2. Barotropic structure of the variables in the lower and middle troposphere [1].
3. The background wind and moisture gradients control the QBWO.

Vorticity budget

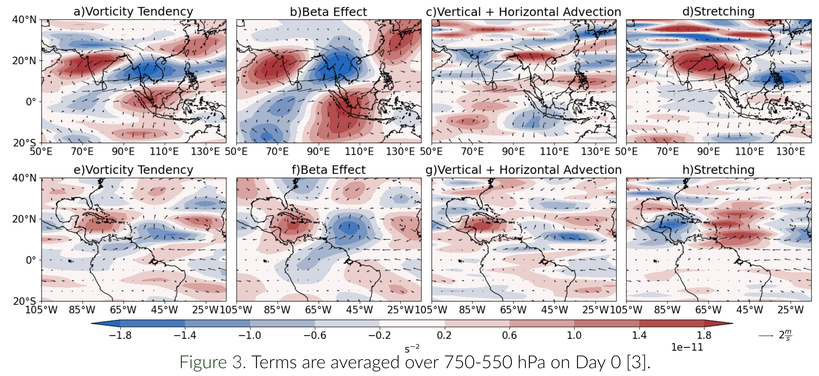


Figure 3. Terms are averaged over 750-550 hPa on Day 0 [3].

Moisture budget

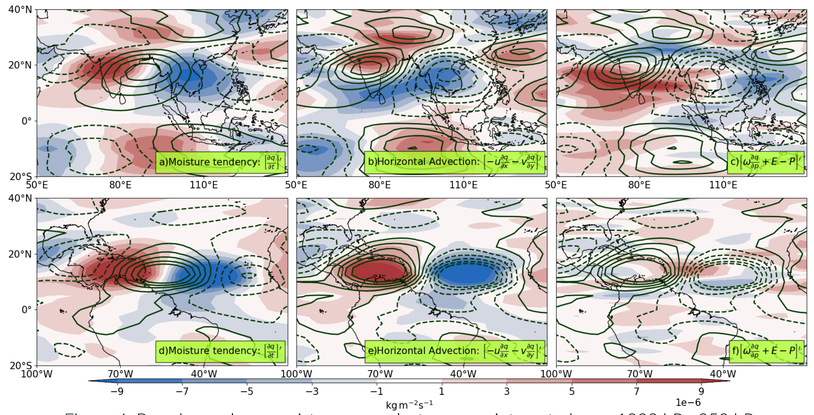
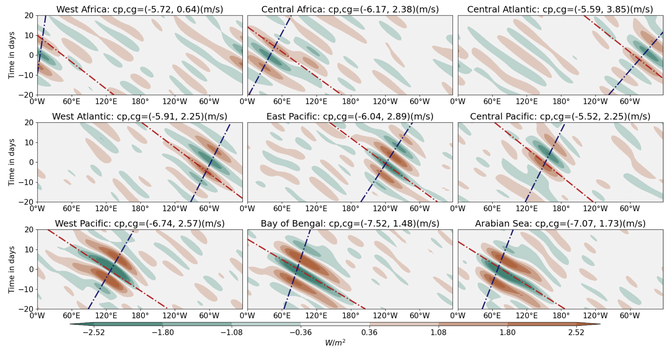


Figure 4. Based on column moisture anomaly, terms are integrated over 1000 hPa-250 hPa.



Future aspects

- Theoretical explanation of different configurations and mechanisms of vorticity and moisture propagation based on moisture mode and background conditions [4].
- Potential vorticity based description of QBWO, especially in the moist regions.
- Simulation of ideal situations using prescribed conditions.
- Simulation using initial value problems for moisture and vorticity.
- Study on eastward propagating tropical QBWO.

Reduced equations

Table 1. Dominant terms in the vorticity tendency of all the nine regions in addition to $-\beta v'$. Note that $\boldsymbol{u}' = (u', v'), \bar{\boldsymbol{u}} = (\bar{u}, \bar{v})$.

Region (% error)	Dominant terms	Region (% error)	Dominant terms	Region (% error)	Dominant terms
W. Africa (18.56%)	$-\bar{u}\frac{\partial \zeta'}{\partial x} - f\nabla\cdot\boldsymbol{u}'$	W. Atlantic (21.38%)	$-\bar{u}\frac{\partial \zeta'}{\partial x} - f\nabla\cdot\boldsymbol{u}'$	Arabian Sea (29.09%)	$-\boldsymbol{u}'\cdot\nabla\zeta - f\nabla\cdot\boldsymbol{u}'$
C. Africa (14.85%)	$-\bar{\boldsymbol{u}}\cdot\nabla\zeta' - f\nabla\cdot\boldsymbol{u}'$	C. Pacific (12.81%)	$-\bar{\boldsymbol{u}}\cdot\nabla\zeta' - f\nabla\cdot\boldsymbol{u}'$	Bay of Bengal (19.17%)	$-\boldsymbol{u}'\cdot\nabla\zeta - f\nabla\cdot\boldsymbol{u}'$
C. Atlantic (20.88%)	$-\bar{u}\frac{\partial \zeta'}{\partial x} - f\nabla\cdot\boldsymbol{u}'$	E. Pacific (16.22%)	$-\bar{u}\frac{\partial \zeta'}{\partial x} - f\nabla\cdot\boldsymbol{u}'$	W. Pacific (12.36%)	$-\bar{v}\frac{\partial \zeta}{\partial y} - f\nabla\cdot\boldsymbol{u}'$

% Error is defined as $\langle \frac{total-approx}{max(total)} \rangle$, where $\langle\rangle$ denotes average over region specific selected box. $total$ is sum of all the terms that contribute to the vorticity tendency, $approx$ is the linear approximation.

Table 2. Dominant terms in horizontal moisture advection for all the nine regions.

Region	Dominant terms	Region	Dominant terms	Region	Dominant terms
West Africa	$-\bar{u}\frac{\partial q'}{\partial x} - v'\frac{\partial \bar{q}}{\partial y}$	West Atlantic	$-u\frac{\partial q'}{\partial x}$	Arabian Sea	$-u'\frac{\partial \bar{q}}{\partial x} - v'\frac{\partial \bar{q}}{\partial y}$
Central Africa	$-\bar{u}\frac{\partial q'}{\partial x} - v'\frac{\partial \bar{q}}{\partial y}$	Central Pacific	$-u\frac{\partial q'}{\partial x}$	Bay of Bengal	$-u'\frac{\partial \bar{q}}{\partial x} - v'\frac{\partial \bar{q}}{\partial y}$
Central Atlantic	$-\bar{u}\frac{\partial q'}{\partial x}$	East Pacific	$-\bar{u}\frac{\partial q'}{\partial x}$	West Pacific	$-\bar{u}\frac{\partial q'}{\partial x} - \bar{v}\frac{\partial q'}{\partial y}$

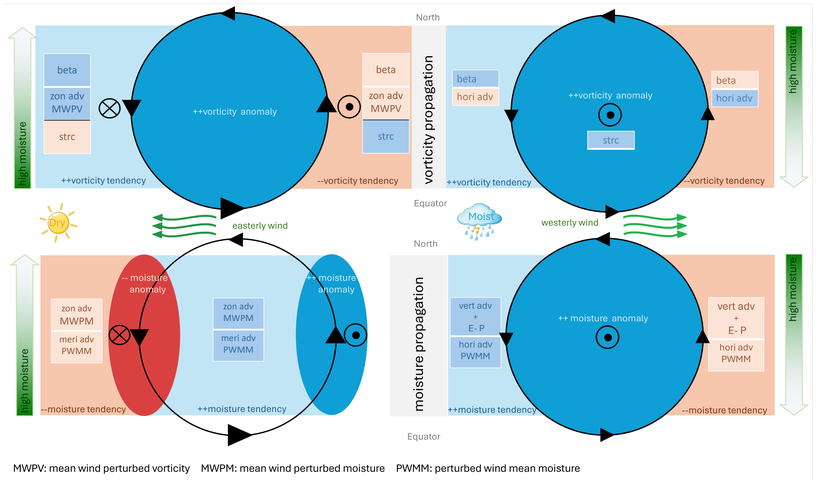
Simplified equations for vorticity and moisture in dry regions

$$\frac{\partial \zeta'_D}{\partial t} = -\bar{u}\frac{\partial \zeta'_D}{\partial x} - f\left(\frac{\partial u'_D}{\partial x} + \frac{\partial v'_D}{\partial y}\right) - \beta v'_D \quad ; \quad \frac{\partial q'_D}{\partial t} = -\bar{u}\frac{\partial q'_D}{\partial x} - v'_D\frac{\partial \bar{q}_D}{\partial y} \tag{1}$$

Simplified equations for vorticity and moisture in moist regions

$$\frac{\partial \zeta'_M}{\partial t} = -u'_M\frac{\partial \bar{\zeta}_M}{\partial x} - v'_M\frac{\partial \bar{\zeta}_M}{\partial y} - f\left(\frac{\partial u'_M}{\partial x} + \frac{\partial v'_M}{\partial y}\right) - \beta v'_M \; ; \; \frac{\partial q'_M}{\partial t} = -u'_M\frac{\partial \bar{q}_M}{\partial x} - v'_M\frac{\partial \bar{q}_M}{\partial y} - \omega'_M\frac{\partial \bar{q}_M}{\partial p} + E'_M - P'_M \tag{2}$$

Simple schematic for lower troposphere



MWPV: mean wind perturbed vorticity MWPM: mean wind perturbed moisture PWMM: perturbed wind mean moisture

References

[1] George N Kiladis, Matthew C Wheeler, Patrick T Haertel, Katherine H Straub, and Paul E Roundy. Convectively coupled equatorial waves. *Reviews of Geophysics*, 47(2), 2009.

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[3] Adrian J Matthews. A vorticity budget for theoretical and convectively coupled equatorial rossby waves: Dynamical propagation and growth mechanisms. *Quarterly Journal of the Royal Meteorological Society*, 151(767):e4917, 2025.

[4] Victor C Mayta, Ángel F Adames, and Fiaz Ahmed. Westward-propagating moisture mode over the tropical western hemisphere. *Geophysical Research Letters*, 49(6):e2022GL097799, 2022.