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The dynamical composition of the Madden-Julian oscillation

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The Madden-Julian oscillation (MJO) is a major intraseasonal tropical atmospheric mode which modulates the precipitation in the Tropical Indian and Pacific oceans. It is a large atmospheric convective system, dominated the zonal wave number one scale, that moves eastward from the east coast of Africa to eastern Pacific in a time scale of 30-70 days.

The MJO can have impact in global weather but is yet poorly simulated in most atmospheric circulation models. Therefore, it is important to understand the convective-dynamical nature of the MJO to understand the reasons for its poor representation in models.

Here we present a diagnostic study of the MJO by decomposing the circulation associated with a multivariate MJO index onto 3-Dimensional inertio-gravitic and Rossby modes, based on the ERA-I reanalysis. Results show that the main dynamical features of MJO are represented by a combination of Kelvin and the first ($l_r = 1$) equatorial Rossby modes with zonal wavenumbers 1 to 4. The vertical structures of the waves correspond to a first baroclinic mode in the troposphere. Moreover, a space-time spectral analysis confirmed the existence of an eastward moving MJO signal in the equatorial Rossby modes.

Nonlinear interactions between the westward moving equatorial Rossby waves and eastward moving Kelvin waves may be the cause for the slow eastward progression of the MJO.