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RISK and Resilience Day 13 March 2025

A Framework for Developing Extreme Scenarios: **Are we storm ready?**

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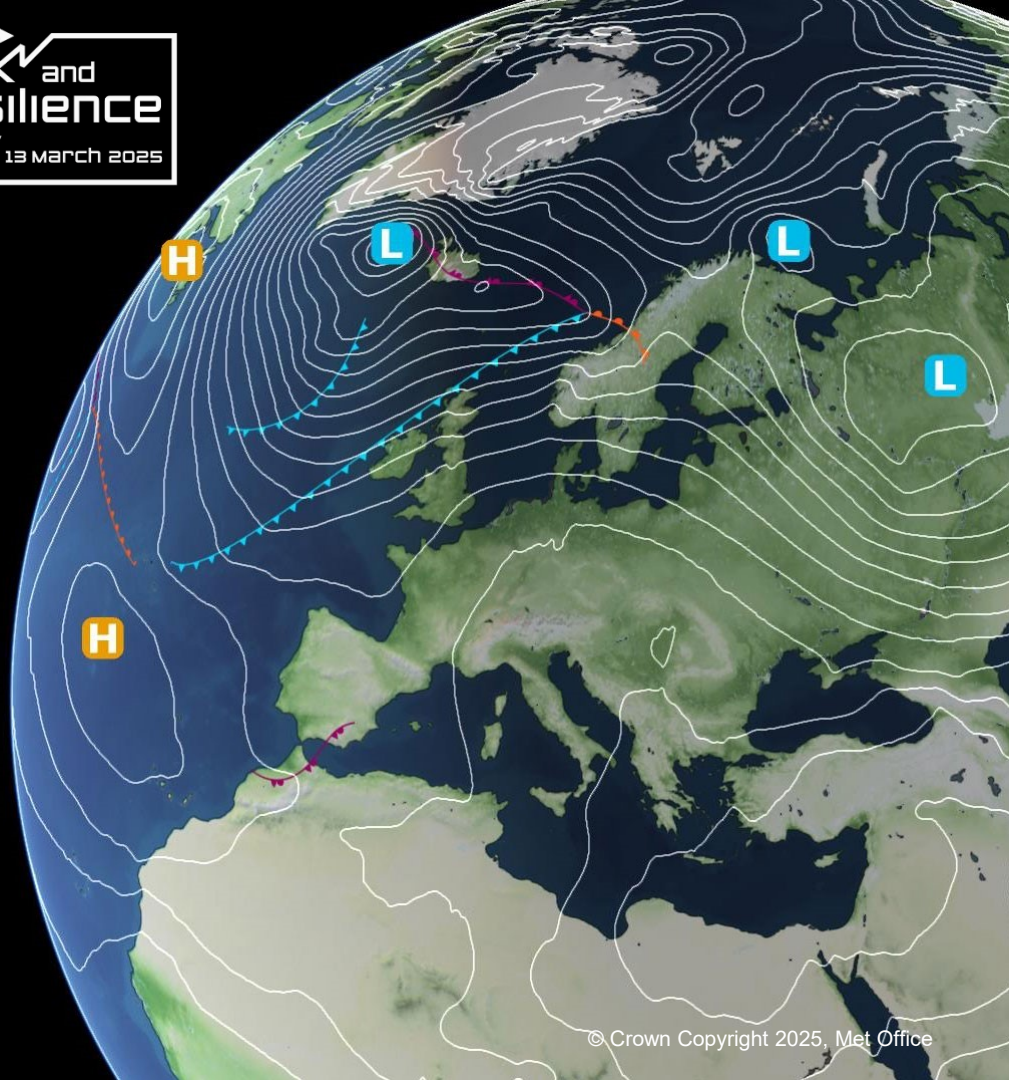

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Background / motivation

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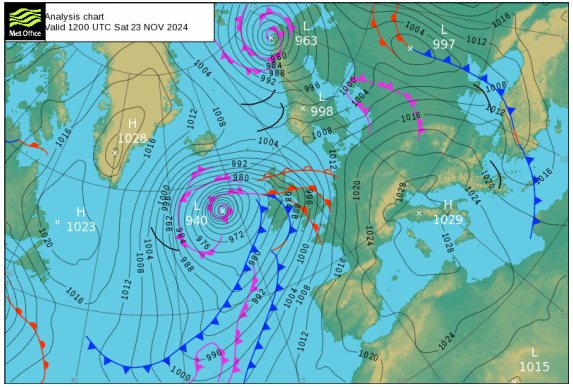
Extra Tropical Cyclone Impacts



Weather conditions in mid-latitudes are largely determined by presence of ETCs

"*no two vortices are ever quite the same*"
(*Zillman and Price,* 1972)

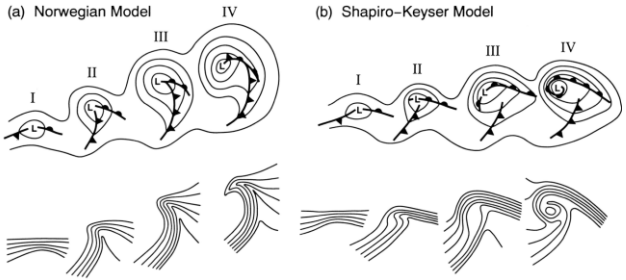
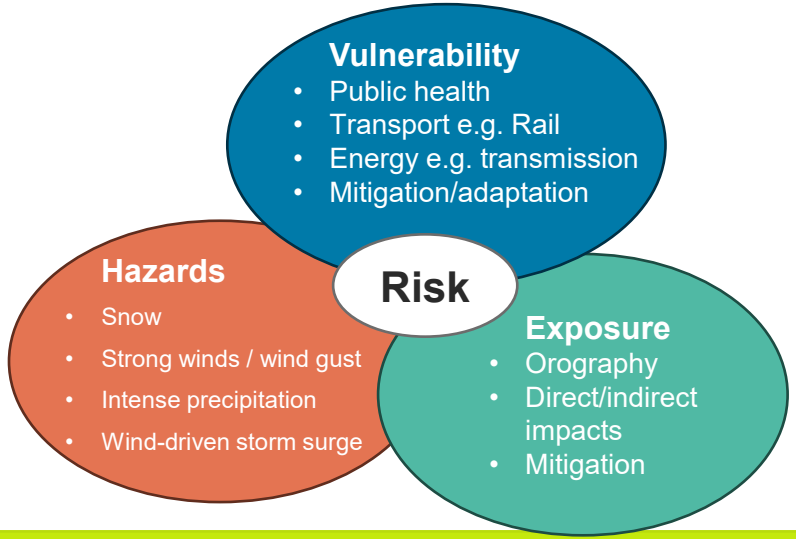
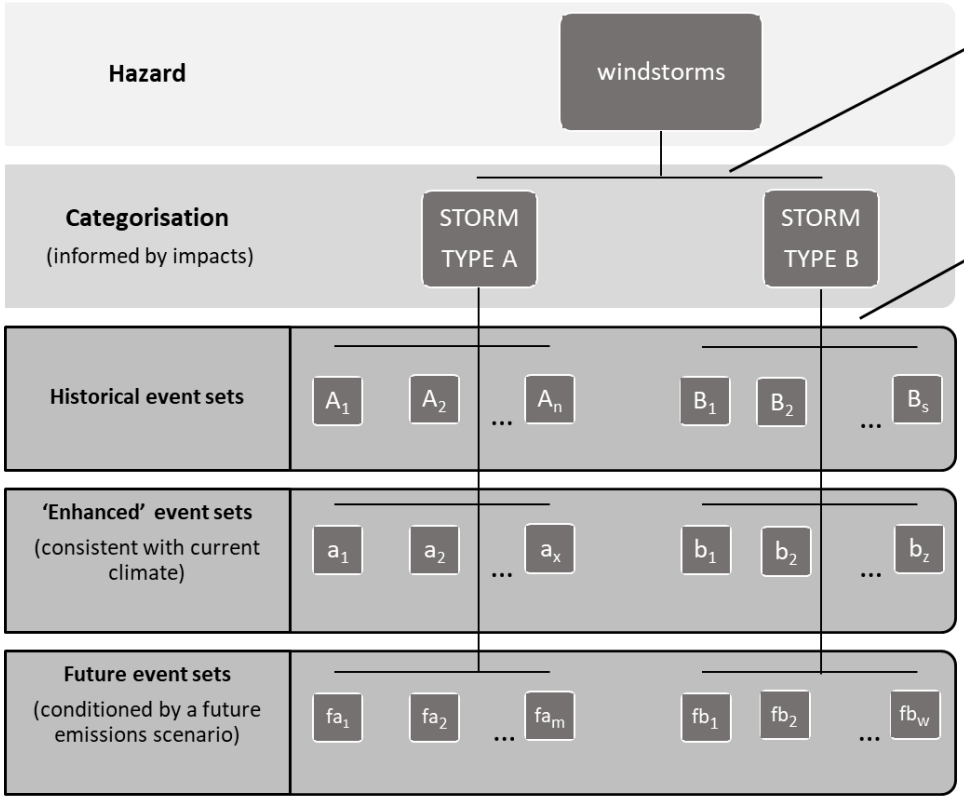


Figure 15 of Schultz et al. [1998]



EVENT SET DEVELOPMENT



Categorisation:

- Informed by empirical/statistical 'types'
- Informed by links to impacts (NaFIRS, stakeholder engagement, Operational Meteorologists)

Types:
Each described by objective criteria

These event sets are then **sifted for desired features**:

- Impacts and affected areas
- Intensity/duration
- Temporal evolution
- Target period
- Etc.

WIND SCENARIO

SCENARIO DEVELOPMENT CYCLE

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Demonstrator

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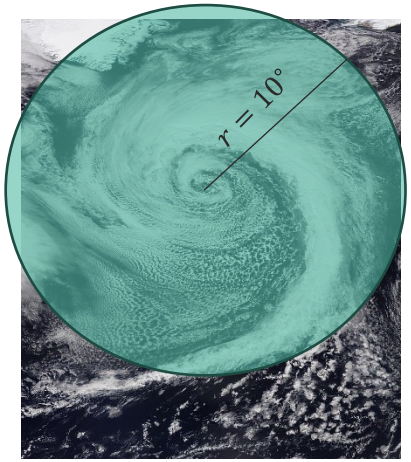
Metrics

- **Defined along the track** (10 degree radius of storm centre)
- Using **known indicators of impact** (such as WSI)
- Exploring **new hypothesised impact metrics** (such as I/X)

Track coords definition T
= {time index, lat, lon}
within Track 10deg radius



- **WSI** (Wind Severity Index)
- **Storm_Number** (# since 1st September)
- **Gust_Max** (max along storm track)
- **Wind_Direction** ([u, v] direction at time of Gust_Max)
  - **Octant** (NNW,NWW,SWW,SSW,SSE,SEE,NEE,NNE)
- **X, accumulated absolute exceedances {region}**
  (Metric integrating P98 exceedance above threshold)
  - **I, accumulated count of exceedances {region}**

    (Indicator that counts P98 exceedance)

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Input data:

- Storm tracks
- Re-analysis data

UK-relevant tracks (SET1)

Processing steps:

- Track interpolation
- IONA box filter
- Add metrics

Significant storms (SET2)

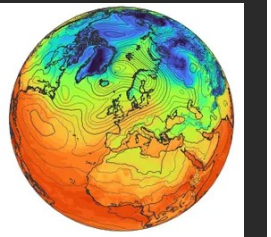
Selection steps:

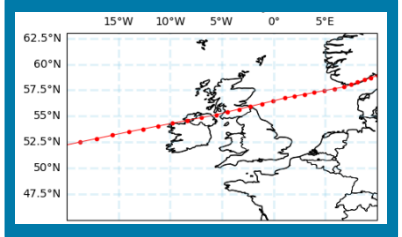
Filter for intensity
(98% percentile gust)

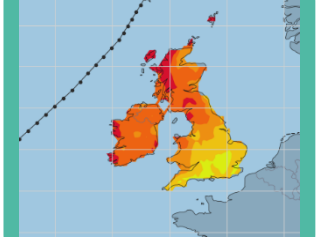
Characteristic Scenario Sets

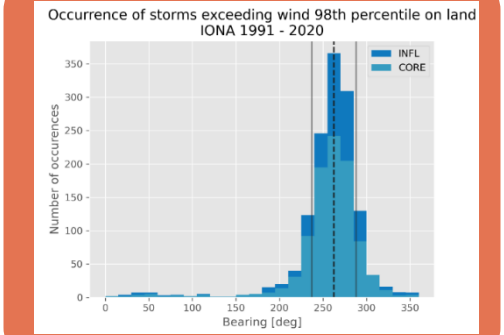
Filter for characteristics:

- e.g. unusual track bearing (SET3)
- e.g. successive storms etc. (SET x, y, z, …)









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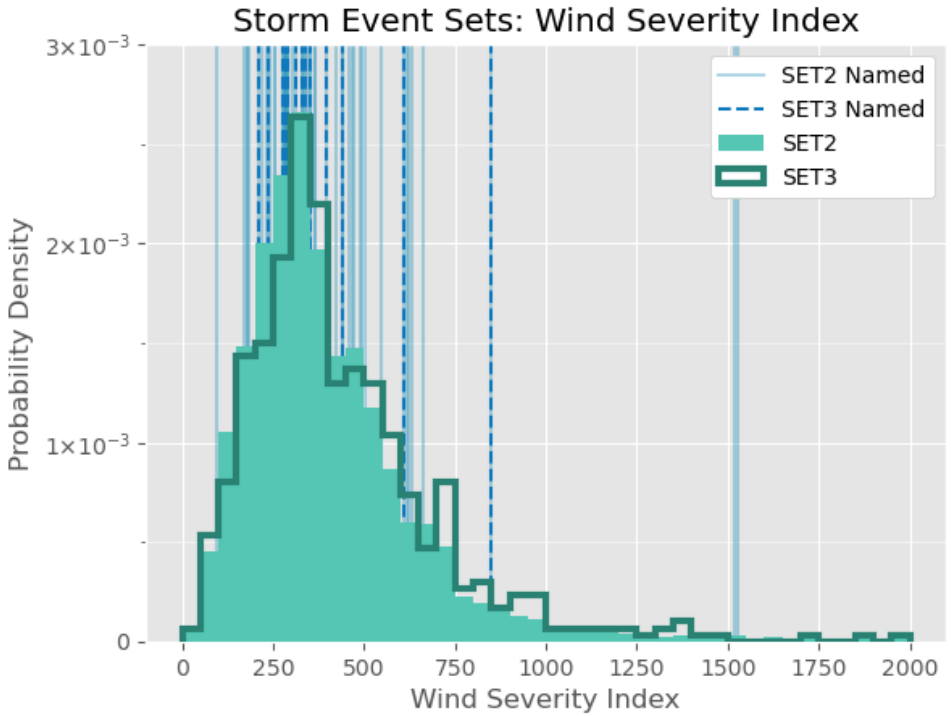
Arwen (2021) – max SET3 named storm WSI, but not very extreme…
Alex (MeteoFrance, 2020) has max SET2 WSI

Arwen ranks highest in WSI of named storms (2015-2022)
But ranks 40th out of 1979-2022

Definition

Wind Severity Index records the relative gust strength along the storm track

$$WSI = \sum_{\text{track}} \max(0, \frac{w_{t,lat,lon}}{w_{p98,lat,lon}} - 1)$$



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X UK

Definition
X is the accumulation of wind threshold exceedance along the storm track

Same vein as WSI & SSI, but teases out different qualities

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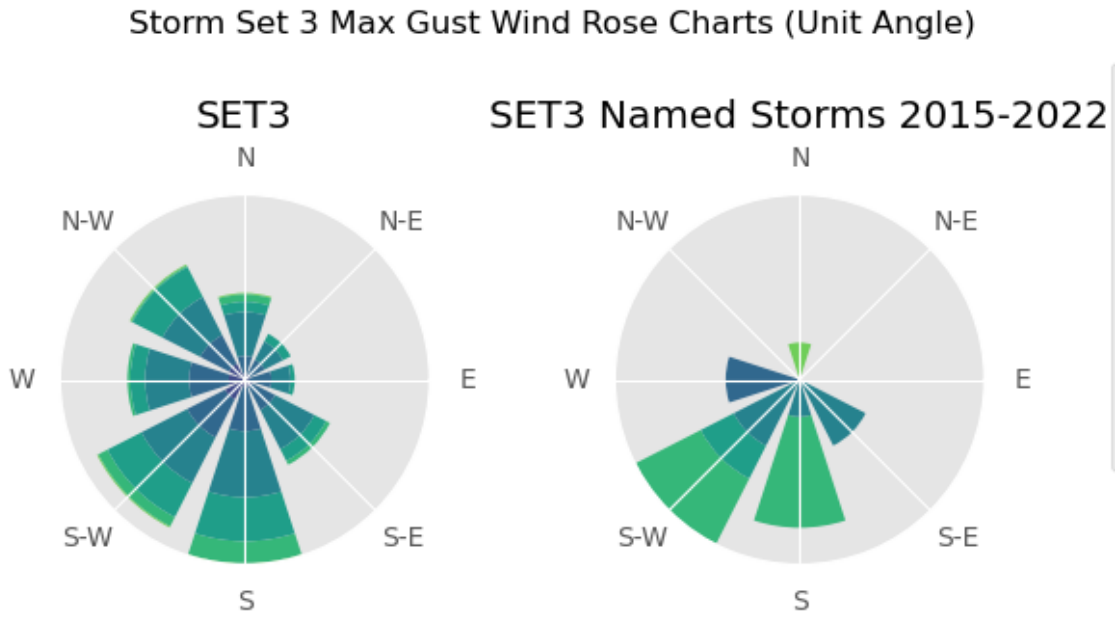
SET3 Named Storms Octant (u,v at gust max)



Average wind direction within storm radius (South of centre) at time of max gust

Recent named SET3 storms severely under-represent unusual bearing!

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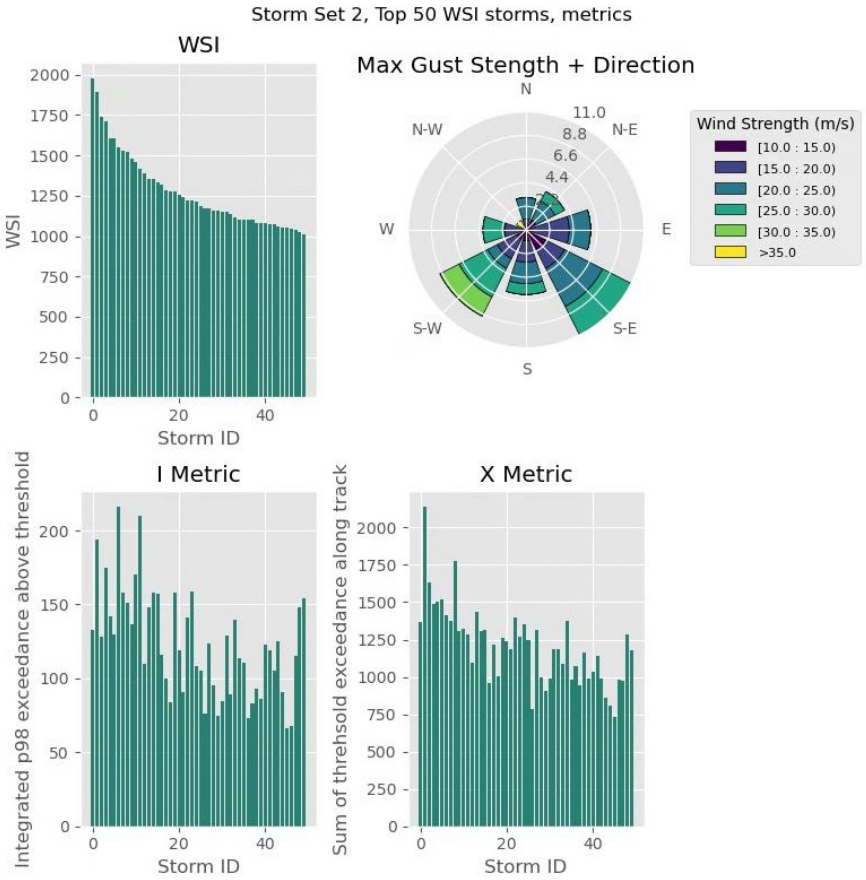
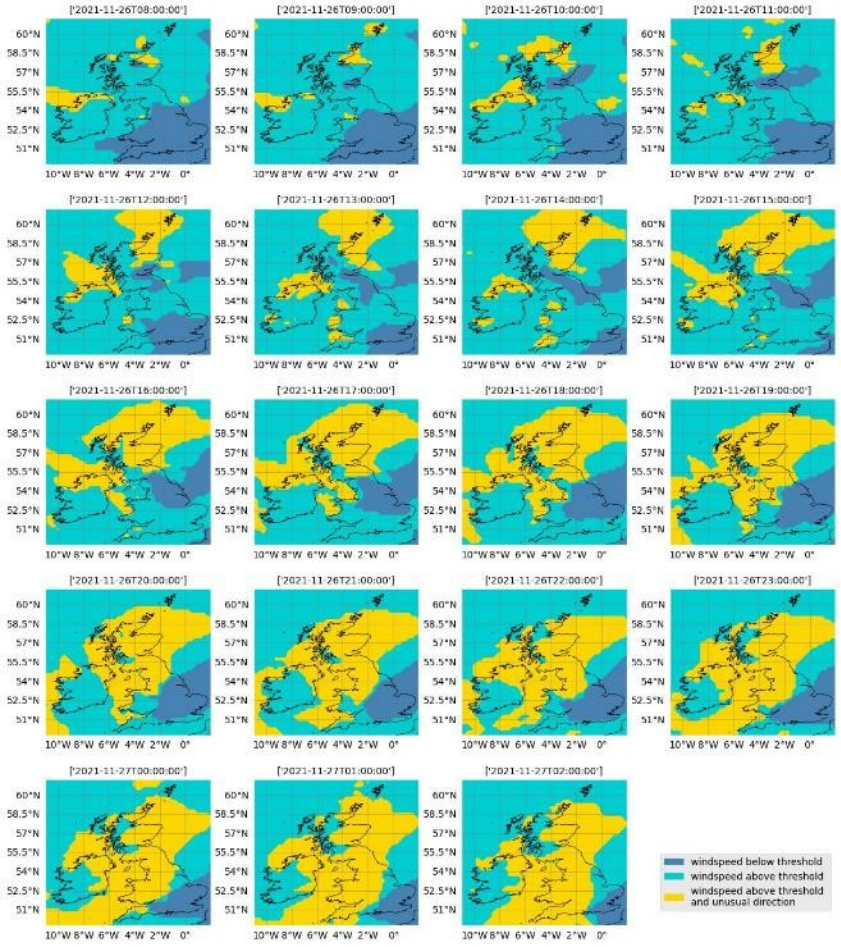


Top 50 WSI storms

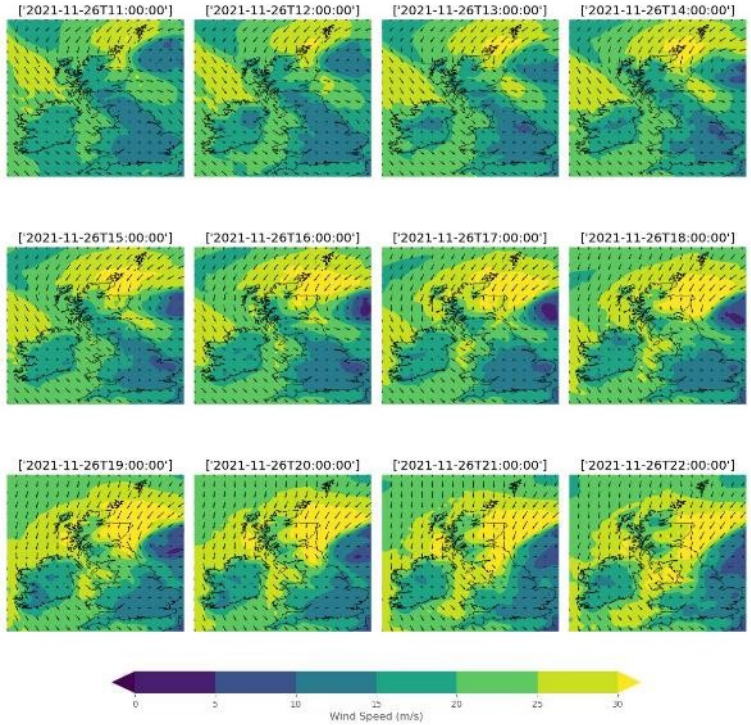
- Strongest storm by one metric not necessarily strongest storm by another metric
- Lots of ways to categorise storms besides wind strength
- Reveals different potentially impactful storms compared to just using wind strength

Storm Arwen 26-11-2021

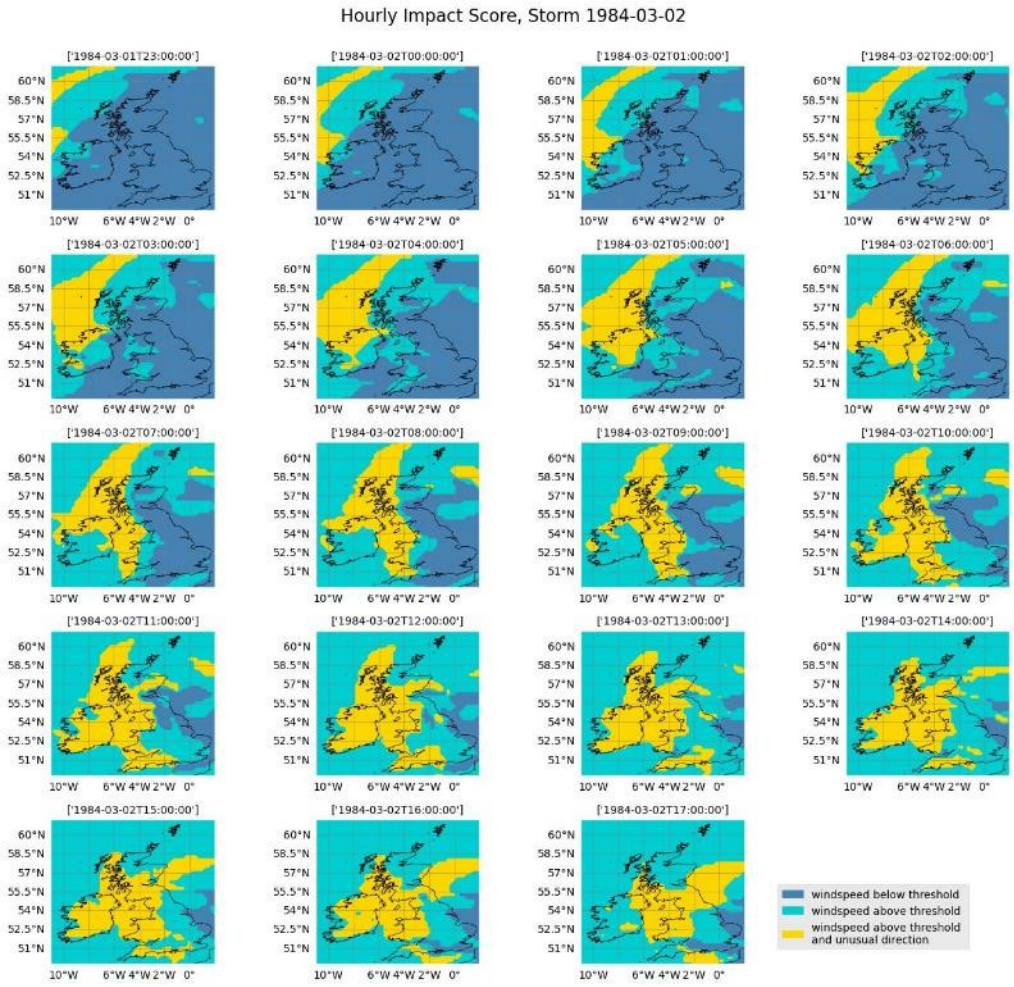
Hourly Impact Score

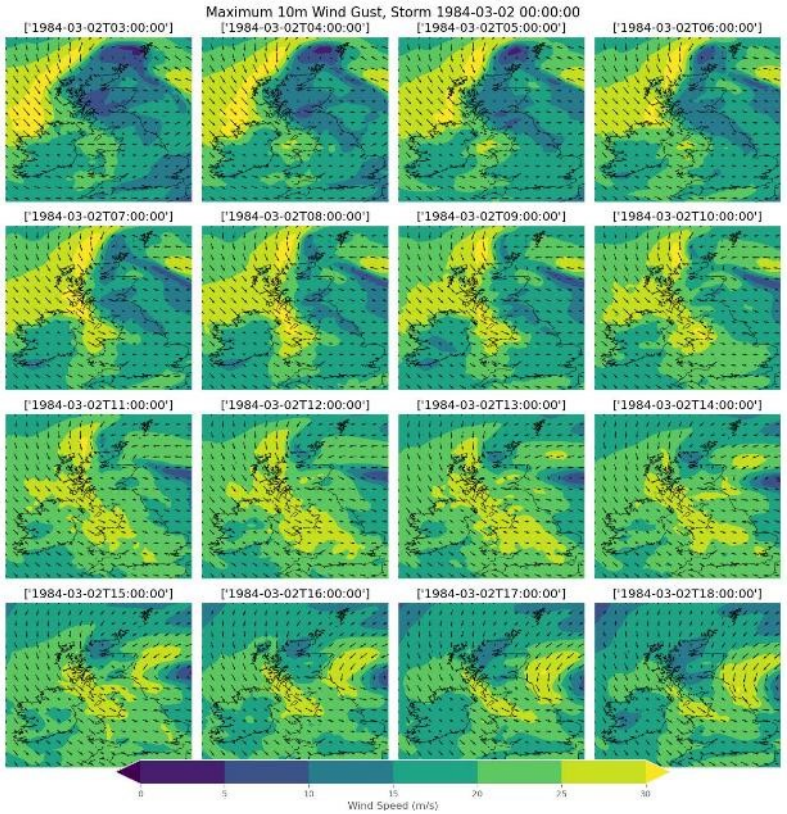


Hourly Maximum 10m Wind Gust



Storm 02-03-1984





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Conclusions

- This demonstrator showed that a robust event set could be derived for a given event type (storms with unusual bearing). The set captured a **range of potentially damaging conditions** that can be subsampled for designing a scenario (e.g., focus on a given metric or region).

- We showed that there is added value in extending beyond the named storms:
  - Event set of storm tracks with unusual bearing (SET3) results in **a higher proportion of extreme gust events with an unusual wind direction** (i.e. not from the prevailing south-westerly direction) than found in SET3 named storms.
  - Event sets constructed from 1979-2022 reanalysis also **better sample the impact metrics** such as the Wind Severity Index