1. INTRODUCTION

The Amazon Region has been the focus of many environmental studies in the past few years aimed to understand its contribution to the equilibrium of the global system. Recently, the government of Brazil has deployed the Amazon Surveillance System (SIVAM) to monitor the entire Amazon Basin. It also includes a network of automatic weather stations and Doppler weather radars. Particularly, the radar network will be very useful for short-term weather forecasting. Thus, radar-based information such as the wind field at constant elevations is relevant operationally.

The present study applies the Zhang-Gal-Chen single-Doppler velocity retrieval (ZG) method (Zhang and Gal-Chen 1996) to the 26 January 1999 squall line monitored by the S-POL and TOGA weather radars (Fig. 1) during the WET AMC and TRMM LBA field experiment campaign in Rondônia, Brazil (Pereira Filho et al. 2002). Sensitivity analysis are performed for variable area sizes and weights of the cost function that conserves the reflectivity and the radial wind field in both stationary and moving frame of reference. The retrieved wind fields by the ZG method are compared to the ones retrieved by the above two weather radars.

\[ J(U, V, W) = \int_{\Omega} \alpha Z_t + UZ_x + VZ_y + (W + W_t)Z_z dx dy dz dt \]  (1)

where \( \Omega = 4D \) domain; \( Z \) = reflectivity; \( Z_t, Z_x, Z_y, Z_z \) = time and spatial derivatives of \( Z \); \( W_t \) = terminal velocity; and \( \alpha_z \) = reflectivity weight. The cost function \( J \) is minimized to get the 3D basal wind field. The stationary frame of reference is changed to a moving one such that advection speeds are zero. The total wind field is \( (u, v, w) = (U + u', V + v', w') \), where \( (U, V) \) = advection speeds; \( W \) = mean vertical speed; \( (u', v', w') \) = perturbation speeds.

Then, the conservation of the reflectivity field: \( Z_t + uZ_x + vZ_y + (w + W_t)Z_z = 0 \). On the other hand, radial velocities can be written as:

\[ V_r = \frac{x - p_1}{r} + \frac{y - p_2}{r} + \frac{z - p_3}{r} \]  (2)

where \( (x, y, z) \) and \( (p_1, p_2, p_3) \) are Cartesian coordinates of a grid point and of the radar, respectively; \( r \) = distance from the radar. Time tendencies of the reflectivity field are minimized in relationship to \( (u, v, w) \) and radial winds:

\[ J(u, v, w) = \int_{\Omega} \alpha Z_t + uZ_x + vZ_y + (w + W_t)Z_z + \alpha_{vr} (v' - v^m)^2 dx dy dz dt \]  (3)

where \( \alpha_{vr} \) = radial velocity weight; \( m \) and \( e \) refer to measured and estimated radial velocities, respectively. The reflectivity field is not conserved in this stationary frame of reference. Then it is changed to a moving one using the basal speeds and the procedure in Eq. 3. More details found in Zhang and Gal-Chen (1996).

3. RESULTS

Several tests were performed with reference frames, radial wind weights, area sizes and spatial resolutions. Below are shown results only for area and times in Fig. 2.
Fig. 3 shows 2-km altitude retrieved winds by the ZG method and by S-POL and TOCA radars together. The ZG retrieval was performed with $\alpha_{vr} = 1$ (Eq. 3) at 0.5 km horizontal resolution using volume scans between 2000 UTC and 2015 UTC. The estimated advection speed is $(U,V) = (-4,-1)$ m s$^{-1}$. The gust front in the leading edge of the system was retrieved by both methods though wind intensities are smaller for the ZG method. A rear to front low level jet is apparent on the Northeast region of the squall line in the retrieval with two radars (Fig. 3). Weak Easterly winds are prevailing for the ZG method. Both methods were able to retrieve a convergence zone where reflectivities are above 50 dBZ.

A sensitivity analysis of radial wind weights and reference frames with altitude is shown in Fig. 4. Best results are associated with the moving frame of reference and $\alpha_{vr} = 1$ between 4 km and 9 km altitude. Above these levels, range-height effects reduce the spatial resolution of the reflectivity field. On the other hand, close to the surface, reflectivity gradients (Fig 2) are high and also ground echoes contaminate measurements. In general, rms errors are higher for the meridional wind (not shown) retrievals. Error magnitudes are similar to those obtained by Lazarus et al. (1999) for a much smaller area.

Figure 4: Root mean square errors of the retrieved zonal wind as a function of altitude within the square shown in Fig. 2. Letters A and B indicate a moving frame of reference for $\alpha_{vr} = 10$ and 1, respectively, and letters C, D, and E indicate a stationary frame of reference for $\alpha_{vr} = 10$, 1 and 0.1, respectively.

4. CONCLUSION

The ZG method was applied to a significantly larger area and height of retrieval than previous experiments performed with the same technique. Overall, results were much better for radial wind weight close to 1. That means the reflectivity and wind fields are both important. Results also improve with the increase of the spatial resolution. The vertical component of the wind were not adequately retrieved in all experiments, but in most instances the wind direction were coherent with those obtained with two-radars. Other constraints can be applied to the cost function (Eq. 3) such as rotation and convergence and alternative methods of estimating terminal velocities (Lazarus et al. 1999). The LBA data are being used to carry out further analysis with the ZG method since it is more cost effective computationally.

ACKNOWLEDGMENTS

The authors are thankful to Dr. Zhang for her kind assistance with the ZG computer code. This research was sponsored by Fundação de Amparo À Pesquisa do Estado de São Paulo - FAPESP under grant number 00/00119-8 and by Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq under grant 302419/2002-0.

REFERENCES


Lutz et al., 1995: NCAR’s S-Pol: Portable Polarimetric S-band Radar, 9th Conf. on Meteorological Observations and Instrumentation. Charlotte, NC. AMS.
