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Rossby and inertio-gravity wave response to tropical heating perturbations resembling MJO

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Madden-Julian oscillation (MJO) is a moist convectively coupled wave system whose envelope propagates eastward from the Indo-Pacific warm pool towards the date line with a period of 30-90 days. One cycle of MJO is traditionally divided into eight phases. Heating perturbations associated with some of this phases resemble heating dipole, and in some phases they are more similar to a heating monopole. The atmospheric response to such heating perturbations consist of Kelvin and equatorial Rossby waves in tropics and Rossby wave train in extratropics. Our research quantifies the role of the Rossby and inertio-gravity wave variance associated with the MJO by using a 3D decomposition of global circulation developed in response to stationary monopole and dipole MJO-like heating anomalies over Indian Ocean and Indonesia.

Two ensembles of 30 model integrations of ICTP AGCM (SPEEDY) model were performed, one with monopole and one with dipole heating perturbations over Indian Ocean and Indonesia during boreal winter. Results from an unperturbed control run were subtracted from the ensemble members and average response was analyzed. Simulated wind and geopotential fields were projected on three-dimensional orthogonal normal-mode functions in order to split the average response to the quasi-geostrophic (Rossby) motions and the inertio-gravity (IG) motions. The projection allows us to distinguish between the response amplitude in particular modes, such as the Kelvin and Rossby n=1 mode.

Dipole heating anomaly produces a stronger response than monopole perturbation, especially in extratropics, where the amplitude of both geopotential height and wind response is up to twice greater in response to dipole than to monopole perturbation. In both cases there is a significant component of the reponse in IG modes, up to about 30%.
In the tropics, the amplitude of the Rossby and IG response is comparable. The tropical response is the strongest in the Rossby n=1 and Kelvin modes, the most energetic balanced and IG modes. The Kelvin mode in upper troposphere accounts for more than 80 % of the IG geopotential height response and more than 60 % of the IG zonal wind response in regions where the response is the strongest. The equatorial Rossby n=1 mode accounts for more than half of the balanced tropical response.