SafeWind

Collaborative project funded by the European Commission under the 7th Framework Program, Theme 2007-2.3.2: Energy

"Multi-scale data assimilation, advanced wind modelling & forecasting with emphasis to extreme weather situations for a safe large-scale wind power integration"

Grant Agreement N°: 213740

Deliverable Dp-5.4

"Suitability and feasibility of integrating Limited-Area EPS (LEPS) for WPF applications"

Appendix L

Skill assessment of GLAMEPS ALADIN-LAEF

DOCUMENT TYPE	Deliverable
DOCUMENT NAME:	swind_deliverable_Dp-5.4_V1.1_Apdx_L.doc
VERSION:	V1.1
DATE:	2011.02.18
CLASSIFICATION:	R0: General Public
STATUS:	Approved/Released

Appendix L: Skill assessment of GLAMEPS ALADIN-LAEF

Details of the February - March 2010 (FM) verification

16-member ALADIN-LAEF (res: 18 km) Vs New 50-member EPS (res: 32 km)

- *ACC & Useful Forecast Interval (UFI) for surface (10-meter height) wind speeds*

ACC values for ECMWF IFS High-Resolution Operational Forecast (IFS-OPER), EPS Control Forecast (EPS-CF) and ALADIN-LAEF (ALAN-OPER) Operational Forecast (also considered as the LAEF Control Forecast) are shown in Figure L.1 over North Europe during FM 2010. European subareas of verification as defined in Figure J.13 (of Appendix J) have been used.

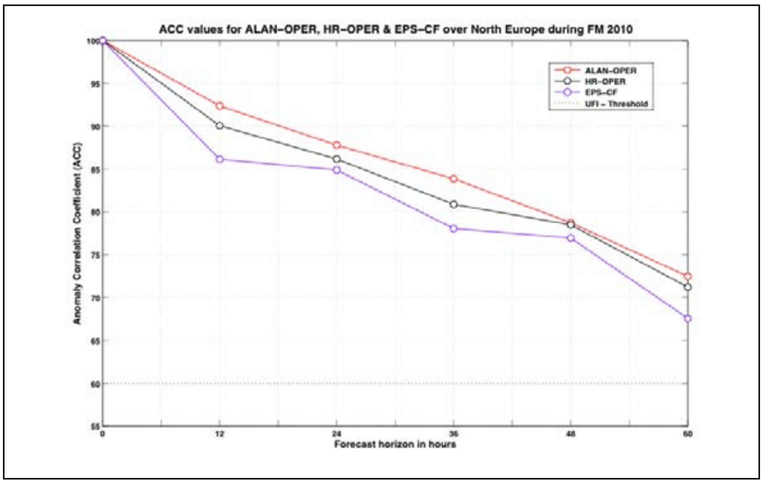

Figure L.1: *ACC values for IFS-OPER, EPS-CF & ALAN-OPER over North Europe during FM 2010.*

Furthermore, Table L.1 contains the difference in ACC skill of IFS and ALAN-OPER. Although IFS appears to be superior to ALAN-OPER over Europe (the largest area of verification), ALAN-OPER seems to provide better forecast guidance over many North European subareas, especially over those belonging in the greater area of Germany, an area with distinct orographic characteristics (as Alps).

Table L.1: *Differences of ACC skill values between ALAN-OPER (also taken as ALAN-CF) and IFS for different European subareas during FM 2010. Shaded boxes denote areas of superiority of ALADIN-LAEF Operational over ECMWF IFS High-Resolution forecast.*

	T+012	T+024	T+036	T+048	T+060
europe	-1.4009	-1.6907	-1.3748	-2.4512	-1.0107
north europe	2.3162	1.6246	2.9749	0.2473	1.2458
south europe	-2.9595	-3.5451	-3.3371	-4.3747	-2.684
france	-0.6086	-1.7298	-0.9419	-4.3465	-1.2946
germany	4.953	3.9323	4.2543	1.8863	2.1196
vatten	4.3319	9.6421	3.8904	6.6979	1.5789
eon	5.1934	4.2805	4.8475	2.1203	2.11
enbw	10.5448	5.9729	15.2583	6.7117	13.4041
rwe	5.7653	7.6078	8.7318	4.9329	2.1145
finol	2.1079	0.5494	1.0198	-0.8128	5.8442
cabauw	-0.1243	-1.5918	-4.8795	-3.3576	-3.9024

Figure L.2: *ACC values for IFS-OPER, EPS-CF and ALAN-OPER over Germany during FM 2010.*

The superiority of ALAN-OPER over IFS for Germany is clearly seen in Figure L.2. This superiority of ALAN-OPER (considered as ALADIN-LAEF Control Forecast also) is even more pronounced over EPS Control Forecast (plotted in Figure L.2 as well).

Details of the difference in skill between ALAN-OPER and EPS-CF are shown in Table L.2. Shaded areas correspond to areas and forecast horizons that ALAN-OPER provides better forecast guidance over corresponding EPS-CF.

Table L.2: *Differences of ACC skill values between ALAN-OPER (also taken as ALAN-CF) and EPS Control Forecast (EPS-CF) for different European subareas during FM 2010. Shaded boxes denote areas of superiority of ALADIN-LAEF operational over ECMWF EPS-CF.*

	T+012	T+024	T+036	T+048	T+060
europe	2.2534	0.3806	1.3872	-0.5111	1.7269
north europe	6.2324	2.8946	5.7957	1.786	4.9105
south europe	1.4595	-0.6028	0.1638	-1.9825	0.5786
france	3.8661	0.6731	2.8013	-1.6328	1.3696
germany	10.401	5.1802	8.4095	3.2769	7.3971
vatten	13.7	12.8213	10.3878	9.2142	8.091
eon	11.527	5.6849	9.5929	3.5711	7.8607
enbw	22.4344	11.5033	20.5067	10.8812	20.8859
rwe	11.2177	9.5063	12.4513	5.8303	6.7364
finol	7.5106	0.9613	4.6109	3.249	11.4745
cabauw	2.3129	-1.6417	-1.0621	-2.4256	-0.3376

Assessing the skill of ALADIN-LAEF and EPS, ACC values of LAEF-EM (Ensemble Mean) and EPS-EM are estimated and plotted in Figure L.3 valid for Europe and Germany subarea. Although both systems perform similarly over Europe, the superiority of ALAN-EM over EPS-EM is well pronounced over Germany. Nevertheless, both ALAN-EM and EPS-EM manage to provide the user with useful forecast guidance during the entire S-R and early M-R horizons.

Figure L.3: *ACC values for ALAN-EM and EPS-EM over Europe & Germany during FM 2010.*

Details of the inter-comparison concerning the ensemble means of LAEF & EPS platforms are given in Table L.3, where shaded boxes correspond to areas and forecast horizons that LAEF-EM provides superior forecast guidance over EPS-EM.

Table L.3: *Differences of ACC skill values between ALADIN-LAEF Ensemble MEAN (ALAN-EM) and ECMWF EPS EM (EPS-EM) for different European subareas during FM 2010. Shaded boxes denote areas of superiority of ALADIN-LAEF EM over ECMWF EPS-EM.*

	T+012	T+024	T+036	T+048	T+060
europe	0.4083	0.3437	0.0623	0.2316	0.5107
north europe	4.516	2.6331	4.0895	1.0186	3.7549
south europe	-0.2425	-0.3842	-0.1946	-0.2488	-0.0395
france	2.7076	1.43	1.8036	0.0615	1.1269
germany	9.0859	4.8917	8.4735	2.68	8.1667
vatten	12.7145	10.2693	10.1086	10.445	8.9593
eon	9.9528	5.4935	9.6319	3.5836	9.3496
enbw	19.1664	13.4386	17.7141	13.7693	15.4129
rwe	10.0607	9.4653	10.8856	5.9265	5.1851
finol	7.3165	3.5785	4.9336	1.0085	9.0528
cabauw	1.1342	-0.3793	-1.0707	-5.4515	-4.9537

- *Ensemble Spread from the Ensemble Mean & Control Forecast for surface wind speeds*

Once more the concept of the perfect EPS has been investigated for the GLAMEPS ALADIN-LAEF platform, i.e., if its time-mean ensemble spread about the ensemble-mean equals (or how small or large the gap is from) the time-mean RMS error (skill) of the ensemble-mean [L.1]. In addition to this investigation, the LAEF spread is also compared to the spread of EPS over Europe and various common European subareas. Besides the “typical” spread from the ensemble mean, the spread from the control forecast has also been investigated.

Figure L.4: *Spread (from the ensemble mean) differences of ECMWF EPS from ALADIN-LAEF over Europe and various European subareas during FM 2010.*

From Figure L.4 it becomes obvious that LAEF has larger spread than EPS over Europe (true for all forecast horizons but for T+048), while the same seems to be true over France. The largest values of LAEF spread seem to exist over South Europe. Comparable or even smaller values of spread for LAEF were found over North Europe and especially over Germany as contained in Table L.4.

Table L.4: *Differences of spread values (from the ensemble mean) between ALADIN-LAEF and ECMWF EPS for different European subareas during FM 2010. Shaded boxes denote areas and forecast horizons that LAEF spread is larger than EPS's.*

	T+012	T+024	T+036	T+048	T+060
europe	0.1089	0.0326	0.0869	-0.0126	0.08
north europe	0.0193	-0.0657	-0.0241	-0.148	-0.0284
south europe	0.162	0.0938	0.1584	0.0768	0.1522
france	0.1077	0.0188	0.1152	-0.0233	0.1177
germany	0.0386	-0.0366	0.0332	-0.0881	0.0474
vatten	0.0079	-0.0709	-0.0241	-0.1322	0.0038
eon	0.0404	-0.0388	0.0453	-0.0903	0.0579
enbw	0.0395	-0.0844	0.0089	-0.1746	0.0202
rwe	0.03	-0.0514	0.0577	-0.1122	0.0263
finol	0.0875	0.1324	0.1322	0.1482	0.1743
cabauw	0.0766	0.0888	0.0743	0.113	0.1176

Same wise, from Figure L.5 it is clear that LAEF has larger spread (from Control Forecast) than EPS over Europe and different European subareas. The largest values of LAEF spread seem to occur over South Europe (as in the case of the spread about the ensemble mean). Comparable or even smaller values of spread for LAEF were found over North Europe and especially over Germany. Further investigation concerning the agreement (harmony) between LAEF spread and skill of LAEF ensemble mean has been performed. It has been already verified that EPS is under dispersive (see Appendix J).

Figure L.5: *Spread (from the control forecast) differences of ECMWF EPS from ALADIN-LAEF over Europe and various European subareas during FM 2010.*

Figure L.6: *Skill of Ensemble Mean and Spread (from Ensemble Mean) of LAEF (denoted by red colour) and EPS (denoted by black colour) over Europe for FM 2010.*

Figure L.7: *Difference of Spread from Skill of the Ensemble Mean for LAEF (denoted by red colour) and EPS (denoted by black colour) over Europe during FM 2010.*

From Figure L.6 it is obvious that similarly to EPS, ALADIN-LAEF is not capable to harmonize its spread from the ensemble mean to the skill of its ensemble mean over Europe. Although LAEF appears to have a larger spread, the error of its ensemble mean is also large. Nevertheless, LAEF seems to perform better than EPS in harmonising its spread / skill relationship for forecast horizons longer than 48 hours (as shown in Figure L.7).

- *Continuous Ranked Probability Skill Score for surface (10-meter height) wind speeds*

Continuous Ranked Probability Skill Score (CRPSS) values have been computed for ALADIN-LAEF and ECMWF EPS platforms, including various system components, as the Ensemble Mean, Control Forecast and their corresponding Operational Forecast, by constructing appropriate "synthetic" Probability Density Functions (PDFs).

Figure L.8: *CRPSS values for ALADIN-LAEF & ECMWF EPS platforms for Europe during FM 2010.*

From Figure L.8 it is clear that ECMWF EPS is capable to provide better probabilistic than ALADIN-LAEF. Both EPS and LAEF platforms found capable to provide the user with probabilities that are better (more reliable) than climatology (the climatological threshed is denoted by the zero dashed line) for all forecast horizons. The superiority of EPS over LAEF (valid for Europe) was not documented over smaller European areas. LAEF found to perform better over North Europe and Germany especially for T+012 – T+036 & T+060 forecast horizons (as shown in Figure L.9). These probabilistic forecasts have been verified against 00 UTC analysis. It seems as the new ECMWF EPS platform has difficulties to simulate correctly the atmospheric flow in early morning hours. Stability issues especially over high terrain (orographic) areas (as Central & South Germany) seem to limit the predictability of both ECMWF IFS and EPS platforms.

Figure L.9: *CRPSS differences of ECMEF EPS from ALADIN-LAEF over Europe (red line), North Europe (black line) and Germany (purple line) during FM 2010.*

Figure L.10: *CRPSS for ALADIN-LAEF (red line), LAEF-OPER (LAEF-CF also) denoted by black line and LAEF Ensemble Mean (purple line) for Europe during FM 2010.*

Furthermore, both LAEF and EPS platforms found to provide superior probabilistic guidance over their corresponding "deterministic" components (i.e., their Operational – Control & Ensemble Mean). In Figure L.10, CRPSS scores are plotted for LAEF, LAEF Operational Forecast (also Control Forecast) and LAEF Ensemble Mean. The superiority of LAEF to provide better probabilistic guidance over its corresponding "deterministic" components is obvious for all forecast horizons. LAEF also manages to stay above the climatological threshold line (denoted by the green dashed line) during the maximum forecast horizon, while both the LAEF-OPER and LAEF-EM fail to provide better probabilistic guidance over climatology after the 48-hour horizon.

- *Talagrand Rank Histograms (TRHs) for surface (10-meter height) wind speeds*

Although ALADIN-LAEF found to exhibit larger spread values for most of forecast horizons (as shown in Figure L.6 valid for Europe) there still exist a considerable "gap" between the LAEF spread and the skill of the its Ensemble Mean. A closer investigation focusing on TRHs seems necessary to examine the true capability of ALADIN-LAEF to "capture" extremes as those falling in the outer Talagrand bins.

Figure L.11: *Left Talagrand bin outliers for LAEF (red) and EPS (black) over Europe during FM 2010.*

Results concerning the left outer bin are plotted in Figure L.11. It is obvious that EPS (in its full 50-member formulation) does a better job in capturing extremes belonging to the left outer bin(s), i.e., it scores less misses. Nevertheless, both LAEF and EPS seem to be far from their optimal "Talagrande" frequency (denoted by the red and black horizontal dashed lines). On the other hand, one very promising signal has been the reduction of outliers for both LAEF and EPS platforms as the forecast horizon is increased (from 12 to 60 hours).

Figure L.12: *Right Talagrand bin outliers for LAEF (red) & EPS (black) over Europe during FM 2010.*

Results concerning the right outer bin are plotted in Figure L.12. ALADIN-LAEF seems to do significantly better than EPS in capturing "real" extremes, i.e., extremes belonging in the right outer bin(s). Overall, LAEF manages to stay close or even below its optimal "Talagrande" distribution (denoted by red line) during all forecast horizons. EPS has found unable to capture all extremes (of the right bin category), although the reduction of "misses" as the forecast horizon is increased is obvious. Based on both Figures L.11 & L.12, it looks like that the ALADIN-LAEF is biased to stronger wind speeds (i.e., it shows a tendency to over-forecast wind speeds), which may be one of the reasons behind its ability to capture higher percentage of "real" extremes for all forecast horizons.

References

[L.1] Palmer T.N., Buizza R., Leutbecher M., Hagedorn R., Jung T., Rodwell M., Vitart F., Berner J., Hagel E., Lawrence A., Pappenberger F., Park Y-Y., Bremen v.L. And I. Gilmour, 2007: The Ensemble Prediction System – Recent and Ongoing Developments. Tech. Memo 540. ECMWF, Reading, U.K.