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The impact of cloud radiative heating on the Madden-Julian Oscillation

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We explore how atmospheric radiative heating, due to the presence of clouds, influences the Madden-Julian-Oscillation (MJO) as simulated by four comprehensive atmosphere general circulation models. For that reason we compare simulations in which clouds are transparent to electromagnetic radiation ("clouds-off") with control simulations in which clouds are allowed to interact with radiation ("clouds-on"). Making clouds transparent to radiation leads to robust changes of the mean state and the MJO: tropical precipitation in the Indian ocean is displaced off the equator, leading to two symmetric bands of precipitation in this basin. In addition, in clouds-off, the MJO weakens compared to clouds-on.

Within the MJO cloud radiative effects lead to stronger convective heating profiles. Heating from non-radiative processes is dominated by the parameterized convection, but large-scale heating associated with cloud microphysical processes acting on the grid-scale, modifies the shape of the profile, leading to a top-heaviness when cloud radiative effects are accounted for. The radiative heating due to clouds slows down the phase speed of the MJO. Averaged over the entire MJO life-cycle the column-integrated radiative heating due to clouds lags the vertically integrated moist static energy by 40° to 60° of longitude (equivalently 7 to 10 days assuming a period of 60 days).

All four models studied reveal more pronounced Kelvin waves when clouds are transparent to radiation (clouds-off) suggesting that cloud-radiative effects on large-scale heating profiles acts to damp smaller scale, or faster, Convectively Coupled Equatorial Waves and amplify MJO-like disturbances.