HYDROMETEOR CHARACTERISTICS UNDER LAND-OCEAN AND URBAN-RURAL INTERFACES

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1. INTRODUCTION

Several SPOL systems have been installed in Brazil, recently. Two SPOL dataset records of 2015 are used to characterize hydrometeors of convective systems under different boundary layer conditions over land, ocean, urban and rural areas of São Paulo and Espírito States as shown in Fig. 1. The hydrometeor types and associated microphysics and dynamics are examined by means of polarimetric variables such as ZDR (db) and KDP (deg km^{-1}) to analyze CCN (ESWR) and differential heat island effects (SPWR) under those boundary layer types.

Figure 1: Surveillance areas (240-km radius) of the S-POL radars in São Paulo (SPWR) and Espírito Santo (ESWR) States, Brazil. Topography features are indicated by green (lower) to brown (higher) color tons. Tree main features are the Brazilian high plains Eastward and the Amazon (W-E) and the La Plata (N-S) Basins.

2. METHODOLOGY

The SPWR and the ESWR operate with eleven and six elevation angles, respectively, both at 5 min. intervals. The SPWR and the ESWR datasets recorded between January to April 2015 and December 2014 to April 2015, respectively, were used in this research. Both SPOL weather radars have identical features and their main characteristics are described in Pereira Filho et al. (2015). Volume scans are performed every 5 minutes for both radars but for six (ESWR) and eleven elevation angles. So, the SPWR might have sampling issues given its faster antenna rotation.

The lowest PPI and fixed cross-sections (Figs. 2BL and 3BL) in between two distinct boundaries were used to analyze polarimetric variables averages of horizontal and vertical structures of weather systems, respectively. Averages (Figs. 2 and 3) and standard deviations (not shown) of non-null data were obtained for Z (dBZ), K_{DP} (deg km^{-1}), Z_{DR} (dB), R_{OHV}; V (m s^{-1}), and W (m s^{-1}). This simple approach is aimed at identified relevant weather microphysical and dynamical features as well as long-term radar artifacts caused by antenna rotation, ground clutter, and anomalous propagation, among others.

3. RESULTS

Figs. 2 and 3 show the lowest PPI averages of non-null polarimetric variables measured by SPWR and by ESWR, respectively. Figs. 2TL and 3TL are the average Z fields. Both radars are affected by ground clutter contamination (mountains), beam blockage (metallic structures and trees (SPWR) at the near field range and far field range (ESWR) caused by mountains Westward (Fig. 1). The melting layer effect on Z (Fig. 2TL), K_{DP} (Fig. 2TR), R_{OHV} (Fig. 2MR) are more clearly seen in the SPWR surveillance area. The SPWR average radial winds (Fig. 2BL) are from NW and consistent with synoptic scale winds (not shown). Fig. 3BL indicates a Southward low level jet (LLJ) and warm advection signatures Northward, and NW winds Southward, both consistent with observations (not shown). Fig. 2ML shows higher Z_{DR} field in the West part of MASP suggesting a bright-band effect though in general drop sizes tend to be larger over MASP. The ESWR 0.3 deg. PPI of Z_{DR} shows larger drop sizes over the ocean near surface, a very shallow microphysical feature that might de caused the LLJ (Fig. 3ML) and maritime CCN.

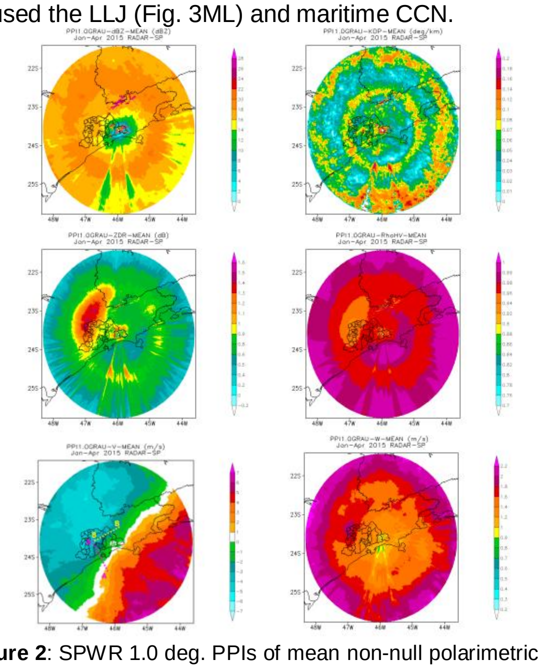

Figure 2: SPWR 1.0 deg. PPIs of mean non-null polarimetric variables from top-left (TL) to bottom-right (BR): Z (dBZ); KDP (deg km^{-1}); ZDR (dB); ROHV; V (m s^{-1}); and W (m s^{-1}) for the period of January to April 2015. Geographic boundaries, latitudes and longitudes and scales are indicated. Cross-sections AA (pink dashed line) and BB (yellow dashed line) are shown in the radial wind field (bottom-left). The boundaries close to the SPWR are cities within the metropolitan area of São Paulo (MASP).

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Fig. 4 (top) shows average vertical profiles of Z_{DR} for the cross-sections in Figs. 2BL and 3BL. Overall raindrops tend to be larger over the Metropolitan area of São Paulo from the surface to up to 6 km altitude indicating more vigorous updrafts caused by the heat island effect and the local sea breeze (Pereira Filho et al. 2013). The ESWR average Z_{DR} profiles (Fig. 3 BL) indicates the dominancy of smaller drop sizes though larger ones observed close to surface Northward of ESWR right at the land-ocean interface that is suggested to be influenced by the observed LLJ (Fig. 3BL and Ocean type CCN. Cells tend to be smaller associated to Easterlies and more organized with Westerlies. Few convective events were monitored and measured with ESWR.

Both have very good quality datasets as indicated by the maximum range of R_{OHV} between 0.96 and 0.98 in spite of the smaller sampling time for SPWR and spatial resolution for ESWR.

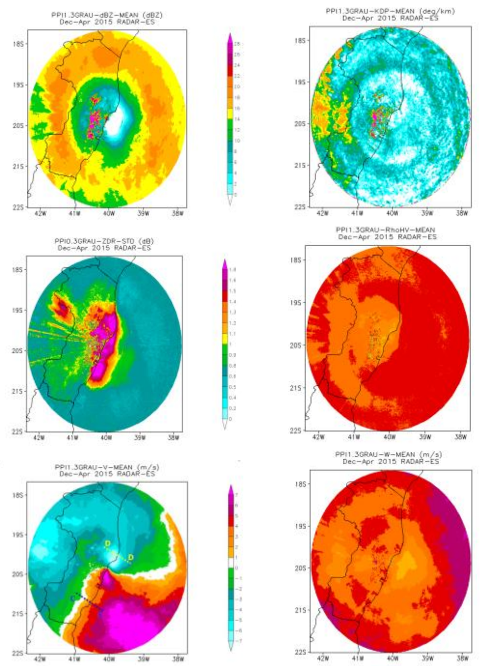

Figure 3: Similar to Fig. 2, but for ESWR 0.3 (Z_{DR}) and 1.3 deg. PPIs (all other polarimetric variables).

An instance of a convective system monitored by SPWR and ESRW is shown in Figs. 5 and 6, respectively. Given the selected cross-sections for the ESWR and the fewer elevation angles, just the second elevation PPI was used. Fig. 5 shows PPIs and cross-sections of a convective episode over MASP at 2025 UTC (1725 LT) on 7 January 2015. This convective system was associated to heat island and sea breeze effects, common features in MASP (Vemado and Pereira Filho, 2015). The PPIs of Z and ZDR indicate higher Z and higher Z_{DR} over MASP than elsewhere. Stronger updrafts, rich urban CCN and moisture injected by the sea breeze result in intense rainfall rates (Pereira Filho et al., 2013). The Z_{DR} cross-section indicates larger drops up to 7-km

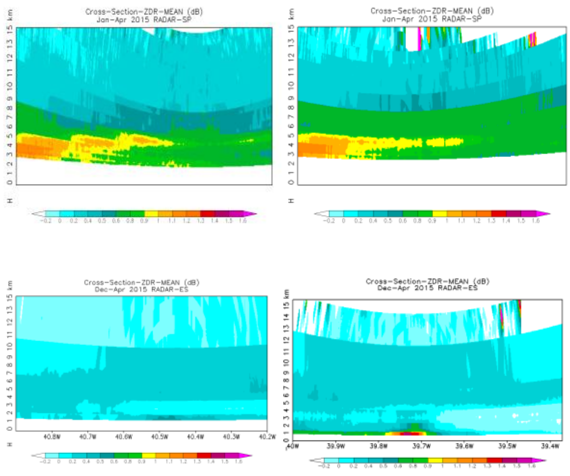

Figure 4: Cross-sections AA (left) and BB (right) (Fig. 2BL) and CC (left) and DD (right) (Fig. 3BL) of ZDR (dB) average for SPWR and ESWR, respectively. Altitude, longitudes and scales are indicated.

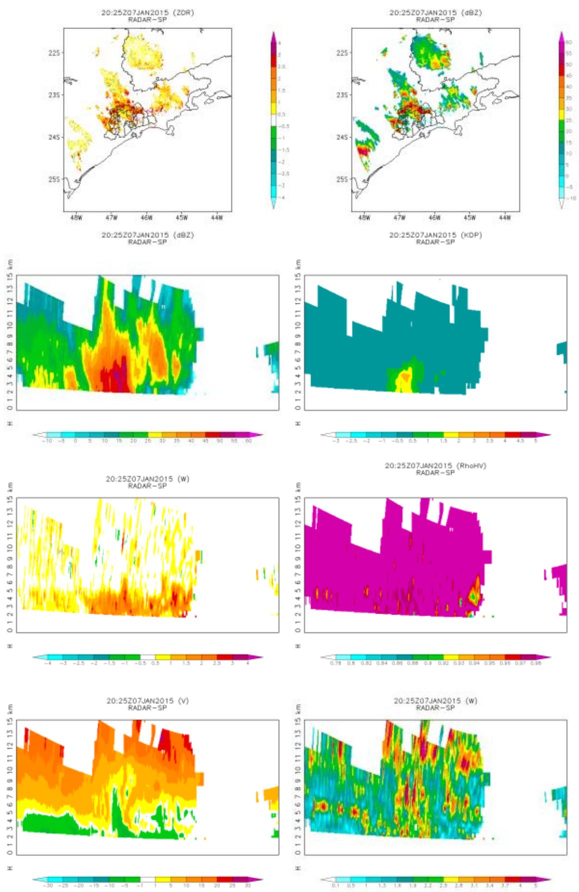

Figure 5: SPWR 1.0 deg. PPIs of ZDR and Z (top) and cross-sections BB (Fig. 2BL) (left to right and top to bottom) of Z (dBZ), K_{DP} (deg km^{-1}), Z_{DR} (dB), R_{OHV}; V (m s^{-1}), W (m s^{-1}) on 2025 UTC 7 JAN 2015. Geographic boundaries, latitudes, longitudes, altitudes and scales are indicated.

altitude, where over-shooting tops in Z are greater than 15-km, KDP above 3 deg km^{-1} with strong radial convergence as well as turbulence indicate by W > 5 m s^{-1}.

Fig. 6 shows 1.3 deg. PPIs of the polarimetric variables for a case of a South-Eastward moving convective system at 2115 UTC (1815 LT) on 5 February 2015. This type o meso-scale convective system tend to be more organized than the ones, also common, Westward moving associated to small ordinary convection initiated over the Atlantic Ocean (not shown). In spite of the higher Z NW of ESWR, ZDR is larger N-S over the ocean close to shore. Winds (V > 15 m s^{-1}) and turbulence (W > 3 m s^{-1}) are stronger in this region where larger drops tend to oscillate more and so reducing (R_{OHV} < 0.9).

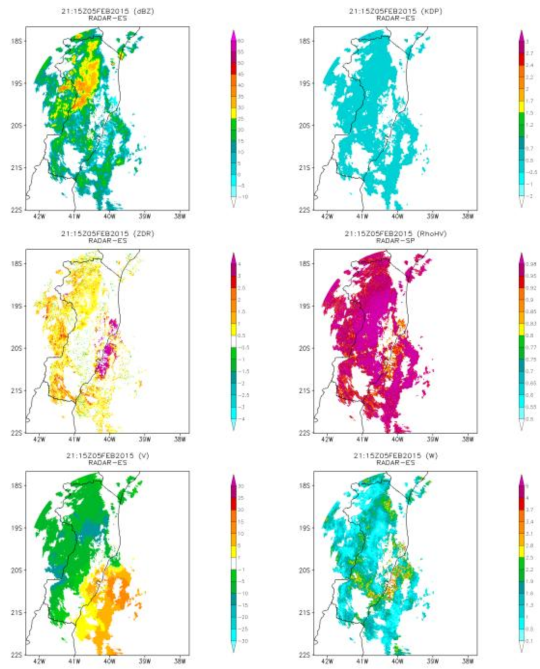

Figure 6: ESWR 1.3 deg. PPIs of ZDR and Z (top) and cross-sections BB (Fig. 2BL) (left to right and top to bottom) of Z (dBZ), K_{DP} (deg km^{-1}), Z_{DR} (dB), R_{OHV}; V (m s^{-1}), W (m s^{-1}) on 2115 UTC 5 JAN 2015. Geographic boundaries, latitudes, longitudes, and scales are indicated.

4. CONCLUSION

The new SPOL weather radars available in São Paulo and Espírito Santo are important new data sources to study specific dynamics and microphysics under continental and oceanic and urban and rural environments. For instance, the heat island effect in the metropolitan area of São Paulo (Fig. 5) produces very deep thunderstorms and is also influenced by a rich urban CCN boundary layer with distinct polarimetric variables as overall features with high values of Z_{DR} at lower levels and negative K_{DP} aloft. On the other hand, strong winds and turbulence over the shores of Espírito Santo seems to enlarger drops over the ocean and where maritime CCN is injected though in general shallower convection was observed during the summer of 2015. Further studies are being carried out to improve nowcasting tools based on richer databases now available at high spatial-temporal resolution.

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