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Autores: María Eugenia Dillon, Yanina García Skabar, Eugenia Kalnay, Juan Ruiz, Estela A. Collini

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Toward the implementation of an Ensemble based Data Assimilation System over Southern South America.

M.E. Dillon[1,2,3], Y. García Skabar[1,2,4], E. Kalnay[5], J. Ruiz[1,3,4,7], E.A. Collini[2,6]

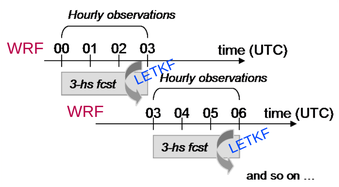
mdillon@smn.gov.ar ; yanina@smn.gov.ar ; ekalnay@atmos.umd.edu

[1] CONICET, [2] Servicio Meteorológico Nacional, [3] Dto. de Ciencias de la Atmósfera y los Océanos (UBA), [4] UMI-IFAECI, [5] Department of Atmospheric and Oceanic Science (UMD), [6] Servicio de Hidrografía Naval, [7] Centro de Investigaciones del Mar y la Atmósfera

Uncertainty is inherent to Numerical Weather Prediction (NWP) Models → Different methods exist in order to reduce and/or quantify this uncertainty → Data assimilation affords the initial condition problem; An ensemble configuration allows a quantification of the model uncertainty → The Local Ensemble Transform Kalman Filter (LETKF) is a great combination to address both issues!

GOAL: **Develop a state-of-the-art Regional Data Assimilation System that can be implemented operationally at the National Weather Service (SMN) of Argentina and provide better forecasts.**

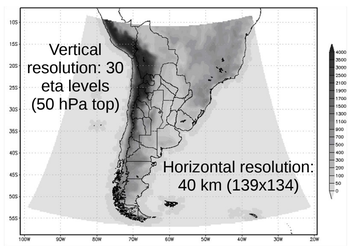
Methodology



Weather Research and Forecasting Model (WRF) coupled with the LETKF developed at the University of Maryland (*Hunt et al., 2007; Miyoshi and Kunii, 2011*)

WRF-LETKF System

3-hour assimilation window
3-hour analyses frequency
40 ensemble members
Test period: Nov-Dec 2012



Spatial localization: Horizontal: 400 km; Vertical: ln 0.4 (0.4 km)

Multiplicative adaptive inflation parameter (*Miyoshi, 2011*)

Initial Conditions (I.C.): 01 Nov 00 UTC. GFS deterministic analysis was perturbed using diferences between consecutive atmospheric states (*Eq. 1*). To generate the 40 perturbations, analyses of Oct and Nov 2010 were used.

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

WRF parameterizations: Kain-Fristch (cumulus); WSM6 (microphysics); YSU (planetary boundary layer); MM5 similarity (surface layer); RRTM (LW radiation); Dudhia (SW radiation); Noah LSM.

Computational Resources: Hydra Cluster (SNCAD-CIMA): 10 servers with two proccessors with six 2.6Gb memory cores each (a total of 120 cores). WRF parallelized with 2 cores and LETKF with 12 cores. Time for one analysis cycle = 90 minutes aproximately.

Boundary Conditions (B.C.): 3-hourly GFS deterministic forecasts (0.5°)

Assimilated observations: from NCEP-PREPBUFR files (Keyser 2013), including surface stations (ADPSFC); radiosondes (ADPUPA); aircrafts (AIRCFT); ships (SHIP); GOES Atmospheric Motion Vectors (SATWND).
Also sea surface winds estimated by ASCAT with a Super-Obbing (SO) technique applied (*Dillon et al., in press*)

EXPERIMENTS

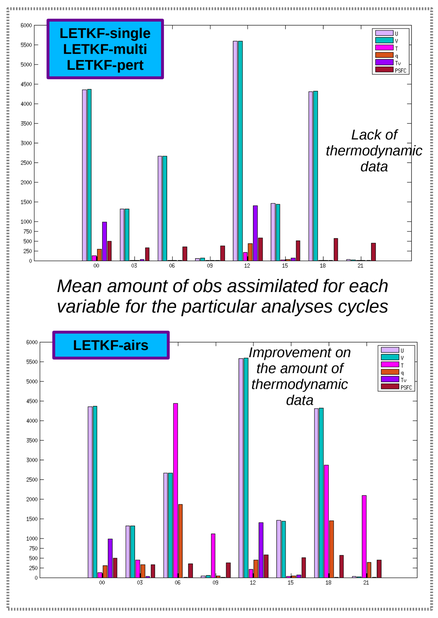
LETKF-single: Is the Control run, with all the specifications indicated on the left.

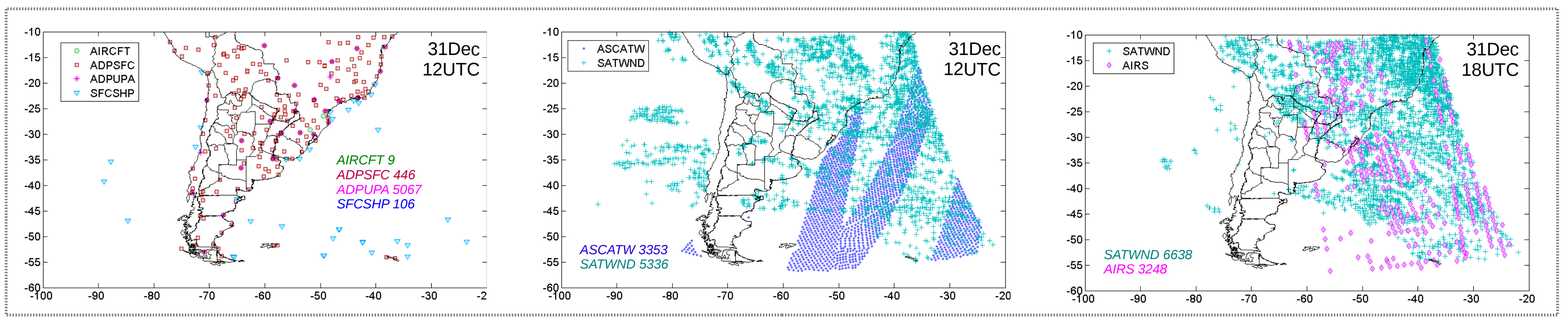
LETKF-multi: A multi-scheme configuration is used in order to better represent the ensemble spread. Cumulus and PBL parameterizations are combined:

	Kain-Fristch *(Kain, 2004)*	**BMJ** *(Janjic, 1994, 2000)*	**Grell** *(Grell and Devenyi, 2002)*
YSU *(Hong, Noh and Dudhia, 2006)*	5 members	5 members	5 members
MyJ *(Janjic, 1994)*	5 members	4 members	4 members
Quasinormal *(Sukoriansky, Galperin and Perov, 2005)*	4 members	4 members	4 members

LETKF-airs: The same configuration of LETKF-single assimilating also the vertical profiles of temperature and humidity from AIRS, using a thinning technique.

LETKF-pert: The same configuration of LETKF-single but including perturbed B.C., which are generated with a similar technique applied to I.C., using consequents dates for each ensemble member.

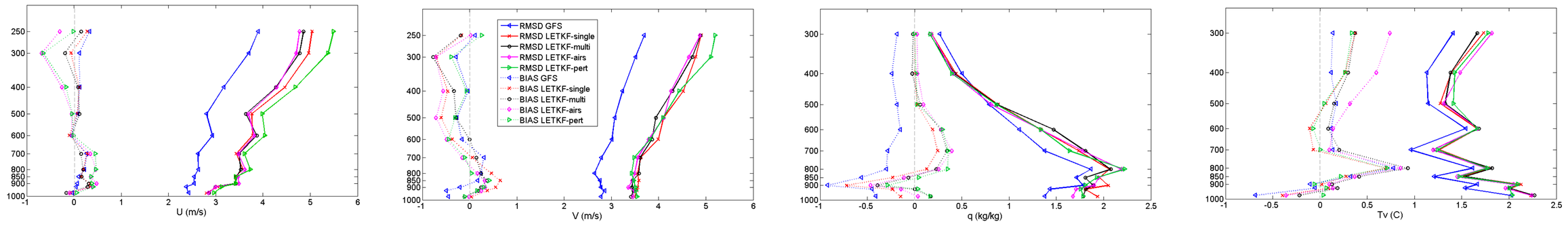




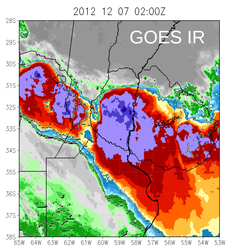
Results

BIAS and RMSD calculated for the 12 UTC 6-hour forecasts for the four experiments and the GFS, considering the whole test period

Although the GFS outperforms the four LETKF experiments with respect to RMSD, the values are not so far. Moreover, many improvements are seen in the different configurations with respect to LETKF-single. The BIAS behaviour depends on the variable considered.



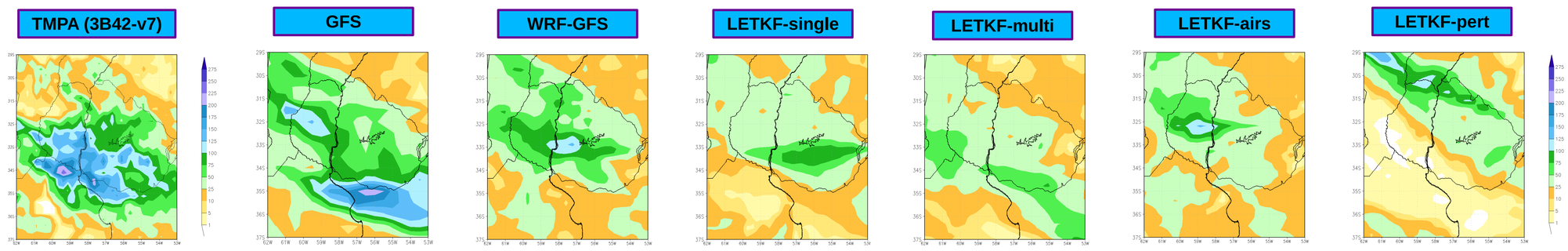
Case study 6Dec



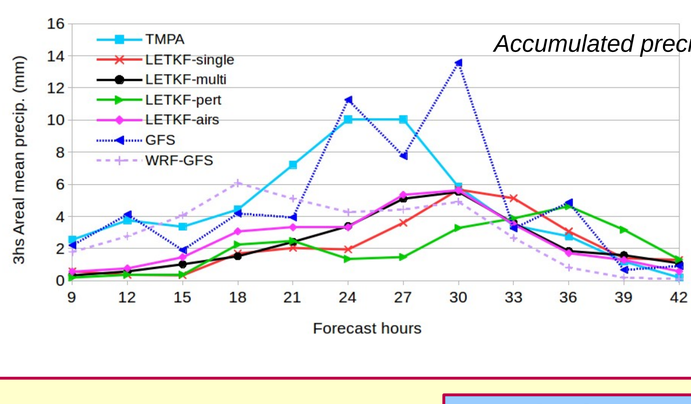
A mesoscale convective system developed ahead of a cold front

Environmental conditions: strong vertical shear, high values of CAPE, warm and moisture advection at 850 hPa

Consequences:
Strong winds, at least a tornado, intense precipitation



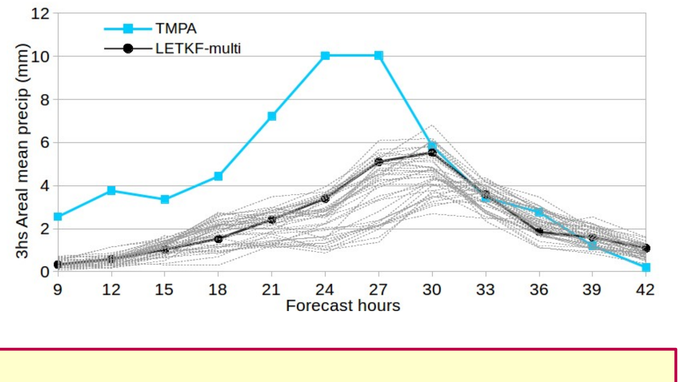
36-h accumulated precipitation between 06 UTC 6Dec and 18 UTC 7Dec 2012, for the TMPA estimate and the forecasts initialized at 00 UTC for each configuration. WRF-GFS refers to a deterministic run without assimilation. The LETKF runs were initialized with each ensemble mean.



Accumulated precipitation averaged in the box 37-29°S 62-53°W

Underestimation of the ensemble means!

The ensemble spread allows to quantify the uncertainty of the forecasts.



Conclusions and Future Work

These experiments represent the first steps in DA of real observations in Argentina.

- Satisfactory performance in the test period
- Improvements when changing the system configuration
- Limitation in heavy rain forecasts (Resolution? Observations?)

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- More verification is needed
- An experiment including AIRS, multi-scheme and perturbed BC would result in a better performance
- An evaluation of other types of inflation parameters should be carried out

An operational implementation of WRF-LETKF in the SMN of Argentina seems feasible!

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