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Characterizing Radar Raingauge Errors for NWP Assimilation

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The statistical characterisation of errors in quantitative precipitation estimates (QPE) is needed when generating QPE ensembles, combining multiple radars into a single mosaic, and when assimilating QPE into numerical weather prediction (NWP) models.

The first step in the analysis was to characterise the errors at pixel resolution (1 km) as a function of radar specification, geographical location under the radar, and meteorology using data from 18 radars and 1500 rain gauges over a two-year period. The probability distribution of the radar - rain gauge residuals was evaluated and, as expected, the log-Normal distribution was found to fit the data better than the Normal distribution. Therefore the subsequent analysis was performed on the residuals expressed as decibels. The impact of beam width on the estimation errors was evaluated by comparing the errors from a one-degree S band radar (S1) with a two-degree S band radar (S2) for the same location (Brisbane) and time period. The standard deviation of the errors was found to increase by 0.2 dB per km for the S2 radar while the standard deviation for the S1 radar was constant out to the maximum range of 150 km. When data from all the S1 radars over the two years were pooled and compared with the S2 radars the standard deviation of the errors for the S1 radars increased by 0.1 dB per km compared with 0.25 dB per km for the S2 radars. The mean of the errors was found to vary significantly with range for all radars with underestimation at close range (< 30 km) and at far range (> 100 km). We think that this points to artefacts in the data due to clutter suppression at close range and over shooting the echo tops at the far range.

The spatial distribution of the errors as a function of the altitude and roughness of the topography was investigated using the data from the S1 and S2 radars in Brisbane, but no relationship was found although there is clearly structure in the field. We also attempted to quantify the difference between summer and winter by comparing all the radar data from January 2011 with that from July 2011, but could not find a significant difference in the variance as a function of range, which we were expecting. One of the reasons for this is the range in the climatology over the radar network which ranges from the sub-tropics to the mid-latitudes, which would mask the increase that we expect for the mid-latitudes.

Assimilating QPE into NWP models requires knowledge of the distribution of the error at scales that are larger than a single pixel. It is evident from our investigations that substantial data sets (many thousands of radar and gauge pairs) are required when evaluating the statistical structure of radar estimation errors and this limits our ability to characterise the errors beyond simple statements of the mean error variance and possibly the linear increase of variance with range. This also implies that the analysis of the scaling behaviour of the errors will not be dependent on location (except perhaps for range from radar) or meteorological situation, but this will be sufficient for assimilation purposes. Variograms of the spatial and temporal errors in the 30-minute accumulations were estimated and used to estimate the errors at scales that are greater than the original resolution.