Proceedings of 8 ICSHMO, Foz do Iguaçu, Brazil, April 24-28, 2006, INPE, p. 707-710.

QUANTITATIVE PRECIPITATION ESTIMATION FOR HYDROMETEOROLOGICAL FORECAST IN PARANA, BRAZIL

Leonardo Calvetti*[1], Cesar Beneti[1], Marcelo Andrioni[1],Diogo Stringari[1], Itamar Moreira[1] and Augusto Pereira Filho[2]
[1] SIMEPAR, Parana, Brazil, [2]USP/IAG, Sao Paulo, SP, Brazil

1. INTRODUCTION

The Curitiba Metropolitan Area (CMA) has been affected by thunderstorms and flash floods in two preferential seasons, spring and summer. In general, the problem was the high precipitation intensity occurred by isolated and convective clouds over the watershed into the city. The main meteorological systems in the CMA include some fast (12ms^{-1} velocity propagation) and small (100km) squall lines that propagate eastward and isolated convective clouds. Sometimes, when the storm is very isolated, the precipitation cannot be registered because the density of stations. Then the streamflow can be rise fast, but it's impossible to forecasting without the precipitation information as input in hydrological model. For these cases has been used integration of radar and satellite rainfall estimates.

Rain gauges networks measure rainfall directly, but usually have a low spatial density, unable to support hydrological requirements and flash flooding forecasts. Estimation from radar measurements has high spatial (1km^2) and temporal (5 min) resolution but this need corrections in the intensities of precipitation. Therefore, the development of improved methodologies to estimate rainfall merging radar and rain gauges data has been an objective from the initial studies of hydrometeorological applications. In this work was used the statistical objective analysis scheme (SOAS) to merge radar and gauge precipitation data (Pereira Fo et al, 1998).

*Corresponding author address: Leonardo Calvetti, Meteorological System of Parana, Curitiba, Parana Brazil. E-mail: leonardo@simepar.br

2. METHODOLOGY

The first analysis was to compare the gauge, radar and satellite data for CMA area. We used 24hr accumulation for 37 gauges over CMA area (Fig. 1). The rainfall estimation from meteorological radar of the SIMEPAR was obtained by Marshall-Palmer ZR relation and with polynomial forth order advection scheme in the 1hr accumulation (section 2.1). In this work was used four month of daily comparison for the 37 station points. For the comparisons the radar and satellite data was interpolated on this points.

The second step was to use the radar data and integrated radar-gauge data in the hydrological model for an urban watershed. The IPH2 model was used for several flash flood cases and stratiform and convective cases (Moreira, 2005).

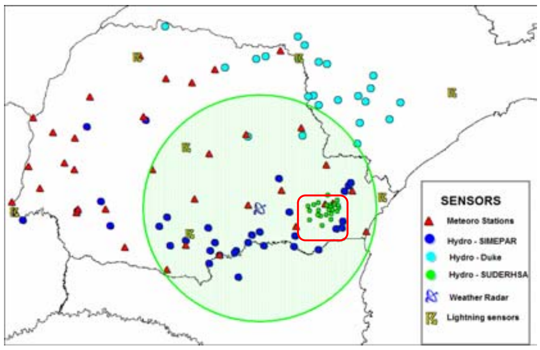


Figure 1: SIMEPAR Hydrometeorological Monitoring System in the south of Brazil operated by SIMEPAR. The Curitiba Metropolitan Area is represented by the red square.

2.1. S-Band Doppler Weather Radar

Since 1998, SIMEPAR operates a radar, installed in the central region of Parana. Doppler coverage (radius of 200km, with wind and precipitation measurements) includes Curitiba metropolitan area and central and east parts of Parana. This is a S-Band Doppler radar, EEC DWSR-95S model, with a 0.95 antenna beam width, configured to provide high spatial ($2km^2$ area) and temporal (5 to 10 minutes) resolution information for precipitation and wind. A selection of products generated by the radar (e.g. rainfall accumulation, wind profile, now-casting algorithms) are automatically transmitted from the radar site to the Weather Forecasting Center at SIMEPAR where they area analyzed by the meteorology staff. For the precipitation estimates used in this work we used 5min measurement over 200km radius from radar and 1hr accumulation. The rainfall estimation from meteorological radar of the SIMEPAR was obtained by Marshall-Palmer ZR relation and with polynomial forth order advection scheme in the 1hr accumulation (Calvetti et al, 2004).

2.2. Meteorological Satellite Data

A system for reception and processing of real-time high-resolution data from meteorological satellites installed at SIMEPAR provides products and algorithms for several applications. Among those are fog and fire detection, precipitation estimation, along with tools for visualization and dissemination of products, which are used in weather monitoring and forecasting, in this second case, for assimilation in a regional atmospheric model. For 24hr estimates from satellite was used the Convective-Stratiform Technique - CST (Negri and Adler, 2002) with the GOES 12 infra red images. The spatial resolution of the images is 8km x 8km and temporal resolution is 30 minutes.

3. RESULTS

Fig. 3 shows a comparison of accumulated precipitation for 37 point gauges from radar, satellite and gauge data. These results indicate better agreement on radar and gage data. In some points there are low accumulated gauge precipitation due the most cases were produced by isolated storms and squall lines. The rapidly convective type precipitation systems have larger rainfall rate spatial gradients that satellite does not take into account. The maximum radar estimation can be caused by the hail contamination that overestimates the rainfall account. None of the measurement systems are good enough to make reliable estimates of rainfall alone, but they can provide useful information and be integrated to produce accumulations with the least error.

The simple comparison of spatial estimation from radar data and rain gauge measurements is showed in Fig. 4 and 5. For the 22 February 2004 case (Fig 4), the stratiform precipitation has good agreement with the rain gauge data and showed that there is an isolated cell northeast from Curitiba point where there is no gauge. Although, the south from Curitiba there is a 5 mm registered in the rain gauge and the radar precipitation was underestimated. This small difference is important in sense of daily accumulation for hydrological catchments.

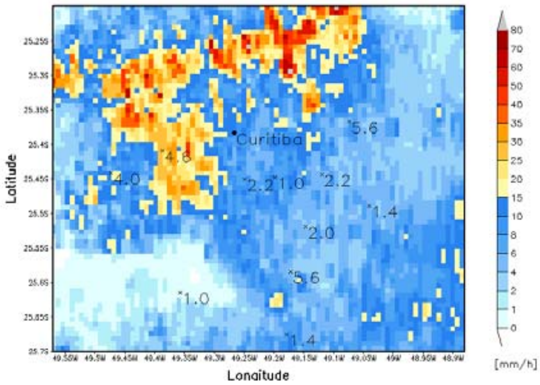


Figure 4: Rainfall 1hr accumulations fields for radar (shaded) and hourly rain gauge data on 22 UTC 22 February 2004. Was only plotted the rain gauge different from zero

In the analysis of convective cells like the event showed in Fig. 5 the identification of cells and the large area of heavy precipitation only is possible using the combination of gauge and radar estimations. There are heavy precipitation on all CMA due the propagation of cells, but the maximum value registered in gauge network was 19,2mm. Therefore, in this specific case the overestimated by radar fields is problematic and need a large serie of statistical correction using SOAS technique. In the summer this event represents the typical mesoscale system over all regions, including isolated cells into convective system.

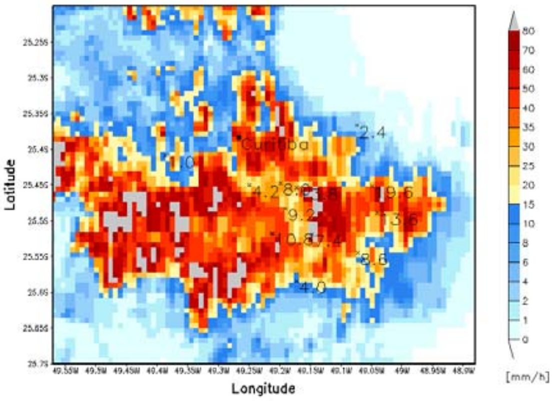


Figure 5: Rainfall 1hr accumulations fields for radar (shaded) and hourly rain gauge data on 19 UTC 09 Mars 2004. Was only plotted the rain gauge different from zero.

The radar and satellite estimations and gauge measurements has been used to test some hydrological forecasts. For the stratiform precipitation (Fig 6) the streamflow simulations were closed to observational streamflow when used satellite and gauge data, but the streamflow were underestimated when we use radar data as input in IPH2 hydrological model. This result is not systematic, but it is frequent in the low and continuous precipitation events.

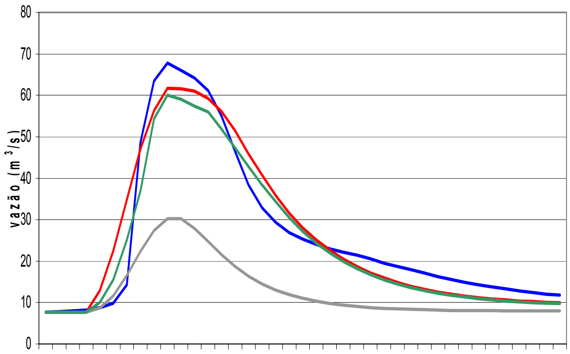


Figure 6: Streamflow simulated by IPH2 hydrological model for barigui watershed using gauge (red line), radar (grey line) and integrated radar and gauge data (green line). The measure streamflow is represented by the blue line. The picture shows the time series streamflow data for 19 October 2001, where a stratiform system occurred in the CMA.

For the convective events (Fig.7), the best result was obtained using the integration with radar and gauge data. If we use separated radar or gauge the streamflow simulations can be under and overestimated respectively. The satellite estimation in this convective event was underestimated due the low time resolution (30 min).

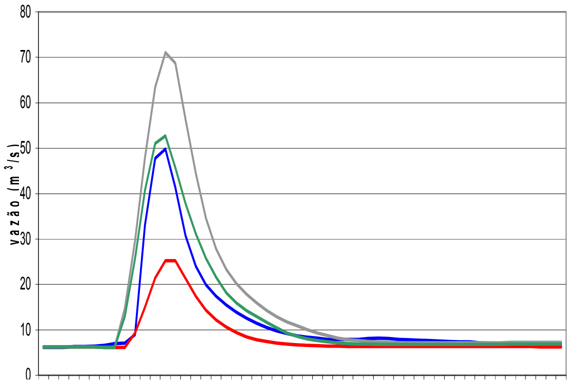


Figure 7: Streamflow simulated by IPH2 hydrological model for barigui watershed using gauge (red line), radar (grey line) and integrated radar and gauge data (green line). The measure streamflow is represented by the blue line. The picture shows the time series streamflow data for 3-5 April 2002, where a convective storm occurred in the CMA.

4. CONCLUDING REMARKS

This study has shown the importance of integration of radar, gauge and satellite data for hydrological proposes in Curitiba Metropolitan Area. The comparison of four months in the summer 2003/2004 showed there are good agreement of the measurements of rain gauge and radar and satellite estimates. But the results had showed that only the use one of these sensors the error of rainfall estimation on watershed can be high then we use integrated system.

For convective and isolated meteo-rological systems the spatial estimation using radar is useful to identify cells of convection and high intensity precipitation areas. Also, the results indicated that the integrated information can be better for hydrological model in to forecast the streamflow for urban catchments.

5. REFERENCES

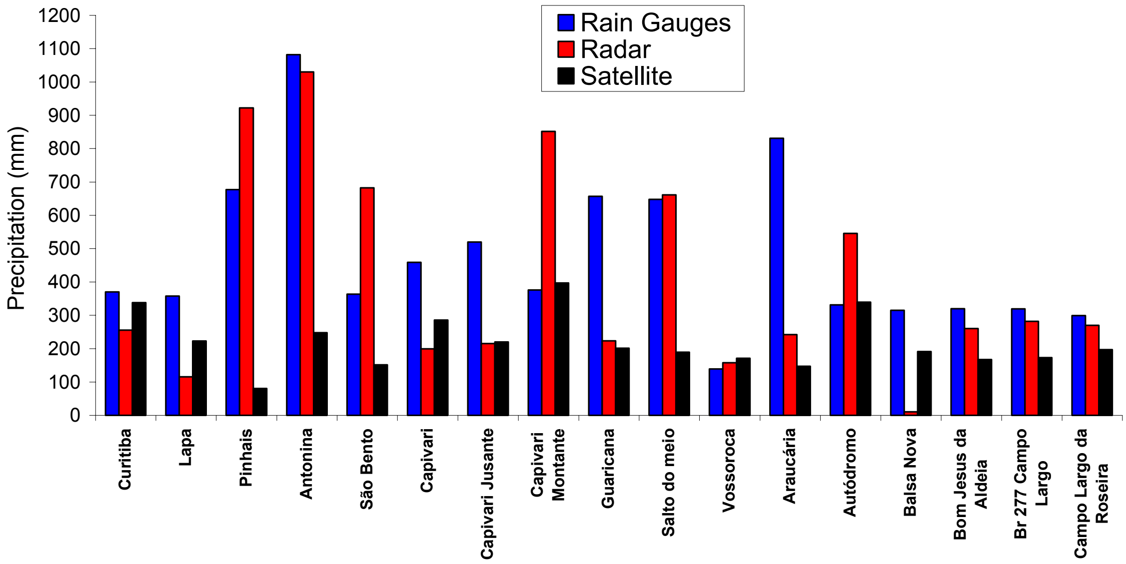
Calvetti, L., Beneti, C.A.A. and Pereira Fo., A.J., 2004: Comparison of daily precipitation estimation from satellite, radar and gauges data for Curitiba Metropolitan Area.. *Brazilian Congress of Meteorology*. Fortaleza-CE Brazil (In Portuguese).

Moreira, Itamar A., 2005: Modelagem Hidrológica chuva-vazão com dados de radar e pluviômetros. Curitiba. 81 pp. (Tese mestrado em Engenharia Hidrológica) – Setor de Tecnologia, UFPR.

Negri, Andrew .J.,Xu, L., e Adler, Robert F., 2002: A TRMM-Calibrated infrared rainfall algorithm applied over Brazil. Journal of Geophysical Research. 107,15pp.

Pereira Fo., Augusto J. and Nakayama, P. T., 2001. Intercomparison of radar rainfall estimates and rain gage measurements in São Paulo, Brazil. Proc. 5 th Int. Symp. Hydrological Applications of Weather Radar, Kyoto, Japan, BR2, 6 pp

Pereira Fo., A. J., Crawford, K. C. and Hartzell, C. L., 1998: Improving WSR-88D Hourly Rainfall Estimates. *Weather and Forecasting*: Vol. 13, No. 4, pp. 1016–1028.



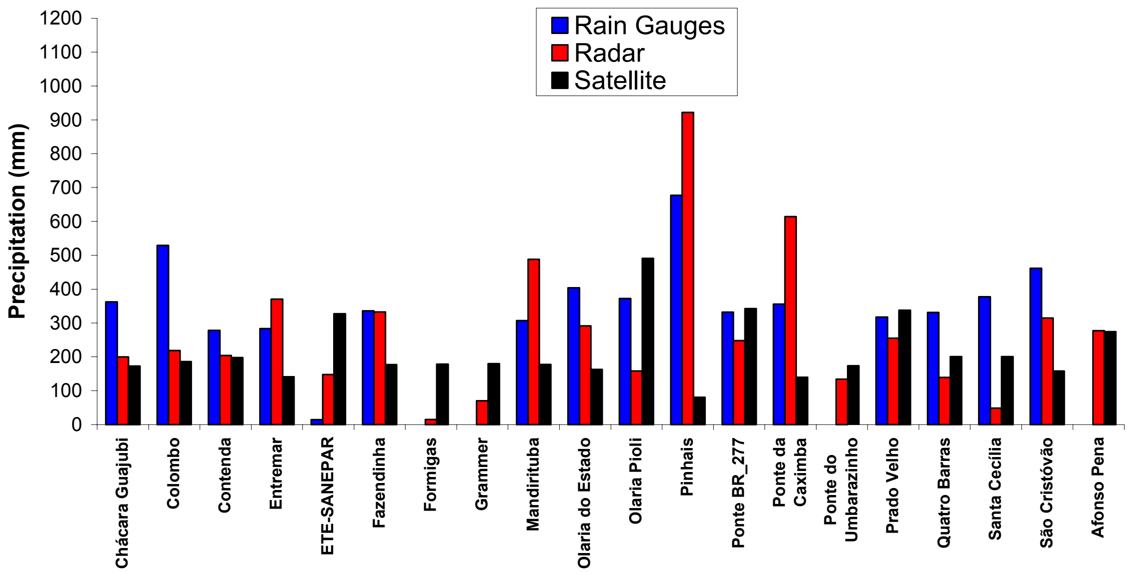


Figure 3: comparison of gauge (blue), radar (red) and satellite(black) daily precipitation for 37 hydro and meteorological stations on Curitiba Metropolitan Area accumulated in four months, December 2003 to Mars 2005.