including a cold pool representation in a convection parameterization and simulating its impacts on the spatial and temporal variability of the precipitation in the NASA GEOS GCM.

Saulo R. Freitas1,2, G. A. Grell3, N. P. Arnould2, and W. M. Putman2
(1) Universities Space Research Association, Columbia, MD, USA. (2) Global Modeling and Assimilation Office, NASA/GSFC, Greenbelt, MD, USA. (3) National Oceanic and Atmospheric Administration, Boulder, CO, USA.

Abstract
We developed and implemented a simple representation of a cold pool in the Grell-Freitas (GF) convection parameterization. The cold pool parameterization is based on the observation that convective-scale downdrafts produce a local ‘deficit’ of the moist static energy (MSE). This information is advected and becoming downwind available to trigger and intensify new convection. The cold pool is dissipated by a simple exponential decay using a lifetime of a few hours, or by interacting with the underneath surface by exchanging latent and sensible heat fluxes. Preliminary results show some improvement of the simulation of the diurnal cycle of the precipitation over the land, mainly during the nighttime.

Brief Description of the GF Convection Parameterization
The GF scheme is based on the mass flux approach and the main features are:
• scale awareness through Arakawa et al. (2011) approach,
• aerosol dependence through auto-conversion and evaporation formulations depending on the environmental cloud concentration nuclei.
• A tri-modal formulation, which allows up to three plumes representing the main convective modes existing in a tropical environment (Johnson et al., 1999): shallow, congestus, and deep plumes.
• A set of closures to determine the mass flux at the cloud base to adequately account for the diverse regimes of convection in a given grid column.
• Transport of momentum, tracers, water, and moist static energy. Includes also wet removal of gases and aerosols particles.
• Application of probability density functions to emulate the vertical mass flux profiles, providing an effective method to set the vertical distribution of heat and mass, which is very useful for fine-tuning the model.
• A new closure for non-equilibrium convection adapted from Bechtold et al. (2014). Here this closure is called ‘diurnal cycle’ closure.

The Cold Pool Parameterization

Definition of Buoyancy-Excess (B_e)
\[ B_e = H_d - H_i \]
where
\[ H_d \] downdraft MSE
\[ H_i \] environment MSE

Prognostic Equation
\[ \frac{\partial B_e}{\partial t} = \text{adv}(B_e) + \text{diff}(B_e) + S + R \]

Source term \( S = \frac{g \delta_i \rho}{\Delta p} \)
\( \delta_i \) is the downdraft detrainment mass flux

Sink term \( R = \frac{B_e}{\tau} \)
\( \tau \) is the cold pool lifetime – 10⁵ - 10⁶ seconds

adv and diff are the grid-scale advection and diffusion operators.

Preliminary Results
The GF scheme with the cold pool parameterization was tested using the NASA GEOS-5 GCM. The model was configured with c360 spatial resolution (~25km) for and ran re-forecasts for December 2017. Each forecast comprised 120 h time integration, with output every 1 h. Model configuration included the non-hydrostatic dynamical core FV3 and the single-moment version of the microphysics scheme. The cold pool lifetime used in this experiment was 6 hours.

Preliminary Results (cont.)
In simulations presented here, the buoyancy-excess (see figure 2) is used in the boundary condition for the MSE of the updraft in the downwind direction, serving as an extra source for the convective air parcels.
The DEC 2017 diurnal cycle of the precipitation averaged over the global domain and land areas only are shown in Figure 3. The curves represent the TRMM precipitation, GEOS-GF without the diurnal cycle closure (DC, green), with the DC (red) and the DC with the cold pool parameterization (blue). With the cold pool scheme, the parameterized convection is kept more active ahead of the afternoon peak (see blue curves).

E-mail: saulo.r.freitas@nasa.gov  |  Web: gmao.gsfc.nasa.gov