1A.7 AN ENSEMBLE PRECIPITATION PROCESSOR (EPP) FOR GENERATING PRECIPITATION ENSEMBLES FOR THE NEXT 24 HOURS

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1. INTRODUCTION

As a part of the National Weather Service Eastern Region's (NWS/ER) Probabilistic Quantitative Precipitation Forecast/Probabilistic River Stage Forecast (PQPF/PRSF) Project, the NWS Hydrologic Research Laboratory (HRL) has developed the Ensemble Precipitation Processor (EPP).

The input to EPP is the Weather Forecast Office (WFO)-produced and the River Forecast Center (RFC)-mosaicked gridded field of PQPF (Krzysztofowicz 1998); the probability of precipitation (denoted as PoP) in the next 24 hours, the 25- and 50-percentile exceedance probabilities of the 24-hr amount of precipitation given that precipitation occurs, (denoteds as X_{25} and X_{50}, respectively), and the expected fractions of 6-hr precipitation amounts in the first three 6-hour subperiods in the 24-hr duration given that precipitation occurs (denoted as z_1 through z_3).

The output from EPP is the user-specified number of traces of 'plausible' four 6-hr precipitation fields on the HRAP (Hydrologic Rainfall Analysis Project, NWS 1998) grid (approximately 4x4 km^2 in mid-latitudes).

From the precipitation traces thus generated, mean areal precipitation (MAP) values are then calculated for each basin, and fed into the rainfall-runoff model (as many times as there are traces) to produce the ensemble forecast hydrographs, from which probabilistic statements may be made about the forecast river stages.

This purpose of this paper is to describe the initial capabilities of the EPP system.

2. OVERVIEW

Overall, two paths exist in EPP to generate 6-hr traces for the first 24-hr period; 1) generate 24-hr traces via space-only simulation, and then temporally disaggregate (i.e., downscale) them into 6-hr traces, and 2) directly generate 6-hr traces via space-time simulation. In the following, we briefly describe the components used in the two paths.

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2.1 Spatial Simulation

Two techniques are available in EPP to generate plausible traces of precipitation fields in space; 1) Schaake et al. (1998) and 2) Seo and Finnerty (1997).

Schaake et al. (1998) linearly-weights independent Gaussian random fields with varying spatial correlation scales, and transforms the resultant trace, which has the Gaussian distribution, into a precipitation trace, which is assumed to have the two-parameter Weibull distribution with a probabiliy mass at zero.

It is extremely CPU-efficient, but requires parameter estimation of the linear weights in order to reproduce the prescribed ensemble correlation structure.

Spatial simulation based on Seo and Finnerty (1997) is merely a conditional simulation application of Seo (1998a). It is significantly more CPU-intensive, but no parameter estimation is necessary to reproduce the prescribed indicator and conditional correlation structures.

2.2 Temporal Disaggregation

Temporal disaggregation of 24-hr traces into four 6-hr traces is achieved either by determinstic disaggregation, which assumes no temporal variability in the ratio of the 6- to 24-hr precipitation, or by stochastic disaggregation, which disaggregates a 24-hr trace first to two 12-hr traces, and then to four 6-hr traces by generating plausible traces of precipitation fractions (Schaake et al. 1998).

2.3 Space-Time Simulation

Space-time simulation of 6-hr traces is merely a conditional simulation application of Seo (1998b). The initial version accounts for the temporal dependence of precipitation amount in the current 6-hr subperiod only to that in the previous 6-hr subperiod (i.e., the 6-hr precipitation fields are assaumed to be Markovian in the Lagrangian domain).

Because of the relatively large time-step of 6 hours, the initial version is not intended to handle advection of the storm, and currently only allows uniform advection. Direct space-time simulation is extremely CPU-intensive, and requires two additional parameters that are not explicitly specified by PQPF.

2.4 Spatial Disaggregation

Either in space-only or in space-time simulation, precipitation traces can be simulated either directly on the HRAP grid or on a coaser grid in order to reduce computational burden. If a coaser grid is chosen, the simulated precipitation traces are spatially disaggregated (i.e., downscaled) to the HRAP grid via Perica and Foufoula-Georgiou (1996).

2.5 Post Processing

The ensemble generators described above are by design unbiased in the mean sense, and hence, if a sufficiently large number of traces can be generated, the ensemble statistics of the traces should converge to PQPF. Simulation experience suggests, however, that the number of traces necessary to achieve acceptable converge may be too large to be operationally viable with the currently available computing power at RFCs.

For this reaon, a post-processing option exists in EPP, which adjusts the individual 24-hr precipitation traces such that the ensemble sample statistics match the prescribed 24-hr PQPF (i.e., PoP, X_{25}, and X_{50}) at each grid point.

2.6 Statistics Package

To validate statistical integrity of the precipitation traces generated, the EPP statistic package calculates ensemble sample statistics and performs statistical tests against the statistics prescribed by PQPF. The statistical tests include the Student t and the Kolmogorov-Smirnov.

2.7 Graphical User Interface (GUI)

For user-friendly generation, visualization, evaluation, and application of precipitation traces, EPP provides a GUI with the computational components described above. The primary displays include the 6-panel display of four 6-hr precipitation traces at the HRAP scale, the summed 24-hr trace at the HRAP scale, and the 24-hr trace at the PQPF scale (approximately 4,000 km^2), and the 4-panel display of the sample ensemble statistic, the prescribed statistic, the difference or the ratio field between the preceding two, and the alphanumeric summary of the statistical tests performed.

3. CONCLUDING REMARKS

The Ensemble Precipitation Processor (EPP) represents the first attempt in the National Weather Service (NWS) at accounting for uncertainties in the short-term Quantitative Precipitation Forecast (QPF) in the framework of ensemble hydrologic forecasting. Though computationally intensive, such an "ensemble" approach is extremely attractive to operational hydrology in that it is scale-transparent: as long as the space-time scale at which the precipitation traces are generated is smaller than that of the MAP scale where the hydrologic model operates, the traces can always be upscaled to the MAP scale).

Systematic evaluation of EPP, with respect to unbiased replication of prescribed statistics, convergence properties, and CPU and parameter requirements will be given in the oral presentation.

4. REFERENCES

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