AOS 801: Advanced Tropical Meteorology

Lecture 20   Spring 2023

Paper discussion

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Final Presentation

The presentations will be the last 2 classes. It is 10% of your final grade

You will choose the topic of your presentation. It can be a paper review. It can be how aspects of your research are related to class (it cannot be directly the project you are working on).

Presentations will be 15 mins. 10 mins for presentation and 5 minutes for questions. Only 4 students can present per day.

You will be evaluated based on a rubric. It will be uploaded to Canvas

Choose preferred date on a Spreadsheet.
https://docs.google.com/spreadsheets/d/1qCP6THaTo-mq1jVIla6XUvFDtPnNHQUhCtG2zq1flVk/edit?usp=sharing

Announcements

Short quiz now. You have 10 mins. Turn it in when done.

We will then review moisture modes and do the paper discussion.

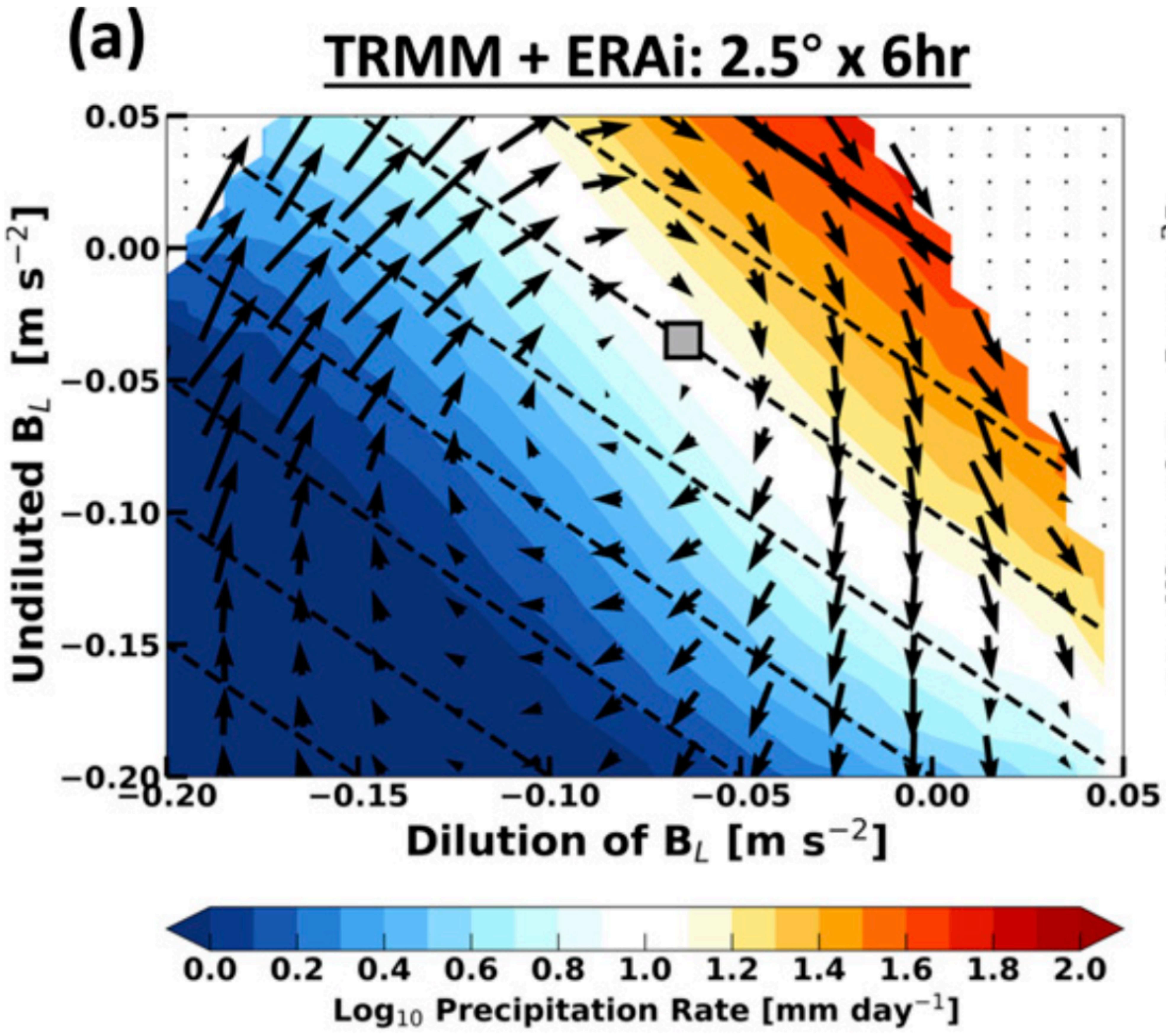
HW4/PA4 are due next Monday. Please come to office hours if you have questions.

Moisture modes and quasi-equilibrium

The main premise behind QE is that instability is quickly removed by convective processes.

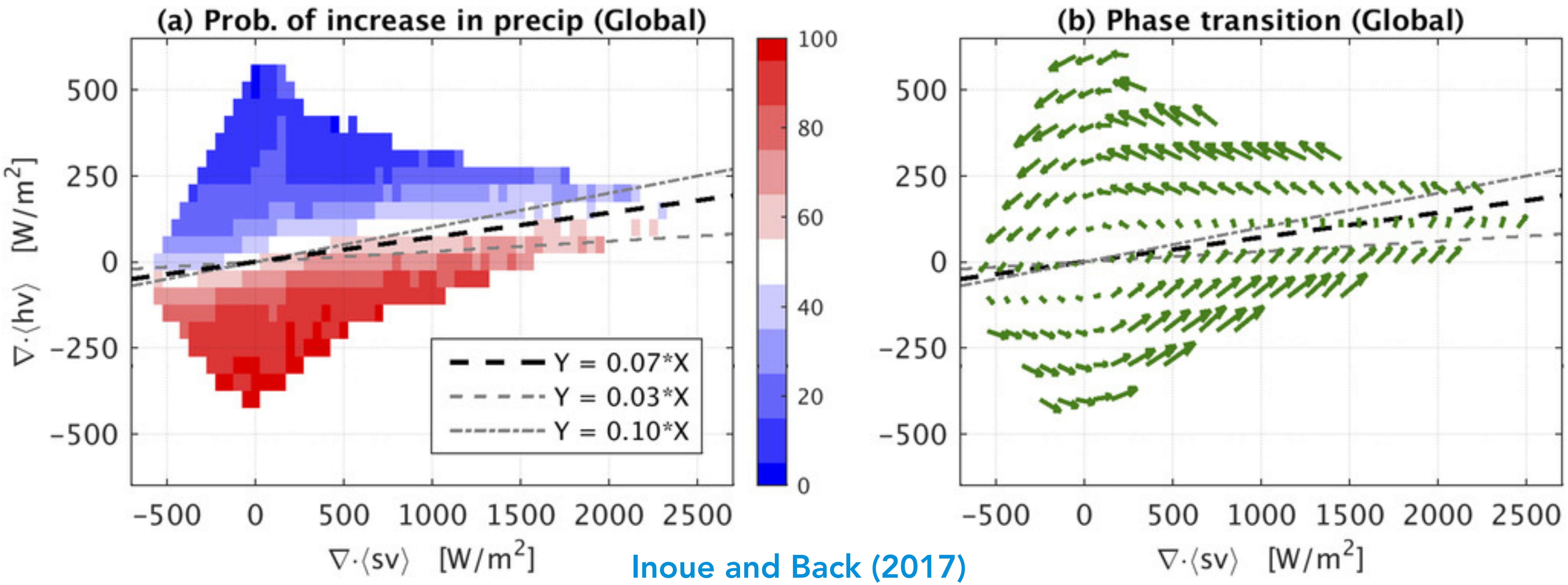
By definition, moisture modes are slow variations in moisture. Through that premise they are inconsistent with QE.

However, they can still be considered fluctuations around a QE state.



MSE budget point of view

$$\frac{1}{\nabla_h \cdot \langle \mathbf{v}\mathrm{DSE}\rangle}\frac{\partial L_v\langle q\rangle}{\partial t} \simeq -\left(\Gamma - \gamma\right)$$

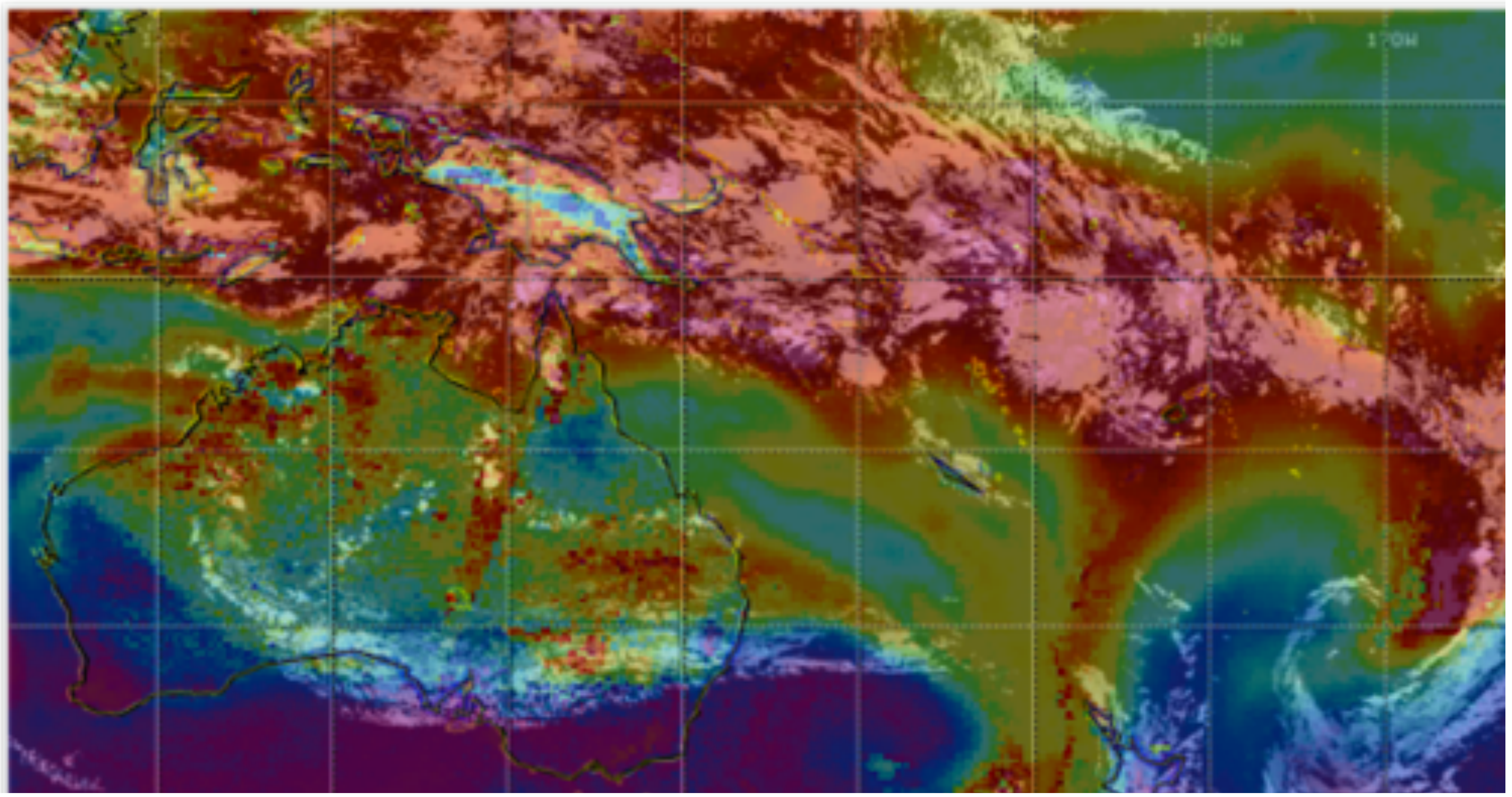


Inoue and Back (2017)

The cloud of points in the diagrams are from all precipitating regions in the tropics.

Temperature anomalies in moisture modes

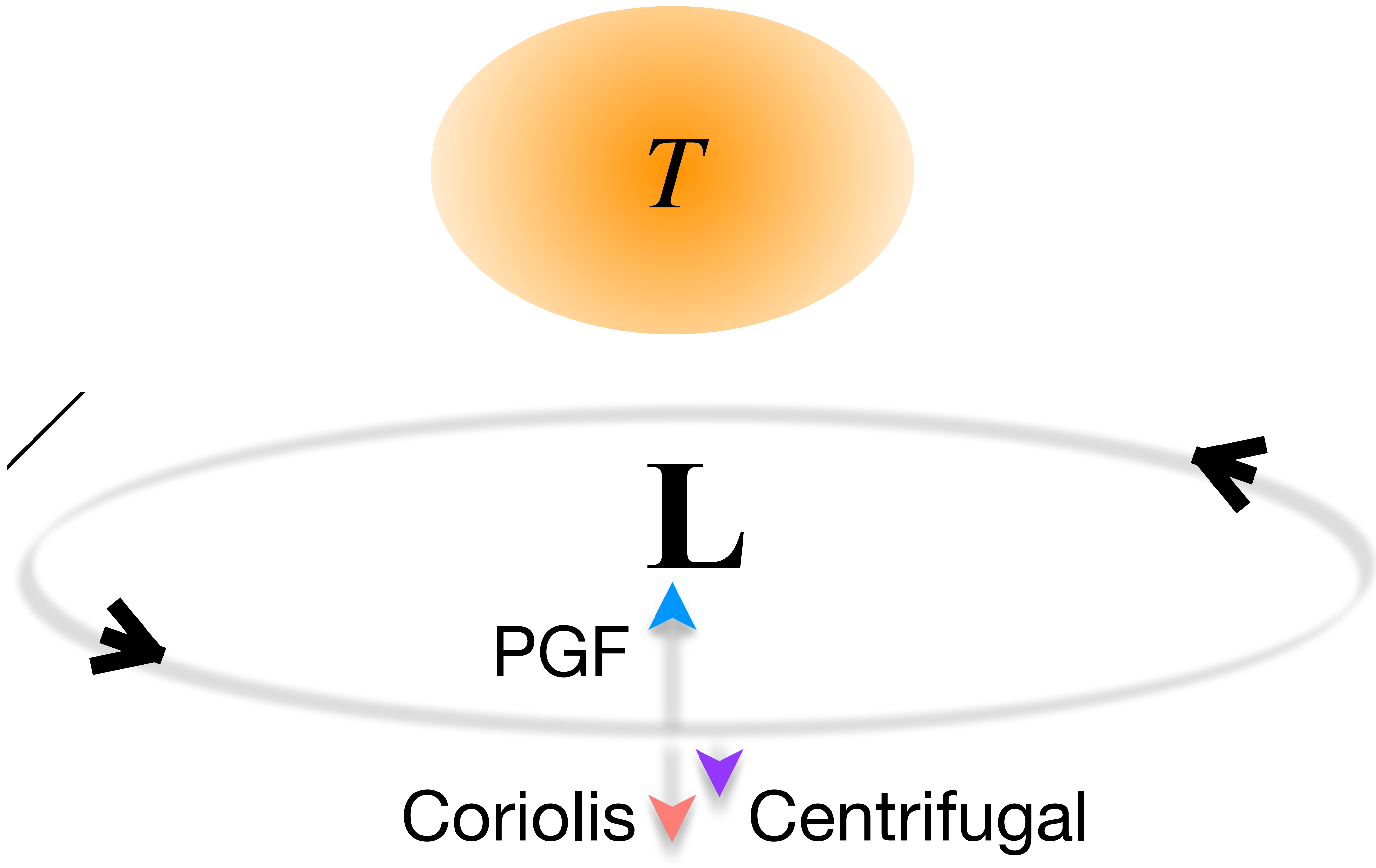
While $C_pT' \ll L_vq'$ in moisture modes, you still need temperature anomalies to maintain a balanced wind field.



Tropics

Nonlinear balance

Gradient wind,
Cyclostrophic
Semi-geostrophic



Today

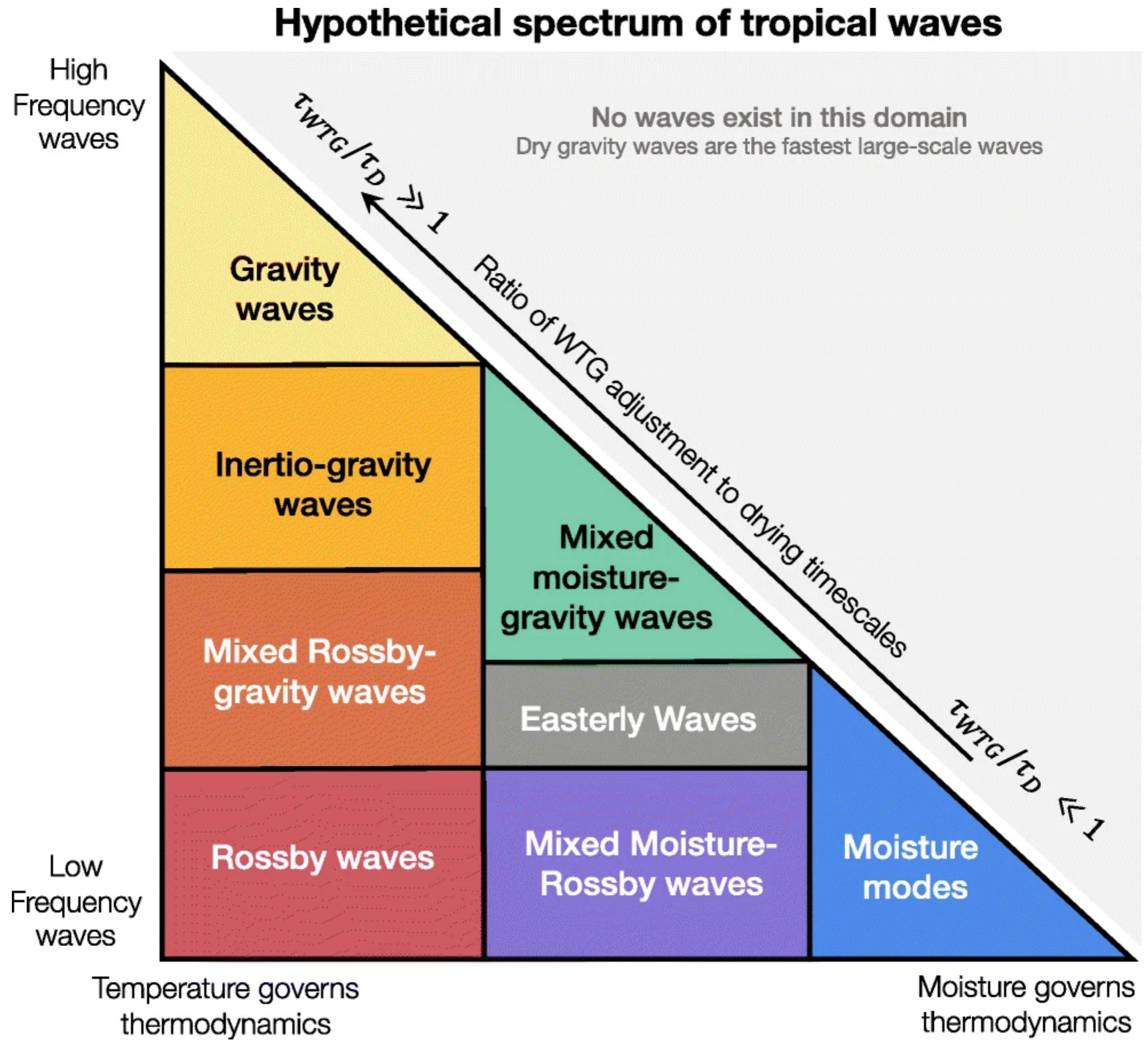
More recent research has shown that moisture modes are commonplace.

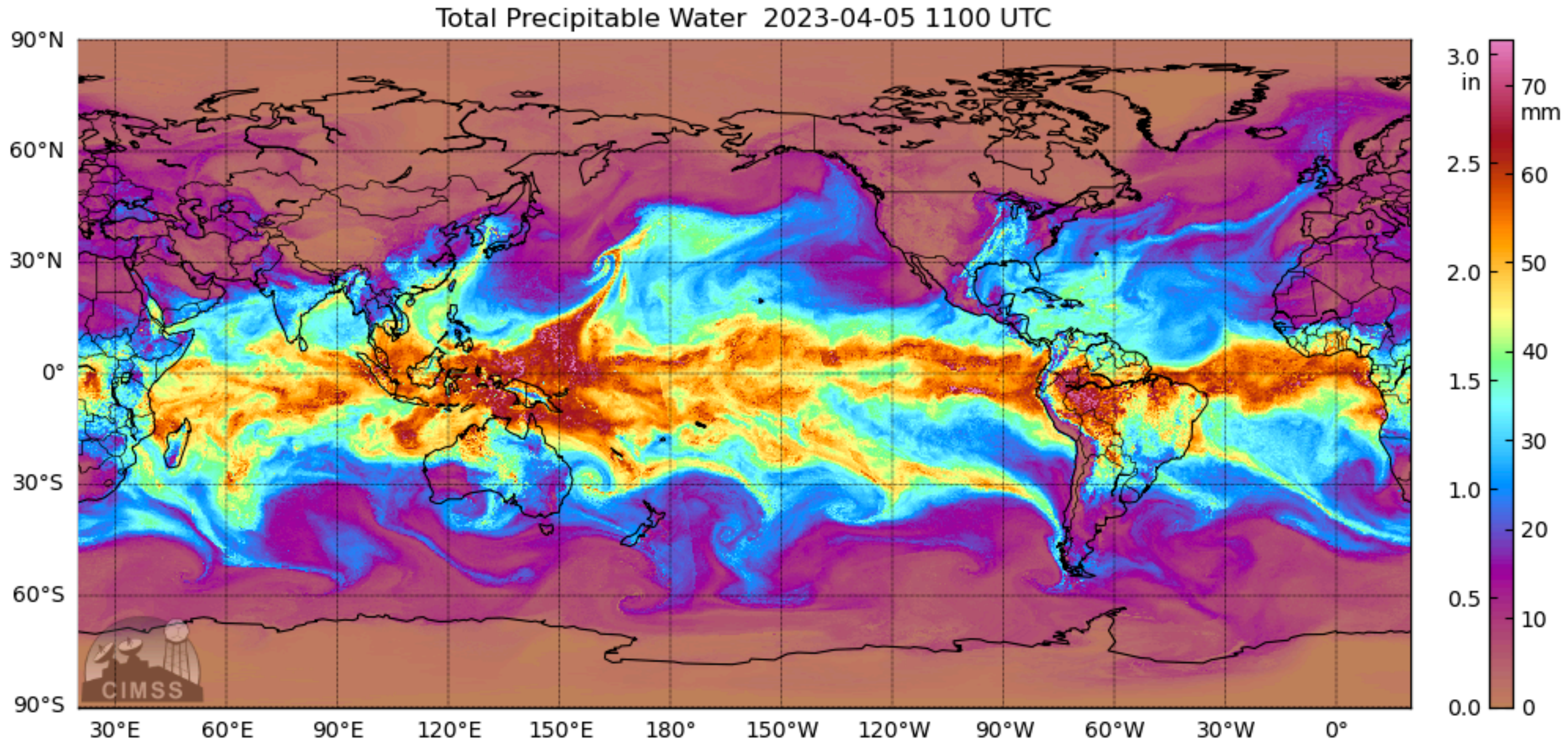
Recent candidates include:

1. Equatorial Rossby Waves
2. Oceanic Tropical depression-like waves
   a. *Easterly waves*
   b. *Monsoon low-pressure systems*

Today we will discuss these

Moisture Modes





Generality

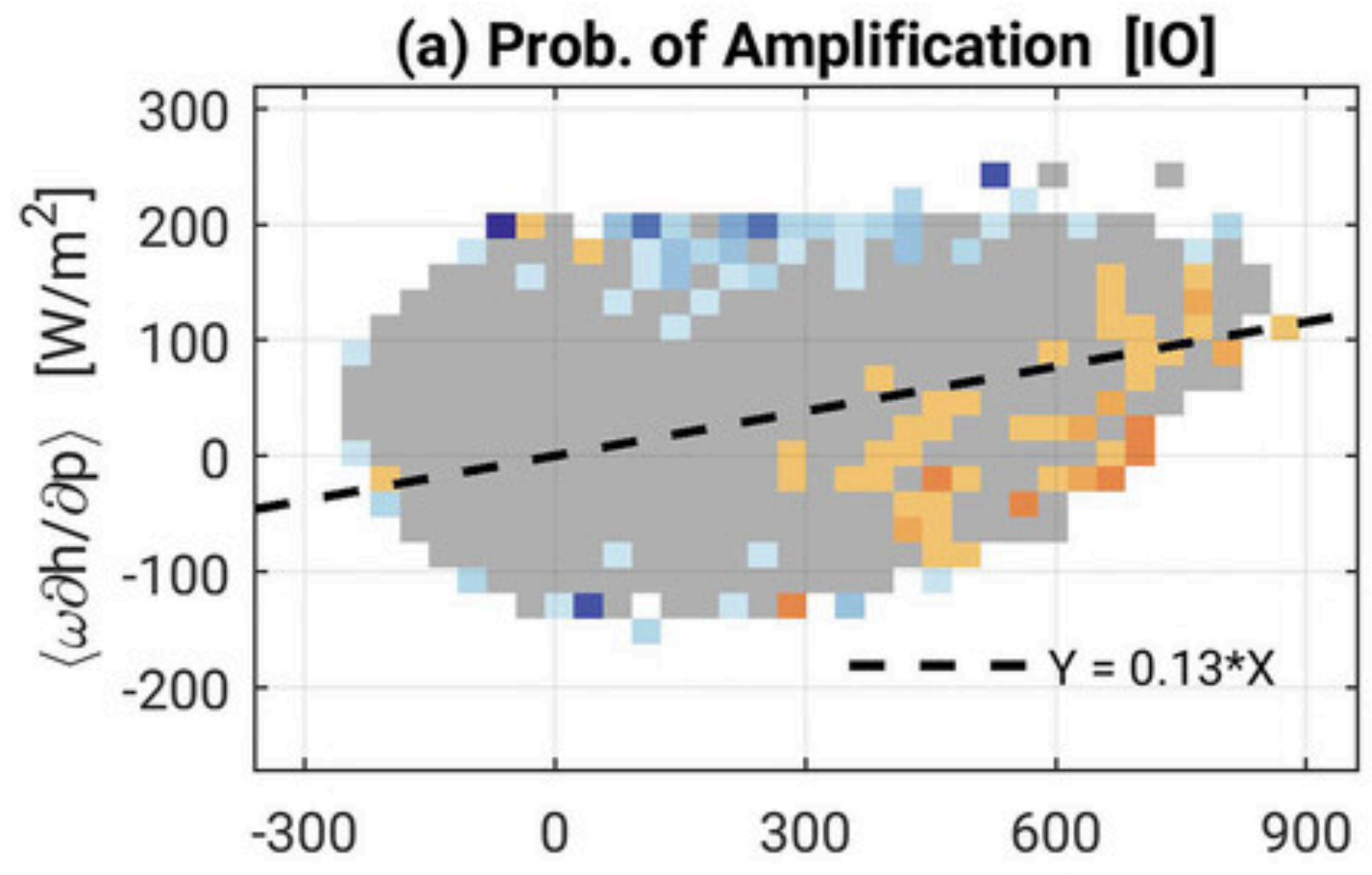
Horizontal moisture advection is a stronger predictor for the evolution of rainfall than vertical MSE advection.

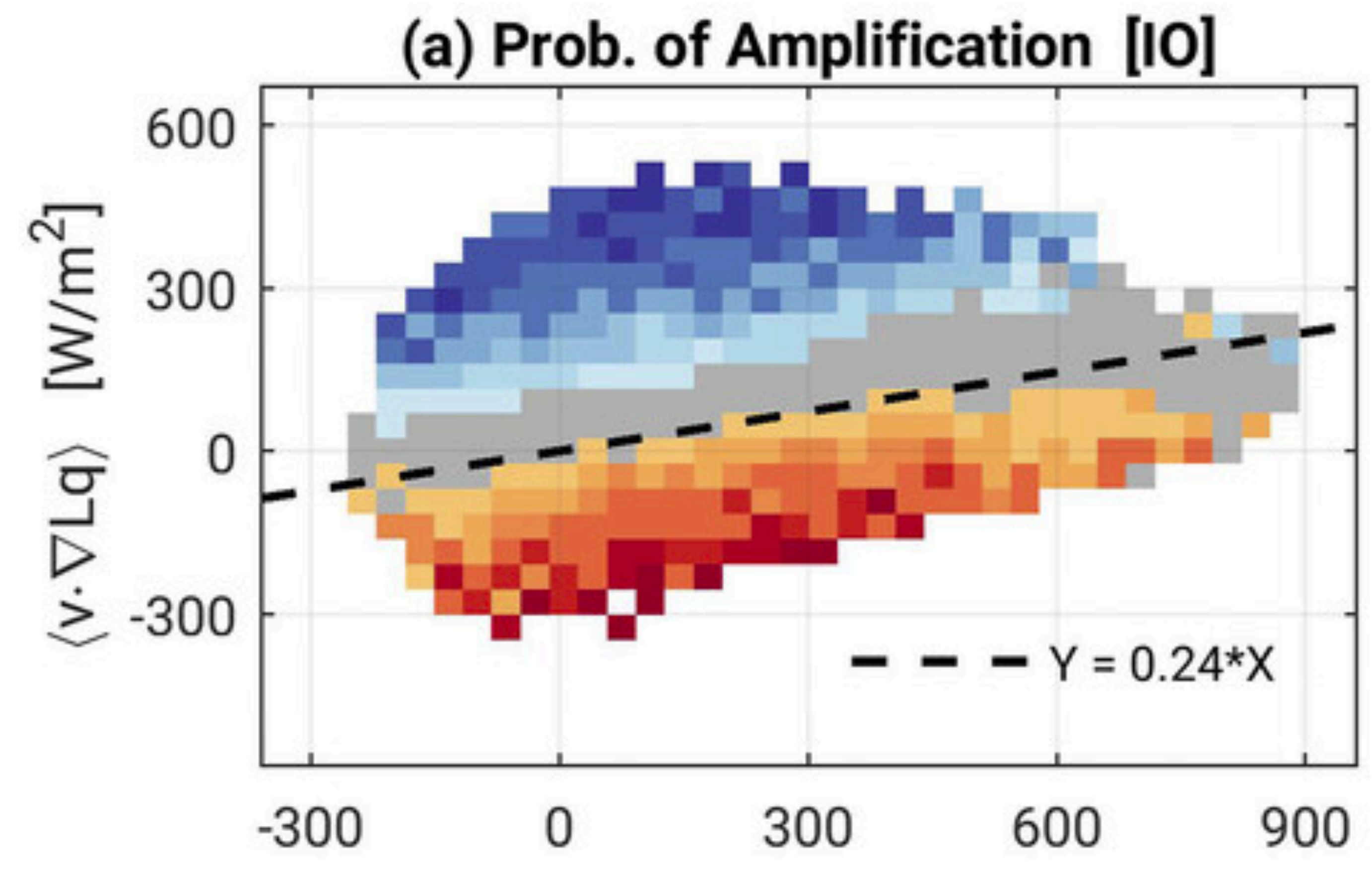
Horizontal advection is a strong control on precipitation occurrence.

Inoue et al. (2021) found that the column moisture budget can be written as:

$$\frac{\partial L_v \langle q \rangle}{\partial t} \simeq -\langle \mathbf{v} \cdot \nabla_h L_v q \rangle - \Gamma_e \nabla_h \cdot \langle \mathbf{v}\mathrm{DSE} \rangle$$

$\Gamma_e = \dfrac{\omega \partial_p \mathrm{MSE} - \mathrm{D}}{\nabla_h \cdot \langle \mathbf{v}\mathrm{DSE} \rangle}$ is the effective gross moist stability.

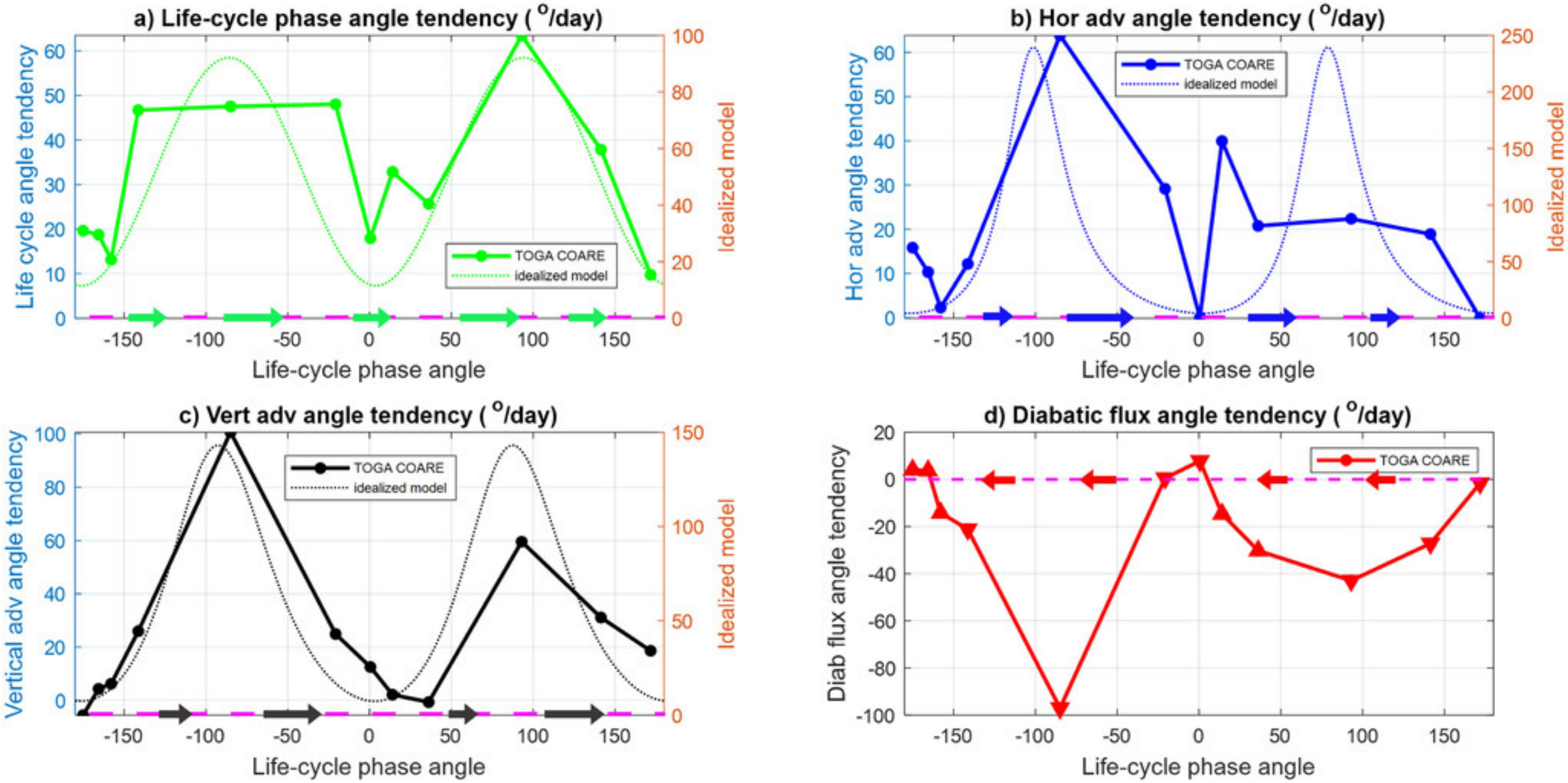




Inoue et al. (2021)

Generality

Discharge-recharge cycles in MSE in the tropics qualitatively match moisture mode behavior, hinting at the commonality of moisture modes.



Maithel and Back (2022)

Today

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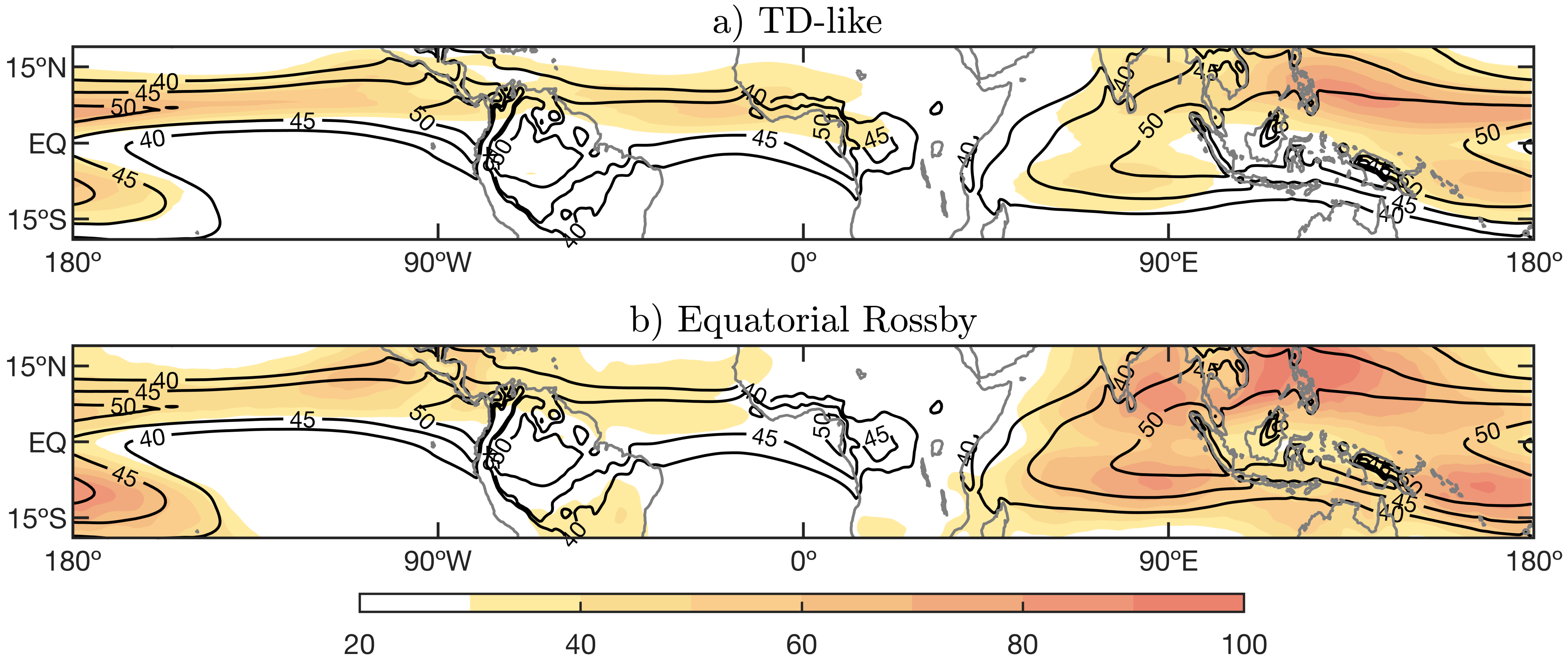
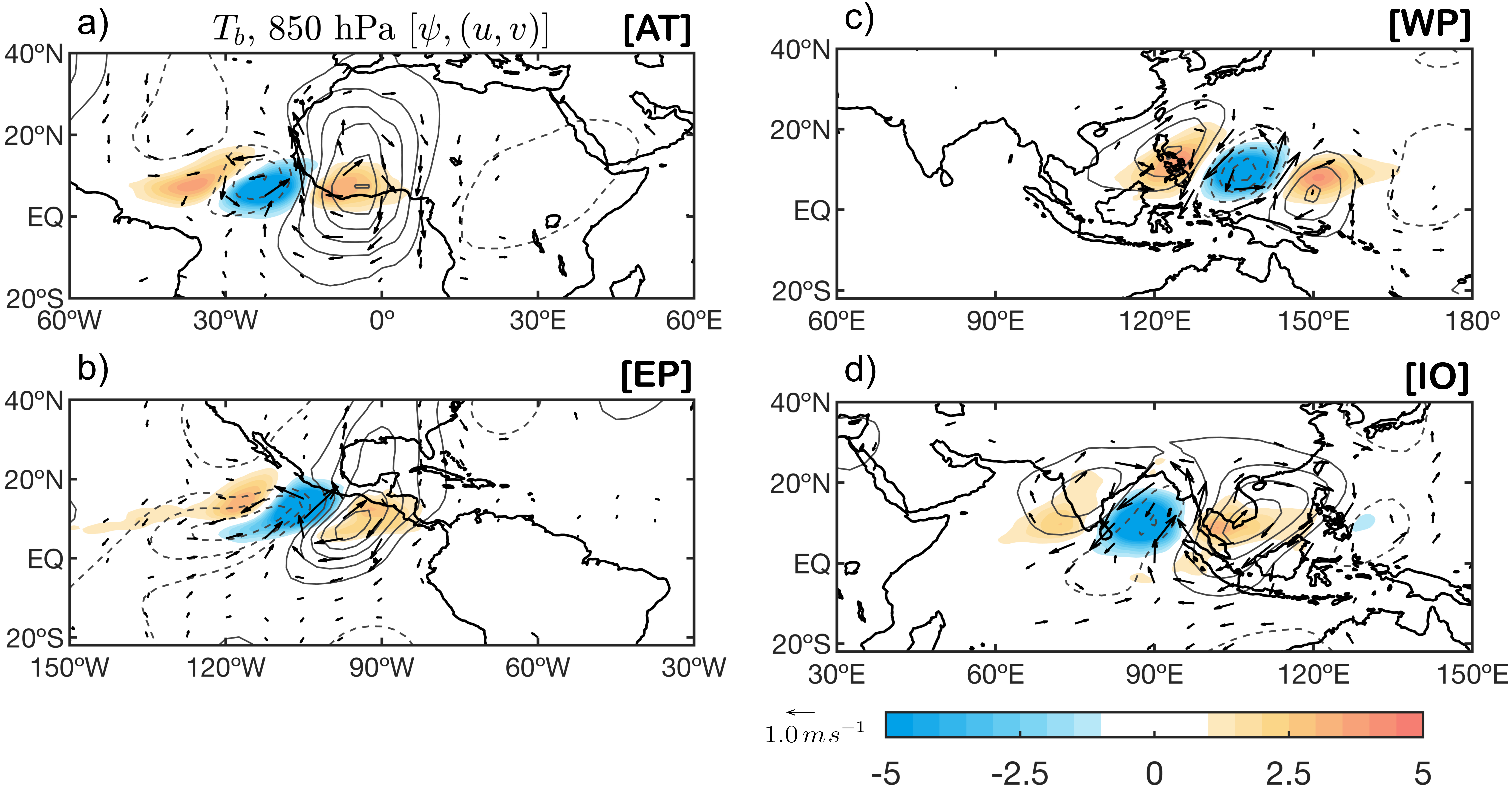
Where is the variance strongest? What might this mean?



What are the similarities and differences of these waves.

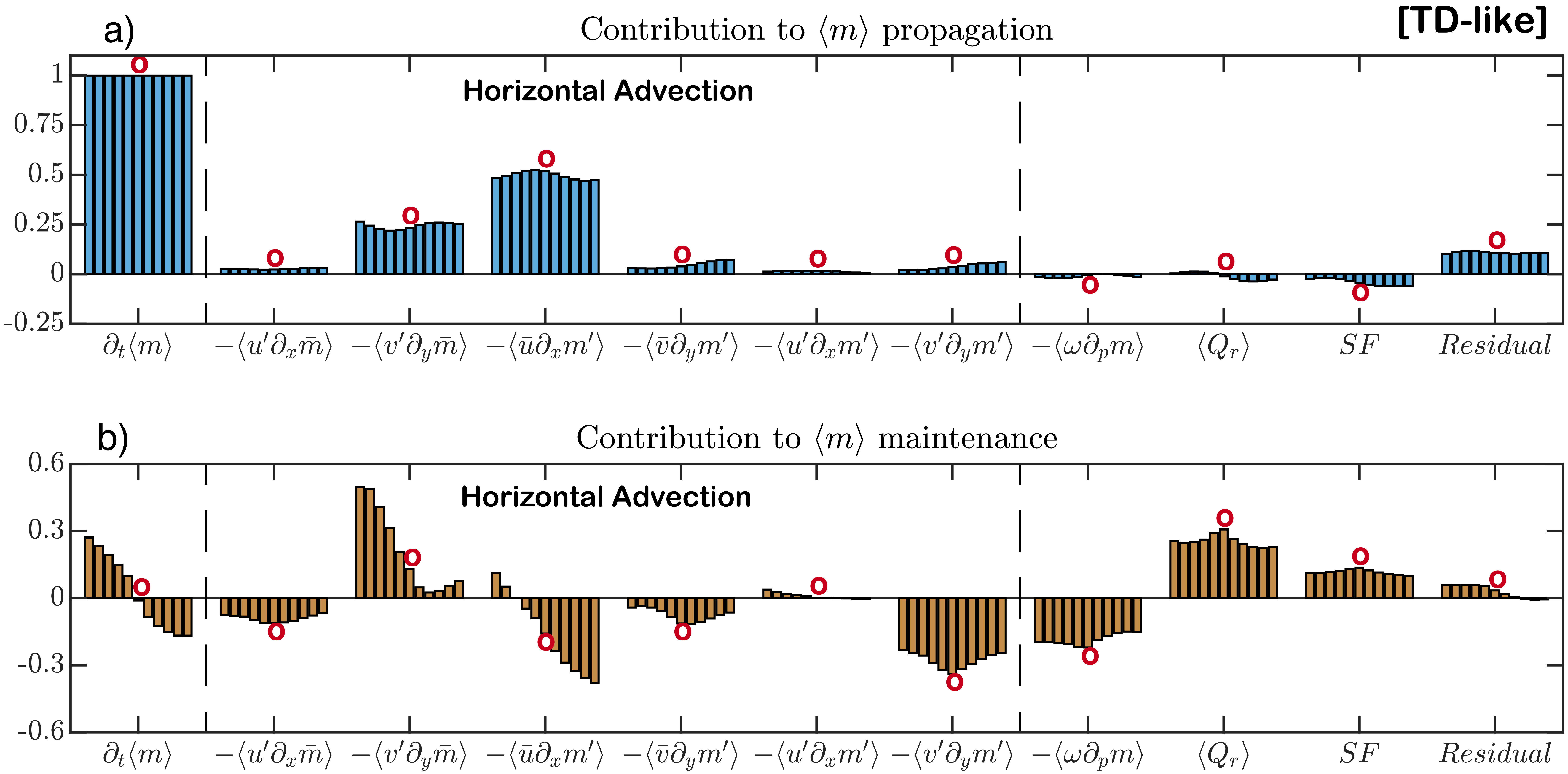


What does this table say about the different Rossby and TD-like waves in the tropics

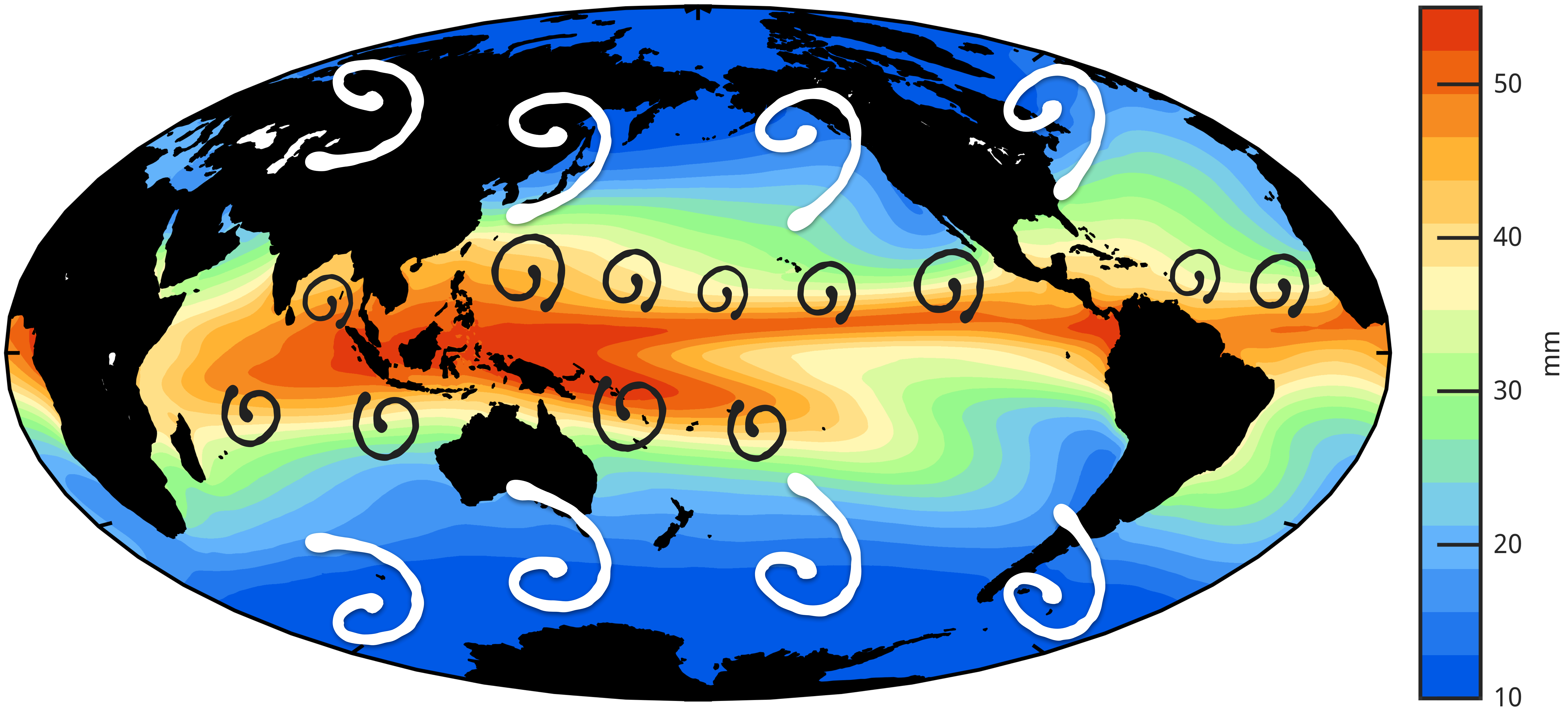
TABLE 2. Moisture mode criteria applied to TD-like and ER-like waves over different tropical regions. The slope of the linear fit and the correlation coefficient are shown in a similar manner to Fig. 5. * The values for the equatorial Rossby mode over the Atlantic region come from Mayta et al. (2022).

		C1: $P' \propto \langle q \rangle'$		C2: $\nabla \cdot \langle s\mathbf{v} \rangle' \simeq \langle Q_1 \rangle'$		C3: $\langle m \rangle' \approx L_v \langle q \rangle'$	
Wave	Region	Slope	Corr	Slope	Corr	Slope	Corr
TD-like	Atlantic	0.60 ± 0.007	0.88	0.95 ± 0.003	0.99	1.06 ± 0.002	1.00
	Eastern Pacific	0.51 ± 0.003	0.94	0.98 ± 0.002	1.00	1.07 ± 0.003	0.99
	Western Pacific	0.60 ± 0.003	0.97	0.96 ± 0.002	1.00	1.02 ± 0.001	1.00
	Indian Ocean	0.53 ± 0.003	0.90	0.89 ± 0.003	0.97	1.06 ± 0.002	0.99
Equatorial Rossby	E. Pacific - Atlantic*	1.63 ± 0.007	0.96	0.99 ± 0.002	0.99	1.04 ± 0.002	0.99
	Western Pacific	0.91 ± 0.003	0.88	0.98 ± 0.001	1.00	0.89 ± 0.001	0.98
	Indian Ocean	1.04 ± 0.004	0.90	1.02 ± 0.001	0.99	0.97 ± 0.001	0.98

What TD-like waves is this plot showing? Discuss the different terms in the budget.



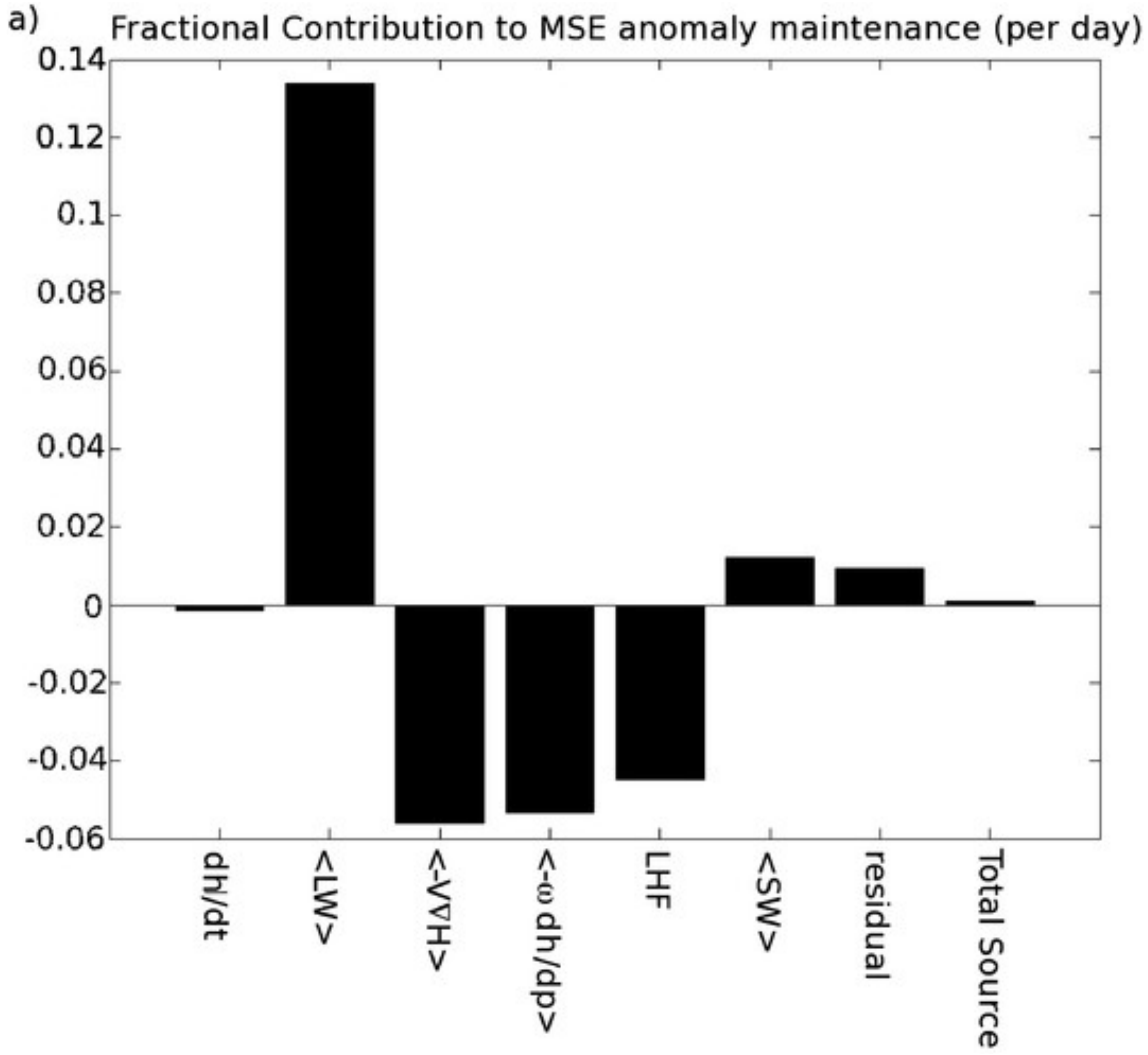
Synthesize everything. Based on the results, what is this schematic telling us?



Mechanism of growth

The mechanism of growth can be understood as a variance budget

$$\frac{\partial L_v \langle q' \rangle^2}{\partial t} = -\langle q' \rangle \left(\langle \mathbf{v} \cdot \nabla_h L_v q \rangle' - \left\langle \omega_w \frac{\partial \mathrm{MSE}}{\partial p} \right\rangle' + \langle Q_r' \rangle + L_v E' + \mathrm{SHF}' \right)$$



For a process to contribute to the growth of moisture anomalies, it must occur in phase with the moisture anomalies.

$$\frac{\partial L_v \langle q' \rangle^2}{\partial t} > 0 \textbf{ growth}$$

$$\frac{\partial L_v \langle q' \rangle^2}{\partial t} < 0 \textbf{ decay}$$