Application of the WRF-LETKF System over Argentina: a Case Study.

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Goal

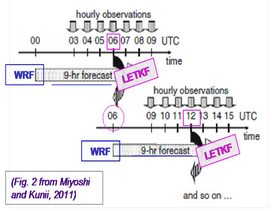
Develop a state-of-the-art **regional data assimilation system**, that can be implemented operationally at the **National Weather Service of Argentina** and provide better forecasts.

Approach

→ **The application of the WRF-LETKF (***Weather and Research Forecasting Model -Local Ensemble Transform Kalman Filter***) Data Assimilation System during a test period.** *(Hunt et al, 2007; Miyoshi and Kunii, 2011; Miyoshi and Kunii, 2012)*

→ **Evaluation of the data assimilation impact upon the forecast, in a case study.**

Methodology



(Fig. 2 from Miyoshi and Kunii, 2011)

- **WRF-LETKF System developed at the University of Maryland.**
- **6 hs Analysis**
- Test period: 01 Nov – 06 Dec 2012
- **40 Ensemble Members**
- **Spatial Localization**

  Horizontal: sigma_obs= 400 km

  Vertical: sigma_obsv= 0.4 (log scale) (~ 4 km aprox)

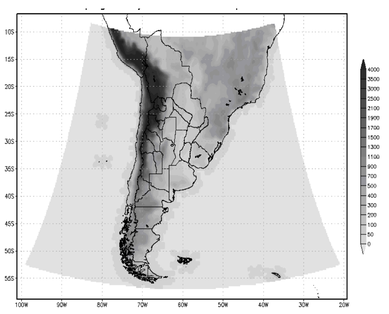
- **I. C.:** 01 Nov 00 UTC. The GFS Analysis was perturbed using differences between consecutive atmospheric states (Eq. 1). To generate the 40 perturbations, analysis from October and November of 2010 were used.

$$X^{M_1}_{1nov} = X_{1nov} + 0.2 * \left(X_{16\,oct} - X_{15\,oct} \right) \qquad \textit{(Eq. 1)}$$

- **B. C.:** 3hs GFS 0.5° deterministic forecasts (not perturbed for each member)
- **Vertical Resolution**: 30 eta levels (top 50 hPa)
- **Horizontal Resolution**: 40 km (139 x 134)
- Lambert projection

WRF Parameterizations:

K-F (cumulus), WSM6 (microphysics), YSU (boundary layer), MM5 similarity (surface layer), RRTM (LW radiation), Dudhia (SW radiation), Noah (land soil model).

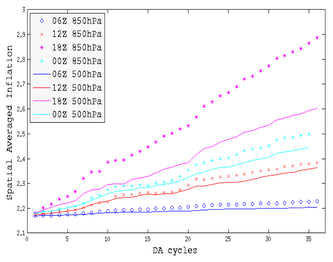


- The observations from the **NCEP prepbufr** were used for this experiment. No observational superobbing was performed. Additional QC was performed rejecting observations too far from the background.

The amount of data assimilated at 00 and 12 UTC is always more than the one assimilated at 06 and 18 UTC.

- An **adaptive inflation** is used (*Miyoshi, 2011*)

The inflation matrix was initiated as a constant field of 2.17.



After 35 days for each hour of analysis, the domain averaged inflation is slowly stabilizing for 00, 06 and 12 UTC.

However, at 18 UTC it is still increasing. The reason for this behavior would need further research.

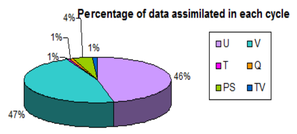
Observations

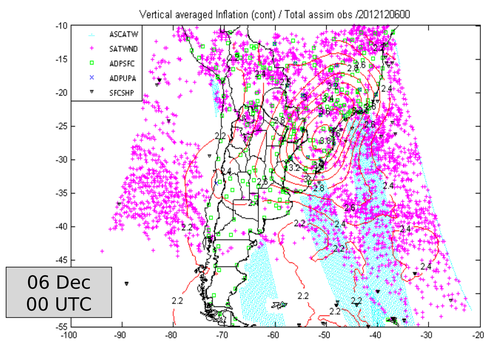
Percentage of type of observation in respect of each variable, assimilated in each cycle (Average 01 Nov – 06 Dec)

	ADPUPA	AIRCFT	SATWND	ADPSFC	SFCSHP	ASCATW	Total number
U	07.51 %	00.01 %	**29.75 %**	00.00 %	00.26 %	**62.47 %**	*10264*
V	07.40 %	00.01 %	**29.66 %**	00.00 %	00.26 %	**62.68 %**	*10308*
T	**98.63 %**	01.03 %	00.00 %	00.00 %	00.34 %	00.00 %	*112*
Q	**99.33 %**	00.00 %	00.00 %	00.00 %	00.67 %	00.00 %	*192*
Tv	**99.83 %**	00.00 %	00.00 %	00.00 %	00.17 %	00.00 %	*764*
Ps	00.00 %	00.00 %	00.00 %	**88.79 %**	11.21 %	00.00 %	*967*

Over this region the ADPUPA observations are very few. The majority of the observations assimilated are winds over ocean (ASCATW)

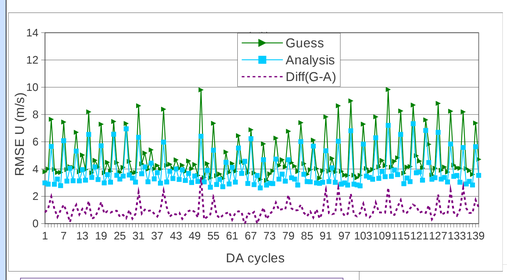
93% of the observations are winds:





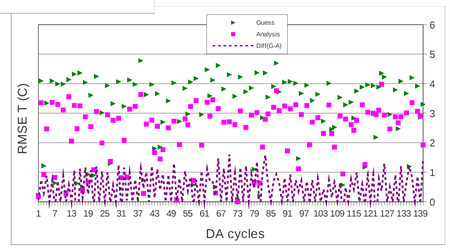
Vertical averaged inflation between levels 1 and 25 (~250 hPa) and the type of observations assimilated over the entire domain.

Analyses obtained with the WRF-LETKF System

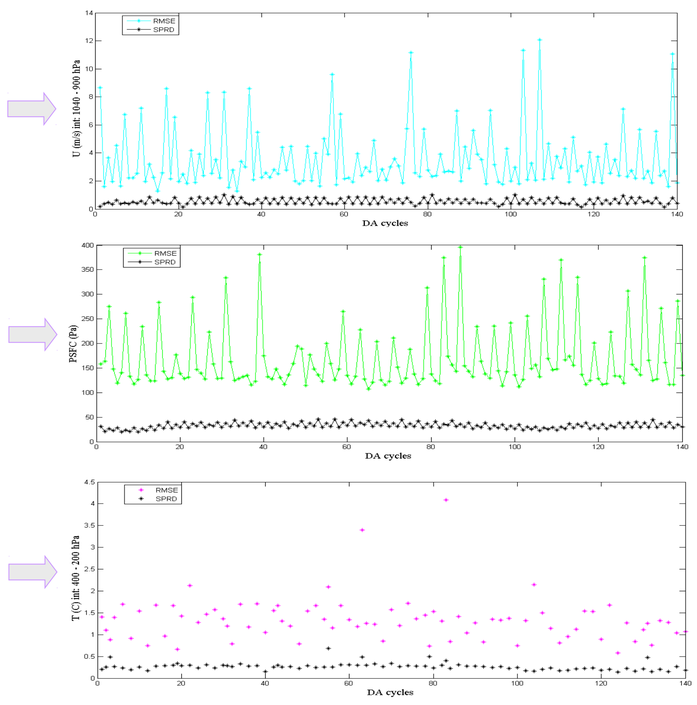


During the entire period, the analysis shows an improvement with respect to the first guess

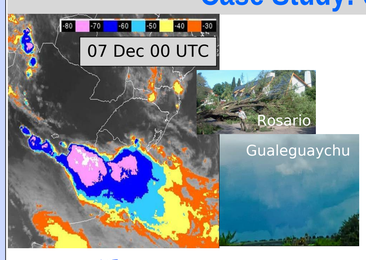
The comparison between the background and the GFS forecasts, and between these analysis and the GDAS, will be carried out soon.



The **analysis ensemble spread** is always much smaller than the RMSE of the mean analysis. However, it remains aproximately constant with time. We have to explore why.



Case Study: 6-7 December 2012



- A mesoscale convective system developed ahead of a cold front
- Strong vertical shear, high values of CAPE
- Warm and moisture advection at 850 hPa

Strong winds (> 100 km/h in Rosario)

Tornado in Gualeguaychu

Intense precipitation (110 mm in 1 hour over Bs As)

Sensitivity experiments:

48 hs forecasts with ICs from GFS and from LETKF

Accum Precip 06 – 18UTC 06Dec

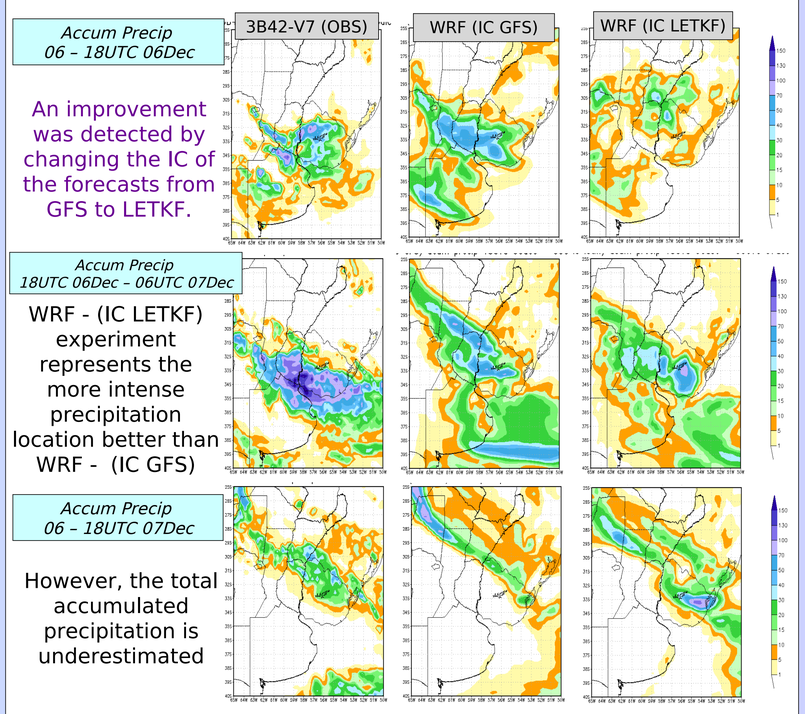
An improvement was detected by changing the IC of the forecasts from GFS to LETKF.

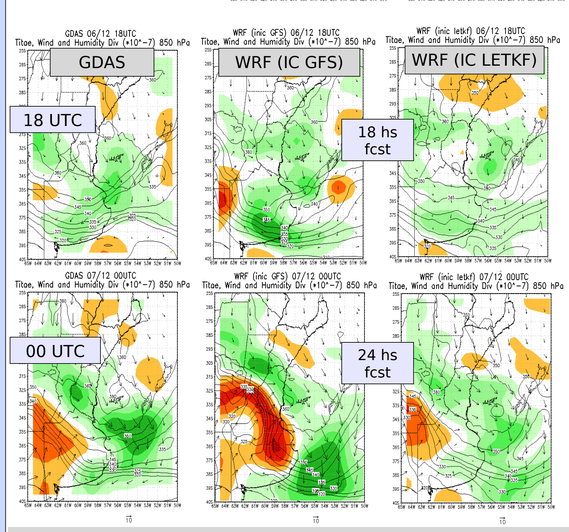
Accum Precip 18UTC 06Dec – 06UTC 07Dec

WRF - (IC LETKF) experiment represents the more intense precipitation location better than WRF - (IC GFS)

Accum Precip 06 – 18UTC 07Dec

However, the total accumulated precipitation is underestimated





The differences in the evolution of the position and intensity of the moisture convergence on 850 hPa, between the experiments and comparing with the GDAS analysis, are probably one of the causes of the different precipitation patterns obtained. (*Titae=* θ_e)

Differences in the evolution of variables such as SLP, 500/1000 hPa thickness, 200 hPa divergence and CAPE, among others, were also detected.

Conclusions and Future Work

The WRF-LETKF DA System was succesfully implemented over the Argentina region during 35 days, using the NCEP prepbufr observations. Additionally, the impact of the data assimilation on the forecast was found to be positive in a case of severe weather.

These preliminary results are a step towards our goal to create a state-of-the-art regional operational data assimilation system, as this is the first time that real observations are assimilated in a regional NWP model over Argentina. Although the results need to be evaluated and the system optimized, preliminary results are encouraging.

Near future work will focus on the optimization of the adaptive inflation, the implementation of perturbed boundary conditions, the implementation of a "no-cost Running in Place" analysis and optimal "super-obbing" of satellite winds, as well as statistical comparisons of observations minus forecasts started from GFS and LETKF.
The assimilation of AIRS temperature and humidity profiles will be an important step towards the assimilation of satellite radiances.

Finally, the implementation of an ensemble forecast based on the LETKF will be a very important and useful development for Argentina.

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