Electricity Network risks from wind gusts using a hi-res Climate Model

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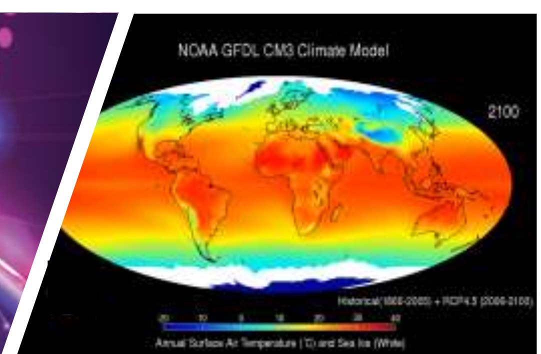


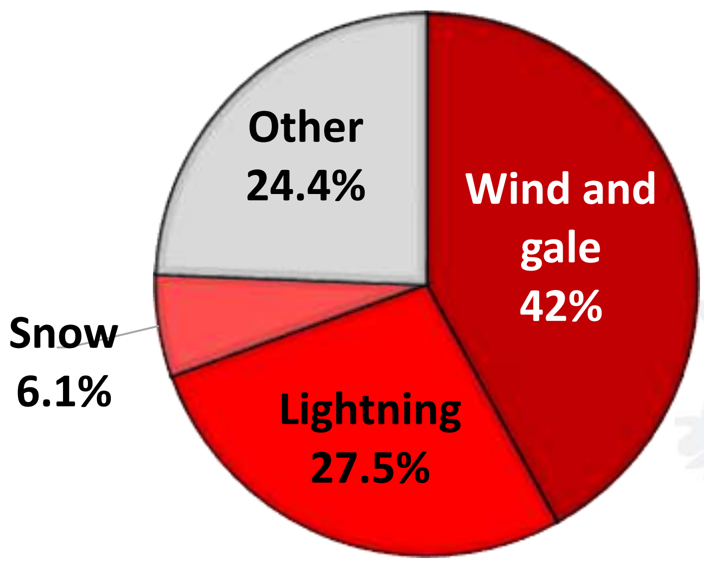
Risks from wind gusts

Wind gust definition (WMO)

Maximum value,
over the observing cycle,
of the 3-second
running average wind
speed
[m/s^{-1}].

Frequency of damage due to natural hazards (Yorkshire and North East HV lines)

NaFIRS database, 2004-2017

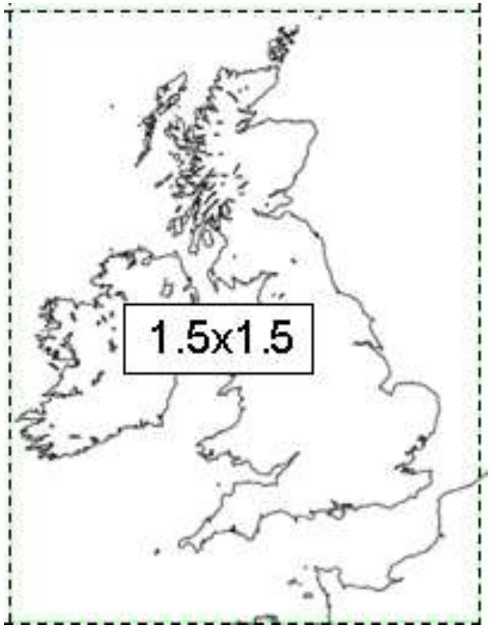


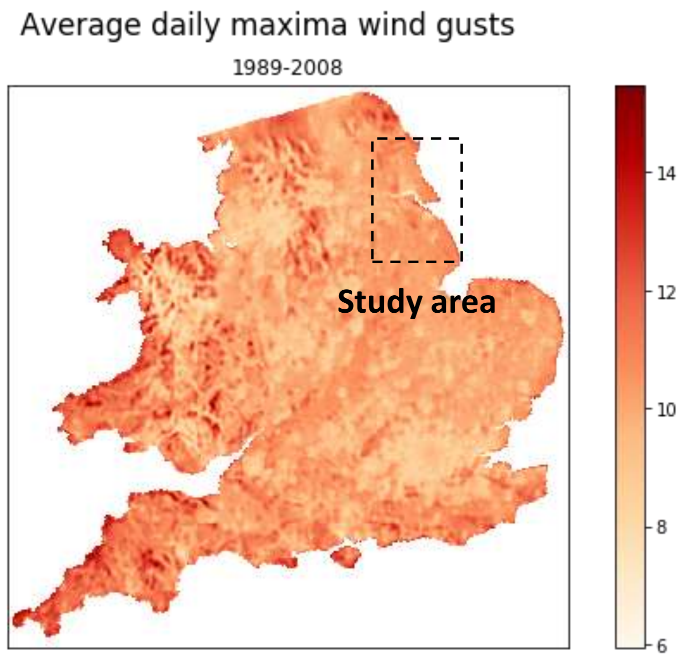
Systemic disruption

State-of-the-art, hi-res Climate Model

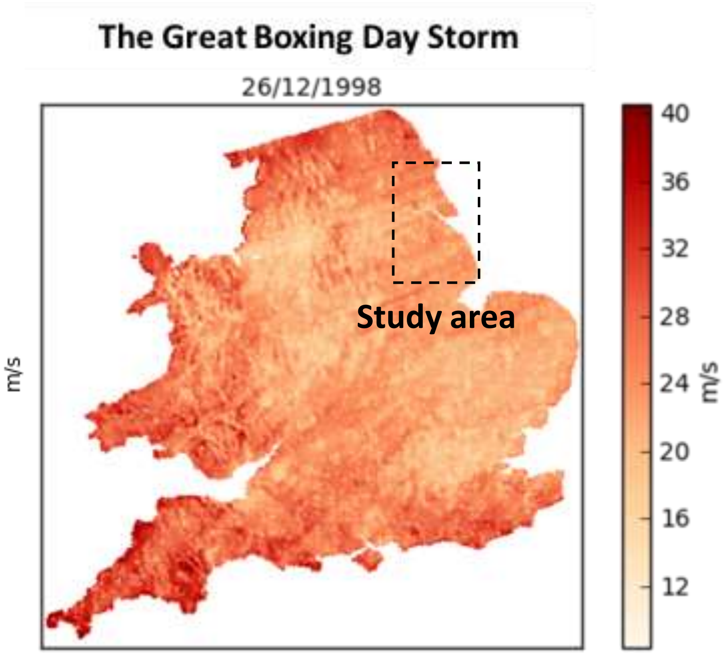
Met Office

UKV 1.5 km convection-permitting Climate Model





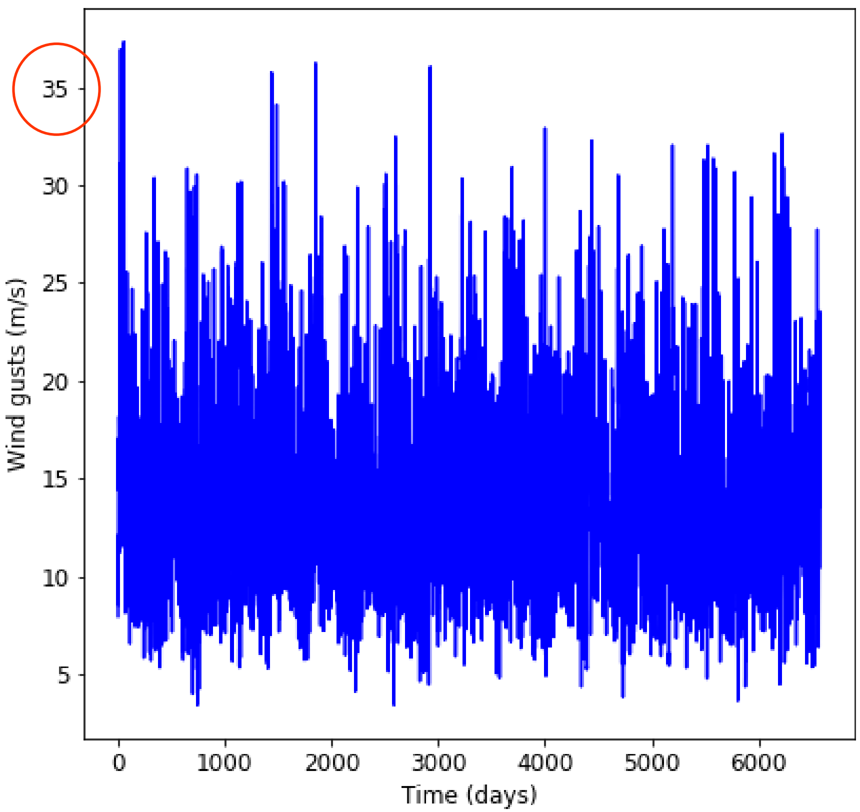
Kichner-Bossi et al., 2017



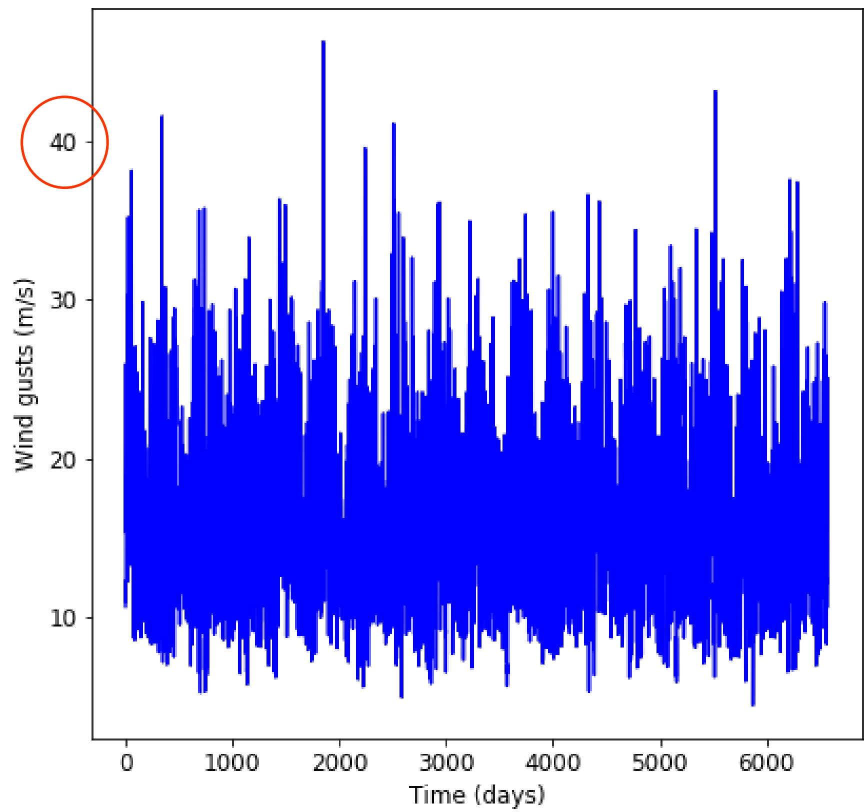
Kichner-Bossi et al., 2017

Time series of daily maxima wind gusts

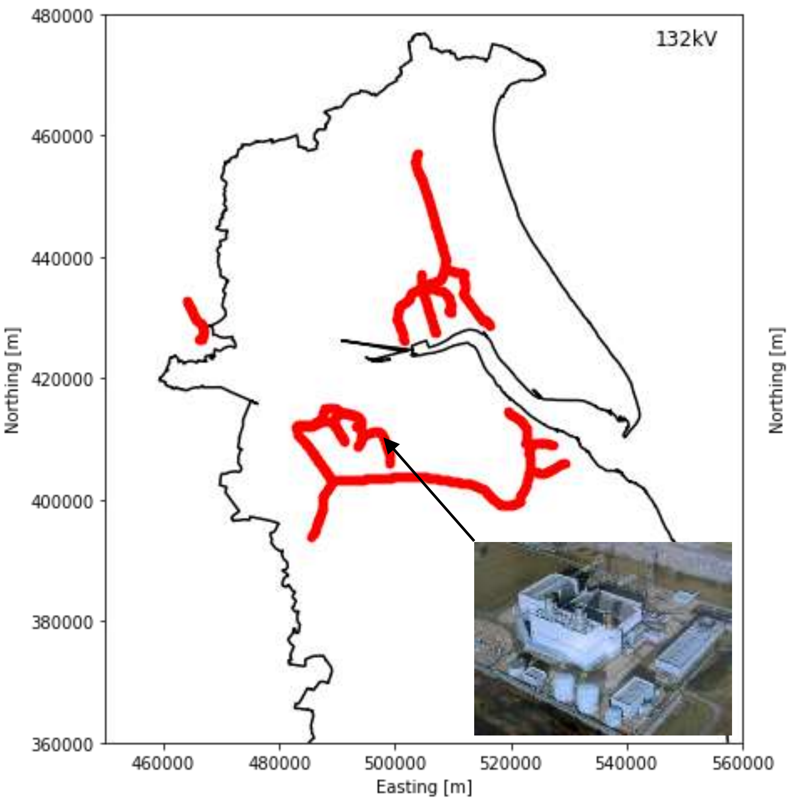
1989-2008 daily maxima wind gusts, 132kV OH

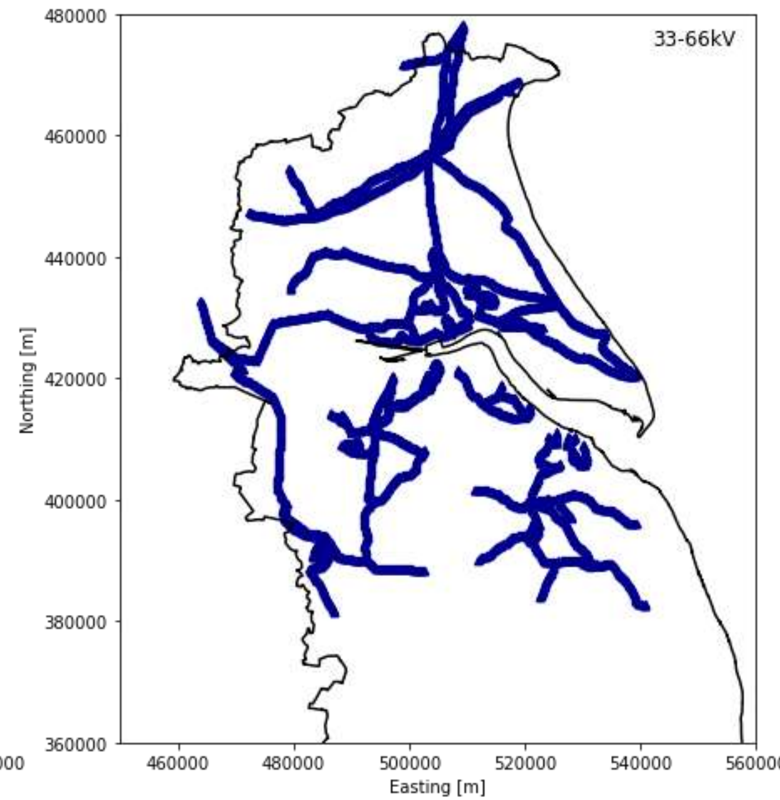


1989-2008 daily maxima wind gusts, 33/66kV OH



Study area and infrastructure assets

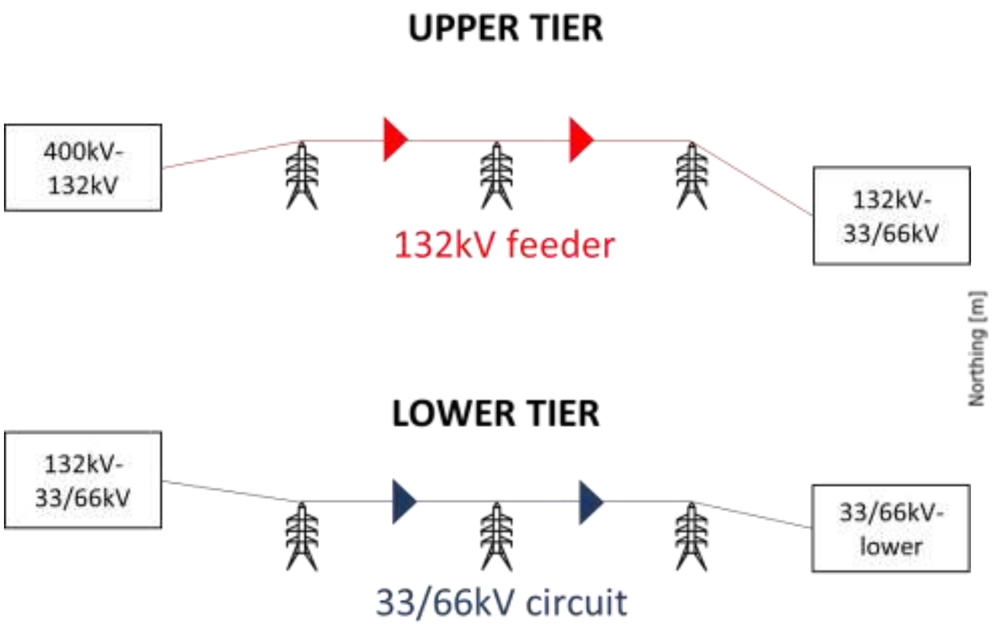


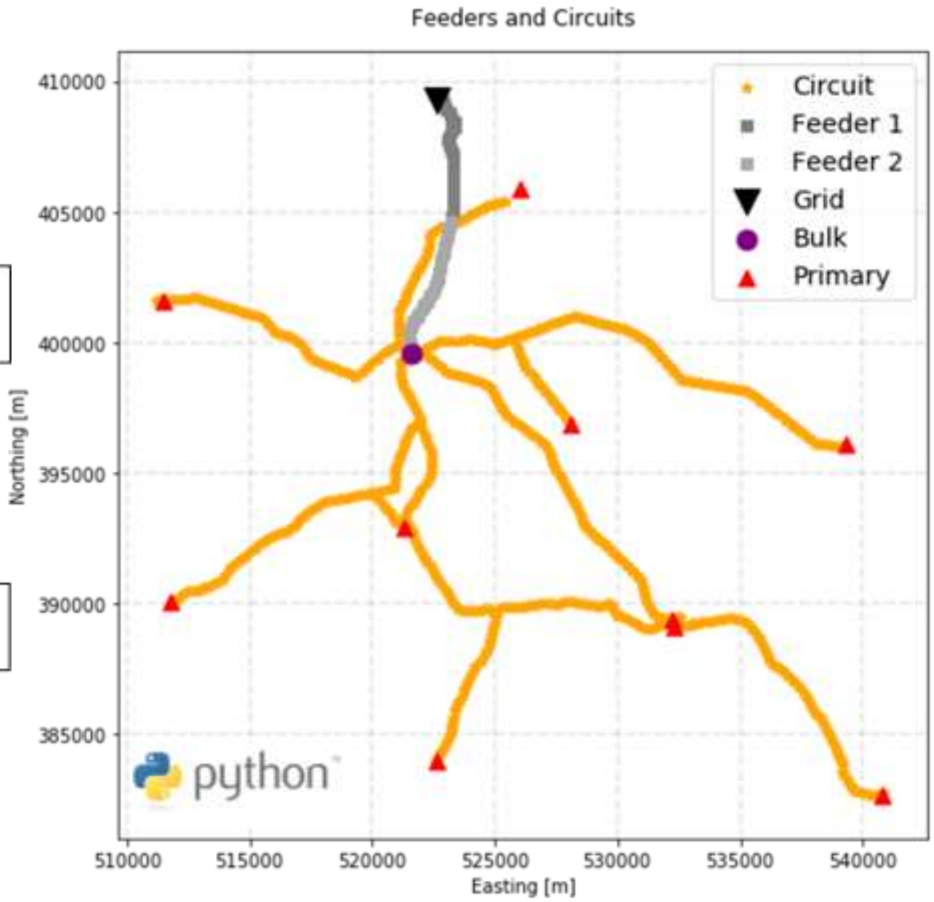


- > 1,000 km of OH cables
- 6 National Grid Substations (400kV-132kV)
- 19 Bulk Supply Points (132kV-33/66kV)
- 95 Primary Substations (33/66kV-lower)
- > 7,000 pylons
- > 260,000 customers served

Data courtesy of Northern Powergrid

Network schematization

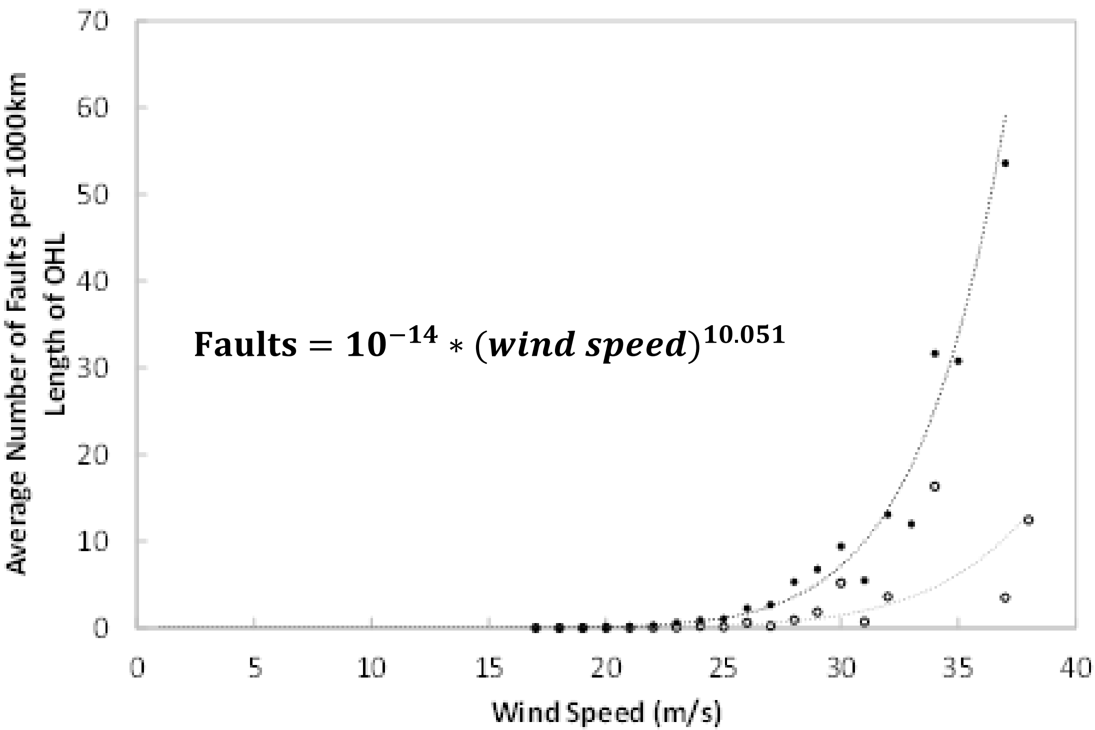




Network robustness to wind gusts

Probabilistic approach to failures: fragility curve

Faults = $f(wind\ speed)$

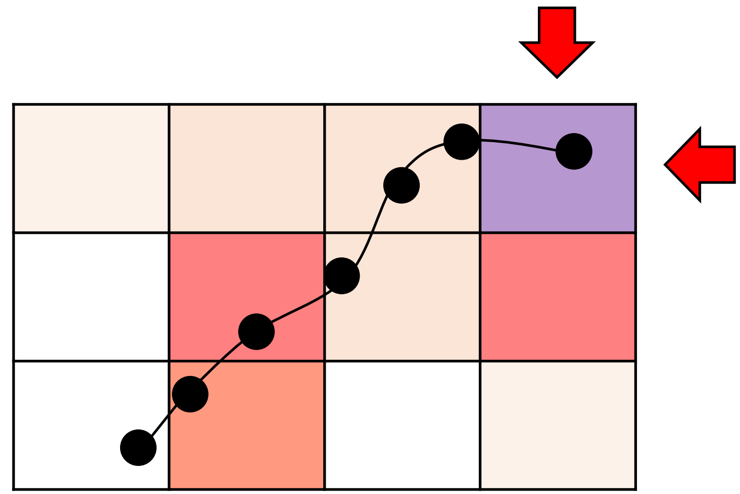


Dunn et al., 2017

DOI: 10.1061/(ASCE)NH.1527-6996.0000267

Worst-case scenario:

Faults = $f(max(wind\ speed))$



wind gust mesh grid

Impact of wind gusts

Non-monetary, quantitative estimate of the service failings of each event

$$\boldsymbol{Impact = F * C} \qquad (1)$$

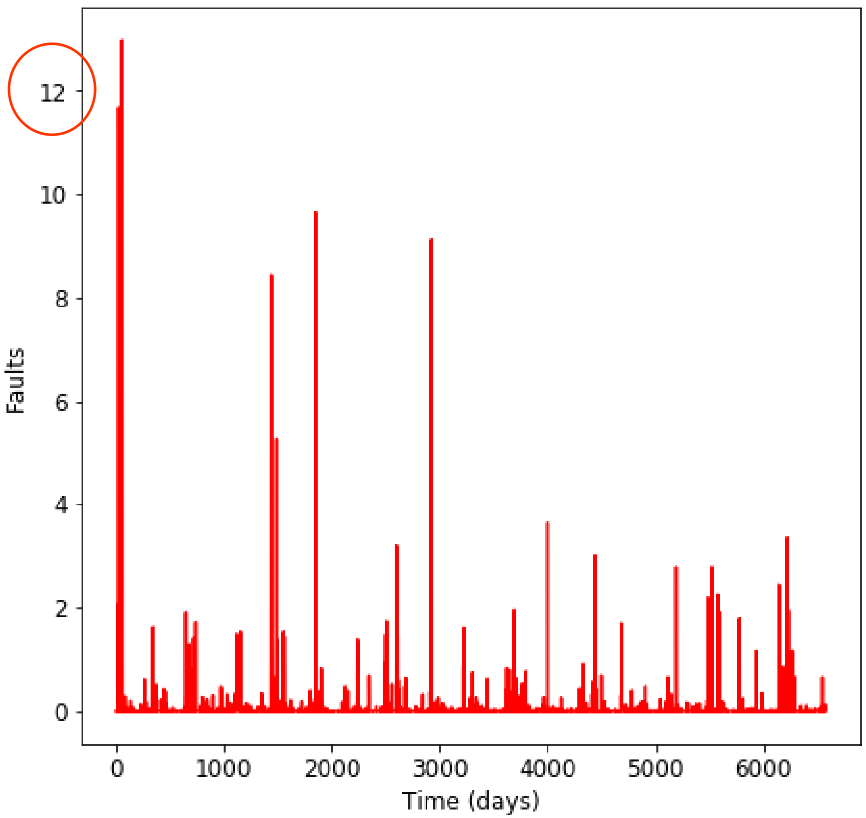
F=number of faults, C=number of customers served by the feeder/circuit

Aggregate estimate of the service failings

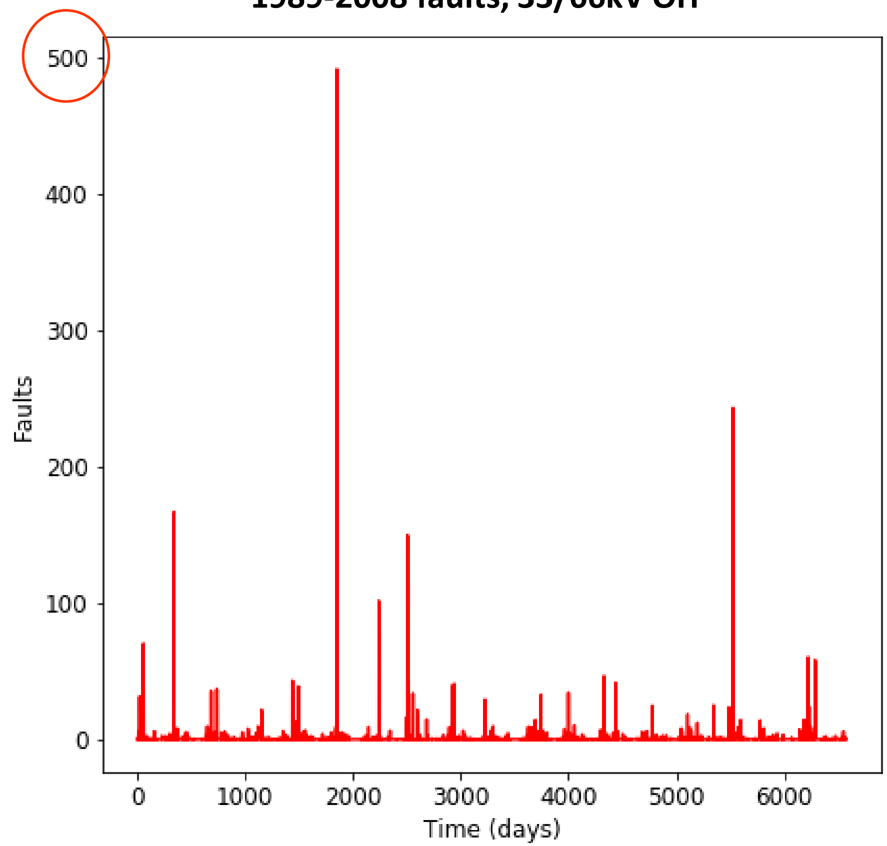
$$\boldsymbol{Total\ Impact = \int_0^T Impact\ dt = \int_0^T (F * C)\ dt} \qquad (2)$$

Results (1)

1989-2008 faults, 132kV OH



1989-2008 faults, 33/66kV OH



Results (2)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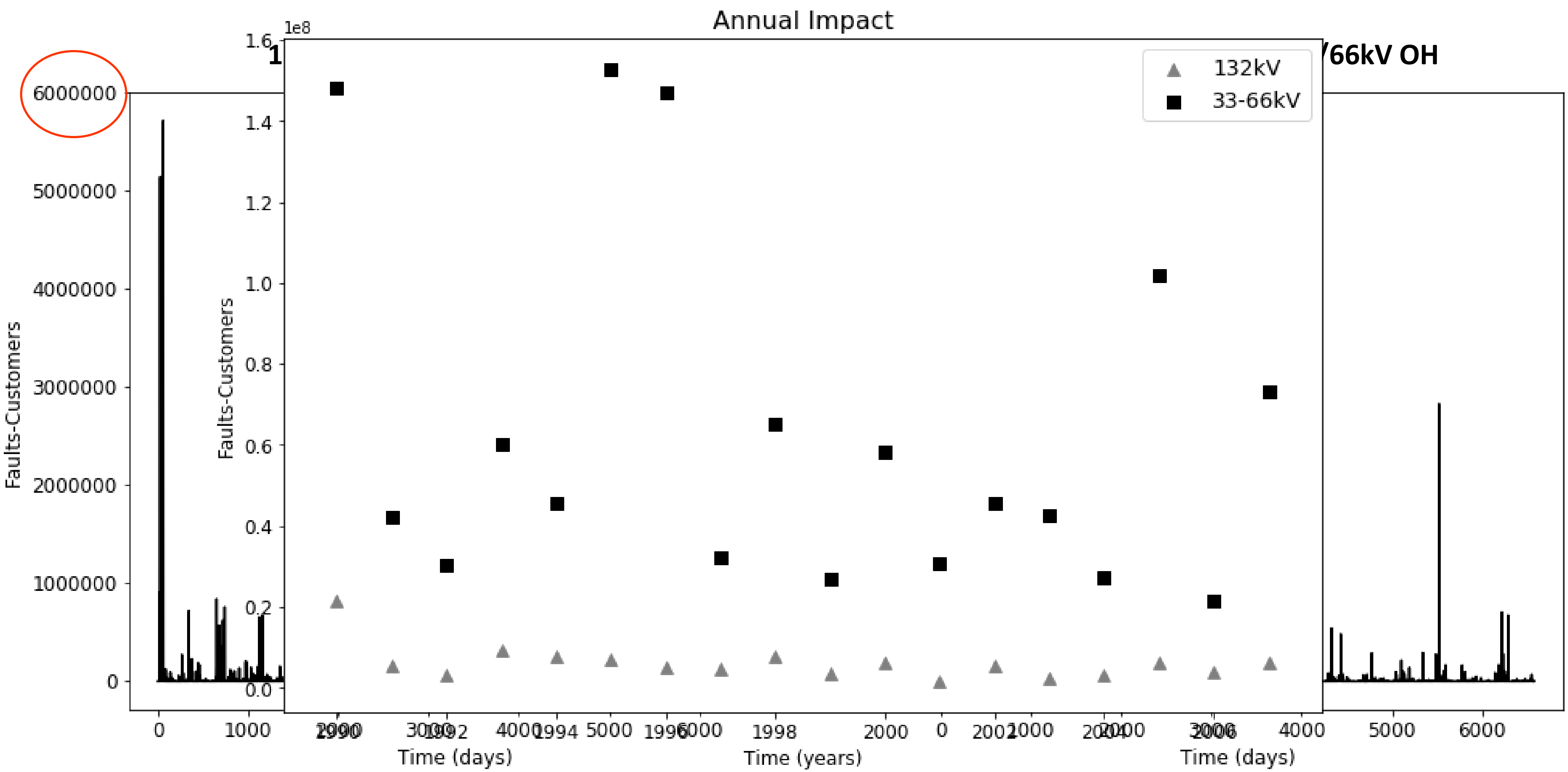
Annual Impact
1e8
Faults-Customers
Time (years)
132kV
33-66kV
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1990
1992
1994
1996
1998
2000
2002
2004
2006
/66kV OH
Faults-Customers
Time (days)
6000000
5000000
4000000
3000000
2000000
1000000
0
1000
2000
3000
4000
5000
6000

Conclusions

- **Lower-tier network more vulnerable to wind gusts;**
- **Network extent is the crucial factor: upper-tier network serves more customers but lower-tier network is the most exposed;**
- **Regional or sub-regional domains to be preferred over large areas for impact studies (climate patterns may vary).**

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Met Office

NORTHERN POWERGRID

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INTERNATIONAL SYMPOSIA FOR NEXT GENERATION INFRASTRUCTURE