Application and verification of ECMWF products 2008

Météo-France

1. Summary of major highlights

- Production of local adapted temperatures for the monthly forecasts
- Design and development of a streamflow ensemble prediction system based on the EPS
- Operational use of combined temperature 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. The production is described in table 1.

Deterministic model T799

Parameter	Method	Domain	Nbr of Sites	Steps
Tri-hourly 2m Temperature	MLR (MOS) +KF	France	2781	+12h to +180h by 3h
Daily extremes 2m temperature	MLR (MOS) +KF	France	2781	D to D+6
10m Wind Speed	MLR (MOS)	France	861	+12h to +180h by 3h
10m Wind Direction	MLR (MOS)	France	822	D to D+6
Total Cloud Cover	MLR (MOS)/LDA	France	164	+12h to +180h by 3h
Tri-hourly 2m relative Humidty	MLR (MOS) +KF	France	1269	+12h to +180h by 3h
Daily extremes 2m rel. Humidity	MLR (MOS) +KF	France	1269	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: Statistical adaptations for the deterministic high resolution model

EPS

Statistical adaptation is applied to individual ensemble runs (table 2). Methods are the same as for the deterministic model output 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 provides local forecast (temperatures) up to 14 days. Professionals are interested in such forecasts, especially the french electricity company, EDF.

EPS Ensemble mean and individual members

Parameter	Method	Domain	Nbr of Sites	Steps
Tri-hourly 2m Temperature	MLR (pPP) +KF	France	2761	+12h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	France	2761	D to D+14
10m Wind Speed	MLR (pPP)	France	792	+6h to +240h by 3h +246 to +360 by 6h
Tri-hourly 2m relative Humidty	MLR (MOS) +KF	France	1146	0h to +240h by 3h +246 to +360 by 6h
Daily extremes 2m rel. Humidity	MLR (MOS) +KF	France	1146	D to D+14
Tri-hourly 2m Temperature	MLR (pPP) +KF	World	3338	+12h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	World	3338	D to D+14

Table 2: Statistical adaptations for the EPS

EPS Distribution

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

Monthly forecast

Statistical models are also applied to the monthly forecasts up to 32 days (table 3). These locally corrected forecasts allow to couple electricity consumption models.

Parameter	Method	Domain	Nbr of Sites	Steps
Tri-hourly 2m Temperature	MLR (pPP) +KF	France	1056	+0h to +768h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	France	1056	D to D+31

Table 3: Statistical adaptations for the monthly forecasts

2.1.2 Physical adaptation

Hydrology

Ensemble forecasts from ECMWF are now used to produce ensemble hydrological forecasts (cf. figure 1 for the scheme). Temperature and precipitation ensemble forecasts are first downscaled on a 8 km grid, with a simple downscaling method that takes altitude effects into account. They are then used as an input for a surface scheme (ISBA) coupled with a hydrological model (MODCOU). This system produces a 51-member 10-day ensemble streamflow forecast, for about 900 river gauges over France.

A statistical analysis of the quality of the ensemble streamflow forecasts was made over nearly one year of predictions, with overall encouraging results.

This ensemble streamflow prediction system runs daily in an experimental mode (examples are shown in figure 2), and is currently under evaluation by hydrological forecasters at the SCHAPI (French Hydrological Office for Floods Prevention).

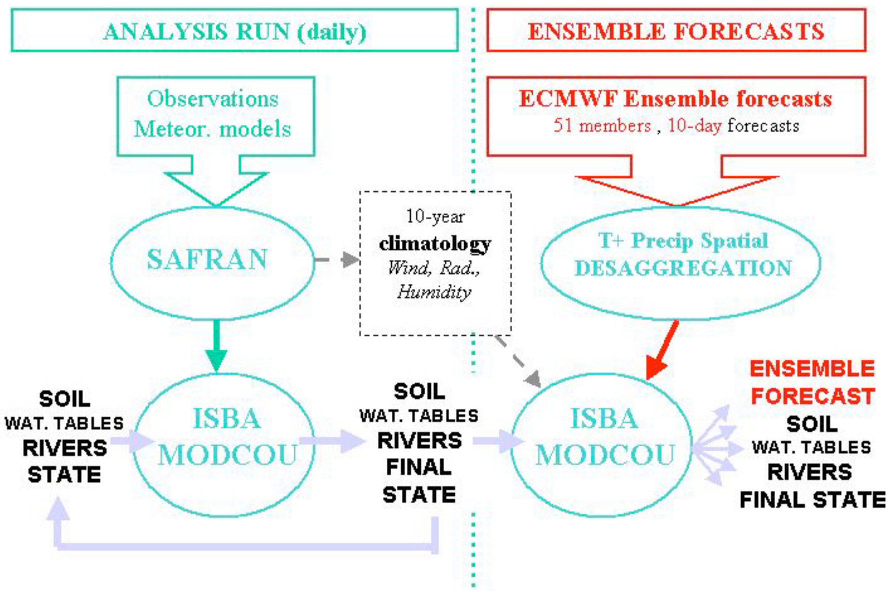

Figure 1: EPS/Safran-Isba-Modcou coupling scheme

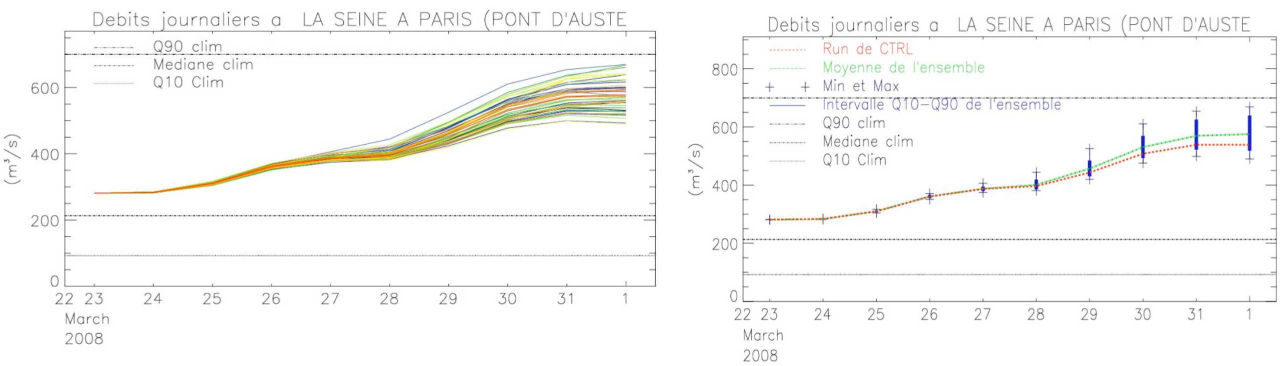

Figure 2: Examples of outputs for streamflow probabilistic forecasts for the river Seine in Paris

Pollutant transport and dispersion forecast

Until now, for the long-range dispersion forecast, Météo-France uses two operational tools to assess impacts in case of an accidental release:

- an air mass trajectories software, describing the evolution of a neutrally buoyant particle in the wind field forecasted by ARPEGE,
- an Eulerian off-line dispersion model, MEDIA, solving an advection-diffusion equation for a passive scalar. MEDIA uses ARPEGE forecasts as meteorological forcing.

A next generation of model is currently implemented for operations, MOCAGE-Accident. MOCAGE-accident is a specific configuration of MOCAGE (cf. section on air quality forecast), which takes into account point sources and relevant sink processes. The start of operational use of MOCAGE-accident is planned in the fall of 2008. In its backward version, MOCAGE-accident can also be used for backtracking.

At local scale, the system PERLE focuses on the local description of the atmospheric pollutant cloud at local and regional scales, in the vicinity of the radionuclide or chemical release. It is based on the meso-scale non hydrostatic model for meteorological fields, Meso-NH, coupled to a lagrangian particle model for the dispersion (currently the SPRAY software developed by Aria Technologies). At present, PERLE is used only over the Metropolitan France in operations by using ALADIN forecasts for the initial and boundary conditions of Meso-NH.

Developments in progress aim to give the possibility to the forecaster in charge to use IFS forecasts as meteorological forcings. Thus, in its first operational version, MOCAGE-accident will be able to consider ARPEGE as well as IFS forecasts for met forcings. At the same time, to ensure consistency, the air mass trajectories software will be updated to allow the use of IFS forecasts. The possibility to use IFS forecasts for the initial and boundary conditions of Meso-NH in the system PERLE is also under development and could be part of the operational set-up in 2009.

The interest of using the outputs of a meteorological ensemble prediction system as forcings for the transport and dispersion models is also under investigation. It could bring a valuable information about the uncertainties in the dispersion fields associated with uncertainties on the meteorology. In the framework of the European project PREVIEW, the 51 members of the EPS have been provided on the period of one release of the European Tracer EXperiment (1994) and used to feed MOCAGE-accident as well as other models involved in the project. Analysis of the results is still in progress.

Air quality forecast

MOCAGE multi-scale Chemistry and Transport Model was developed at Météo-France for both research and operational applications in the field of environmental modelling. MOCAGE considers simultaneously the troposphere and stratosphere at the planetary scale. In addition, it is possible within MOCAGE to zoom down to the regional scale over limited-area sub-domains, the model providing its own time-dependent chemical boundary conditions. Depending upon applications, MOCAGE can run in both on-line, coupled to a general circulation model for climate studies for instance, or off-line modes, forced by meteorological analyses or forecasts. The off-line configuration can use ARPEGE, ALADIN or IFS operational Numerical Weather Prediction products.

In the context of the partnership consortium "Prév'Air" in charge of the pollution monitoring for France, the operational version of MOCAGE run to provide daily air quality and sand dust forecasts uses ALADIN and ARPEGE forecasts. In parallel, air quality MOCAGE forecasts relying on IFS operational forecasts are also daily running in the context of the EU-funded GEMS project. 0-72h forecasts are displayed on ecmwf website (***http://gems.ecmwf.int***).

Downscaling

In the past four years, the Studies and Consulting Division of Météo-France has set up several service delivery suites based on real time applications of meso-scale models, taking some advance on the AROME model that will be operational on the French metropolitan territory in the very near future.

The Division has explored the potential use, in the institutional or commercial sector, of meso-scale forecasting suites. Systems coupling ECMWF-IFS, Meso-NH (10 km) and Meso-NH (2.5 km) have been used and targeted for applications all over the world. Example of applications are the estimation of the electromagnetic propagation conditions in the atmosphere (figure 3), the re-analysis of the wind speeds on islands after cyclonic disastrous events, meteorological assistance to F1 car races.

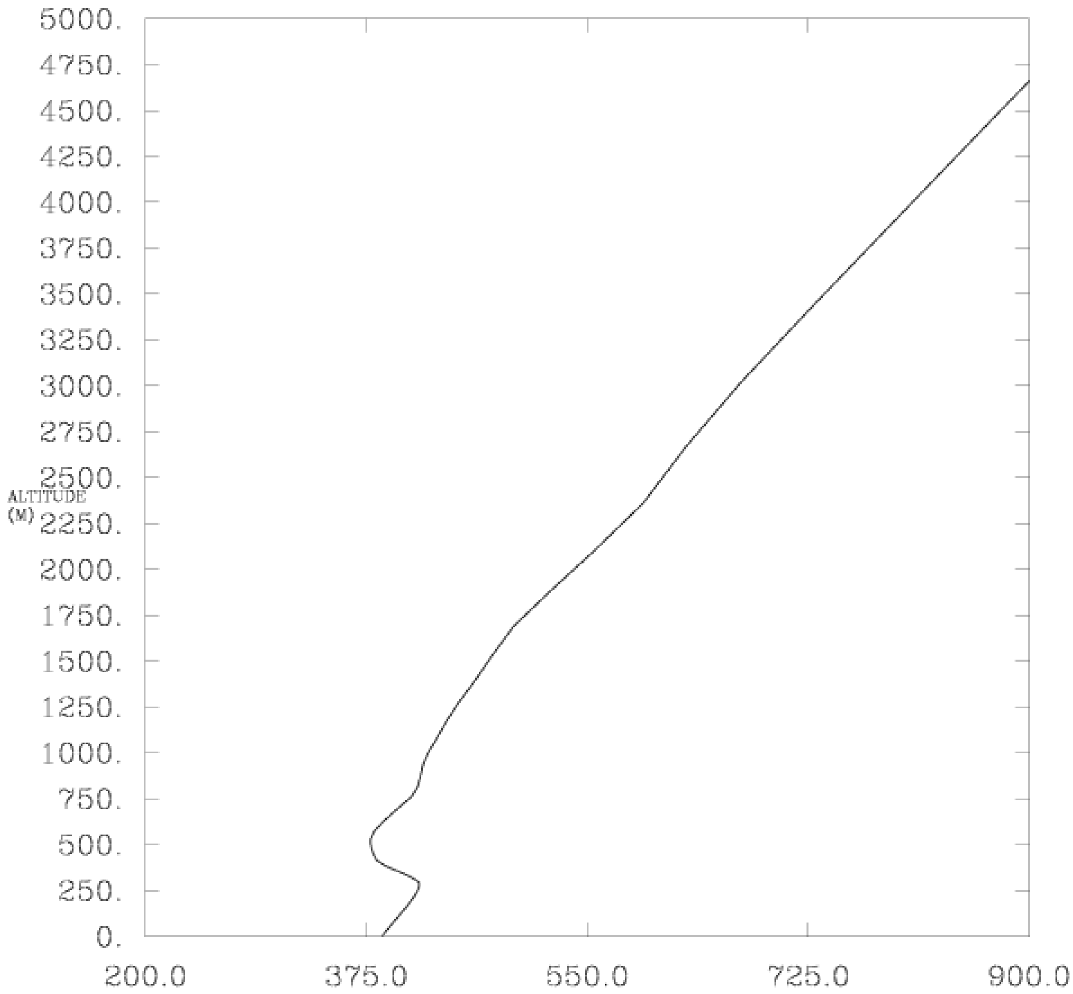

Figure 3: Example of a downscaling product: Vertical profile of the M-index (modified propagation co-index) on the Red Sea which indicates the presence of a propagation duct in the first 500 metres of the atmosphere

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

Focus on local weather parameters verified for locations which are of interest to your service

3.1.2 ECMWF model output compared to other NWP models

Comparison of performance of ECMWF model to other NWP models used by your service

3.1.3 Post-processed products

Combined statistical adaptations forecasts :

Since 2007, Météo-France produces combined statistical adapted forecasts. These forecasts are built from ECMWF model statistical adaptations (eg MLR+ Kalman filtered forecasts) and ARPEGE statistical adaptations. Each forecast are weighted considering the 40 days past errors over the site.

Results (figure 4) show a significant improvement in the skill by using such forecasts. The following picture gives for extreme temperatures a comparison between ARPEGE forecast (blue), ECMWF forecast (green) and the combined forecast (orange) from July to December 2007.

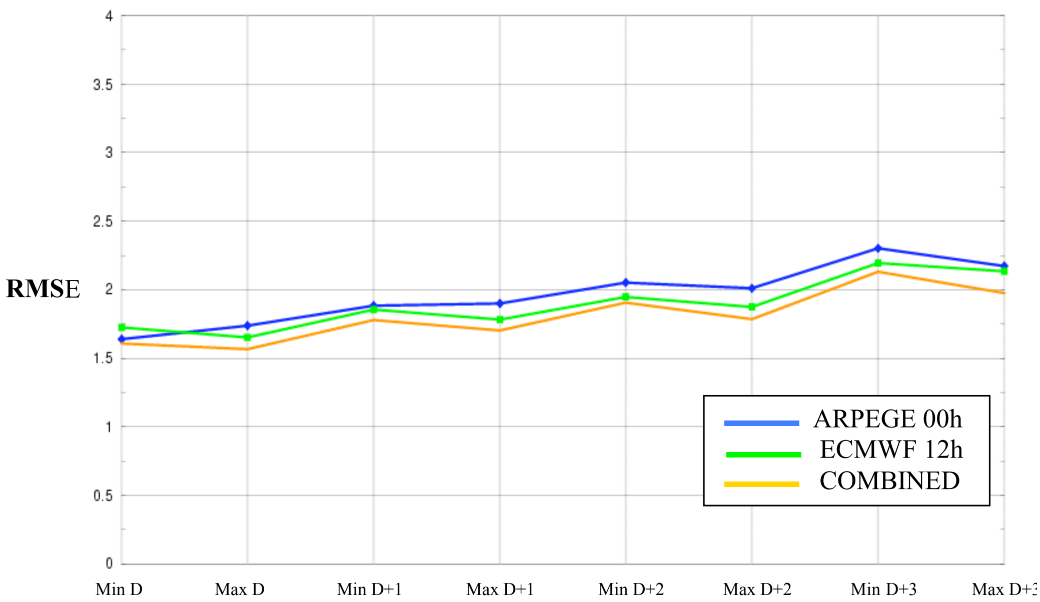

Figure 4: Root Mean Square Error for different locally adapted forecasts from July to December 2007 averaged over 169 french sites.

3.1.4 End products delivered to users

3.2 Subjective verification

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

Subjective Confidence Index

Since 1997, a confidence index is defined by the forecaster. This confidence index is linked to the number of tubes, which are, in term of weather parameters over the area of interest, significantly different from the central cluster mean. It is then evaluated in a subjective way, on a scale of 1 to 5:

- 4 if the confidence is strong (0 or 1 tube)
- 3 if the confidence is normal (2 or 3 tubes)
- 2 if the confidence is weak (more than 3 tubes)

Values of 1 and 5 are rarely used and only in very specific cases: very strong confidence, which is more often very difficult to appreciate, or on the opposite, very weak confidence due to a great number of tubes with significant variants over the country. Finally, the confidence index can be modified by the forecaster according to the kind of weather expected. For example, the forecaster may have a very strong confidence for a warm block, but a lower confidence for the corresponding kind of weather (generally fair), due to a possible presence of low clouds, especially in winter.

Subjective evaluation (cf. table 4) of the forecaster weather flow analysis is conducted in a daily basis. Four marks are used :

- A: very good forecast.
- B: good forecast, large scale circulation well forecasted, small differences on chronology or spatial localization of forecast flow patterns.
- C: rather bad, not necessarily a bad forecast of large scale circulation but differences are too important on France.
- D: bad forecast of large circulation.

If A and B forecast are considered to be "good" forecasts, the percentage of good forecasts over the period January 2007 - June 2008 was 87 % for D4-D5 and 63% for D6/D7. Considering the correlation between confidence index and skill forecast, it appears that when the confidence index is high the forecast is good, while when the confidence index is low, the correlation with bad forecasts is not so evident. As a consequence it can be said that forecasters are rather inclined to "overprotect" but also that there are still too many non detected bad forecasts.

Confidence Index	2	3	4	All CI
% of good forecasts D4/D5	52 (9/17)	84 (176/210)	91 (264/290)	87 (449/517)
% of good forecasts D6/D7	48 (55/114)	66 (217/63)	75 (67/76)	64 (329/517)

Table 4: Percentages of good forecasts for each value of confidence index