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The effect of stochastically perturbed parametrization tendencies on rapidly ascending air streams

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Most of the precipitation formation in extratropical cyclones occurs in the warm sector along an elongated air stream ahead of the cold front - the so-called warm conveyor belt (WCB). The WCB ascends slantwise from the planetary boundary layer into the upper troposphere, where its outflow interacts with the upper-level jet and modifies the Rossby wave structure. The ascent of WCBs is strongly driven by cloud-condensational processes, which are parametrized in numerical weather prediction models, and is therefore associated with forecast uncertainty. In the European Centre for Medium-Range Weather Forecasts (ECMWF) ensemble prediction system (EPS), model uncertainty related to parametrizations is represented by the so-called stochastically perturbed parametrization tendencies (SPPT)-scheme, which introduces multiplicative noise to the physics tendencies.

In this study, we investigate the systematic effect of the SPPT-scheme on rapidly ascending air streams in the extratropics (i.e. WCBs) and on tropical convection by conducting sensitivity experiments with the ECMWF EPS based on the Integrated Forecasting System (IFS) model. The comparison of an experiment with an operational setup (initial condition and model physics perturbations) to one where model physics perturbations are switched off demonstrates that the SPPT-scheme systematically influences the activity of WCBs and tropical convection.

Globally, rapidly ascending air streams, which are detected by applying trajectory analysis in each ensemble member, are enhanced by about 37% when SPPT is activated. Also the dynamical and physical characteristics of the trajectories are systematically modified: the latent heat release and the ascent speed are increased, while the outflow latitude is decreased. This systematic modulation is stronger in the tropics and weaker in the extratropics. A detailed investigation of vertical velocities indicates that SPPT increases the frequency of relatively strong upward motion related to WCBs and tropical convection, while slower upward motion is suppressed compared to the unperturbed experiment. Despite the symmetric, zero-mean nature of the perturbations, the response of rapidly ascending air streams to the SPPT-scheme is systematically

unidirectional, pointing towards non-linearities in the underlying processes.

This study shows that process-oriented diagnostics of weather systems help to advance the understanding of upscale impacts of the ensemble configuration on the representation of the large-scale circulation in numerical models.