1. Introduction and Motivation

- Organized convection (e.g., mesoscale convective systems [MCSs]) is typically associated with heavy rainfall and thick anvils (ice clouds). While occurring infrequently (~5% of the time), organized convection may contribute up to ~50% of Earth’s rainfall.

- Organized convection is important for vertical momentum transports relevant to MJO dynamics, for instance; associated anvils may be important for deep convective cloud feedbacks as well.

- Most global climate models (GCMs) do not simulate organized convection. Since many GCMs will remain at the ~50-200 km resolution for CMIP6, substantial effort must be devoted toward parameterizing organized convection (which is our goal for the GISS GCM).

- Organized convection is often associated with diabatic heating profiles that peak at higher altitudes (initially due to convectively-detained ice content increasing by deposition in a moist environment). The House (1988) schematic below notes a few important organized convection processes (region where detrained ice occurs: boxed in red).

- In this paper, we discuss ways to delineate unorganized from organized convection using GCMs.

2. Delineating Organized from Unorganized Convection Using GPM

- GPM samples systems of varying sizes (see figure to left, and at varying lifecycle stages. From March – December 2014, ~30K systems were observed. We analyze convective systems only if GPM system coverage exceeds 25% of the system spatial extent (as identified by IR). We also analyze system duration and lifecycle stage to determine to what extent organization is tied to duration or stage.

- GCMs must make (and/or sustain) the right heating profile at the right time, which requires observational knowledge of such distinctions. What is the best way to sort convective states? Below, we show that more than one sorting approach provides useful information on convection.

- Using the CPC Globally Merged IR product (top panel above), we identify MCSs (center panel above; using the Floiteau and Roca [2013] algorithm) and map GPM data products (e.g. Spectral Latent Heating [SLH] product, DPR rainfall, convective/stratiform) to MCS tracks. Example GPM orbits for 2014 April 06 are shown in the bottom panel; orbital swaths co-located (in time) with the MCSs identified at 21:45 UTC are outlined in the boxed regions of the above figure for visual reference.

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- In this paper, we discuss ways to delineate unorganized from organized convection using GCMs. The new convective ice parameterization (that can yield the detrained ice that feeds an anvil) is parameterized.

3. Recent GCM Parameterization Development

- Detraining of ice in our improved convective ice parameterization is informed by a number of NASA field experiments (Elsaesser et al., 2016, J. Climate, in press). We use data from in-situ flights associated with deep anvil clouds (e.g. black segments to right). We assume gamma functions for ice particle size distributions (PSDs), and allow the intercept/shape parameters to vary as a function of temperature (T) and WEC (below).

- Our new ice mass distributions agree with observations better than our old fits (left). While particles are smaller, the new fit is not as sensitive to wind speed. Radiative feedback is incorporated. Ice particles detraining per hour run speeds are within a small interval of the parameterized convective updraft velocity. This detrained ice can serve to initiate the stratiform anvil cloud.

3b. Impacts on Clouds and Surface Rainfall

- Even before we parameterize organized convection, incorporation of the new convective ice parameterization into the GISS GCM leads to model improvement (e.g., a too-high MWC climatology in the CMPS GISS GCM is now substantially reduced, with closer agreement between GCM cloud profiles and satellite retrievals noted for a number of environmental states). Stratiform rainfall decreases (global: 1.72 to 1.53 mm day⁻¹) and convective rain slightly increases (on average) as IWP decreases. The percent of stratiform rainfall drops from 40% to 35% over the 20N-20S domain (Schumacher and Houze [2003] estimated an average of 40% using TRMM). OLR and absorbed shortwave radiation (Abs SW) changes are more weakly correlated with changes in WPC. Despite decreases in WPC, the highest-WPC clouds (which is the cloud type that the convective ice parameterization mostly impacts) remain optically thick, and thus, there is some reason to expect a more muted change in radiation fields. However, the impacts on radiation require further analysis to be fully understood.

4. Conclusions/Future Work

- Our GCM convective ice parameterization will serve as a starting point for simulating stratiform anvils (which is an important component of organized convection). The simulation of organized convection (especially the anvils) requires information on temperature/moisture structures, detrained condensate, PSIs, particle fall speeds and diabatic heating profiles. In addition to using GPM diabatic heating as benchmarks for heating profiles, our future work will entail using environment information (T / qv) from satellite sounders, ice/liquid condensate retrievals from GPM DPR/GMI (and constellation members), vertical wind shear (likely from re-analysis products), and convection/environment characteristics from the GPM Precipitation Feature (PF) database. The overall goal is to have a parameterization that not only makes the right convection in the appropriate environment, but responds in a physically plausible way to a climate change so that the complete deep convective contribution to cloud feedback is understood.