1. The Great Africas Cup: ECMWF vs MOGREPS ensemble precipitation forecasts

Introduction: It has long been known that Numerical Weather Prediction models have difficulties predicting precipitation in tropical regions. This is true of both deterministic models and ensemble systems. Tropical precipitation is showery in nature, dominated by small-scale atmospheric processes, with very large accumulations possible over all time ranges. Global models and especially ensemble models which operate at lower spatial and temporal resolution, cannot directly resolve these processes meaning they must be parameterized. The ensemble forecasting systems attempt to estimate the effects on the forecast of the uncertainty inherent in the parameterization of physical processes and the uncertainty in the initial conditions of the forecast. The latter is especially significant in Africa because of the low density of the surface and upper air observation network.

This project offers the opportunity to compare the quality of ensemble forecasts from the European Center (ECMWF) 51 member ensemble and the UK Met Office 24 member ensemble (MOGREPS) for one rainy season, over the East African area.

Goal: Determine which of the two ensembles is superior for this set of forecasts, and explain how and why using appropriate verification metrics.

Dataset: One rainy season (8.5 months) worth of ensemble forecasts from the ECMWF 51 member ensemble (50 members + control forecast), the ECMWF deterministic forecast, and the UK Met Office MOGREPS 24 member ensemble (23 members + control). Forecasts are for 24h accumulations, 12 UTC to 12 UTC from day 1 to day 5. All ensembles are presented matched to all available precipitation observations from the WMO Global Telecommunications System for stations in 6 Eastern Africa countries: Ethiopia, Burundi, Kenya, Tanzania, Rwanda and Uganda (Although I don't think there is any Ethiopian data in the database). Station lat/long locations are included in case there is an interest in plotting a map of the stations included in the study.

The dataset has been organized with the observation and the forecast verifying at the observation location and time all on a single row. There is a header row containing the definitions of the variables. Each event (row) consists of FCDATE, STEP (projection in hr), LAT, LON, STN_ID, VALID TIME, OBS, ECDETFC, ECCNTRLFC, ECEnsemble forecast M1 to M50, then UKMETCNTRLFC, UKMET Ensemble forecasts M1 to M23.

Analysis suggestions: Since the quality of forecasts depends strongly on the projection, the data have been separated into 5 files, one for each forecast day, in the same format. Verification results can then be obtained separately for each projection and plotted. The observations are from the WMO Global Telecommunications System (GTS); precipitation amounts in mm per 24h. Since the forecasts are presented as raw ensemble output, you have latitude to choose the form of the forecast variable for verification. Most commonly, the probability of specific precipitation events is calculated from the ensemble by choosing a threshold (e.g. 1 mm/ 24h) and computing the proportion of ensemble member values which exceed the threshold, as an estimate of the forecast probability of occurrence of the event. Then scores for the verification of probability forecasts can be used. (Brier score, Brier skill score, reliability diagrams and associated measures, and the ROC and associated measures). Note that the ECMWF deterministic forecast is included in the dataset for each event. This can be included on the ROC plot as a single point, which allows direct comparison of the deterministic forecast quality with the ensemble quality.) As an alternative for probability estimation from the ensemble, one can fit a distribution to each raw ensemble using kernel density methods (gamma kernels are most appropriate for precipitation), for example, and estimate the probabilities from that distribution. This might be too much work for the time available however.

The ensembles can also be verified as discrete cdfs using the CRPS (and the CRPSS). The spread can be evaluated with the Rank Histogram, but special consideration needs to be given for 0's in the data: When the observation is 0, randomly select the rank from all the forecasts which are identically 0.

As a separate project, the ECMWF deterministic forecast, the ECMWF control forecast and the MOGREPS control forecast could be considered as three different deterministic forecasts and verified using contingency tables, for selected precipitation thresholds of interest, similar to project 2.

Suggested steps:

1. Plot the ensembles vs the observed precipitation for each of the two ensemble systems. These can be used to check the numbers of extreme precipitation events in the sample, for setting category thresholds.
2. Choose thresholds of interest for probability estimation from the ensembles, for example 0.5 mm/24h as the occurrence/non-occurrence boundary, and 30mm/24h to indicate risk of local flooding. Setting several different thresholds allows for an assessment of the full ensemble distribution
3. Evaluate both ensembles using the verification metrics for probability forecasts. Repeat the analysis for all chosen probability thresholds, and for the available projections. NOTE: The ROC should be set up according to the number of predictable probability values, 52 for ECMWF (0, 1/51, 2/51….50/51, 1) and 25 for MOGREPS (0, 1/24, 2/24,….,23/24, 1).
4. Prepare a presentation on the comparative verification, in terms of the forecast attributes measured by the metrics. Which ensemble is superior overall? Does that change with forecast projection?

If time permits, the ensembles themselves can be compared using rank histograms and the CRPS, CRPSS.

All comparative results should be supported by bootstrapped confidence intervals wherever possible.