Application and verification of ECMWF products 2011

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1. Summary of major highlights

- Implementation of a new surface scheme in the 3 limited area models ALADIN over tropical areas coupled to IFS
- Good results of the wave model MFWAM forced by the ECMWF surface winds

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.

Note the new production of grid point total cloud cover forecast based on a statistical adaptation using satellite data as predictand.

Deterministic model T1279

Parameter	Method	Domain	Nbr of Sites	Steps
Tri-hourly 2m Temperature	MLR (MOS) +KF	France	2781	+3h to +180h by 3h
Daily extremes 2m temperature	MLR (MOS) +KF	France	2781	D to D+6
10m Wind Speed	MLR (MOS)	France	861	+6h to +180h by 3h
10m Wind Direction	MLR (MOS)	France	822	+6h to +180h by 3h
Total Cloud Cover	MLR (MOS)/LDA	France	164/152	+12h to +180h by 3h
Total Cloud Cover	LDA	France	GRID 0.5x0.5	0h to +156h by 3h
Tri-hourly 2m relative Humidty	MLR (MOS) +KF	France	1269	+6h 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	7128	+1h to +180h by 1h
Daily extremes 2m temperature	MLR (MOS) +KF	World	7128	D to D+6
Mixed ARPEGE+IFS	MLR (MOS) +KF	France	2781	+3h to +102h by 3h
Mixed ARPEGE+IFS	MLR (MOS) +KF	World	4367	+1h to +102h by 1h

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	+3h to +360h by 3h
Daily extremes 2m temperature	MLR (pPP) +KF	France	2761	D to D+14
10m Wind Speed	MLR	France	792	+6h to +240h by 3h +246 to +360 by 6h
Tri-hourly 2m relative Humidty	MLR (pPP) +KF	France	1146	0h to +240h by 3h
Daily extremes 2m rel. Humidity	MLR (pPP) +KF	France	1146	D to D+10
Tri-hourly 2m Temperature	MLR (pPP) +KF	World	3338	+0h to +360h by 3h (by 1h for ensemble mean)
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.

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)	France	1056	+0h to +768h by 3h
Daily extremes 2m temperature	MLR (pPP)	France	1056	D to D+31
Tri-hourly 2m Temperature	MLR (pPP)	World	7128	+0h to +768h by 3h
Daily extremes 2m temperature	MLR (pPP)	World	7128	D to D+31

Table 3 : Statistical adaptations for the monthly forecasts

2.1.2 Physical adaptation

The first physical adaptation is performed by the limited area model (LAM) ALADIN which operates over western Europe (Figure 1). This models performs a dynamical adaptation of the IFS forecasts using a higher horizontal resolution of 7.5 km. Objective scores have been computed for the surface parameters measured by European surface stations and compared to the IFS forecasts. The rms is improved for the temperature at 2m AGL with a reduction less than 5 % depending on the lead time (Figure 2). This improvement is likely due to the more detailed orography and to a different turbulence and soil scheme. The rmse for wind at 10 m AGL and relative humidity at 2m AGL are comparable.

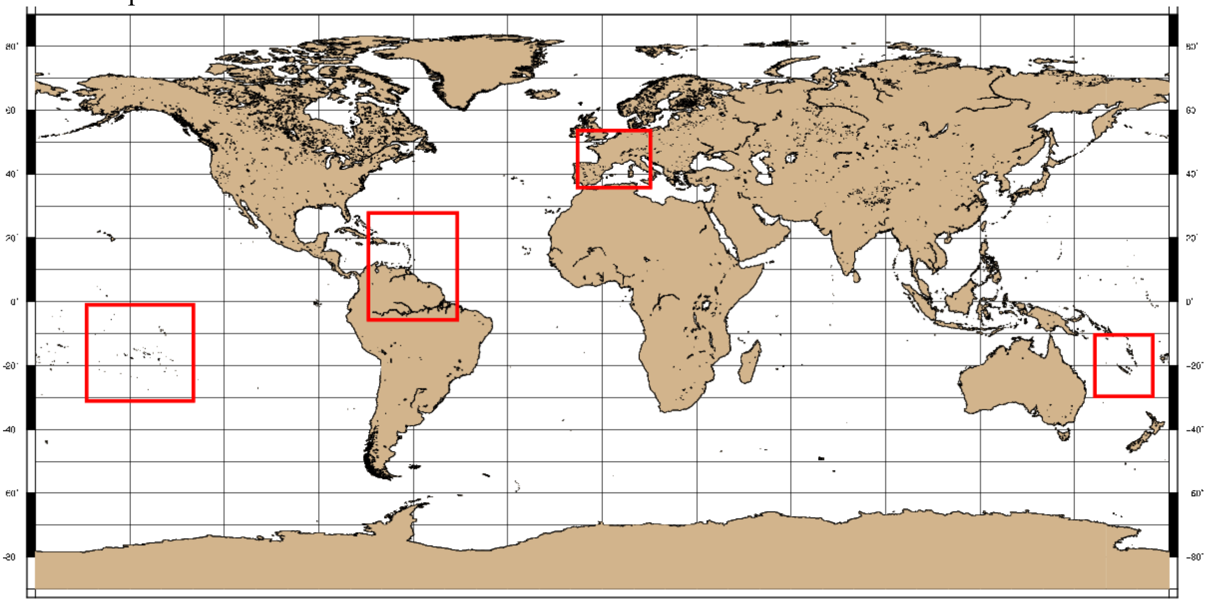

Figure 1 Geographical extension of the ALADIN models coupled to IFS

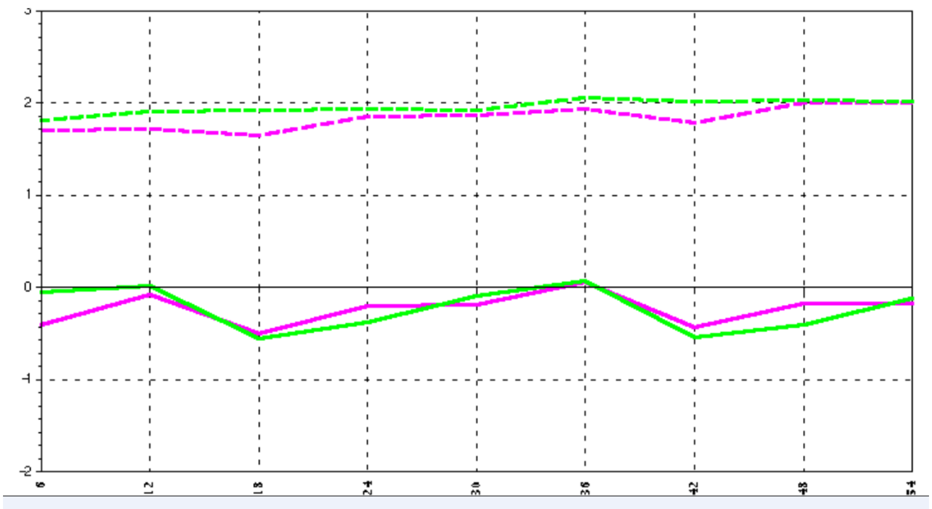

Figure 2 Rms (dotted lines) and bias (full lines) against the surface data observations included in the domain FRANCE in Kelvin for the temperature at 2 m AGL forecasts performed by the ALADIN-ECMWF (pink) and IFS (green). The scores are plotted against the lead time (in hours) of the simulations. The comparison is performed from 01/07/2011 to 30/06/2012.

Three LAM ALADIN have been operated by Météo-France to provide high-resolution forecasts for tropical area including French overseas territories (Figure 1). Their horizontal resolution is equal to 8 km. A 3DVAR assimilation scheme has been developed for these three LAM with 6 hours temporal windows. Two daily runs are performed at 0 and 12 UTC taking their boundary conditions in the IFS runs starting 6 hours before. The maximum lead time is 54 hours. The surface conditions are computed by a specific surface analysis similar to the one used by the French global model ARPEGE since September 2011. The quality of the LAM forecasts is compared with the IFS forecasts for surface parameters. For 6 hours accumulated rain, the LAM results are better than their IFS counterparts as shown by the Proportion Correct (PC) diagnostic defined as the number of good forecasts over the number of forecasts (Figure 3). Both PC present a diurnal cycle with better results during the nights over ANTILLES-GUYANE. The diurnal cycle is less marked on CALEDONIE in particular for ALADIN.

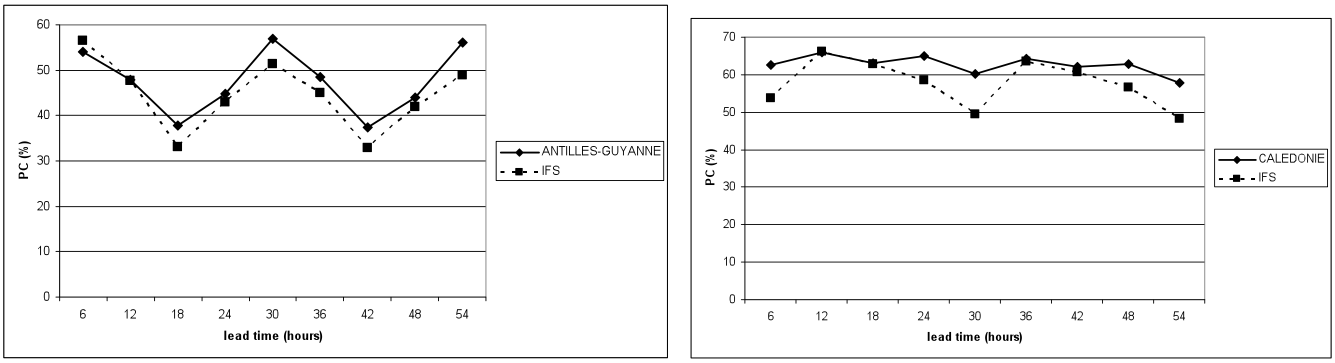

Figure 3 Proportion Correct for the 6 hours accumulated rain forecasted by ALADIN ANTILLES-GUYANNE (full line and diamond) and IFS (dotted line and square) on the left panel. The reference is provided by the rain gauges included in the LAM domain and the results are accumulated from July 2011 to June 2012. The same comparison is presented for the ALADIN CALEDONIE on the right panel.

The temporal series of the rmse for the temperature at 2m AGL shows better results for IFS until September 2011 when a specific surface assimilation scheme been implemented in each ALADIN (Figure 4). This leads to a strong improvement of the temperature forecasts near the ground particularly during the night (where the previous ALADIN soil scheme produced the maximum bias) of the ALADIN forecasts, which have now quite the same rmse as IFS even if the nocturnal bias remains stronger for ALADIN than for IFS.

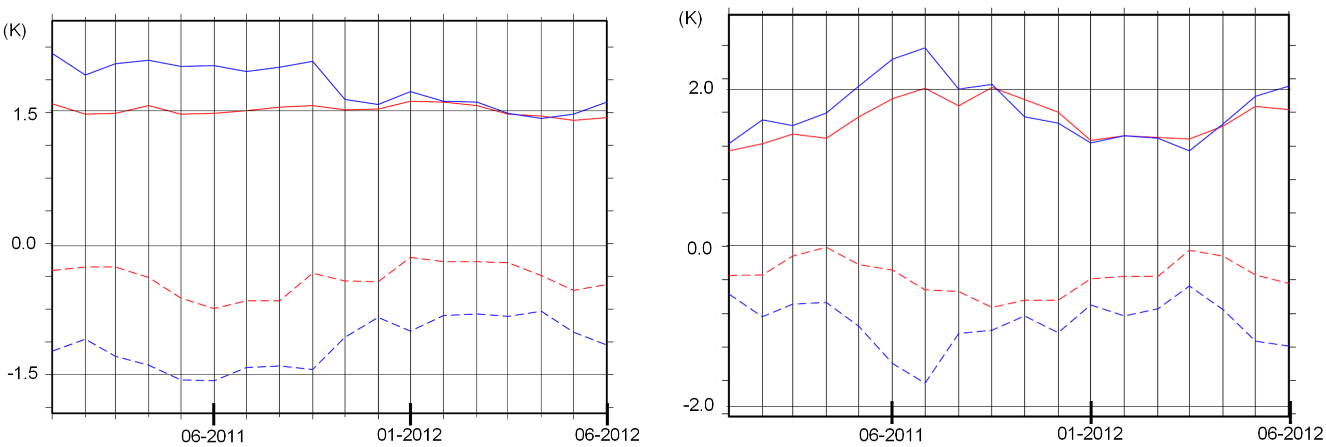

Figure 4 Temporal series of the rmse (full lines) and bias (dotted lines) for the temperature 2m AGL in K forecasted at 54 hours by ALADIN ANTILLES-GUYANE (blue lines) and IFS (red lines) on the left panel. The reference is provided by the surface stations included in the LAM domain and the errors are monthly averages. The same comparison is presented for the ALADIN CALEDONIE on the right panel at 36 hours.

The wind fields of the deterministic ECMWF model provide the forcing of the third generation wave model MFWAM, which is derived from the wave model WAM of ECMWF but used a different physical package. A global version and a regional version centred on Europe used horizontal meshes of 0.5° and 0.1°, respectively.

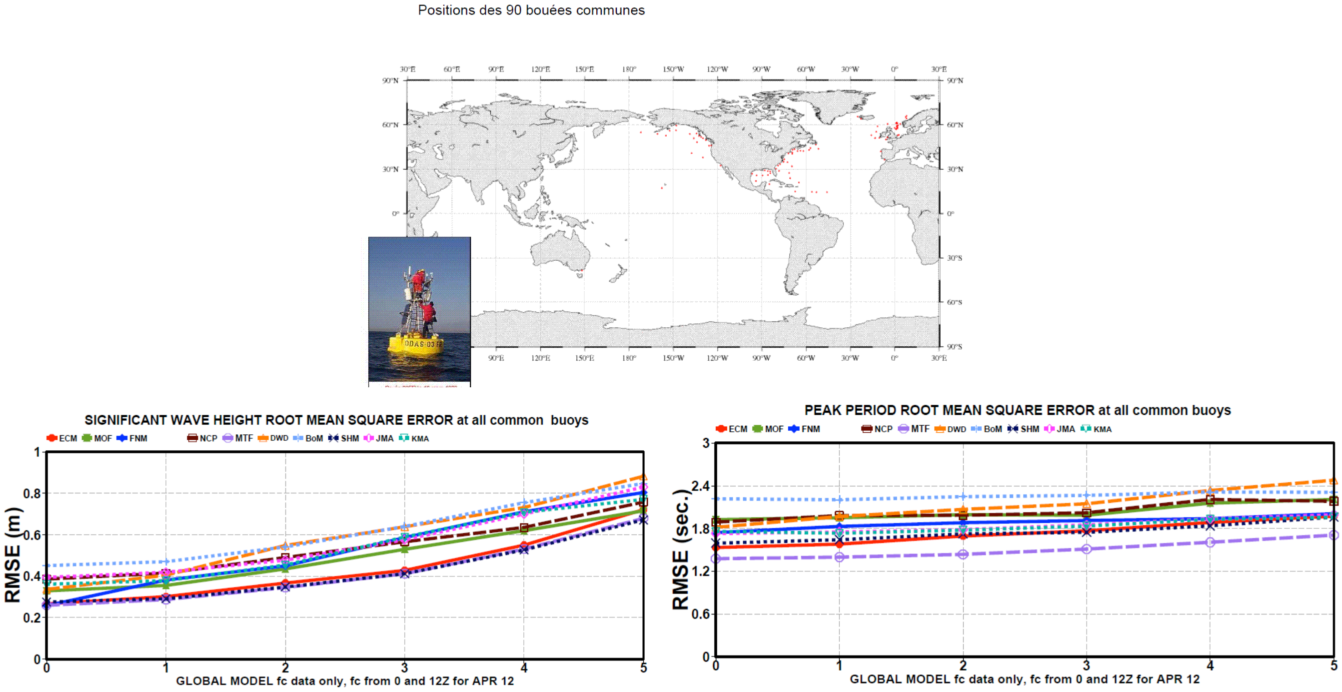

Figure 5 Positions of the 90 buoys used for the verification of the global models (first panel). RMSE of different global wave model forecasts for the significant wave height (panel bottom left) and the peak period (panel bottom right). WAM is plotted in red and MFWAM in purple.

The global model MFWAM is compared to others wave models using the buoys data as a reference. The improvement of the alternative physical package used in MFWAM (purple lines) is clear in Figure 5 for the peak period for all lead times and less important for the significant wave height.

2.1.3 Derived fields

Derived fields like probabilities, tubes and EFI are used by the forecasters via the Synergie workstation or the ECMWF web site.

Probabilities for specific thresholds are also calculated and available for the forecasters, for example significant wave height of at least 3 m or 9 m.

2.2 Use of products

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

3.1.2 ECMWF model output compared to other NWP models

3.1.3 Post-processed products

3.1.4 End products delivered to users

3.2 Subjective verification

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

<u>Monthly forecast verification</u>

The monthly forecasts of 2m-temperature anomalies have been assessed by the forecasters since November 2004. A sample of 390 elements is available covering the period from November-2004 to April-2012.
For every week, the marks vary from A to D with the following meaning:

A : good localisation and intensity of the anomaly,
B : slight differences (localisation and/or intensity) between observed and forecast anomaly,
C : anomaly forecasted but not observed (miss) or (more frequently) anomaly observed but not forecasted (false alarm),
D : observed anomaly opposite to the forecasted anomaly.

The proportion over the whole period of each mark for week 1 to week 4 is plotted in Figure 6.

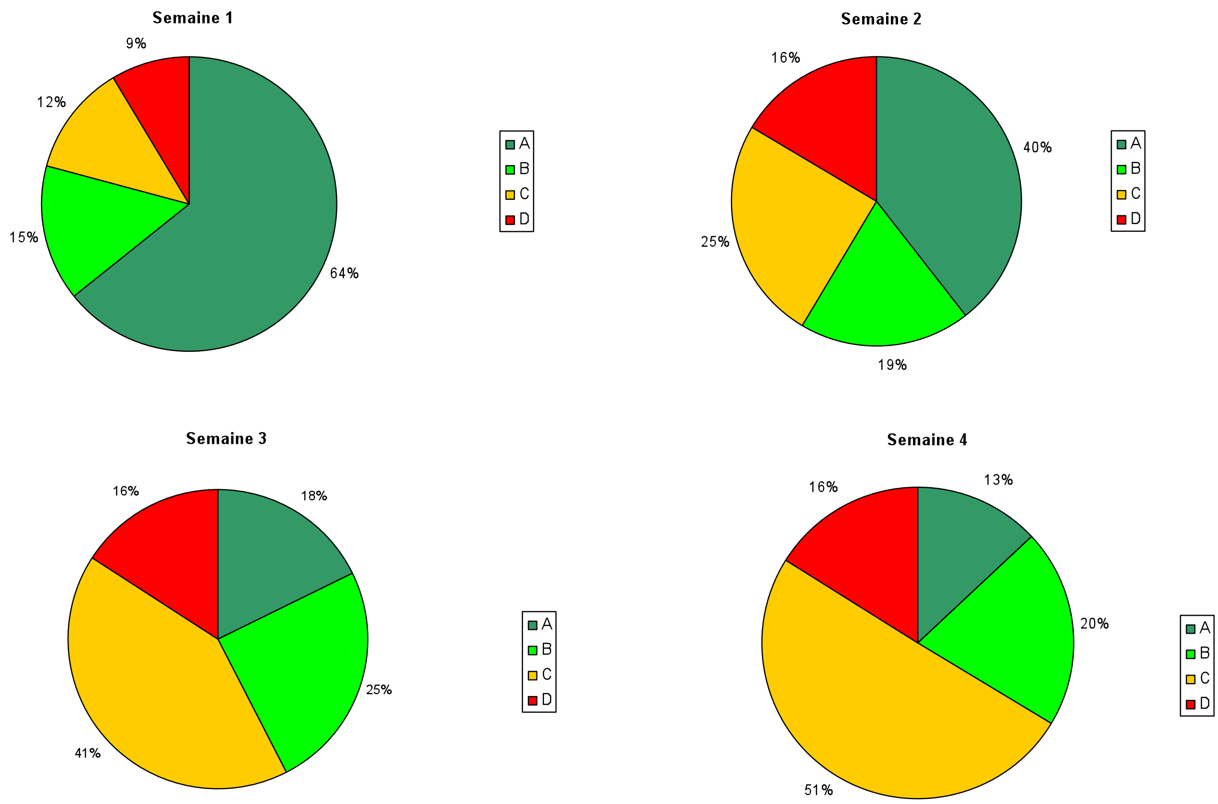

Figure 5 Proportions of subjective notations for the forecast of the anomalies over France monthly temperature at 2m AGL from November 2004 to April 2012 (sample size=390).

The forecast quality is very good for week 1 and good for week 2. For the weeks 3 and 4, there are more bad forecasts than good ones. This is mainly due to the important number of C marks, which often correspond to misses where there is no signal in the forecast and an observed anomaly. If we remove the cases where there is no signal in the forecast, the number of good forecasts becomes around 59% for week 3 and 51% for week 4.
Note that the proportion of bad forecasts (D marks) is similar from week 2 to week 4 (16%).

	Week 1	Week 2	Week 3	Week 4
A	11	5	2	1
B	1	3	5	3
C	1	4	6	10
D	1	2	1	0
Total	14	14	14	14

Table 4: Proportions of subjective notations for the forecast of the anomalies over France monthly temperature at 2m AGL for winter 2011/2012 (from 8 december 2011 to 8 march 2012)

Table 4 corresponds to the winter 2011-2012 and it shows very good marks for week 1. Furthermore the cold period in february has been well anticipated two weeks ahead.

3.2.2 Synoptic studies

4. References to relevant publications

Ardhuin, F., E. Rogers, A. Babanin, J.-F. Filipot, R. Magne, A. Roland, A. van der Westhuysen, P. Queffeulou, J.-M. Lefevre, L. Aouf, and F. Collard, 2010: Semi-empirical dissipation source functions for ocean waves: part I, definition, calibration and validation. *J. Phys. Oceanogr.,* **40**(9), 1917-1941, http://dx.doi.org/10.1175/2010JPO4324.1.