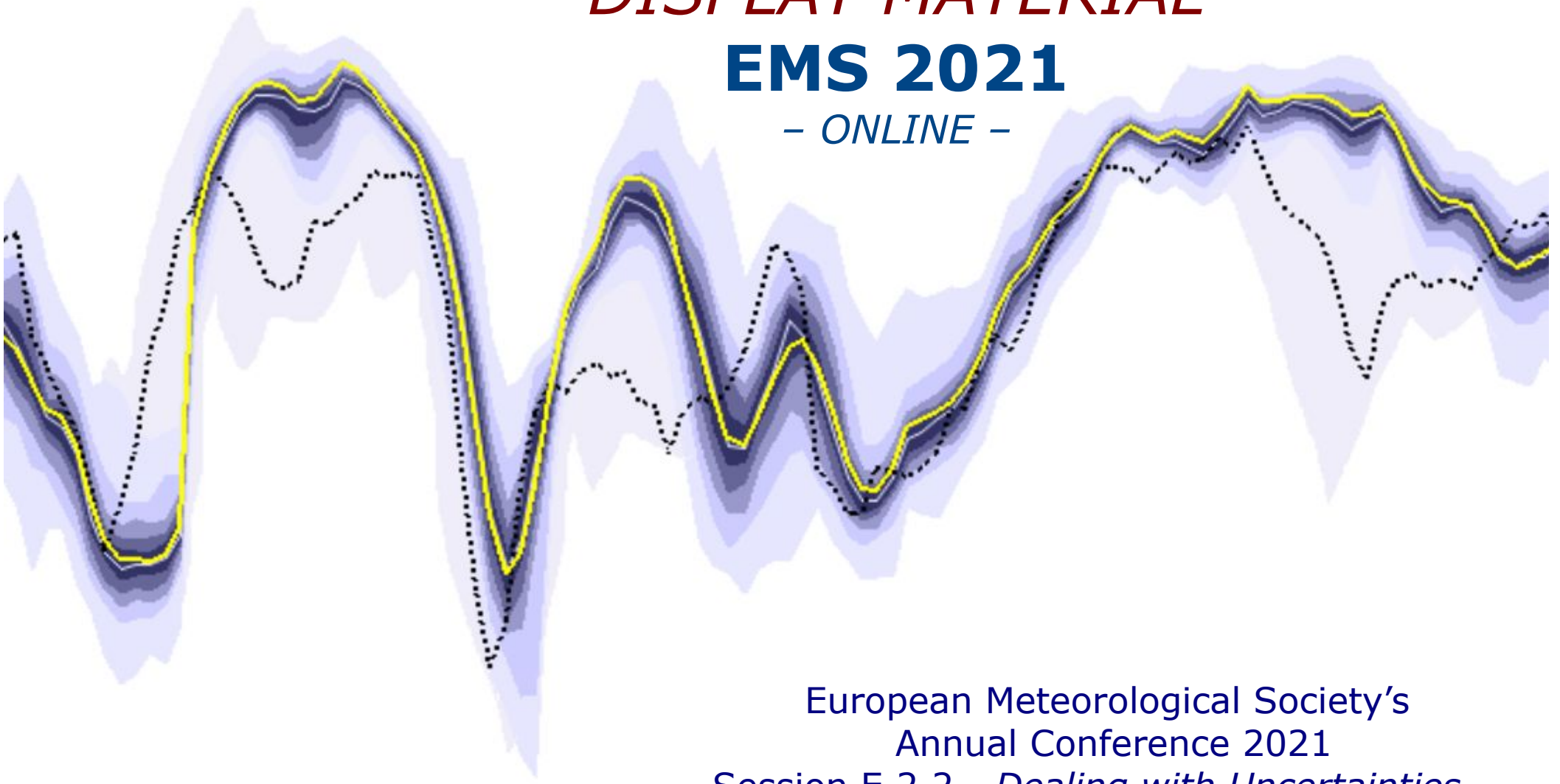
High-speed Shutdown warning system for extreme events in electric power grids

DISPLAY MATERIAL

EMS 2021

– ONLINE –



European Meteorological Society's
Annual Conference 2021
Session E.2.2 - *Dealing with Uncertainties* -
7th September 2021, 14:30

About **WEPROG**

Download our free weather APP @ http://weather.weprog.com

First commercial established Windpower Forecast Vendor in Europe in 2003!

WEPROG's name is an abbreviation of **W**eather & **E**nergy **PROG**noses.

We provide customer tailored **real-time ensemble forecasts** for improving efficiency & sustainability from the use of uncertainty weather forecast products.

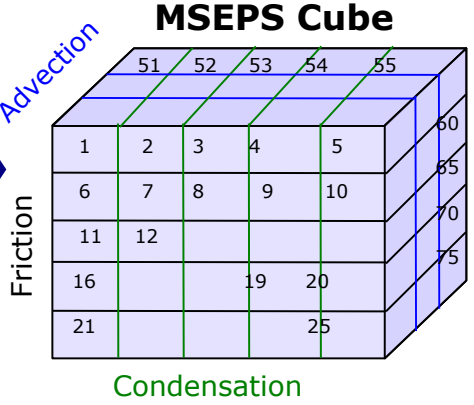
WEPROG operates and maintains HPC clusters distributed over 3 countries for **maximum redundancy and security** for **continuous forecasts production.**

Real-time products are available four times per day **at 00,06,12,18 UTC** and **up to 180 hours ahead** as regional model system on **all continents**.

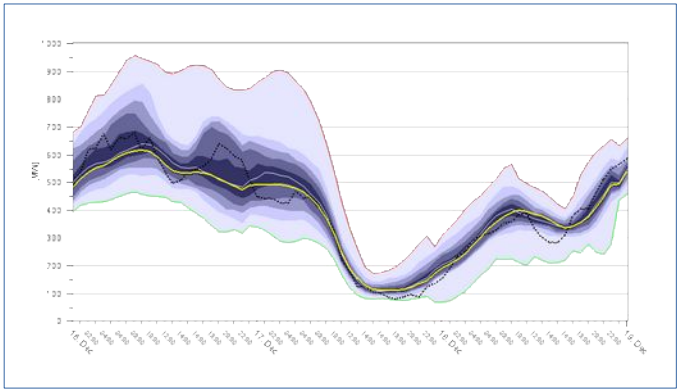
Global Analysis (State Estimate)

75 independent weather forecasts

MSEPS Cube

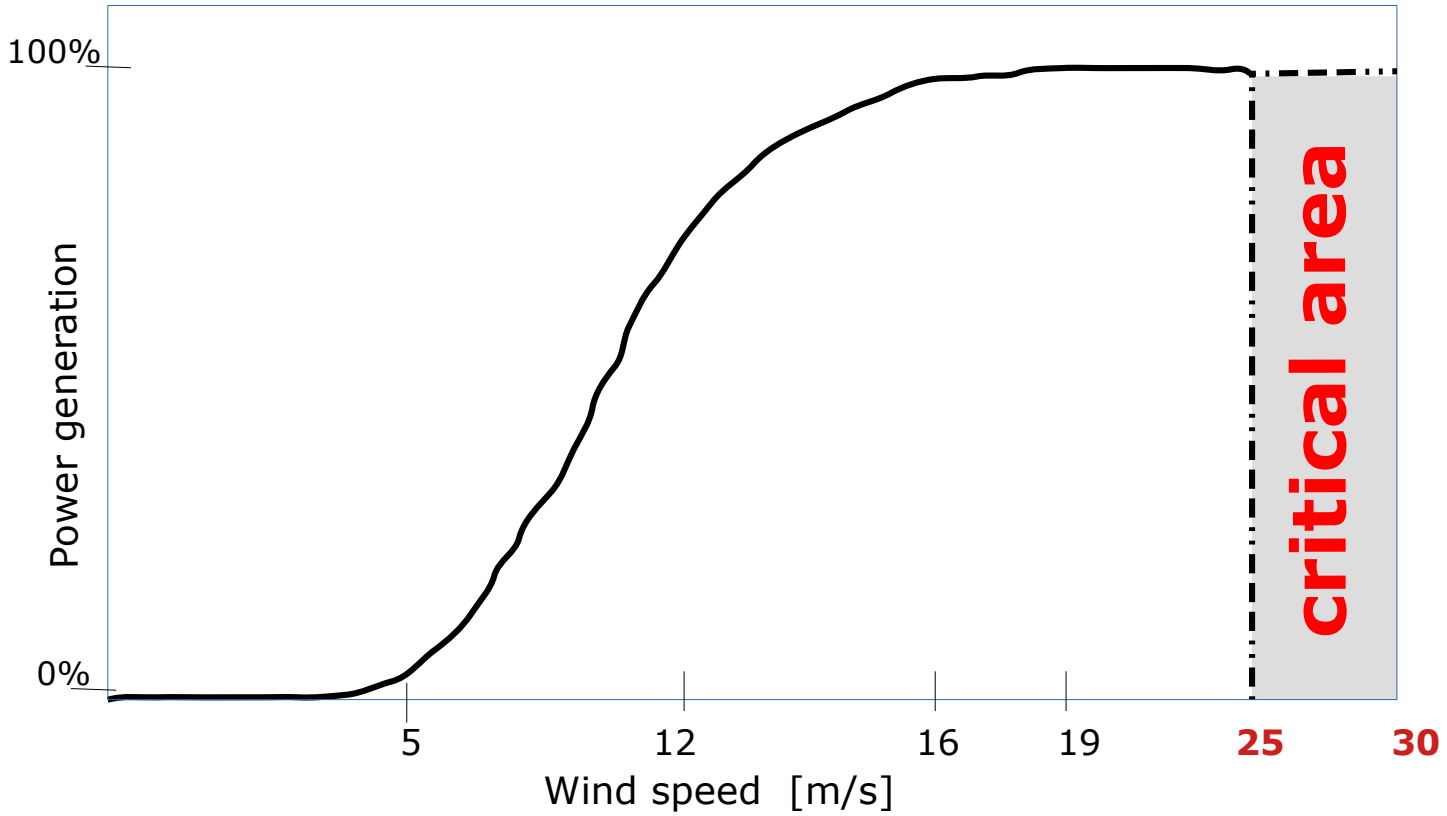


Probabilistic weather, wind & solar power forecasts



Wind Power Generation extremes occur at moderate extreme wind speeds seen from a meteorological perspective...

WMO argues that "...if a forecaster issues a deterministic forecast the underlying uncertainty is still there, and the forecaster has to make a best guess at the likely outcome. ***Unless the forecaster fully understands the decision that the user is going to make*** *based on the forecast, and the impact of different outcomes, the* ***forecaster's best guess may not be well tuned to the real needs*** *of the user".*



- High-speed shutdown of turbines start at 20m/s, if gusts reach 25-30 m/s
- High-speed shutdown is critical for system operation of the electrical grid
- High wind penetration (~65% of demand) with limited reserve capacity (island)

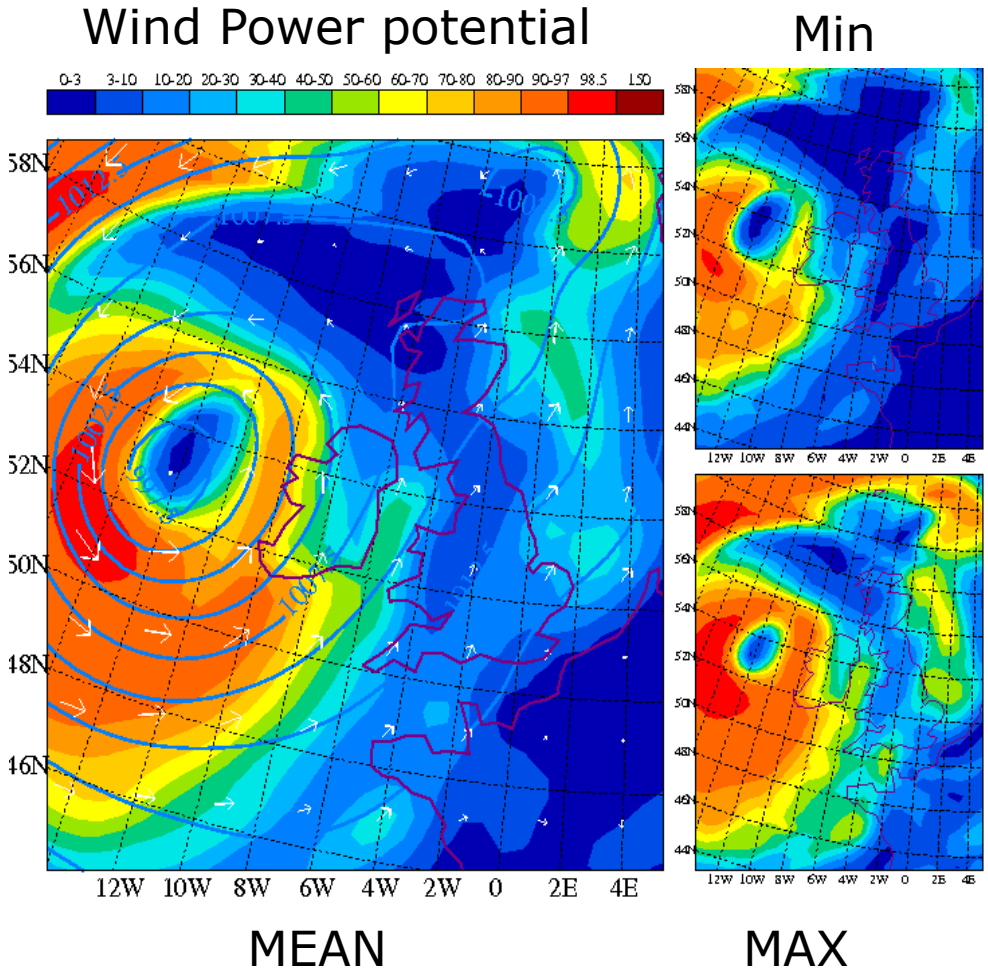
Forecast Uncertainty for the Irish power grid

Why is Ireland a perfect show case for uncertainty forecasts ?

Ireland is the first country in Europe to experience Atlantic storms propagating from west to east

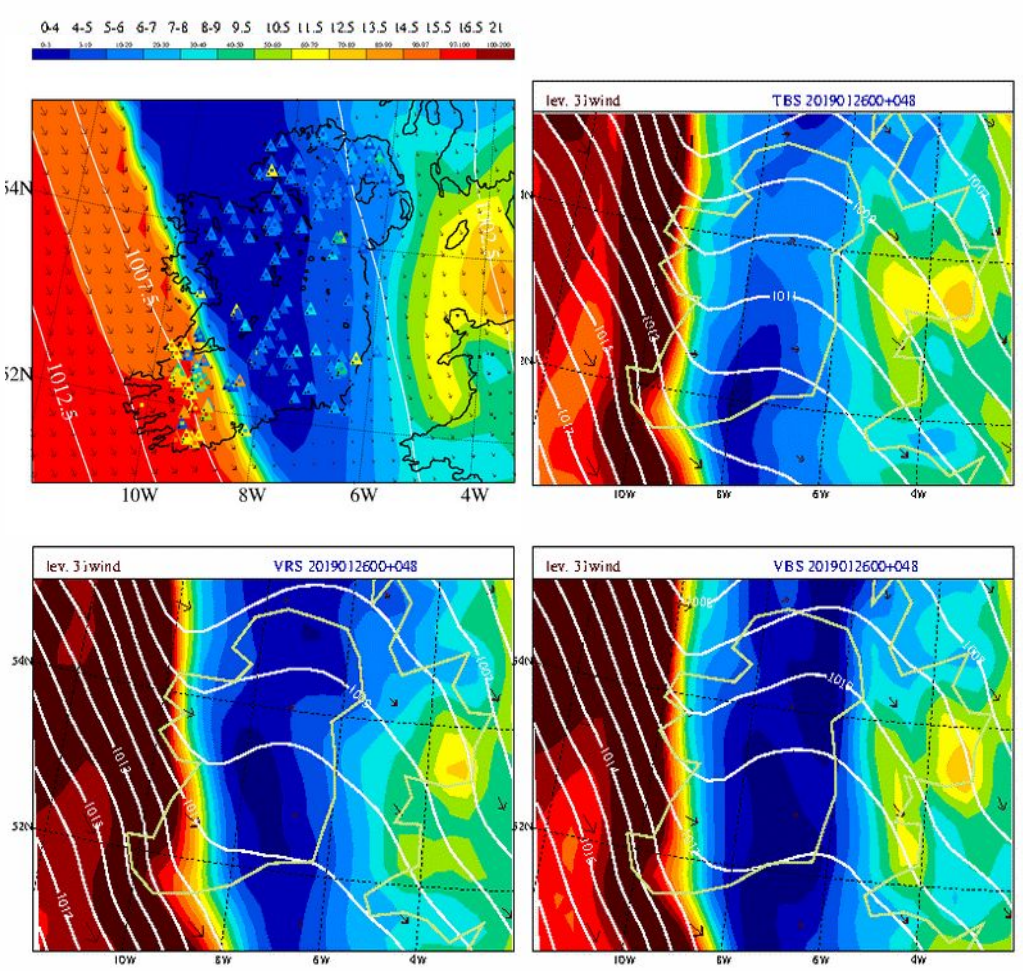
Information on the track and intensity of low pressure systems in the Atlantic is sparse.

The growth rate of the uncertainty is mostly high during storm events



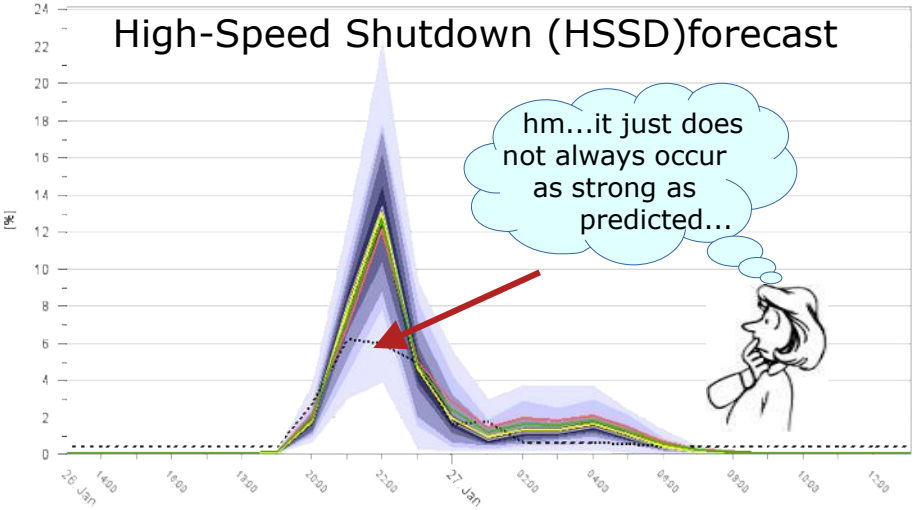
... and at some stage, the growth rate of Renewables penetration limits the available reserve for mitigation actions...

Why and when forecasts are uncertain for Ireland's power grid...



...unresolvable small scale phenomena ... small errors in sharp fronts or fast moving lows can cause large errors with uneven distribution of wind farms...

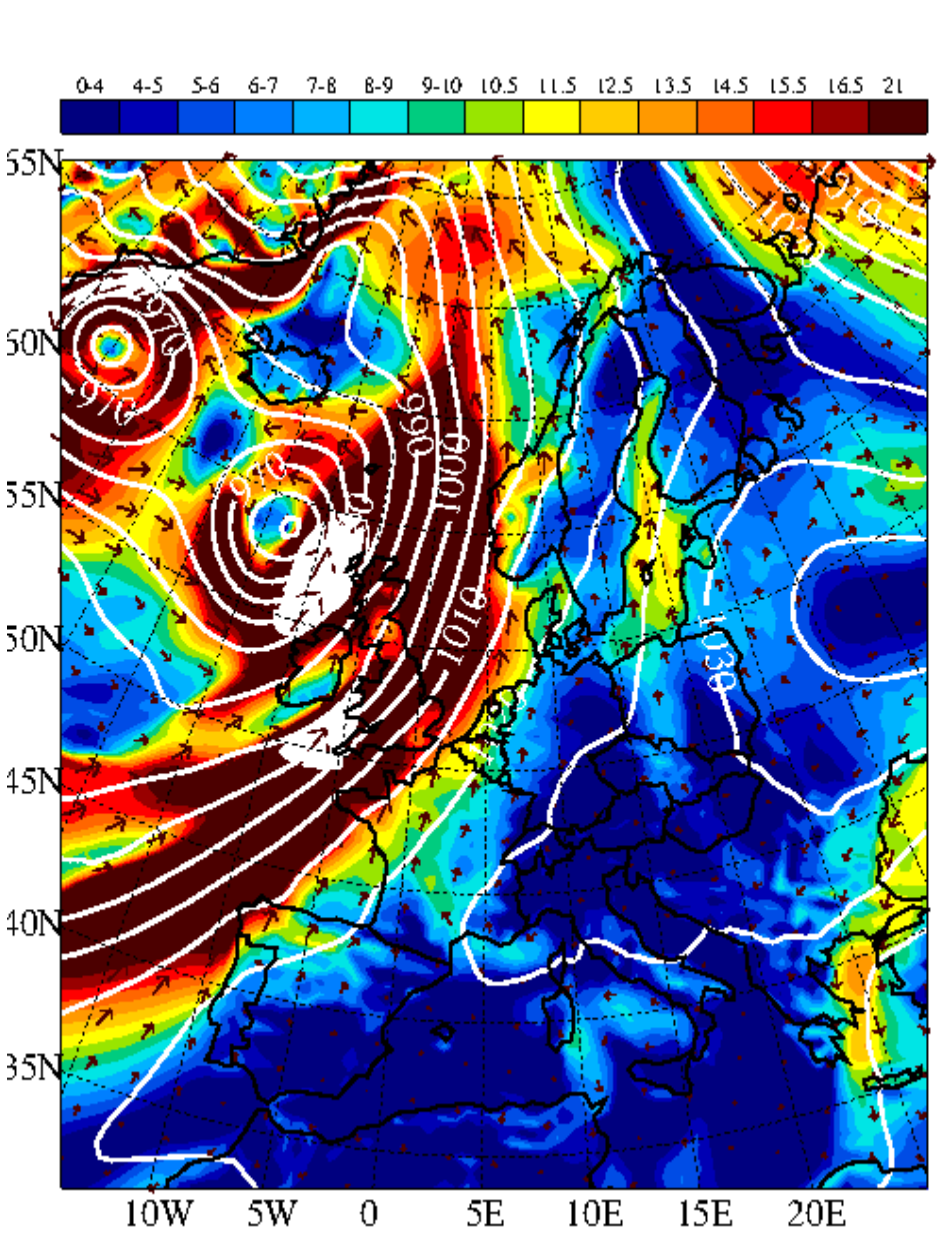
4 main clusters of Windfarms
almost empty middle part

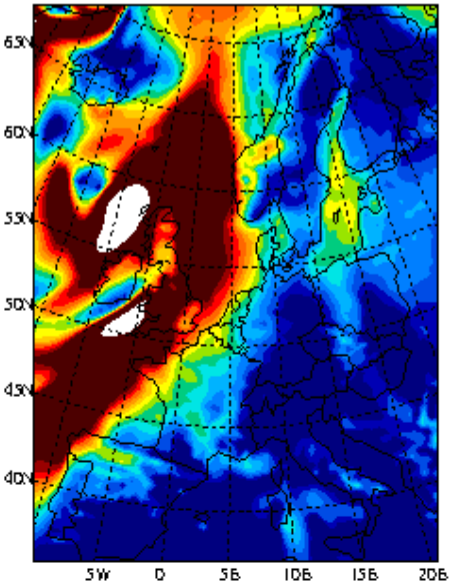


Typical winter situation in Ireland: strong jet stream, fast moving lows with sharp fronts

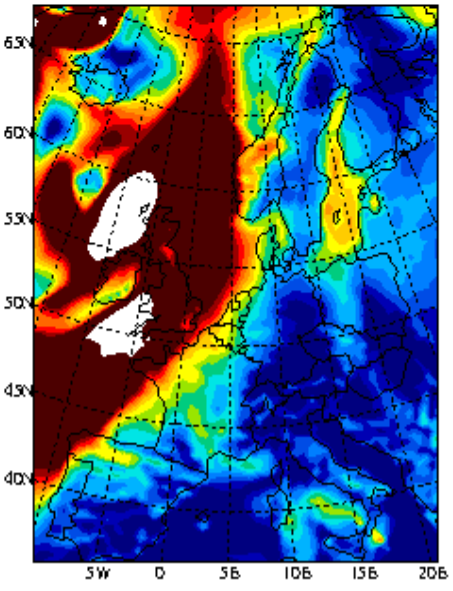
Wind Speed [m/s]

MEAN





Minimum



Maximum

When the penetration level increases....

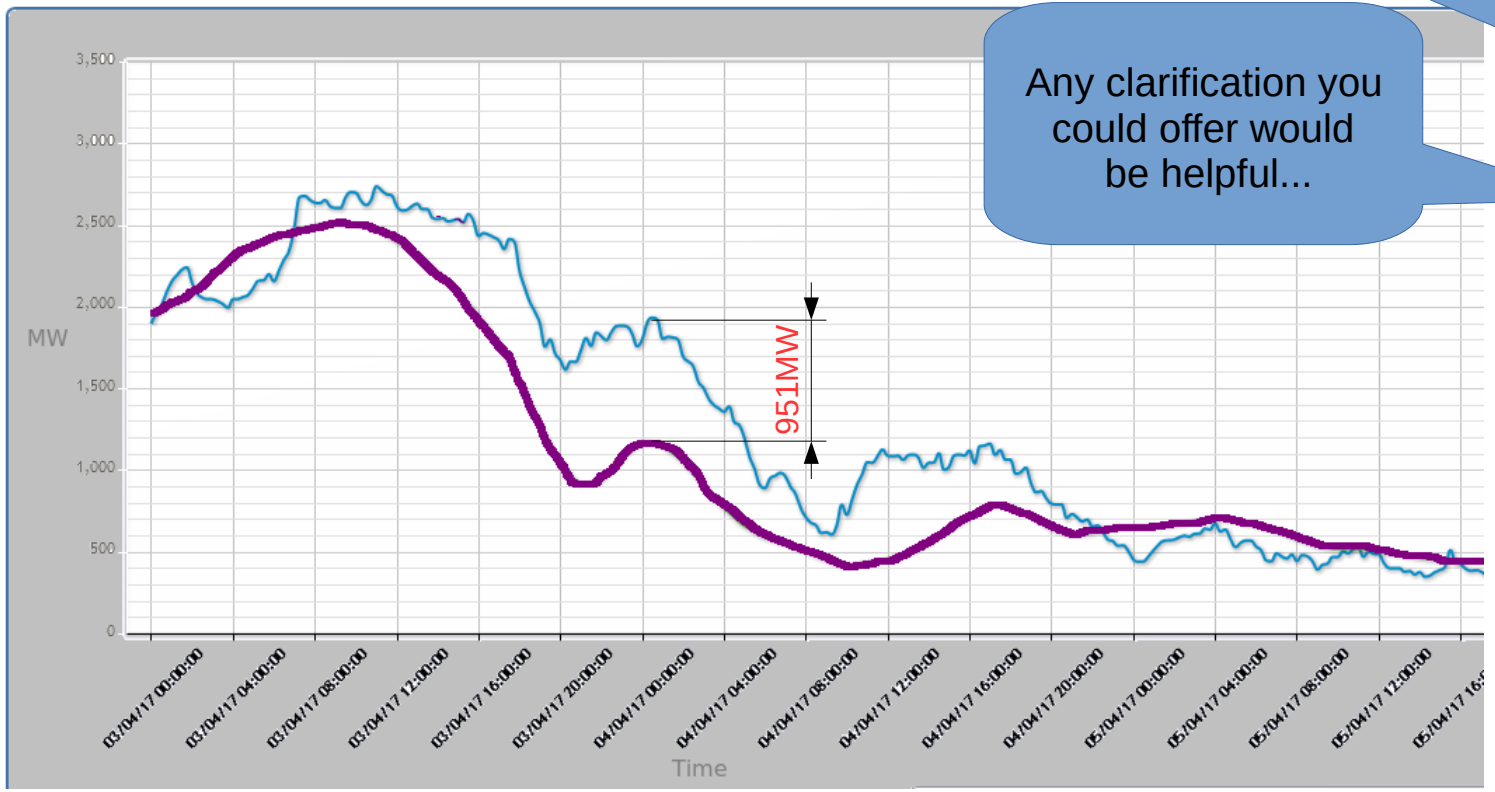
... deteministic information becomes insufficent...

Questions from an operator working with 1 forecast...

What was the weather Situation at the time and would this have caused the error?

Does the actual value lie within the confidence bands of your model(s) ?

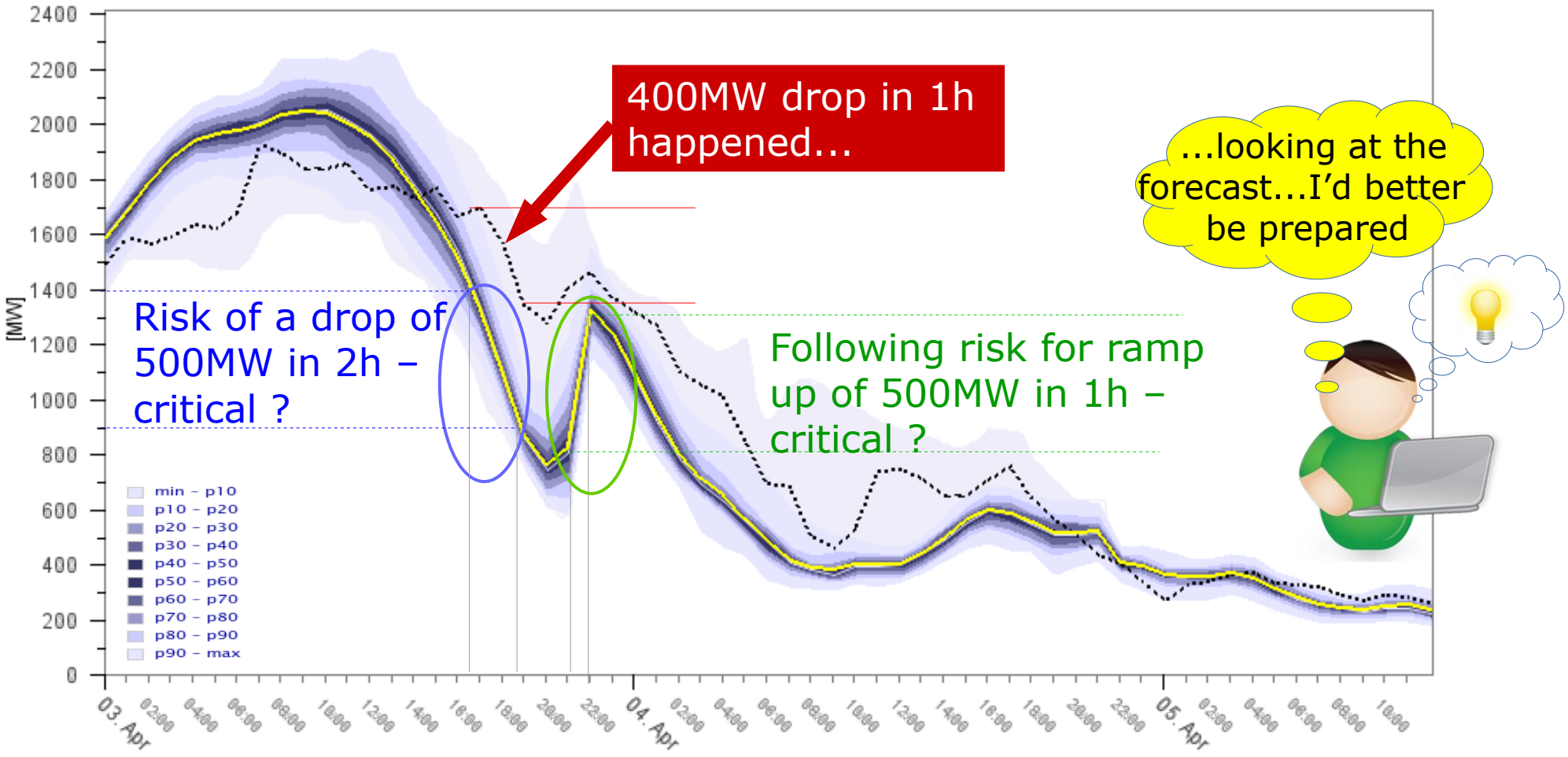
Any clarification you could offer would be helpful...



Forecast off with 950MW over-prediction at 22 hours in a grid with 4500MW peak demand

Knowing risks in advance from uncertainty forecasts provides confidence and security

- high uncertainty in the evening with low demand!
- possible extreme event with large forecast error



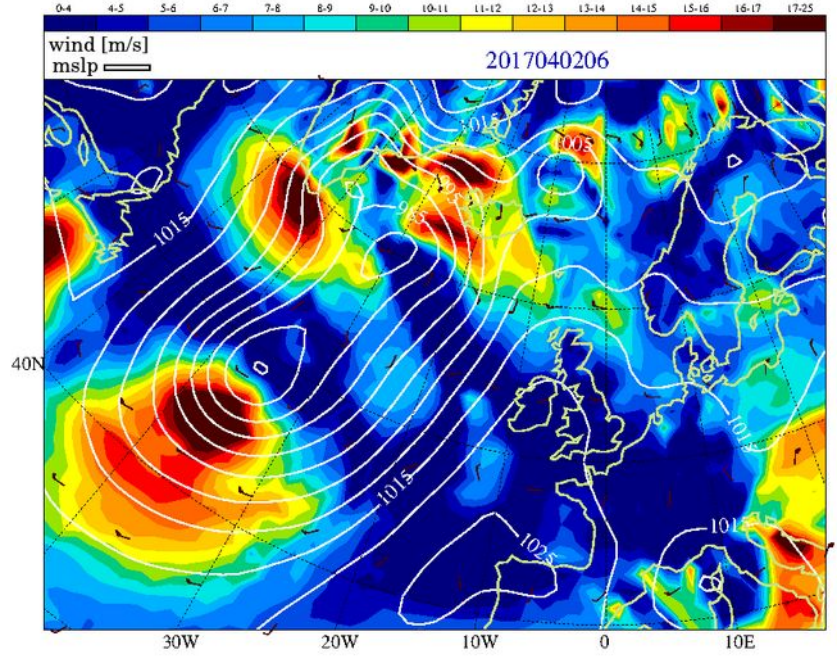
BACKGROUND INFORMATION

Wind Generation in Ireland

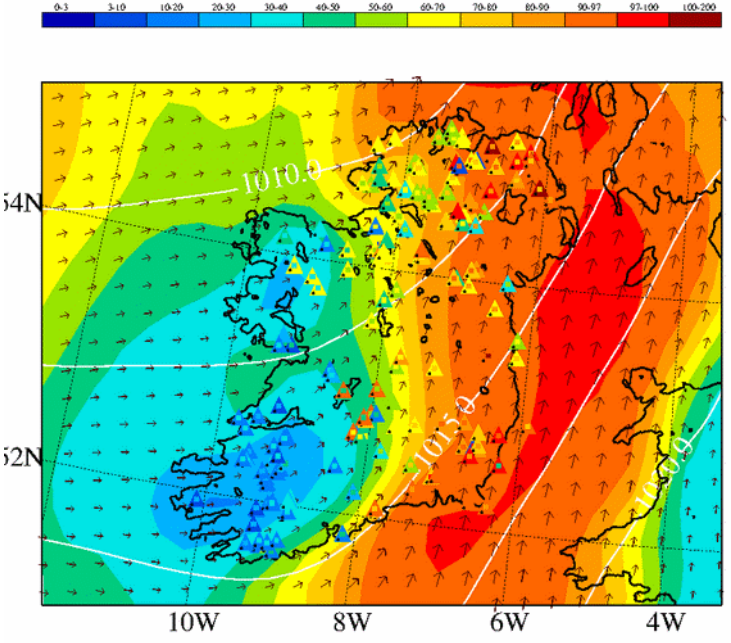
- **High penetration of wind** (32% of generated electricity from wind)
  Installed Cap. 5.500 MW (All Island) | Cap. 4.200 MW (Rep. Of Ireland)
  Wind Record on the grid: 4.471MW (81%) on 12th Feb. 2021

Challenges:

Weather
– jet stream -



Wind Parks Distribution
- uneven -



Electric grid
-weak@west coast-

Statistics: cases > 10% cut-off**

winter* 2017/18**:	20 cases	winter* 2019/20:	43 cases
winter* 2018/19:	2 cases	winter* 2020/21***:	6 cases

* Oct. - Apr
** ca. 450MW
***ca. 550MW

Warning System: 3-component Module (MSEPS-HSSDA)

WEPROGs warning system contains 3 components:

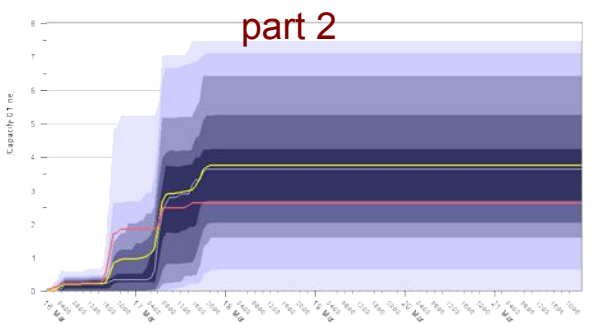
(1) **Probability of the expected cut-off capacity**
In cooperation with the end-user the system critical part of the capacity has been determined (e.g. 30% of the capacity)

(2) **Accumulated part of the expected cut-off capacity**
This component provides the accumulated cut-off probability of the expected temporal shortage of capacity and ramps

(3) **Table of the information of** (1) and (2) for the more detailed analysis and action planning

Probabilities of the expected cut-off capacity

+



Accumulated probability of the cut-off capacity and long-term shortage of capacity

+

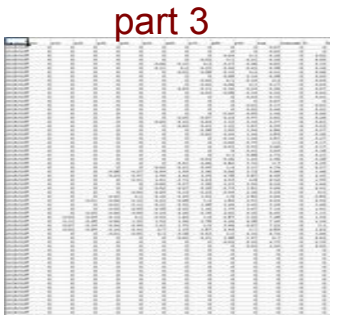


Table with detailed information of part 1+2

High speed ShutDown (HSSD): application Setup

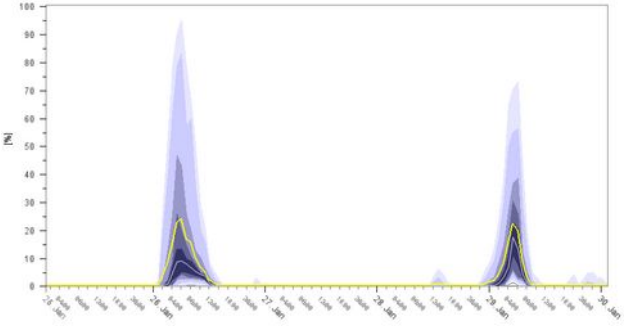
Communication is crucial for the interpretation of the probability for a certain event to take place

The information needs to be visually accessible and easy to interpret
--→ the operators need to be able to "read" probabilities !!!

Establish Guide lines
+
Training and Analysis

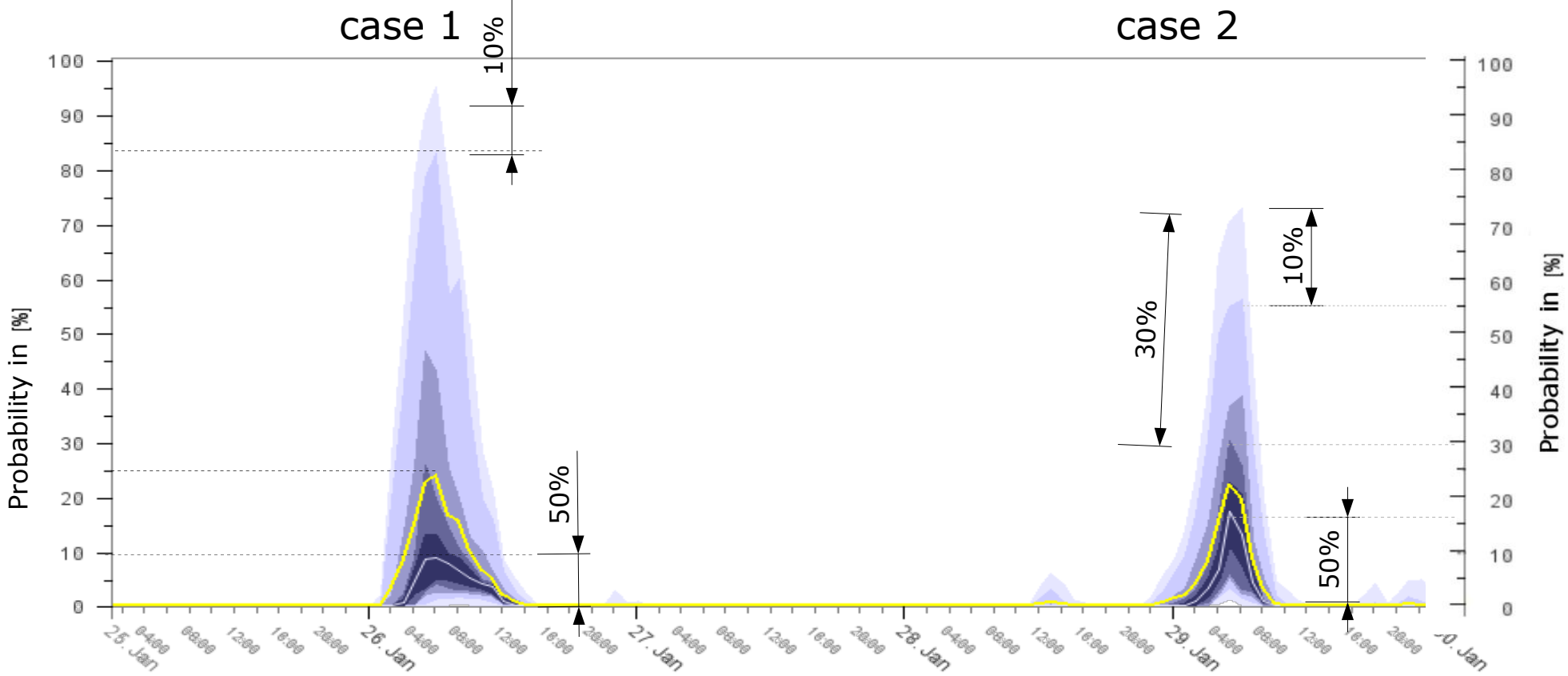
Warning examples...

10% probability of a 50% high-speed shut-down
5% probability of 90% shutdown
90% probability of a 10% shutdown



High speed shutdown events

Definition of the critical amount of cut-off is crucial for the interpretation of the probability for a certain event to take place



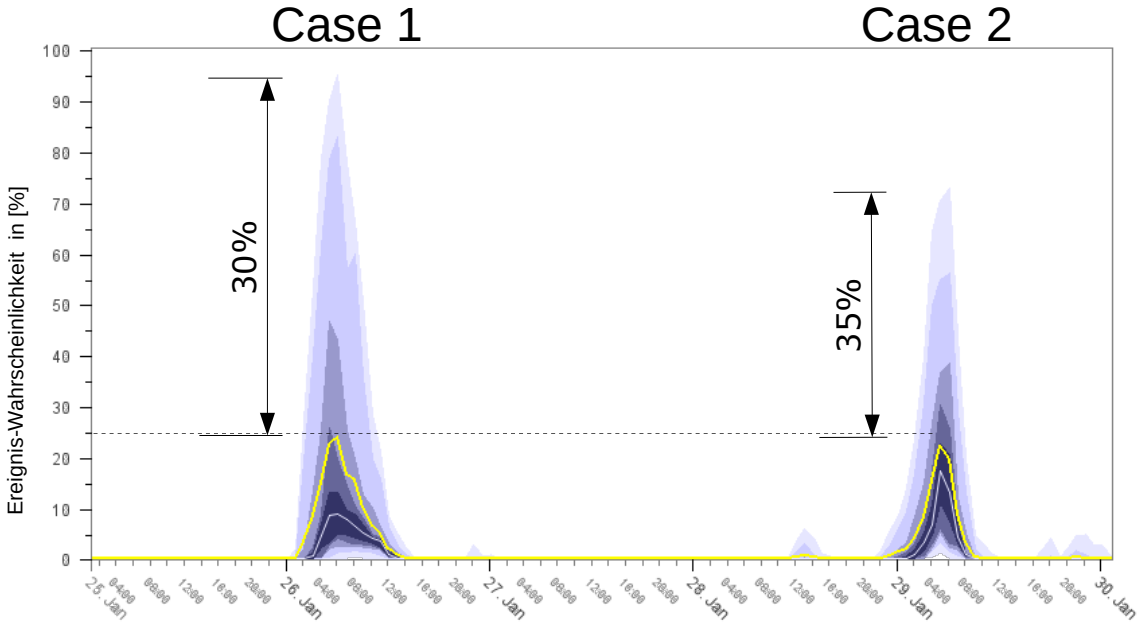
The dilemma: ….interpretation of and action plan from the information ...

Examples for case 1:
10% probability of >84% cut-off
30% probability of >25% cut-off
50% probability of >10% cut-off
90% probability of ~5% cut-off

Examples for case 2:
10% probability of >55% cut-off
30% probability of >30% cut-off
50% probability of >16% cut-off
90% probability of ~5% cut-off

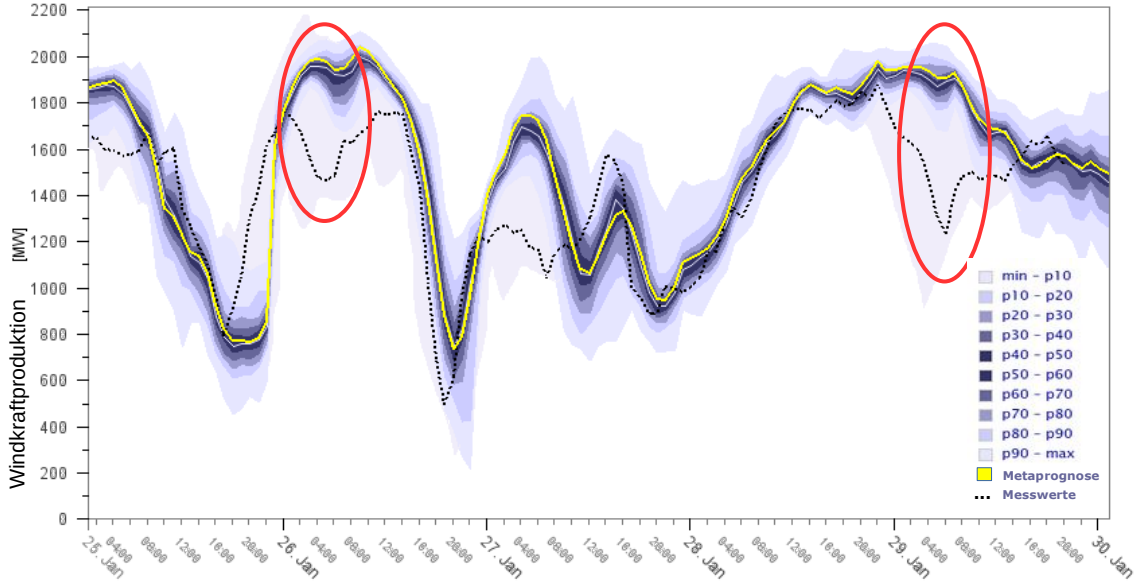
Example: Shutdown in 2 consecutive high-speed events

Definition for Alarm: warning at shut-down risk > 25% of production over 2 run cycles



Case 1:
30% Probability of >25% Cut-off
(P90-P60)

Fall 2:
35% Probability of >25% Cut-off
(P90-P60)

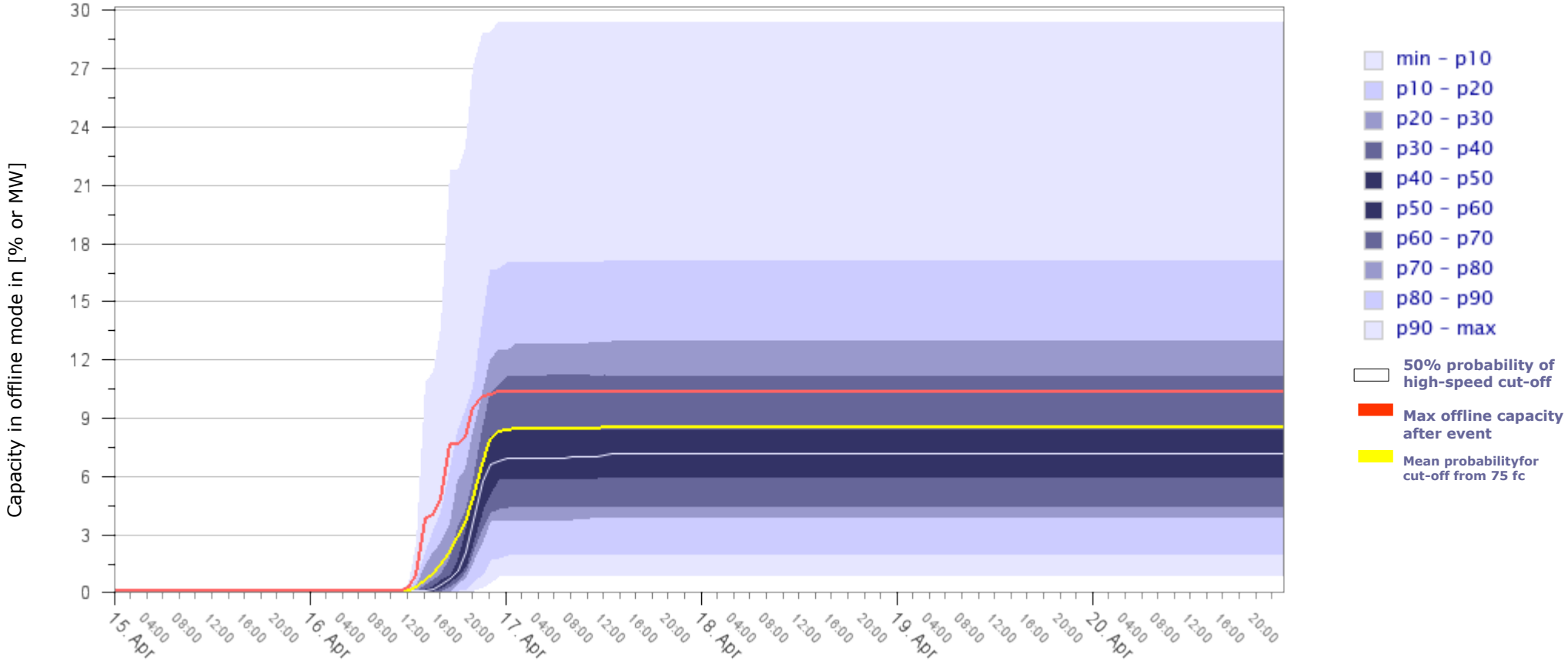


Result of actual cut-off scenario:

Case 1: 25% peak cut-off

Case 2: 35% peak cut-off

1. Enhancement: Temporal Accumulation of shut-down capacity



Main information made visible:

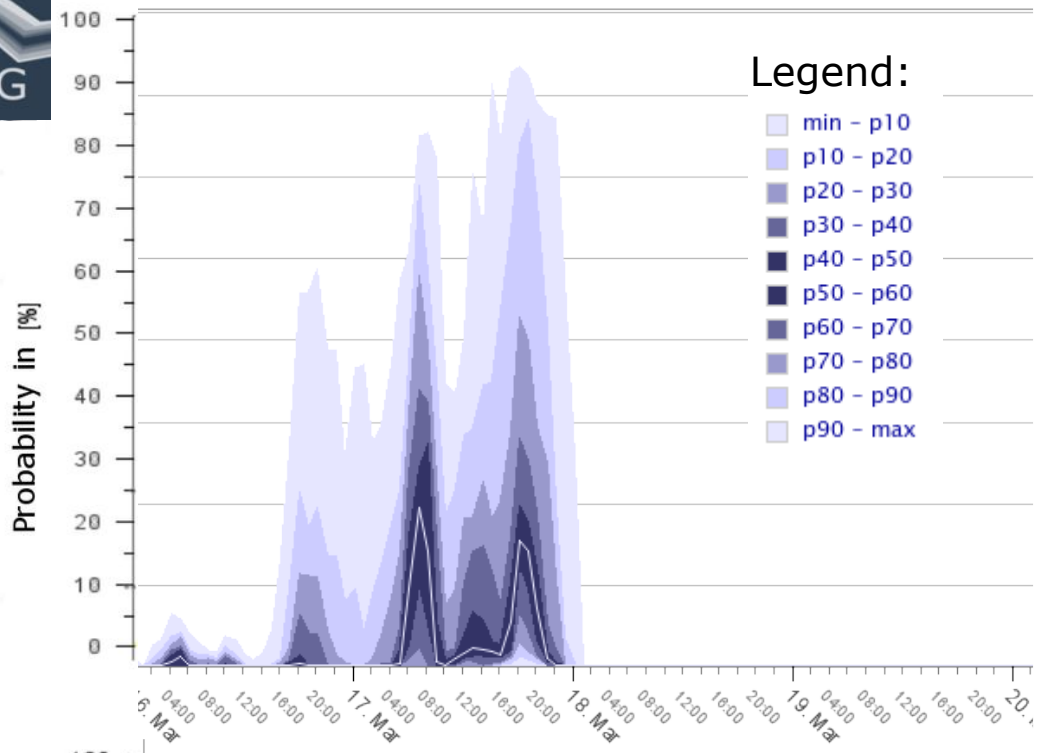
1) Accumulated capacity of a high-speed event in probability space

2) Ramp effect can be seen clearly and is part of the warning

3) Maximum-Minimum provides required reserve capacity

A typical HSSD "cut-off" event over 2 days

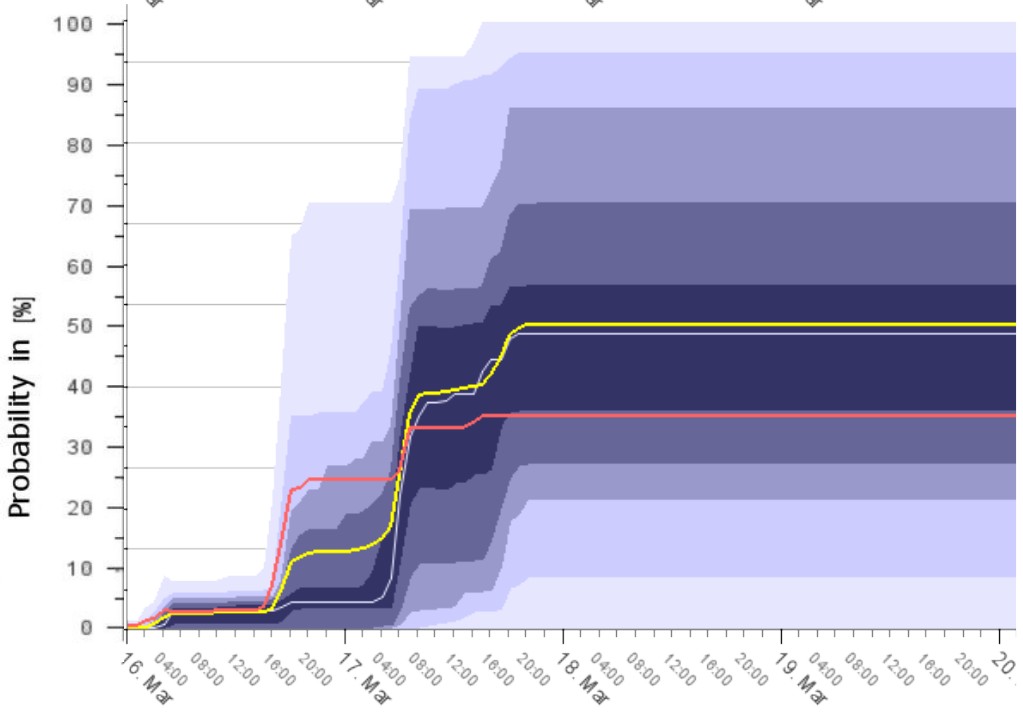
Probability of cut-off



Amplitude important for:

- max reserve requirement
- risk for max shortage
- rist for max overflow
- risk for congestion

Accumulated cut-off Probability



Temporal Acummulation important for:

- amount of required reserve
- length of event
- ramps up- and down

max. unavailable capacity

mean cut-off probability

High speed shutdown events
- how to build up a warning system -

Communication is crucial for the alerts to be taken serious when required !

The frequency of alert generation need to be adjusted to:

- lead time of the alert
- change of severity level since previous alert
- initial week day
- valid week day
- time of day
- severity of the event computed from a ramp-rate
- the actions required
- the need and possibility to call back and/or revert actions

Strategy of alert issuing:

- issue every alert according to a simple scheme (e.g. probability exceeding 10% for more than 2 subsequent forecasts)
- reduce the amount of alerts to prevent that critical alerts are not accidentally overlooked (observe before an alarm is issued...)

Uncertainty forecasts in the High-speed Shutdown warning system creates value for the user

- Automatic filtering of unpredictable weather phenomena
- Limits double punishment and thereby volatility and consequently risk
- Allows the end user to strategically prepare for the increased risk
- Faster interpretation of conditions with a suitable presentation
- Increased forecast confidence by bridging models and measurements
- Flexible decision making with various objective formulae
- Forecast uncertainty without use of historical measurements

Thank you for your attention …

Overcoming barriers…

Questions ?
…Join Session ES2.2 of
EMS 2021 Annual Meeting -
Dealing with Uncertainties - on Tuesday,
7 September 2021, 14:30..
or contact me...

Contact:
Dr. Corinna Möhrlen
com@weprog.com

WEPROG ApS Denmark
5610 Assens - Tel. +45 46922907

WEPROG GmbH Germany
71155 Altdorf/Böblingen Tel. +49 (0)7031 414280

Email: info@weprog.com
Web: www.weprog.com