Impact of Radar Data Assimilation for a Case Study in Brazil

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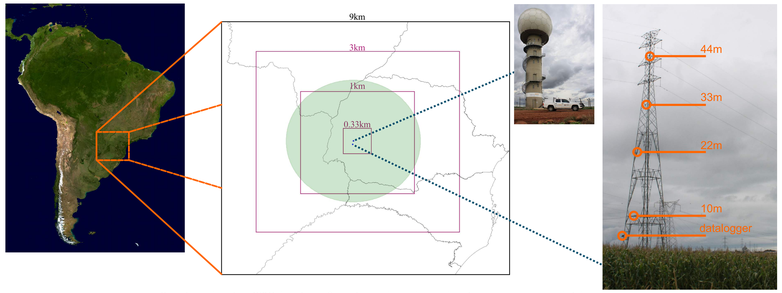
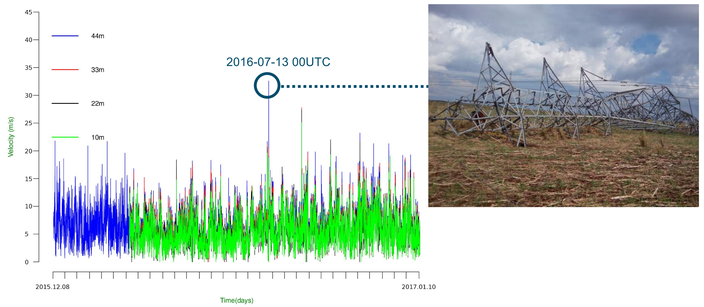
Introduction

Due its large extension, Brazil has several areas that are prone to produce severe storms (strong winds, heavy rainfall, lightning, flooding) which may lead to downbursts and tornadoes. The south of Brazil, specially the west of Parana state, is an area prone to severe weather, mostly related to mesoscale convective systems, due to the influence of low level jets bringing humidity from tropical region. Such phenomena produce wind speed that are greater than 30m/s and cause, every year, damages on many high structures such as power transmission lines and towers. Paraná Meteorological System (SIMEPAR) operates a dual polarization S-Band weather radar in this region. Numerical weather prediction is essentially a boundary conditions problem which means that better initial conditions relate to better forecasts. The aim of this study was to improve model skill in short-range forecasts (about 1 hour) by assimilation of radar reflectivity, radial velocity along with automatic surface meteorological stations.Since December 2015 a series of anemometers were installed in four energy towers within the weather radar range to study the behaviour of wind around and in these structures.

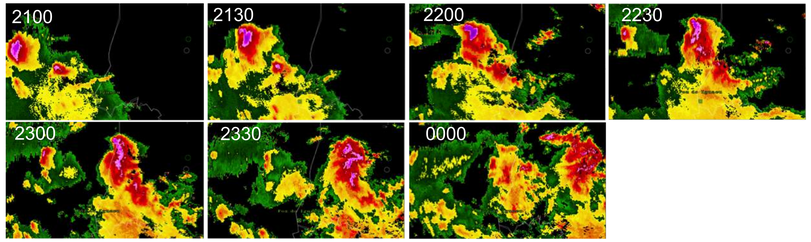


Experiment location: WRF domain configuration, radar and tower location and anemometers heights.

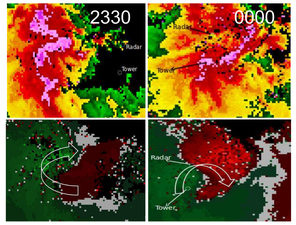
On July 13th at 00UTC an energy tower 12km from the radar was toppled due a strong wind gust. At 300m distant from this tower, an anemometer at 44m height recorded a wind gust of 32m/s.



Case study event: a severe weahter storm toppled the transmission tower (above right). During this event a wind gust of 32m/s (above left) was recorded at the anemometer installed at 44m height in the instrumented tower, 300m apart of the toppled tower.



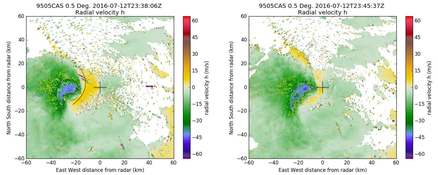
Supercell evolution on July 12th-13th 2016



Mesocyclone signature

The series of images above show the supercell evolution up to the time of the event.This storm started in Paraguay, west of the radar, as a result of small cells merging into a supercell, around 19UTC.At 23h30UTC a clear signature of clockwise circulation was presented in the radar images, characterizing it as a supercell. At the time of the event, the mesocyclone had a radius of 45km. The image on the left shows the mesocyclone signature of this event.

In the Doppler radial velocity images (see images on the right) it was observed the mesocyclone and the gust front. The tower toppled between 2330 and 2400 UTC, The wind that loaded the tower was originated part from the gust front and part from the downdraft core. The intensity of radar estimates and anemometers measurements were very similar, varying between 35 and 40 m/s.



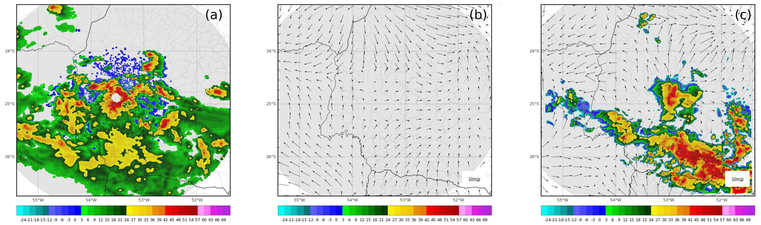
Methodology

This study used WRF model version 3.7.1(Skamarok et al, 2008) and WRF3DVAR (Sun, 2010) with three nested grids with 9km, 3km and 1km horizontal resolution centered near the radar site. The boundary conditions were obtained from Global Forecast System (GFS) model with a horizontal resolution of 0.25 degrees.
The simulations used Lin et al. microphysics, RRTM for longwave radiation, Dhudia shortwave radiation scheme and surface physics of Revised Monin-Obukhov scheme. This set of physics parameterizations were chosen among four other based on a previous study on february 18th, 2016. The assimilation was performed over the 0.33km and 1km grids only. Nested feedback carried out information throughout the domain.

In order to use the radar data into the WRF model, a routine in Python was used to read the raw radar data, perform quality control and output in ASCII for WRFDA. This routine uses the Python ARM Radar Toolkit, PyART (Helmus and Collis, 2016), a Python module with radar algorithms and utilities. There is two main quality controls used, the first is the attenuation correction (using PyART for attenuation function), the second is the removal of noise in the data where the spectrum width is near zero. Radar beams where reflectivity was too high (more than 72dBZ) or low (less than 12dBZ) were also removed.
Two experiments were made to evaluate the differences between assimilation strategies. The first experiment was a cold start with assimilation at the time of the event. In the second experiment three cycles every one hour were made prior the analysis.

Results

While the model without assimilation was not able to generate the convection as observed with radar data, the high-resolution simulation with radar data assimilation yield a development of the convection cells compared to the observations. In some areas the reflectivity simulated were overestimated. The spatial distribution of reflectivity, and the magnitude of the wind forecasted by the model were similar to those observed, although the reflectivity amplitude were again overestimated.



(a) observed reflectivity on July 13th 2016 at 00UTC. (b) Analysis without cycling. (c) Analysis after three cicles

Conclusions

These preliminary results encourage further investigation in radar data assimilation for short-range forecast. Quality control is a major issue that should be investigated thoroughly, and in particular when regarding radial velocity.
Using polarimetric variables can improve the quality control and is already in the process of analysis of this project.
The simulations show promising results to improve model skill in short-range forecasts (about 1 hour) by assimilation of radar reflectivity, radial velocity along with automatic surface meteorological stations.

References

Calvetti, L. et al. (2016). An Study of Severe Storms and Wind Gusts on High-Power Transmission Towers during a Southern Brazil Campaign. 28th Conference on Severe Local Storms.

Helmus, J.J. and Collis, S.M., (2016). The Python ARM Radar Toolkit (Py-ART), a Library for Working with Weather Radar Data in the Python Programming Language. Journal of Open Research Software. 4(1), p.e25. DOI: http://doi.org/10.5334/jors.119

Skamarock, W. C. et al (2008). A Description of the Advanced Research WRF Version 3. Boulder, Colorado, USA.

Sun, J. (2010). Doppler Radar Data Assimilation with WRFDA. WRFDA Pratical Sessions. http://www2.mmm.ucar.edu/wrf/users/wrfda/Tutorials/2010_Aug/docs/WRFDA_radar.pdf

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COPEL Geração e Transmissão
ANEEL Agência Nacional de Energia Elétrica

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