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Stochastic plume ensembles for an unified shallow-deep mass flux cumulus parameterization in the Community Earth System Model (CESM)

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Many biases in global climate models (GCMs) have been associated with the poor representation of unresolved variability due to organised convection in the tropics by the underlying cumulus parameterizations (CP). Many researchers have suggested that the quasi-equilibrium assumption (QEA) on which these CP's are based is to blame. This is even more problematic with the recent and future increases in grid resolutions as the cloud large ensemble requirement for QEA breaks down. The stochastic multi-cloud model (SMCM) of Khouider et al. 2010 was proposed as a cheap alternative of overcoming this QEA dilemma by emulating the variability of the three cloud types which characterize tropical convection via a Markov jump birth-death process. The SMCM has proven to be very successful in terms of the simulation of the main modes of tropical variability when used as a simple alternative CP in a GCM.
Here, we propose to incorporate the SMCM directly into the Zhang-McFarlane scheme (ZMS; Zhang and McFarlane 1995) to break the QEA dead end by using instead a stochastic plume ensemble and generalise the SMCM framework to cumulus schemes. The new stochastic ZMS (SZMS) uses a random number of plumes that are launched for each one of the three cloud types, shallow, congestus and deep, and that detrain at random levels, according to the SMCM. The new approach somehow combines the idea of Cohen and Craig (2006) of assuming a Poisson process for the number of plumes and that of Gentine et al. (2013) of prescribing a distribution of plume detrainment levels.

Here we shall show the results of our experiment, for the single column version of the Community Earth System Model.

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