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The Impact of Radar Data Assimilation for Simulate a Supercell in Brazil Southern.

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Introduction

Doppler radar measurements has a significant advantage due its temporal and spatial high resolution, allowing a good identification of patterns and signatures of mesoscale systems.

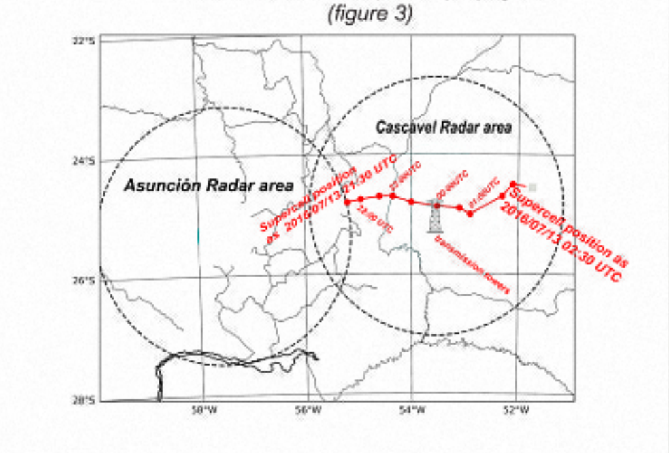
On 12 July 2016, a supercell was registered by the S-Band Dual-Pol Weather Radar of Cascavel in Southern Brazil (*Calvetti et al. 2016*) this supercell produced a downburst that blown down a high-voltage transmission tower in the region *(figure 1,2)*. supercell developed and propagate over Paraguay and western Paraná State in Brazil during 5 hours at 18 ms-1 (*figure 3*), this supercell produced a downburst that blown down a high-voltage transmission tower in Cascavel City, was been registered wind gust of 32.6 ms-1 at 40m in a tower installed 300m from the tower that blown down.

The purpose of this study is analyzing the impact of radar data assimilation on the numerical weather model with different assimilation methods to simulate the genesis and the propagation of the supercell.

figure 1 ,2 The fallen hingh voltage transmission tower

Study Area

Radar Mosaic and Supercell propagation
(figure 3)



Methodology

The data is provided from Cascavel S-Band Radar (Operated by SIMEPAR).localized in the city of Cascavel-PR Brazil *(Radar localization, Lon =-53.529, Lat = -24.870)*, and also Asunción S-Band Radar localized Asunción, Paraguay *(Lon =-57.523, Lat=-25.333)*.

Radial velocity is assimilated, the indirect methods, as used to retrieved rainwater and water vapor from reflexivity data (*Xiao et al. 2007*)

In this study it has been used the WRF model version 3.9*(Skamarock, J. et al. 2008)* for simulations, and it was tested the in four data assimilations methods: 3DVAR, *(Xiao and Sun 2007)*, 4DVAR *(Mahfouf et al. 2005)* the variational hybrid 3DEnVar *(Gao et al, 2015)* and 4DEnVar *(Liu et al. 2008)*. all assimilations methods , from the WRF Data Assimilation version 3.9 (WRFDA) packpage *(Barker et al.2004)*.

The bondary were obtained from the Global Forecast System (GFS) with a resolution 0.25 degrees. For calculate the background error is used one month backward the event of analyze x forecast. In hybrids, the physical and dynamical ensemble with 40 members for ensemble-estimated error covariances

Configuration of the experiments

Assimilation cycles = 2;
Start time of first cycle = 19UTC;
Start time of the second cycle =23UTC;
First cycle data time windows =
3 hours forward and 3 hours backward;
Second cycle data time windows =
1 hours forward and 2 hours backward;

cv_options=5;

Minimization options
4DVAR,4DEnVar,3DEnvar,3DVAR;
EPS = 1^-3, 1^-7, 1^-10, 1^-25 ;
ntmax = 200, 400, 400, 400;

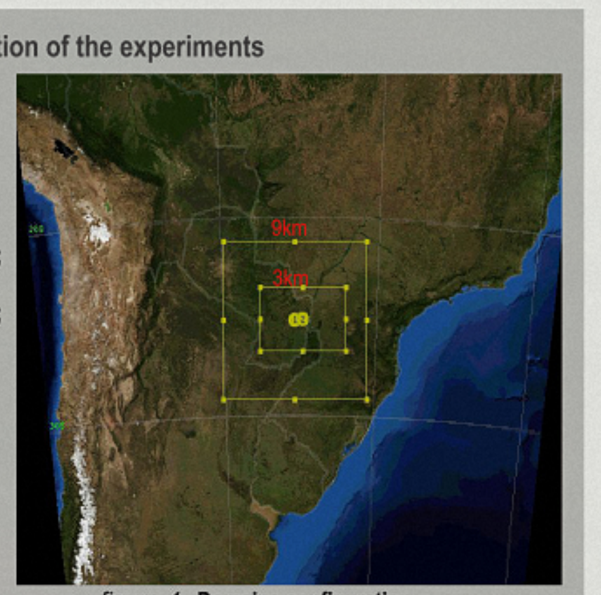


figure 4 - **Domains configuration**

Pysics Options

	9km	3km
mp_physics	= Thompson,	Thompson
ra_lw_physics	= RRTMG ,	RRTMG
ra_sw_physics	= RRTMG ,	RRTMG
radt	= 5,	5
sf_sfclay_physics	= Monin-Obukhov,	Monin-Obukhov
sf_surface_physics	= Noah,	Noah,
bl_pbl_physics	= MYJ,	MYJ
bldt	= 0,	0
cu_physics	= 3,	0
ptop_requested	= 5000,	5000
e_vert	= 60,	60
time_step	=30s	15s

One Way nest option is used.

Results

In the figure 5, without assimilation the radar data, was not able to simulatethe supercell, whith yielding a scattered convection. In the experiments with assimilation, there was an improvement, approaching observed radar data, can reproduce characteristics more similar to those observed in radars data, but the results vary greatly, for each of the assimilation methods, this is extremely visible in figure 5 and 16, when when intercepting a moment, the dBZ field in the model is dirderent for each assimilation method (figure 5), and over time, the propagation varies (figure 16).

With wind as 10 meters with the 3DVAR it is possible to detect much similarity in the wind direction, as well as its intensity, when compared with the radar data in figure 7,in the figures 12,13,14 with vertical data on the region where the tower fell, showing a burst of propagation with very similar intensity,and generating a wind flows turbulent in the atmosphere (figure 15),t is also possible to visualize a good spatial spatial accuracy if we compare with the radar radial velocity in figure 14.

Another characteristic visible in figure 9, if compared with figure 10, the model data also presents an accuracy placing high reflectivity values in a region very close to the observation by the radar.

In this case, the 3DVAR among the methods studied (figure 5) was the only one that presented these signs and features for forecast in 1 hour (figure 16),because the other methods of assimilation in the analysis did not present these signals and characteristics that can be observed in the radar data, and with a smaller spatial precision when compared,including propagation over time (figure 15).

WRF out model data and Radar Observation 2016/07/13 00:00 UTC

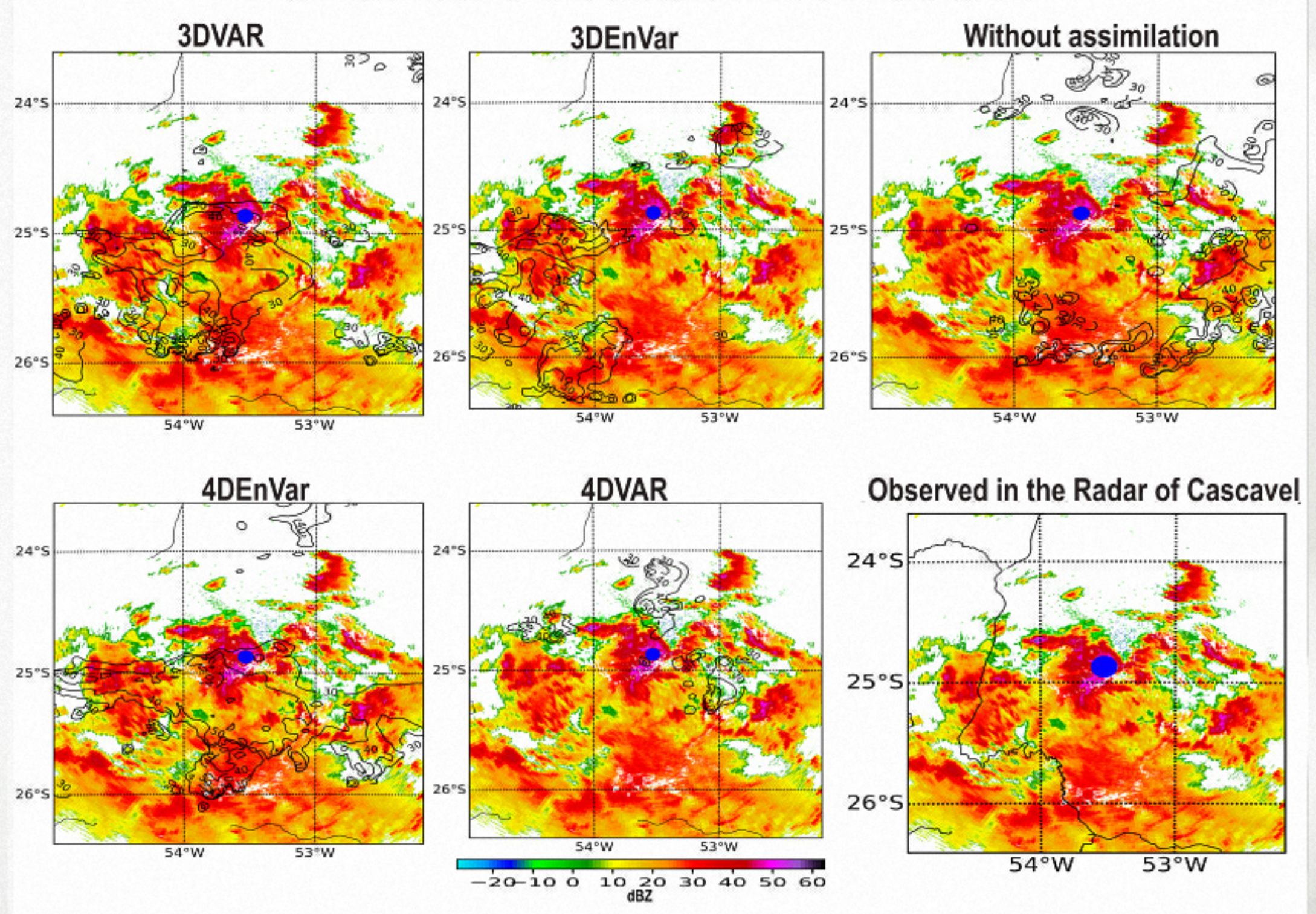


Figure 5. Contour = dBZ > 30 from WRF Simulation
shaded dBZ from Cascavel Weather Radar

Area of the Cross-Section

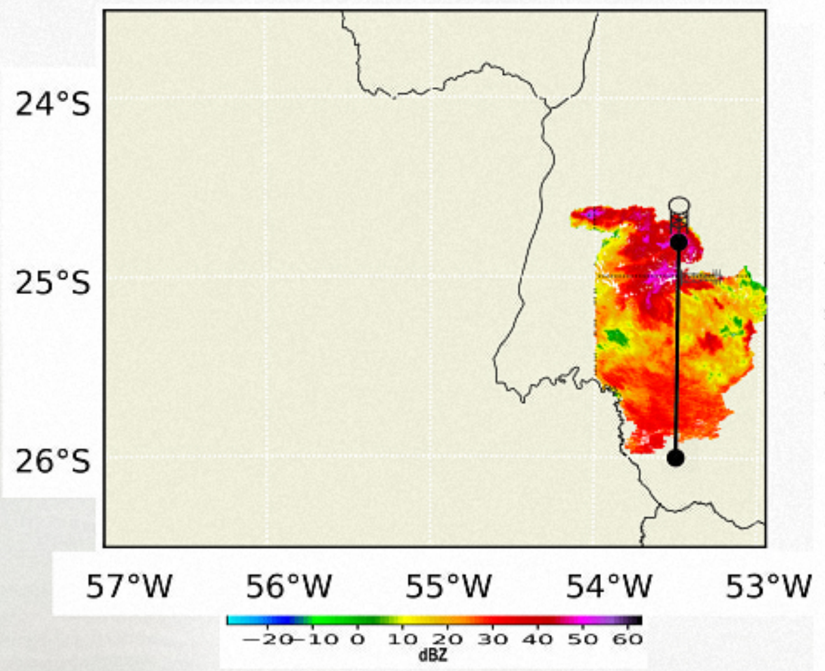


Figure 8. In this figure, shows the location of the vertical cross-section in figure 9,10,11,12,13,14,15
Shaded dBZ from Cascavel Weather Radar

To make the figures, some modules of the python programming language were used: for the figures whith radar data the Pyart module (Helmus, J.J. et al 2016), and for the geolocalized figures the Basemap, and the figures with model data the module wrf-python(UCAR, 2016) all 2D figures we used the graphic libraries of matplotlib (Hunter J. et al. 2012).
For 3D figures the VAPOR sofware is used (Clyne, J. et al. 2007).

Cross-Section, dBZ field from WRF model

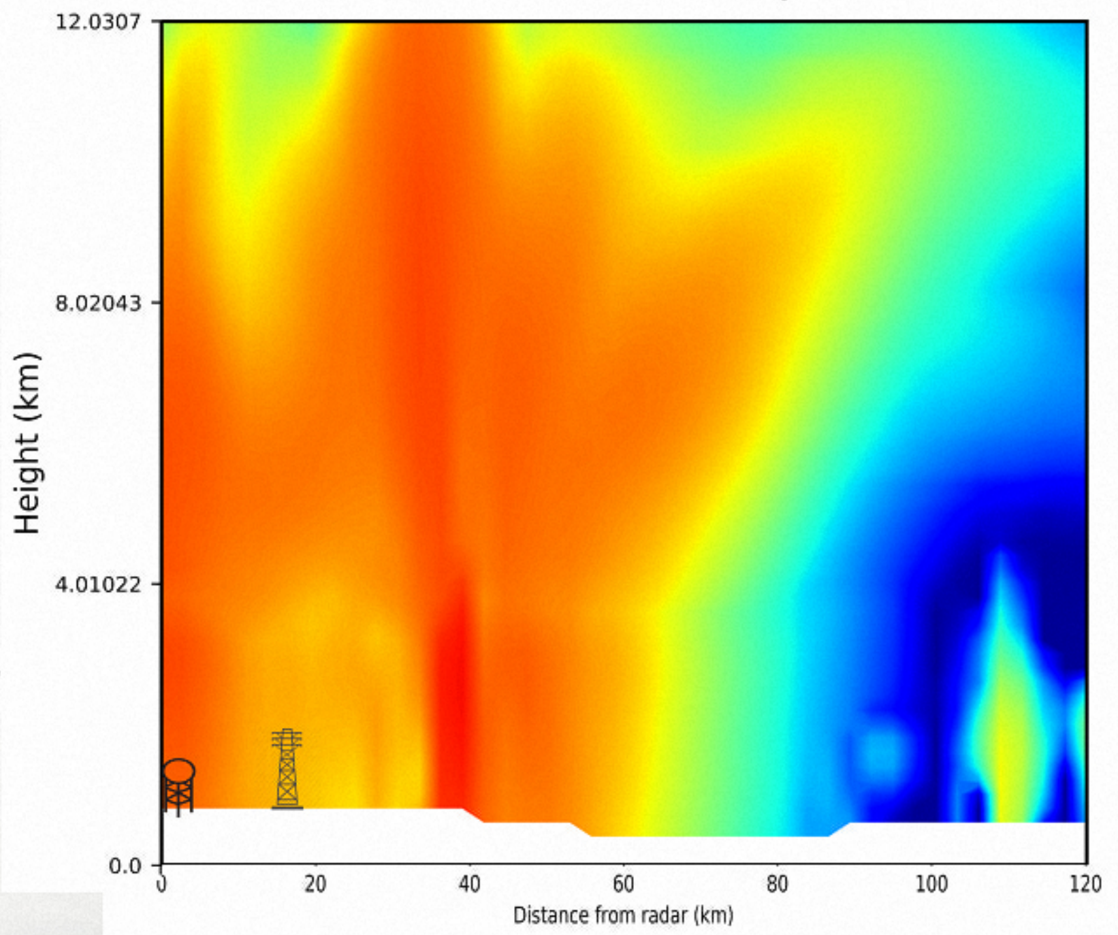


Figure 9, The figure above represents the dBZ field from WRF model with 3DVAR method on 2017/07/13 00UTC, the icons represent the approximate position of the radar ,and the tower of high transmission

Cross-Section, dBZ field observed on the radar of Cascavel

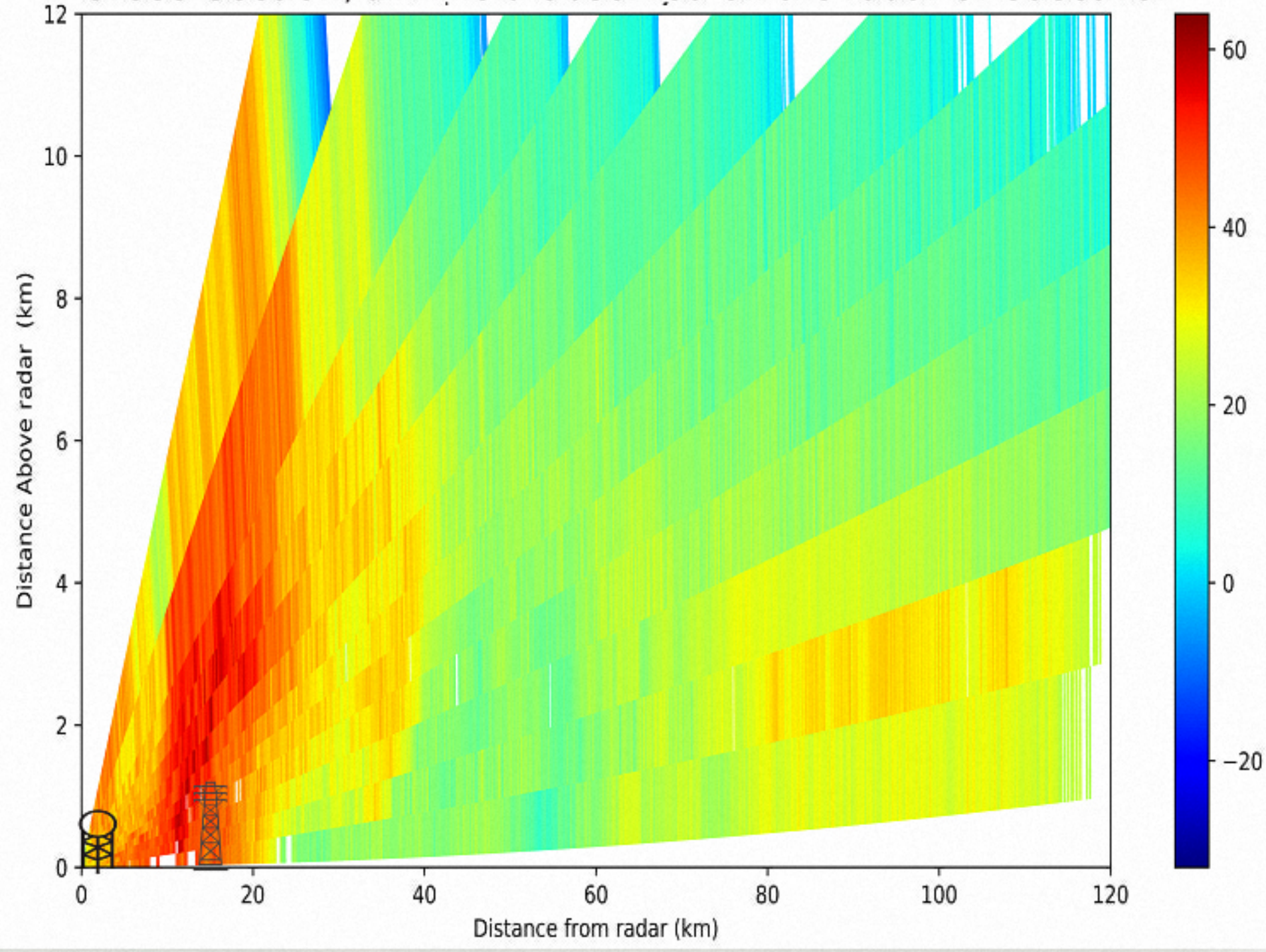


Figure10,The figure above represents the dBZ field of the Cascavel radar on 2017/07/13 00UTC the icons represent the approximate position of the radar ,and the tower of high transmission

Cross-Section, 3D dBZ field from WRF model

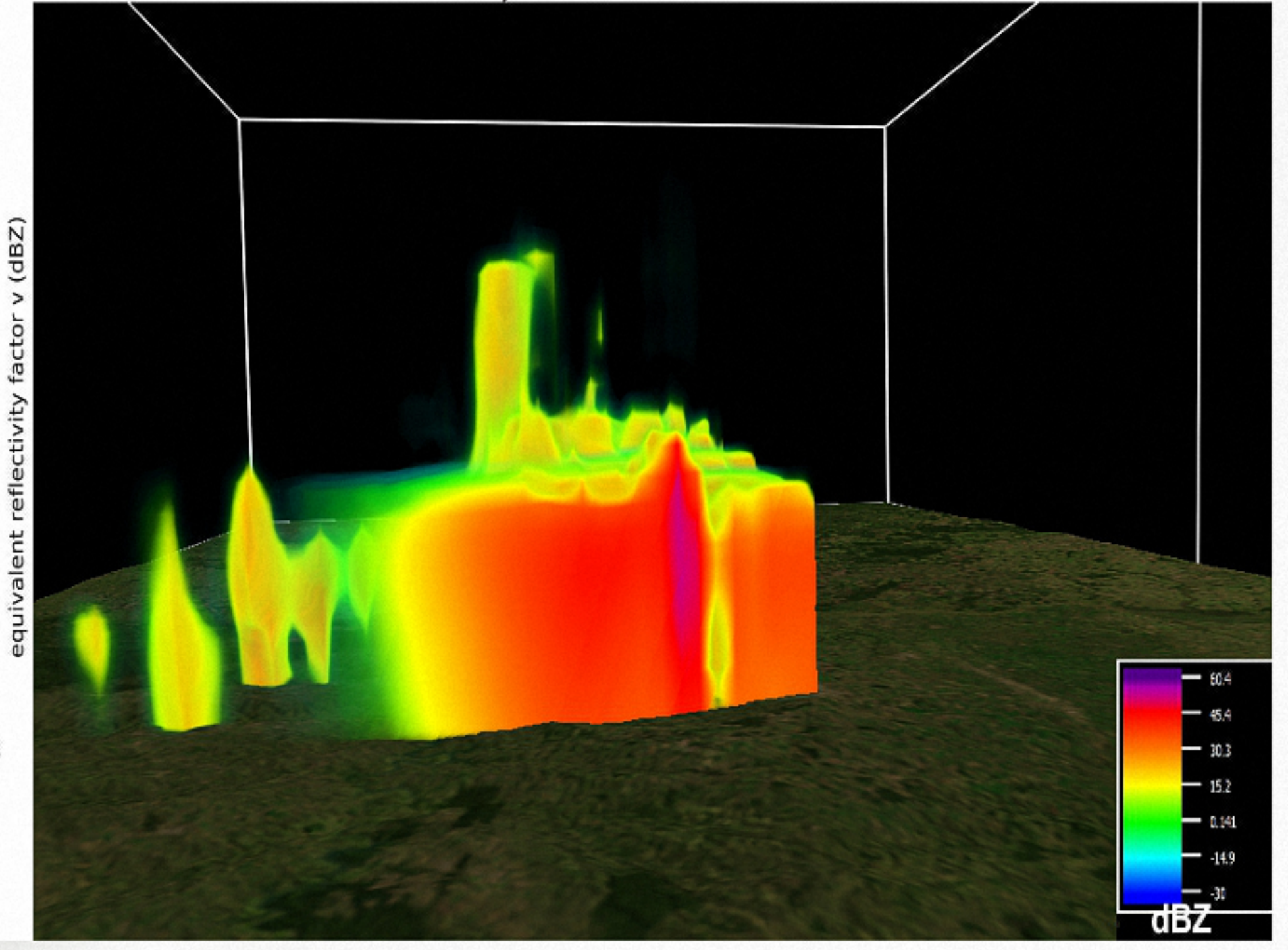


Figure 11. The shaded is the dBZ field from the model, with the method 3DVAR, on 2016/07/13 00 UTC, the area forward whith a cut is the same indicated area of the figure 8.

Wind fields 2016/07/13 00 UTC

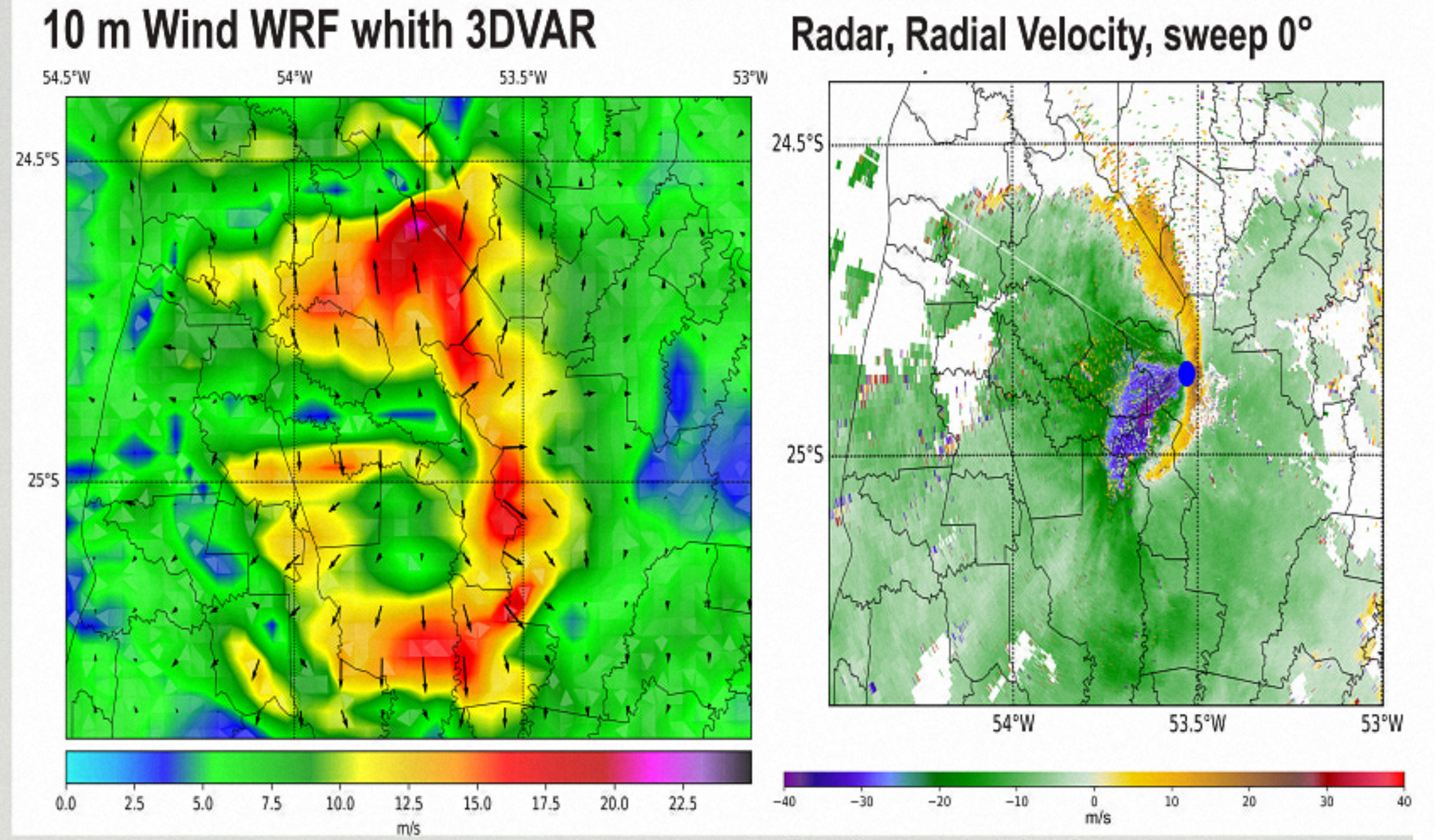


Figure 06. UV wind 10m, on 2016/07/13 00 UTC

Figure 07. radial velocity from Cascavel weather radar, on 2016/07/13 00 UTC

Cross-Section, W-component of Wind *(m/s)*

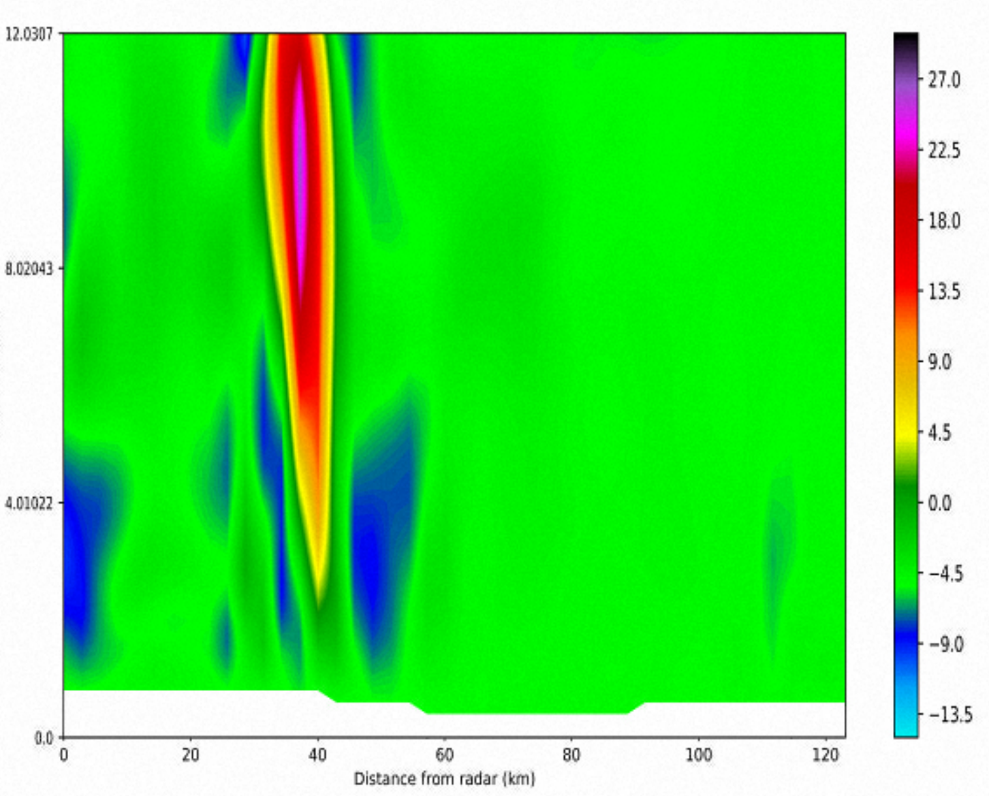


Figure12, Vertical Wind speed from WRF simulation with 3DVAR analysis, on 2016/07/13 00 UTC

Cross-Section of UV-component Wind Speed *(m/s)*

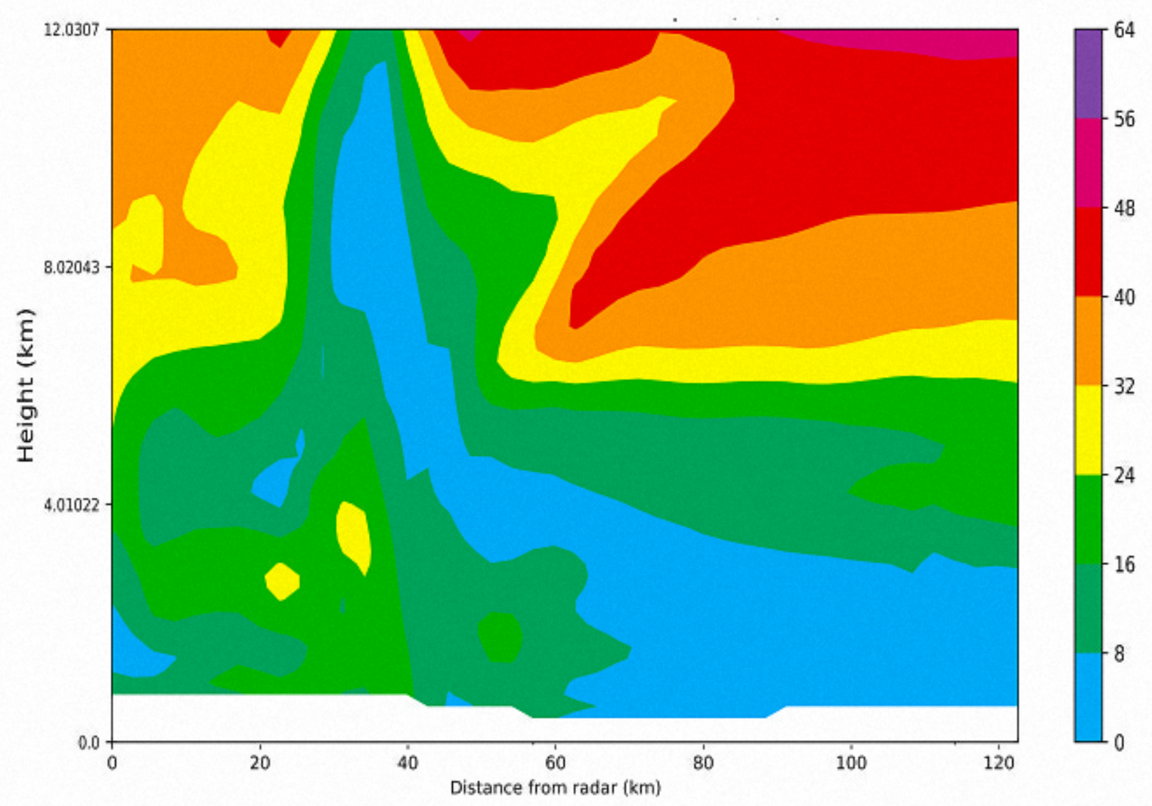


Figure13, Wind speed from WRF simulation with 3DVAR analysis, on 2016/07/13 00 UTC

Cross-Section, Radial velocity field observed on the radar of Cascavel *(m/s)*

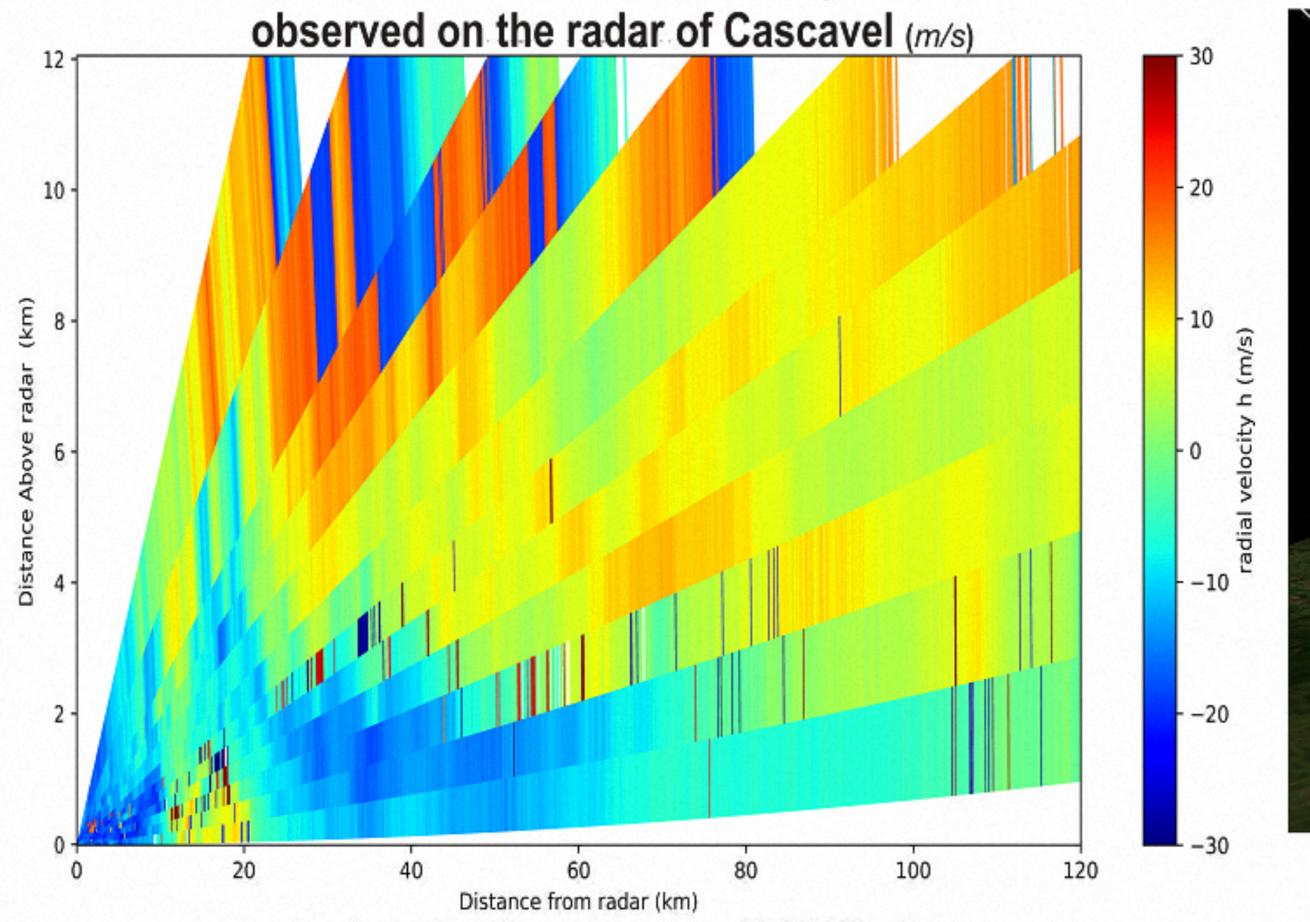


Figure14, Radial Velocity from Cascavel Weather Radar on 2016/07/13 00 UTC

Cross-Section, 3D Flows

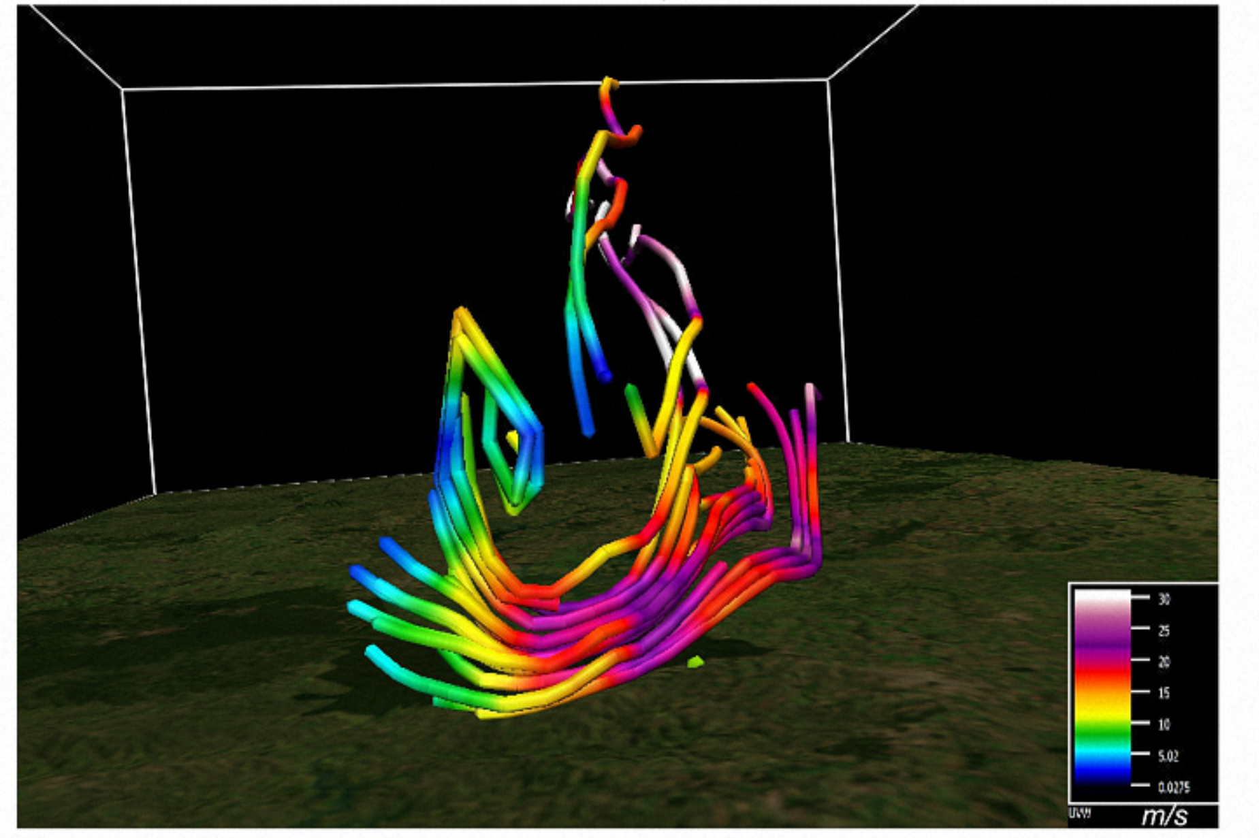


Figure 15.The colors represent the magnitude of the wind UVW field
Up to 2500 above the surface

Supercell propagation, since 2016/07/12 22:00 UTC

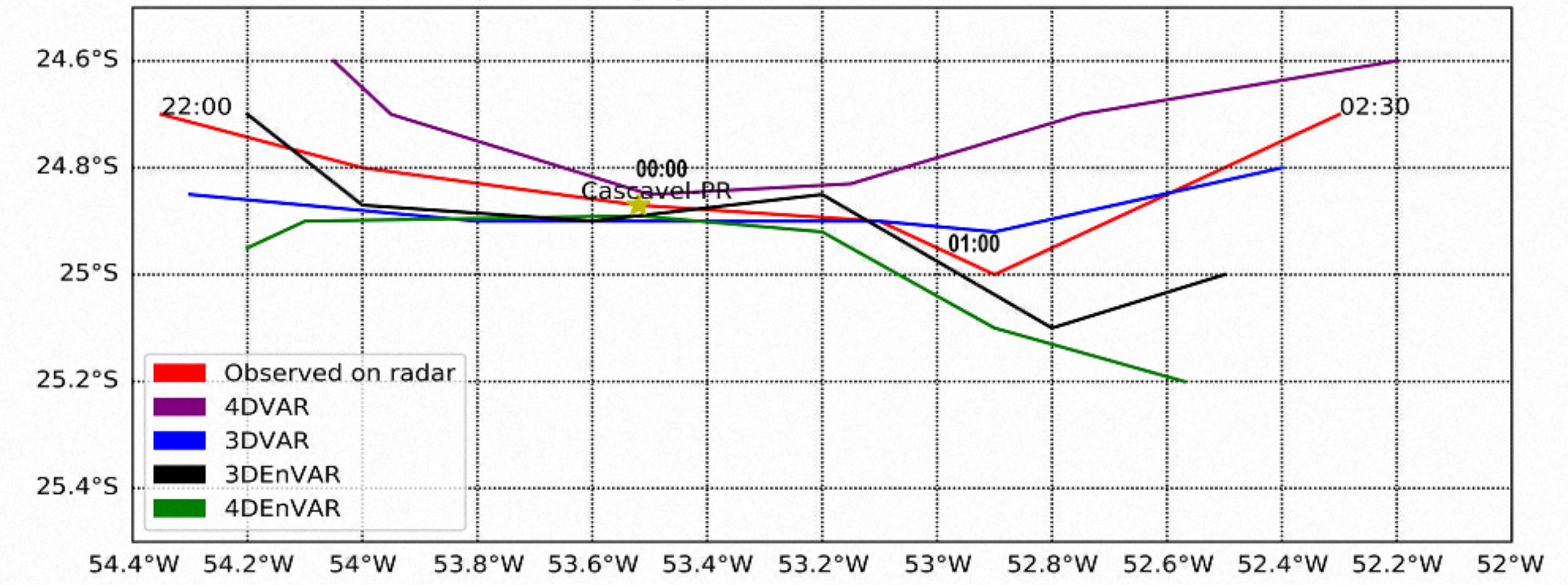


Figure 15. Propagation of the supercell between 22 UTC from day 12 to 02:30 UTC on the day 13, method by method

Radar and 3DVAR dBZ field

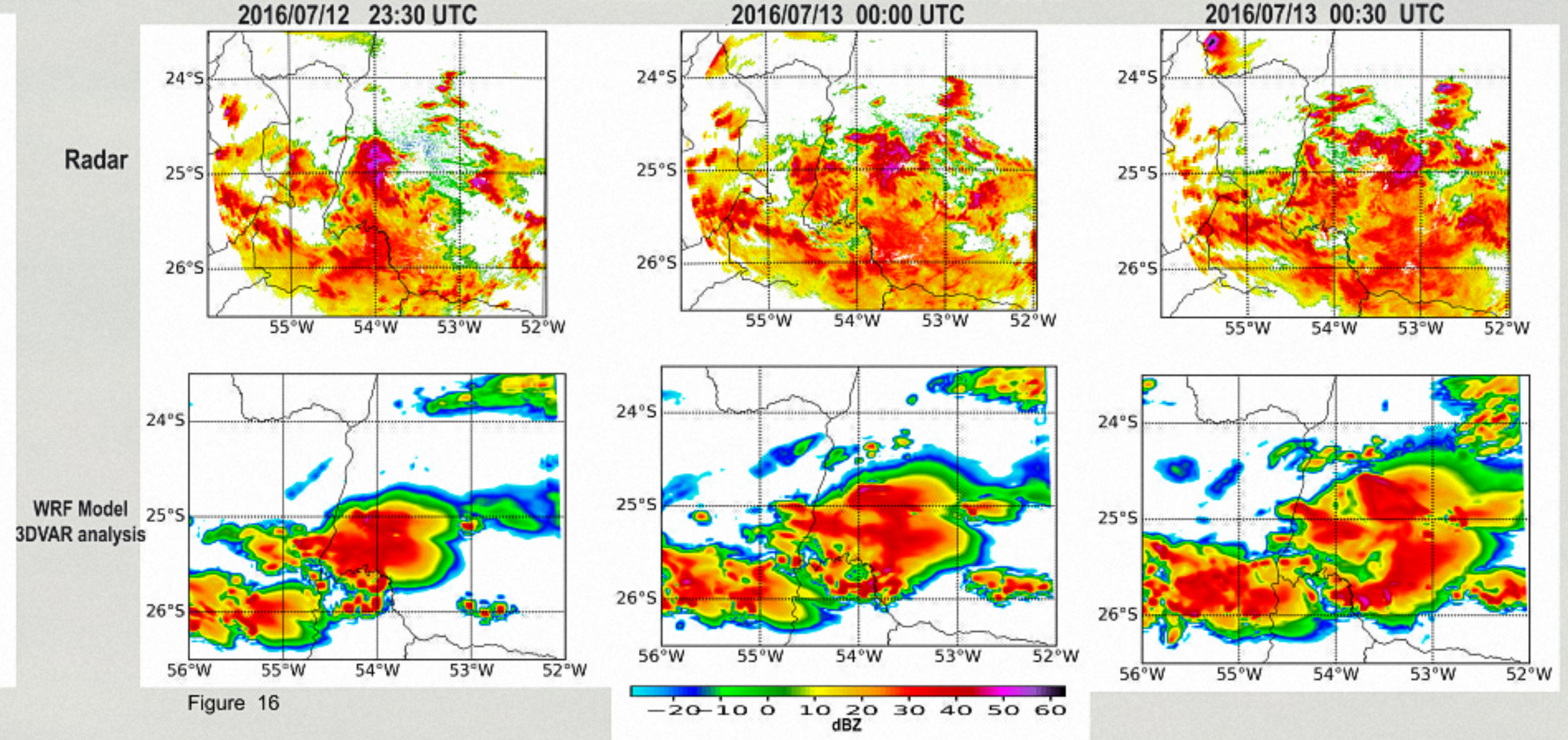


Figure 16

Conclusions

To gain better insight into the evolution of the storms the radar data assimilation shows essentials in this experiment allows simulations and detect more accurately dynamical and thermodynamical structures inside the supercell, including finding signatures of the phenomenon, and is apparent from the results with assimilation, they have created an environment on a temporal and spatial scale very close to that observed (especially with 3DVAR),but with different results between the experiments.

Another point that is observable was the propagation of the supercell (figure 16), which can be represented with high precision in forecast, especially with 3DVAR analyze, but with a very high variation from method to method.

Future studys are needed to explore the impact different variational methods mainly for nowcasting, and the impact of change of convergence criterio (EPS) between the methods.

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