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WSN 12
Rio de Janeiro - Brasil

HIGH RESOLUTION WRF SIMULATIONS FOR WIND GUST EVENTS

Preliminary results

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Rio de Janeiro 06 to 10 August 2012

Introduction

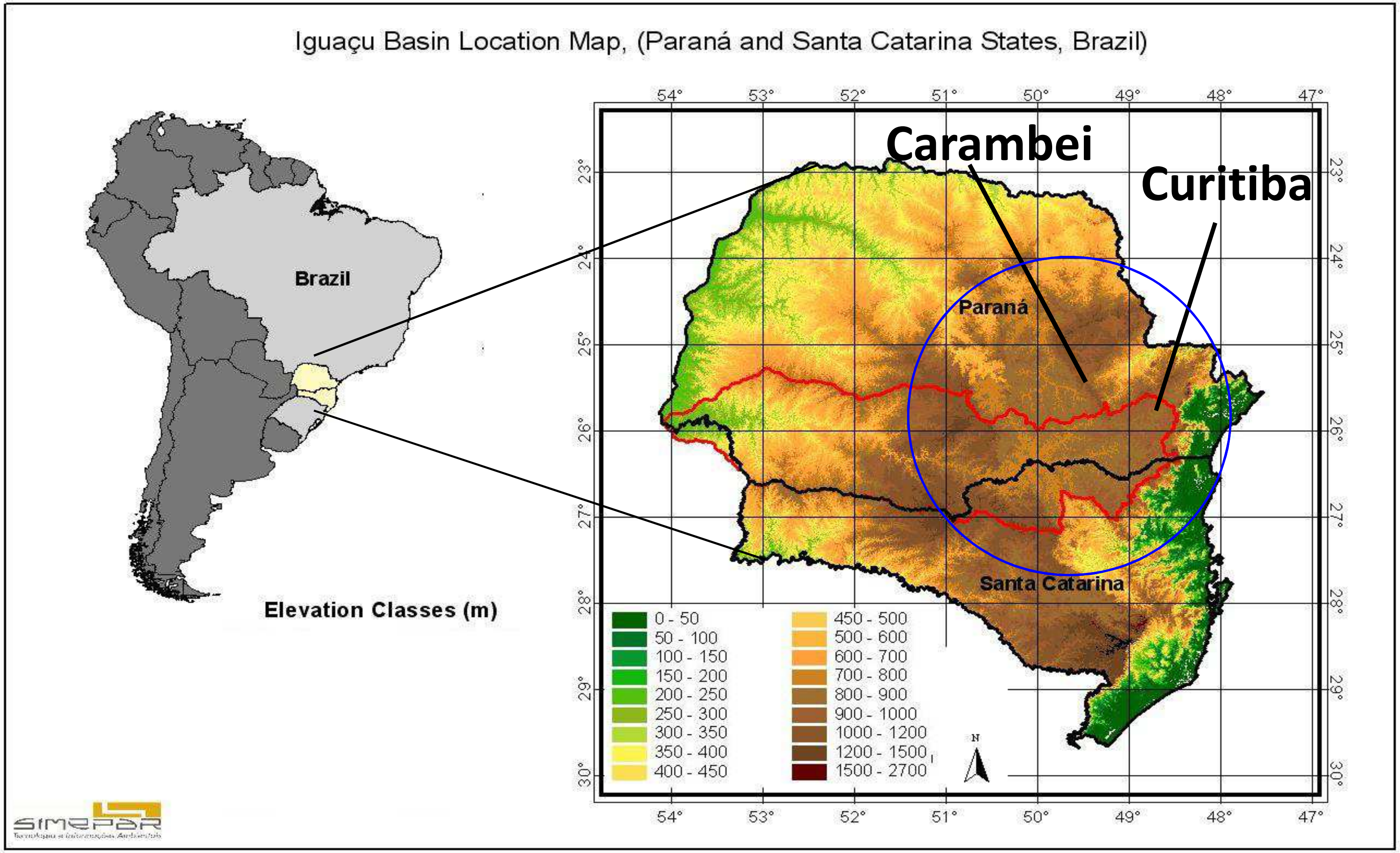
Every year, wind gusts and flash floods have damaged a lot of structures in several activities in Paraná State, southern Brazil. In this paper we describe some results about nowcasting and very short range forecasts of storms and wind gusts using an operational mesoscale network.

Introduction

2 events in Paraná State – Brazil:

Curitiba Metropolitan Area (3 million habitants) Gust winds and hail

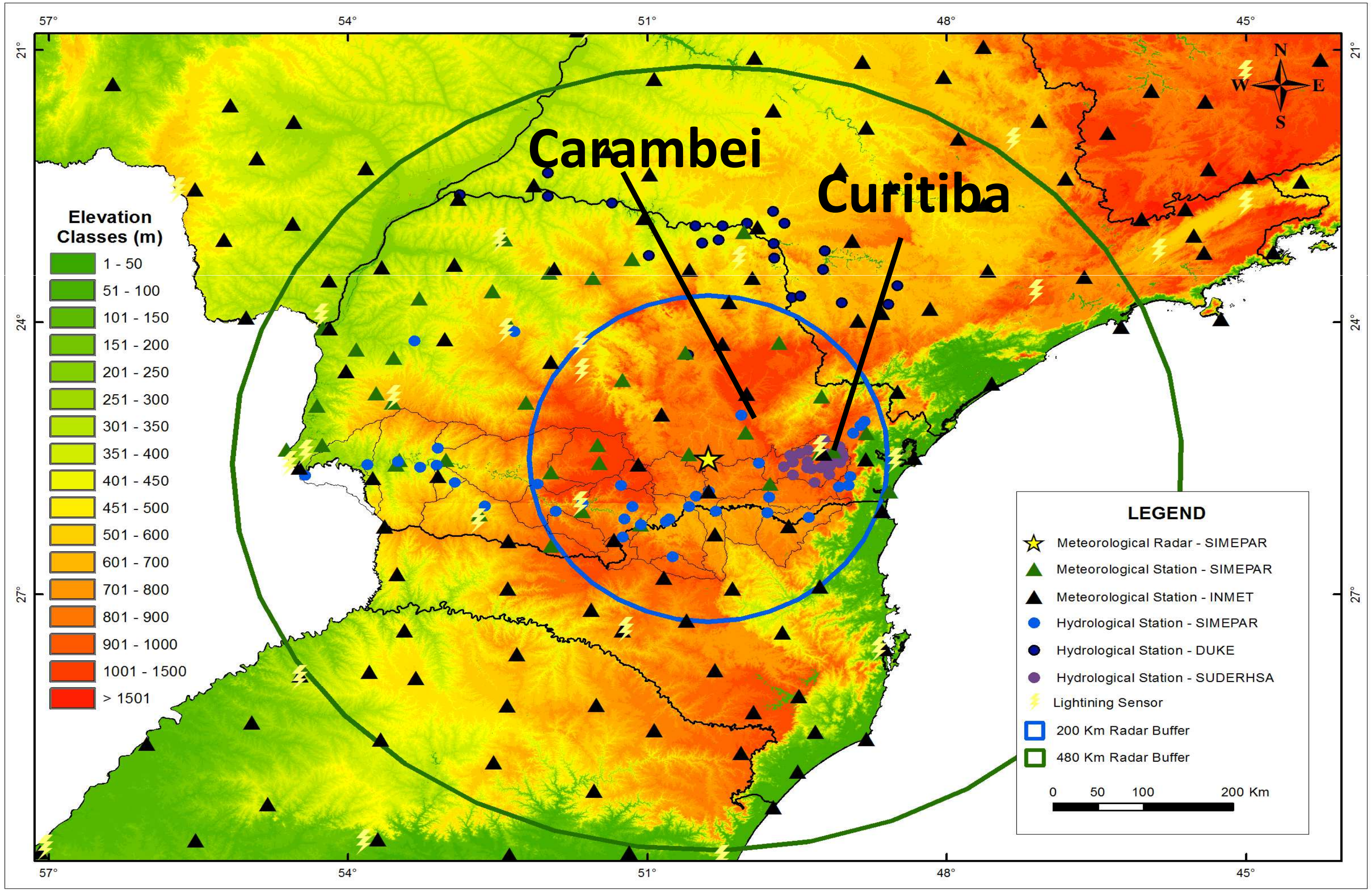
Carambeí: high voltage pylons were blown down .



Hydrometeorological network in Paraná State

1 weather station every 27 km
S-Band Doppler Radar (center)
S-Band Dual Pol (to be installed)

62 weather stations
45 hydrological stations (gauge + river level)
6 lightning detection sensors



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Methodology

Nowcasting and Very Short Range Forecasting at SIMEPAR

0 – 3 hours
5 min. Radar images
Real time Lightning Detection System
15 min Satellite Goes 13 and Meteosat Images
TITAN (in testing)

NWP:
0 – 12h
WRF 3km horitontal km with 3 domains (27km, 9km and 3km)
No assimilation
Obsgrid (objective analysis tests)
VSRF Ensemble (coming soon)

All the forecasts are supervised by meteorologists.

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Methodology

Very Short Range Forecasts
WRF ARW version 3.4:

Lateral Boundary Conditions GFS 0.5 degree, updated every 6h

Station data with OBSGRID (Objective Analysis – Cressman)

Timestep 30 sec.

Horizontal Resolution: 3km (27 km, 9km and 3km)

Vertical levels: 45 to 65 with hyperbolic tangent distribution (high levels near surface and at the tropopause)

Complex Microphysics: includes graupel and 2 moments (prediction of particle mixing ratio and concentration)

No data assimilation

Methodology

Very Short Range Forecasts
WRF ARW version 3.4:

WDM 6 microphysics scheme
Yonsei University boundary layer scheme (tests with MYJ)
Noah landsurface model (RUC for MYJ pbl scheme)
RRTM longwave radiation
Goddard shortwave radiation scheme
Monin-Obukhov surface model
Kain Fritsch cumulus scheme for coarser domains (9km and 27 km)

Tests with Microphysical Double Moment scheme: predict both the particle mixing ratio and concentration. Ex. WDM 6, Morrison, Thompson

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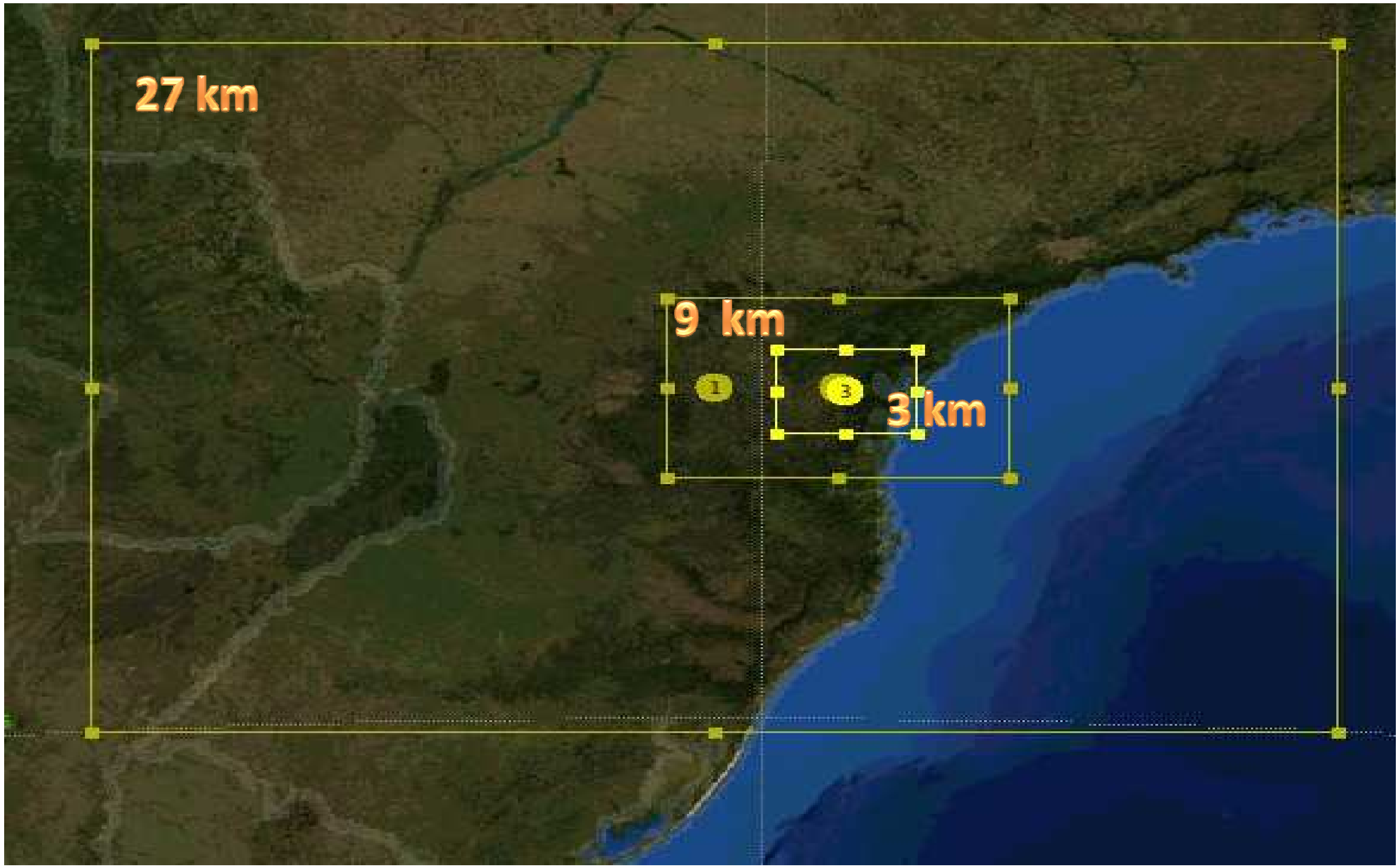
Methodology

From GFS 0.5 degree boundaries, we use:
3 domains: dx=dy= 27 km ; 9 km ; 3 km
The center of the 3km domain is located at the Curitiba city (the capital of Paraná State)



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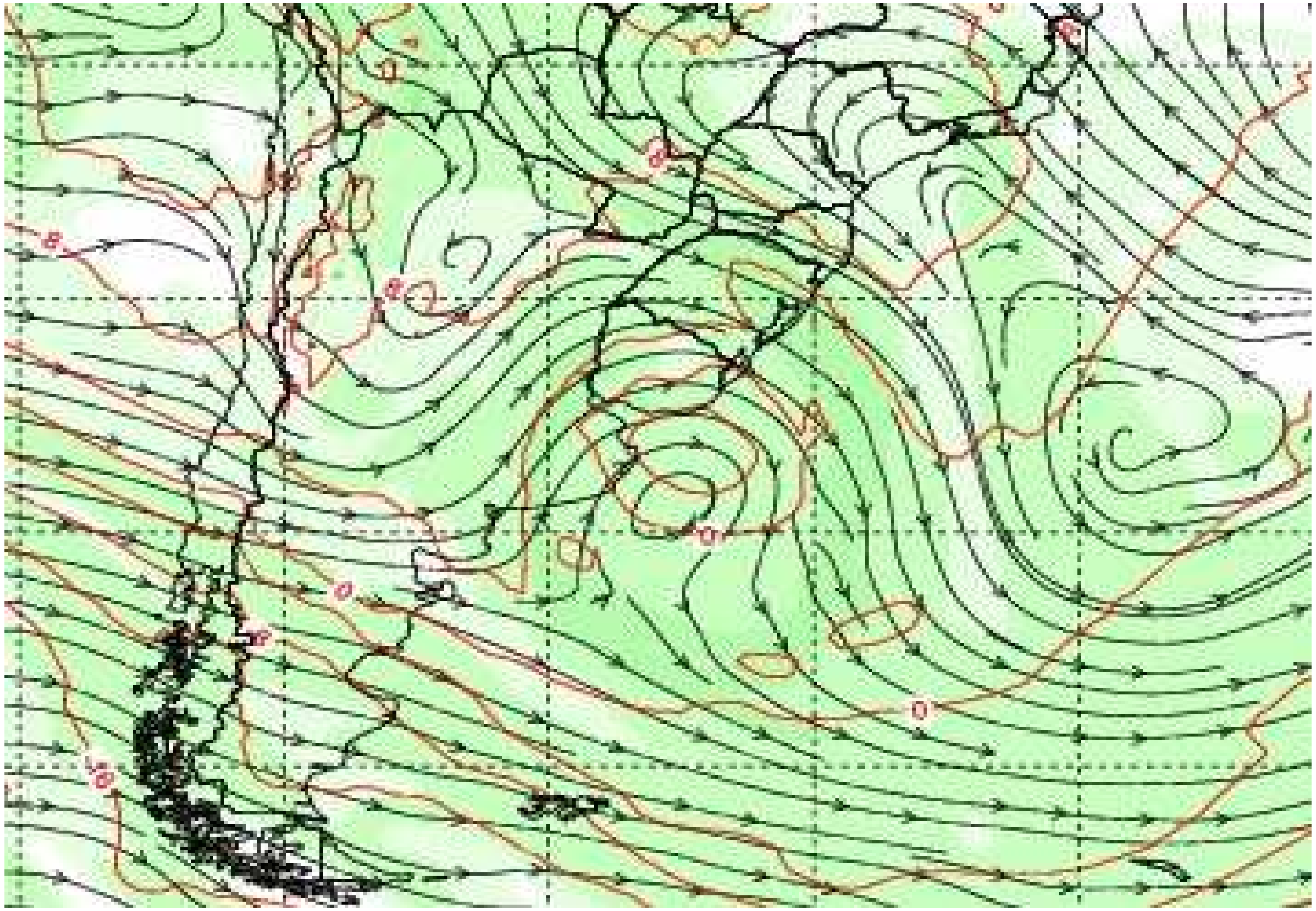
Introduction

Typical synoptic pattern in storm events in Paraná state: The storms propagate itself along the flux near 700mb and sometimes they move orthogonally to the fronts.



Streamlines, specific humidity and temperature at 700 mb

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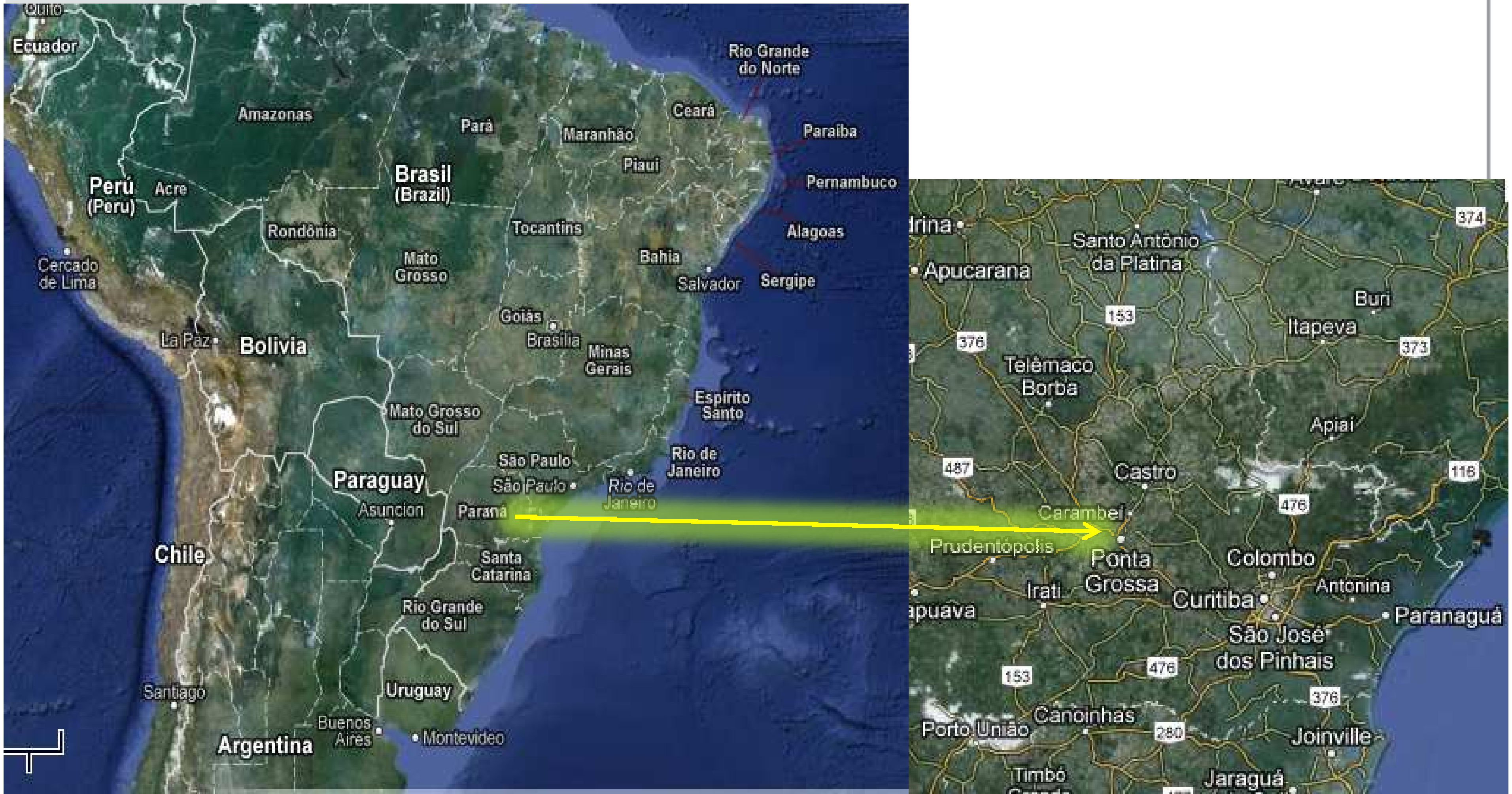
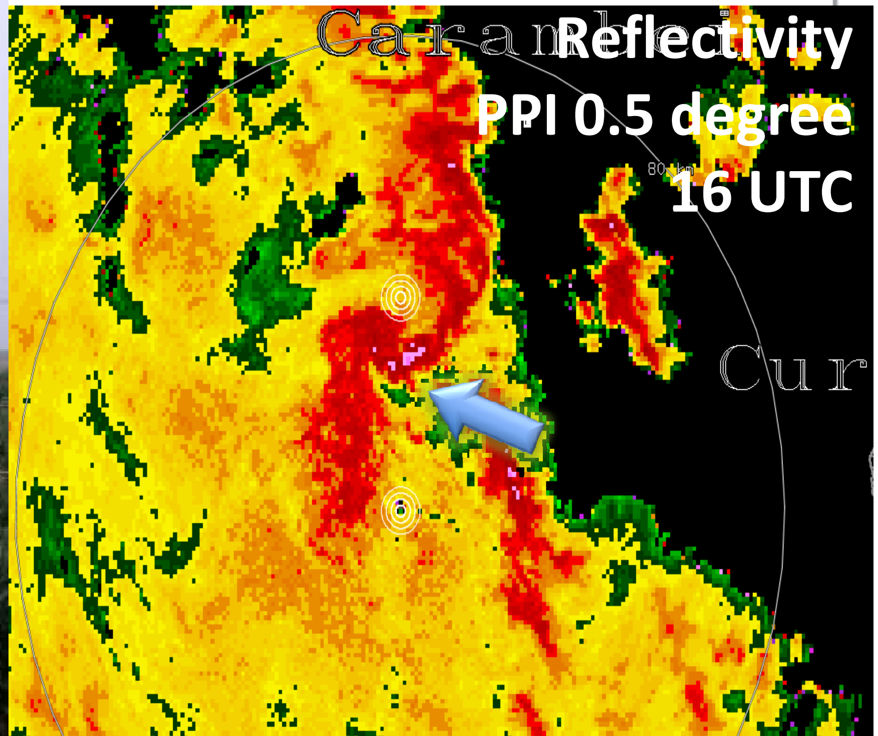
Carambei – Paraná State, Brazil
19 November 2006



Carambei – Paraná State, Brazil

On 19th November 2006, 6 high voltage pylons were blown down. The wind gusts were not detected by the weather station network. Usually, at these events, the gusts are about 20-30 ms^{-1}.



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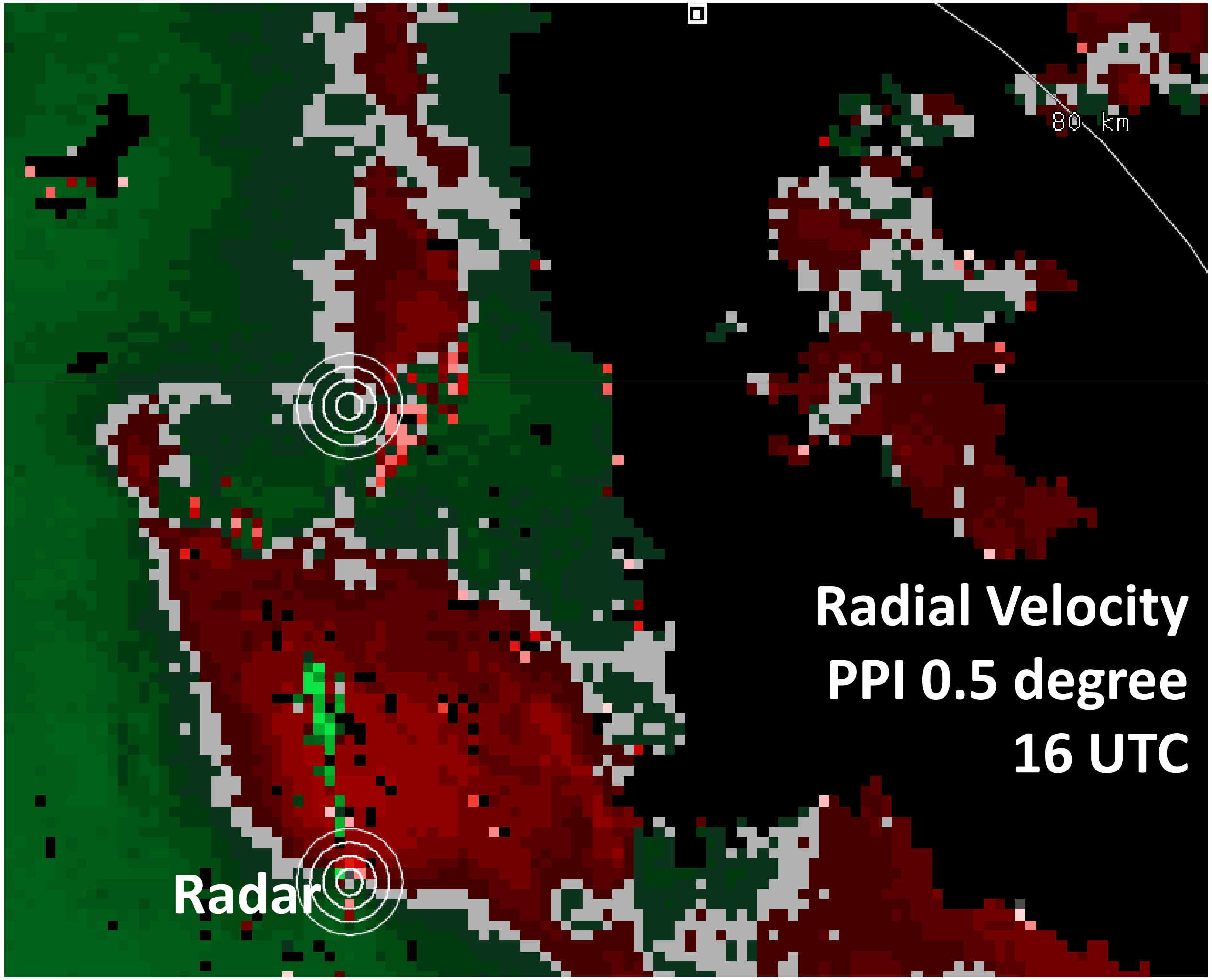
Carambei – PR , 19th November 2006
S-Band Radar Data
Radial Velocity

We can observe some peaks About 30 ms^{-1} at 1km altitude.
There is some signature of rotation on the radial velocity field in 0.5 PPI.
The region where the gusts took place was about 70 km from the radar.

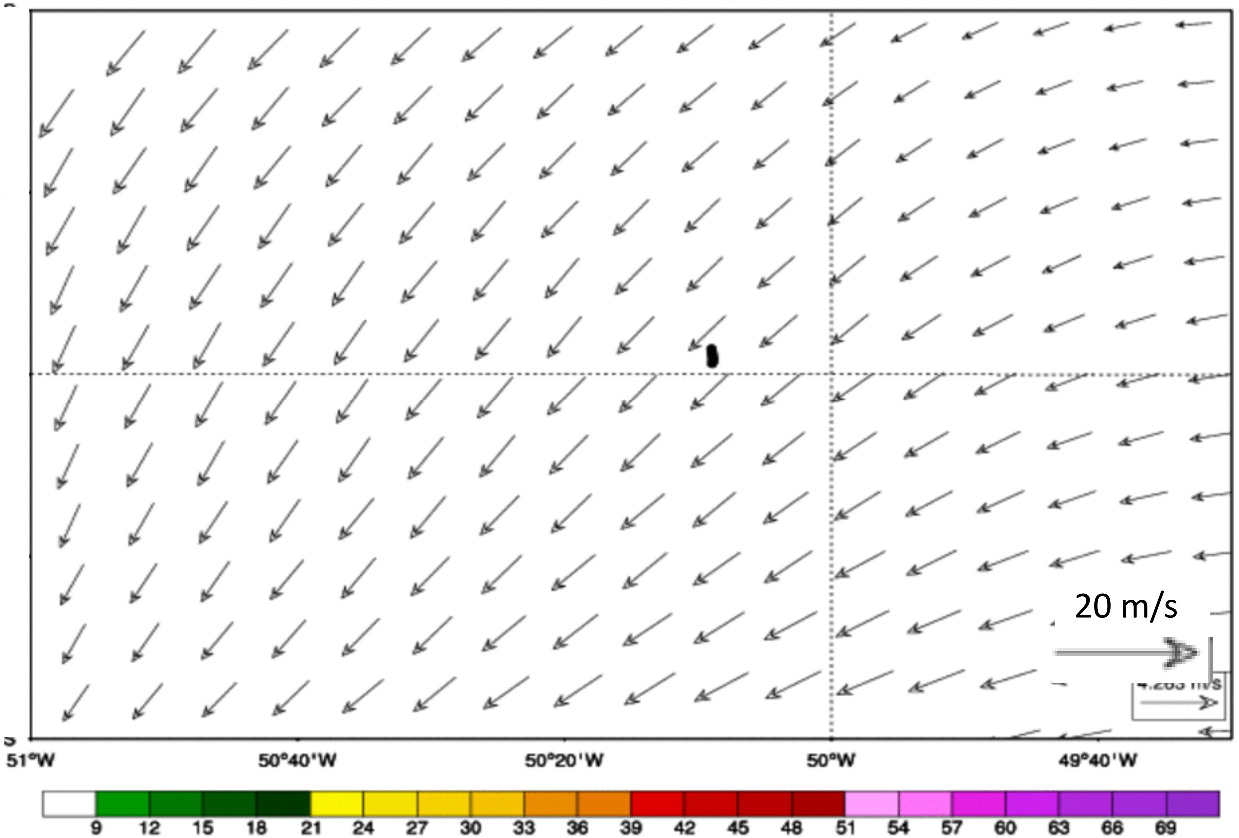


Carambeí – Paraná State, Brazil

WRF Simulations:
10 m wind and Reflectivity

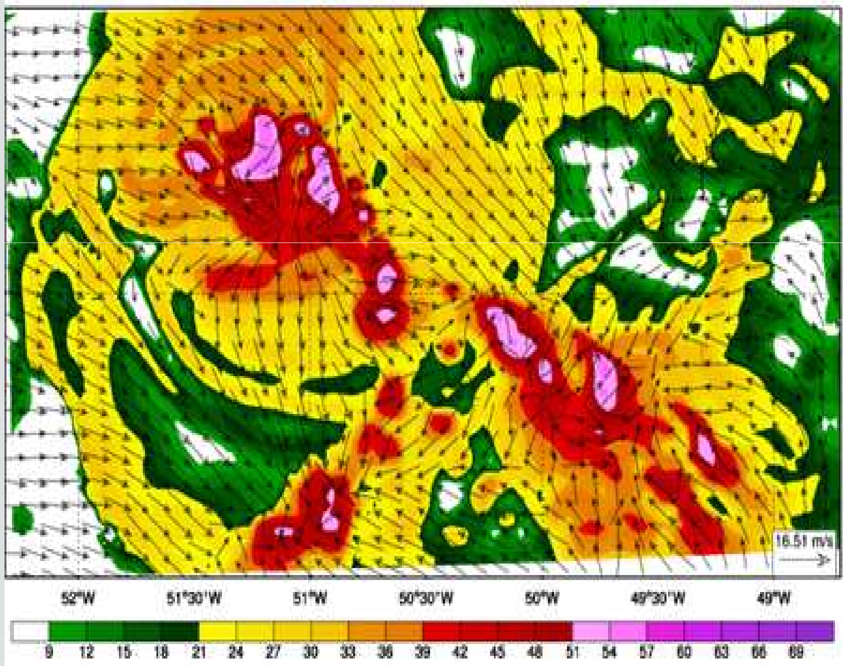
WRF starts at 12 UTC, 4 hours before the wind gust event.

The simulations captured the storms and the divergence due to the downdrafts.

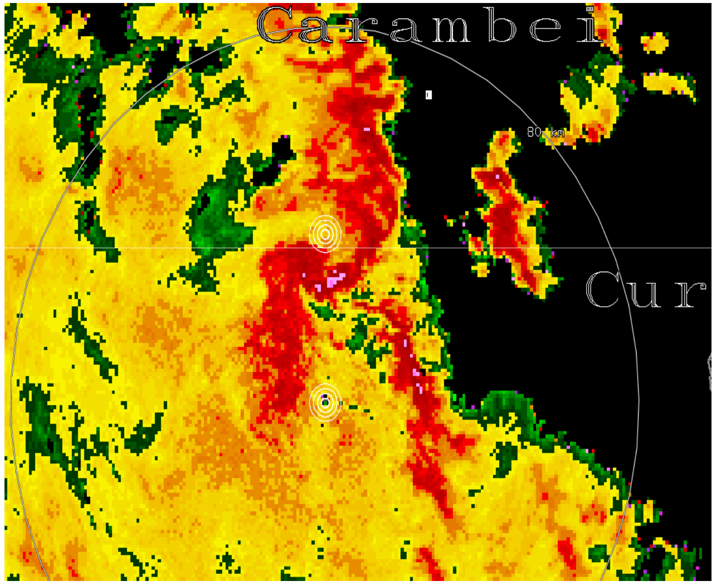


Carambeí – Paraná State, Brazil

Reflectivity (dBZ) and wind at 10 m, both simulated with WRF at 1,6 km resolution for 1650 UTC 19th November 2006.



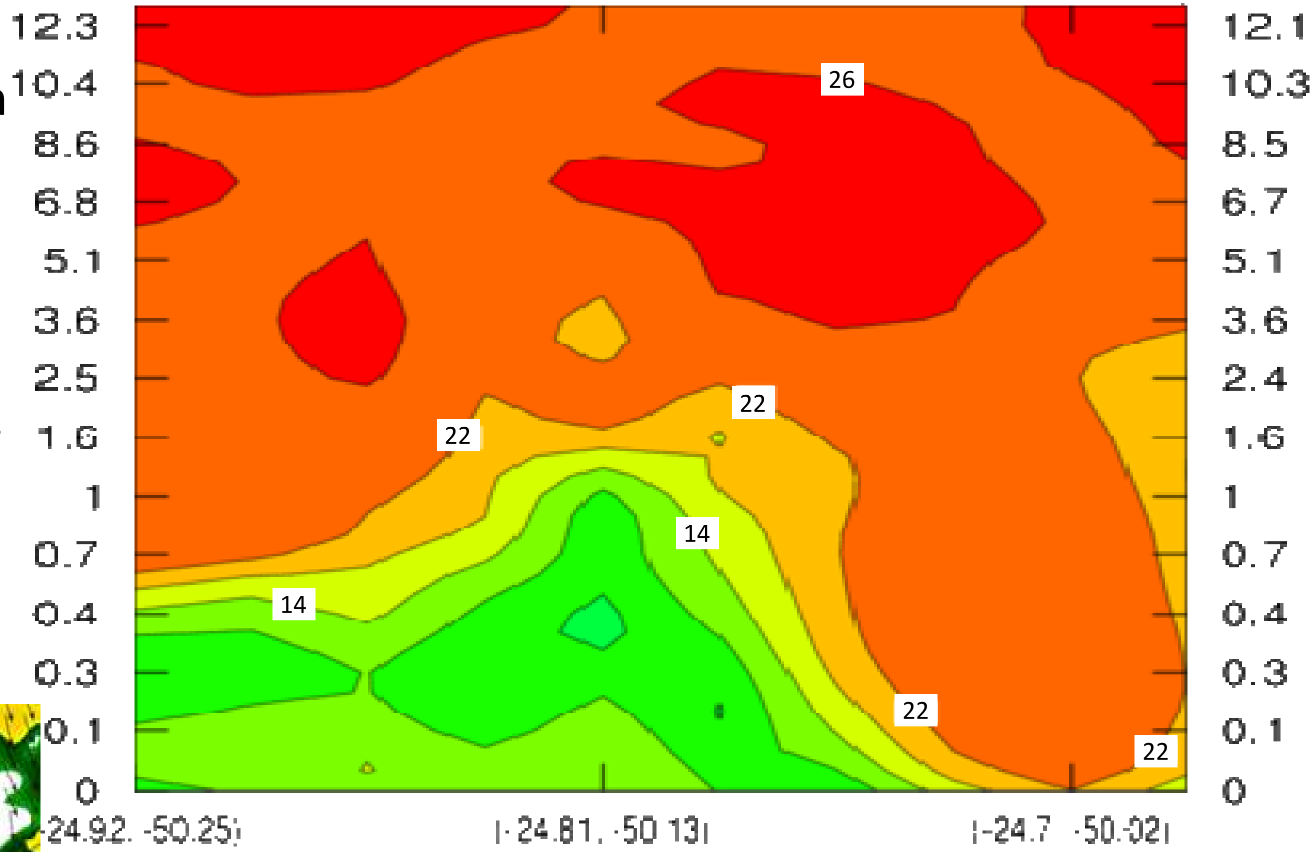
Reflectivity (dBZ) S-Band Radar 1600UTC 19th November 2006.

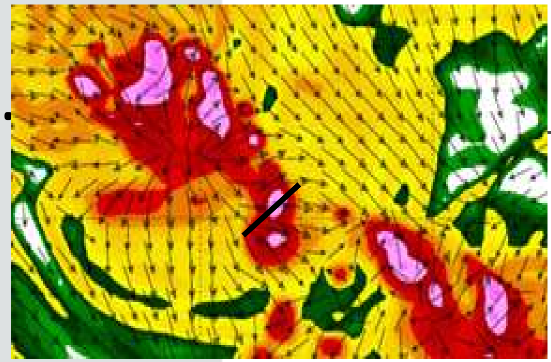


Carambeí – Paraná State, Brazil

Vertical cross section of the wind of the Storm at 1640 UTC 19th November 2006.

The downdraft was simulated about 40 min late.
To obtain downdrafts we use 20 sec of timestep.
Output each 5 minutes.
Sometimes, it is necessary to increase the horizontal resolution to 1 or 2 km.





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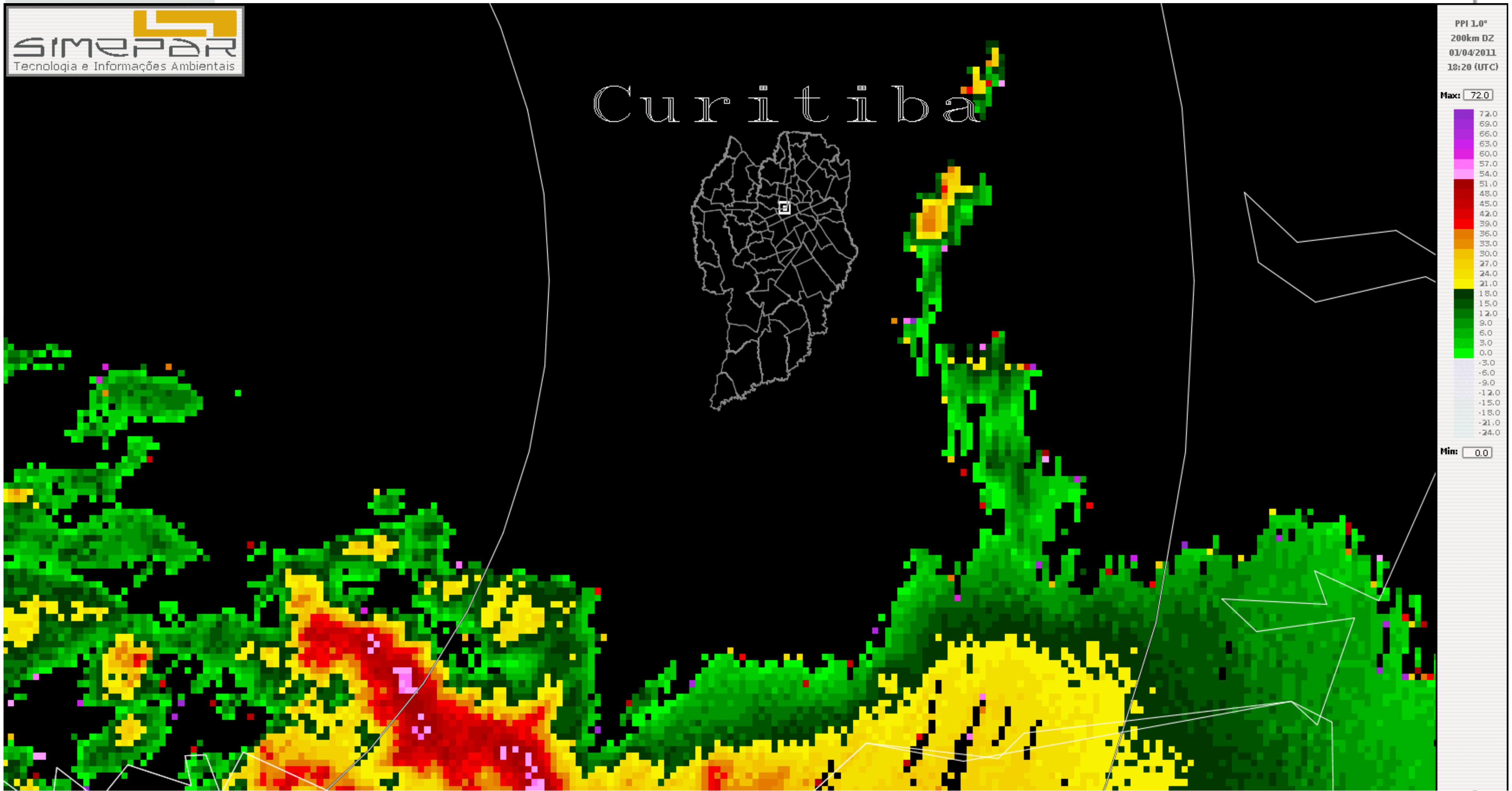
Curitiba – Paraná State, Brazil

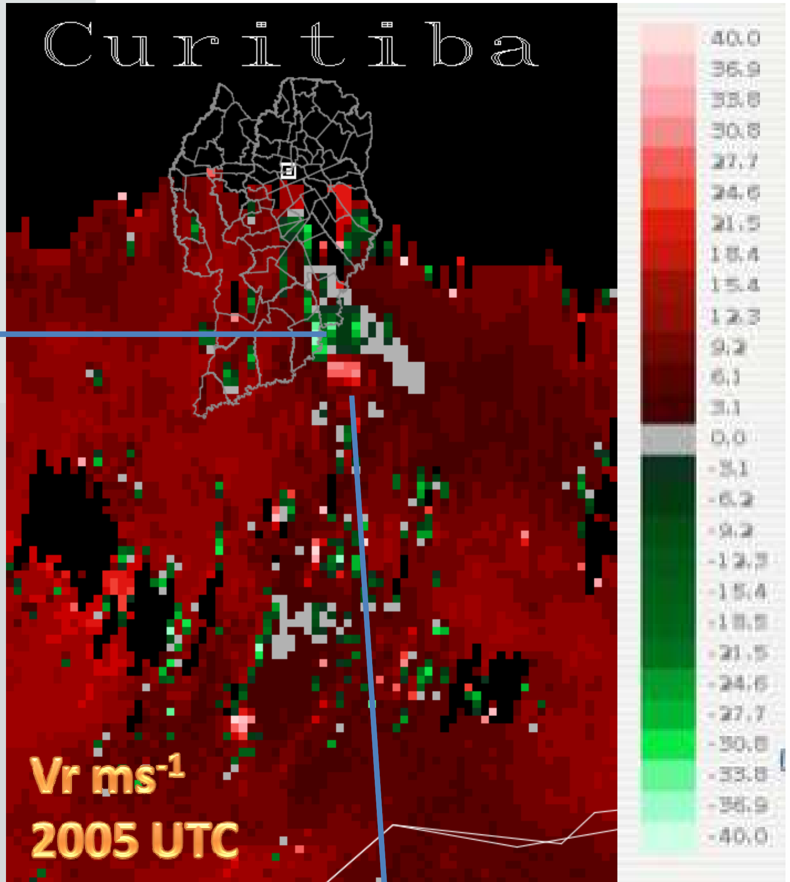
S-Band Doppler Radar: Curitiba is about 120 km away from the radar
Reflectivity (dBZ) from 1825 UTC to 20 25 UTC **1st April 2011**.

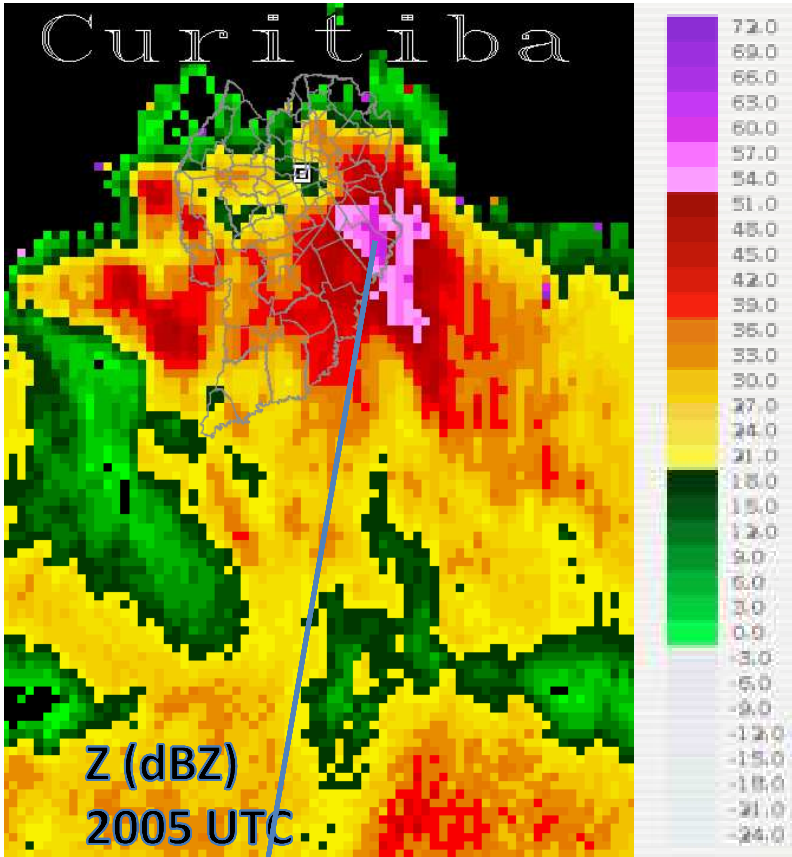


Curitiba – Paraná State, Brazil

Radial Velocity and Reflectivity (dBZ) S-Band Doppler Radar 20 UTC 1st April 2011.

32 ms^{-1}





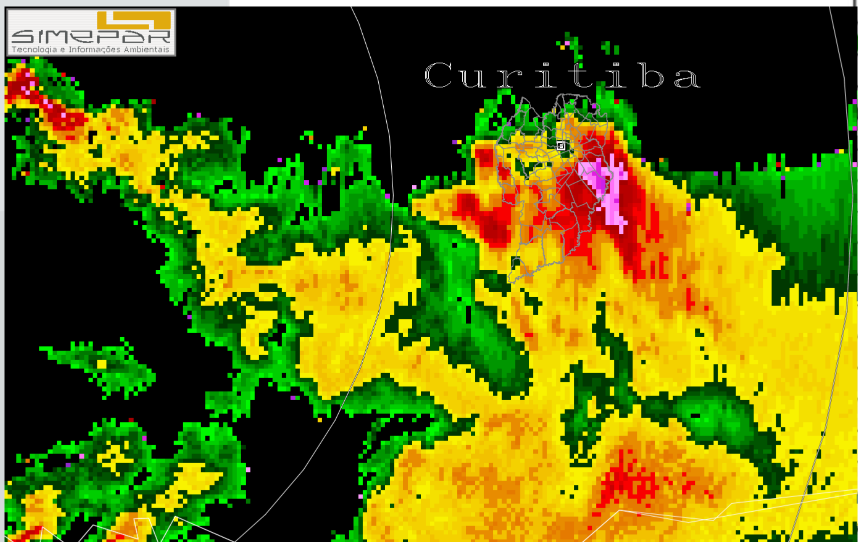
27 ms^{-1}
~ 2.5 km altitude

- 60 dBZ

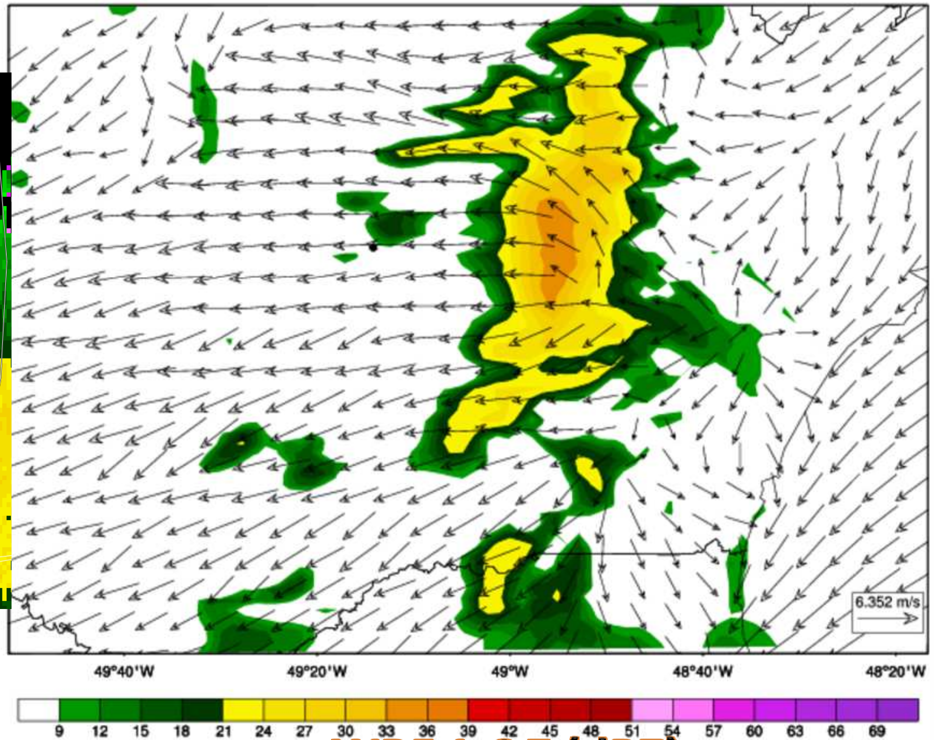
Usually, above 55 dBZ in PPI 0.5° hails fall to surface

Curitiba – Paraná State, Brazil

The 3km and 1.6 km WRF simulations indicate an instability area, but it cannot predict the storm and its trajectory.
Maybe, it is necessary better analysis or assimilation .



Z (dBZ)
2005 UTC
1st April 2011

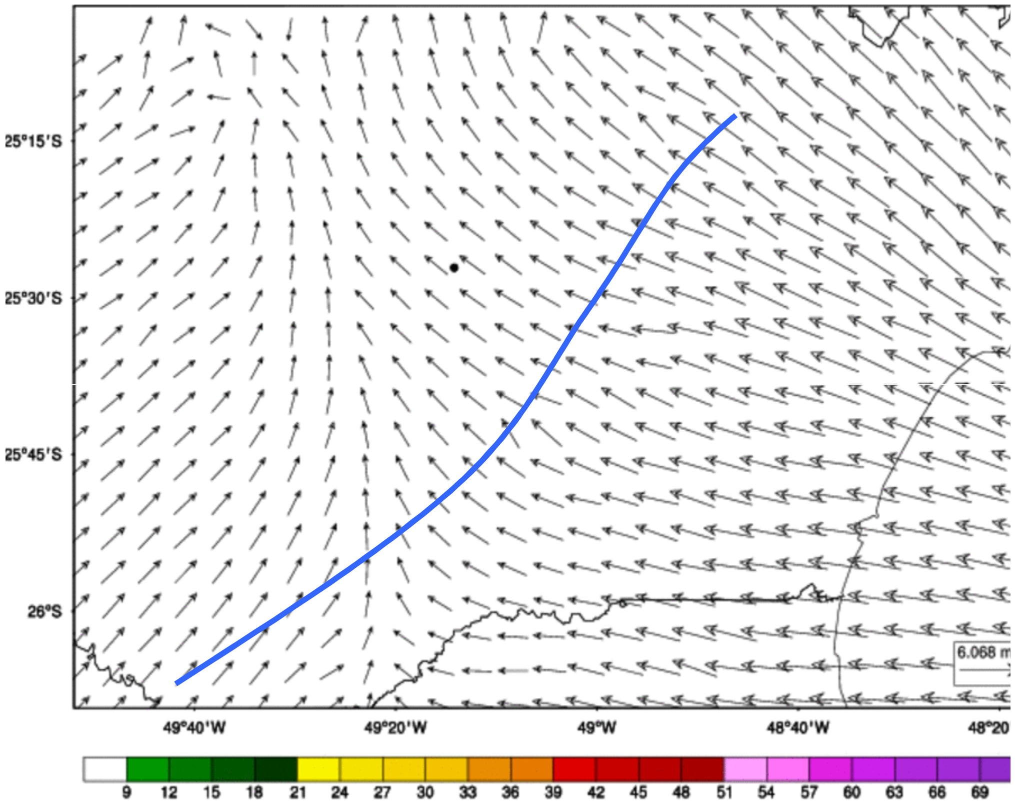


WRF 1.6 Z (dBZ)
2005 UTC
1st April 2011

Curitiba – Paraná State, Brazil

10m wind and Reflectivity (3km) from WRF simulation for 1st April 2011

Opposed the Carambeí event, the model simulates a instability area over Curitiba, but it cannot predict the storm which propagates from southwest to northeast.



WRF dx = 1.6 simulated from 18 to 22 UTC 1st April 2011

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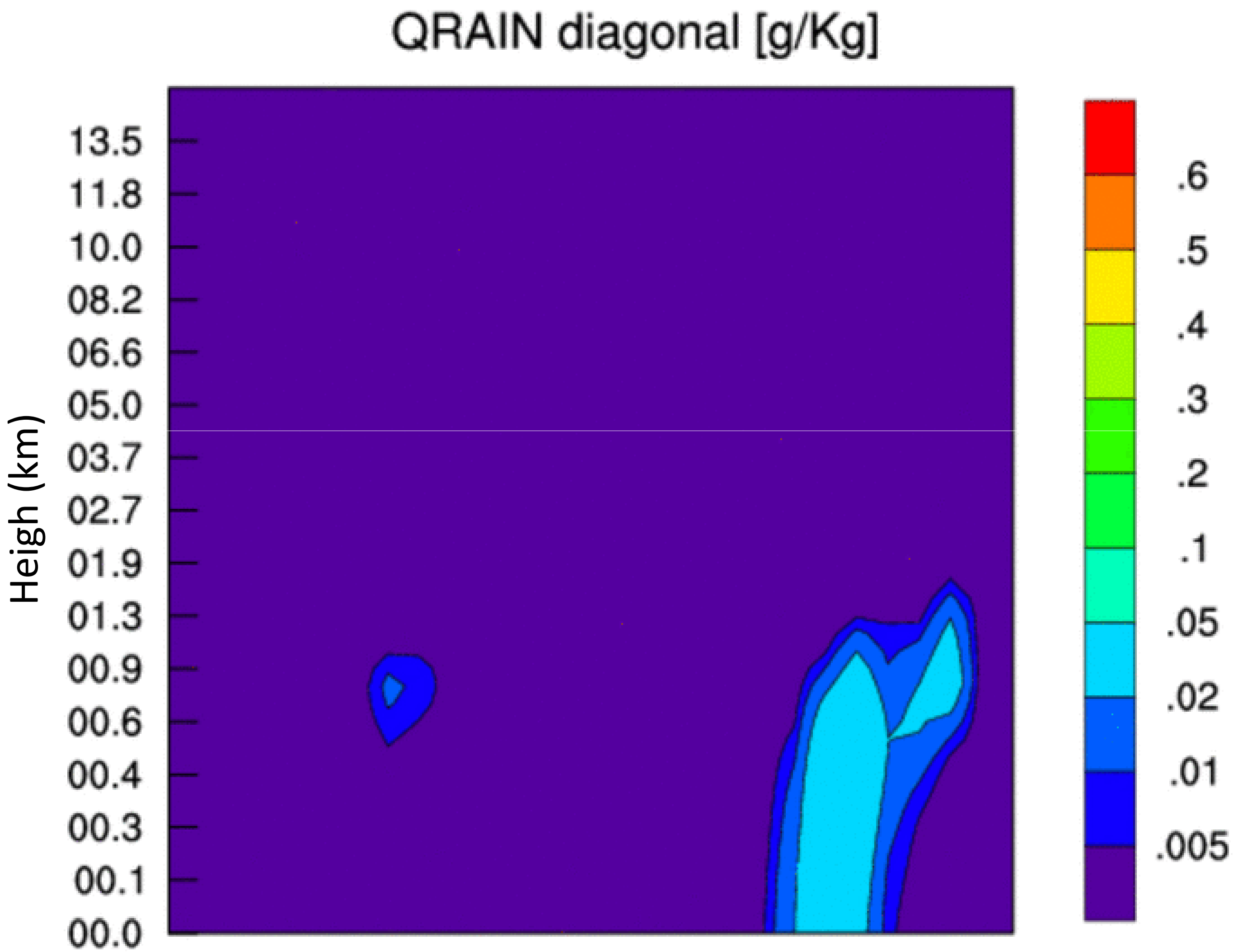
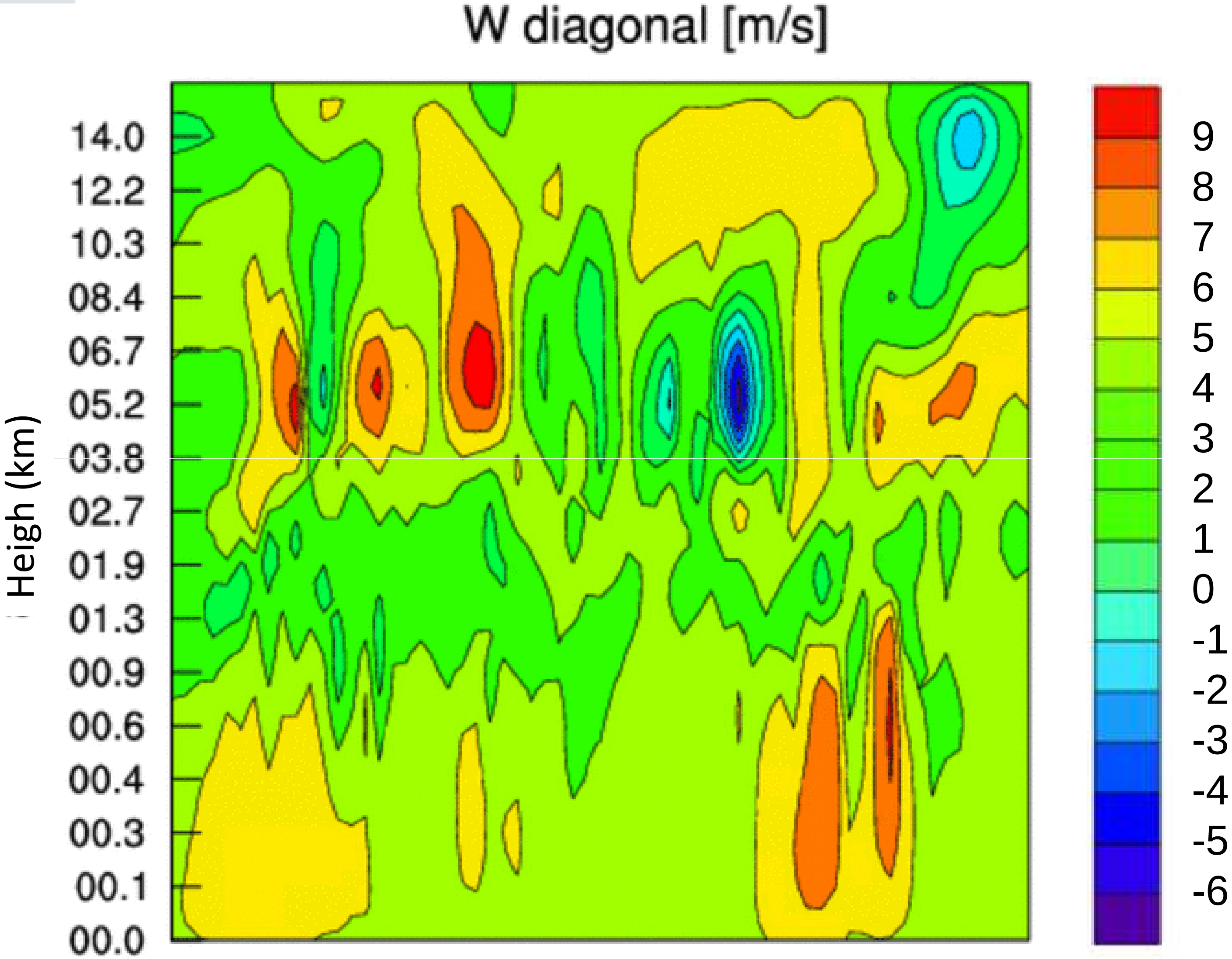
Rain water mixing ration simulated with WRF dx = 1,6 km resolution for 1st April 2011.



WRF dx = 1.6 simulated from 18 to 22 UTC 1st April 2011.

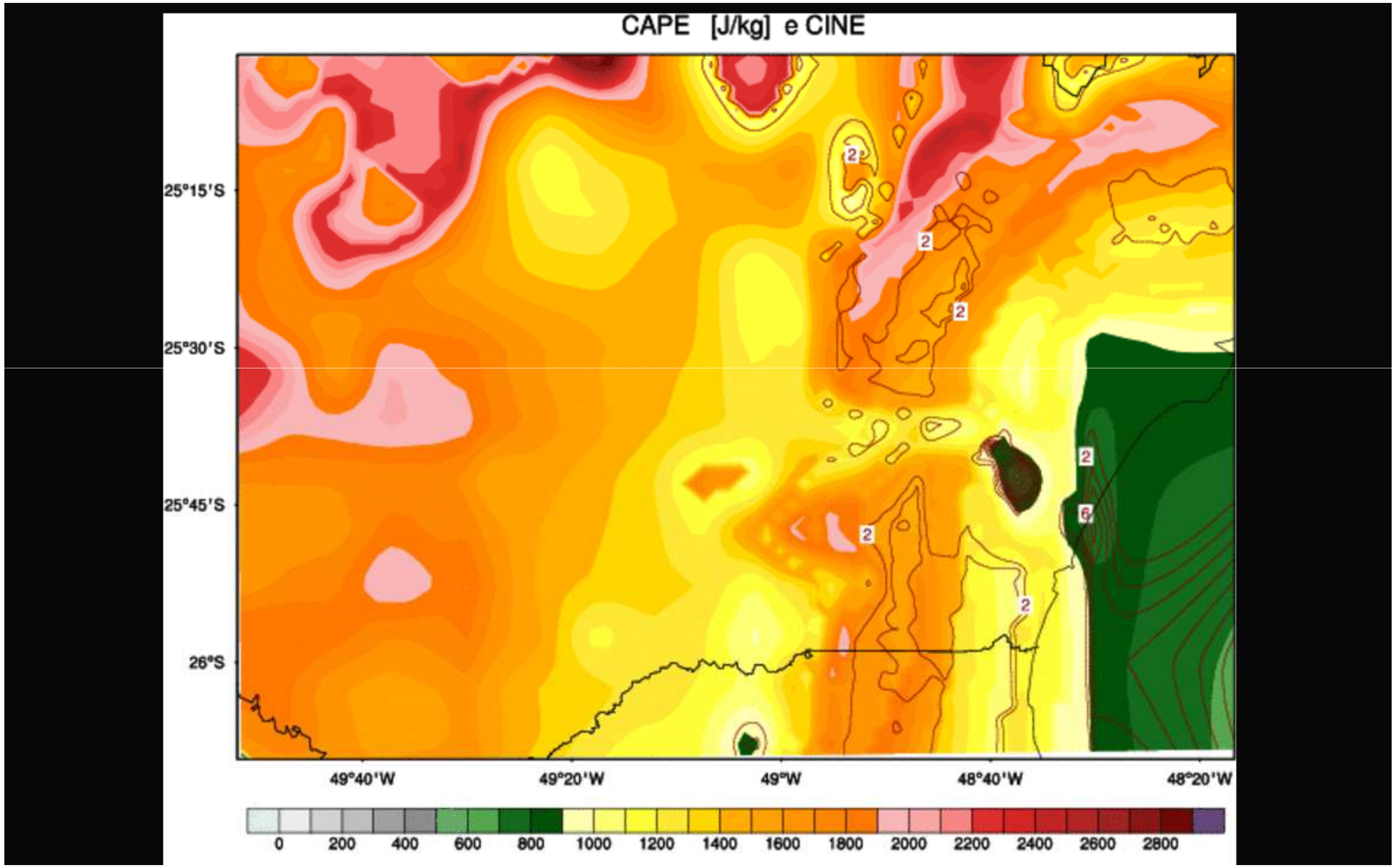
VERTICAL WIND W during Storm event in Curitiba 1st April 2011



WRF dx = 1.6 simulated from 18 to 22 UTC 1st April 2011.

CAPE and CINE (J/kg) for 1st April 2011 event

The instability was generated from local heat, heat advection from north and humidity advection from the sea (east)



WRF dx = 1.6 simulated from 18 to 22 UTC 1st April 2011.

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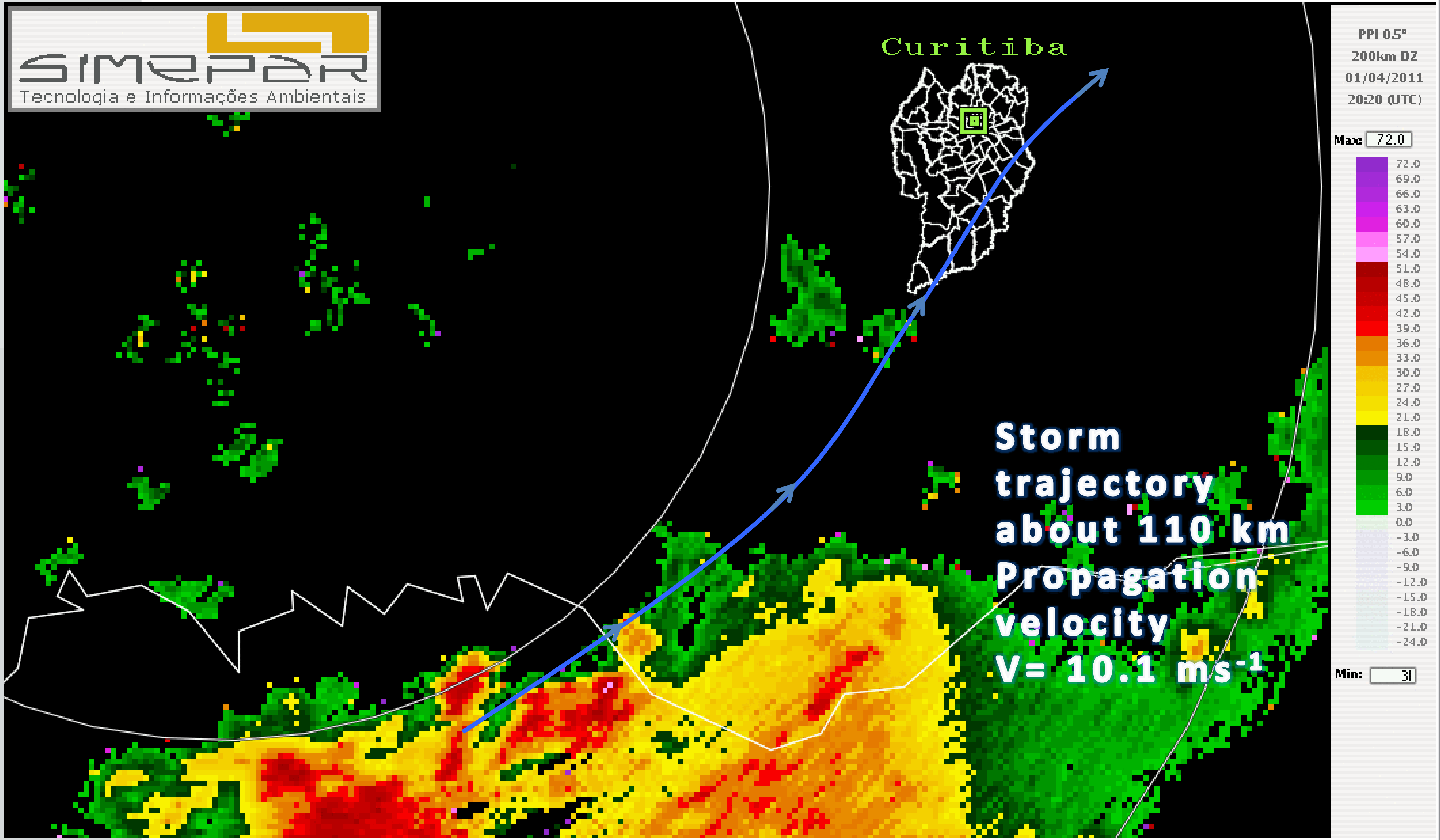
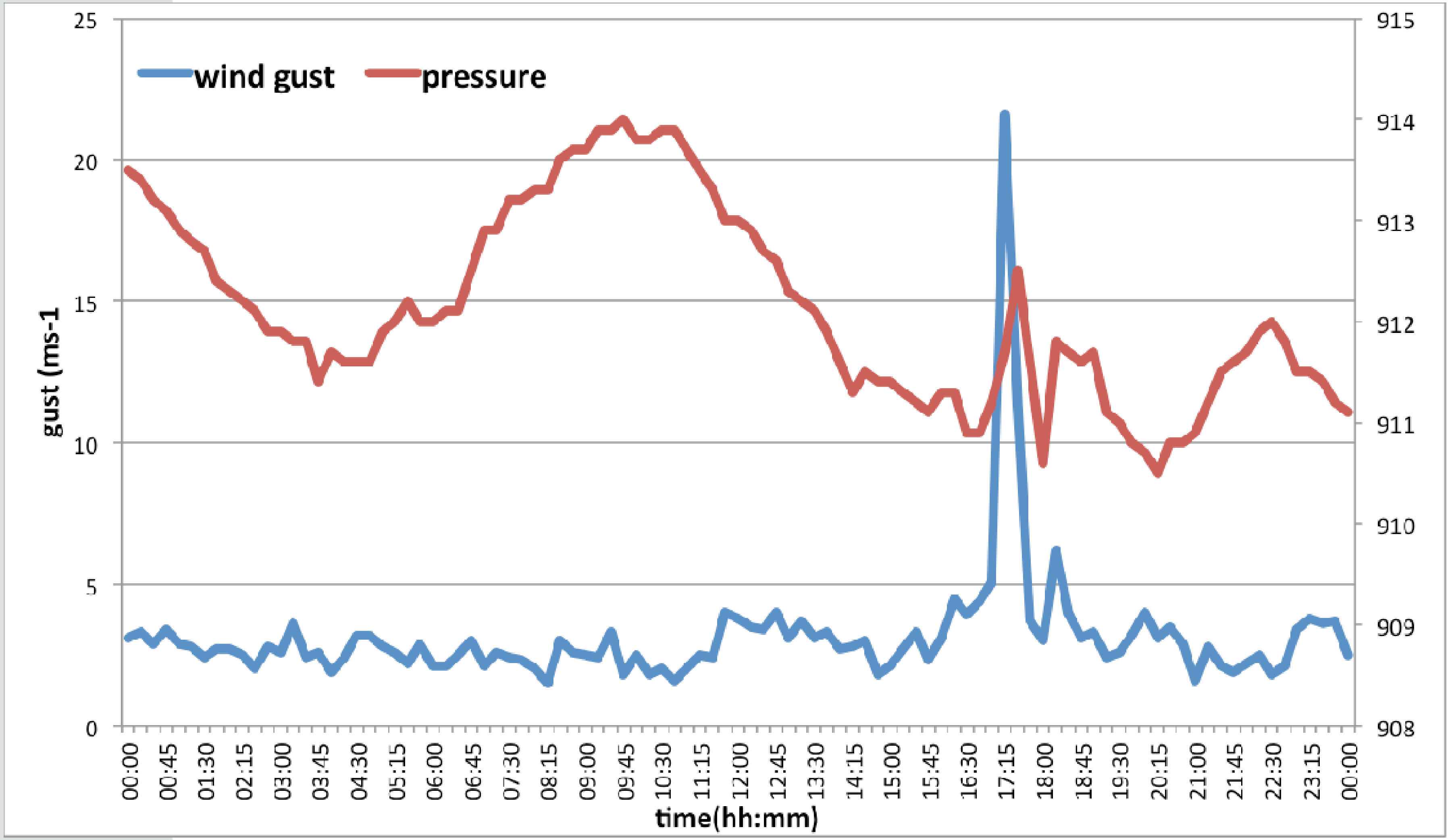
Reflectivity (dBZ) S-Band Doppler Radar 17 to 21 UTC 01 April 2011.



Wind gust and pressure for 1st April 2011 at Curitiba Weather Station
The storm passes over the station.

The wind gust reach 21.6 m.s^{-1}



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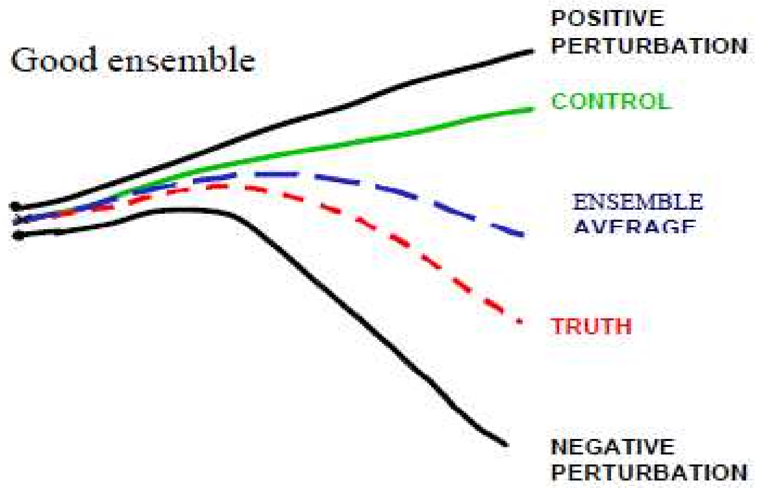
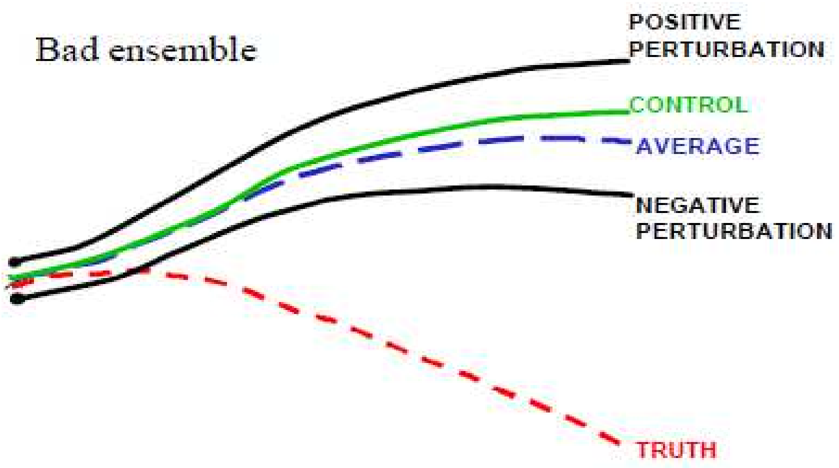
Ensemble Short Range QPF example

WRF simulations for QPF over Iguaçu Basin in Paraná State show encouraging results.

The ensemble mean get 20 % better score then deterministic.

Ensemble provide uncertainty of the prediction at the moment.





Calvetti, L. 2011
Doctoral Thesis,
Department of Atmospheric Sciences,
University of São Paulo
Advisor: Augusto José Pereira Filho

Kalnay, 2002

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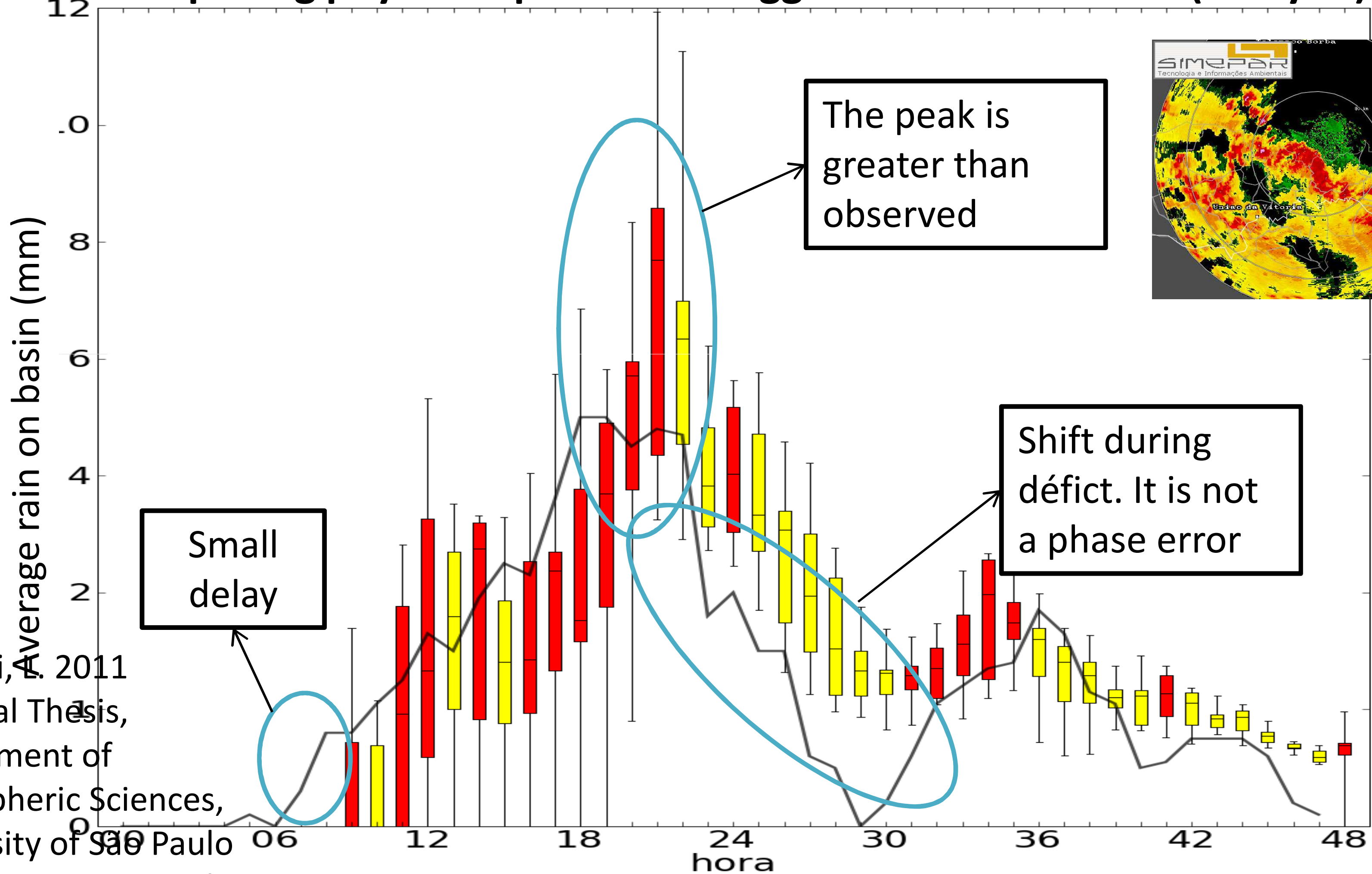
Ensemble Short Range QPF example

48h QPF from WRF ensemble for a 27 000 m² basin. The members comprising physical options and lagged initial conditions (analysis)



11 - 12 September 2005 – Cold Front event

Calvetti, L. 2011
Doctoral Thesis,
Department of
Atmospheric Sciences,
University of São Paulo
Advisor: Augusto José
Pereira Filho

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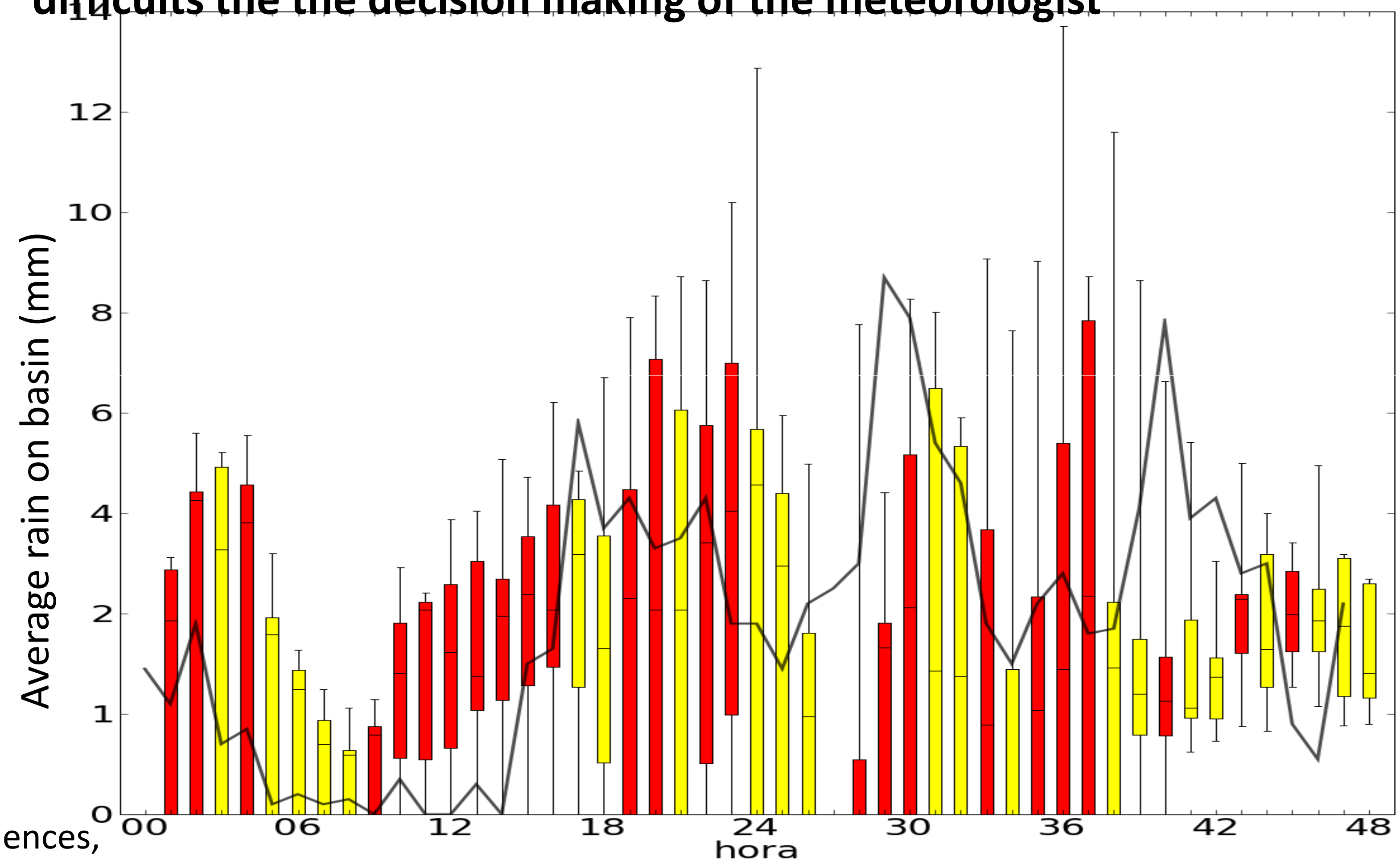
Ensemble Short Range QPF example

Of course, sometimes the dispersion can be very large which difficults the the decision making of the meteorologist



25 - 26 April 2010 pre-frontal convection

Calvetti, L. 2011 Doctoral Thesis, Department of Atmospheric Sciences, University of São Paulo Advisor: Augusto José Pereira Filho

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Conclusions / Future Work

- ✓ For Nowcasting, 0 – 2h, and sometimes up to 3 h , extrapolation and tracking storms is the best solution. Here, the model can provide some indicators such as heat and humidity advection, thermodynamic environment and synoptic pattern.

- ✓ For 3 up to 12 hours, NWP is a better guide for thunderstorm prediction, but with bad analysis (or bad assimilation), the model can miss some storms.

- ✓ For simulation of wind gusts, it's necessary lower timestep (as 20 sec.) and high horizontal resolution (<3 km). Furthermore, the density of the layer is important to simulate the mass and heat transport through the troposphere. But, you can set higher density layers near the surface and lower density in the middle.

- ✓ The next steps comprise to combine extrapolation nowcasting (0-2h) with NWP model for very short range forecast(2-12) using ensemble approaches.

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Thank you !

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