Application and verification of ECMWF products 2009

METEO-FRANCE

1. Summary of major highlights

- Development of monthly forecasts
- ECMWF model as the best tool for cyclone 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.

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

Pollutant transport and dispersion forecast

Until now, for the long-range dispersion forecast Météo-France uses three 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 or IFS,
- an Eulerian off-line dispersion model, MEDIA, solving an advection-diffusion equation for a passive scalar. MEDIA uses ARPEGE forecasts as meteorological forcing. MEDIA will probably be no longer used in 2010.
- a new semi-Lagrangian off-line dispersion model, 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 possibility is given to the forecaster in charge to use ARPEGE or IFS forecasts as meteorological forcing. 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 use IFS forecasts for the initial and boundary conditions of Meso-NH in the system PERLE; it could be part of the operational set-up in 2010.

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. A scientific publication is in preparation.

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 provides daily air quality and sand dust forecasts, using 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 MACC project; MOCAGE is one of the six pre-operational air quality suites. 0-72h forecasts are displayed on the project website.

2.2 Use of products

Vertical profiles :

Vertical profiles have been developed at Météo-France using all the vertical informations provided ECMWF model:

- Temperature and humidity on 56 model levels
- U and V wind components and geopotential heigh at 8 pressure levels
- Surface parameters : 2m temperature, 10m wind direction and speed, 2m dew-point temperature ...

These new products provide a better estimation of isotherm levels and instability indices

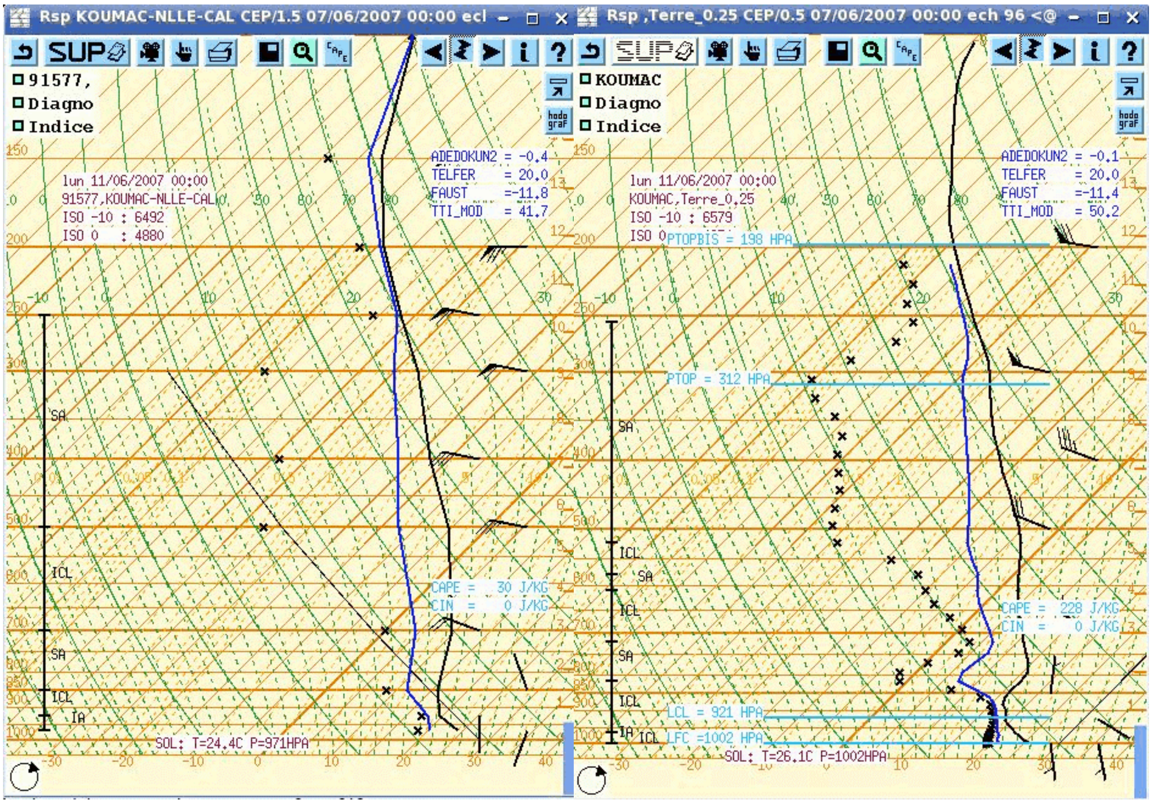

Figure 1: old and new forecast vertical profiles from ECMWF model

Monthly forecasts :

A classification on monthly forecast has been set up using seasonal weather regimes (negative and positive North Atlantic Oscillation, Atlantic Ridge and Blocking). This classification gives indications on the predictability of each weather regime and will help forecasters to improve the benefit from the monthly forecasting system especially concerning precipitations.

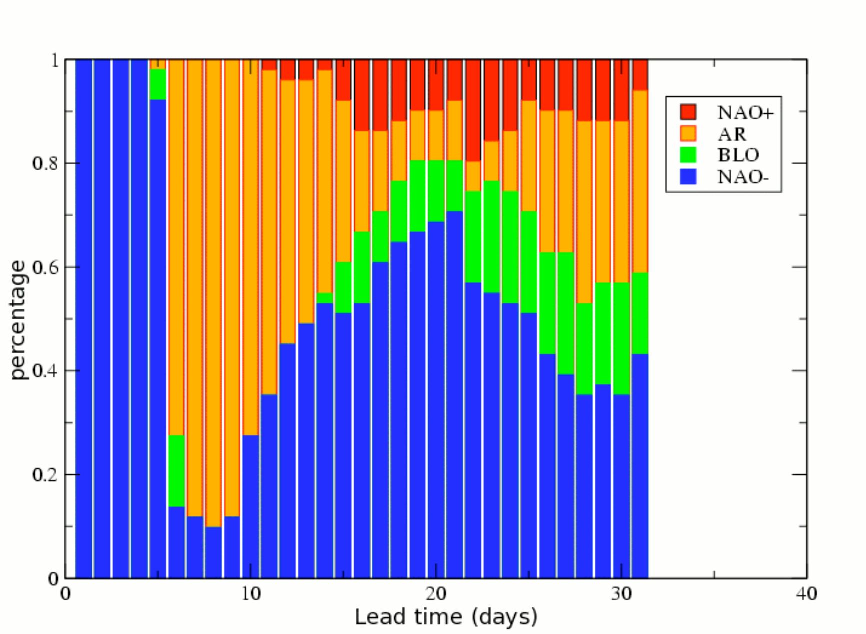

Figure 2: Ensemble members distribution onto winter weather regimes

3. Verification of products

3.1 Objective verification, *ECMWF model output compared to other NWP models*

Cyclonic forecasts :

ECMWF model is used in cyclon tracking. A comparison was made for different models in terms of direct position error. Figure 3 shows the results of this comparison for the season 2007-2008 over the Indian Ocean and for 5 models : ECMWF, UKMO, a non-stretched version of ARPEGE (ARPTROPIC), ALADIN and the american consensus forecast. ECMWF model presents the best skill especially at D+1.

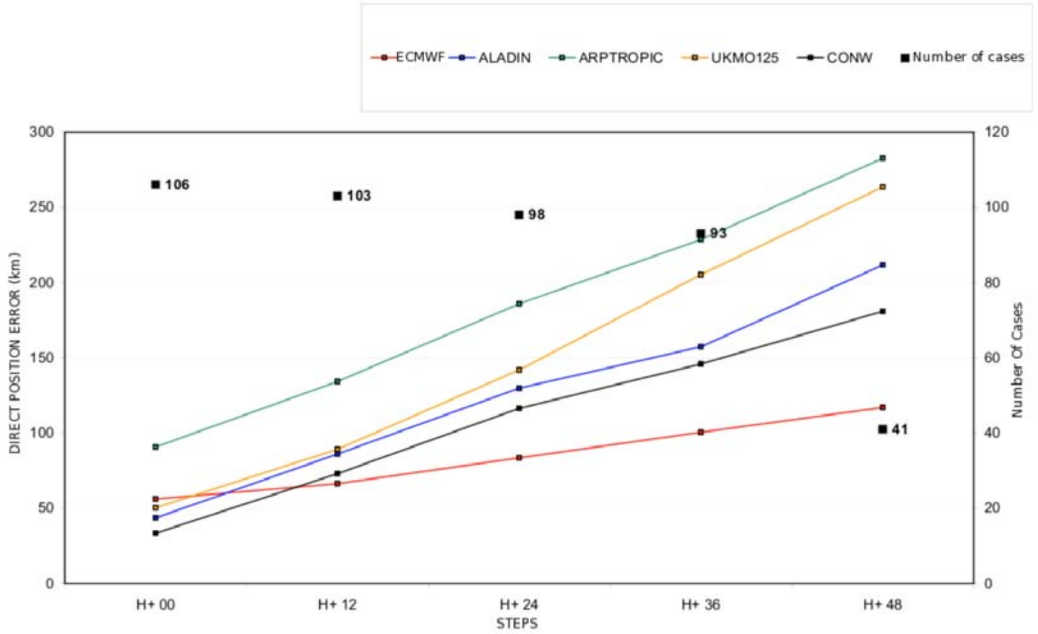

Figure 3: Direct cyclon position error for the different models - season 2007/2008

3.2 Subjective verification

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

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 July 2008 – June 2009 was 88 % for D4-D5 and 65% 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	75 (6/8)	83 (/155)	92 (146/158)	88 (281/321)
% of good forecasts D6/D7	44 (33/74)	70 (145/208)	77 (30/39)	65 (208/321)

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