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Effects of deep convective entrainment on GFS hindcasts of the south Asian monsoon

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The biases associated with tropical precipitation in Numerical Weather Prediction models are strongly related to parameterization of deep moist convection. Some modelling studies have reported reduced tropical precipitation biases and improved tropical variability using an entrainment formulation dependent on free tropospheric humidity. A convective parameterization scheme with entrainment based on free tropospheric relative humidity and height of parcel from cloud base was implemented in National Center for Environmental Prediction Global Forecast System (GFS), and was only shown to reduce grid point storms over the continental United States. The goal of this study is (1) to understand tropical precipitation biases in GFS, (2) explore the sensitivity of tropical precipitation forecasts in GFS to this numerical formulation of entrainment and hence inform the efforts to improve convective parameterization.

Using 20-day hindcasts initialized day from mid-may to mid-october of 2008, sensitivity experiments were performed over a range of two entrainment parameters, relative humidity dependent part and standard (height dependent) part. The impact of relative humidity part is weak in its current implementation in GFS, the impact was similar to increasing or decreasing entrainment weakly rather than anticipated dynamical feedbacks with free tropospheric humidity. This was traced to its weak contribution to total entrainment of a convecting parcel. The impact of increasing/decreasing entrainment via height dependent term has a one dimensional thermodynamic response of decreasing/increasing deep convection during the first days of forecast and a complex dynamical response with increasing forecast lead-time. The nature of this impact pattern is presented in detail, with ITCZ and monsoon fingerprint patterns distinct, with possible reasons. Unfortunately, the impact of these feedbacks to the model forecast skill over midlatitudes is weak.