Meteorological analysis & model intercomparison of Storm Doris

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Introduction

Between February 20th and March 7th a series of low pressure systems passed through the North of Europe. One of these low pressure systems brought with it Storm Doris, which affected Ireland, the United Kingdom and France on February 23rd with strong wind gusts. This analysis presents details of the meteorological situation between February 21st and 23rd 2017 and also describes how the storm was forecast by the different meteorological models available to forecasters in Met Éireann.

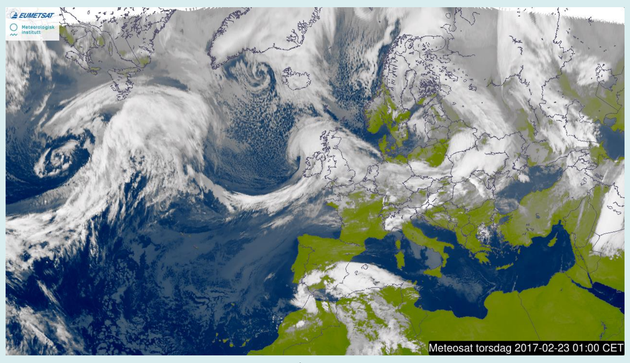

Figure 1: A satellite image from EUMETSAT at 00 UTC on the 23rd February 2017 showing Storm Doris pushing in over Ireland and the UK. Sourced at [1].

Analysis: 21st of February

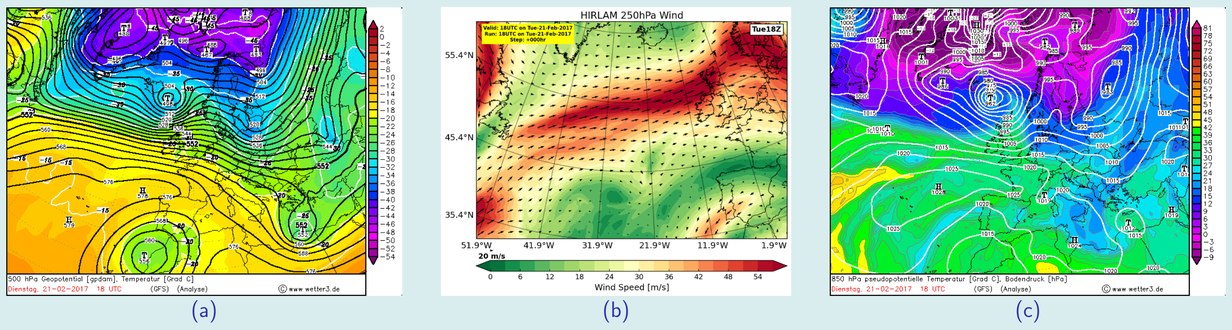

Figure 2: (a) Temperature (°C) and geopotential (gpdam) at 500hPa from the GFS analysis at 18 UTC (b) Wind (m/s) at 250hPa from the HIRLAM analysis at 18 UTC and (c) Potential temperature (°C) at 850hPa and mean-sea-level pressure (hPa) from the GFS analysis at 18 UTC. [(a) and (c) Source: [2], (b) Source: Met Éireann]

Fig.2 indicates a heavy baroclinic zone and the potential for an explosive deepening of the low pressure system to the north of Ireland. (a) demonstrates a strong geopotential and temperature gradient at 500hPa, (b) illustrates the presence of a rapid jet at altitude and (c) shows a strong potential temperature gradient in the lower layers. The combination of these ingredients lead to the formation of Storm Doris.

Analysis: 22nd of February

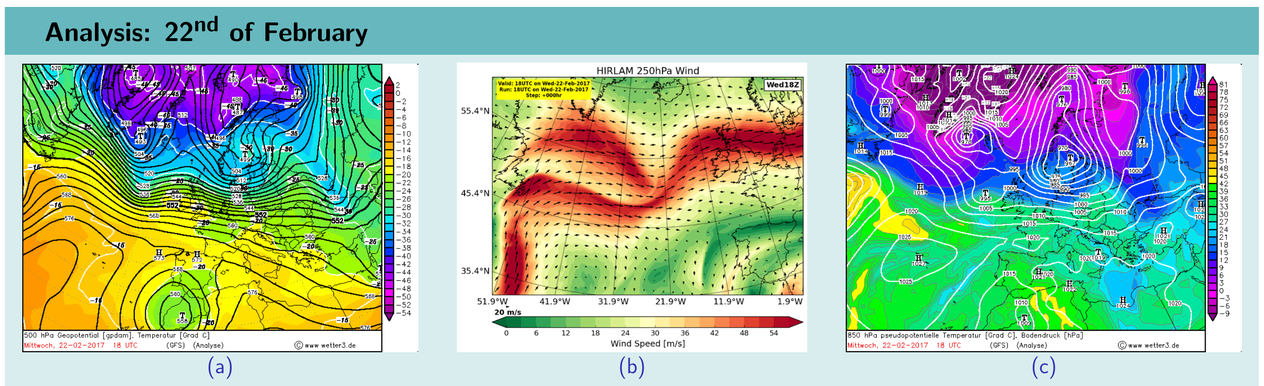

Figure 3: (a) Temperature (°C) and geopotential (gpdam) at 500hPa from the GFS analysis at 18 UTC, (b) Wind (m/s) at 250hPa from the HIRLAM analysis at 18 UTC and (c) Potential temperature (°C) at 850hPa and mean-sea-level pressure (hPa) from the GFS analysis at 18 UTC. [(a) and (c) Source: [2], (b) Source: Met Éireann]

Fig.3 (a) and (c) show the deepening of the low pressure system in the presence of the temperature gradient. The low pressure system strengthens as it connects to and passes across the the strong upper-level jet (b). This interaction causes the low pressure system to deepen further.

Analysis: 23rd of February

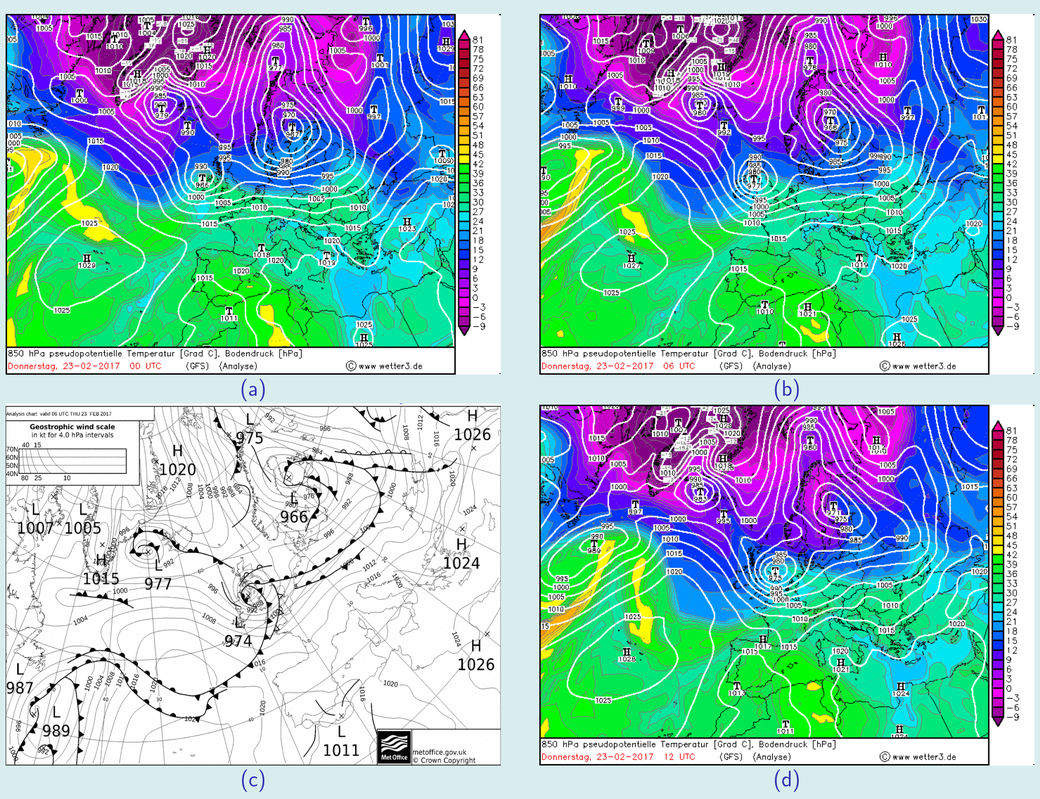

Figure 4: (a) Potential temperature (°C) at 850hPa and mean-sea-level pressure (hPa) from the GFS analysis at 00 UTC, (b) Potential temperature (°C) at 850hPa and mean-sea-level pressure (hPa) from the GFS analysis at 06 UTC, (c) Analysis chart produced by the UK Met Office at 06 UTC and (d) Potential temperature (°C) at 850hPa and mean-sea-level pressure (hPa) from the GFS analysis at 12 UTC. [(a), (b) and (d) Source: [2], (c) Source: [1]]

In Fig.4 (a) and (b), the fronts linked to Storm Doris are quite pronounced. Between 00 UTC and 06 UTC, the surface trough is well defined and a low-level jet forms. This jet combined with the potential temperature gradient and strong upper-level forcing accentuates the surface gusts. As the low pressure centre reaches its nadir between 00 UTC and 06 UTC, there is a potential sting jet formation. The frontal analysis in Fig.4 (c) resembles the conceptual model for a sting jet setup as described in [3]. The winds ease as the potential temperature gradient decreases (Fig.4 (d)).

Model Intercomparison

The meteorological models available to Met Éireann forecasters had some difficulties representing the details of Storm Doris. Below is a comparison between deterministic models (HARMONIE-AROME, HIRLAM and the HRES forecast from the ECMWF), observations and Ensemble Prediction Systems (EPSs) (ECMWF ENS and GLAMEPS, a regional EPS used within the HIRLAM/ALADIN community) at the time of the storm.

Deterministic Models

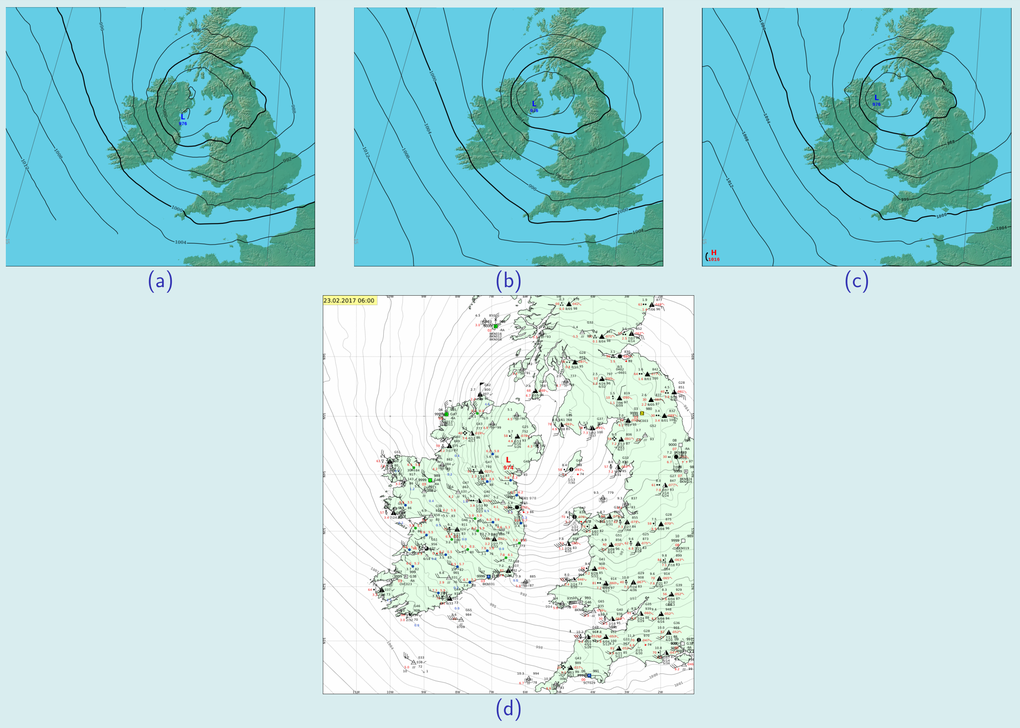

Figure 5: (a) ECMWF (b) HIRLAM (c) HARMONIE-AROME and (d) Observational mean-sea-level pressure (hPa) at 06 UTC on the 23rd of February. The model plots are from the 18 UTC runs on the 22nd of February. [Source: Met Éireann]

The main issue with regards to forecasting Storm Doris is that the models all predicted that the storm would move very quickly whereas in reality the storm moved through more slowly. Thus, as is seen in Fig.5, the models all placed the low pressure centre too far to the east. This led to the models underpredicting the value of the low pressure centre, the location of the strongest gusts and the magnitude of the gusts. The strongest gusts were recorded in the north-west with Met Éireann's station in Mace Head recording gusts of 140km/h at 02UTC. The deterministic models predicted the highest winds to occur around 06UTC over the east of Ireland as seen in Fig.6.

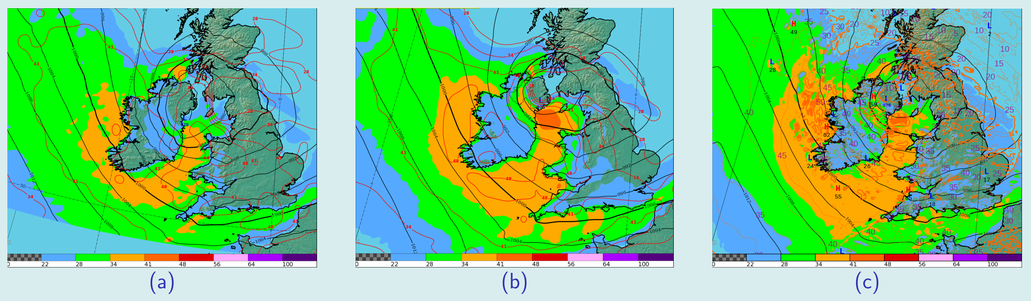

Figure 6: (a) ECMWF (b) HIRLAM and (c) HARMONIE-AROME wind (shaded colour regions), warning isotachs (orange lines show wind gusts above 28kts) and MSLP (black lines) at 06 UTC on the 23rd of February. The model plots are from the 18 UTC runs on the 22nd of February. [Source: Met Éireann]

EPSs

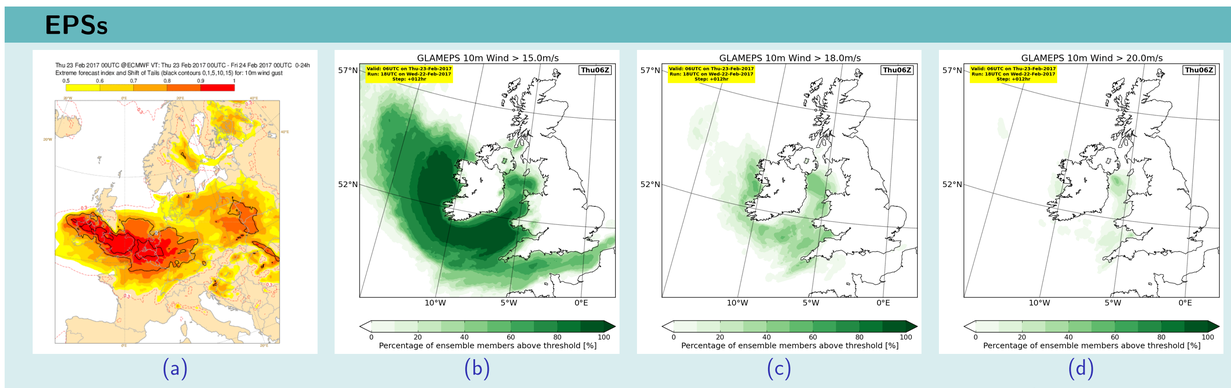

Figure 7: (a)Extreme Forecast Index (EFI) and Shift of Tails (SOT) from ECMWF's ENS run at 00UTC on the 23rd of February 2017 along with probability maps of wind speed for the 18 UTC run of GLAMEPS on the 22nd of February for thresholds of (b)15m/s, (c)18m/s and (d)20m/s. [Source: Met Éireann]

ECMWF's ENS Extreme Forecast Index (EFI) gives an indication of extreme weather over Ireland for the period of Storm Doris, but as was the case for the deterministic models, the EFI indicates the greatest risk of extreme winds over the east of the country (Fig.7(a)). Some members of GLAMEPS (Fig.7(d))do indicate the possibility of wind speeds over 20m/s in the north-west of the country, but percentages are low. Mean observational wind speeds in the west were 27m/s.

Conclusions

The main elements in the development of Storm Doris were:

(1) **A strong potential temperature gradient**
(2) **A very fast-moving jet at altitude**
(3) **The interaction of the Storm Doris low pressure system with this upper-level jet**
(4) **The presence of a sting jet, which led to destructive wind gusts as evidenced in Fig.8**

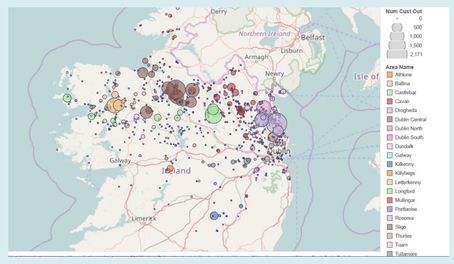

Figure 8: Post Storm Doris analysis of the outages observed by the Electricity Supply Board (ESB) network. [Source ESB]

References

[1] https://software.ecmwf.int/wiki/display/FCST/201702+-+Windstorm+-+Doris. Accessed: 2017-06.

[2] http://www1.wetter3.de/Archiv/. Accessed: 2017-06.

[3] David M. Schultz and Keith A. Browning. What is a sting jet? *Weather*, 72(3):63–66, 2017.

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