TESTING GEOMETRIC BRED VECTORS WITH A MESOSCALE SHORT-RANGE ENSEMBLE PREDICTION SYSTEM OVER THE WESTERN MEDITERRANEAN

Martín, A. (1), V. Homar (1), L. Fita (1), C. Primo (2), M. A. Rodríguez (2) and J. M. Gutiérrez (3)

alberto.martin@uib.es

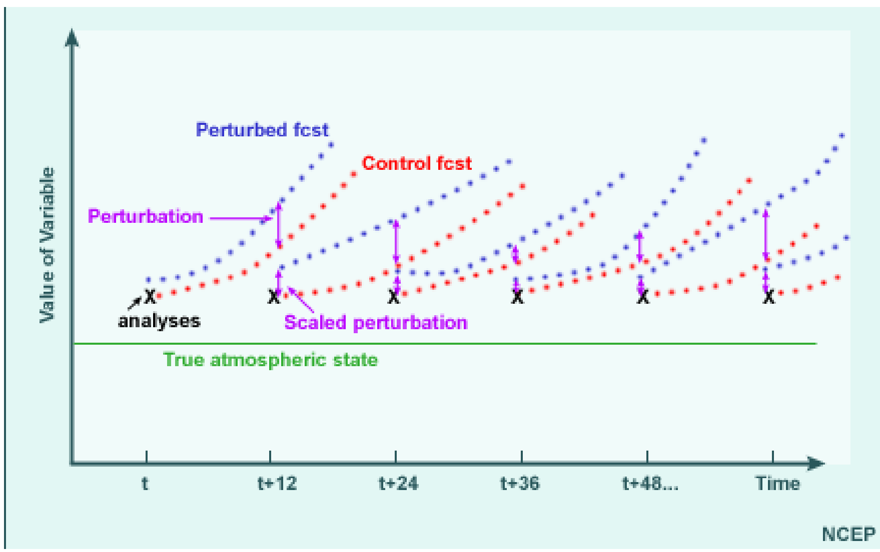
(1) Meteorology Group, Department of Physics, Universitat de les Illes Balears, Palma de Mallorca, Illes Balears, Spain

(2) Institute of Physics of Cantabria, Santander, Cantabria, Spain

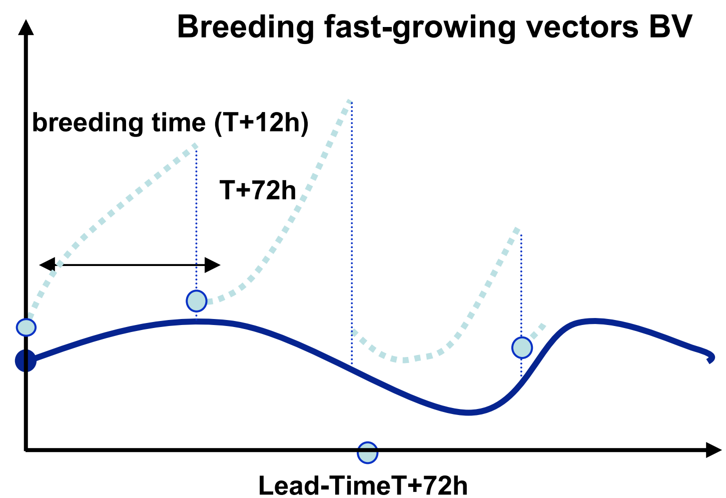
(3) Department of Applied Mathematics, Universidad de Cantabria, Santander, Cantabria, Spain

Overview of the proposed methodology: Bred Vectors

- There are dynamical methods that try to estimate the fastest growing error modes in the IC:
  - Singular vectors (ECMWF)
  - Bred vectors (NCEP): The first method proposed by ENSEMBLE to explore the "best guess" pdf. The fastest growing modes are obtained from the nonlinear model by periodically rescaling the bred perturbations (Toth and Kalnay, 1993)



Toth and Kalnay (1997): "The bred growing modes are akin to local Lyapunov vectors"



Overview of the proposed methodology: Bred Vectors

1) The control run is perturbed by a random seed and after time *dt:*

$\boldsymbol{\delta x}(dt) = \mathbf{x}^*(dt) - \mathbf{x}(dt)$

$\mathbf{x}(t)$ control integration

$\mathbf{x}^*(dt)$ perturbed integration

dt = breeding time (12h)

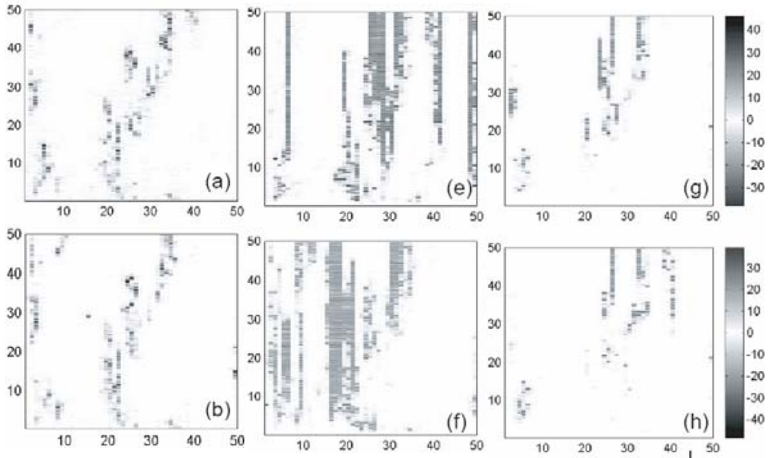
2) Design of the Ensemble members:

$\mathbf{x}(dt)_{pos} = \mathbf{x}(dt) + \boldsymbol{\delta x}(dt)$

$\mathbf{x}(dt)_{neg} = \mathbf{x}(dt) - \boldsymbol{\delta x}(dt)$ → + 72 h

3) Rescaling bred-cycle: → + 72 h

Different correlation lengths



$$\mathbf{x}(dt) \equiv bv(l,\Delta t) = \frac{\mu_0}{\mu(\Delta t)}\delta x(l,\Delta t) \quad \begin{cases} \mu_0 = 0.75 \\ \mu(\Delta t) = \left\| \delta x(l,\Delta t) \right\| \end{cases}$$

→ **Arithmetic bred-cycle: SD of T 850 hPa (K)**

$$\mathbf{x}(dt) \equiv bv(l,\Delta t) = \frac{\rho_0}{\rho(\Delta t)}\delta x(l,\Delta t) \quad \begin{cases} \rho_0 = -1.3 \\ \rho(\Delta t) = \left(\prod_{l=1}^{L} \left| \delta x(l,\Delta t) \right| \right)^{\frac{1}{L}} \end{cases}$$

→ **Logarithmic bred-cycle: Geometric mean of T 850 hPa (K)**

Model setup: MM5 configuration

✓ Standard version 3.7 of MM5

✓ A coarse domain of 160 x 151 grid points under a Lambert conformal map projection

✓ The domain measures 5565 x 5250 km (grid length 35 km)

✓ In the vertical, 24 σ levels were used with higher density near the surface

✓ Lateral boundary conditions are defined by linear interpolation between the Global analyses ECMWF available at 00, 06, 12 and 18 UTC with 0.3º resolution

➢ The grid-resolved mycrophysics processes are represented by the Reisner scheme, with considers graupel and ice number concentration (Reisner et. al, 1998)

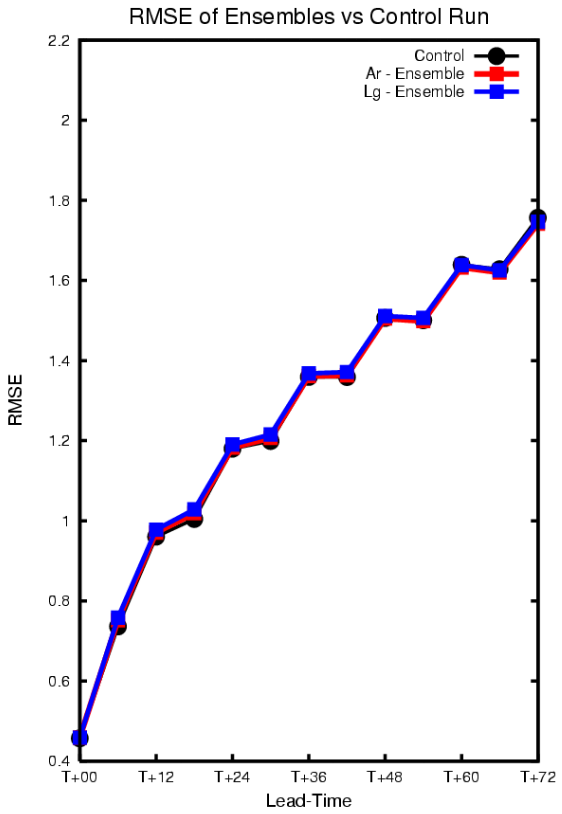
➢ The convection is parameterized by the modified Kain-Fritsch scheme that includes shallow convection (Kain, 2002)

➢ Planetary boundary layer (PBL) processes are parameterized with the Medium-Range Forecast (MRF) PBL Hong-Pan scheme (Hong and Pan, 1996)

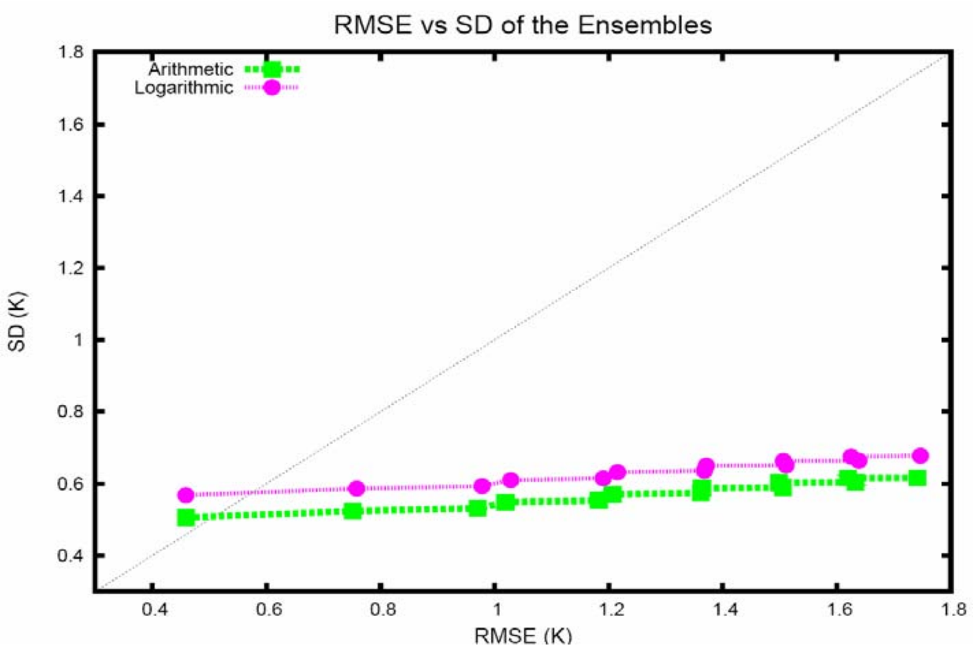
➢ Atmospheric radiation is parameterized using a Cloud-Radiation scheme

A four-month period, from September to December 2001, which includes a high impact severe weather episode affecting the Balearic Islands, has been selected for development the proposed methodology of Bred Vectors

MM5 Ensembles vs Control Run - RMSE T 850 hPa (K)
ECMWF Analysis 00, 06, 12 and 18 UTC
H+00 … 12h … H+72
Average 2001/08/15 - 2001/12/31 (12 UTC)



MM5 Arithmetic vs Logarithmic – SD and RMSE T 850 hPa (K)
ECMWF Analysis 00, 06, 12 and 18 UTC
H+00 … 12h … H+72
Average 2001/08/15 - 2001/12/31 (12 UTC)



References

- Charney, 1951: Dynamic forecasting by numerical process. Compendium of Meteorology. *Amer. Meteor. Soc.***,** 470-482
- Lorenz, E. N., 1963: Deterministic nonperiodic flow. *J. Atmos. Sci.,* **20,** 130-141
- Leith, 1974: Theoretical Skill of Monte Carlo Forecasts*. Mon. Wea. Rev.,* **6**, 409-418
- Toth, Z., and Kalnay, E., 1993: Ensemble Forecasting at NMC: The Generation of Perturbations. *Bull. Amer. Meteorol. Soc.,* **74**, 2317-2330
- Tracton, M. S., and Kalnay, E., 1993: Operational Ensemble Prediction at the National Meteorological Center: Practical Aspects. *NMC Office Note,* **392**, 2317-2330
- Toth, Z., and Kalnay, E., 1997: Ensemble Forecasting at NCEP and the Breeding Method. *Mon. Wea. Rev.,* **125**, 3297-3319
- López, J. M., Primo, C., Rodríguez, M. A., and Szendro, I., 2004: Scaling properties of growing noninfinitesimal perturbations in space-time chaos. *Physical Review E,* **70 (5)**
- Primo, C., Rodríguez, M. A., and Gutiérrez, J. M., 2005: Logartihmic bred vectors. A new ensemble method with adjustable spread. *Submitted to J. Atmos. Sci.*
- Primo, C., Rodríguez, M. A., López, J. M., and Szendro, I., 2005: Predictability, bred vectors and generation of ensembles in space time chaotic systems. *Submitted to Physical Review*