Contribution ID: **79** Type: **Poster presentation**

All-sky microwave radiances assimilated with an ensemble Kalman filter

The ability of variational data assimilation to deal with moderate non-linearity and non-Gaussianity is thought to have underpinned recent success in assimilating cloud and precipitation-affected satellite observations using the all-sky approach. A pure ensemble assimilation framework relies on linear and Gaussian assumptions, so its ability to handle all-sky observations is less clear. This work evaluates all-sky assimilation in a 50-member global ensemble Kalman filter (EnKF) system of near operational quality, derived from the four-dimensional variational (4D-Var) system used at the European Centre for Medium-range Weather Forecasts (ECMWF). The assimilation of 8 microwave instruments in all-sky conditions has similar benefit in the 4D-Var and EnKF, generating similar increments in winds, temperature and humidity, and giving around a 2% to 4% improvement in medium-range forecast scores. Ensemble correlations show that information from the all-sky observations in water vapour channels is on smaller vertical and horizontal scales than clear-sky temperature sounding channels, and there is stronger sensitivity to wind. This boosts the evidence that both 4D-Var and ensemble data assimilation can make good use of all-sky observations, including the extraction of wind information. Two new all-sky observation error models were investigated to replace the standard symmetric approach. One model inflates errors as a multiple of the ensemble nonlinearity, and the most successful inflates as a multiple of the ensemble spread. However, further testing is needed to confirm the best approach. In absolute terms the EnKF forecast performance in the troposphere was still worse than the 4D-Var, though the gap was reduced by going from 50 to 100 ensemble members. EnKF errors are however much larger in the stratosphere, where there is a need to address excessive gravity-wave increments that are not connected with all-sky assimilation.

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Session Classification: Poster session with self-serve tea and coffee

Track Classification: 4th workshop on assimilating satellite cloud and precipitation observations for NWP