HEAT ISLAND, SEA BREEZE AND HP THUNDERSTORMS IN METROPOLITAN AREA OF SÃO PAULO

Felipe Vemado

Augusto José Pereira Filho

LabHidro

Department of Atmospheric Science

Institute of Astronomy, Geophysics and Atmospheric Science, University of São Paulo

INTRODUCTION

The MASP is composed of 39 cities including São Paulo city and occupies an area of 8051 km^2 of the São Paulo State (SPS). In 2014, the population was close to 21 milion inhabitants, 50% of the total population of São Paulo State (SPS) according to the Brazilian Institute of Geography and Statistics (IBGE).

SB fronts reach MASP (Fig. 1) about 50% of the days as can be seen in. Oliveira and Silva Dias(1982) indicated wind veeringfrom NE to SE, backing from NW to SE and intensification of the SE wind. According to Pereira Filho et al. (2005), weak synoptic conditions, air temperature above 30°C and dew point above 20°C in the afternoon hours tend to yield greater rainfall amounts over MASP due to heat island effect.

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A total of 125 SB events related to severe rainfall occurred in three and half years. The data used to analyze were GOES IR, surface weather variables, radio-soundings, weather radar reflectivity (Z), CAPPI 3 km from São Paulo radar and the GFS.

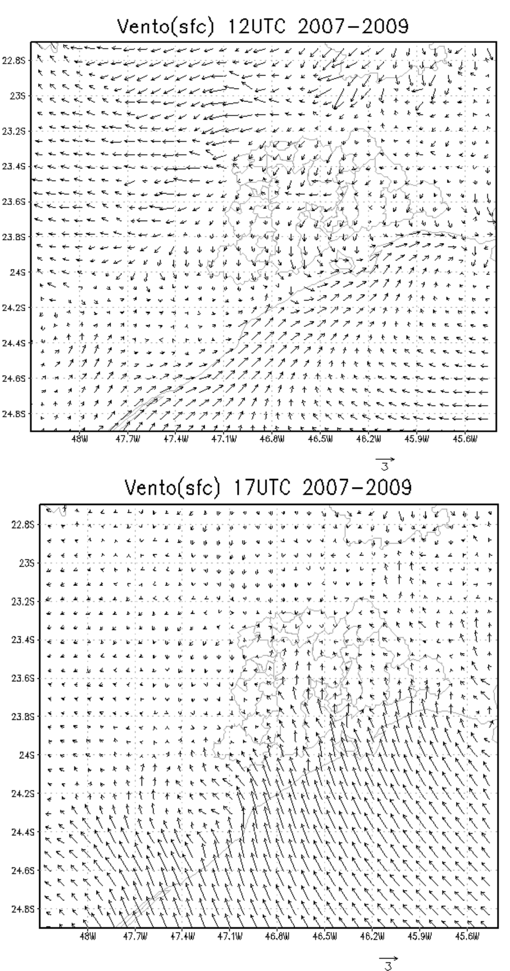

Figure 1: Wind field average at 1200 UTC and 1700 UTC for 2007 to 2009. Geographic boundaries in MASP are indicated.

The figure 1 shows the mean wind field for all day between in 3 year (2007, 2008, 2009). As 50% of the days occurs SB circulation. It appear in the mean wind field.

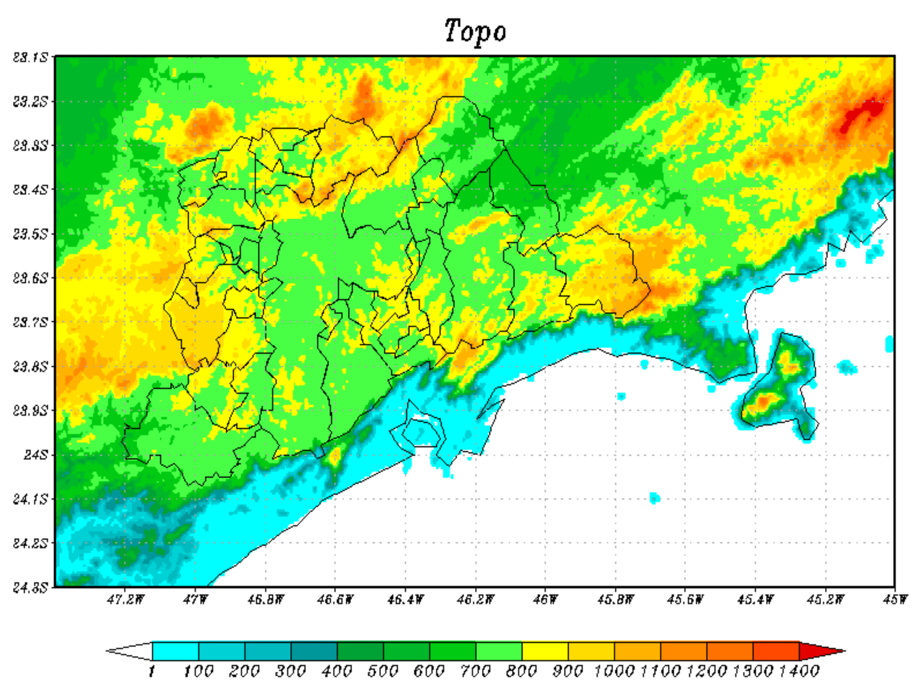

Figure 2: MASP Topography. Latitudes, longitudes and political boundaries are indicated. Altitude (m) in color scale.

RESULTS AND DISCUSSION

The Marshall and Palmer (1948) ZR relationship was used to estimate rainfall intensity from measurements of Z. SB events with rainfall intensity greater than 30 mm h^{-1} in 10 minutes anywhere in the MASP were selected.

Soundings, surface data, weather radar and satellite images were used to identified storms caused by SB and UHI. In 74% of SB events, the wind backed from NW to SE between the early afternoon and late afternoon. The mean air temperature decreased from 29.7° C to 25.8 °C, and dew point, increase from 17.9° C to 20.7° C with the SB incoming.

Fig. 3 (Left) shows a 600 mm high rainfall accumulation right over MASP associated to the UHI under SB events. This is downstream from maximum urbanization area in the MASP where NDVI is low (Fig. 4 – Right).

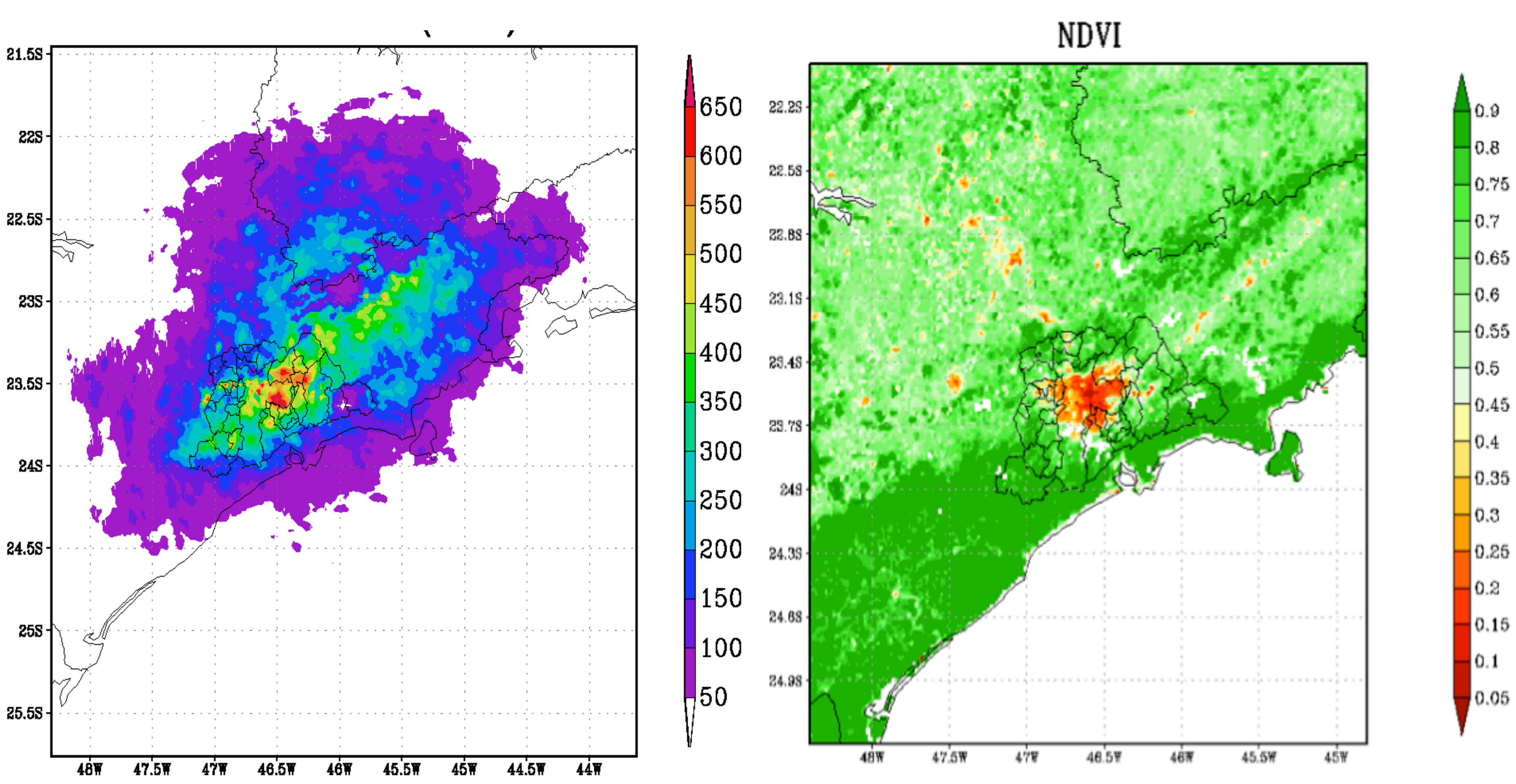

Figure 3: Rainfall accumulation (mm) estimated with the São Paulo weather radar for all SB events in 2005 (left) and Normalized Difference Vegetation Index (NDVI) in the same region (right).

The average fields of all SB simulations indicate the mean circulation patterns. Fig. 4 shows 850-hPa wind field average in the early afternoon (NW) and late afternoon (SE). A clockwise rotation of the wind occurs during the day, consistent with surface measurements (not shown).

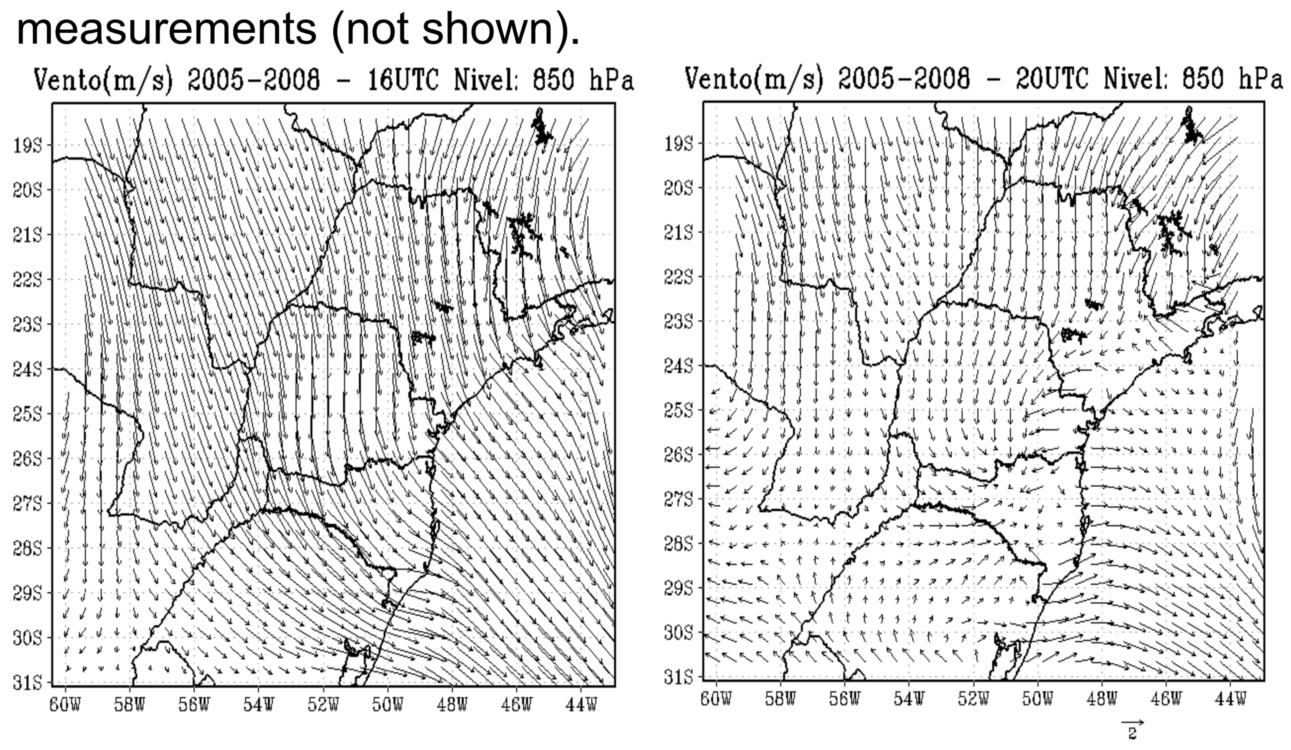

Figure 4: ARPS simulated mean 850-hPa wind field for all SB events between 2005 and 2008. Latitudes, longitudes, and political boundaries area indicated.

At the upper levels the pattern is also coincident with the Bolivian high pressure system (not shown). The ARPS simulations also produced maximum precipitaion along the coastline passing over the MASP (not shown).

The 11 JAN 2010 SB episode showed that without the urban heat island, the total precipitation over MASP is significantly smaller. The sea breeze interacts with heat island circulations and triggers convective cells over MASP as depicted in Fig.7. The ARPS simulations indicated that without the urban heat island, deep convection is not triggered as depicted in Fig. 5

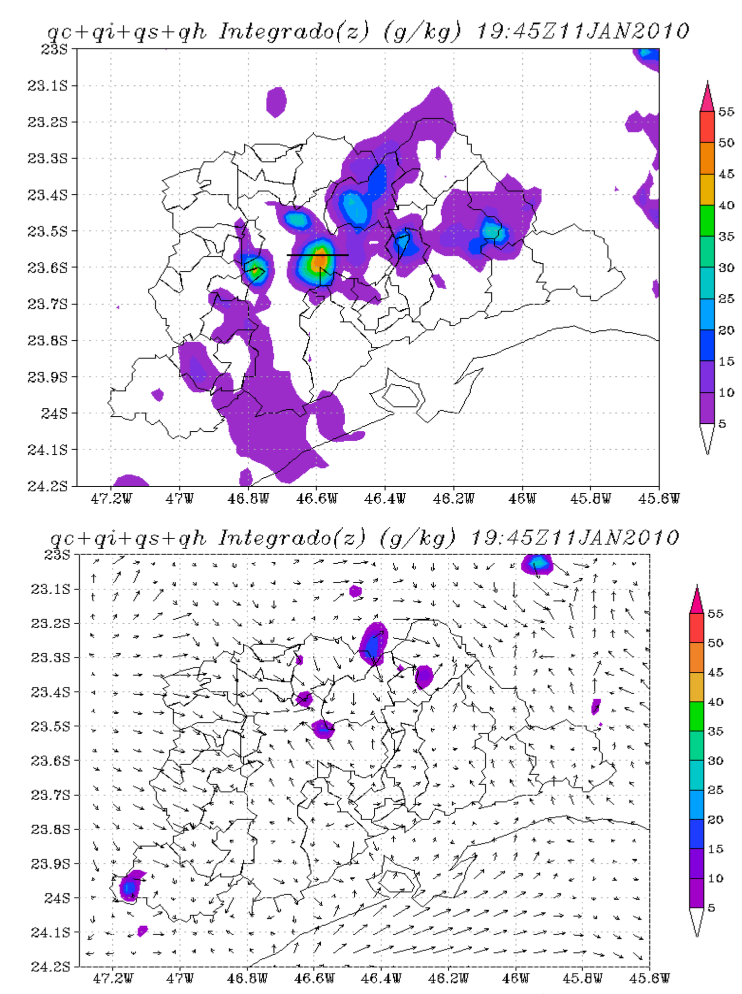

Figure 5: The ARPS vertical integrated cloud water, snow, hail and ice crystals (g/kg) at 1945 UTC on 11 January 2010 for a control run (top) and without UHI (bottom).

Deeper SB fronts tend to increase boundary layer shear and horizontal vorticity that support stronger updrafts able to make the layer unstable to maintain deep convection. Advancing cold fronts in Southern Brazil tend to increase NW warm advection and shear to support a deeper SB front as outlined in Fig 6.

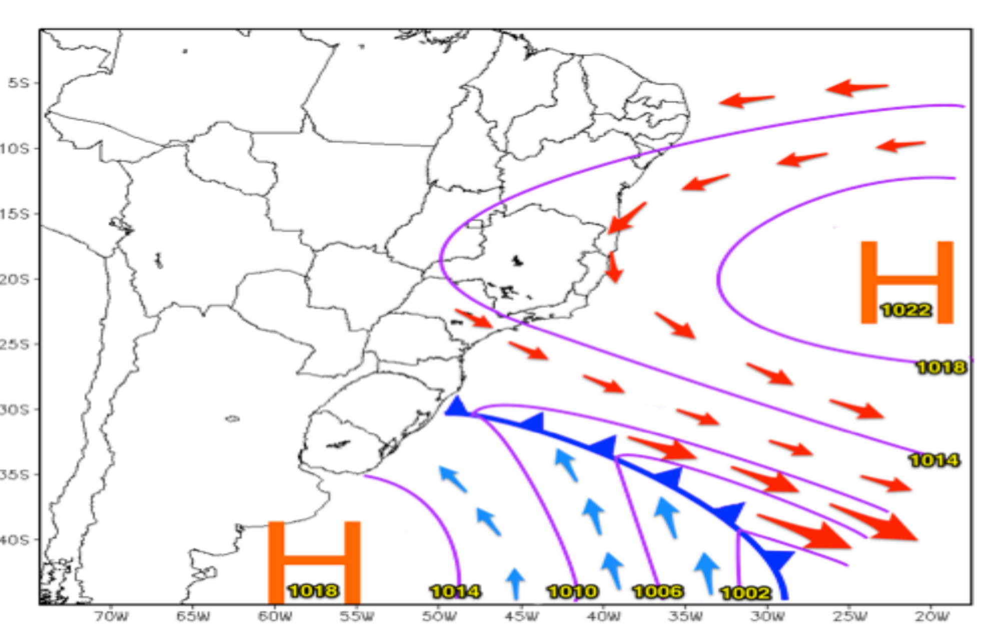

Figure 6: Schematics or a typical synoptic condition associated with deep convection development over MASP caused by intense SB and UHI circulation. Isobar (hPa) and winds and frontal boundaries are indicated. Source: Vemado and Pereira Filho (2015)

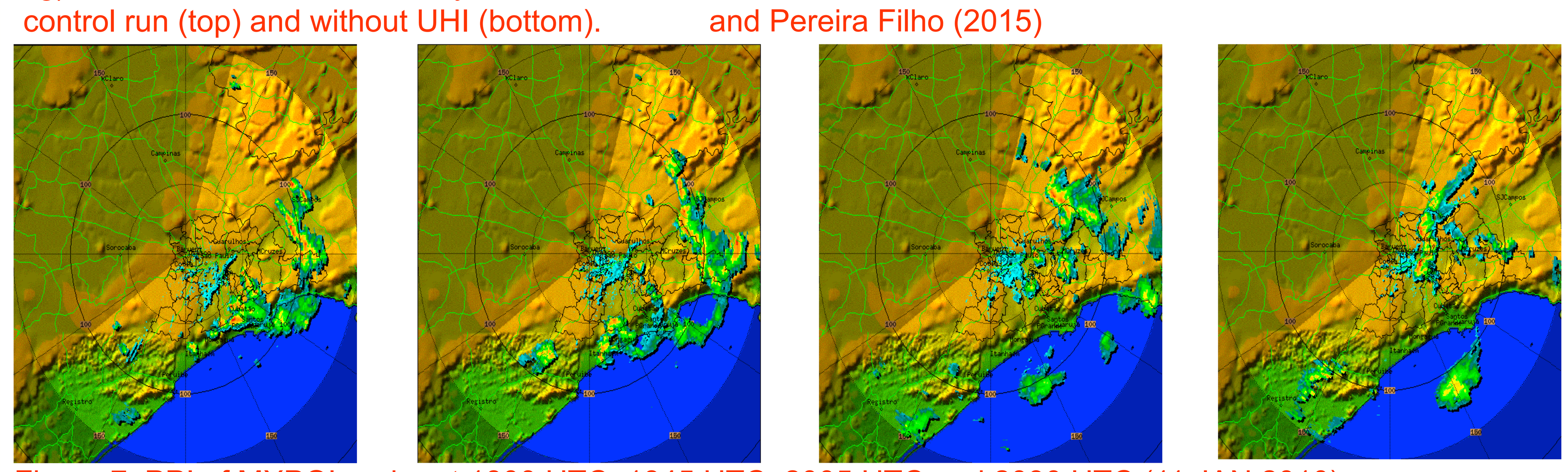

Figure 7: PPI of MXPOL radar at 1800 UTC, 1845 UTC, 2005 UTC and 2030 UTC (11 JAN 2010).

CONCLUSION

The UHI tends to increase precipitation over MASP especially in summer. The warmer urban environment intensifies thunderstorms and given its impervious urban soil conditions, flash floods, high wind gusts and other impacts are common. Deeper SB fronts seem to be associated to cold fronts in Southern Brazil. Thicker SB circulation results in deeper boundary layer shear.

The SB interacts with the MASP heat island circulation and generates deep thunderstorms. Thus, the thickness of SB can be used in nowcasting severe convection in MASP. The MXPOL radar (Pereira Filho, 2012) can be used in conjunction with the ARPS system for that purpose to adequately estimate the SB thickness and thermodynamics to produce more accurate forecasts.

REFERENCES

Available in the paper.