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How to make changes in hydrometeors at the observation location - adjoints, incrementing operators and ensemble correlations

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The quality of a numerical weather prediction (NWP) system depends on the reliability of its forecasts in both its deterministic and probabilistic configurations. Forecast skill then is affected by the accuracy of the NWP model and its physical parametrizations, as well as by initial condition errors, which include the contributions from observation errors, both random and systematic. It follows that one of the avenues to improve the NWP scores is to assimilate more observational information, particularly on water in its different phases due to its high spatial variability and relatively high forecast uncertainty.

This is why all major NWP centres are currently assimilating satellite microwave radiances in all-sky conditions and have plans to extend their all-sky assimilation system to infrared radiances. However, a critical condition to benefit from observational information is to be able to estimate increments in all relevant cloud and precipitation forecast fields. In a hybrid variational data assimilation system, these updated fields need to be given as input to observation operators as well as to tangent linear (or perturbed forecast) and adjoint models. This can be achieved using one or more cloud control variables as well as a complete description of the forecast fields as part of the forecast ensemble used to describe flow-dependent forecast errors. In alternative to cloud control variables it is possible to make use of physical-statistical relationships to distribute increments to a single control variable. Finally, water increments can arise from moist physics parametrizations, both in their nonlinear and linearized configurations.

In this talk an outline of the design of the moist control variables, moisture incrementing operator and tangent linear physics that are currently operational at the Met Office and other operational centres will be provided.

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