NOWCASTING SEA BREEZE CIRCULATION AND RAINFALL IN SÃO PAULO

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Abstract

Sea breeze events (SB) are common in Metropolitan area at São Paulo (MASP). Particularly, in the summer, SB triggers over MASP deep convection, heavy rainfall, wind gusts, hail and lightning. Oliveira and Silva Dias (1982) method was used to identify SB events. SB events between 2005 and 2008 were analysed by means of surface and upper air measurements, weather radar, satellite and numerical modelling. The annual rainfall partition due to SB was estimated using the São Paulo weather radar. The results indicate a core of maximum rainfall accumulation of 600 mm over MASP. The ARPS system was used to simulate SB with control and specific runs. Results suggest significant impact of surface cover on rainfall distribution. MXPOL weather radar measurements of SB were important in detecting and nowcasting SB inflow at very high spatial- and temporal resolution.

1. INTRODUCTION

SB circulation occurs more than half of the days in MASP. Oliveira and Silva Dias (1982) indicated wind veering from NE to SE, and backing from NW to SE. Pereira Filho et al. (2005) studied SB and heat island effects on rainfall in MASP. 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.

These local circulations were simulated with the ARPS system (Xue et al., 1995) at 12-km spatial resolution for all days with deep convection associated to SB in between January 2005 and April 2008. Near surface average conditions were estimated as well as mid and upper level variables such as CAPE e LI.

Simulated wind fields were compared to available weather stations. Model thermodynamic indexes were compared to soundings. Furthermore, the 11 JAN 2010 SB event was used to study soil cover impacts on in the rainfall by changing urban surface (desert) to rain forest conditions. In some instances, the SB front propagates over MASP without triggering convection, even in unstable (e.g, 21 FEB 2010). The simulations indicated significant differences between these days.

2. SEA BREEZE CIRCULATION

A total of 125 SB related severe rainfall events occurred in 3.5 years. In 74% of them, the wind backed from NW to SE between the morning and afternoon. The mean air temperature decreased from 29.7º C to 25.8º C, and dew point increased from 17.9º C to 20.7 ºC with the SB incoming. The average SB front speed was 9 m s^{-1} at 1800 UTC over IAG in MASP.

Synoptic conditions indicated the presence of the Bolivia High circulation over Brazil, and at low levels, the South Atlantic subtropical high with Northern winds in São Paulo State in the morning. SB circulation is active throughout the coastline of Brazil in the afternoon. A moving cold front in Southern South America is observed. CAPE and the LI are 2000 J kg^{-1} and -4.0ºC, respectively, for extreme SB events.

3. RADAR MEASUREMENTS

The results indicate a core of maximum rainfall accumulation of 600 mm over MASP associated to SB and heat island circulation (Fig 1). The maximum is downstream from the MASP which agrees with other research results. It is caused by sensible heat advection.

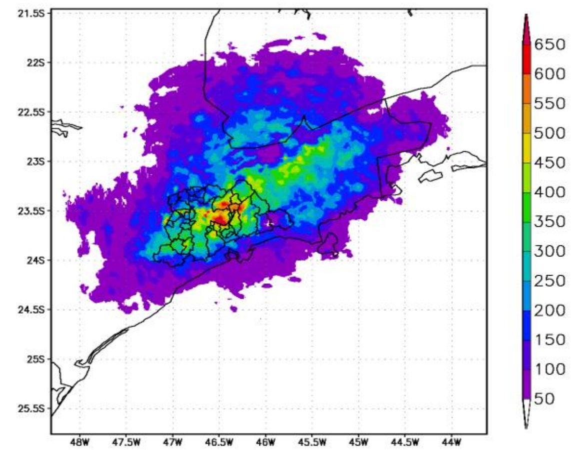

Figure 1: Rainfall accumulation (mm) estimated with the São Paulo weather radar for all SB events in 2005.

4. SEA BREEZE MODELING

The 11 JAN 2010 SB episode showed that without the urban heat island, the total precipitation over MASP is smaller. The sea breeze interacts with heat island circulations and triggers convective cells over MASP as depicted in Fig. 2. The ARPS simulations indicated that without the urban heat island convection yields less intense updrafts and smaller cells since the surface sensible heat flux is reduced.

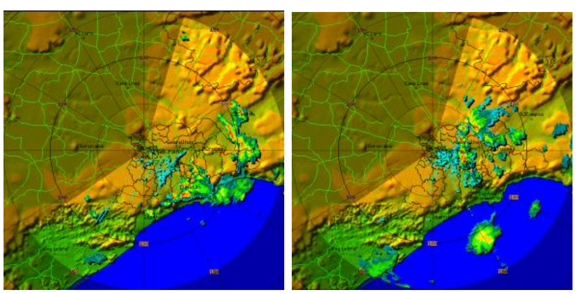

Figure 2: PPI of MXPOL radar at 1800 UTC (left) and 2030 UTC (right).

The depth of the SB front on 21 FEB 2010 was 800 m, while for the 11 JAN 2010 episode was 1600 m. The first did not produced significant updrafts and convective cells while the second did. Deeper SB fronts tend to increase boundary layer shear and horizontal vorticity to support upright and stronger updrafts reaching the top of the boundary stable layer to trigger and maintain deeper convective cells. On the other hand, advancing cold fronts in Southern Brazil tend to increase NW warm advection and shear to support a deeper SB front.

5. CONCLUDING REMARKS

The urban heat island tends to increase precipitation over MASP in summer. The warmer urban environment intensifies thunderstorms and given impervious urban soil conditions, flash floods, high wind gusts and other impacts are common. The thickness of SB front seems to be associated to a cold front in Southern Brazil.

Thicker SB layer result in deeper shear with higher moisture contents. 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) is being used in conjunction with the ARPS system for that purpose to adequately estimate the SB thickness and thermodynamics to produce more accurate forecasts.

6. REFERENCES

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