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An ensemble approach to estimation of uncertainty on satellite-based rainfall estimates

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An attractive feature of satellite-derived rainfall estimates is that they provide full area coverage in situations where ground-based measurements are sparse or non-existent. This is particularly relevant to hydrological or crop-yield modelling where often the requirement is for areal average rainfall for a catchment or growing district at a specified time step. In such applications, it is important to be able to provide an estimate of uncertainty on the averaged rainfall amount because of its contribution to the uncertainty on the downstream model output(e.g. riverflow or crop yield). Estimation of this uncertainty is non-trivial, particularly when the only independent comparison is with sparse gauge data. Careful account must be taken of
• the spatial mismatch between the gauge (point observation) and satellite (pixel average),
• the stochastic uncertainty attributable to the gauge data,
• the separate statistics of the rain/no-rain and rainfall amount distributions (particularly important for small time steps -eg daily or shorter),
• the spatial correlation of rainfall across the area under investigation.

One solution to the estimation of uncertainty is to generate an ensemble of rainfall fields which take account of all the above points. The uncertainty on areal rainfall amount can then be easily obtained from analysis of the distribution of the areal rainfall averages across the ensemble members. While computationally intensive, this approach avoids any assumption of normality which is important in dealing with rainfall at small time steps. The method proposed here makes use of the geostatistical technique of sequential simulation in a two pass process. In the first pass an ensemble of rain/no-rain maps is generated; the second pass fills the rainy area of each rain/no-rain map with an ensemble of rainfall fields. In each pass, the spatial correlation of the rainfall pattern is honoured.

This methodology can also be applied to temporal downscaling of seasonal rainfall forecasts to give an ensemble of daily time series of areal rainfall averages consistent with a regional, seasonal rainfall total forecast and with the climatological statistical descriptors of individual raingauges within the study region.

The method is discussed in the context of satellite-based rainfall estimates used for crop yield forecasting in Africa.