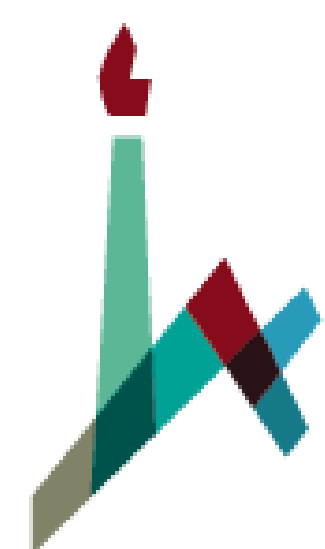


A "bottom-up" pathway for the tropical precipitation response to SSWs: the role of trade winds for the convective response in SNAPSI



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1. Introduction

- SSW events lead to a robust strengthening of the Brewer–Dobson circulation with more upwelling in the equator, but the details of the precipitation response differ widely across different models. Why? What's the main factor driving the spread?
- We use output from the SNAPSI ("Stratosphere Nudging and Predictable Surface Impacts") model intercomparison project, to focus on the response to three recent SSW events.

2. SNAPSI Data

- Model:** GLOBO, GEM-NEMO, IFS, GloSea6-GC32, CNRM-CM61, and GRIMs.
 - Experiments:** Nudged and Control.
 - Initialization dates:** 25 January 2018
 - Time period:** 13-19 February 2018 (week1 after the onset of SSW-2018 event).
- Note that: all results show the anomalies between Nudged and Control experiments.

3. Methodology

1. Moisture budget: $\frac{\partial w}{\partial t} + \frac{1}{g} \nabla \cdot \int_0^{p_s} qU dp = E - P$

2. Moist static energy (MSE): $S = C_p \cdot T + g \cdot z + L_v \cdot q$

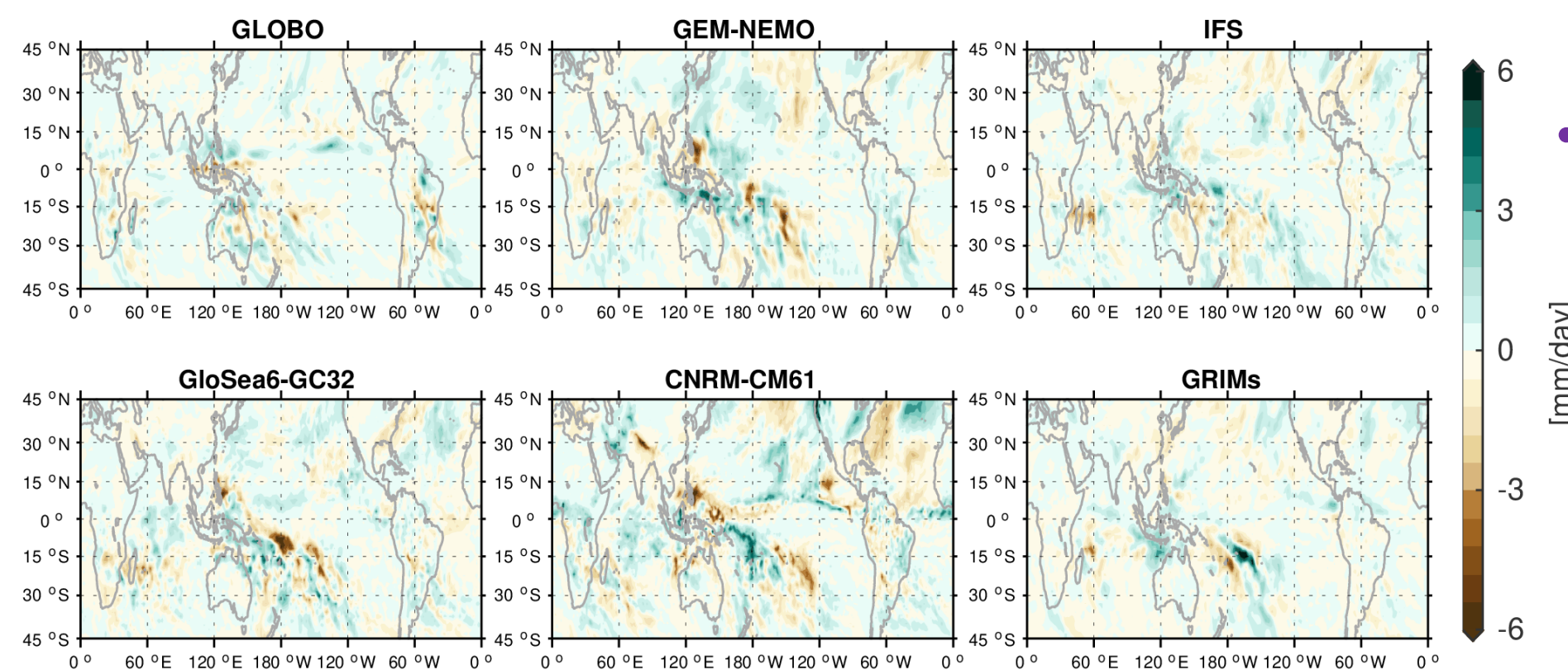
3. Psi vector: $\nabla_p \cdot U + \frac{\partial \omega}{\partial p} = 0 \quad U_{div} = \nabla_p \chi \quad \chi = \frac{\partial \mu}{\partial p}$
 $\omega_\theta \cos \theta = \frac{1}{a^2} \frac{\partial}{\partial \theta} (\cos \theta \frac{\partial \mu}{\partial \theta}) \quad \omega_\lambda \cos \theta = \frac{1}{a^2 \cos \theta} \frac{\partial^2 \mu}{\partial \lambda^2}$

Therefore:

$$\nabla \cdot [qU] = \left[u_r \frac{dq}{dx} + v_r \frac{dq}{dy} \right] + \left[u_d \frac{dq}{dx} + v_d \frac{dq}{dy} \right] + \left[-q \frac{\partial \omega_\theta}{\partial p} \right] + \left[-q \frac{\partial \omega_\lambda}{\partial p} \right]$$

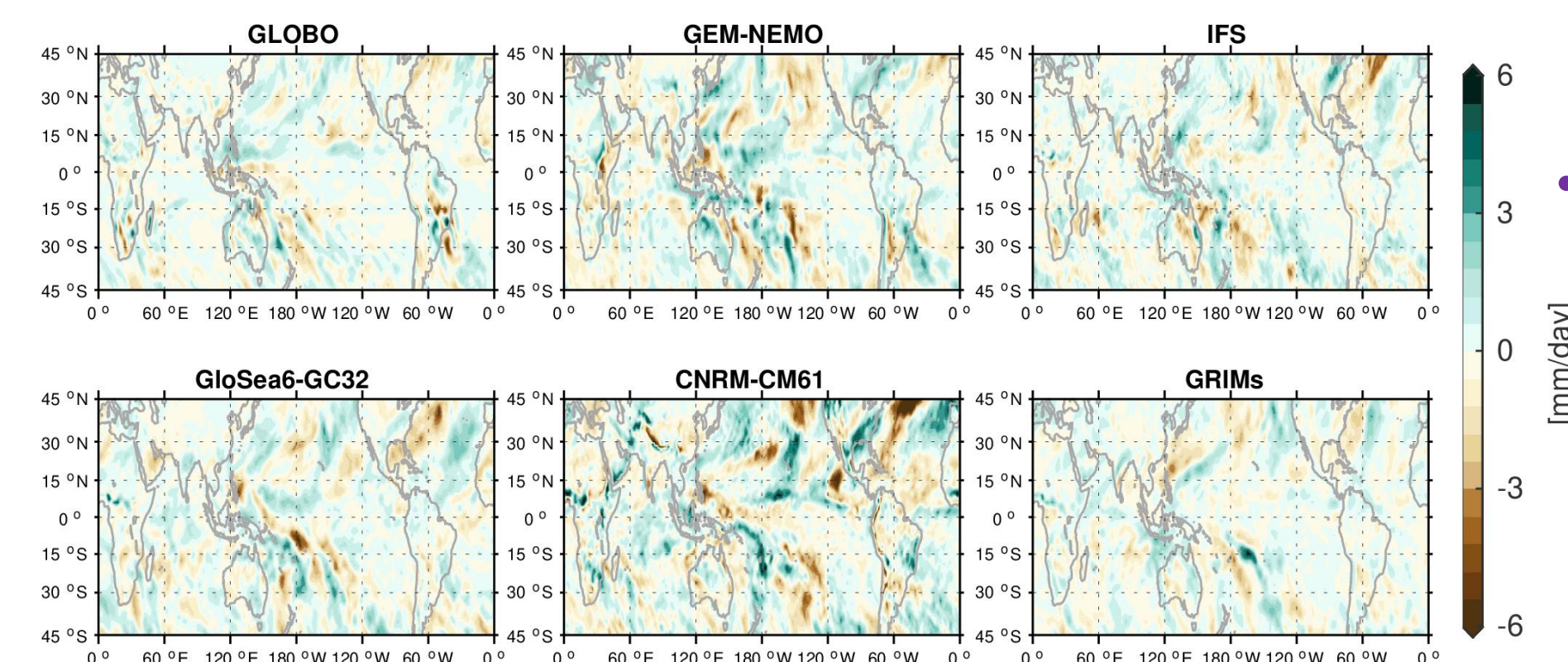
4. Precipitation & moisture budget

Precipitation



- Response of precipitation is significant around Maritime continent across models, but shows different pattern over tropics and subtropics.

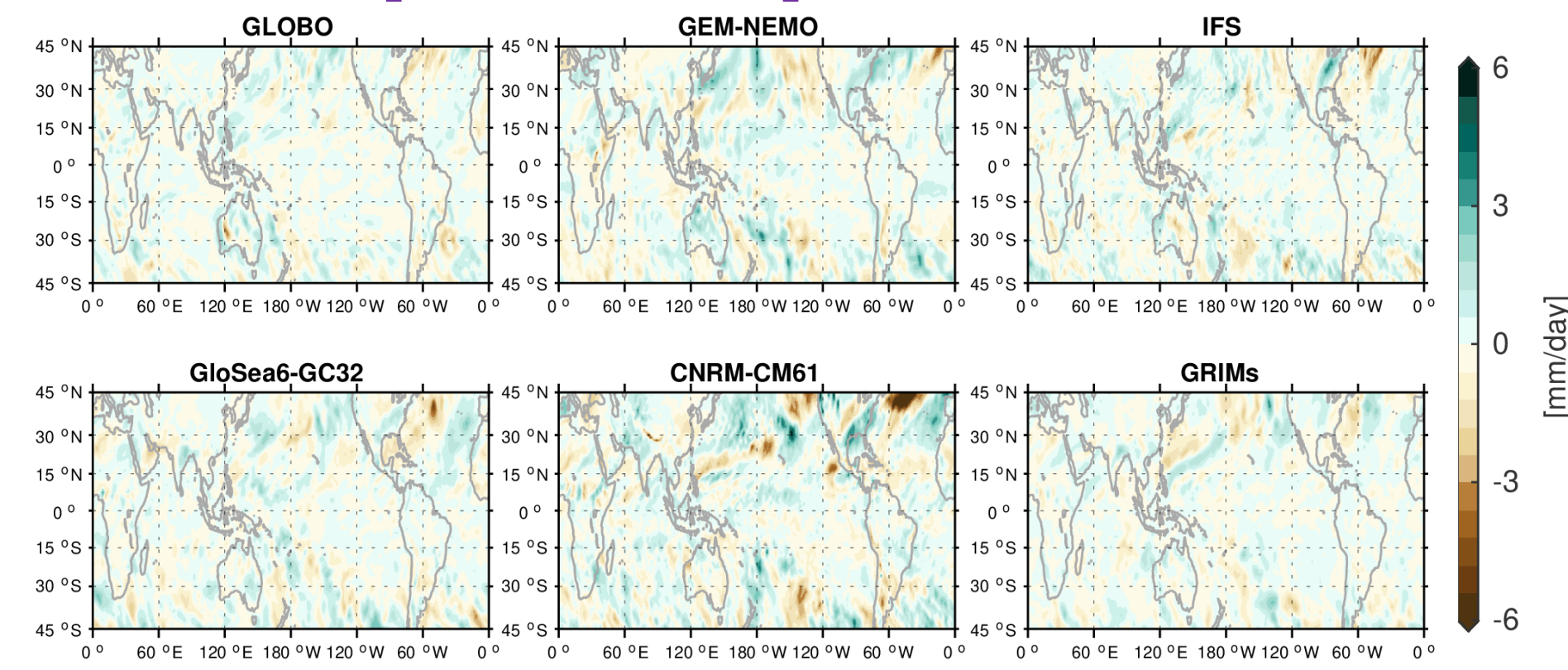
$-\nabla \cdot [qU]$ (400-1000 hPa)



- Divergence of moisture flux matches well with the pattern of rainfall.

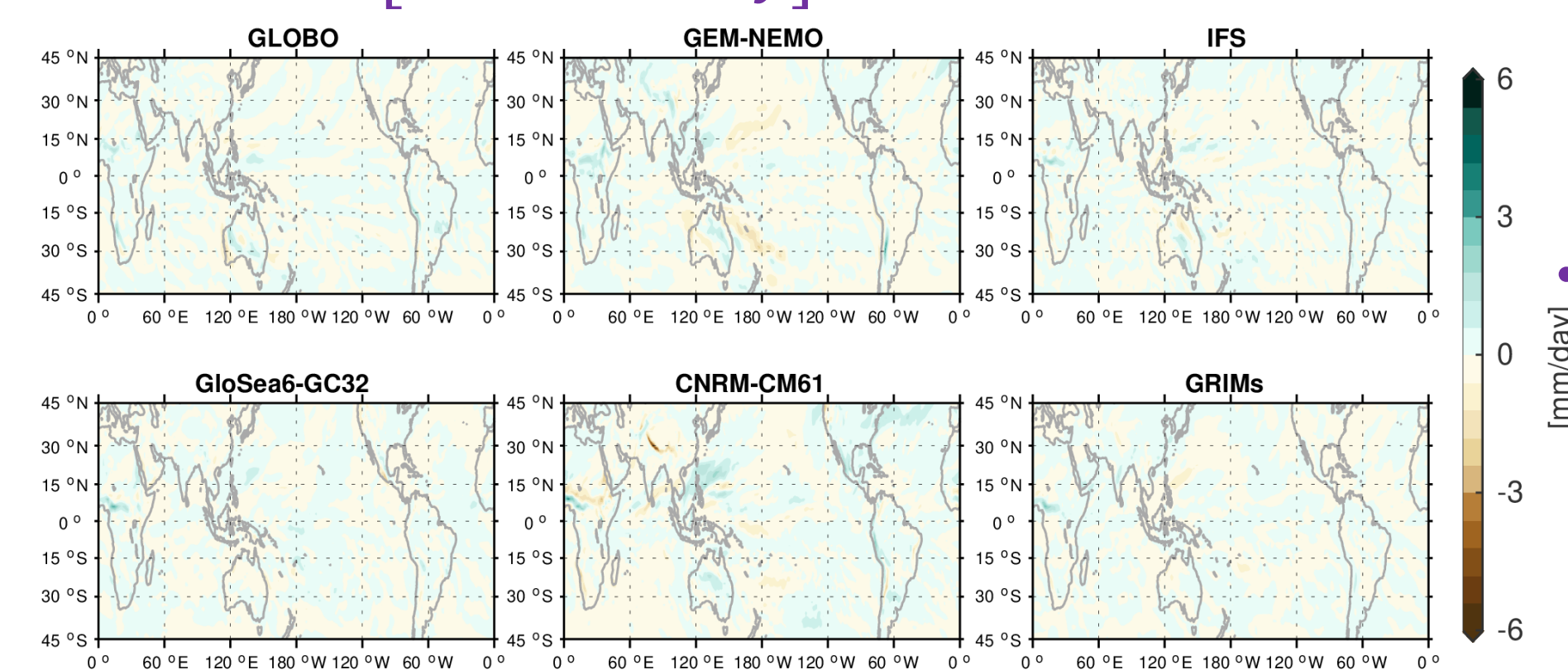
5. Advection impact

$$-\left[u_r \frac{dq}{dx} + v_r \frac{dq}{dy} \right] (400-1000 \text{ hPa})$$



- Rotational part of advection is strongest in the subtropics, extending to the tropics.

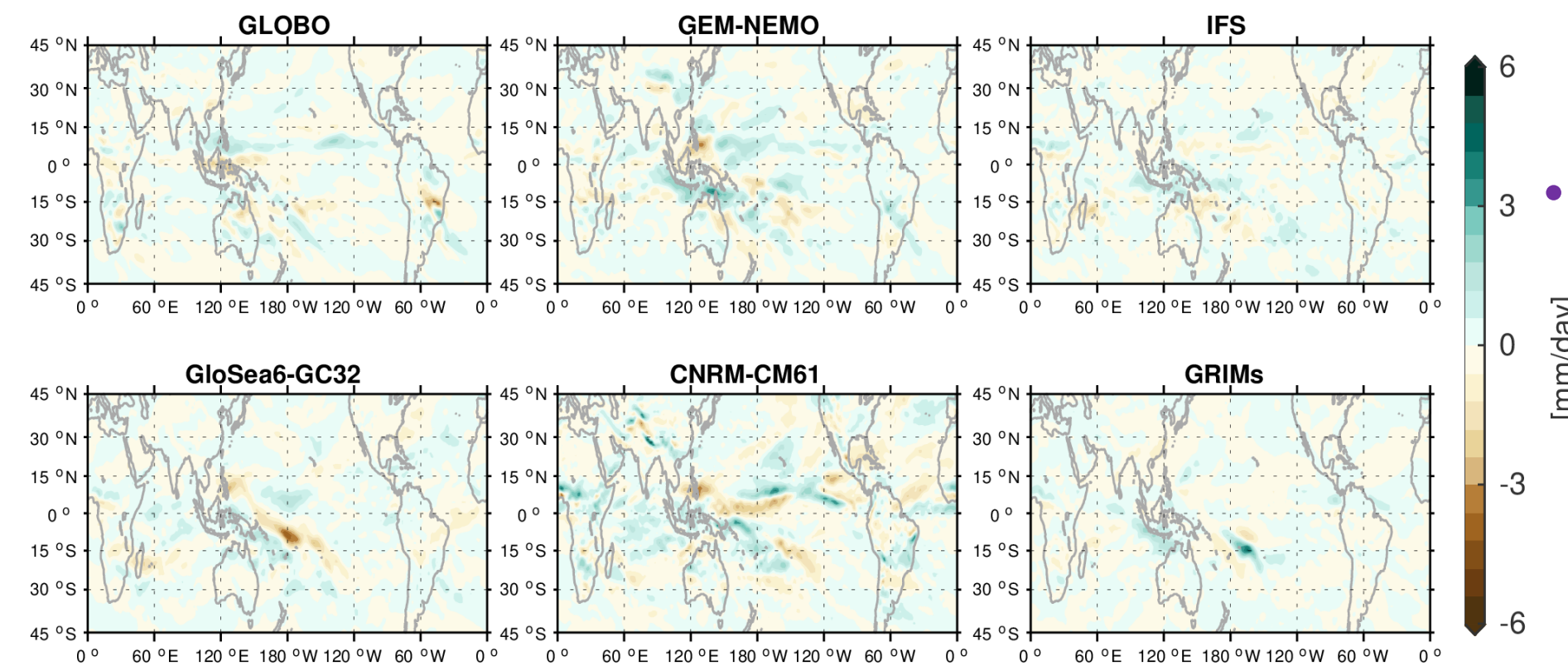
$$-\left[u_d \frac{dq}{dx} + v_d \frac{dq}{dy} \right] (400-1000 \text{ hPa})$$



- Divergent part of advection is less significant in the subtropics and tropics.

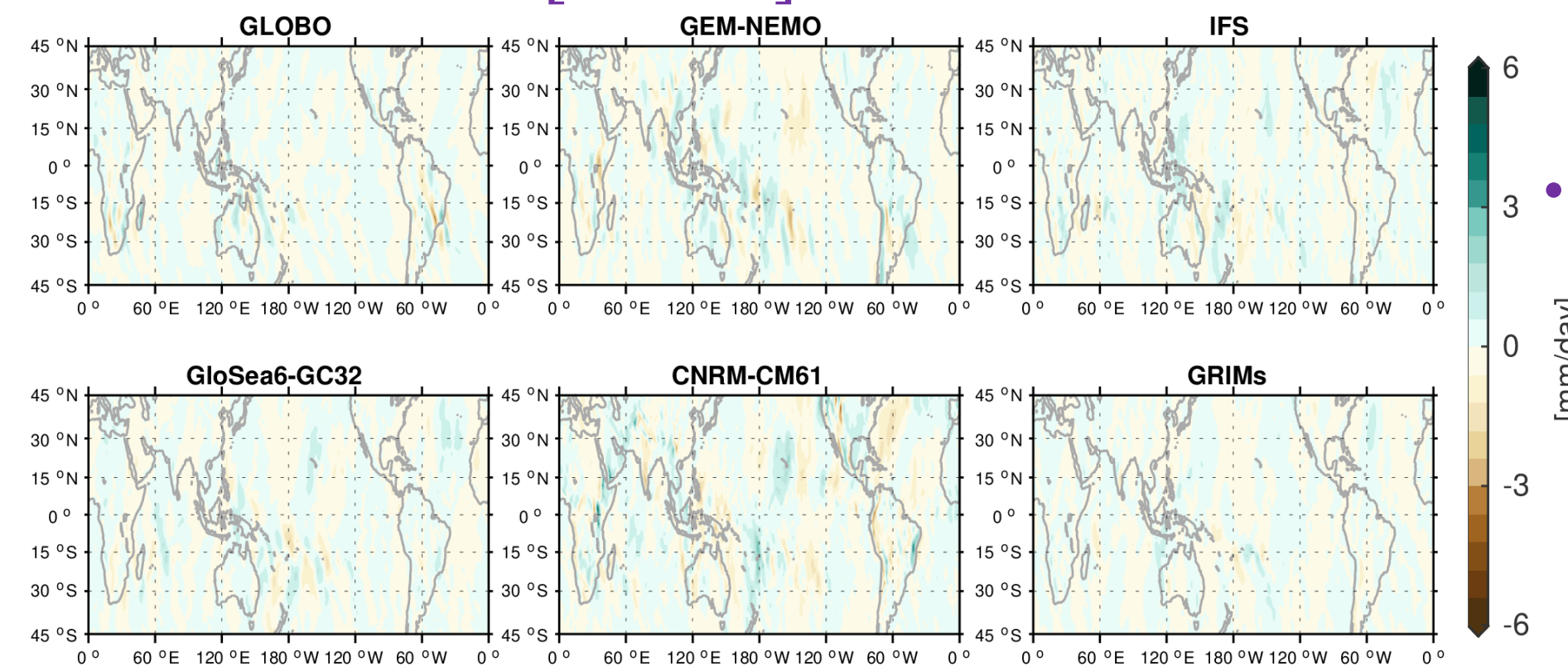
6. Divergence impact

$$-\left[-q \frac{\partial \omega_\theta}{\partial p} \right] (400-1000 \text{ hPa})$$



- Divergence due to meridional circulation results in significant response of rainfall in the tropics.

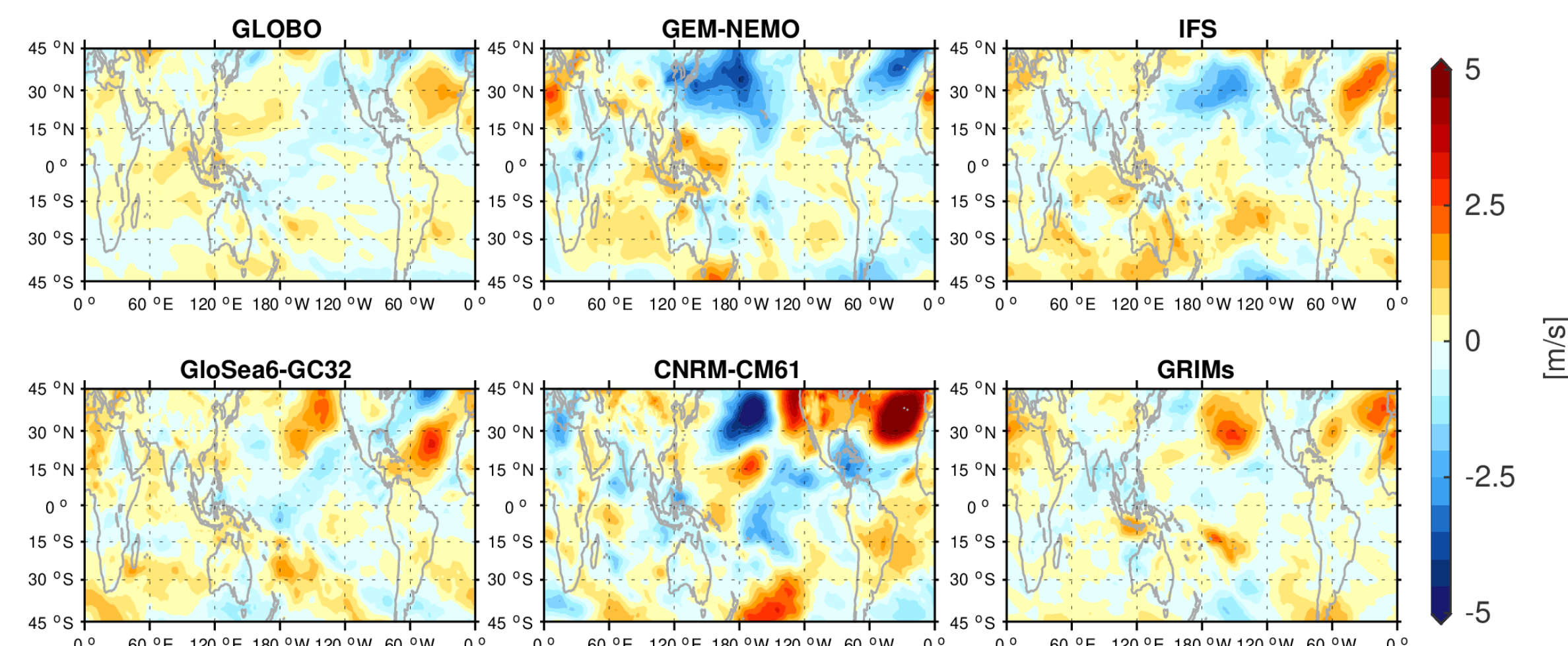
$$-\left[-q \frac{\partial \omega_\lambda}{\partial p} \right] (400-1000 \text{ hPa})$$



- Divergence due to zonal circulation does not make a big difference in the rainfall.

7. Impact of jet shift

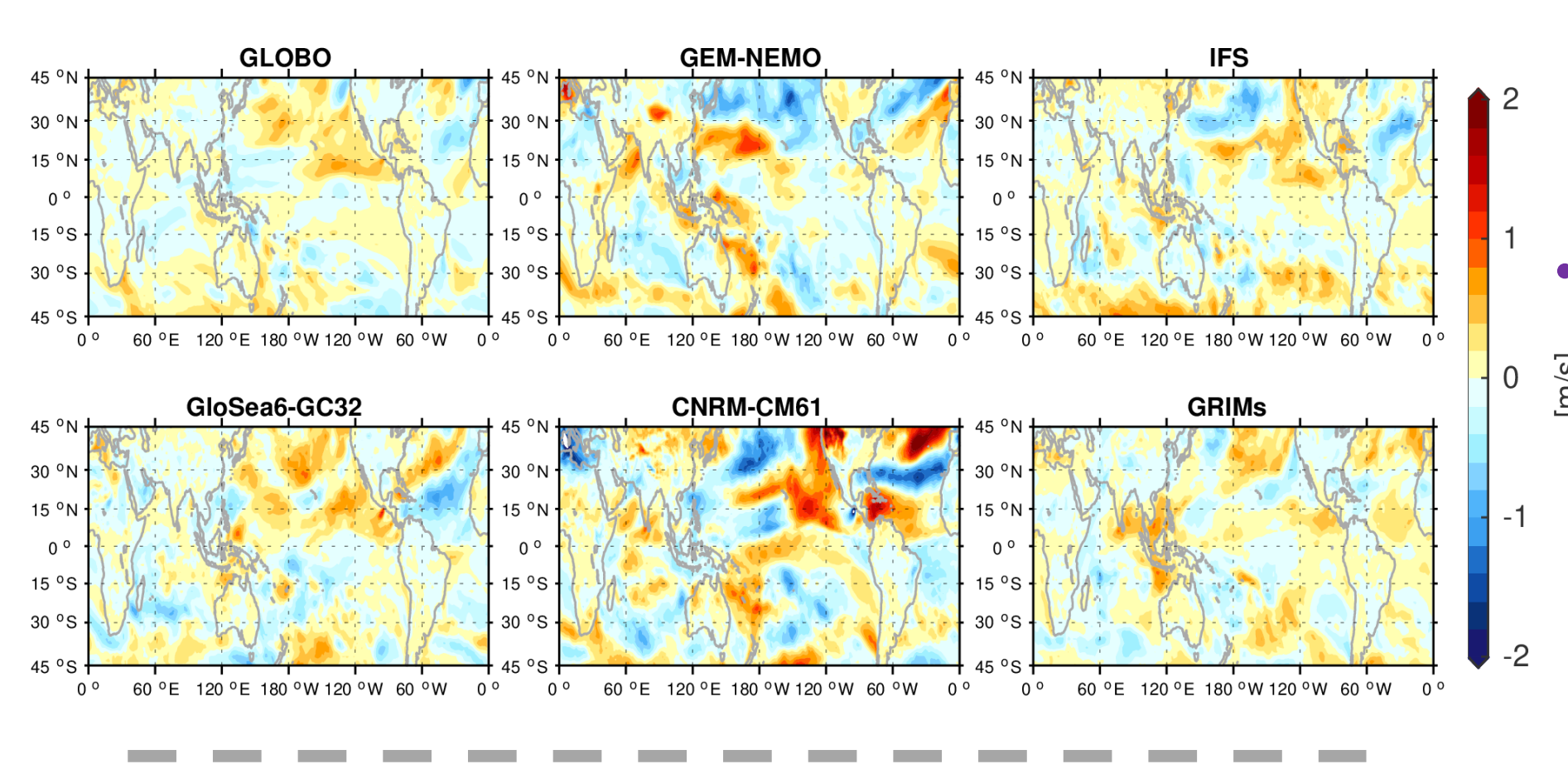
Zonal wind at 850 hPa



- SSW results in the jet shift in the upper troposphere, and changes the zonal wind fields in the lower troposphere with different pattern across models.

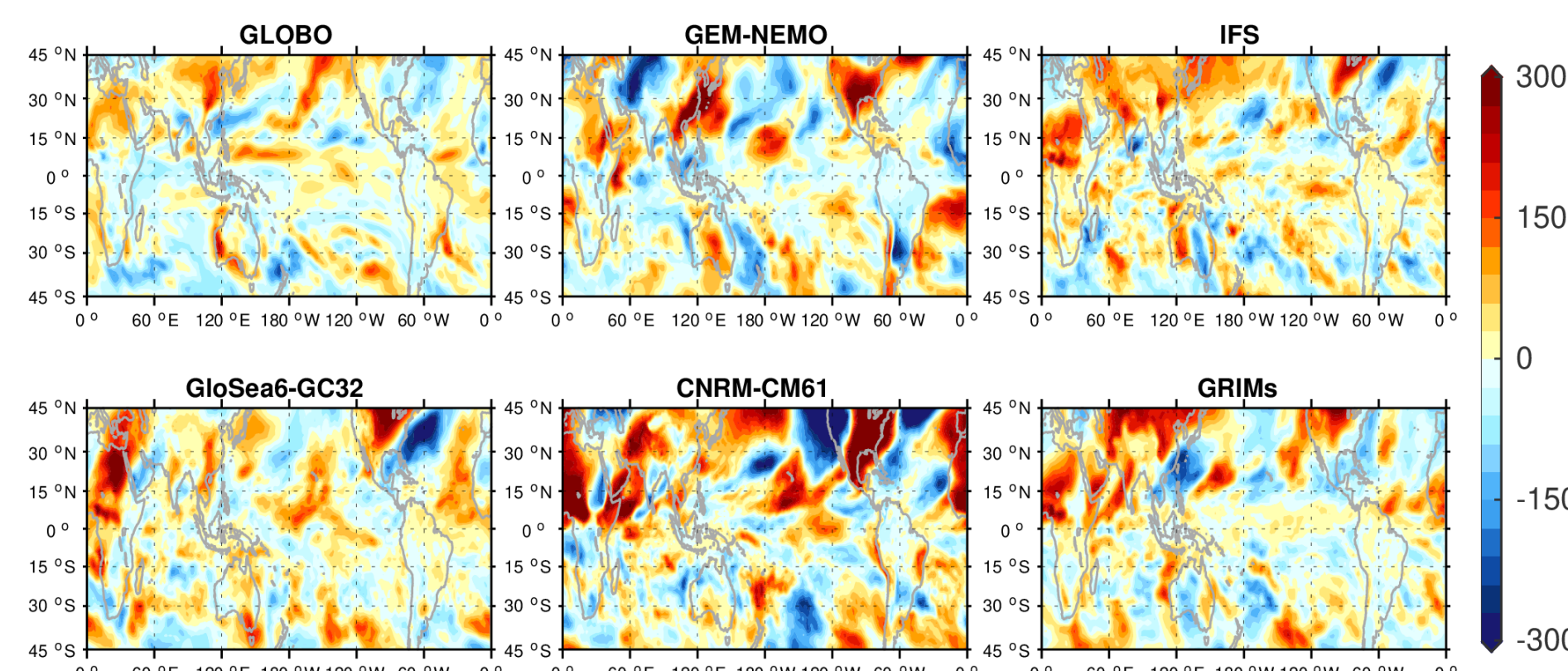
8. Surface signal

Absolute surface wind at 10 m



- Strengthened trade wind results in more evaporation and subsequently more tropical precipitation.

MSE at 850 hPa



- MSE shows strong response but differs widely across models in the lower troposphere.

9. Key conclusions

- SSW affects tropical precipitation, but with different pattern across models.
- Divergence due to meridional circulation plays a great role in the tropical precipitation response to SSW through a "bottom-up" pathway wherein strengthened trade winds result in more evaporation.
- Rotational part of advection also make a big difference in the tropical precipitation response to SSW through a "up-bottom" pathway.