



UNIVERSITY OF SÃO PAULO
INSTITUTE OF ASTRONOMY, GEOPHYSICIST AND ATMOSPHERIC
SCIENCES
DEPARTMENT OF ATMOSPHERIC SCIENCES

***NOWCASTING SEA BREEZE CIRCULATION AND RAINFALL IN
SÃO PAULO***

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INTRODUCTION

Metropolitan Area of São Paulo

- SB circulation occurs more than half of the days in MASP
- 20 millions inhabitants; 50% of state total;
- (PEREIRA FILHO, 2000, 2002, 2004):** SB circulation develop SCM's; 65% floods, 13 per year;

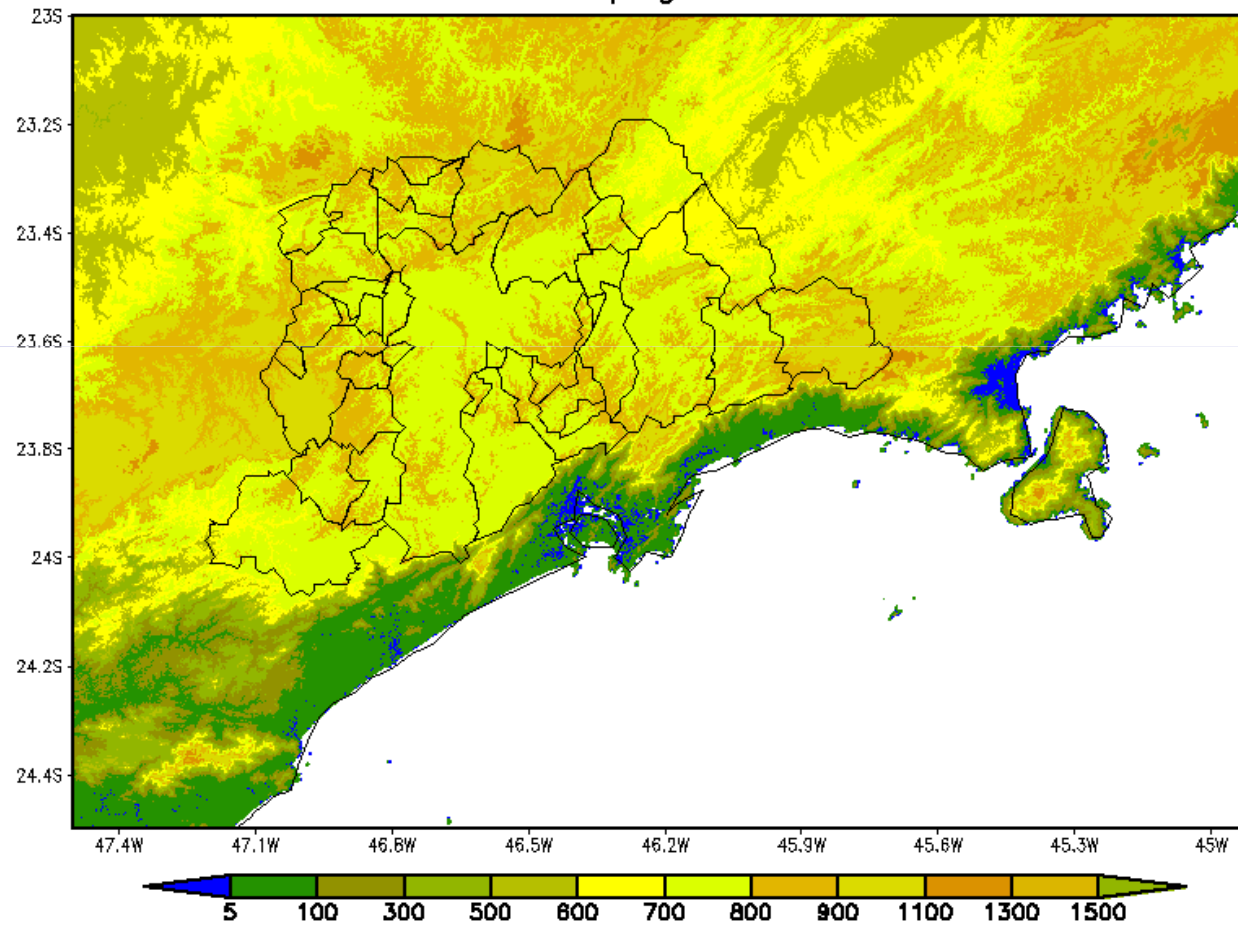
INTRODUCTION

SB and MASP

- **OLIVEIRA AND SILVA DIAS (1982):** NE-SE; NW-SE; SE-SE; 13 e 14 LT; rain preceded for change of the wind, increase in the moisture reason
- Rain preceded for change of wind direction, increase of dew point, temperature fall (summer);
- Topography intensifies SB (slope, length, localization ...) (**ATKINSON,1981**);

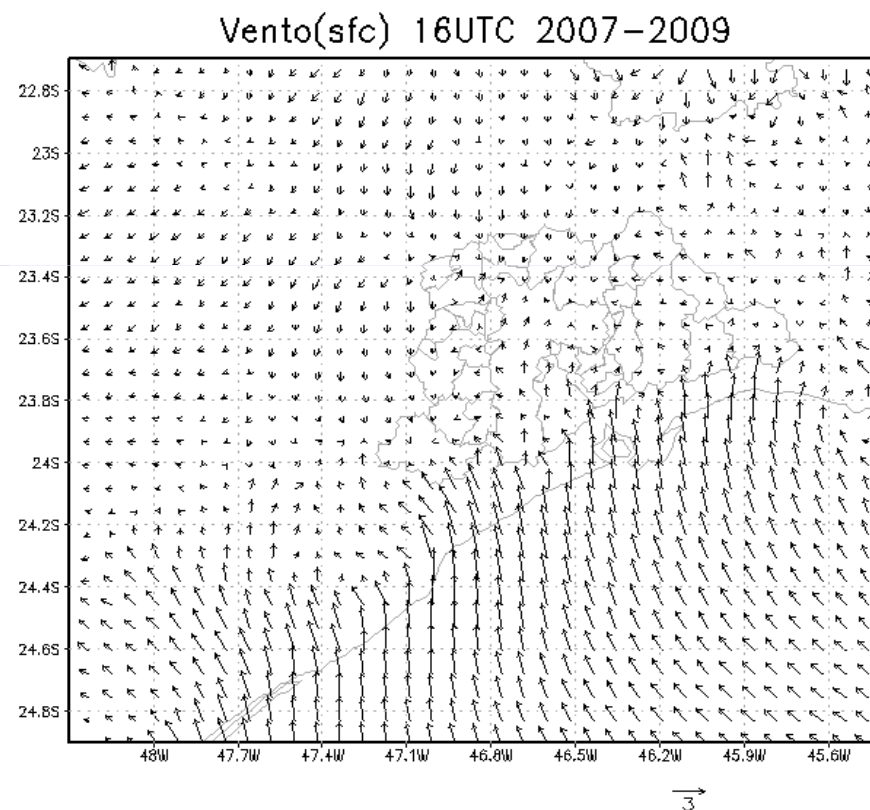
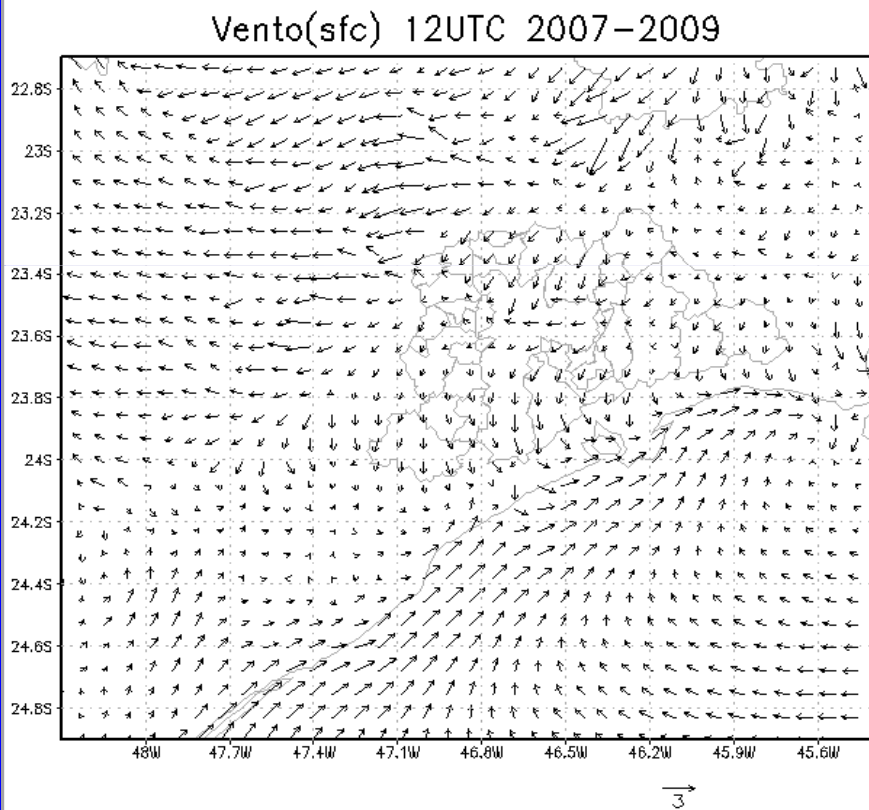
INTRODUCTION

Topografia



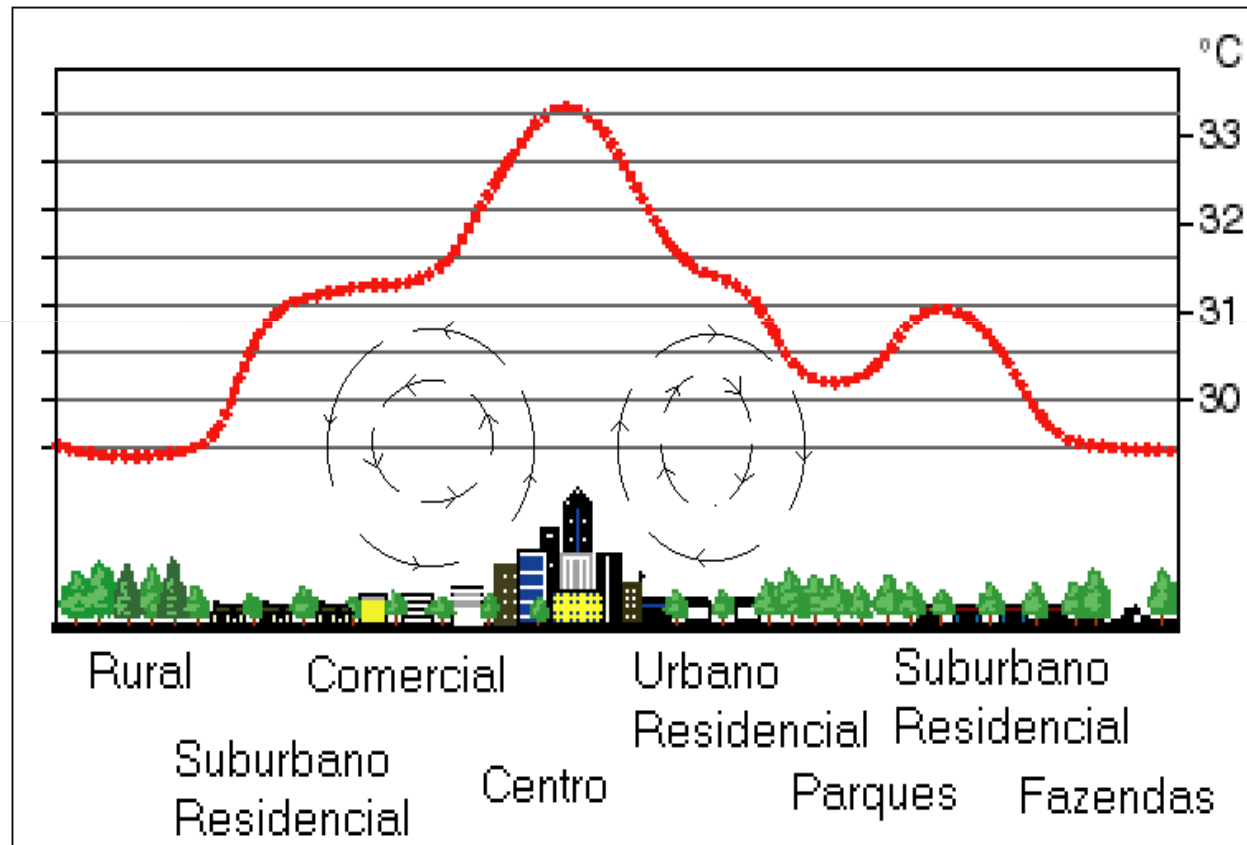
INTRODUCTION

SB and MASP



INTRODUCTION

Urban Heat Island



Source: Heat Island Group – Livermore National Labs

METHODOLOGY

- SB events between 2005 and April, 2008; 1216 days;
- Satellite images GOES-8 e GOES-12;
- Surface station, Sounding;
- Weather Radar (SP) CAPPI 3 km;
- MXPOL -> Z;
- Analysis GFS;
- Numerical Simulations (ARPS) - 12 km e 2 km;

METHODOLOGY

- BM de 2005 a 2008

Surface Stations: IAG in Água Funda, Airport of Campo de Marte and Congonhas.

Oliveira e Silva Dias (1982):

- 1 – Wind NE – SE;
- 2 – Wind NW – SE;
- 3 – Increase in SE intensity SE Wind;

Change in the wind, Increase in dew point and CAPPI $R > 30$ mm/h
> rainfall generated by the SB;

METHODOLOGY

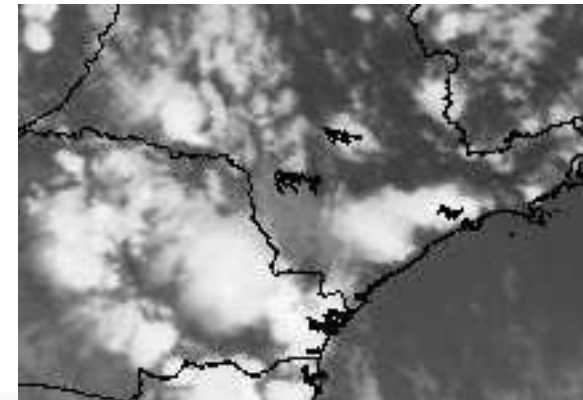
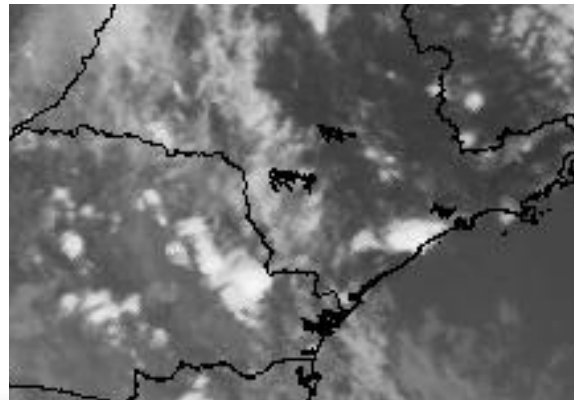
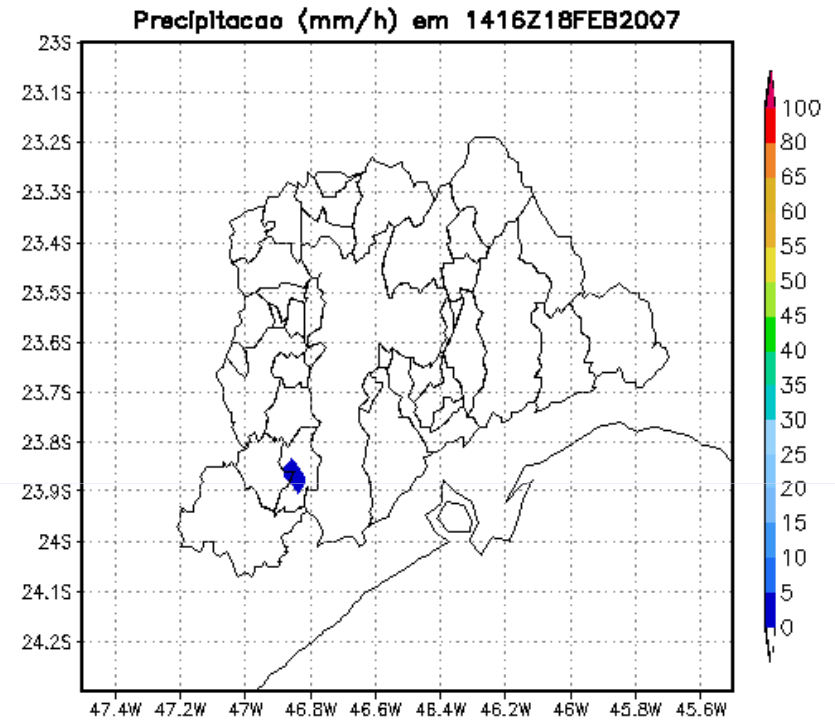
18/fev		
0 - 1	ENE	5
1 - 2	NE	4
2 - 3	NE	3
3 - 4	NE	3
4 - 5	NE	3
5 - 6	NNE	5
6 - 7	NE	5
7 - 8	NNE	6
8 - 9	NNW	6
9 - 10	NNW	8
10 - 11	NNW	9
11 - 12	NNW	9
12 - 13	NNW	8
13 - 14	SSW	10
14 - 15	NNE	11
15 - 16	NNE	4
16 - 17	ESE	5
17 - 18	SSE	5
18 - 19	ESE	3
19 - 20	SE	4

20 - 21	ESE	2
21 - 22	ESE	2
22 - 23	SE	3
23 - 24	S	2

1800UTC

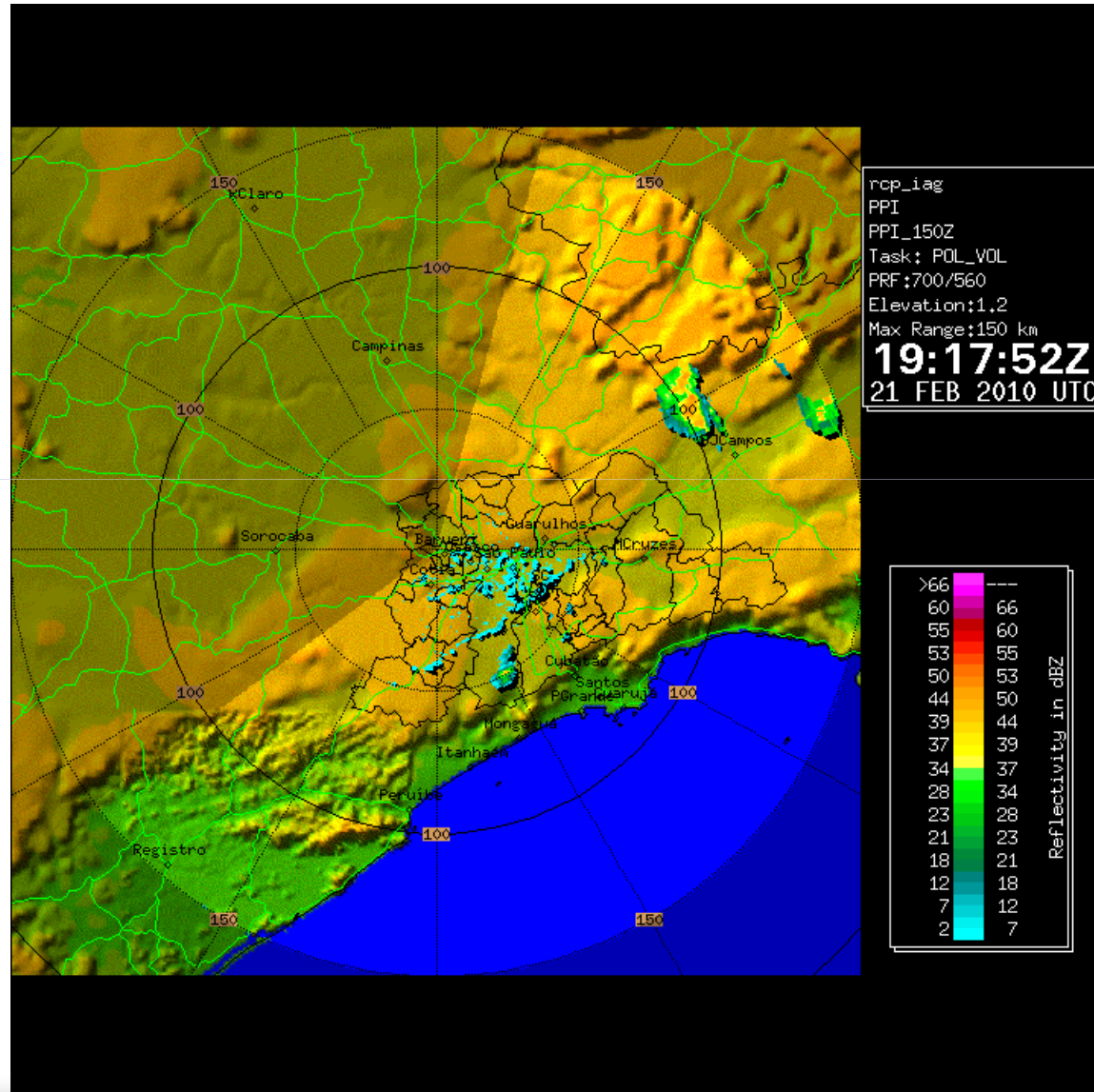
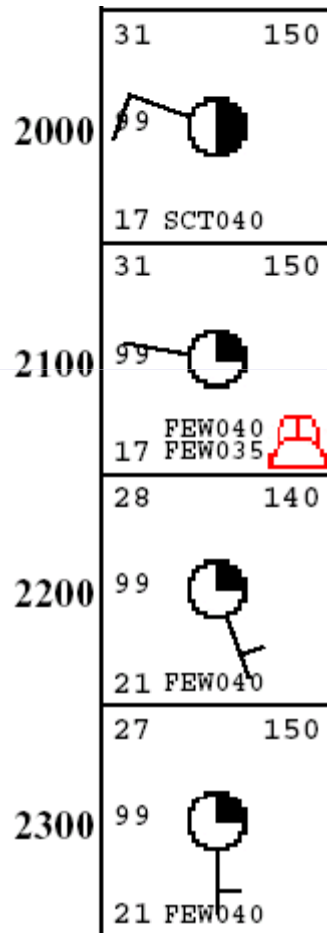
T – 32°C

T_d - 15.5°C – 20.9°C



METHODOLOGY

Airport of Campo de Marte
(REDEMET)



METHODOLOGY

- Domain:

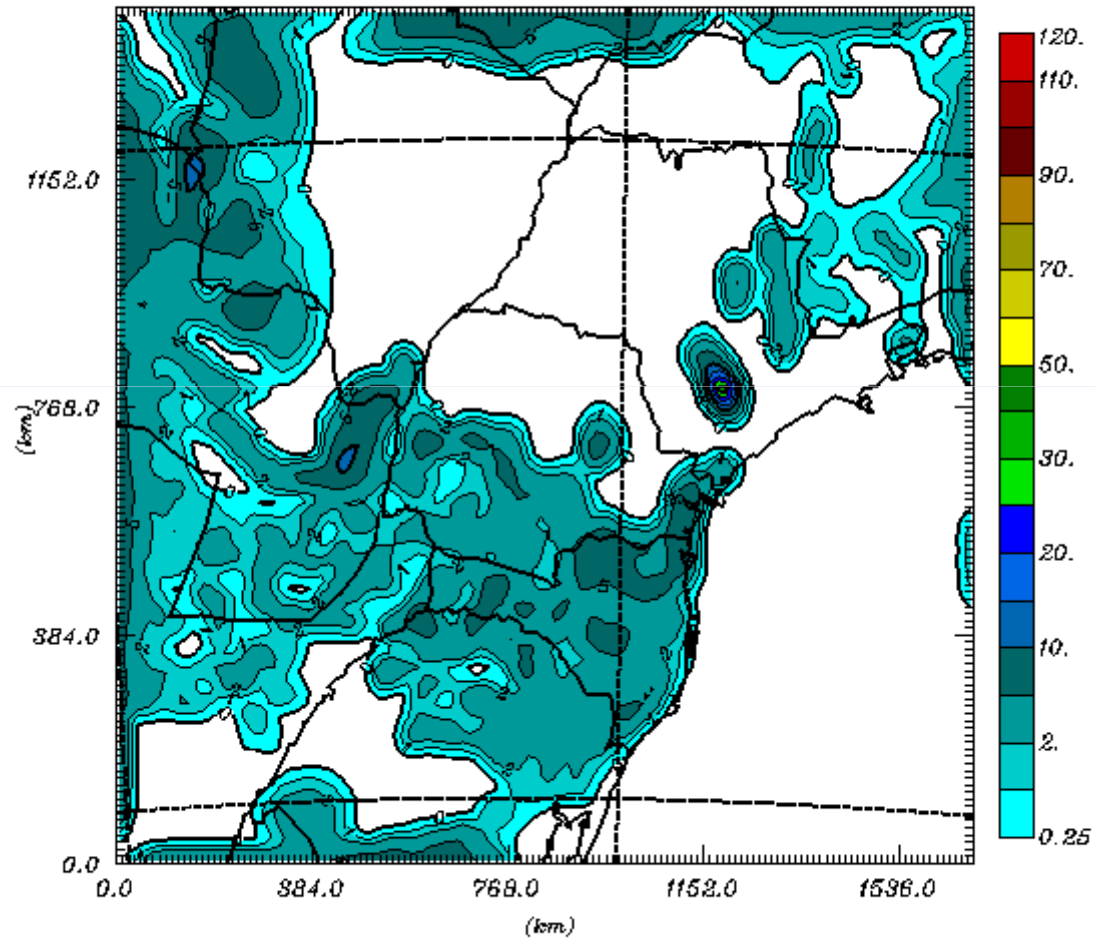
- 12 km – 143x123x42 (00Z e 12Z);
- 2 km – 163x143x42 (00Z e 12Z);

- Mean fields:

- WIND (1000, 850, 500 e 200 hPa);
- CAPE;
- Dew point (Td);
- Equivalent potential temperature;
- Lift index;
- Simulated rainfall;

METHODOLOGY

20:00Z Seg 11 Jan 2010

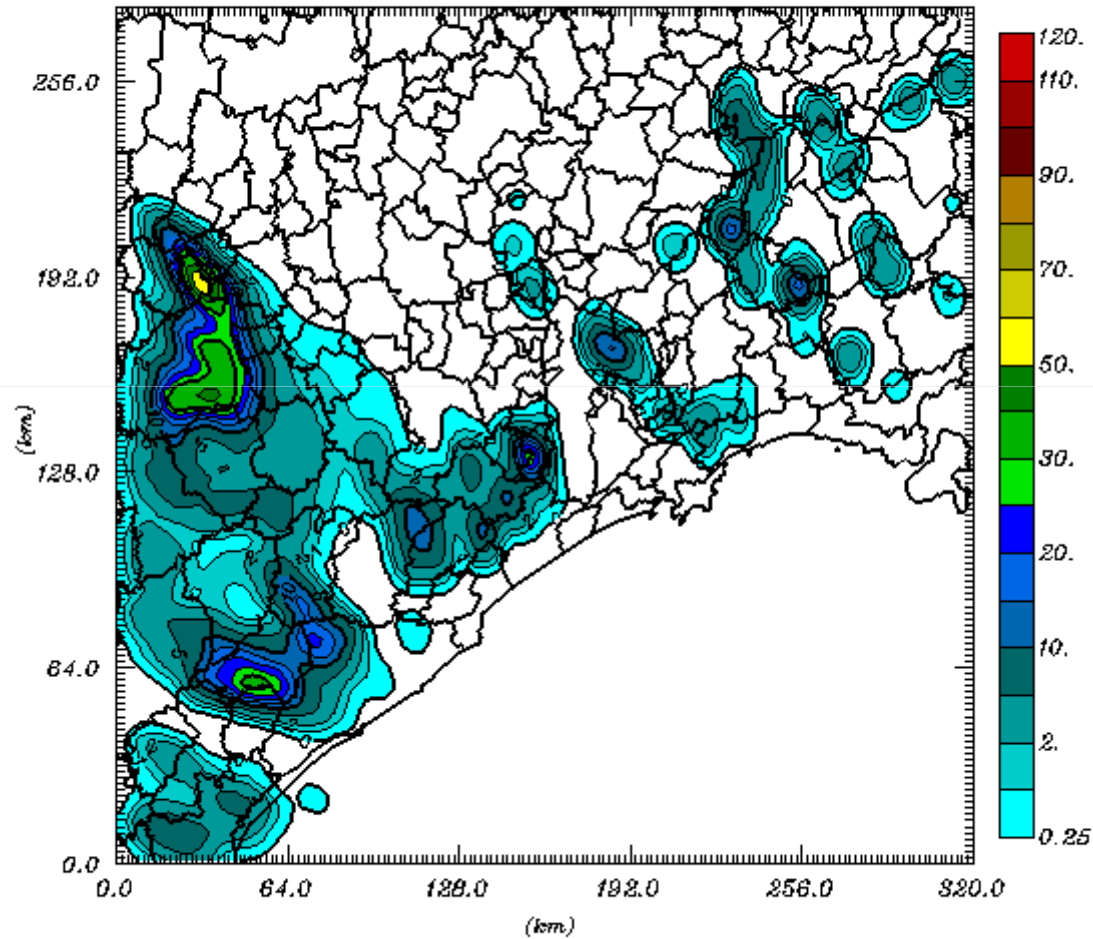


7200.0 s Accumulated Rainfall (mm, SHADED/CONTOUR)

MIN=0.00 MAX=31.5

METHODOLOGY

20:00Z Sep 11 Jan 2010

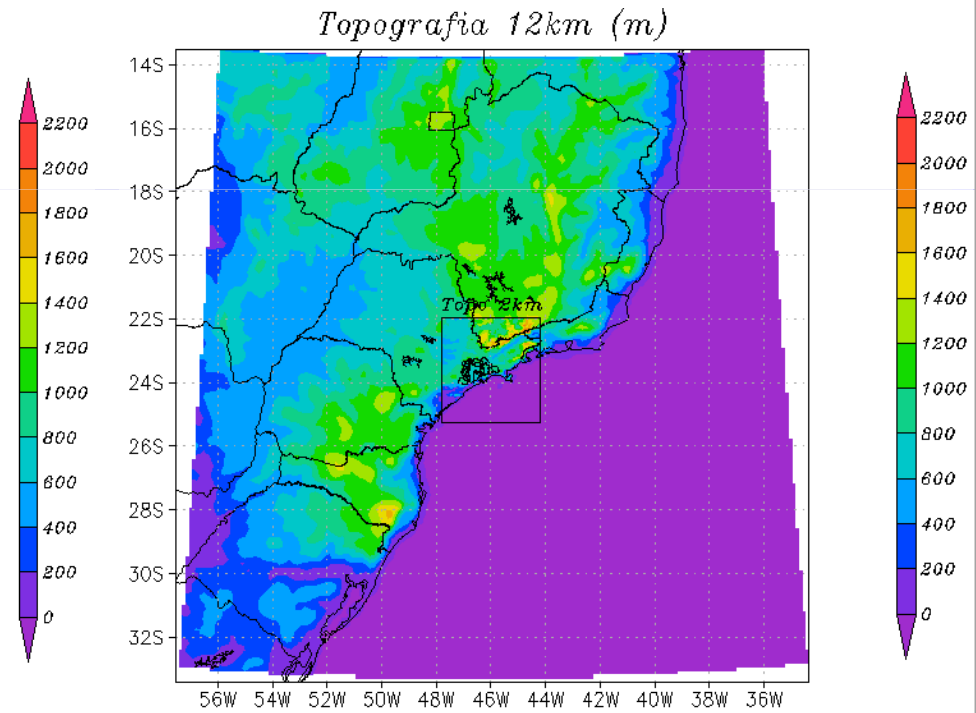
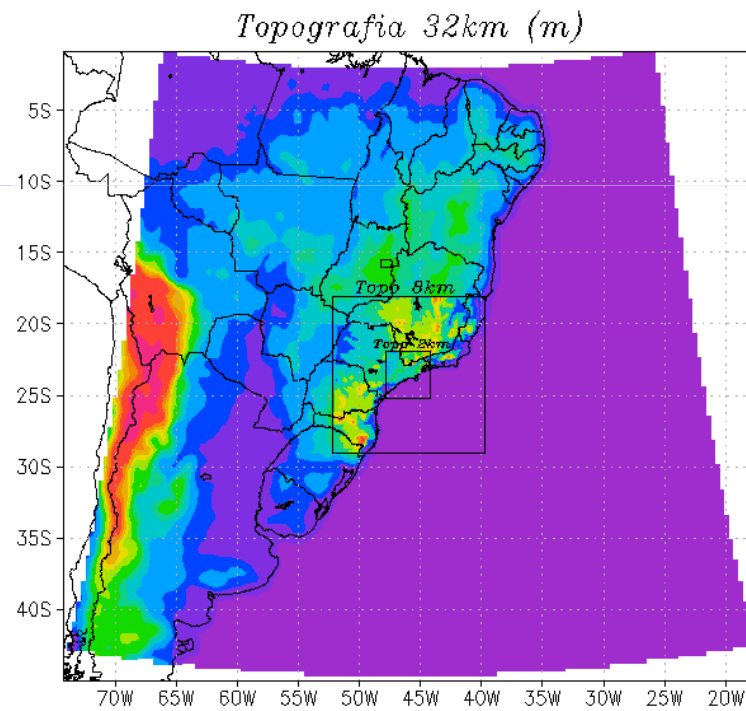


3600.0 s Accumulated Rainfall (mm, SHADED/CONTOUR)

MIN=0.00 MAX=59.3

METHODOLOGY

Experiments - Lambert Conformal



RESULTS

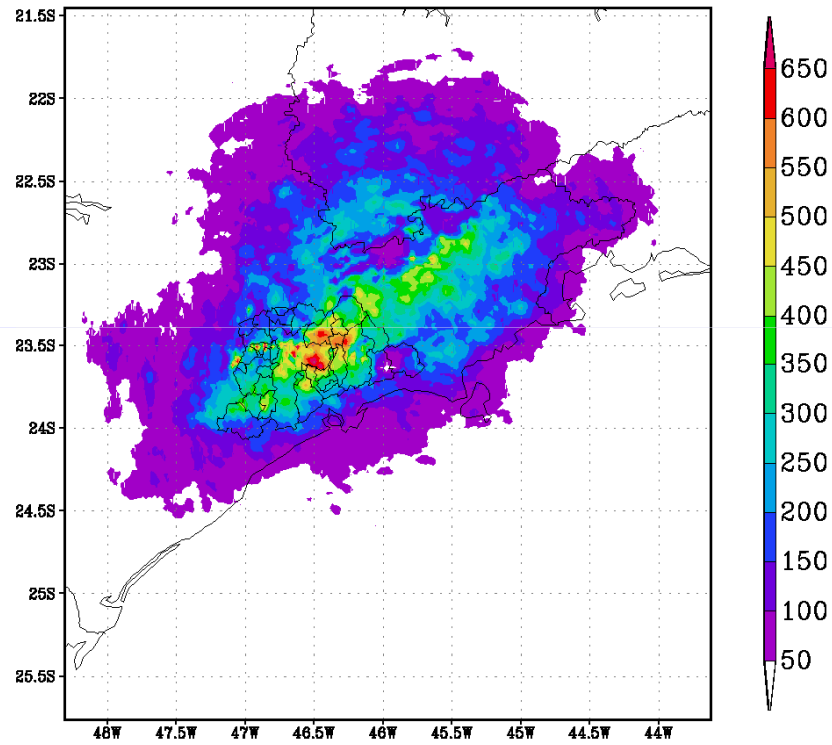
Horário médio de dias com BM e tempestade

YEAR	Campo de Marte Airport (SBMT)	Congonhas Airport (SBSP)	IAG-USP Station (Cientec)
2005 (46)	19:36UTC (17:36LT)	18:27UTC (16:27LT)	18:17UTC (16:17LT)
2006 (30)	19:12UTC (17:12LT)	18:15UTC (16:15LT)	18:09UTC (16:09LT)
2007 (30)	19:18UTC (17:18LT)	18:18UTC (16:18LT)	18:14UTC (16:17LT)

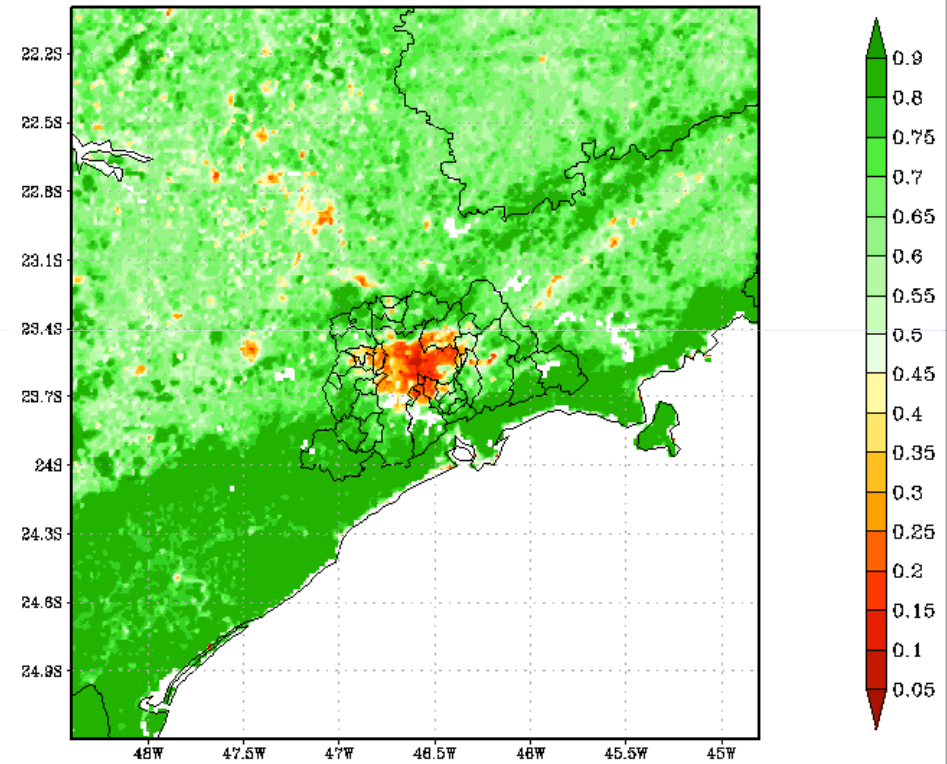
- 74%, NW to SE;
- 11%, NE to SE;
- 15%, increase in SE wind intensity ;
- Td, 17,9°C to 20,7°C (IAG);
- T, 28,6°C – 24,9°C (IAG) e 29,7°C to 25,8°C (Campo de Marte);

RESULTS

BM Acumulado (2005)

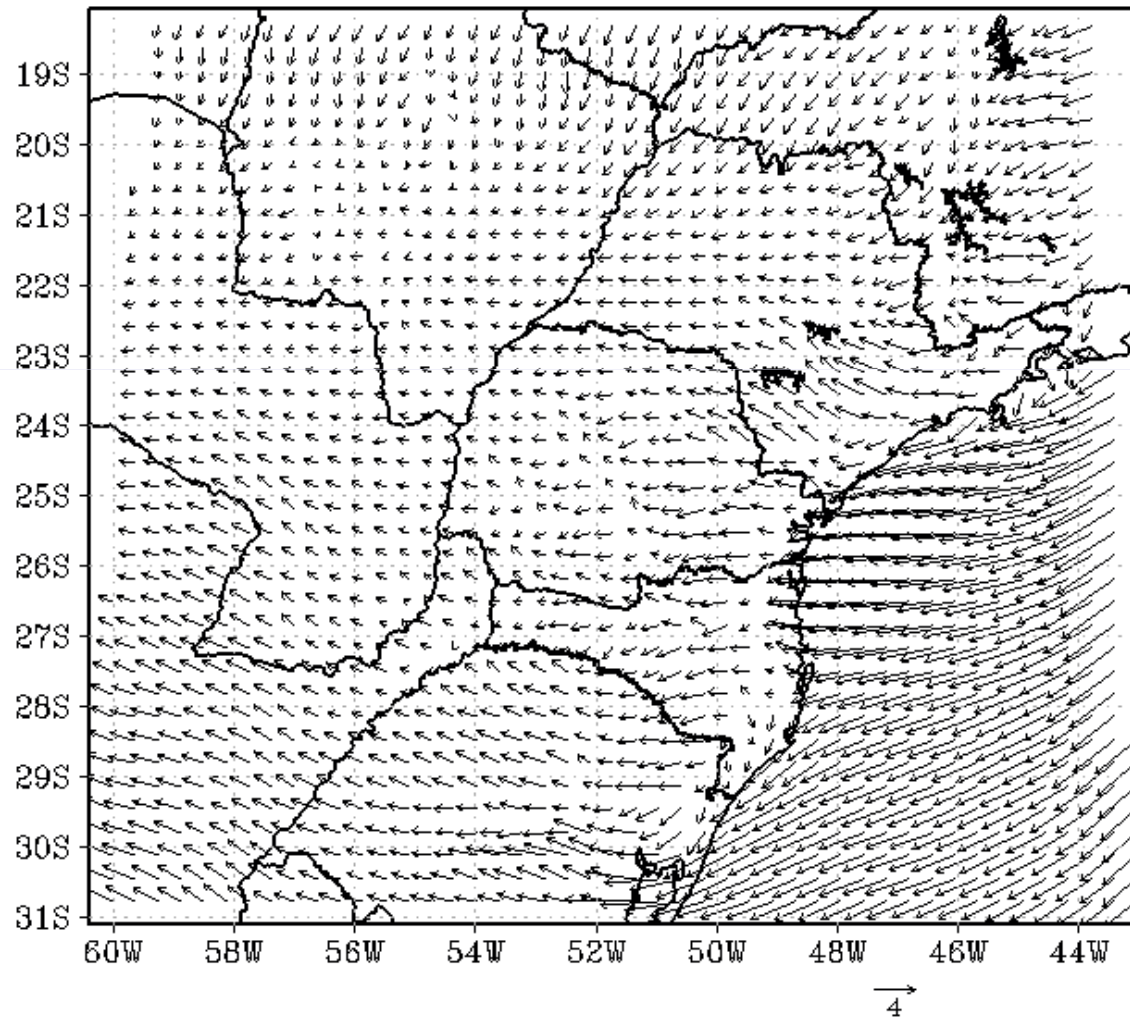


NDVI



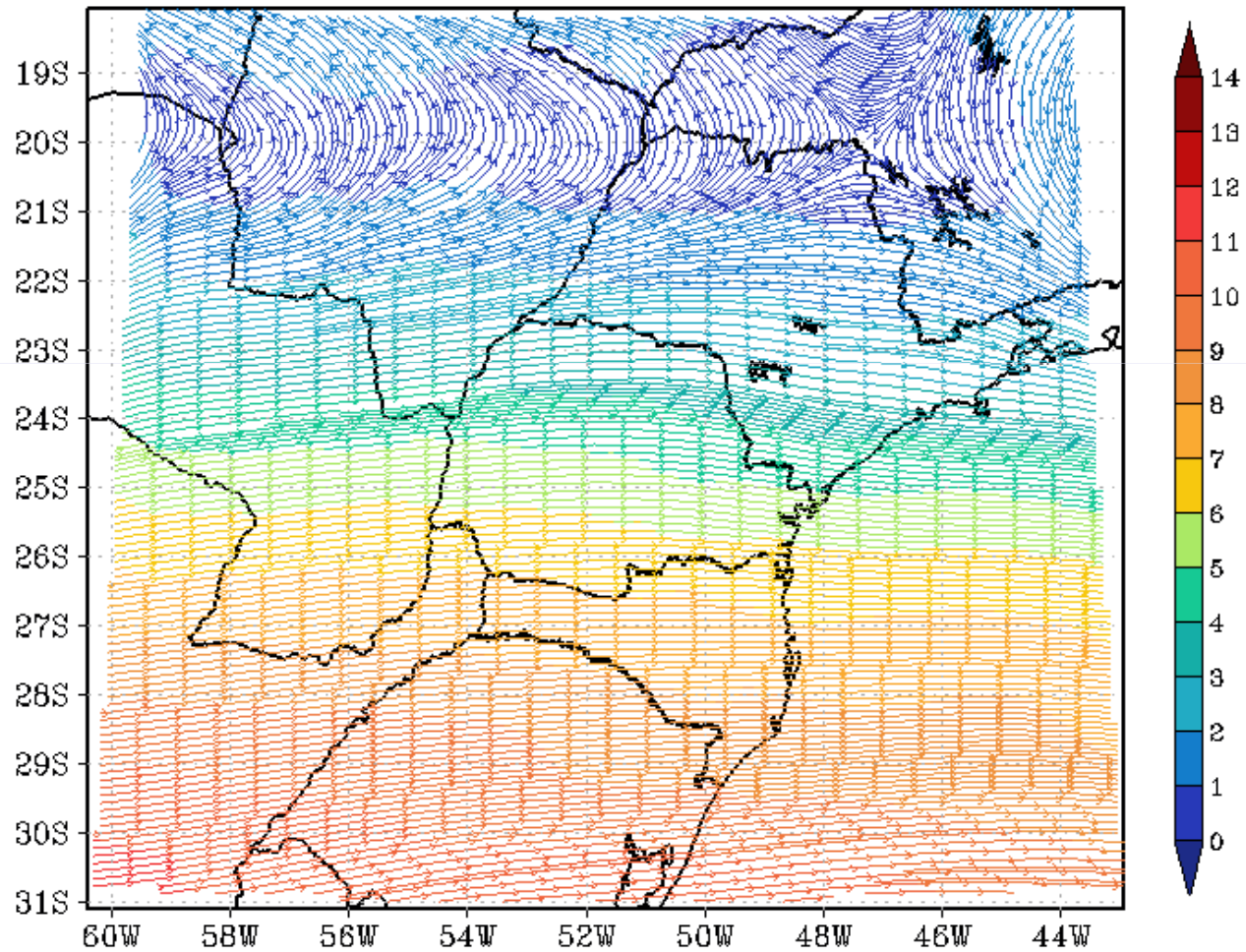
RESULTS

Vento(m/s) 2005-2008 - 00UTC Nivel: 1000 hPa



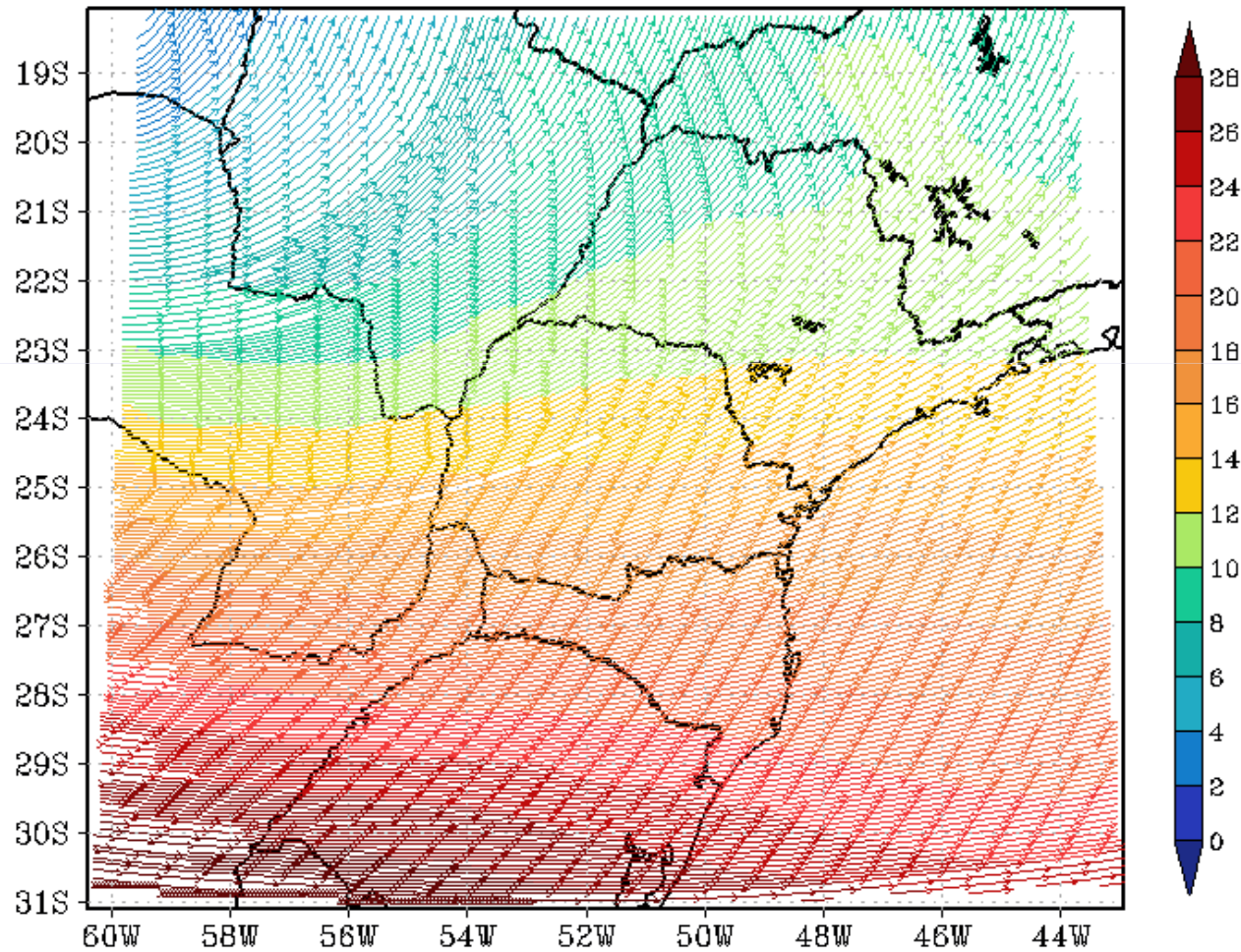
RESULTS

Vento(m/s) 2005-2008 - 00UTC Nivel: 500 hPa



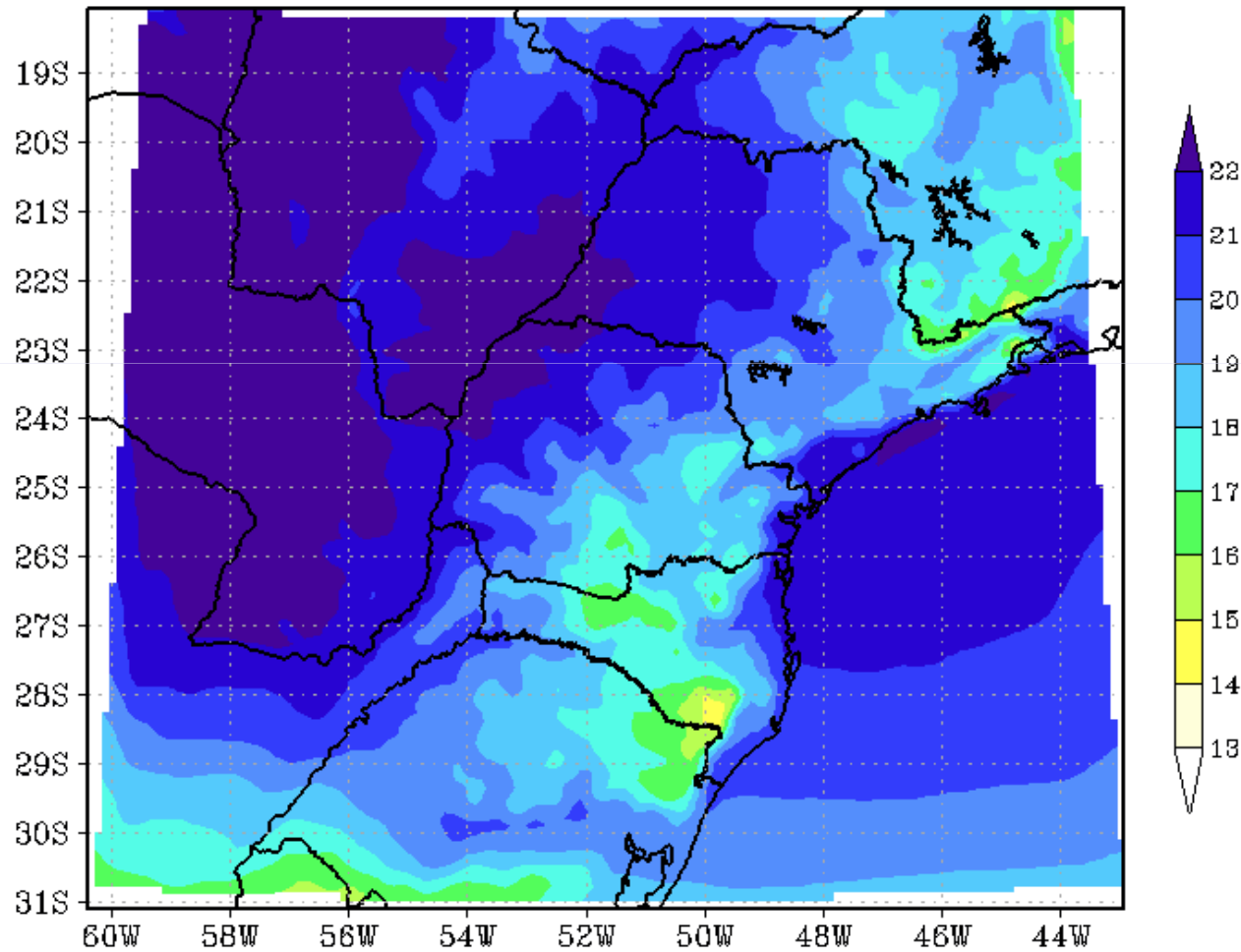
RESULTS

Vento(m/s) 2005-2008 - 00UTC Nivel: 200 hPa



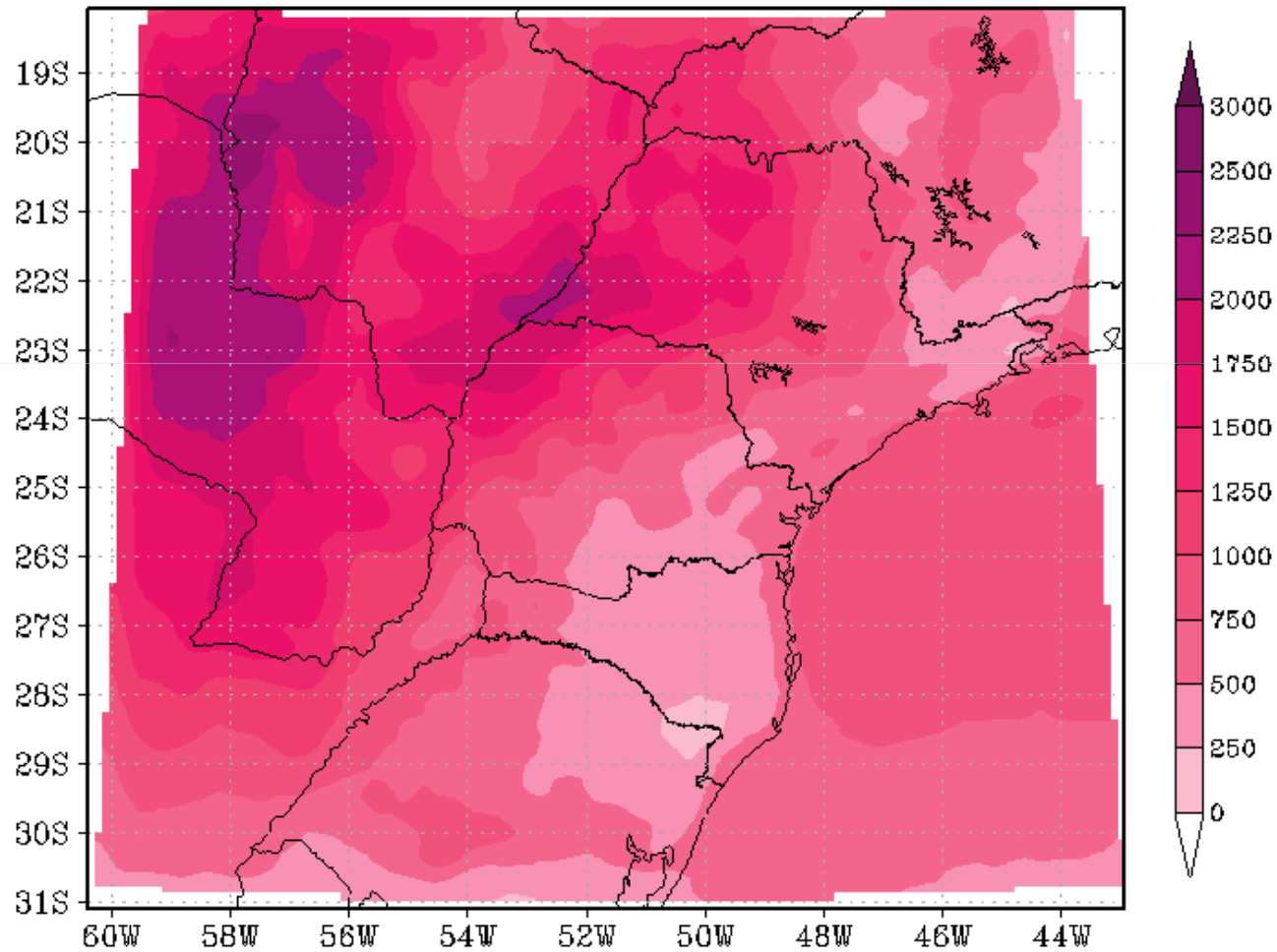
RESULTS

Ponto de Orvalho(C) 2005-2008 - 00ZUTC



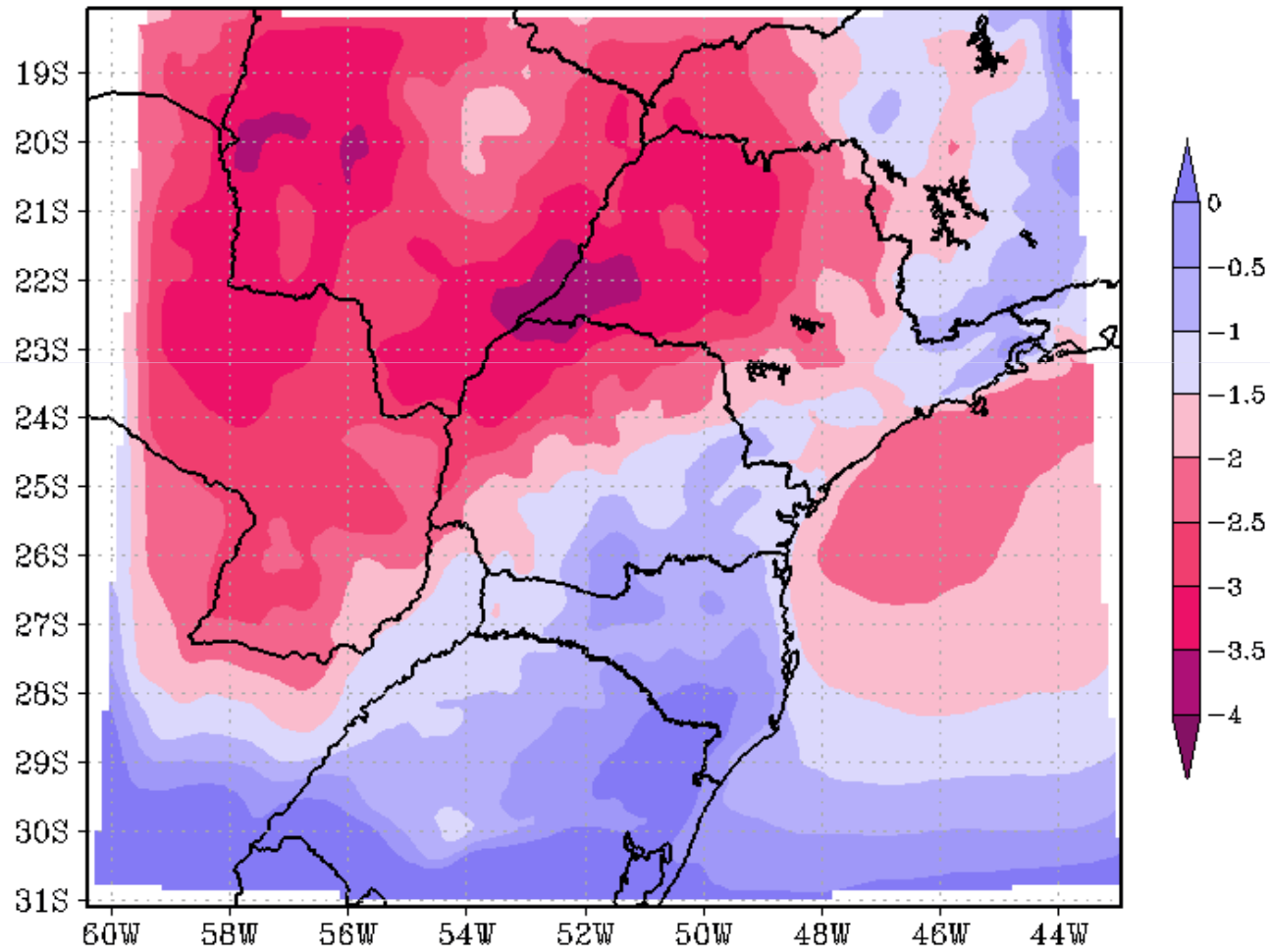
RESULTS

CAPE(J/Kg) 2005-2008 - 00UTC



RESULTS

IL 2005-2008 - 00ZUTC



RESULTS

Sounding versus Numerical Simulation

- CAPE: 616 J kg^{-1} x 559 J kg^{-1} ;

- LI: $-2,2 \text{ }^{\circ}\text{C}$ x $-1,5 \text{ }^{\circ}\text{C}$;

RESULTS

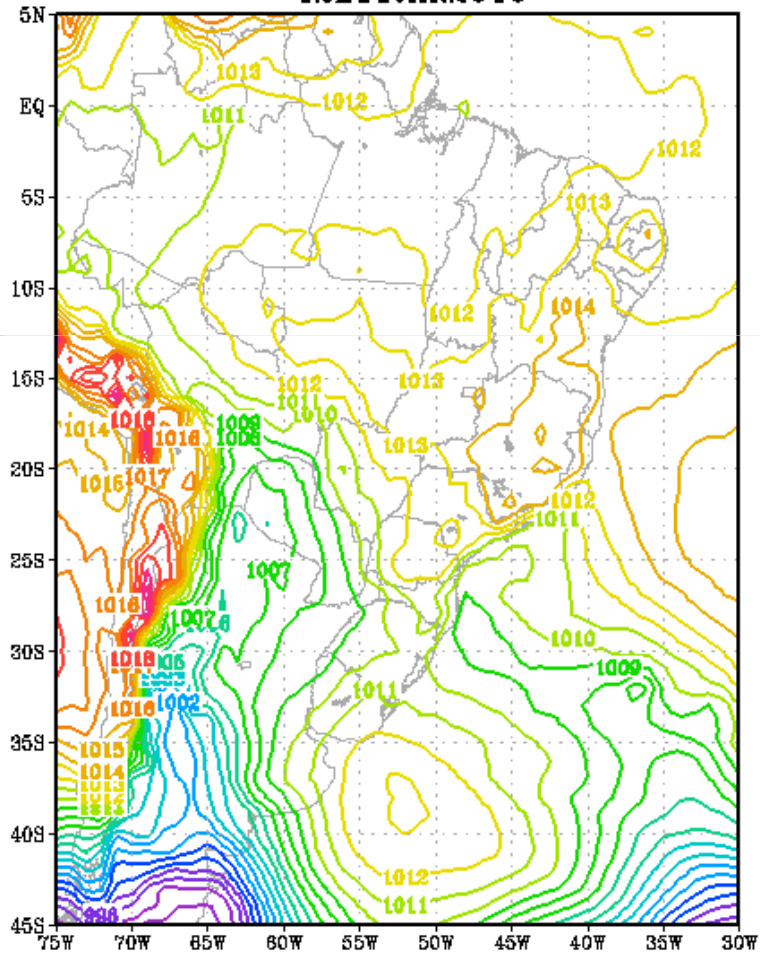
January, 11 2010

- High accumulation of rainfall;
- SB, HI and synoptic circulation;

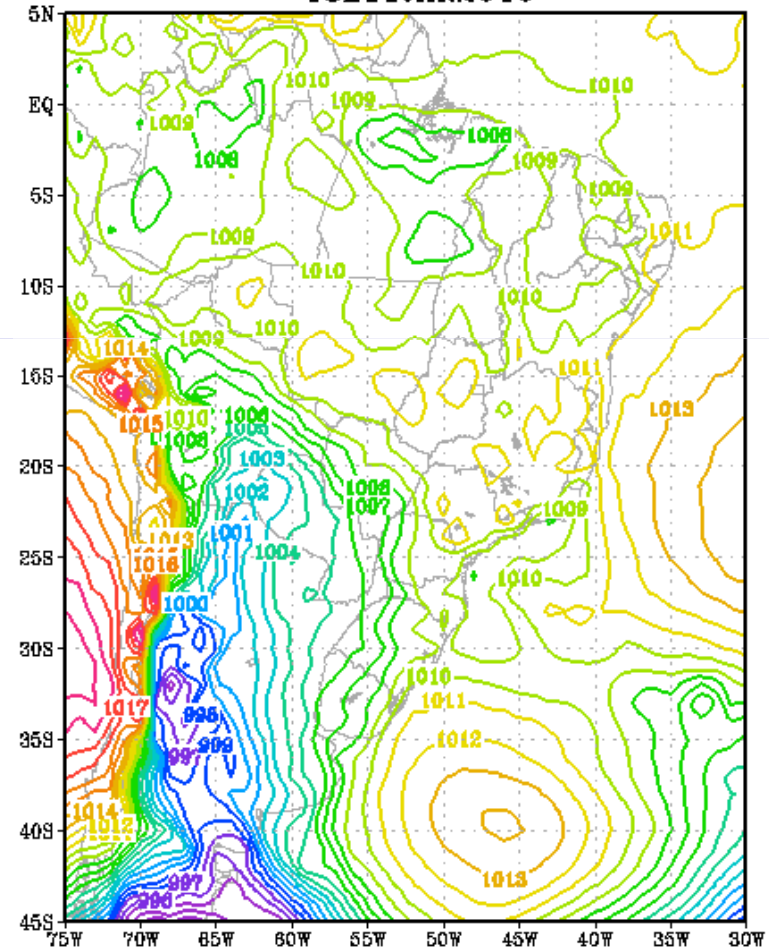
RESULTS

GFS

Pressao Reduzida ao Nivel do Mar (hPa)
12Z11JAN2010



Pressao Reduzida ao Nivel do Mar (hPa)
18Z11JAN2010

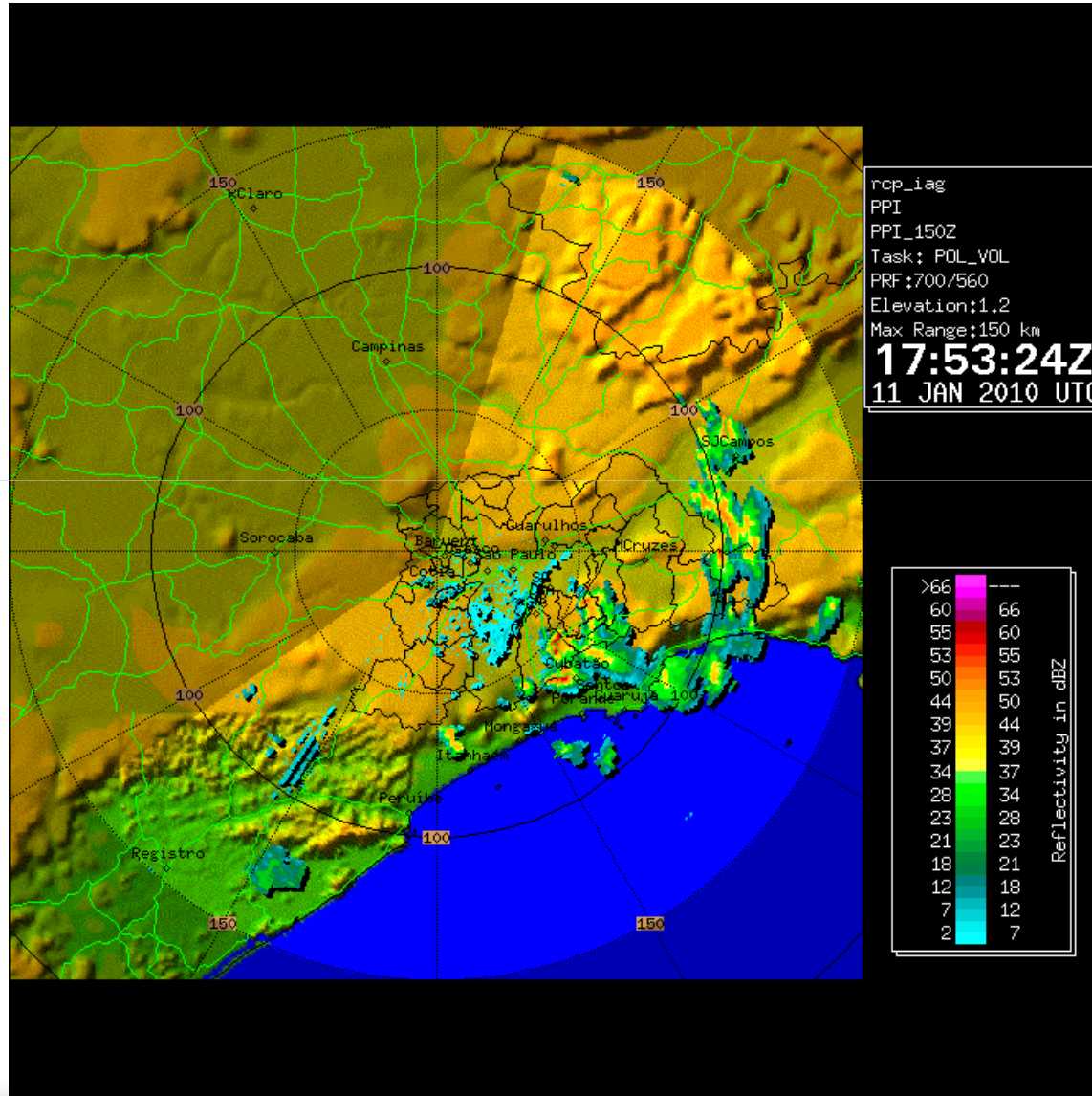


RESULTS

January, 11 2010

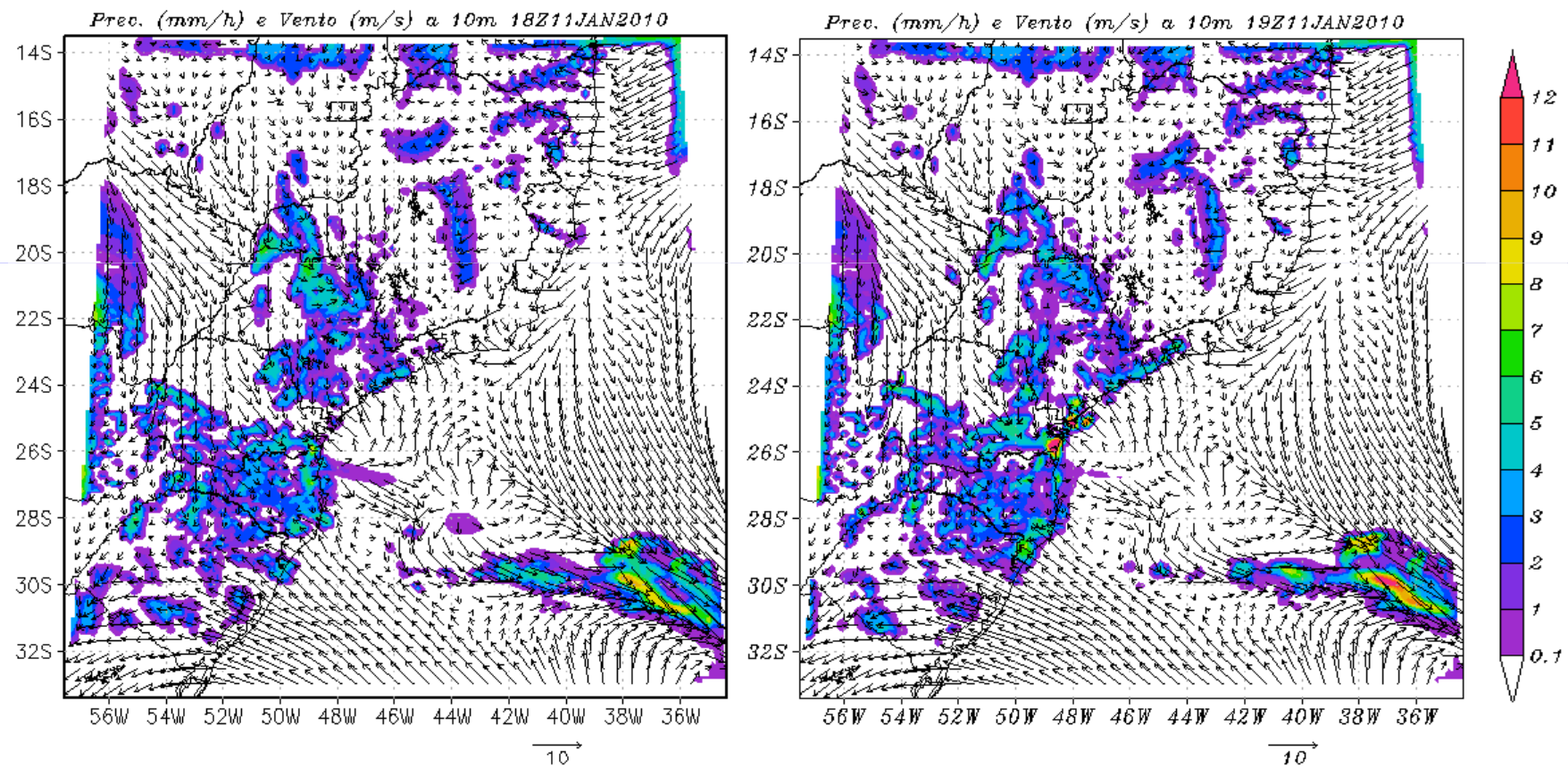
- Sounding: CAPE: 1491 J kg^{-1} e IL: $-4 \text{ }^\circ\text{C}$;
- CAPE between 2250 e 2700 J kg^{-1} (afternoon);

RESULTS



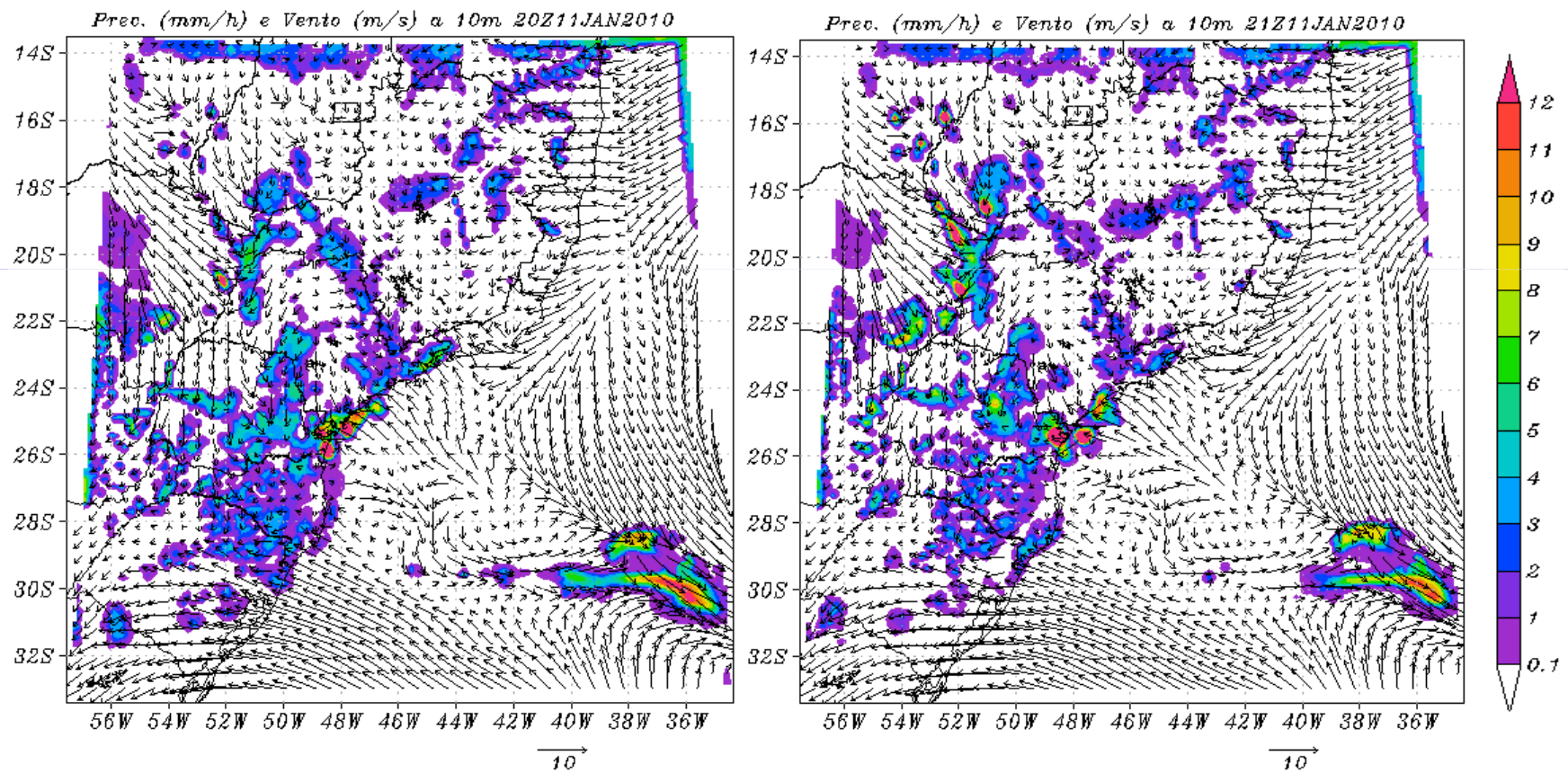
RESULTS

ARPS 12 km

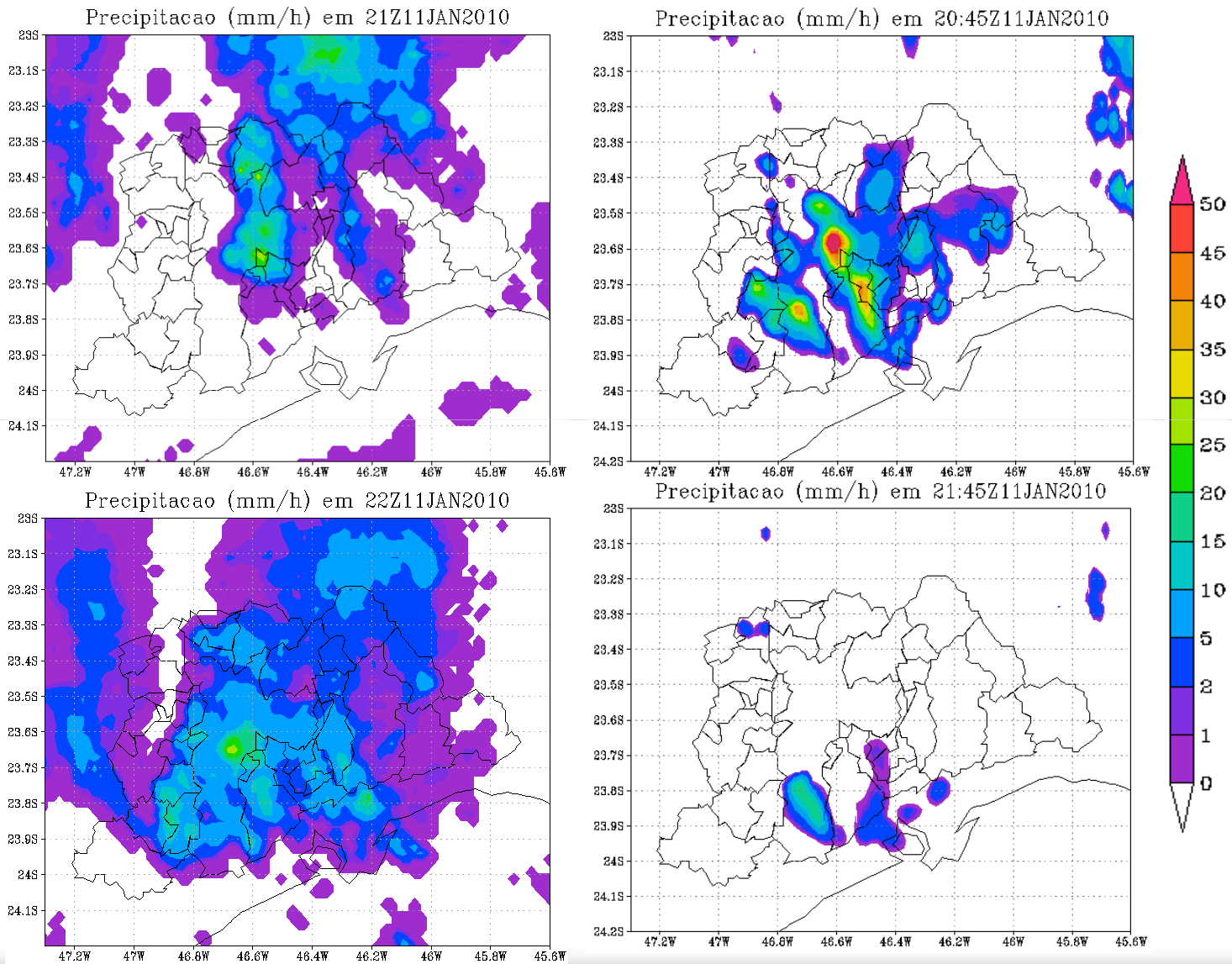


RESULTS

ARPS 12 km



RESULTS



RESULTS

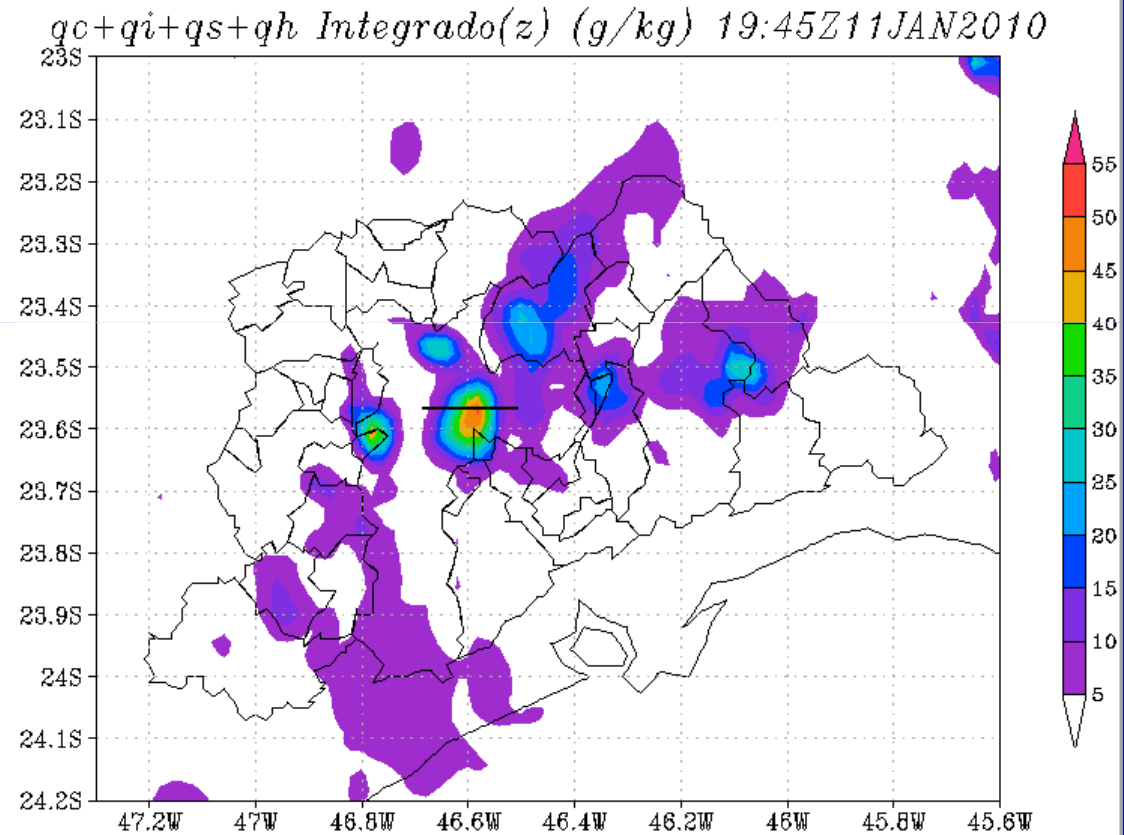
Cloud water;

Snow;

Hail;

Ice crystals;

30 min before;



RESULTS

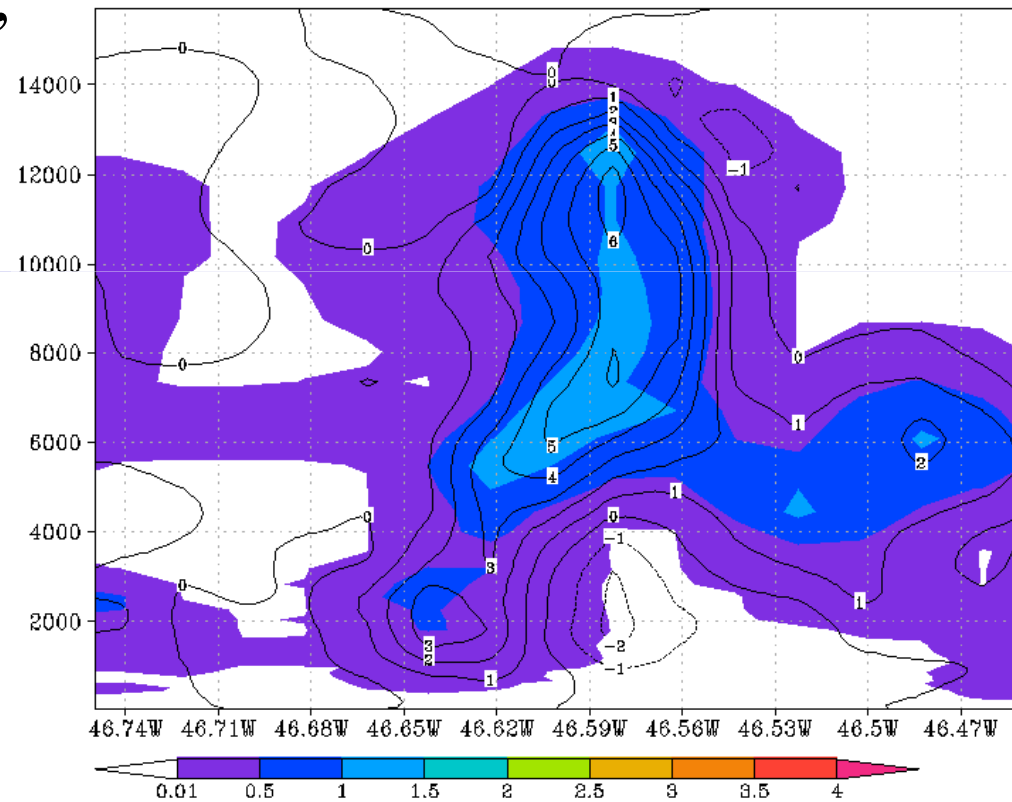
Máx w (11 e 12 km);

$w = 6 \text{ m s}^{-1}$;

Máx w = Máx qc;

D = 15 e 20 km;

Corte Vertical qc+qi(g/kg) e w (m/s) 1945Z11JAN2010



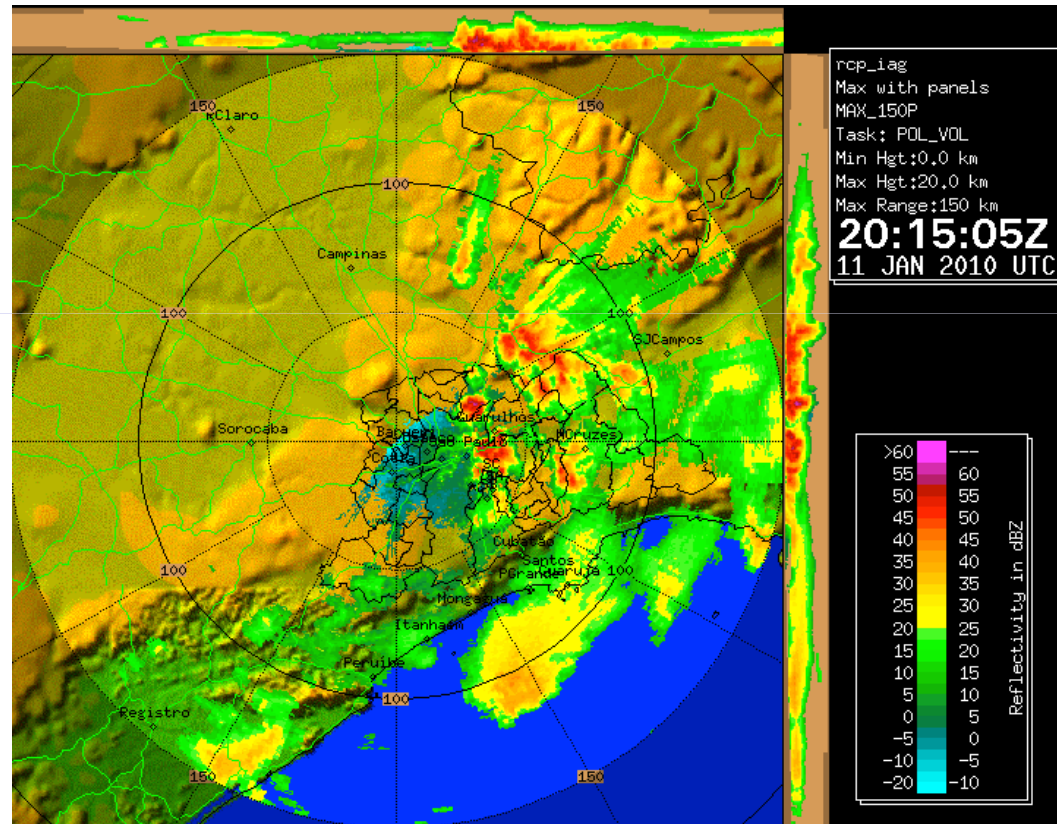
RESULTS

Máx w (11 e 12 km);

$w = 6 \text{ m s}^{-1}$;

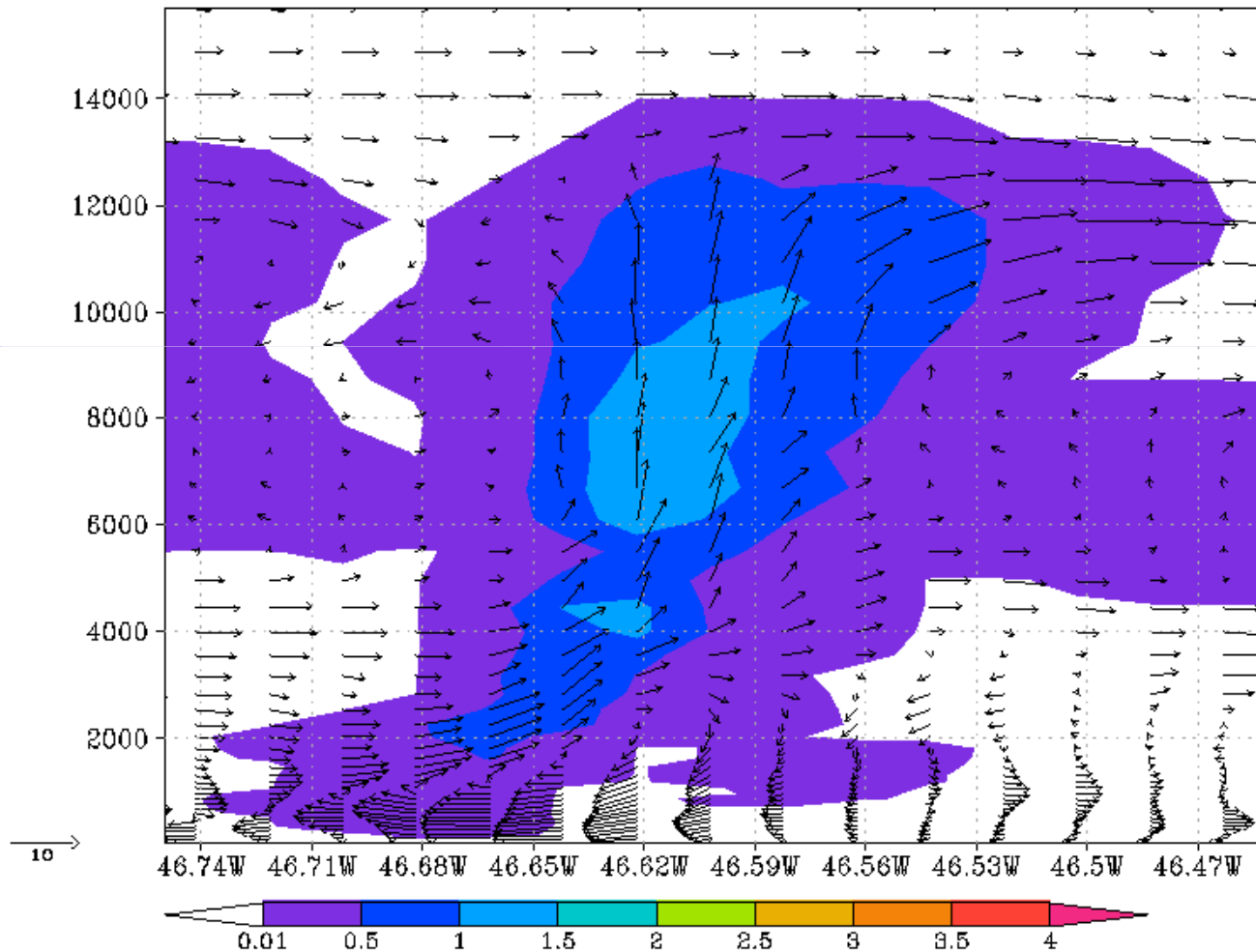
Máx w = Máx qc;

D = 15 e 20 km;



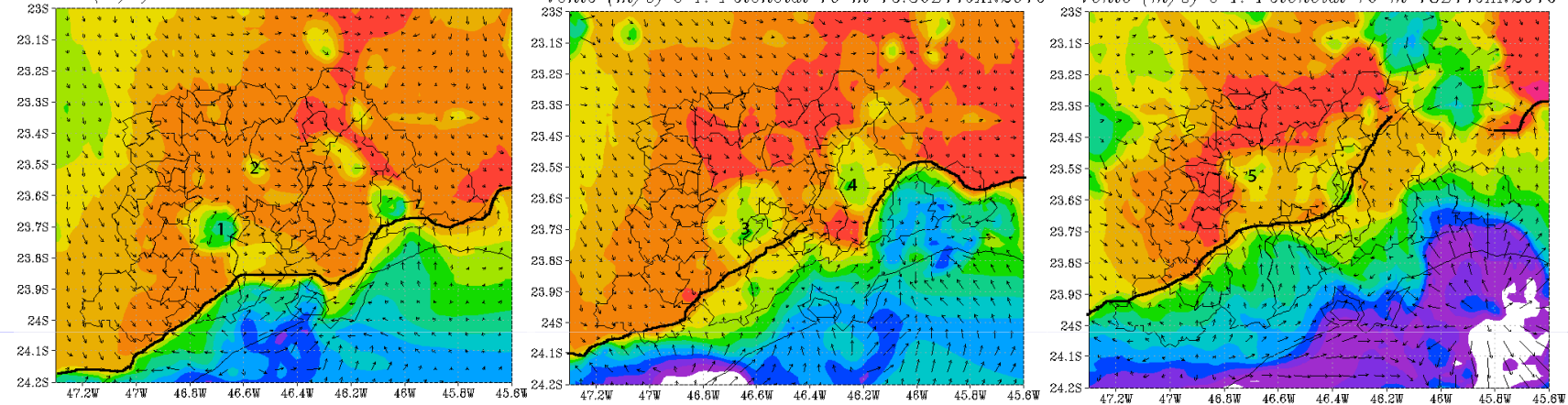
RESULTS

Corte Vertical qc+qi(g/kg) e u;w (m/s) 20Z11JAN2010

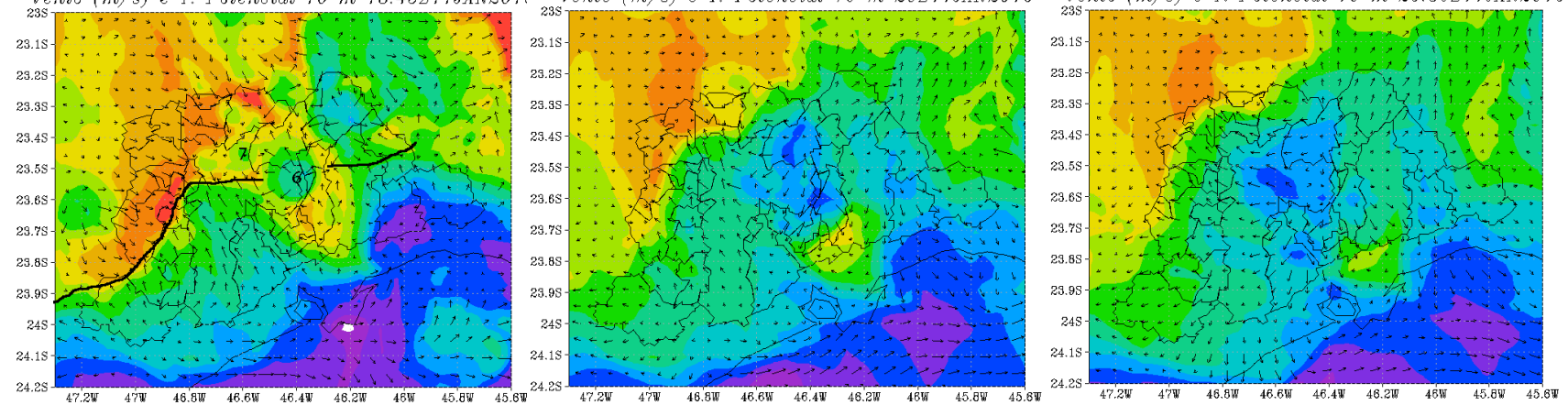


RESULTS

Vento (m/s) e T. Potencial 10 m 15:30Z11JAN2010 *Vento (m/s) e T. Potencial 10 m 16:30Z11JAN2010* *Vento (m/s) e T. Potencial 10 m 18Z11JAN2010*

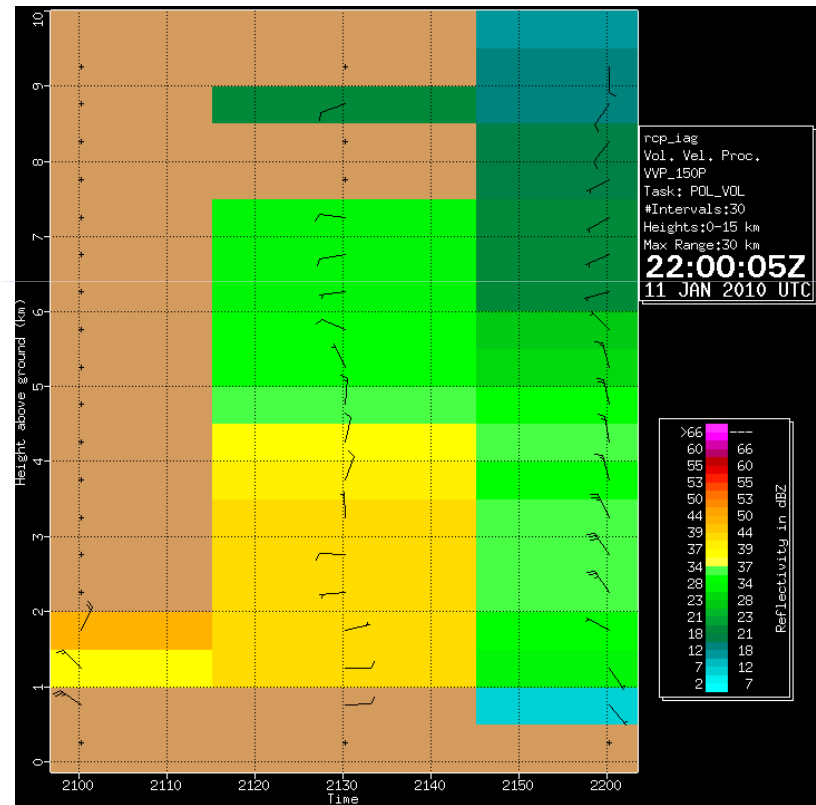
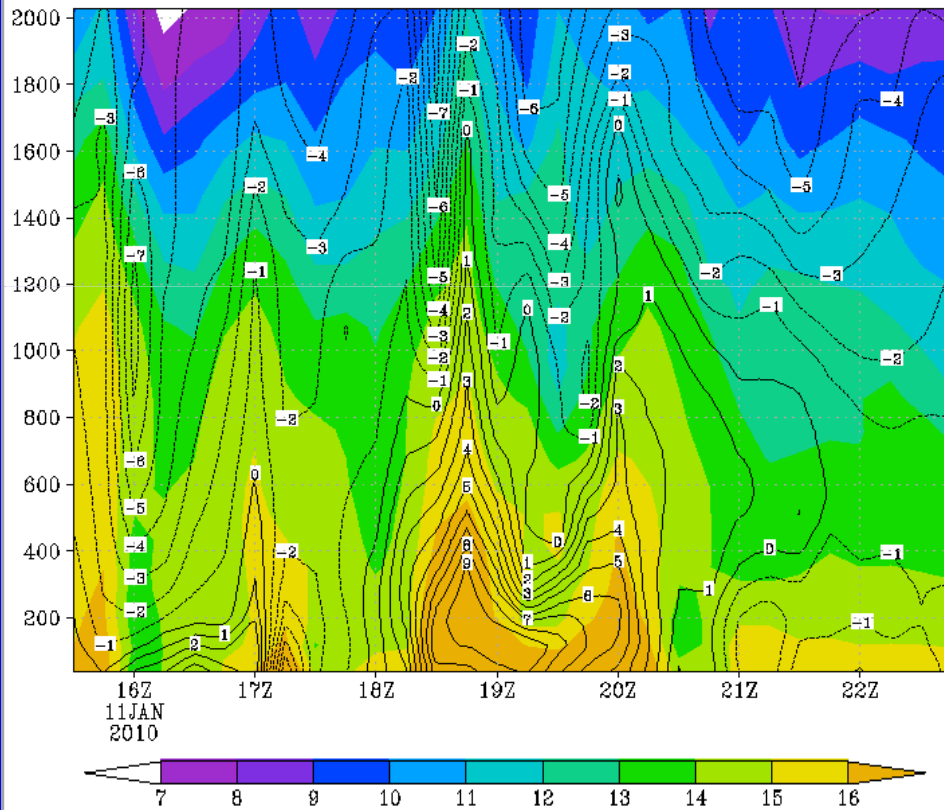


Vento (m/s) e T. Potencial 10 m 18:45Z11JAN2010 *Vento (m/s) e T. Potencial 10 m 20Z11JAN2010* *Vento (m/s) e T. Potencial 10 m 20:30Z11JAN2010*



RESULTS

Corte Vertical qv(g/kg) e v (m/s) -23.6 -46.7



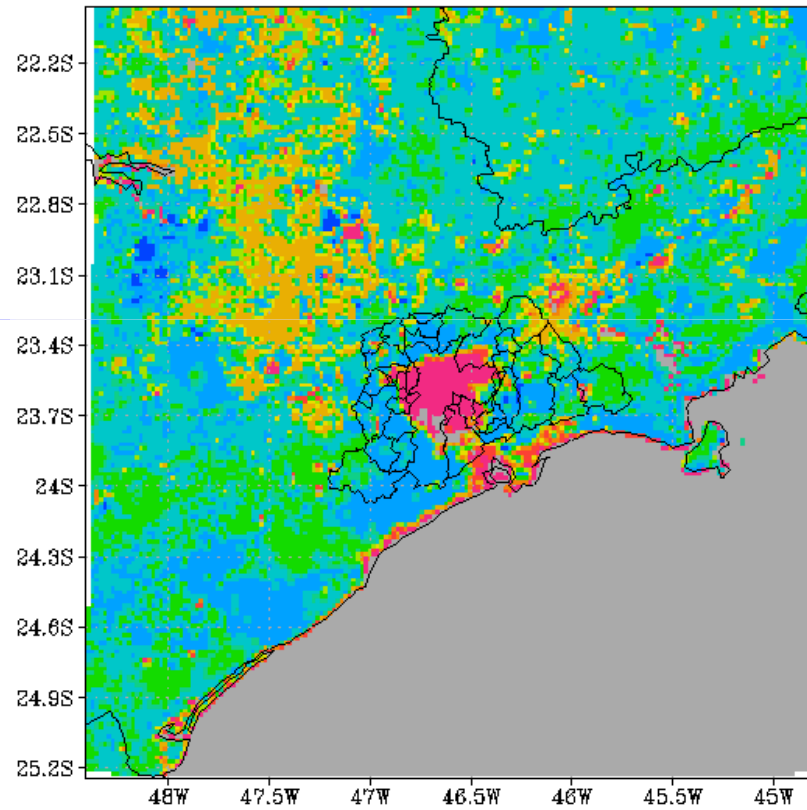
RESULTS

Numerical simulation without heat island

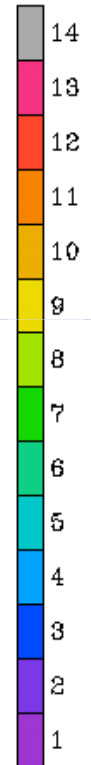
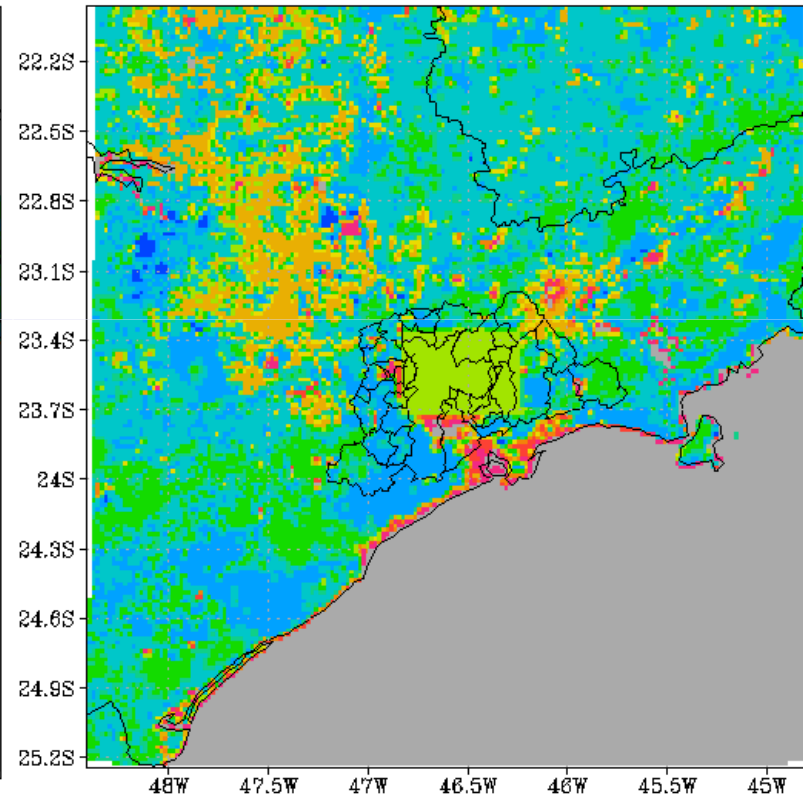
- Surface effect ;
- Real surface for rainforest;
- Heating effect of city in rainfall;

RESULTS

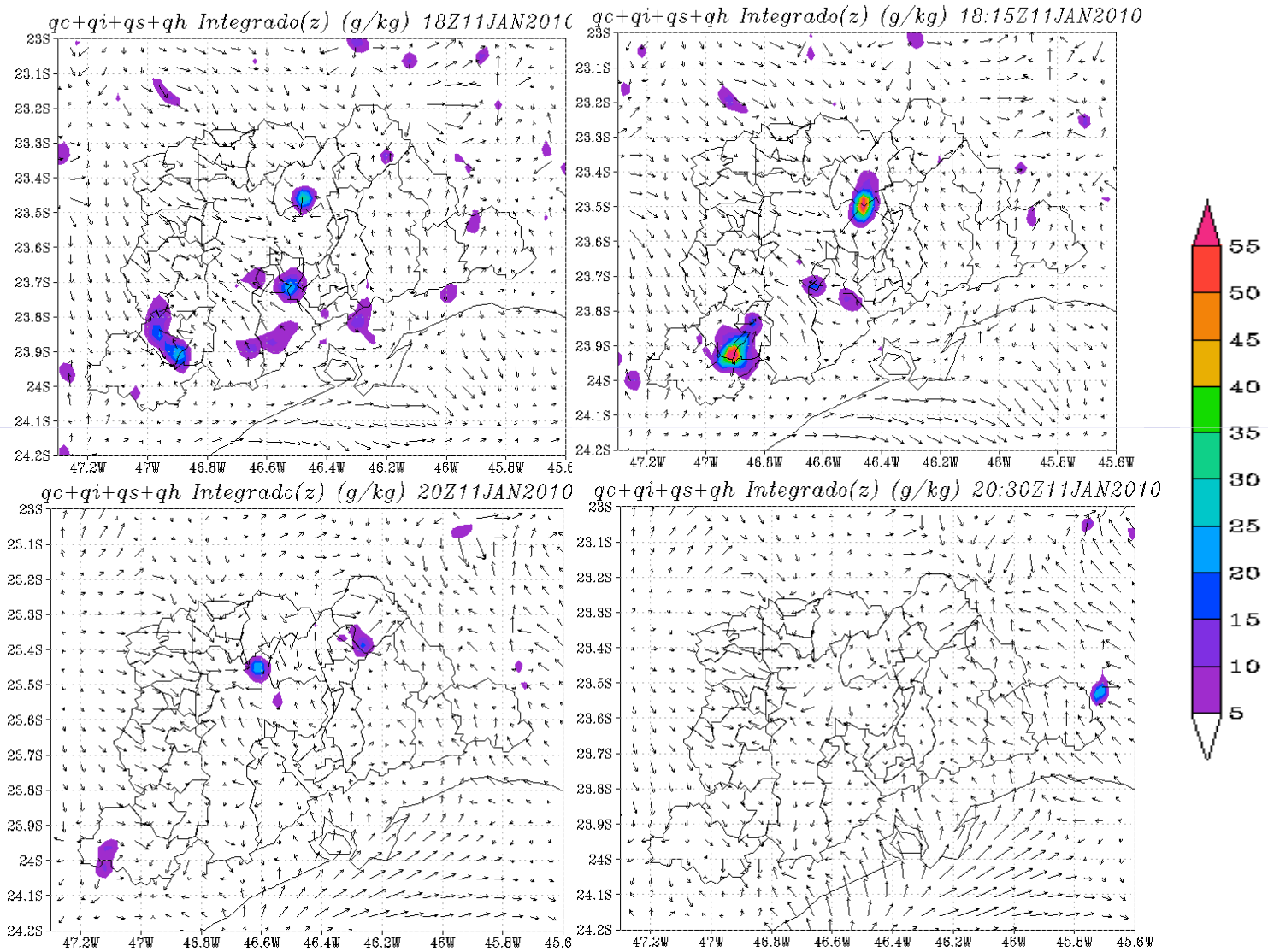
Tipo Veg.



Tipo Veg. (modificado)

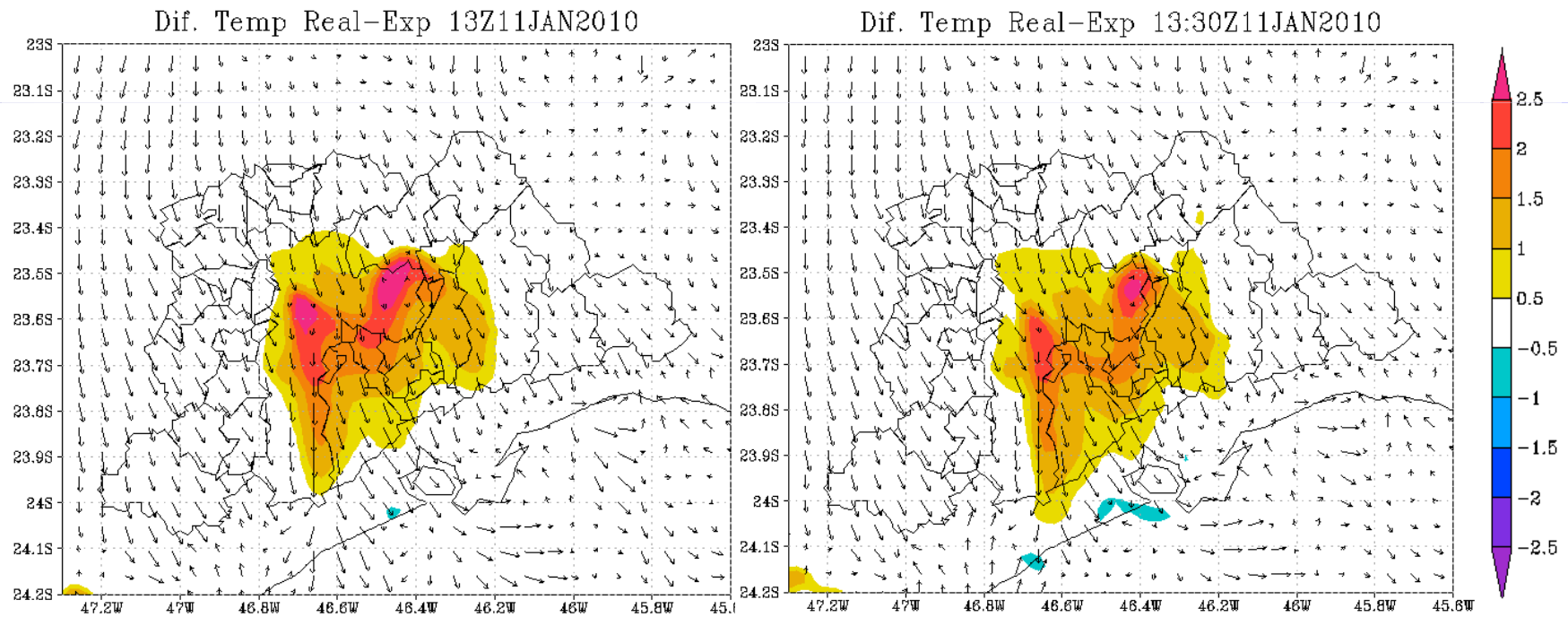


RESULTS

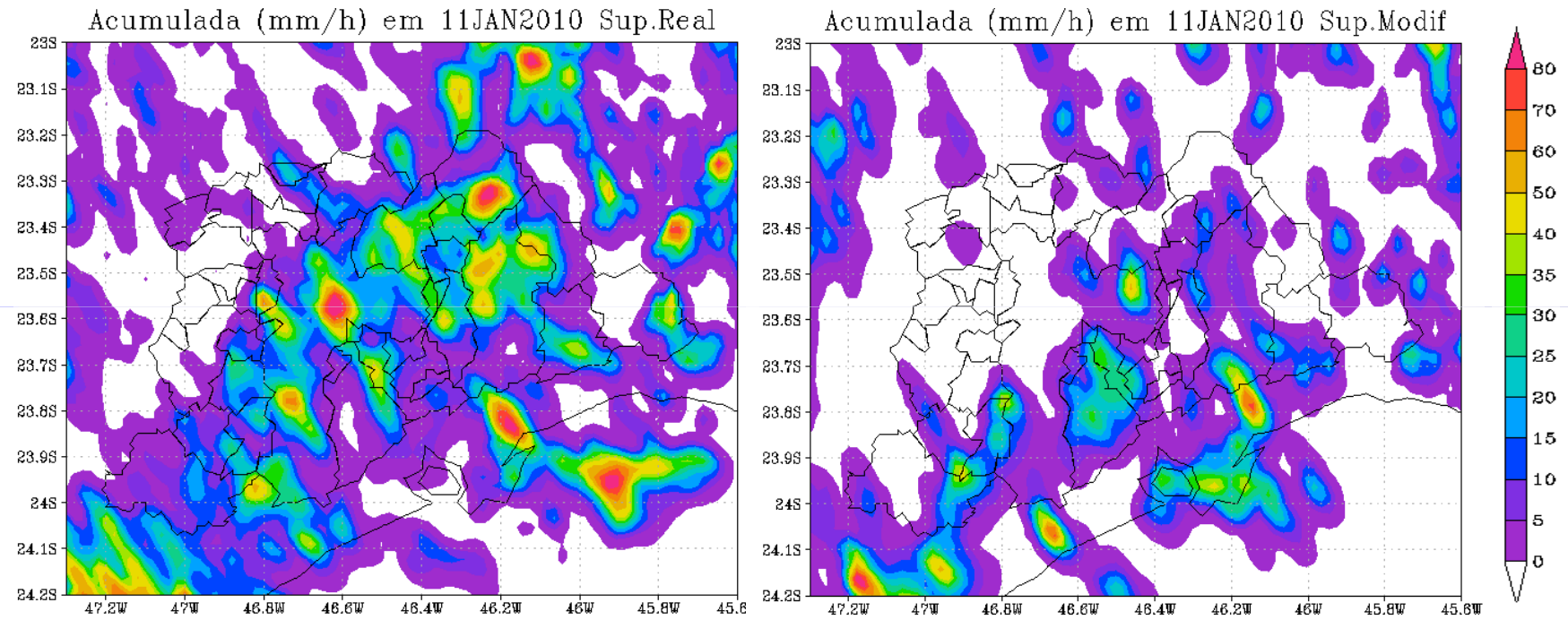


RESULTS

- Over 2.5 °C;
- Weak stream = more warming;



RESULTS



CONCLUSIONS

Local circulation of SB = Storms over MASP;

1800UTC, 74% NW – SE, increase in dew point 20 °C;

Core maximum of 600 mm = 2/5 average annual of IAG;

Heat island is transported to southeast;

IL (-3.5 a -4.0°C) and CAPE (1750 J Kg⁻¹ e 2000 J Kg⁻¹)
(afternoon), 616 J kg⁻¹ e -2,2 °C (morning);

CONCLUSIONS

Heat island produces intense rains in the area east of the São Paulo

Interactions with gusts front of cells formed in the MASP;

Heat Island is transported to mountain regions near the sea

Thickness of the SB front (1600 m);

Thanks