P3R.4 AN EVALUATION OF ENSEMBLES BASED UPON

# MAPLE PRECIPITATION NOWCASTS AND NWP PRECIPITATION FORECASTS

Alamelu Kilambi* and Isztar Zawadzki
Atmospheric and Oceanic Sciences, McGill University, Montréal
J. S. Marshall Weather Radar Observatory, Sainte Anne de Bellevue, Québec, Canada

## *1*. INTRODUCTION

It has been conjectured that radar based precipitation forecasts have better skill than Numerical Weather Prediction (NWP) model forecasts over a time scale of few hours (Austin et al. 1986). Lin et al. (2005) confirm this concept and estimate quantitatively that radar based precipitation forecasts in a Lagrangian persistence framework (henceforth called nowcasts) have better skill than NWP forecasts for up to 6 hours from the radar forecast initiation. As pointed out by Germann et al. (2005), the two main factors that limit the predictability of nowcasts are the evolution of precipitation systems (growth and dissipation) and of the storm motion field. Numerical Weather Prediction model precipitation forecasts attempt to include the evolution of the meteorological systems. Hence NWP forecasts and radar nowcasts could overcome each other's shortcomings and complement positively in an ensemble and provide better forecasts over longer periods. Our objective in this study is to find an optimum method of combining the NWP forecasts with radar nowcasts and to evaluate the skills of these ensembles. Nowcasts obtained by the application of MAPLE (McGill Algorithm for Precipitation nowcasting by Lagrangian Extrapolation) to continental scale US radar composites and precipitation forecasts from NWP models WRF and GEM are used in the evaluation of their relative skills. MAPLE uses variational echo tracking based upon radar composites in an assimilation window of ~1 hour to determine the precipitation motion field. A semi-Lagrangian advection scheme generates precipitation nowcasts in the 1-12 hour period using this motion field. Further a scale based filtering and appropriate rescaling of the filtered nowcast fields is used to improve the forecast precision. Germann and Zawadzki (2002, 2004) and Turner et al. (2004) describe the methodology of MAPLE and discuss the predictability issues of radar based nowcasts.

* Corresponding Author address: Alamelu Kilambi, J.S. Marshall Weather Radar Observatory, P.O. Box 198, Macdonald college, Sainte Anne De Bellevue, Quebec, Canada, H9X 3V9 (Alamelu.Kilambi@McGill.ca)

## 2. DATA SETS USED IN THE EVALUATION

US radar composites of radar reflectivity used in this study have a temporal frequency of 5 minutes, a reflectivity resolution of 5 dBZ and a spatial resolution of ~1km. The maps are converted to rainfall rate maps with a spatial resolution of ~5 km using a Z-R relationship. One hour composite accumulations generated based on these maps are used for verification.

MAPLE algorithms are applied to US radar composites of radar reflectivity to generate 5 minute step nowcasts. These nowcasts are converted to rainfall rate maps and accumulated to obtain one hour nowcast precipitation accumulations for up to 12 hours. Two types of radar nowcasts are considered in this study: "MAPLE" nowcasts resulting from the semi-Lagrangian advection scheme and "OMAPLE" nowcasts with further scale-based filtering and rescaling for the removal of non-predictable scales from MAPLE nowcasts.

One hour precipitation accumulations from two NWP models are considered. GEM (Global Environmental Multiscale model from the Meteorological Services of Canada, Cote et al. 1998) output is available with initialization times of 0, 12 Z and a spatial resolution of 15 km. WRF (Carpenter et al., (2004)) output is available with initiation times of 0, 6, 12, 18 Z and spatial resolution of 28 km. These model accumulations are remapped into arrays with the projection and spatial resolution of the radar composite accumulations.

Ensembles are generated using a weight scheme based upon the climatological or long term average value of Critical Success Index (CSI) of each individual component of the ensemble. Climatological CSI as a function of time of forecast (1-12 hours) and type of forecast (4 types: MAPLE, OMAPLE, GEM, WRF) are computed for the entire period first and then used for the generation of the ensembles. The CSI weight for a given type of forecast *i*, and time of forecast *t* is

$$weight = \frac{1}{1-(CSI_{i,t})^{2.5}} - 1$$

## 3. SKILL SCORES

The use of radar-based composite accumulation as the verification map in computing the skill scores does give advantage to radar based nowcasts. In order to reduce this bias the domain over central and eastern continental US east of $102^0$ W with good radar detection is used in the skill computation. The model forecasts in the 6-24 hour period from the model initiation time are used to avoid the spin up problems of models.

The skill parameters Probability of Detection (POD), False Alarm Rate (FAR), Critical Success Index (CSI), and Conditional Mean Absolute Error of the logarithm of rainfall (CMAE) are computed for 3 thresholds of 0.1, 1 and 3 mm for hourly precipitation accumulation. Skill parameters are determined for radar nowcast precipitation accumulations for up to 12 hours, initiated at every hour, and for the model and ensemble forecasts at the corresponding forecast times.

## 4. RESULTS

Figure 1 displays the average values of the four skills during the 13th August - 26th September 2004 period representative of predominantly convective cases. Figure 2 displays the average values of the skills during the 13th January 2005 – 30th March 2005 period representative of widespread cases. The skills are plotted as a function of the forecast time from the radar nowcast initiation. A pixel size of 40 km and a threshold of 0.1 mm are used in the computation of the skills displayed in the figures. The skills for the 4 basic types of forecast are shown by broken lines. Skills for 3 types of ensembles GEM+WRF, MAPLE+GEM+WRF, OMAPLE+GEM+WRF are shown by solid lines. The skills of nowcasts are higher than those of models initially since they have the advantage of assimilating the correct precipitation field at the forecast initiation. Radar nowcast skills decrease with forecast lead time as the evolution of the precipitation systems and the motion field is not included in the Lagrangian advection scheme. The NWP model skills individually and in ensemble (GEM+WRF) are lower initially and remain relatively constant over the entire period but become better than radar nowcasts after ~6 hours. POD of MAPLE_NWP ensembles is high over the entire period. However in the 1-4 hour period

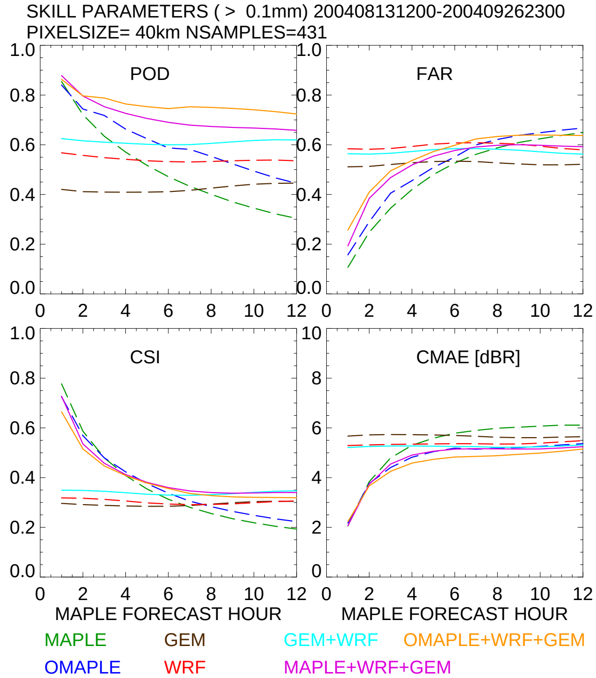


Fig.1 Skills: for 13th August – 26th September 2004 period (predominantly convective cases)

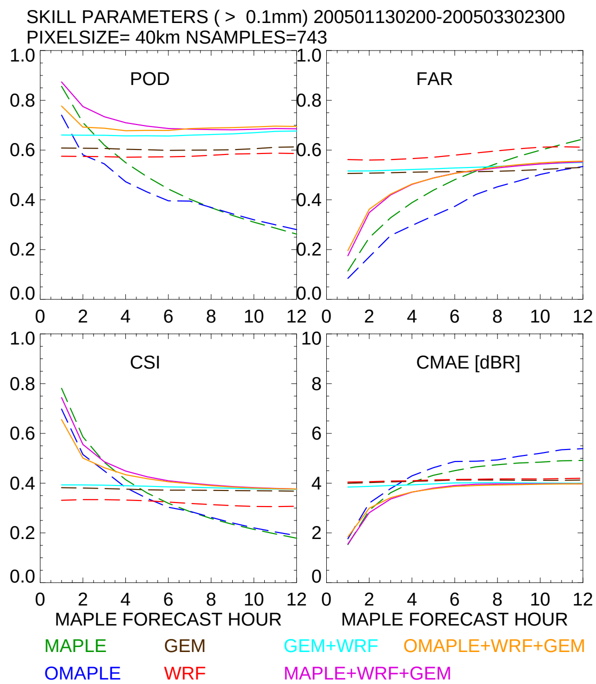


***Fig. 2** Skills for 13th January – 30th March 2005 period (predominantly widespread cases)*

increases in the False Alarms offset the gains in POD, resulting in ensemble CSIs which are less than those of radar nowcasts. In the 4-12 hour period, POD gains of ensembles are greater than the False Alarm increases and CSI scores of

MAPLE-NWP ensembles are higher than those of the four basic types of forecasts. CMAE scores of the ensembles are also lower in the same period. GEM+WRF ensembles also have better skills than the individual models in the entire period and compare favourably with MAPLE-NWP ensembles in the 9-12 hour period. NWP model skills are better in the widespread cases than in the convective cases because the dynamics is better captured and hence ensembles skills are also better.

## 5. CONCLUSIONS

Skills of precipitation forecasts from radar nowcasts, Numerical Weather Prediction models and ensembles of the above two are evaluated. One hour nowcast precipitation accumulations obtained by the application of MAPLE to continental scale US radar composites and one hour precipitation forecasts from two models GEM and WRF are considered in this evaluation. One hour precipitation accumulations generated from US radar composites are used for validation. Average values of the skills as a function of forecast lead time are computed for two time periods, 13 August – 26 September 2004 and 13 January – 30 March 2005. Our conclusions are based upon these average values of the skills. Critical Success Index is used for the assessment of the relative skills of various types of forecasts. Radar based MAPLE nowcasts have better skills than NWP forecasts for up to ~ 6 hours from forecast initiation. MAPLE-NWP ensemble skills are slightly lower than those of radar nowcasts for up to ~ 4 hours and are higher than any of the individual forecasts in the 4-12 hour period. Hence radar nowcast and NWP model ensembles have the potential for providing better forecasts for up to 12 hours, our study period. In this study we have used a simple blending algorithm for the generation of ensembles. Further enhancements to the blending technique such as phase error corrections to NWP model forecasts and use of a blend of model wind and storm motion fields in MAPLE Lagrangian advection scheme could lead to improvement in the ensemble skills.

## 6. ACKNOWLEDGEMENT

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