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Is there a limit to forecast accuracy? The impact of temporal sampling

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At present synoptic observations tend to be treated as if they represent an "error-free" truth, though it is generally understood this is not the case. As a result, when these observations are used to verify Numerical Weather Prediction (NWP) forecasts (raw or post-processed), the total error is wholly attributed to the forecast. This is particularly true for site-specific temperature forecasts, where typical forecast errors are now 0.1K for early lead times. The instrument error for temperature is $\sim$0.1K. It is conceivable that the observation uncertainty is comparable in magnitude to the forecast error, and this aspect is currently ignored.

In the United Kingdom (UK) one-minute resolution synoptic observations sampled every minute are available across the observing network and this provides an opportunity for considering the within-hour variability and how this creates uncertainty when compared to the hourly values used for verification. Several locations around the UK are analysed to consider the impact of location and season.

Results considering post-processed temperature forecasts suggest that at t+6h 25% of the forecast mean absolute error (MAE) can be attributed to temporal sampling uncertainty with a 10-minute offset. As synoptic observations are typically taken 10 minutes before the hour, this offset is often inadvertently introduced if NWP output is taken as instantaneous values on the hour, which is standard practice for many. Percentage errors for raw NWP temperature forecasts are larger, at 30%. Temporal sampling uncertainty depends on location and time-of-year, with higher values in the warmer seasons and inland sites.