Introduction

Cold pools and sub-grid organization offer a potential solution to the "entrainment dilemma," an apparent tradeoff between realistic convective variability and biases in the mean state. Here we implement a cold pool (CP) parameterization based on Del Genio, et al. (2015) in the NASA GEOS AGCM run with Grell-Freitas convection. We examine two potential CP effects on deep convection: (1) Entrainment is made a decreasing function of cold pool area, and (2) source parcel moist static energy is drawn from the non-cold pool environment.

Cold pool parameterization

Downdrafts are generated by congestus and deep plumes from the Grell-Freitas convection scheme. New cold pools are initiated when downdraft $\theta_d$ is at least 0.5 K colder than the environment. Cold pool area fraction, $a_{cp}$, $\theta_{cp}$, and $a_{cp}$ evolve prognostically based on additional downdraft input and a decay timescale of 4 hours.

$$\frac{\partial a_{cp}}{\partial t} = m_a g \frac{\Delta p}{\Delta \theta} - a_{cp} \frac{\partial a_{cp}}{\partial \tau}$$

where $\tau = 4$ hr

Environmental properties are diagnosed,

$$\theta_{env} = \frac{\theta - a_{cp} \theta_d}{1 - a_{cp}}$$

$\theta'$ is the convective source air perturbation (similarly for $q'$). In "ENT" experiments, deep convective entrainment is scaled based on cold pool area.

Diurnal cycle

Diurnal cycle averaged 30S-30N over land and ocean.

A high entrainment factor reduces diurnal cycle magnitude.

Both approaches delay (~1 hour) the peak precipitation.

Cold pool area and source air MSE perturbation peak in early evening, following maximum precipitation.

Process metrics

(top) PDFs of precip, precipitable water, and their relationship. (bot) Profiles of humidity tendency binned by precip rate, for three cases.

Summary

- Source parcel MSE perturbation and variable entrainment linked to cold pool area both produce a modest (~1 hr) delay in diurnal peak precipitation.
- Combined effects have a weak impact on MJO statistics.
- Variable entrainment shifts PW distribution to drier values, weaker precipitation, and strengthens relationship between precipitation rate and moisture tendency.
- MSE shifts distributions to wetter PW, stronger precip.

References