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Diagnosing the Systematic Effects of Parametrized Physical Processes in a Numerical Weather Prediction Model

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Numerical models of the atmosphere combine a dynamical core, which approximates solutions to the adiabatic and frictionless governing equations, with the tendencies arising from the parametrization of physical processes. Tracers of potential vorticity (PV) can be used to accumulate the tendencies of parametrized physical processes and diagnose their impacts on the large-scale dynamics. This is due to two key properties of PV, conservation following an air mass and invertibility which relates the PV distribution to the balanced dynamics of the atmosphere.

Applying the PV tracers to many short forecasts allows for a systematic investigation of the behaviour of parametrized physical processes. The forecasts are 2.5 day lead time forecasts run using the Met Office Unified Model (MetUM) initialised at 0Z for each day in November/December/January 2013/14. The analysis of the PV tracers has been focussed on regions where diabatic processes can be important (tropopause ridges and troughs, frontal regions and the boundary layer top).

The tropopause can be described as a surface of constant PV with a sharp PV gradient. Previous work using the PV tracers in individual case studies has shown that parametrized physical processes act to enhance the tropopause PV contrast which can affect the Rossby wave phase speed. The short forecasts show results consistent with a systematic enhancement of tropopause PV contrast by diabatic processes and show systematically different behaviour between ridges and troughs. The implication of this work is that a failure to correctly represent the effects of diabatic processes on the tropopause in models can lead to poor Rossby wave evolution and potentially downstream forecast busts.