Radar Data Assimilation in a Case of Deep Convection in Argentina

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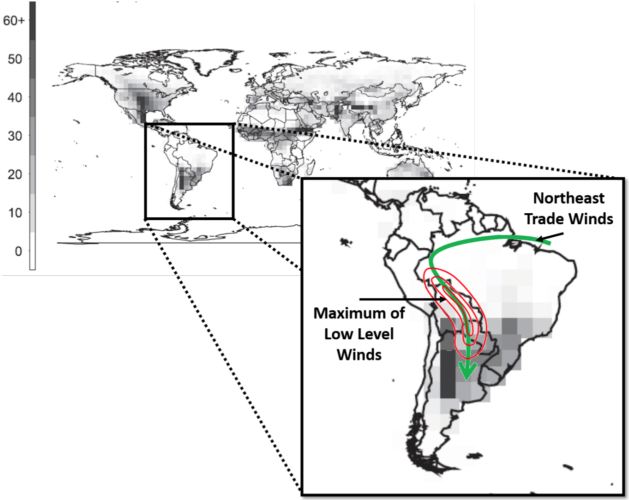
DA Seminar
June 16th, 2017

High-impact Weather Events

Days per Year with Favorable Severe Parameters (Brooks et. al, 2003)

Soundings with $CAPE \geqslant 100\ J\ kg^{-1}$ and $\frac{\partial\theta}{\partial t}(2-4\ km) \geqslant 6.5\ K\ km^{-1}$

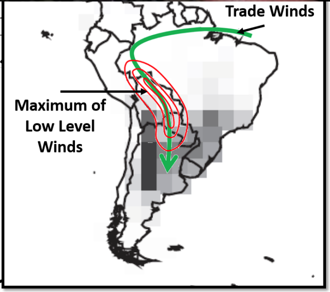


High-impact Weather Events


March 9th, 2017 - Buenos Aires


May 18th, 2017 - Córdoba


April 3rd, 2013 - La Plata



Convective-scale Forecasts

High-resolution NWP Models (< 4 *km*)

- ✔ Eliminate uncertainty associated with cumulus parameterization
- ✗ Significant errors in location and timing of convective systems

Remote Sensing Observations

- ✔ Describe the state of the atmosphere in the convective scale

Advantages of Using Radar Data

- High-resolution, 3D observations
- Temporal frequency necessary to retain the storm's structure

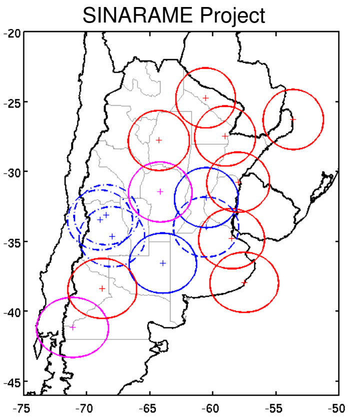


FIGURE – Weather radar network nowadays (blue line) and SINARAME radars (red line). Simple-pol (dash line) and dual-pol (solid line) radars.

Objectives

MAIN GOAL

Develop, implement and evaluate a **radar data assimilation system** based on the Local Ensemble Transform Kalman Filter (LETKF) to improve very short-term weather forecast of high-impact weather events in South America

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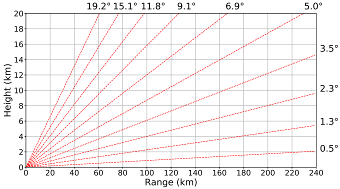
TALK'S GOALS

1. Evaluate the performance of the SCALE–LETKF system using different assimilation strategies
2. Assess the sensitivity of the system to :
   - Initial and boundary conditions
   - Filter parameters

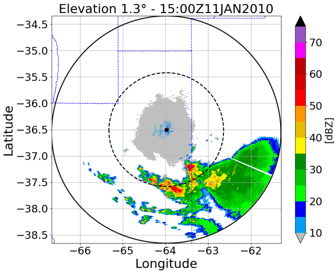
Radar Observations

Radar Characteristics

- C-band, dual-pol, Doppler radar
- Resolution : 500 m (range), 1° (azimuth)
- Scanning mode :
  1. 120 km scan : 10 min (Ref and DV)
  2. 240 km scan : 10 min (Ref)



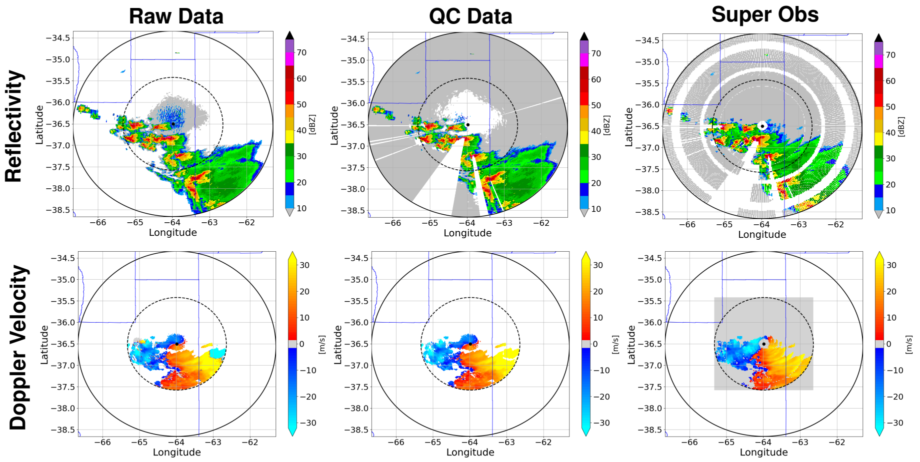
Case Study : Anguil, La Pampa (Argentina) - January 11th, 2010



Strong deep convective clouds including supercells were observed

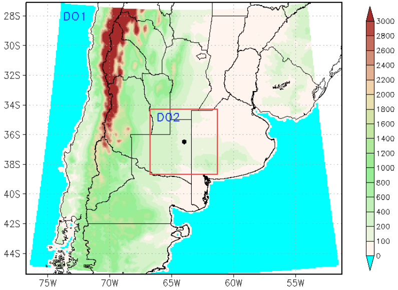
FIGURE – Photographs taken by locals

Quality Control and Superobbing



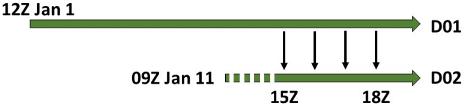
Experimental Design

Model Domains



	D01	D02
Resolution	10 km	2 km
Domain Size	$(2000\ \text{km})^2$	$(500\ \text{km})^2$
IC-BC	GFS 0.5°	D01
Observations	PREPBUFR	Radar
Cycle Length	1 hr	***
Assimilation Period	10 days	3 hs

Ensemble size : 60

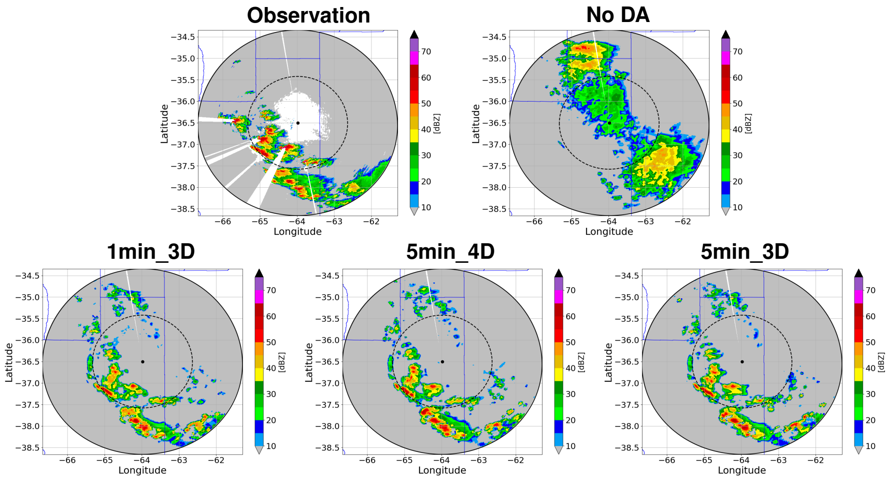


Assimilation Strategy Experiments

- **5min_3D** : Assume whole volume is measured at same time
- **5min_4D** : Assimilation window with 1 min slots
- **1min_3D** : Divide radar volume in 1 min files

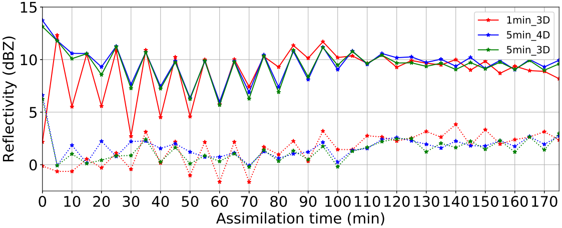
Qualitative Evaluation

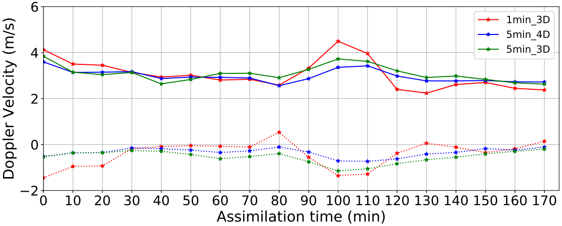
Analysis mean after 135 minutes at 1.3° elevation



Quantitative Evaluation

Analysis mean RMSE (solid) and BIAS (dot)

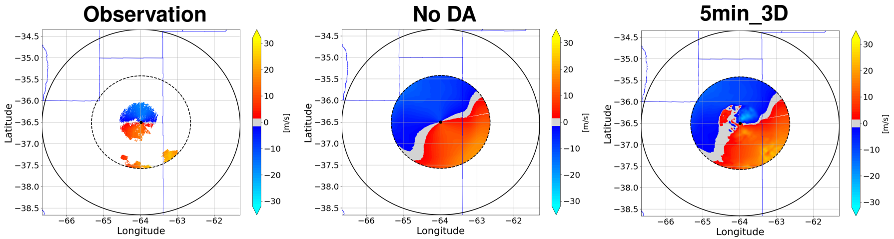




- RMSE increase between 60 min and 90 min
- Systematic error for both variables
- Small error difference between **5min_4D** and **5min_3D**
- Overall, assimilating the whole radar volume at one time (**green line**) seems to show the best results

Doppler Velocity

Analysis mean after 10 minutes at 0.5° elevation

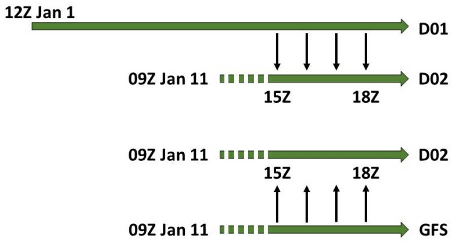


- Poor representation of Doppler velocity in low levels near the radar site
- Synoptic-scale initial condition is not "good" enough

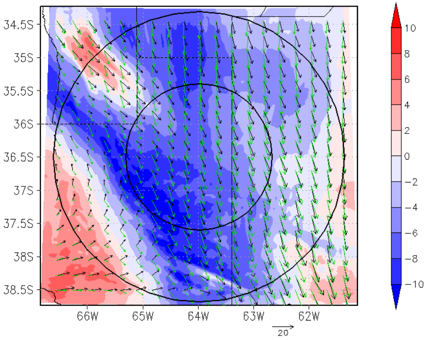
Experimental Design

IC and BC Experiments

- **5min_3D_D01** : IC and BC from D01
- **5min_3D_GFS** : IC and BC from GFS analysis



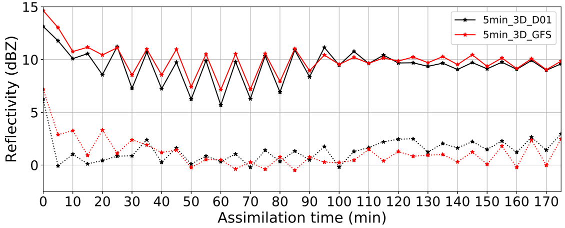
Wind difference at 15Z at 1000 m

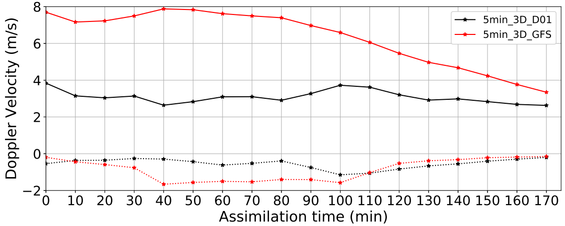


D01 (black vector), GFS (green vector), D01-GFS (shaded)

Results

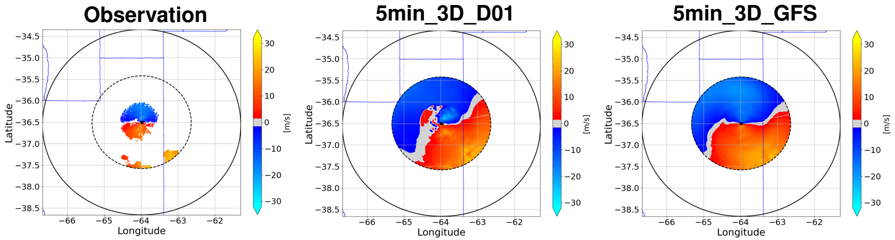
Analysis mean RMSE (solid) and BIAS (dot)



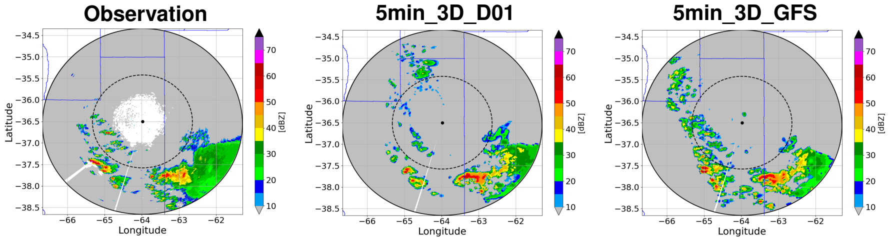


- Similar errors in reflectivity
- Systematic errors are still present
- Fewer DV observations are rejected by LETKF quality control in **5min_3D_GFS** than in **5min_3D_D01**

Analysis mean after 10 minutes at 0.5° elevation



Analysis mean after 65 minutes at 1.3° elevation



Experimental Design

Based on the 5min_3D_GFS experiment :

1. **Assimilation of clear–sky observations** to eliminate spurious convection
   - Clear–sky observation : *ref* < 10 *dBZ*
   - Assimilation : XX number of members of the background ensemble have *ref* $\geqslant 10$ *dBZ*

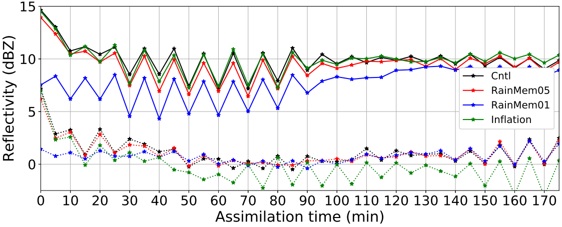
2. **Covariance inflation** to increase ensemble spread
   - Multiplicative inflation factor
   - Relaxation to prior spread (RTPS)

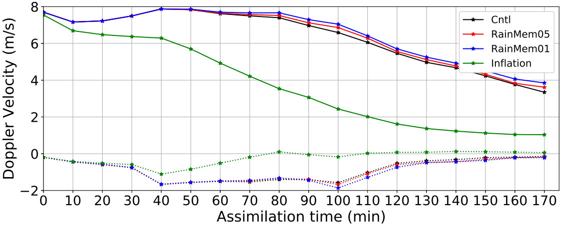
Filter Parameters Experiments

- **Cntl (5min_3D_GFS)** : RainMem $= 10$; Multiplicative inflation $= 1.0$; RTPS $= 0.9$
- **RainMem05** : At least 5 members of the first guess ensemble must have rain
- **RainMem01** : At least 1 members of the first guess ensemble must have rain
- **Inflation** : Multiplicative inflation $= 1.1$; RTPS $= 0.95$

Results

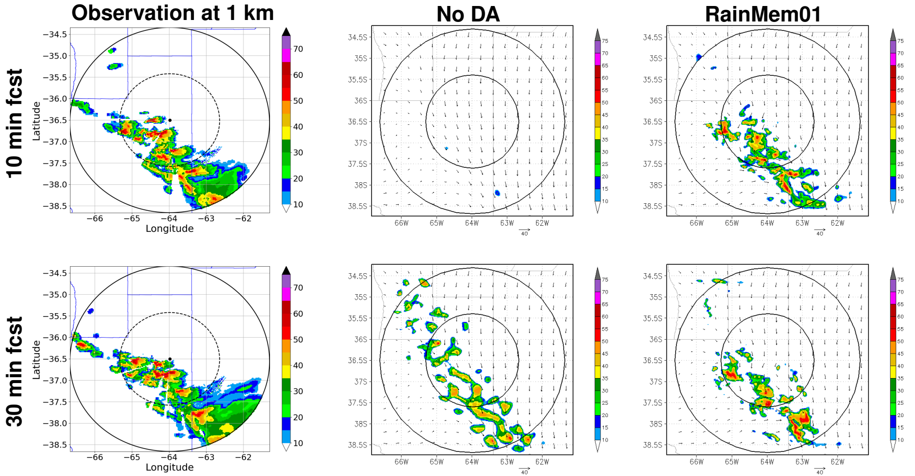
Analysis mean RMSE (solid) and BIAS (dot)





- Assimilation of a larger amount of clear-sky observations improves the reflectivity RMSE
- Increasing inflation has a clear impact on Doppler velocity

Short-term deterministic forecast



Summary

- Assimilation of radar observations using the SCALE–LETKF system has a positive impact on both, analysis mean and very short-term weather forecasts
- Initialization of the ensemble from the GFS analysis shows better results possibly because of the lack of conventional observations in the Southern Hemisphere
- Assimilation of clear-sky observations improves the reflectivity pattern by eliminating spurious convective zones
- Bigger ensemble spread helps reduce errors in the Doppler velocity field

Future Work

- Improve quality control of observations
- Test the assimilation system for other cases (i.e. for different types of convection organization)
- Assimilation of satellite observations to improve the mesoscale ensemble
- Assimilation of polarimetric variables

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Thank you very much !