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Measurements and Numerical Simulations of Wind Gusts on High-Power Transmission Towers

Every year high-power transmission towers are blown down by wind gust during severe storms in southern of Brazil.

Sonic anemometers were installed in four towers in the west of Parana State, southern Brazil, to investigate the dynamic characteristics of these winds and their relationship with the storms (Fig. 1).

It had been installed 3D anemometer at the top of towers and 2D sonic in another levels (Table 1). The towers were located within a 60km radius distance of the dual-polarization S-band weather radar operated by the Meteorological System of Parana State (Simepar).

Table 1: Height of the anemometers installed in towers

Anemometer Levels (m)			
Tower 1	Tower 2	Tower 3	Tower 4
44	-	-	-
33	29,5	29,5	28
22	19	19	19,5
10	10	10	10

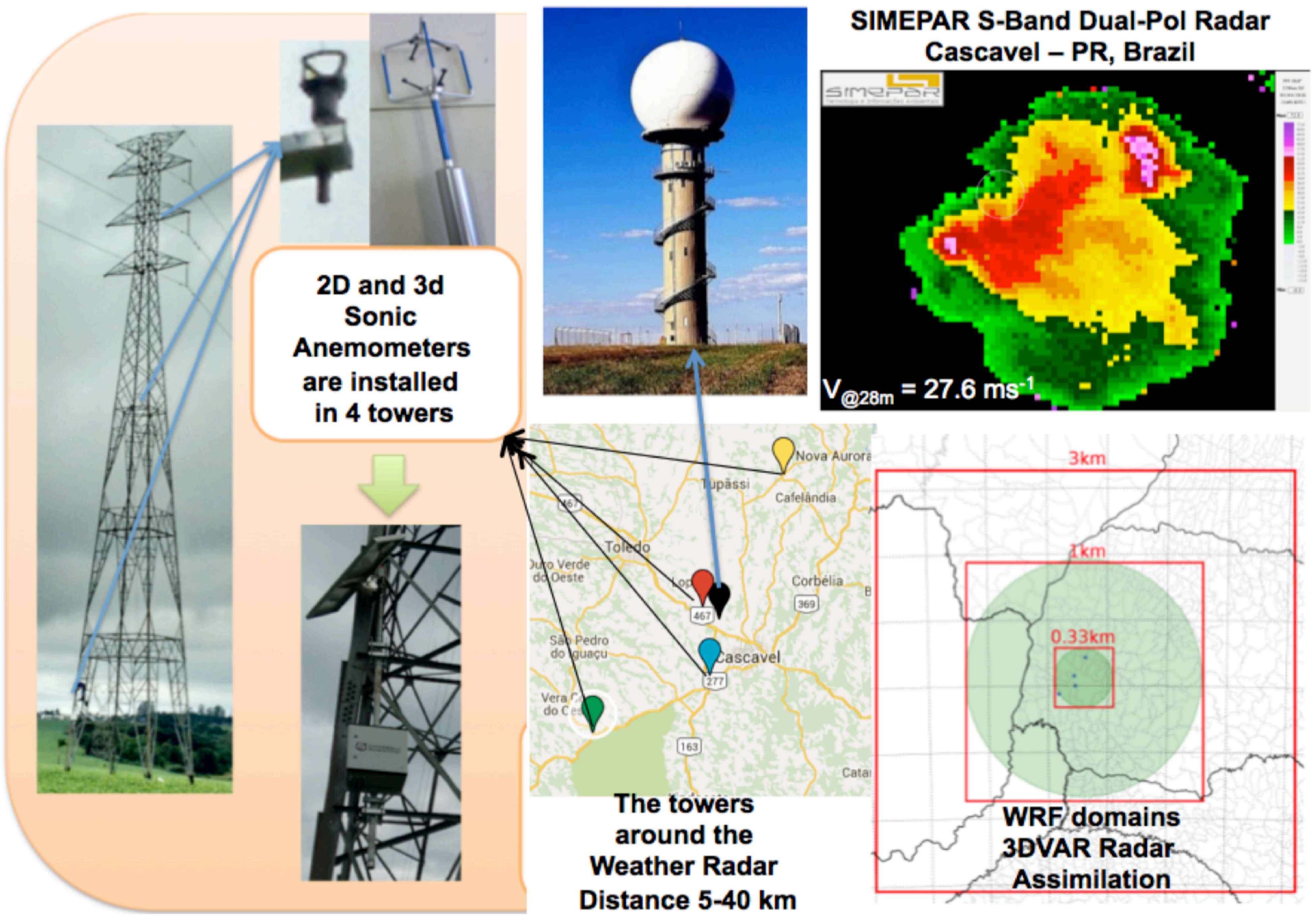
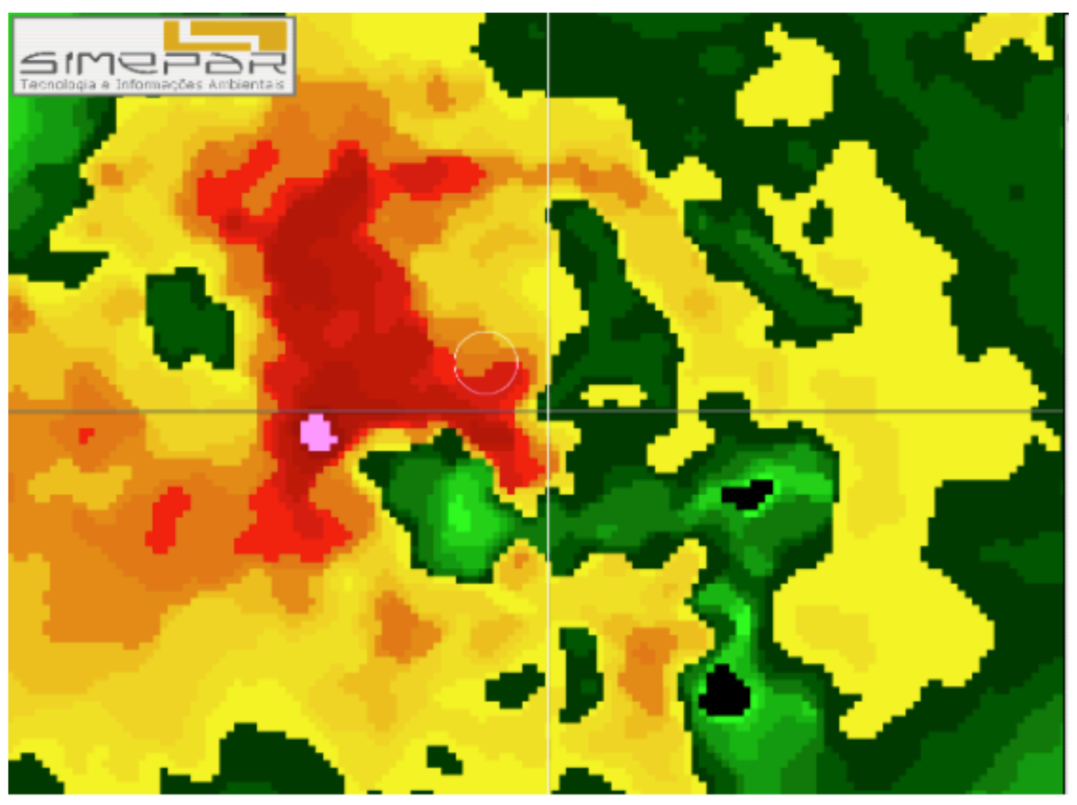


Figure 1: The Campaign Study Area, the sonic anemometers installed in towers, the S-Band dual-pol Weather Radar and the domains of the simulation with WRF and 3DVAR.

During the campaign it was observed squall lines, supercells and thunderstorms cells. Since January 2016, the stronger wind gust registered at the anemometers was 27.6 m/s at 28m level in tower 4 in 28 Feb 2016. At the moment of the peak, the sensor was located at the northwest flank of the convective cell (figure 3), probably inside a gust front. If the storm nucleus passed over the tower it could be generated more intense gust winds. The radial velocity (PPI 0.5) indicate strong winds (more than 20 ms^{-1}) and a rotation signature at low levels (Fig. 2) indicating a high thermodynamic activity.

Another interesting result found in the campaign was that during strong gusts, the profile of the vertical structure of winds shift from exponential to linear with similar values from 10m up to 44m level, probably due to the propagation of the gust fronts.



(a)

(b)

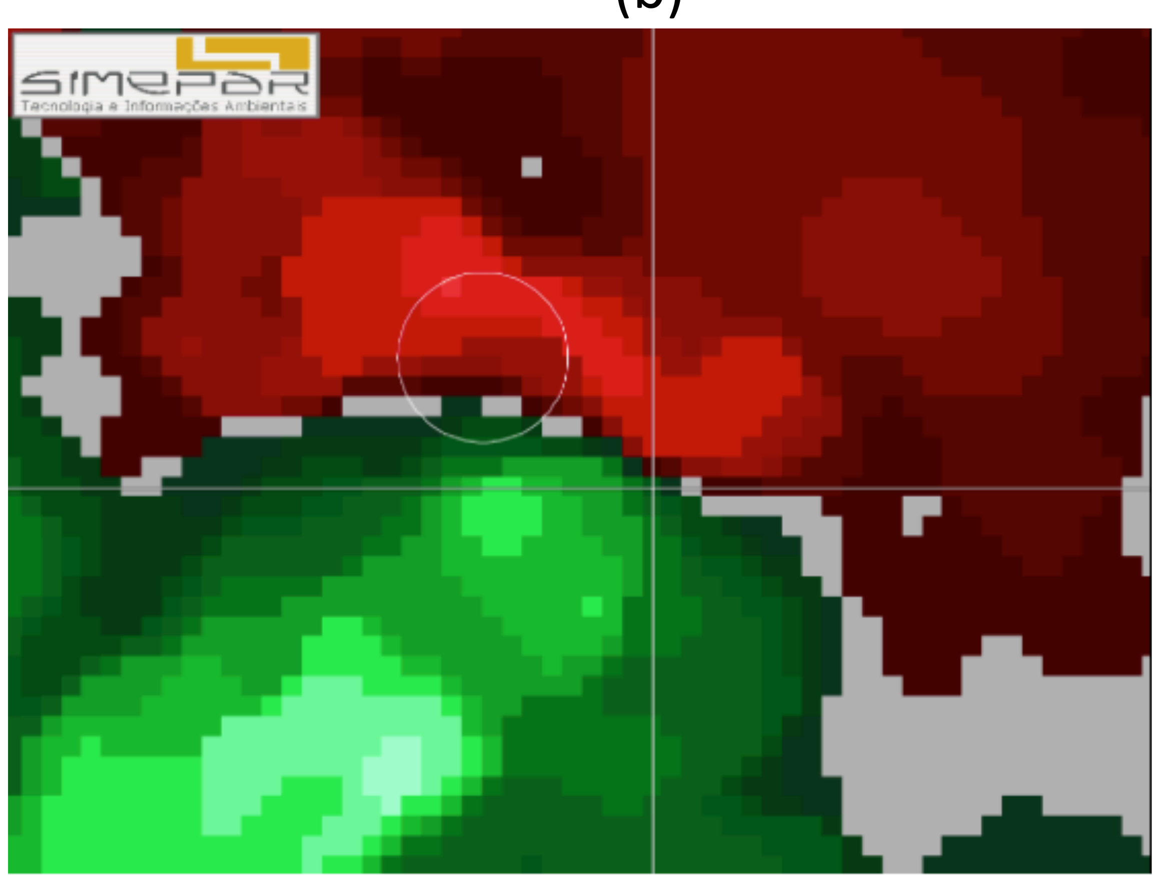


Figure 2: Reflectivity (a) and Radial Velocity (b) from Cascavel-Simepar S-Band Weather Radar. The circle indicate the position of the tower with anemometers.

High-resolution simulations (3 km) using WRF/NCAR MARS (Model Rapid Assimilation of Simepar) and 3DVAR data assimilation of radar reflectivity and radial velocity were performed for strong and moderate convection events. The assimilation of MARS run under a rapid updated cycle where radar data was used as input every 15 minutes. Lateral boundary conditions were updated every 3h from GFS model. The model has proven to be a useful tool to simulate the storms, but it cannot properly solve the observed intensity of the wind gusts. Better results were found increasing the horizontal resolution (up to 1km), vertical resolution (up to 60 levels) and time-step (up to 30s). For the 18 Feb 2016 event, the 1km horizontal-resolution 2h simulation could solve the convection that generate the 27 ms^{-1} (Fig. 3) although it cannot forecast the wind gust properly indicating about 22 ms^{-1}.

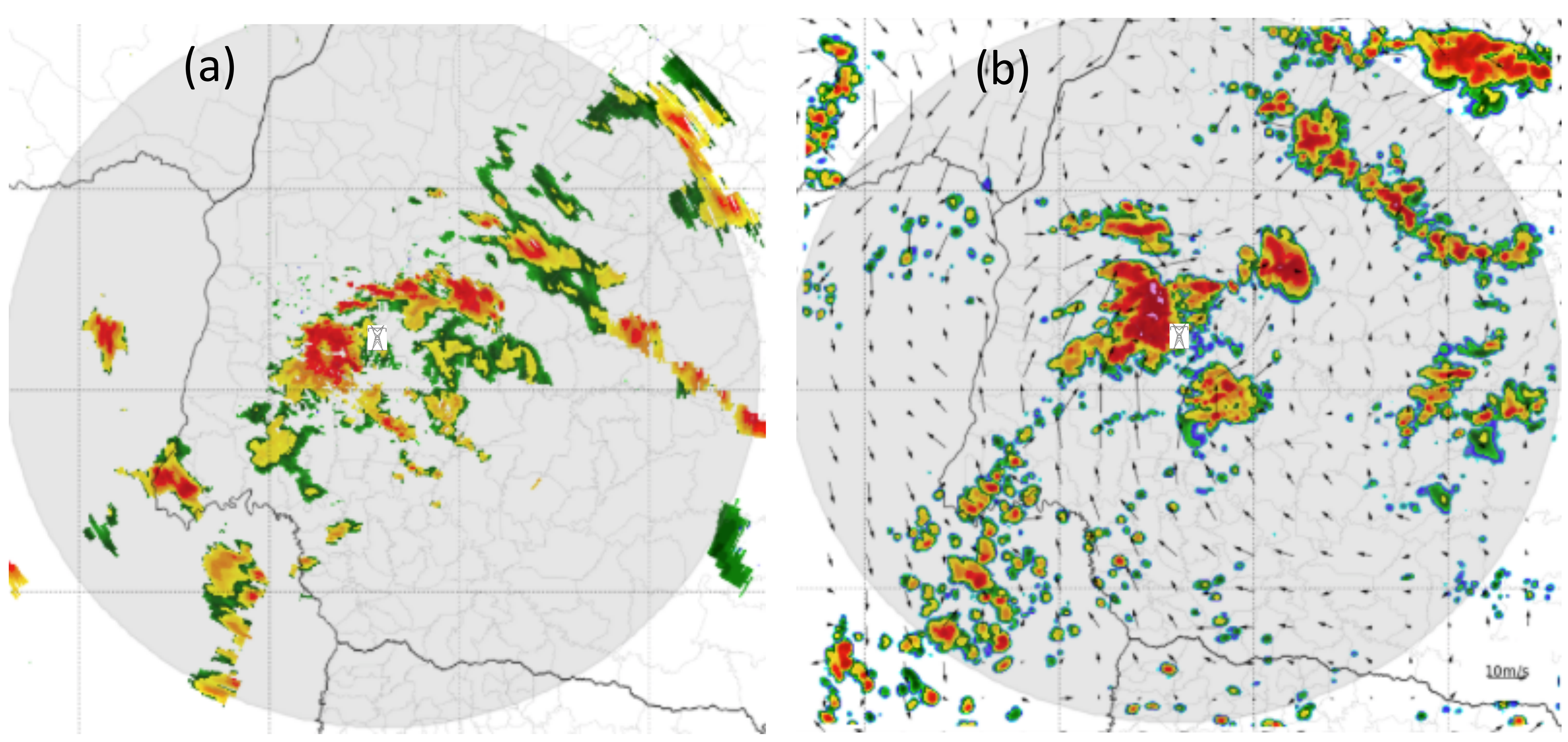


Figure 3: Reflectivity from S-Band Weather Radar (a) and simulated by WRF with 3DVAR radar assimilation (b).

Acknowledgments:

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