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A stochastic convective approach to account for model uncertainty due to unresolved humidity variability

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Forecast uncertainty can result from the neglect of humidity variability on spatial scales not resolved by forecast models. To account for this, a stochastic convective scheme for the European Centre for Medium-Range Weather Forecasts (ECMWF) ensemble prediction system is presented that uses the subgrid humidity distributions provided by the cloud scheme. Each member of a forecast ensemble randomly samples this distribution to perturb the convective parcel's initial humidity and/or the humidity of the air entrained during ascent. Accounting for humidity variability with the new scheme has a smaller impact on tropical ensemble spread in the short range compared to the ECMWF operational scheme that represents uncertainty because of parameterization error. Combining the two schemes to account for both parameterization error and subgrid humidity variability simultaneously generally improves the skill of the operational system for most variables in the short to medium range in midlatitudes, while results in the tropics are mixed, with a notable deterioration in medium-range probabilistic skill for temperature and zonal wind. This deterioration is a consequence of the methodology employed. Since the convective scheme is highly nonlinear, providing zero-mean humidity perturbations to the scheme's input profiles does not lead to zero-mean perturbations to the output tendencies. For some parameters, this results in an increased bias of the ensemble mean and a deterioration in probabilistic skill. As future convective schemes are optimized to maximize deterministic forecast skill, the methodology will require modification to ensure zero-mean convective output perturbations.