P5A.7 CLONING RADAR CELLS AT OUTER RANGES: A TEST WITH THE BAURU RADAR

Roberto Machado (1) and Roberto V. Calheiros (1, 2)
(1) Meteorological Research Institute/UNESP, Bauru, São Paulo 17033-360, Brazil
(2) National Institute for Space Research/MCT, S.J. Campos, São Paulo, Brazil

1. INTRODUCTION

Since the early days of operations of the Bauru weather radar – at the time a non-coherent C-band system – the detection of well developed convective cells at the outermost range, i.e., the approximate ring from 350 to 400 km was clearly evidentiated (Calheiros,1975).

Because of the advantages of being able to monitor precipitation at relatively far distances, an effort was then carried out to identify means of quantitatively estimating rainfall at those ranges. This ultimately led to the development of the statististical method of rain measurements through comparison of cumulative probabilities of Z and R (Calheiros and Zawadzki, 1987). While mostly successful, the method could not overcome the problem of the loss of the rain going undetected at the boundary region of the cells because of the higher MDZ at far ranges. This is a limiting factor for both nowcasting practices and numerical weather prediction. Regarding the latter, the flux of latent heat release (LHR) may be significantly impacted by the equivalent rain not seen by the radar (Calheiros, 2001). While of general high interest for any Brazilian area covered by radar surveillance in the country, it were the problems involved in the monitoring of the Paraíba Valley, which is a very important region embedded in the Rio de Janeiro – São Paulo geographical axis, by radar that have more recently drawn attention. This is due to the significant role to be played by the Bauru radar facility in providing better radar surveillance of the boundaries of the Valley, just off the surrounding highlands. Because the area is at the furthest range ring (Figure 1), the loss of the boundaries of the detected cells is severe.

This prompted the development of a project to mitigate that negative effect on the usefulness of radar as a monitoring tool of rainfall in the area. This paper presents a preliminary verification of a methodology devised to retrieve, to a certain degree, the actual cell at far range, in a “clone”- like procedure. While the far range cells occur routinely during summer, due to radiometric microwave data availability, an event from the transition winter-to-summer period was used in the test. The nature of the vertical developments in October, while much less frequent than in summer, qualified the event for this test. These limited results indicate that a substantial improvement can be obtained with the proposed procedure for cell structure retrieval. Continuation of the project and comparisons with recent satellite microwave rainfall retrieval work are presented.

Corresponding author address: Roberto V. Calheiros, Instituto de Pesquisas Meteorológicas, UNESP, CX-281, 17001-970 Bauru, S.P., Brazil;
e-mail: calheiros@ipmet.unesp.br

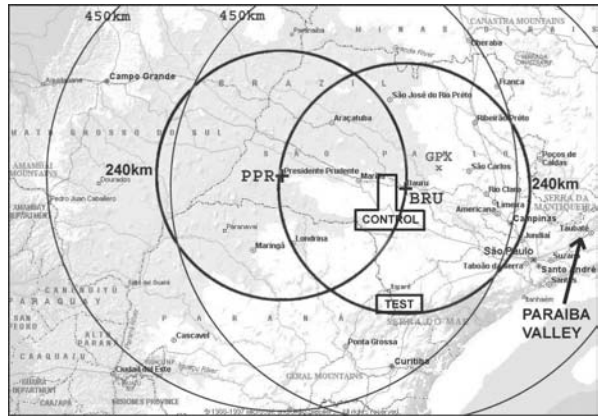

Figure 1. Bauru (BRU) and Presidente Prudente (PPR) radar sites, with 240 and 450 km ranges are indicated. Approximate positions of the Control Cell and the Test Cell, as well as the Paraíba Valley are shown.

The Bauru radar is located at Lat: 22° 21’ 28” S, Lon: 49° 01’ 36” W, 624 m amsl, while the second radar is in Presidente Prudente, 240 km west of Bauru (275° azimuth), at Lat: 22° 10’ 30” S, Lon: 51° 22’ 22” W, 460 m amsl. Both have a 2° beam width and a range of 450 km for surveillance (0° PPI every 30 min), but when operated in volume-scan mode every 15 minutes (or less) it is limited to 240 km, with a resolution of 1 km radially and 1° in azimuth, recording reflectivities and radial velocities.

2. DATA

The event analyzed was from 12 October 2002, at 13: 30 LT (UTC-3 hours). Data provided by the HSB (Humidity Sounder for Brazil) instrument (Lambrigtsen and Calheiros, 2003) on board the AQUA/EOS near-polar platform were utilized. These satellite measurements included brightness temperature, Tb, level 1 calibrated and geo–referenced radiances, from granules 169 and 170. The frequency is 183.33+/-7 GHz, just at the water vapor wings; this is channel 4 in the HSB instrument. The rainfall field covered the cross-track width between HSB pixels 43 and 27; since nadir is between pixels 45 and 46 the distortion of the FOVs in the segment corresponding to the rainfall field is less than 10%. FOV at nadir is a circle of 13.5 km diameter and the HSB scans “on-the-fly” (not stepped), resulting in some smearing.

Radar data were from the Bauru (BRU) and Presidente Prudente (PPR) radars, which are depicted in Figure 1. They are reflectivities, Z, from the following operational products:

PPI, 450 km range, elevation of 0.2 degrees, for both BRU and PPR, and, for BRU only, PPI of 1.7° elevation and CAPPI of 3.5 km height, both to 240 km range. The 1.7° PPI was used because it reached the rain cell of interest (later in the text) at about the same height as the 0.2° PPI from PPR; the 3.5 km height CAPPI helped to identify clutter. Data collected from two areas, or set of cells, as indicated in Figure 1, were focused on. The ones near BRU were designated "control cell" and, those at further range as "test cell". Radar data were converted from Z to R using the Marshall-Palmer Z=200*R**1.6 and, then averaged to approximately match the HSB FOV; in a few cases there were some adjustments performed in the matching process, due to registration uncertainties. Use of the Marshall- Palmer relationship is justified both by the fact that October is the first of the 6-month wet period and that the structure of the rainfall is more like the daily interval outside the peak of convective activity during summer. The final radar data set was, then, a rainfall field with approximately 13.5 km resolution.

3. PROCESSING AND RESULTS

In summary the procedure adopted was:
a) Obtain a Tb x R relationship for a set of cells near BRU, designated "control cell",
b) Select a "test cell" as far as possible of PPR, retain its central area and surround it with the HSB data, as a "shell",
c) Correct the "test cell" central area for range effects, and
d) Re-label the HSB "shell" with the R values from the Tb to R conversion obtained in a).
The re-labeled structure is designated a "clone"-cell.
The resulting Tb x R relationship is shown in Figure 2.

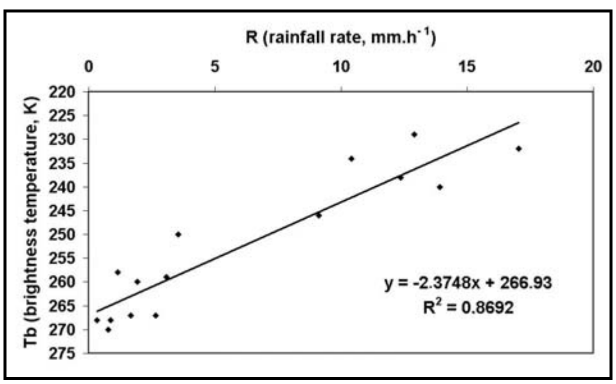

Figure 2. Tb vs R relationship for the Control Cell, observed by BRU.

Possible causes for the relative absence of values noticed in the middle range of R values are the satellite cell (low) resolution and the characteristic scale of the precipitating cells. It appears that similar rain fields as presented by Chen and Staelin (2003) contain the same kind of effect. No saturation effects were noticed in the upper range of R (lower range of Tb) values, and the adjusted linear relationship obtained was extrapolated to the comparatively lower values of Tb (higher values of R) in the "test cell". No impacts in the "cloned" radar cell could be identified. Notwithstanding, as is the case with weather radars, such an effect – as well as for the lower range o R values – should always be considered.

The cut-off value of Tb for no-rain is about 268 K, and the Tb range is around 230-270 K. Compared to the results of Chen and Staelin (2003), the no-rain threshold is a bit higher and the Tb range somewhat smaller for this cell. However, when the "test cell" is considered, the Tb range compatibility is higher, mainly because of the presence of stronger convection which leads to lower Tb minima.

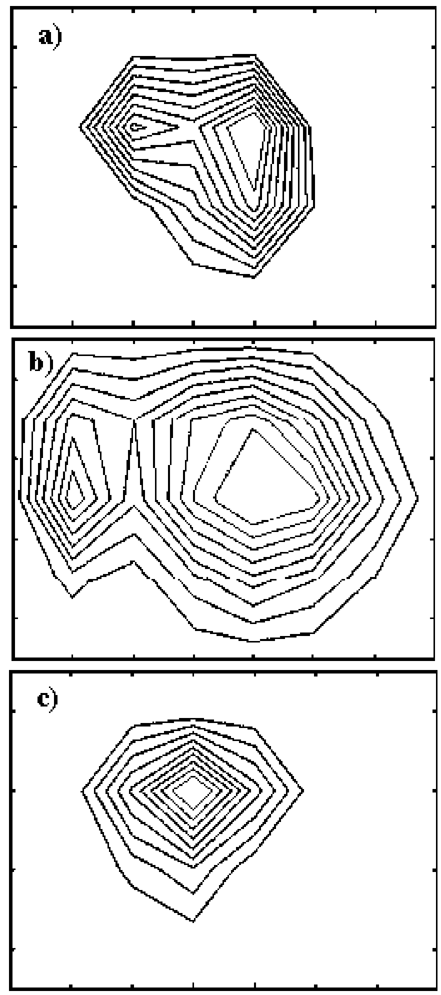

Figure 3. Cell structures. Scale elements on the x and y axis are 13.5 km. **a)** Test cell (observed by BRU), **b)** Cloned cell, **c)** Test cell (observed by PPR). R range in each cell is divided in 9 equally spaced iso-contours. Maxima of R are approximately 15 mm.h^{-1} for the test cell (BRU), 33 mm.h^{-1} for the cloned cell and 3.3 mm.h^{-1} for the test cell (PPR).

The "test cell" selected, as indicated in Figure 1, is presented in Figure 3a, as observed by BRU and 3c, as seen by PPR, with the averaging performed to match the corresponding satellite FOVs. The core region of the “test cell” from PPR was range corrected (Calheiros, 1994) by about 20 dB and surrounded by the satellite observations converted to R. The core region was taken as the area of the corresponding satellite pixel. The cell shown in Figure 3b resulted from it. The radar versions of the “test cell” vis-à-vis one another present the expected degradation of the radar observations with range, i.e., the BRU test cell, at about 230 km is better reproduced than the PPR test cell, which is around 360 km away from the radar (PPR). Figure 3 was derived through iso-contouring the satellite resolution cells.

The radar values at the original resolution have maxima of 6.5 and 75 $mm.h^{-1}$, respectively for PPR and BRU. Regarding the area covered in each case, an indication is obtained by considering the discrete FOV resolved presentation (before isocontouring) : the cloned cell has about 10360 km^2, the BRU cell 5730 km^2 and the PPR cell 2860 km^2. The retrieval procedure, then, compensates for the loss of approximately ¾ of its original size. The impact of this loss in the LHR flux might not be negligible if, for instance, many cells were popping up in the outer radar range and a mesoscale model were to be run there.

4. CONCLUSIONS

The test of the radar cell cloning procedure proposed here suggests that this methodology has good potential for mitigating the effects of the low sensitivity of weather radars at long ranges. Microwave radiometry seems to reliably perform the task. Nowadays it is only possible with near-polar satellites, but missions like GPM (Global Precipitation Mission) with a considerable increase in sampling frequency and technology advances rendering it possible to have microwave sensors in geostationary orbits, will offer effective possibilities for operational implementation of the method solely based in microwaves. In the meantime, combined IR and MW might be implemented. This last scheme is the object of continuation of the present project which should lead to the implementation of operational testing within months, in the area of the Paraíba Valley.

5. REFERENCES

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