Controls on the vertical profile of moistening as a function of precipitation rate
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Introduction
The relationship between moisture tendency and precipitation rate has been identified as a process diagnostic relevant for simulation of the MJO. AGCMs with moistening that progressively deepens with precipitation rate demonstrate greater MJO skill (Klingaman et al., 2015). However, the processes that give rise to this net moistening pattern are poorly understood. Here we use the NASA Global Earth Observing System (GEOS) AGCM to examine the moisture budget in precipitation-space and understand its sensitivity to changes in model parameters. Comparison is made with the MERRA-2 and ERA-5 reanalyses to place model results in context.

Moistening profiles from reanalysis
Moistening patterns using 3-hourly ~0.5 degree MERRA-2 reanalysis, over Indian Ocean (10S-10N, 60E-160E) for DJF, except as otherwise noted.

The pattern varies little with season (JJA vs. DJF), tropical location (Pacific vs. Indian Ocean), or number of years included. The MERRA-2 analysis tendency is only weakly correlated with precipitation.

Moistening patterns using ERA-5 reanalysis. Pattern is insensitive to horizontal resolution (0.25° vs 1.0°) but degrades when using daily vs. 3-hourly input.

Effect of convective entrainment on moisture tendency
The difference (EXP-CTRL) in moistening from increased convective entrainment is shown below.

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Using a “replay” with constrained T, Q, U, V
Internal variability in AMIP simulations requires long integrations to extract a stable tendency difference. Comparable differences are seen in “replay” mode, with GEOS constrained by the MERRA-2 analysis, with a single month of run time.

Summary
• Moistening structure is sensitive to temporal, but not spatial, resolution of input data. It is insensitive to season and tropical longitude band, but varies between reanalyses.
• Increasing entrainment in parameterized convection – known to increase MJO variability in many models – enhances the pattern of progressive moistening in both free-running and “replay” experiments.
• This raises questions about the mechanism by which convective entrainment influences model MJO skill.
• The impacts of parameter changes on moistening structure can be difficult to predict, with large indirect effects filtered through secondary terms.