SafeWind

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

Appendix M

Case study: Xynthia windstorm

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Appendix M: Case study of Xynthia windstorm

A considerable amount of various LEPS data sets are available to SafeWind participants (See Section 9: Conclusions) for further use & exploitation. So far, activities concerning collection of test cases and assessment of selected LEPS runs in terms of surface winds suitable as input to wind power prediction platforms have been focused on COSMO-LEPS in S-R & early M-R forecast horizons and ALADIN-LAEF in S-R, verified over various strategically selected subareas of Europe. Meteo-France PEACE/PEARP platform has been also utilized for the assessment of the Xynthia windstorm over Central Europe.

Potential weaknesses and strengths of various LEPS platforms concerning their ability to provide useful (and early warning) forecast guidance in the case of Xynthia windstorm have been investigated by inter-comparison to ECMWF EPS, which has been considered as the backbone ensemble prediction system utilized by the SafeWind Project.

- *Xynthia windstorm*

A severe storm named "Xynthia" affected Portugal, Spain, Switzerland, France, parts of southeast England, Belgium, the Netherlands, Luxembourg, Germany and Austria. Strong gusts on 27-28 February 2010 caused extended damage on traffic routes, electrical power outage, and destruction due to flooding at the French Atlantic coast. In France, where it was described by the civil defence as the most violent since Lothar and Martin windstorms in December 1999, at least 51 people were killed, with 12 more said to be missing. A further six people were killed in Germany, three in Spain, one in Portugal, one in Belgium and another one in England, i.e., more than 60 losses of lives [38]. Most of the damage was in France and western Germany.

The strong winds also downed trees and caused roof top damage across a wide swath of France, extending in a northeast trajectory from La Rochelle in the coast to Metz and the Strasbourg region and into Germany. High winds causing tree falls, widespread debris and disruption are reported from the Parisian suburbs and Brittany to pockets of damage to high-elevation ski resorts in the Haute-Garonne and Hautes-Pyrenees, which could force them to close for the rest of the season. The track of this storm (shown in Figure M.1) and its rapid development were outstanding, but the magnitude of the gusts was comparable to other violent storms in the past.

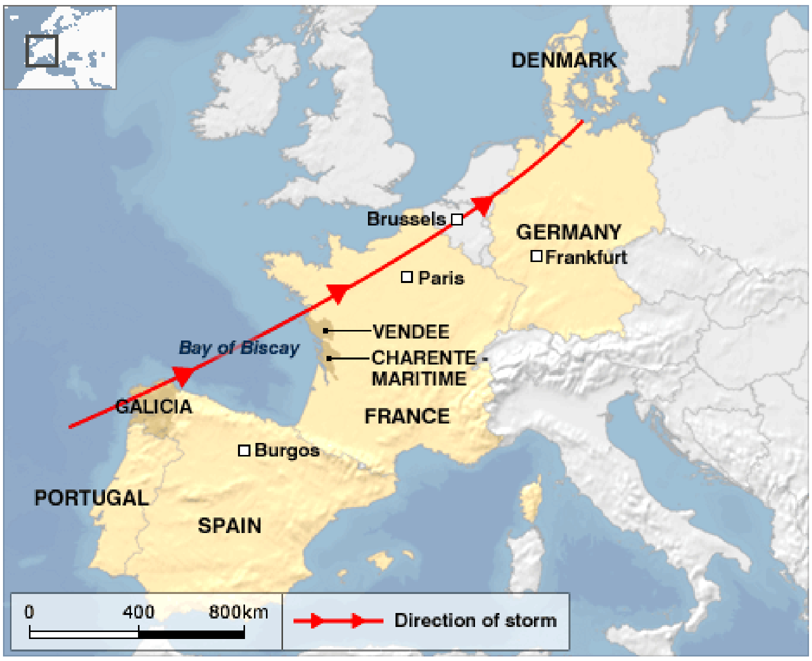

Figure M.1: *Depiction of the direction of Xynthia windstorm as denoted by the red arrowed line.*

- *Synoptics of Xynthia*

Xynthia arose from an initially shallow surface barometric low system that formed over the subtropical sea area south of the Azores Islands on Friday, 26 February 2010. The southward flow of colder air masses in the upper air caused the deepening of a broad trough over the central and eastern North Atlantic. A shortwave trough within this broader system and a high temperature difference between extremely warm air over Africa and colder air over the eastern Atlantic caused a strong cyclogenesis of Xynthia. On Saturday, February 27, the cyclone moved north-eastwards over Portugal and the Bay of Biscay (as shown in Figure M.2) and then to the westernmost areas of France and intensified very rapidly to a core pressure of about 967 hPa around midnight that means a deepening of about 20 hPa within 24 hours

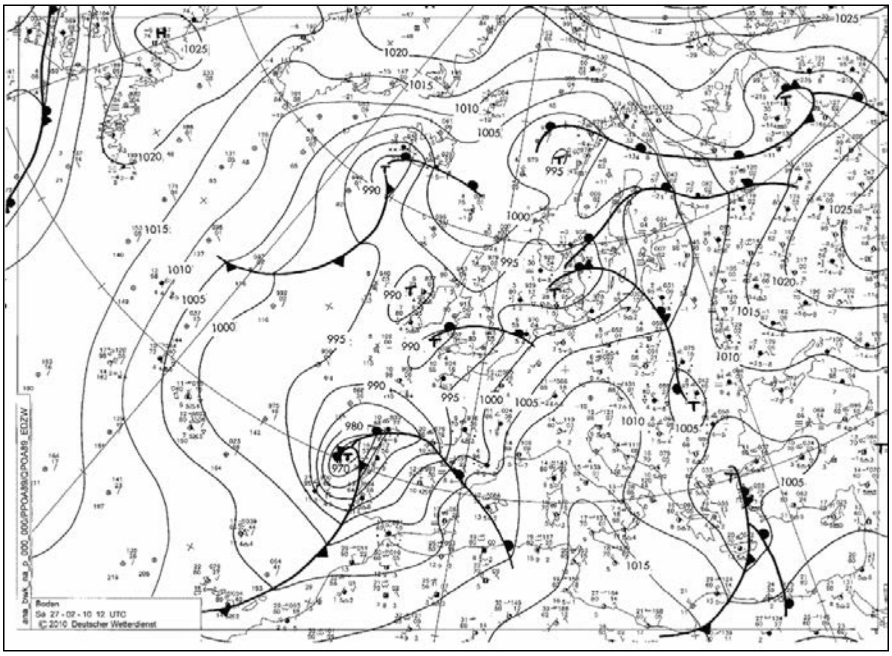

Figure M.2: *DWD surface map depicting Xynthia's centre approaching Portugal on 27-2-2010 12UTC.*

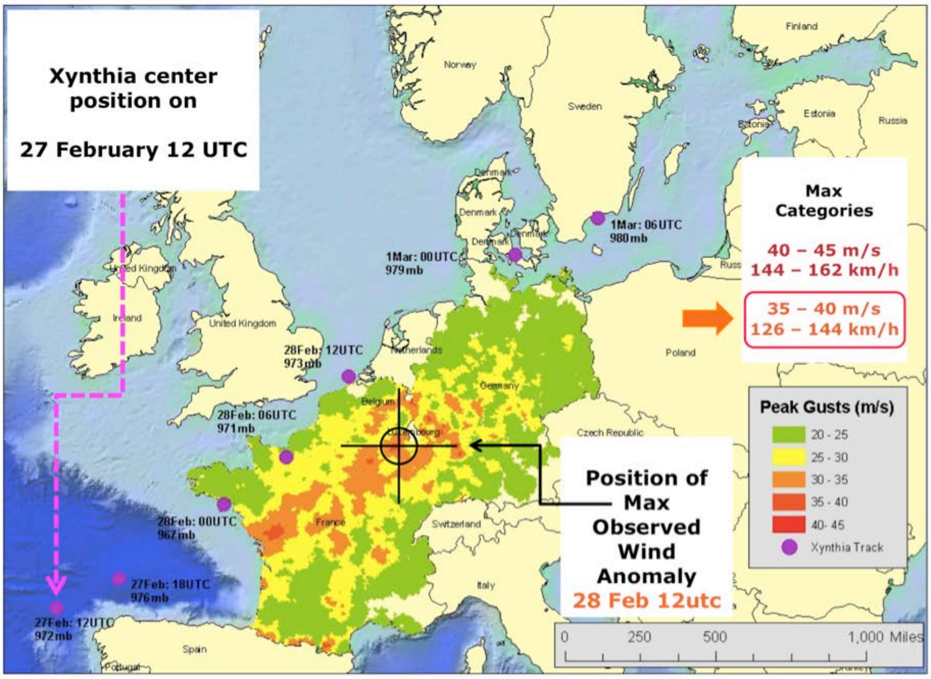

Figure M.3: *Track of Xynthia denoted by magenta dots. Peak gust values are also plotted.*

During the following three days it began weakening and moved further north-eastwards along the coastline of northern France and the North Sea, and then it crossed the southern Baltic Sea to southern Finland until March 3. There it had a core pressure of 990 hPa with further slow dislocation and weakening. It is worth to point out that Xynthia had a quite unusual track (shown in Figure M.3) for such a cyclone. In most cases such storms develop further northwards over the Atlantic and then move eastwards over western and central Europe. Wind gusts were highest at the southeast flank of Xynthia, particularly after cold front passage. During the night from Saturday to Sunday, gusts at hurricane force (120-130 km/h) were recorded at many stations in France. On Sunday (28 February) morning, gusts of the same magnitude affected northern France, Luxembourg, Belgium, western and southwestern Germany, and Switzerland, while over the Alps even higher than 140 km/h due to locally Foehn phenomena. The duration of the storm was about 7 hours in places of western Germany and that was much of the daytime on Sunday (the exact position of Xynthia on Sunday midday is shown in Figure M.4).

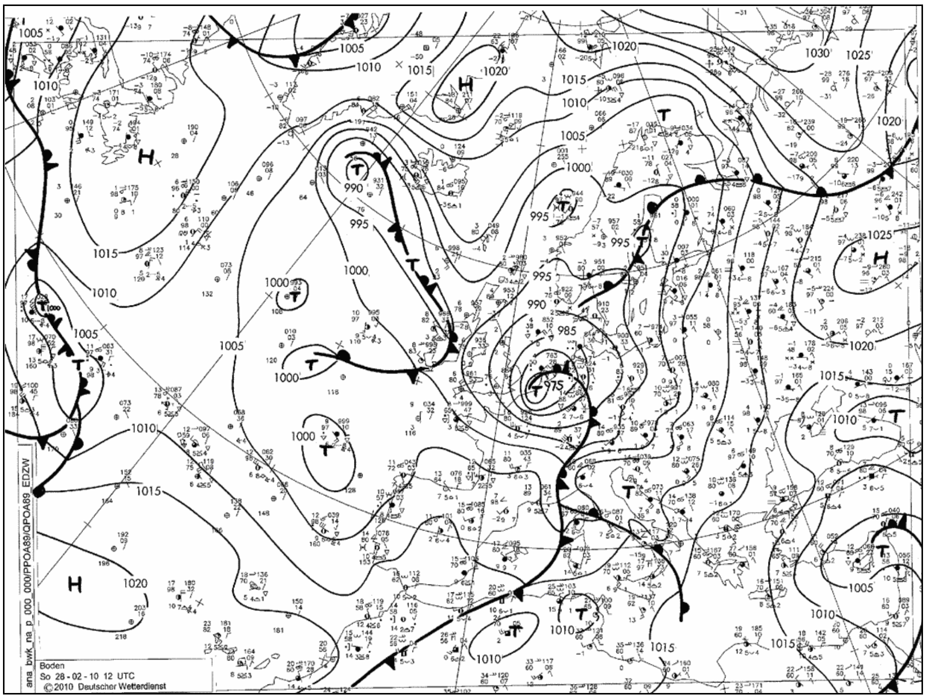

Figure M.4: *Position of Xynthia's centre on the DWD surface map of 28 February 12 UTC (such a map represents a diagnostic tool produced and used daily by forecasters on the bench).*

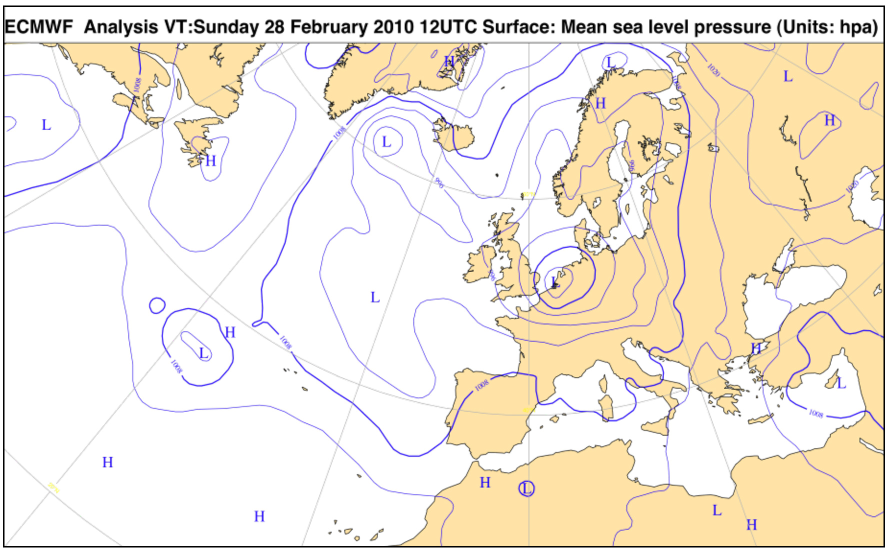

Figure M.5: *Position of Xynthia centre as it is depicted on the ECMWF MSLP (Mean Sea Level Pressure) analysis map of 28 February 12 UTC.*

The highest measured wind gust in Germany (taken from DWD stations) was 180 km/h on Sunday evening on the Brocken Mountain, which is a very exposed mountain station. But also on other lower mountain stations, local gusts of 140 up to even more than 160 km/h were reached. Widespread stormy gusts, but no longer at hurricane force still occurred on Monday morning. Northern coastal areas of Germany did not have very strong gusts due to their vicinity to the low pressure core. In Austria, gusts were generally lower than in other parts of central Europe, though quite high. Wind speeds of 80-100 km/h were recorded in some places, while on high mountains in the Alps up to 145 km/h were observed. Values of 100 km/h were also exceeded in Belgium and the Netherlands. In the sections that are following a set of different forecast maps have been utilised. Most of the maps and point values have been produced by ECMWF IFS & VarEPS platforms. Rather smooth fields (compared to the analysis surface maps used by forecasters on the bench) were examined concerning their capabilities to provide useful forecast guidance in the case of Xynthia storm. As an example, such a smooth analysis filed corresponding to the analysis displayed in Figure M.4 can be seen in Figure M.5.

- *ECMWF IFS & EPS forecast guidance concerning Xynthia windstorm*

Both ECMWF IFS and EPS platforms performed well forecasting Xynthia windstorm for the total M-R (day 1 to day 10). Since the maximum forecast horizon of COSMO-LEPS has been the end of the early M-R (i.e., 5.5 days), the comparison between COSMO-LEPS and ECMWF EPS has been focused on day 1 (T+024), day 2 (T+048), day 3 (T+072), day 4 (T+096) and day 5 (T+120) forecasts.

Same wise, since the maximum forecast horizon for PEACE/PEARP platform has been 72 hours (for forecasts based on 06 UTC) and 108 hours (for forecasts based on 18 UTC), the comparison between PEACE/PEARP and EPS has been focused for T+030 & T+054 for PEACE/PEARP forecasts based on 06 UTC and T+018 – T+042 – T+066 & T+090 for forecasts based on 18 UTC. It is obvious that all forecasts are verified against 12 UTC corresponding analysis fields.

Furthermore, since the maximum forecast horizon for the GLAMEPS ALADIN-LAEF platform has been 60 hours (2.5 days), the comparison between ALADIN-LAEF and EPS has been focused for T+024 & T+048 (both verifying against 12 UTC corresponding analysis fields).

Figure M.6 contains the T+120 IFS MSLP (Mean Sea Level Pressure) forecast, initiated from 23 February 12 UTC and verifying on 28 February 12 UTC. Although it is not a perfect forecast, it gives a very good indication of the possibility of an extreme event such the Xynthia windstorm. That is the reason why it shares many similarities with the actual analysis (shown in Figure M.5).

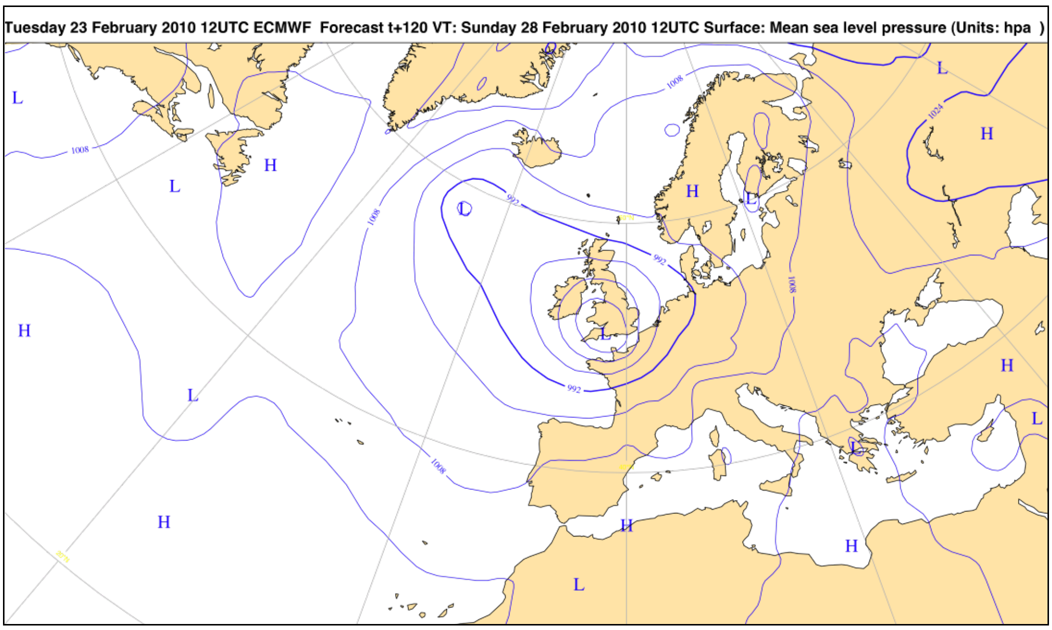

Figure M.6: *T+120 (day 5) IFS MSLP high-res forecast corresponding to IFS analysis (Figure M.5).*

Complementary to the day 5 IFS, EPS has been supporting IFS forecast guidance with many of its 50 members, such as the EPS member 37 (shown in Figure M.7), which shares a lot of similarities with the day 5 IFS (Figure M.6) and its corresponding analysis (Figure M.5).

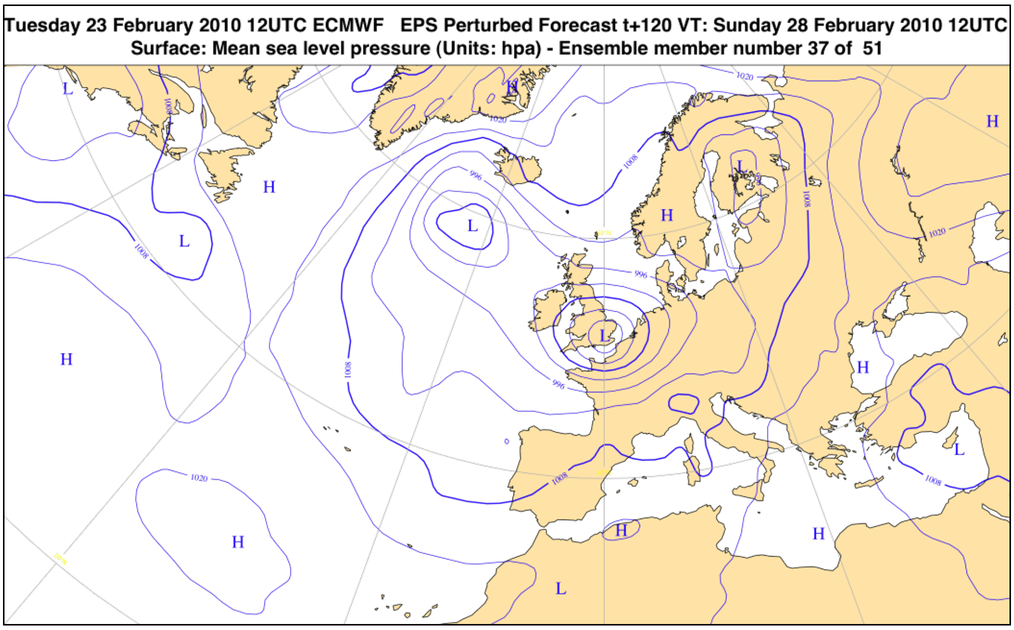

Figure M.7: *T+120 (day 5) EPS member 37 forecast corresponding to IFS analysis (Figure M.5).*

Although day 5 IFS MSLP forecast is capable of providing the user (or TSO on duty) with useful forecast guidance, day 4 IFS forecast fails to provide the user with a forecast of the same quality. From Figure M.8, it becomes obvious that the centre of the storm is wrongly displaced far to the west.

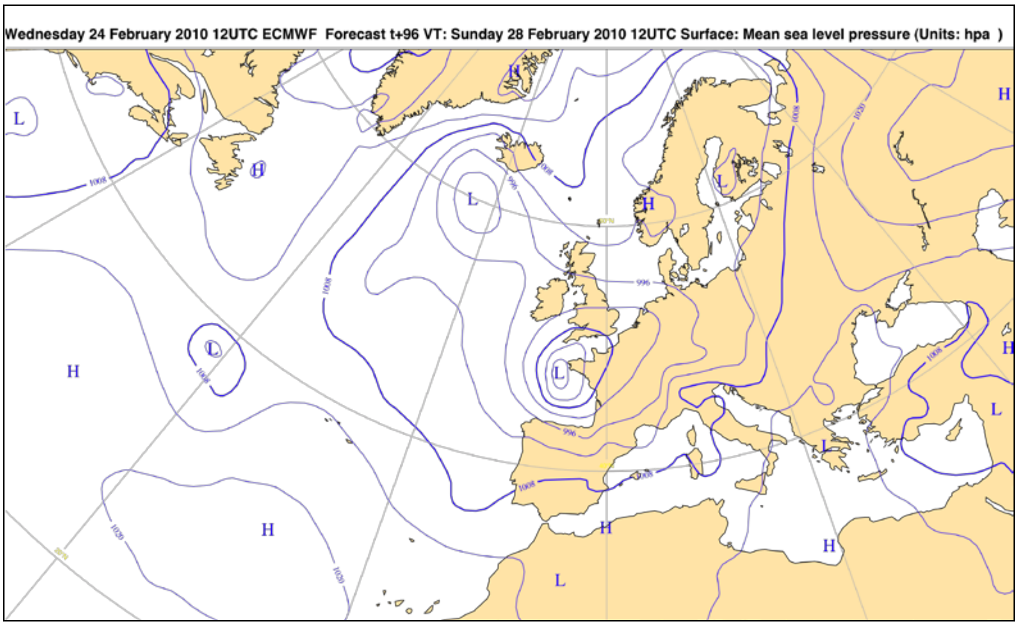

Figure M.8: *T+096 (day 4) IFS MSLP high-res forecast corresponding to IFS analysis (Figure M.5).*

This inadequacy (i.e., the displacement of the storm centre) of the day 4 IFS forecast has a significant impact on the accuracy of forecasted surface (10-meter) wind speeds. To highlight this deficiency, the exact position of the maximum impact has been defined by estimating the area of the maximum wind speed climatological anomaly. Figure M.9 contains the wind speed anomalies (from climatology) prevailed over Europe for 28 February 12 UTC, based on the IFS T+000 analysis field. It becomes clear that the area of maximum anomaly is defined over the borders of France and Luxemburg.

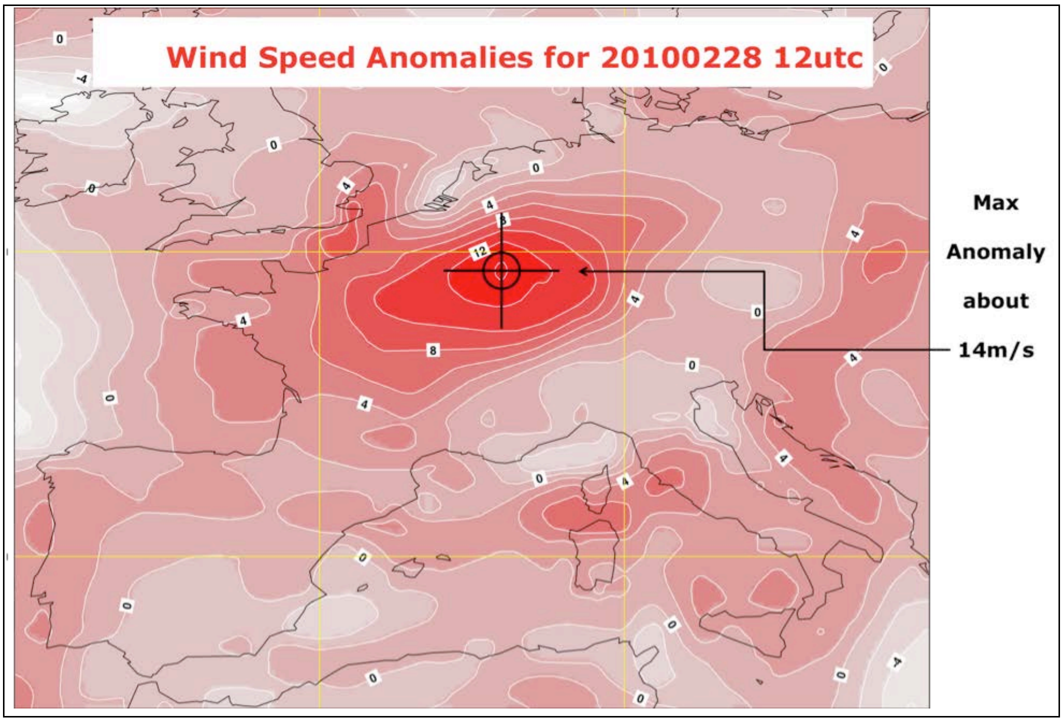

Figure M.9: *IFS analysis (T+000) wind speed anomalies (from climatology) for 28 February 12 UTC.*

Figure M.10 (left) contains the actual IFS analysis wind values, while the misleading T+096 IFS forecast values are shown in the right panel. It is clear that IFS does not provide a useful day 4 forecast over the Area of Maximum Impact (AMI), since speed values of about 9 m/s are prevailing over AMI compared to the correct 17 to 18 m/s.

Furthermore, IFS for day 4 provides a misleading area of maximum wind speeds quite far to the west with values close to 25 m/s. At this point it seems necessary to investigate if the operational mesoscale forecast of COSMO can complement IFS and provide the user with another (more useful) T+094 forecast. COSMO model runs with a higher resolution (7 km) compared to the 16 km resolution of IFS, so, it is hoped that a mesoscale forecast could score better in simulating the atmospheric flow over the AMI. COSMO operational forecast represents also and COSMO-LEPS Control forecast.

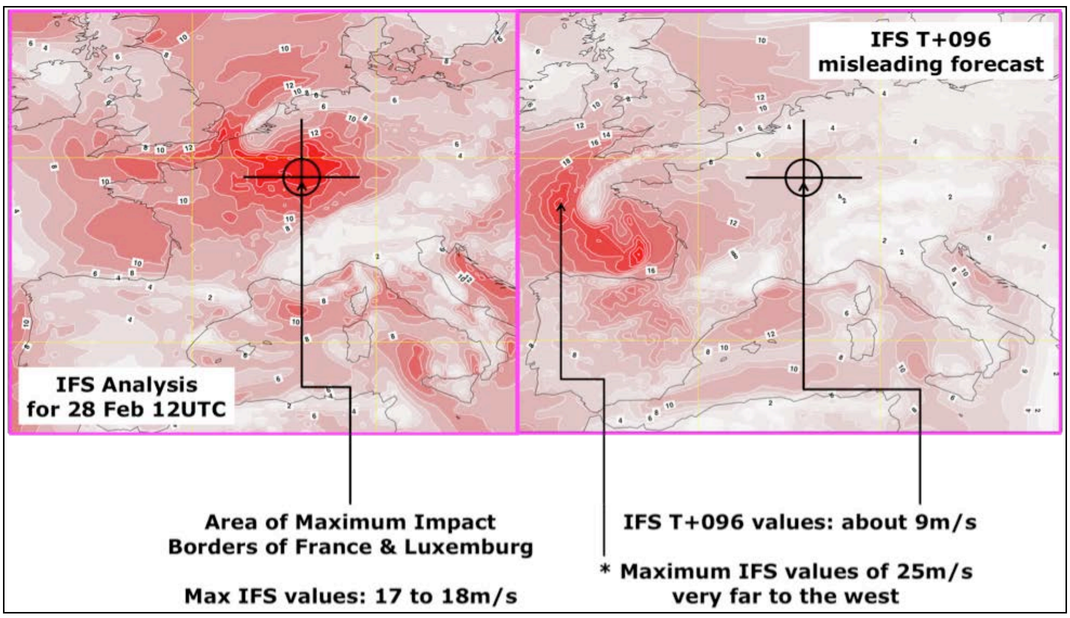

Figure M.10: *IFS high-resolution wind speed analysis (left) and forecast for T+096 (day 4).*

It is worth mentioning that this obvious deficiency of day 4 IFS forecast seems to be counterbalanced by many EPS members that manage to position more correctly the low centre as it is clearly shown in Figure M.11 (EPS members No.31 & No.39) and Figure M.12 (EPS members No.41 & No.45).

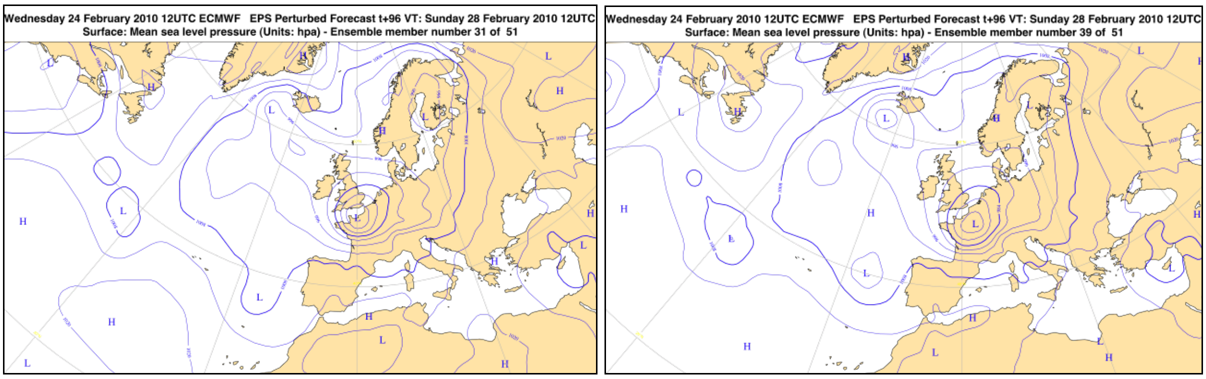

Figure M.11: *EPS members No.31 (left) and No.39 (right) for T+096 (day 4).*

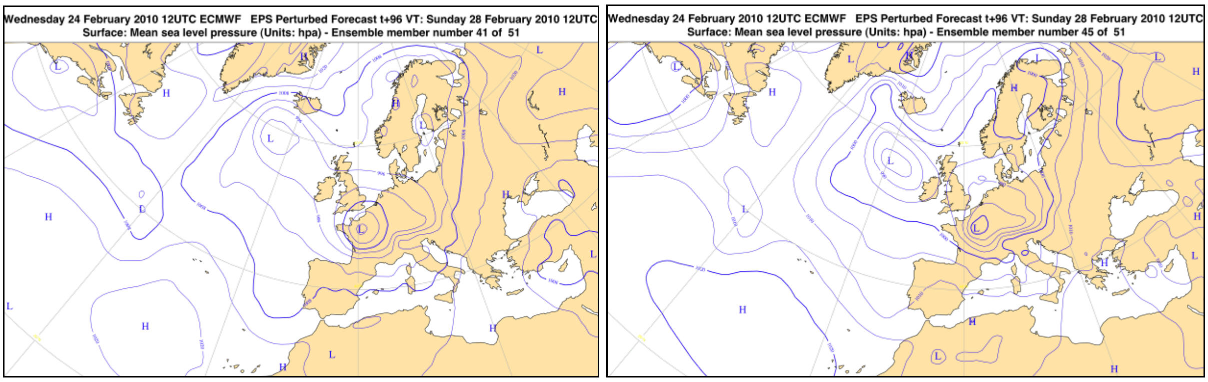

Figure M.12: *EPS members No.41 (left) and No.45 (right) for T+096 (day 4).*

Another interesting point is the similarities that T+096 EPS member No.40 (Figure M.13) bears to analysis (Figure M.5). Looking closer at T+096 EPS members someone has a feeling that EPS is "screaming" for something extreme.

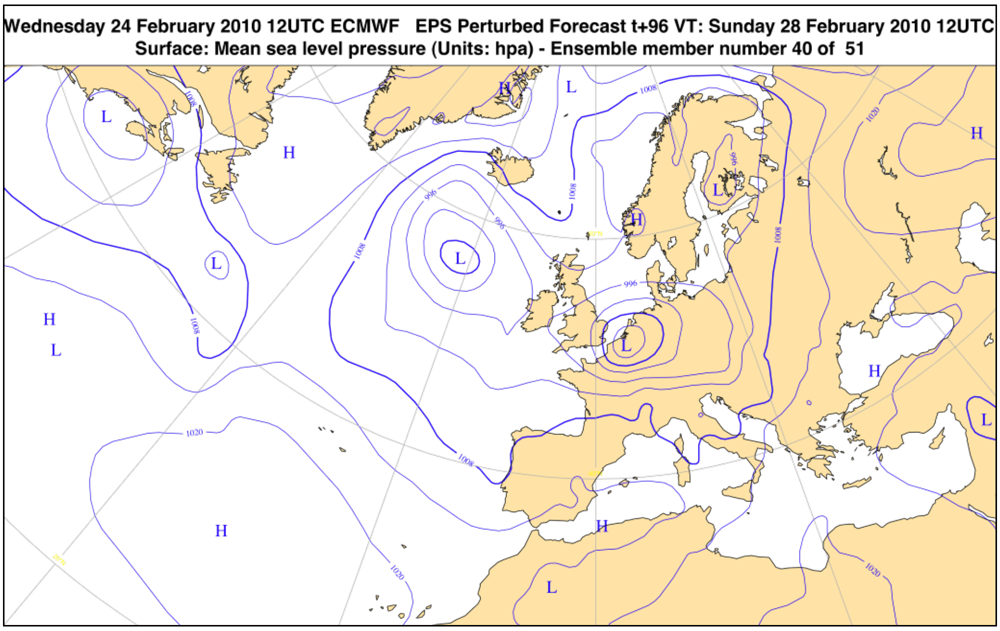

Figure M.13: *EPS member No.40 for T+096 (day 4).*

COSMO mesoscale high-resolution T+096 forecast is shown in Figure M.14. It is obvious that COSMO is not capable to suggest a better forecast guidance for day 4 over AMI. Once more, very smooth flow (of about 7 m /s) is forecasted by COSMO over AMI, while an area of very intense values (even greater than 30 m/s) is forecasted quite far to the west. It becomes clear that COSMO suffers from the so-called “flock syndrome”.

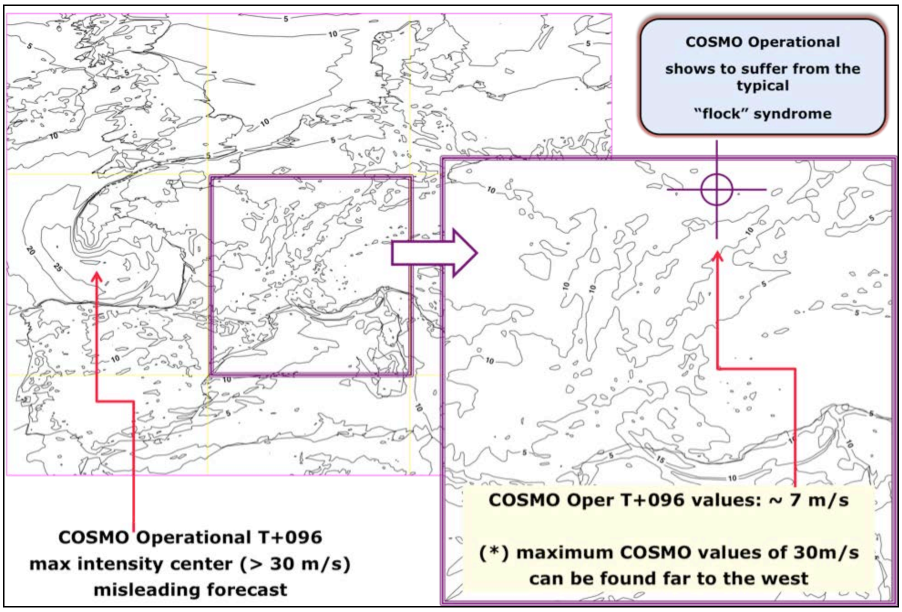

Figure M.14: *IFS high-resolution wind speed analysis (left) and forecast for T+096 (day 4).*

This flock syndrome behaviour is also pronounced in most of the T+024 COSMO forecasts during the interval of 18 February to 10 March 2010 (12 UTC) as can be seen in Figure M.15 (right). The T+000 values for both IFS and COSMO operational analysis are also plotted in Figure M.15 (left).

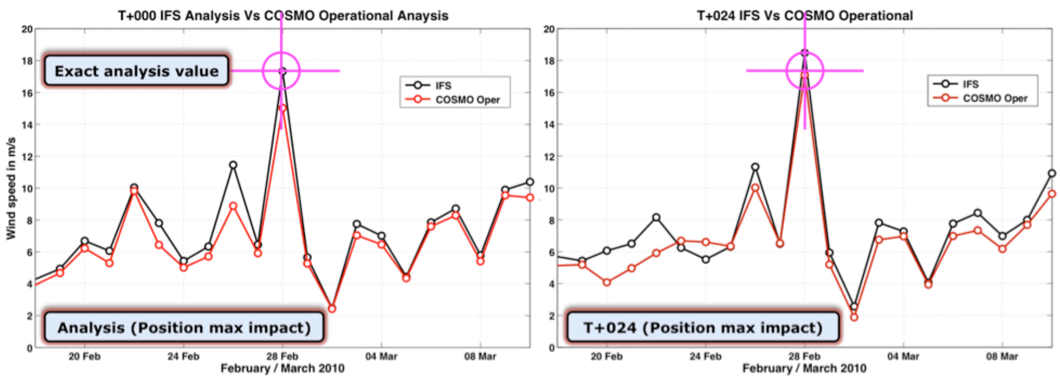

Figure M.15: *IFS & COSMO wind speed analysis (left) and forecast values for T+024 (right).*

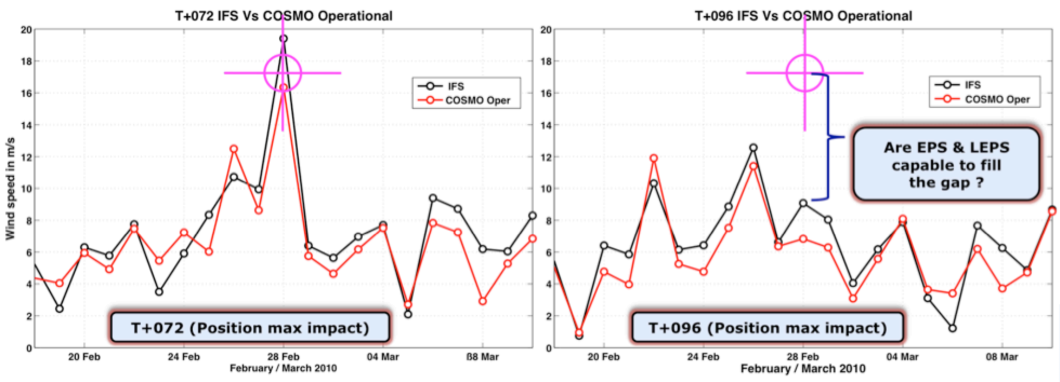

Figure M.16: *T+072 IFS & COSMO wind speed (left) and T+096 values (right).*

Same wise, T+072 COSMO forecasts found to agree well with corresponding T+072 IFS forecasts as shown in Figure M.16 (left). This seems to be the case for T+096 forecasts as well. That is why in the case of 28 February both IFS and COSMO are not capable to provide a useful forecast of the Xynthia maximum wind speed over the area of maximum impact as clearly seen in Figure M.16 (right). What seems to be of great importance is the potential capability of EPS to fill the gap between T+096 IFS forecast and analysis. The capability of COSMO-LEPS to fill the gap between (COMSO) analysis and T+096 COSMO operational forecast has also to be investigated.

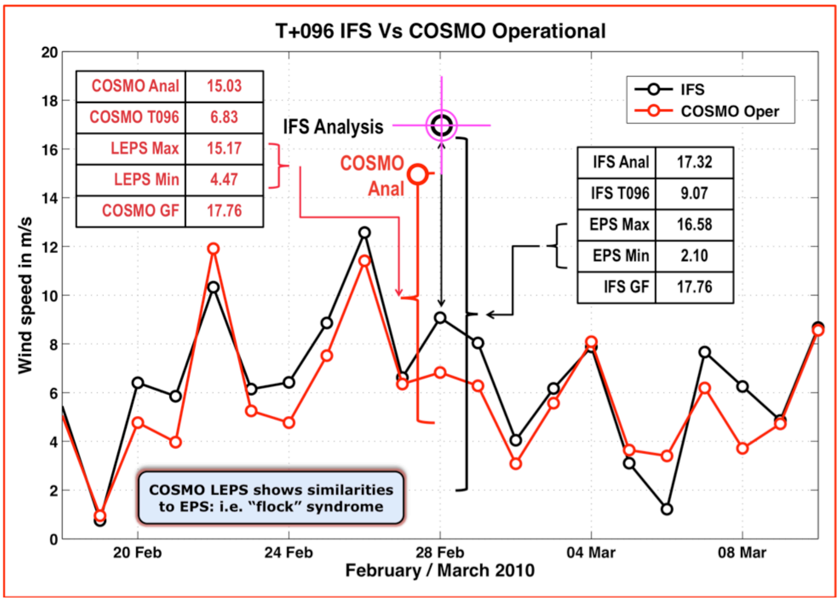

Figure M.17: *T+096 ECMWF forecasting gap (between IFS forecast and analysis) denoted by a black bracket. COSMO corresponding gap is also denoted (by a red bracket).*

From Figure M.17, it is obvious that EPS has the capability to fill the IFS forecasting gap, since EPS manages to provide an ensemble for day 4 that spans from 2.10 m/s (minimum value of EPS members) to 16.58 m/s (maximum value of EPS members). There seems to be a very small gap between the maximum EPS value (16.58 m/s) and the actual analysis value (17.32 m/s) but this gap is totally filled by EPS "gusty" components. Our investigation showed that many members of EPS in their "gust factor" formulation could easily fill IFS forecasting gap. For instance, EPS No.40 (in its "gust factor" formulation) is plotted in Figure M.18, with values greater than 30 m/s (> 110 km/h) over AMI. Its similarities with the observed destructive speed values (shown in Figure M.19) are remarkable.

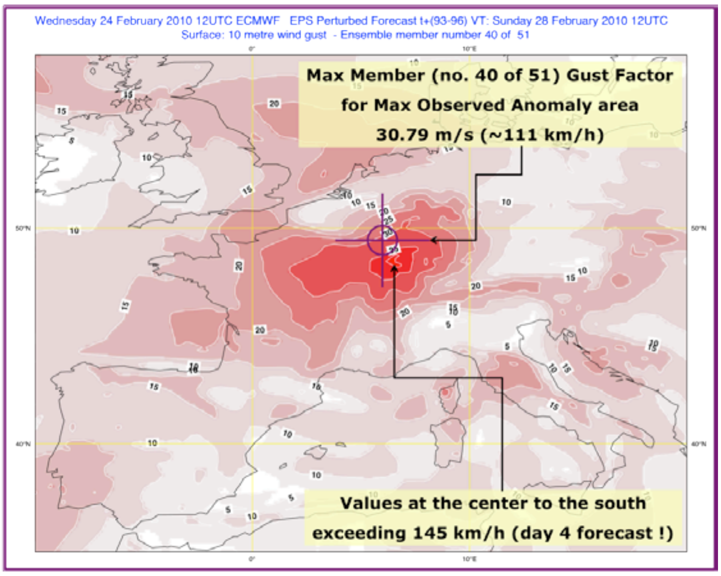

Figure M.18: *T+096 ECMWF EPS No. 40 in its "Gust Factor" formulation.*

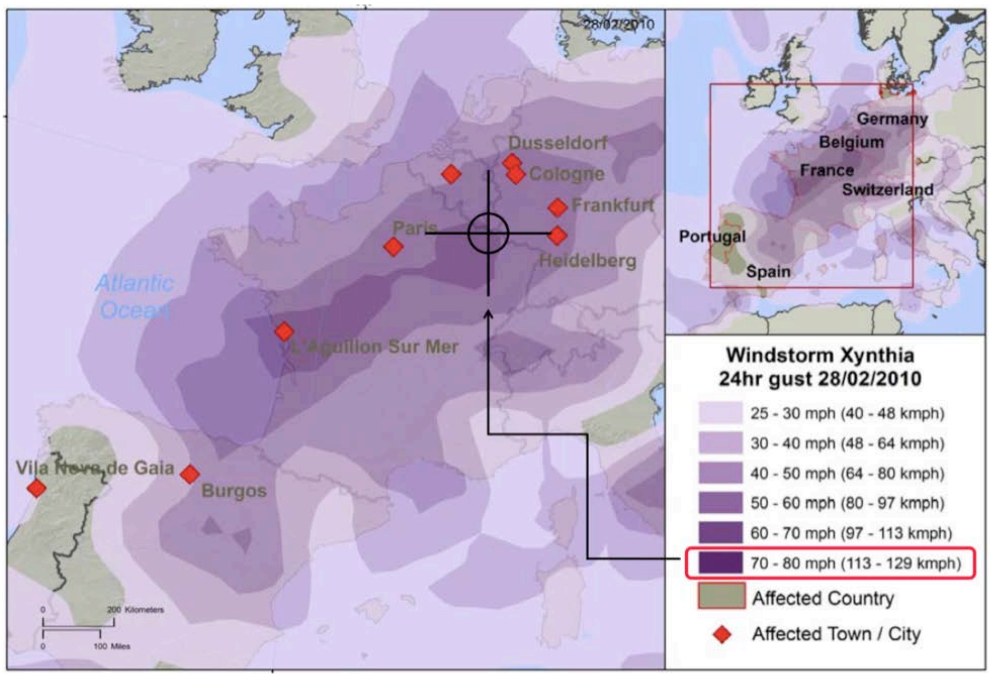

Figure M.19: *Affected areas and maximum wind gusts observed during Xynthia windstorm.*

Furthermore, the ability of COSMO-LEPS to provide complementary forecast guidance to ECMWF EPS in the case of Xynthia windstorm is also investigated for other forecast horizons besides T+096 hours (day 4).

Table M.1: *Various EPS – LEPS & PEARP forecast values over AMI (Area of Maximum Impact) for different forecast horizons (T+018 – T+024 – T+030 – T+042 – T+048 – T+054 – T+066 – T+072 – T+090 - & T+096 hours).*

ANALYSIS	28 Feb 12utc	T+000	IFS: 17.32 (CO: 15.03)		Not really much help from another EPS as PEARP
PEARP	27 Feb 18utc	T+018	8.75	18.15	
EPS	27 Feb 12utc	T+024	16.46	19.28	Day 1 Max of all Max → EPS
LEPS	27 Feb 12utc	T+024	15.60	17.98	
PEARP	27 Feb 06utc	T+030	6.79	16.43	
PEARP	26 Feb 18utc	T+042	5.81	16.30	
EPS	26 Feb 12utc	T+048	10.31	22.43	Day 2 Max of all Max → EPS
LEPS	26 Feb 12utc	T+048	9.49	17.82	
PEARP	26 Feb 06utc	T+054	5.78	15.48	
PEARP	25 Feb 18utc	T+066	3.06	13.21	
EPS	25 Feb 12utc	T+072	4.29	22.78	Day 3 Max of all Max → EPS
LEPS	25 Feb 12utc	T+072	3.63	16.52	
PEARP	24 Feb 18utc	T+090	2.57	14.76	
EPS	24 Feb 12utc	T+096	2.10	16.58	Day 4 Max of all Max → EPS
LEPS	24 Feb 12utc	T+096	4.47	15.17	

Table M.1 contains all minimum and maximum EPS and its corresponding LEPS values for T+024 (day 1), T+048 (day 2) and T+072 (day 3). In the same table (M.1) the different minimum and maximum values produced by the PEARP platform are also shown.

Due to the different initialisation times (06 & 18 UTC) of PEARP forecasts, different forecast horizons have been utilised. For instance, for day 1 forecasts, the corresponding T+018 PEARP forecast initialised on 18 UTC of the previous day has been utilised for inter-comparison with EPS and LEPS T+024 components. Every block of forecasts (belonging to a specific verification day interval) is denoted by a red bracket, while the absolute maximum, (i.e. the maximum of all different maximum coming from EPS – LEPS & PEARP) is denoted by a red rectangular. From Table M.1, it becomes clear that all absolute maximum values are coming out from the ECMWF EPS platform, suggesting that there is no real advantage of using LEPS or PEARP platform in capturing the "extremicity" of Xynthia windstorm for T+024 – T+048 & T+072. Furthermore, the same holds for the T+096 forecast horizon (already investigated for EPS and LEPS platform). It should be noted that EPS has a resolution of 32 km, but it comprises 50+1 members. LEPS on the other hand has a (higher) resolution of 7 km, but it only comprises 16 members, while PEARP seems to have some how intermediate characteristics, since it has a resolution of 23 km (over Central Europe) and comprises 35 members.

Lastly, although ALADIN-LAEF (comprising 16 members with a resolution of 18 km) maximum forecast horizon is limited in S-R, its potential capability to complement EPS in the case of Xynthia has also been investigated for T+024 and T+048 forecast horizons, both verifying on 28 February 12 UTC.

Table M.2: *LAEF Max & Min values compared to EPS. ALADIN Control values are also shown. Absolute maximum values (highlighted by yellow colour) correspond to ECMWF EPS.*

	T+024	T+048
ALADIN Control	14.32	12.44
LAEF Min	13.65	7.56
EPS Min	16.46	10.31
LAEF Max	16.23	15.06
EPS Max	19.28	22.43

Based on Table M.2, ALADIN-LAEF does not seem capable of providing a more useful (max) value for the coming (Xynthia) windstorm. For both the T+024 and T+048 forecast horizons, EPS managed to provide a more representative envelope (of wind speed values) that contained the IFS T+000 analysis value over the area of maximum impact.