Application and verification of ECMWF products 2007

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1. Summary of major highlights

ECMWF products are widely used at Météo-France :

- T799 for the short-range forecast in addition to other models and EPS from day 4 to day 9 forecast to propose a scenario with confidence index linked to the number of tubes.
- monthly forecast is now used in operations.
- IFS is used to start ARPEGE-Climat seasonal forecasts.
- ECMWF analysis remains one of the main references for global models verification.
- web site products are widely used by the forecasters.

Three main new features have to be underlined :

- Automatic confidence index are derived from the EPS
- VAREPS is used for temperatures forecast (by the french electricity company)
- New mixed statistical adaptations have been developped for temperatures and provide better forecasts.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

Millions of local forecasts of weather parameters are produced daily through statistical adaptation of NWP output. Main methods are multiple linear regression (MLR) and linear discriminant analysis (DA). MOS (model output statistics) is generally preferred to PP (perfect prognosis). Kalman filter (KF) is applied when relevant.

Parameter	Method	Domain	Number of Sites	Steps
Tri-hourly 2m Temperature	MLR (MOS) +KF	France	2588	+12h to +180h by 3h
Daily extremes 2m temperature	MLR (MOS) +KF	France	2588	D to D+6
10m Wind Speed	MLR (MOS)	France	811	+12h to +180h by 3h
10m Wind Direction	MLR (MOS)	France	788	D to D+6
Total Cloud Cover	MLR (MOS)/LDA	France	150	+12h to +180h by 3h
Tri-hourly 2m relative Humidty	MLR (MOS) +KF	France	1156	+12h to +180h by 3h
Daily extremes 2m rel. Humidity	MLR (MOS) +KF	France	1156	D to D+6
Tri-hourly 2m Temperature	MLR (MOS) +KF	World	6010	+12h to +180h by 3h
Daily extremes 2m temperature	MLR (MOS) +KF	World	6010	D to D+6

Table 1 T799 statistical adaptations production

Statistical adaptation is applied to ensemble mean (table 2) and individual ensemble runs (table 3). Methods are the same as for the deterministic model output (see 2.1.1) but pseudo-PP (statistical equations computed during the first 24 hours then applied to the other corresponding steps) is preferred to MOS. VAREPS is used and Météo-France provide local forecast (temperatures) up to 14 days. Professionals are interested in such forecasts, especially the french electricity company, EDF.

Parameter	Method	Domain	Number of Sites	Steps
Tri-hourly 2m Temperature	MLR (pPP) +KF	France	2588	+12h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	France	2588	D to D+14
10m Wind Speed	MLR (pPP)	France	811	+12h to +360h by 3h
Tri-hourly 2m Temperature	MLR (pPP) +KF	World	6010	+12h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	World	6010	D to D+14

Table 2 Ensemble mean statistical adaptations production

Parameter	Method	Domain	Number of Sites	Steps
Tri-hourly 2m Temperature	MLR (pPP) +KF	France	2588	+12h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	France	2588	D to D+14
10m Wind Speed	MLR (pPP)	France	811	+12h to +360h by 3h
Tri-hourly 2m Temperature	MLR (pPP) +KF	World	6010	+12h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	World	6010	D to D+14

Table 3 Individual members statistical adaptations production

Calibration is applied to the EPS distribution in order to optimize reliability. Operationally, a calibration based on rank diagrams (Hamil, 1998) is used for 10m wind speed and total precipitations. BMA (Raftery, 2005) calibration is under development and will be used for temperatures at the end of the year.

2.1.2 Physical adaptation

The dispersion and trajectory model MEDIA can be driven by ECMWF output. The limited area model ALADIN will be coupled with IFS by the end of the year.

2.1.3 Derived fields

New local temperatures forecast are produced by combining T799 statistical adaptations forecast and ARPEGE ones. For each location, specific coefficients are computed by using the previous 40 days forecasts for both models. In average, this new “mixed” forecast is the best one (Fig. 1).

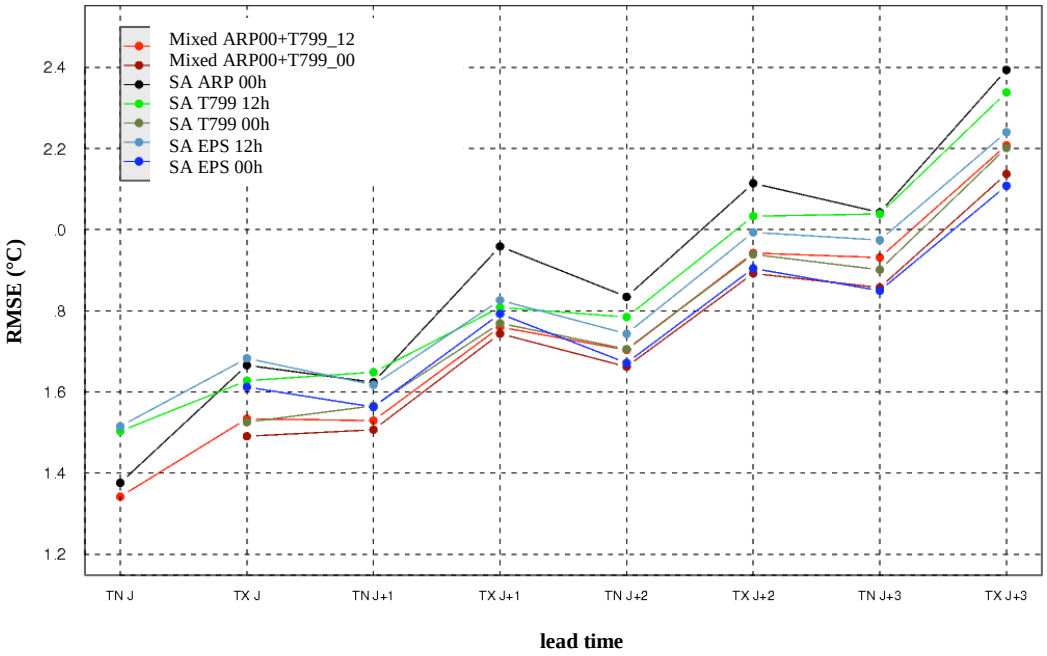

Fig. 1 Comparison in terms of RMSE of the mixed statistical adaptations to other different local forecasts – 2m temperature – average over one year (2006) and 26 main sites

Automatic confidence index are operationally produced by statistical adaptation. EPS spread fields are used in order to forecast a probability of having a low error for the ensemble mean. Four confidence index are computed for 2m temperature, total precipitations, 10m wind speed and total cloud cover. In addition, a global index is provided from all of the parameters.

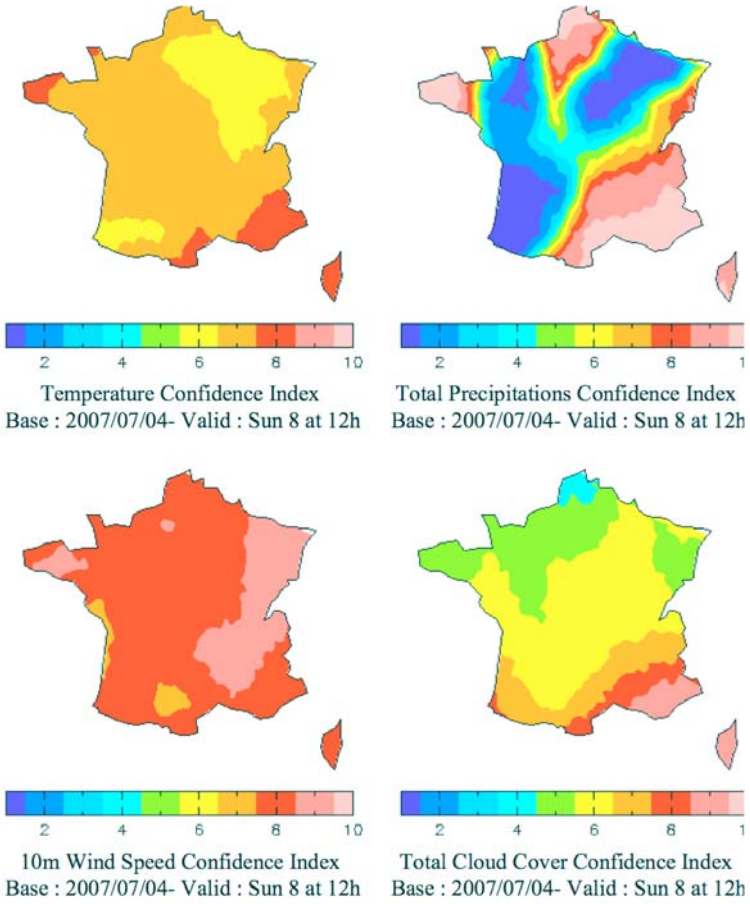

Fig. 2 Confidence index for local parameters

2.2 Use of products

Medium-Range forecast

The EPS is daily used in the Medium-Range forecast guidance through the tubing classification. The most probable forecast is given by the central cluster mean in terms of weather type. The confidence index is directly linked to the number of tubes but subjectively fixed by the forecaster.

Other graphical products are available for the forecasters in order to detect extreme phenomena like deep cyclones, strong convection from the EPS members.

The general flow orientation and wind speed over 3 basins (North-Sea, NE-Atlantic and Mediterranean sea) is evaluated in the marine Medium-Range forecast, looking at EPS-based wind roses. The marine forecasters produce a medium-range bulletin.

Monthly forecast

Since January 2006, the forecasters from the national centre produce a weekly bulletin for a specific user. The bulletin is based on the products available on ECMWF web server: probabilities of T2m anomaly, multi parameter outlook, weather regimes clustering, Hovmoeller diagram… The Bulletin describes the evolution of general flow, the consistency of the model and focuses on the temperature anomalies.

Seasonal forecast

ECMWF daily analysis are used to define initial atmospheric conditions for the Météo-France seasonal ensemble forecast (9 members). ERA15 is used to compute the renormalization (to observation) of seasonal forecast indices (T850 and Z500).

ERA15 and ECMWF analysis are used to compute monthly and seasonal climate anomalies disseminated by an internal web page. These anomalies are used to perform a subjective verification of our seasonal forecast.

ECMWF seasonal forecast are used monthly to assess the confidence of the seasonal forecast from Météo-France. All the seasonal information available on the web page (Ocean analysis, ocean forecast, atmospheric forecast, forecast indices, …) are checked monthly as additional input and verification for the M-F forecast (subjective comparison) and to compare the behaviour of forced versus coupled ensemble forecast.

A climate bulletin is monthly edited taking into account available information on the state of the climate system and providing a consensual seasonal forecast based on products from different centres (including ECMWF). Note that this bulletin is for internal purpose and that a monthly briefing is planned in the future. However, ACMAD (Niamey) has asked to receive and disseminate it. An end-user bulletin is updated monthly and sent to partners for a pilot experiment.

The coupled version of the Météo-France model is evaluated in the frame of the Demeter experiment. This model could be included in the Demeter multi-model ensemble planned at ECMWF and could be used at Météo-France in operational mode in the future.

Tropical area guidance

ECMWF model provides a particularly useful forecast guidance in French tropical regions and for cyclone forecasting.

Forecasters of the national and regional centres visualize ECMWF outputs (deterministic model, EPS and wave model) through the SYNERGIE system implemented on workstations. They can daily compare ECMWF output to other models outputs and choose a scenario based on ARPEGE, Unified Model of the Met Office ECMWF, or mix for the short range forecast.

In the tropical areas (French West Indies, La Réunion, New-Caledonia, French Polynesia), the EPS is used for cyclone tracking (strike-probability maps). La Réunion is a Regional Specialised Meteorological Centre, it is responsive for cyclone forecasting in the southwest Indian Ocean.

Furthermore several EPS-based charts are produced on the tropical areas for the daily forecasts: MSLP spaghettis, ensemble mean of MSLP and Theta'w at 850hPa, probability that Theta'w at 850hPa is greater than 20 and 22°C, probability that CAPE is greater than 1000 and 2000 J/kg, EPSgram with fixed y-axis for the 6h-precipitations.

Products based on Wave EPS are also very useful: probability of swell height greater than 3m, which is a pertinent danger threshold, EPSgram of total swell height, wave roses.

A new index has been defined. It is designed to detect cyclone genesis and it is based on probabilities from EPS for different events (see fig. 4) :

- CAPE > 1400 J/kg
- HU700 > 85 %
- Vo850 > 6.10-5 s-1
- DGP> 8.10-5 s-1

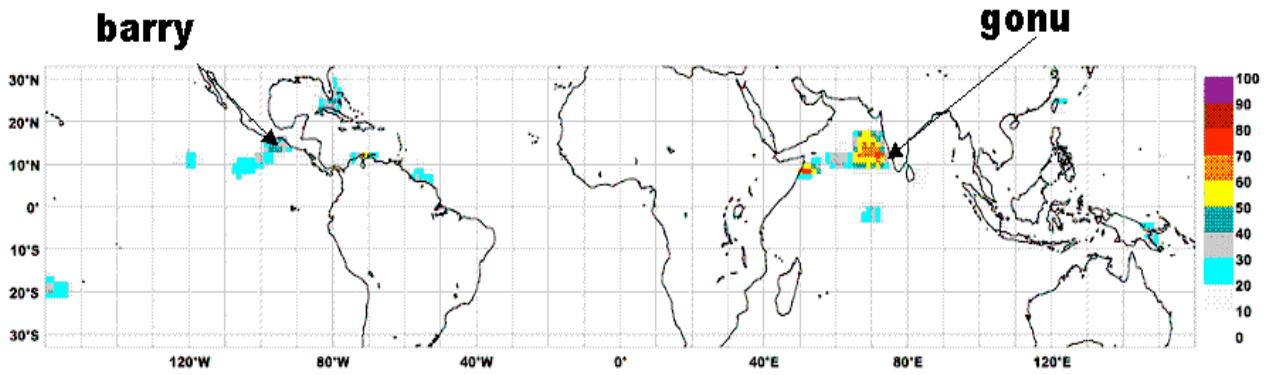

Fig. 3 cyclogenesis index (%) - EPS based on 20070530-00h - Step 120h

3. Verification of products

Include medium-range deterministic and ensemble forecasts, monthly forecast, seasonal forecast. ECMWF does extensive verification of its products in the free atmosphere. However, verification of surface parameters is in general limited to using synoptic observations.

More detailed verification of weather parameters by national Services is particularly valuable.

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

ECMWF model is compared to soundings, SYNOP and analyses (ARPEGE and ECMWF). Scores show high skill.

3.1.2 ECMWF model output compared to other NWP models

T799 model is one of the main tools for the short-range forecasts over France. In addition it provides very useful information all over the world, thanks to its high resolution. Even forecasters are using mainly tow models (ECMWF T799 and ARPEGE), ECMWF model remains in average the best one. At the medium range EPS is fully used and give skilful guidance.

3.1.3 Post-processed products

Statistical adaptations are compared to Direct Model Output. Scores show an improvement of the skill for all the parameters. Figure 4 shows the comparison between SA and DMO for the 2m temperatures forecast at different lead times over one year and averaged over all of the sites.

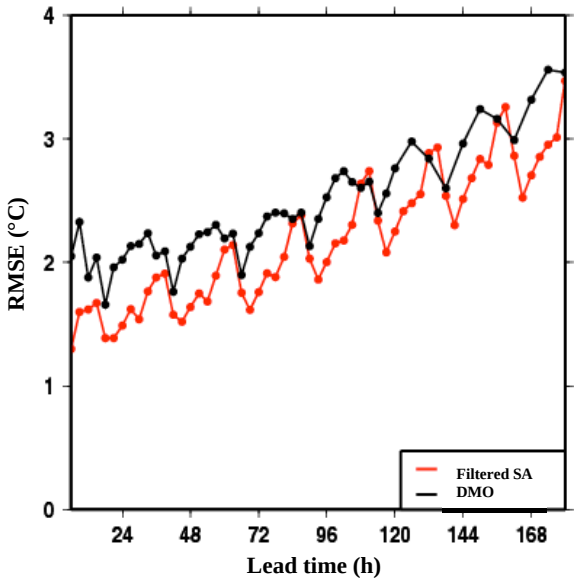

Fig. 4 Comparison of statistical adaptations and direct model out in terms of RMSE (average over one year from june 2006 to june 2007)

3.1.4 End products delivered to users

No evaluation.

3.2 Subjective verification

3.2.1 Subjective scores (including evaluation of confidence indices when available)

Short range forecast

Forecasters at the national centre perform a daily subjective verification of the short-range forecasts. A note is given to ARPEGE and to ECMWF model. Moreover, the differences in the North Atlantic Ocean and Europe regions are checked every day between UKMO, Météo-France and ECMWF forecasts and reported if they are important. A verification is performed at the validity date of the forecasts. The reference for the verification can be either the analyses of the models or in situ observations.

Medium range forecast

Forecasters go on evaluating EPS outputs. Automated forecasts use the probabilistic approach, however weather reports issued by the forecasters are mainly based on the interpretation of the central cluster of the tubing method. This has been found to be the best method to produce the deterministic part of the medium-range forecasts.

Subjective evaluations therefore aim at measuring the ability of the central cluster to predict large scale (``supra-synoptic'' scale) flow types above western Europe.

Monthly forecast

Since the monthly forecasting system has been used in operations, the forecasters have assessed the T2m anomaly forecasts over France. For every week, the notations vary between A (good) and D (bad). Figure 5 plots the proportion of each notation for week 1 to week 4, over 130 weeks. Figure 6 shows a 3 months averaged scores from Jan, 2005 to June, 2007. Weeks 1 and 2 give very good signals. There is sometimes good signal in weeks 3 and 4, but most of the time, the forecaster doesn’t find relevant information.

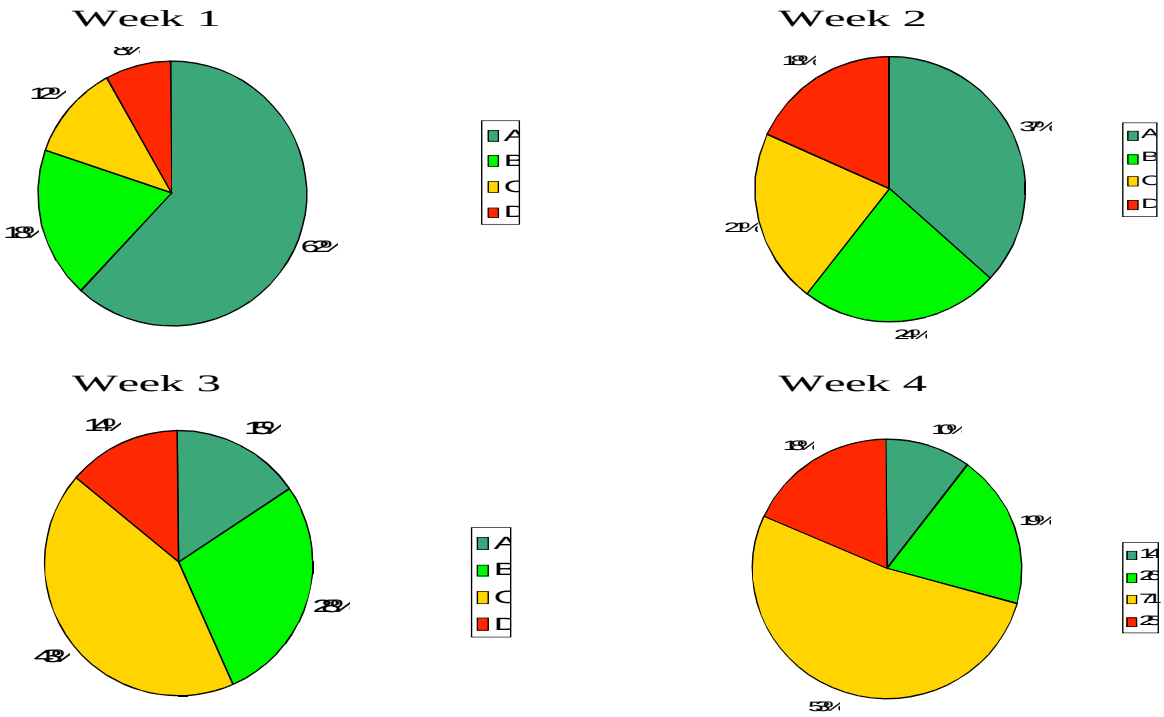

Fig. 5 Subjective verification of monthly forecast with 4 levels : A=Good, B=rather good, C= rather bad, D=bad

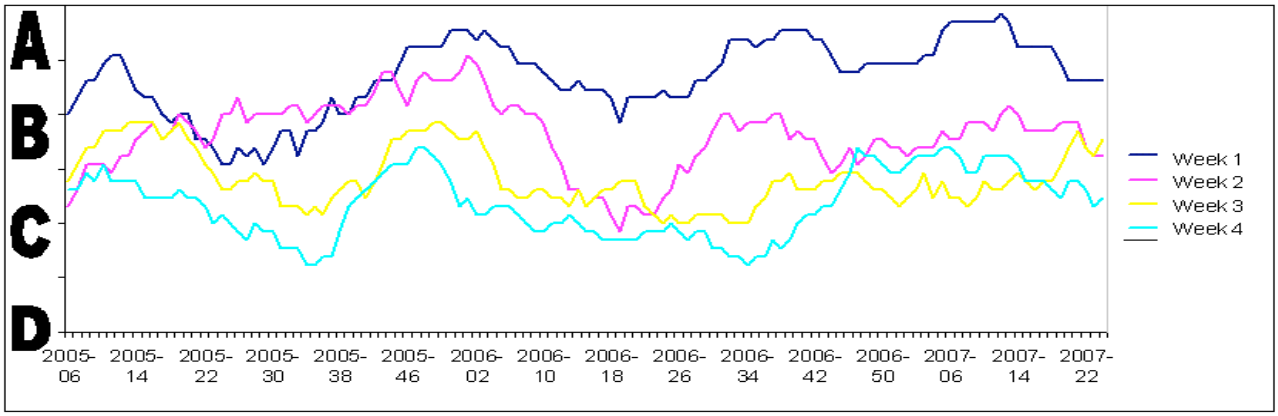

Fig. 6 Evolution of 3-months averaged scores

3.2.2 Synoptic studies

None

4. References to relevant publications

Hamill, T. M., and **S. J. Colucci**, 1998 : Verification of Eta-RSM ensemble probabilistic precipitation forecasts. *Mon. Wea. Rev.*, **126**, 711-724.

Raftery, A.E., Gneiting, T., Balabdaoui, F. and **Polakowski, M.** (2005). Using Bayesian Model Averaging to Calibrate Forecast Ensembles. *Monthly Weather Review*, **133**, 1155-1174.