An update on the CMC Ensemble medium-range forecast system

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1. Introduction

Since 2005, the Meteorological Centre (CMC) ensemble prediction system is making use of an Ensemble Kalman Filter (EnKF) as data assimilation scheme to produce the initial conditions for the forecast model (see for details Houtekamer and Mitchell, 2005 and Houtekamer et al. 2005). Twice per day 16 days global forecasts was made using the CMC NWP models (named GEM and SEF) run with different physics packages. This forecast system is described in Candille et al. (2007) and in Pellerin et al. (2003).

The system was upgraded on July 10 2007. A description of the improvements made to the assimilation part as well to the forecasting part is presented in the section 2 and 3. The performance of the new system is compared to the one of previous system in the third section. In section 4 the web links to the operational products made with the EPS forecast are given. The NAEFS initiative is briefly discussed in the section 5. At the section 6, a summary is presented of an EPS training tour that was given to MSC weather forecasters in 2007. Finally in the last section a summary is made.

2. Modifications to the data assimilation component:

- Horizontal resolution is increased from 1.2 to 0.9 degree (grid of 400x200 points instead of 300x150 points).
- Different configurations of the GEM model are now used to produce the trial fields.
- Trial fields at 3, 4.5, 6, 7.5 and 9-h allow time interpolation toward observations - become a 4-D data assimilation cycle.

The data assimilation component is illustrated at the Figure 1. It has to be noted that the inclusion of 24 different configurations of the forecast model used to do the trial fields has lead to a decrease of the amount of isotropic model error required. The EnKF now assimilates the observations at their times of validity.

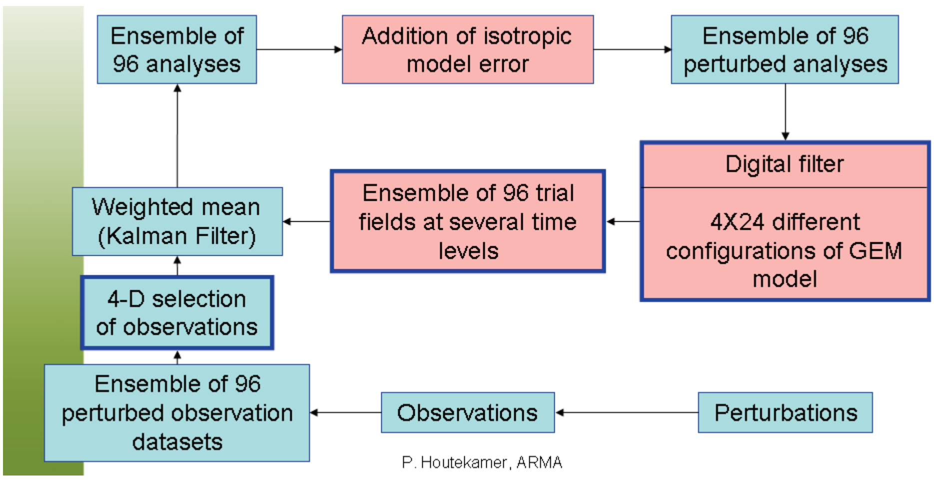

Figure 1: Schematic of the data assimilation part of the Canadian system.

3. Modifications to the forecast component:

- Now only one dynamical core is used: GEM (SEF is dropped).
- Horizontal resolution is increased from 1.2 to 0.9 degree as for the assimilation component.
- 4 additional members (ensemble size is now 20).
- Addition of stochastic perturbations of the physical tendencies as in Buizza et al. (1999) (random number between 0.5 and 1.5).
- A stochastic kinetic energy back-scattering parameterization is used as in Shutts (2005).
- The physical parameterization package was extended to include the Kain&Fritsch (1993) deep convection scheme and the Bougeault&Lacarrère (1989) mixing length formulation.

The release of one dynamical model core led to a simplification of the forecast system that should decrease the cost of future maintenance.

4. Performance of the updated system

To test the system before the operational implementation, 4 months of 2006 were run in hindcast mode (one in each season). The addition of stochastic parameterizations has result in an increase of forecast spread of the total energy norm for all lead time up to 240 hours (see for example in January at the Figure 2a). The new system forecasts have a lower RMS for energy norm forecast at all lead times (solid lines in Figure 2b). The spread (dash-dot lines in Figure 2b) is now lower at the beginning of the forecast period but higher beyond day 2. This leads to a better agreement between the ensemble mean forecast error and the ensemble spread.

a) b)

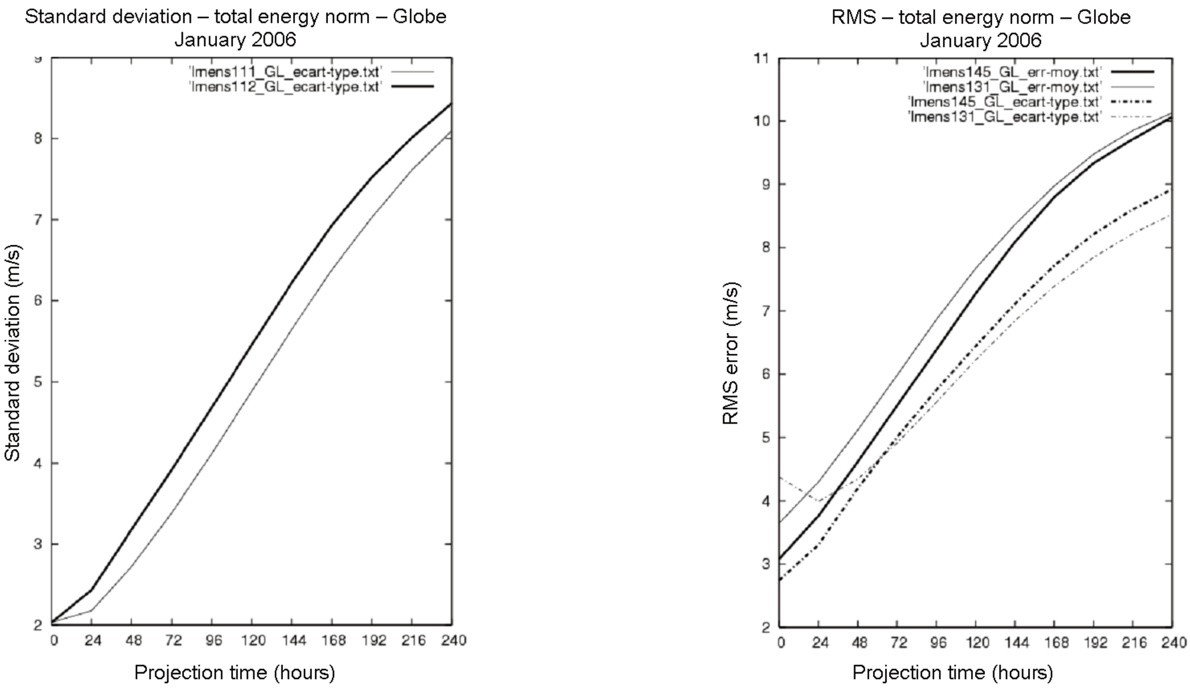

Fig. 2 a) spread of the total energy norm with stochastic physics (thick solid line) and without (thin solid line) in January 2006, b) RMS (solid lines) and spread (dash-dot lines) of total energy norm for the new system (thick lines) and the previous one (thin lines). Forecasts were compared against analyses.

Another example of a better error/spread balance is the ratio of the forecast error over the ensemble spread of the new and the previous systems as displayed in Figure 3a for the 500 heights in January 2006. There is a clear improvement since the black line is closer to the dotted line that represents a perfect match between the error and the spread of the forecasts (dispersion ratio of 1.0) up to day 10. In Figure 3b the corresponding CRPS is shown. Again a significant improvement is seen up to day 10.

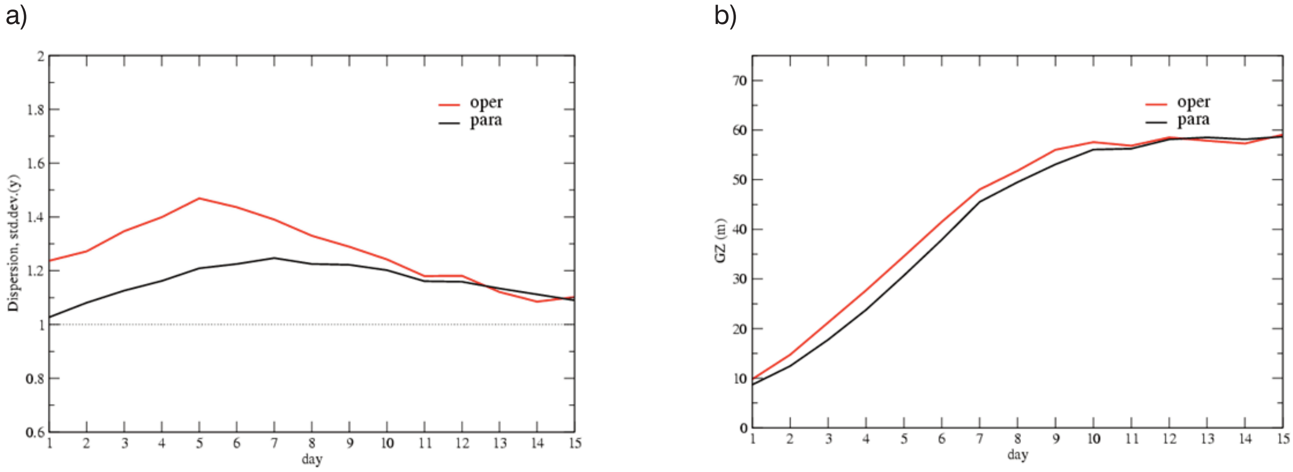

Fig. 3 Ratio of error over the spread and CRPS for January 2006 of the new system (para in black) and the previous one (oper in red). The forecast are compared against global radio-sounding data.

We have obtained similar results for the experiments in 2006 for the months of April and October and to lesser extent of July.

5. Products

Here are the links to the Canadian EPS and the NAEFS products:

- Images:
  - http://www.weatheroffice.gc.ca/ensemble/index_e.html
    http://www.meteo.gc.ca/ensemble/index_f.html
  - NAEFS:
  - http://www.weatheroffice.gc.ca/ensemble/index_naefs_e.html
    http://www.meteo.gc.ca/ensemble/index_naefs_f.html
- Digital data (GRIB1):
  - http://www.weatheroffice.gc.ca/grib/index_e.html
    http://www.meteo.gc.ca/grib/index_f.html

6. North American Ensemble Forecast System: NAEFS

Since 2004, NCEP and MSC have established an operational data exchange of raw model outputs twice per day. 51 variables on 6-hourly output frequency over 16 days are sent in GRIB1 format files (moving to GRIB2 in 2008). The benefits for both centers are numerous: better and more reliable forecasts, common software and exchange of expertise.

An example of the gain in predictability coming from this initiative is shown at the Figure 5 where the CRPS skill score of October-November 2006 500 hPa heights is shown for the NCEP system, CMC and the combination of the twos. The combined system has a higher score at every lead time which results in a significant gain in predictability (0.5 to 1 day). It was found that generally the NCEP system has a better resolution (in probabilistic sense) but the CMC forecasts are more reliable.

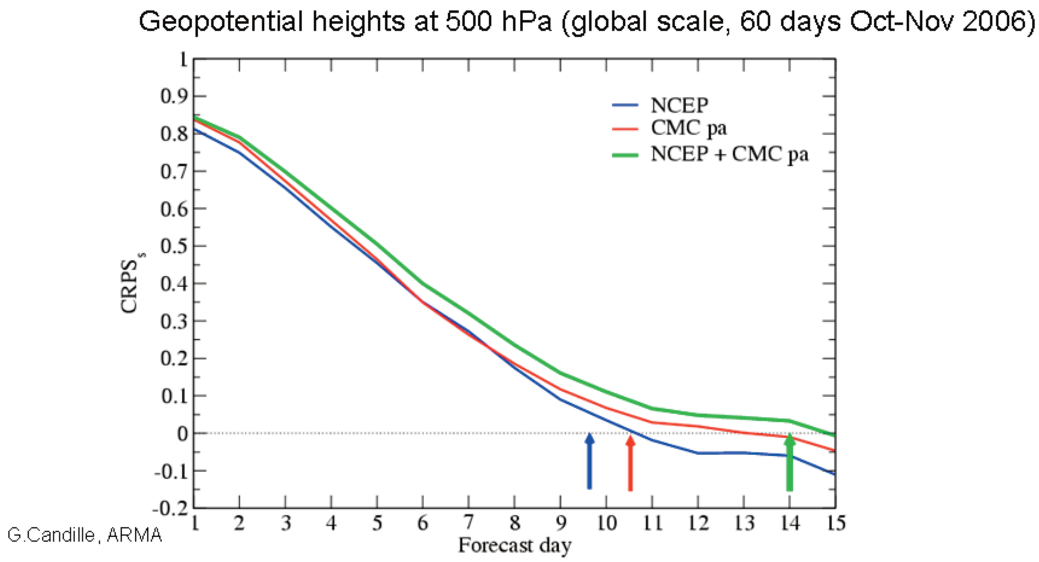

Fig. 4 Continuous ranked probability skill score of the 500 hPa heights for the NCEP system (blue), CMC (red) and the combination of the twos (green). The forecasts were compared to the global radio-sonde data.

7. EPS Training Tour

A 2-day workshop was developed essentially by Richard Verret on a special assignment for a few months. A colossal work of more than 800 slides! The workshop was given twice in each Canadian forecast centers in the Spring and Fall of 2007 by two teams of 2 persons with operational and development background. It was prepared in French and English. Local case studies developed by regional forecasters were included. It has reached a majority of the MSC operational forecasters. Some of the content will be included in the initial training for new forecasters. The package of the training is available at:

http://collaboration.cmc.ec.gc.ca/cmc/ensemble/Formation-Training/Lisez-moi.html

http://collaboration.cmc.ec.gc.ca/cmc/ensemble/Formation-Training/Read-me.html

8. Summary

In 2007, the operational Canadian EPS becomes:

- bigger (addition of 4 members),
- finer (higher resolution = 0.9 deg instead of 1.2 deg),
- better (RMS, CRPS),
- wider (more spread in the medium range),
- more balanced (spread / error),
- simpler (only one dynamical core),
- more equi-probable (more uniform quality of members),
- more « trendy » (4D assimilation of observations),
- more « tropical » (much better skill there)
- more collaborative (NAEFS,TIGGE),
- and better known (training tour).

9. References

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