

Vulnerability curves for clusters of storms – A case study with Generali France

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1 Context

European Windstorms :

- €3 billion average annual insured loss in France [1] and costliest hazard for Generali France [2]
- Costliest when occurring in clusters [2], Lothar & Martin €13.8 billion in France [3]
- Clustering damage is likely underestimated [5]
- Need for compounded vulnerability curves better represent the complexity of the hazard [6]

How frequent are temporally compounded wind events in France ?
Is the damage related to temporally compounded wind events driven by the maximum wind gusts only ?

2 Data

• Storms **304** events 1998-2024

ERA5 Reanalysis data + TRACK algorithm
1300km radius for storm footprint

• Clustering

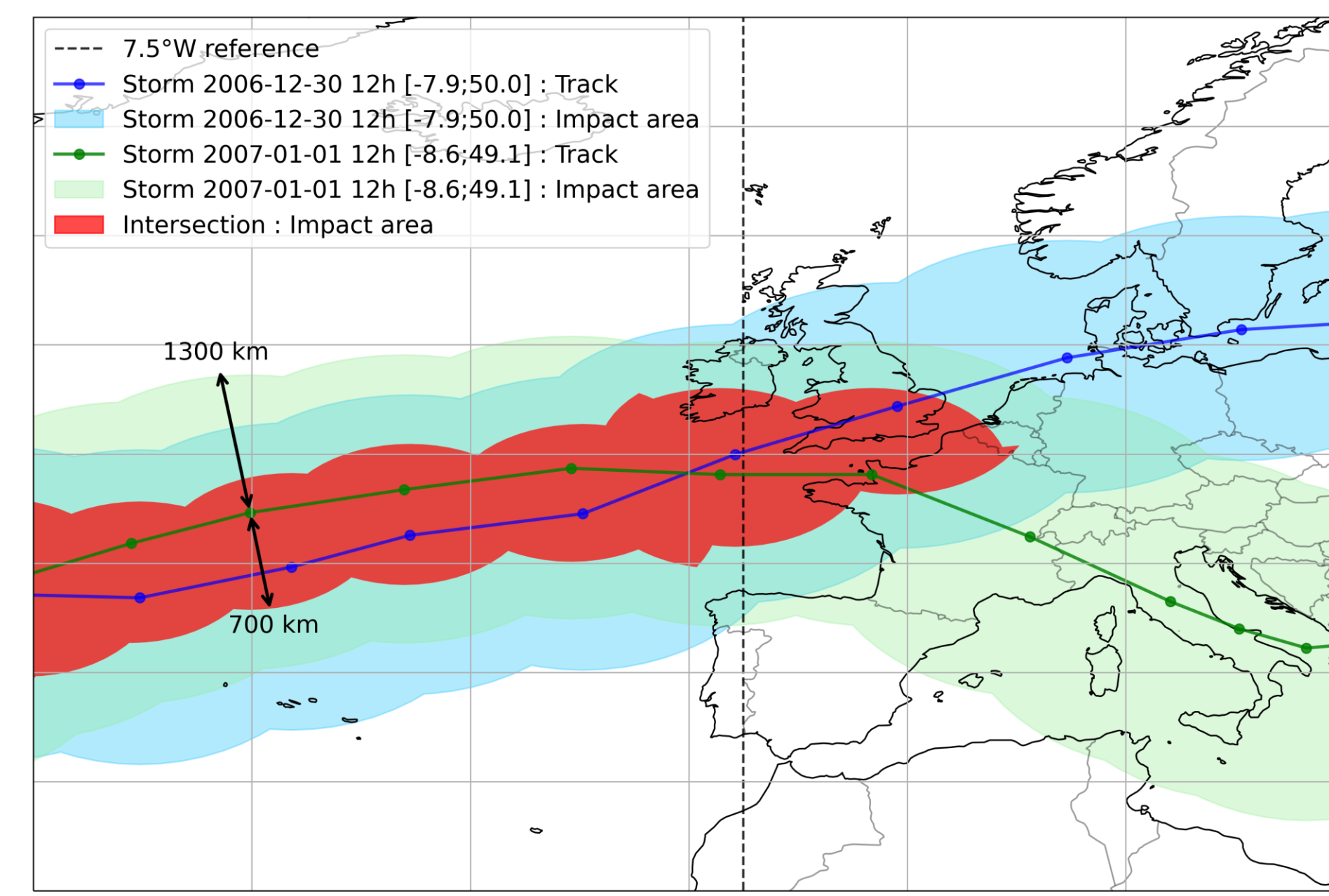
Temporal windows [3days to 6months]

• Damage **≈120k** claims 1998-2025

Generali IARD, Houses, Gather ERA5-res
Linked to storm events [2]

• Exposure **≈1m** policies varying yearly

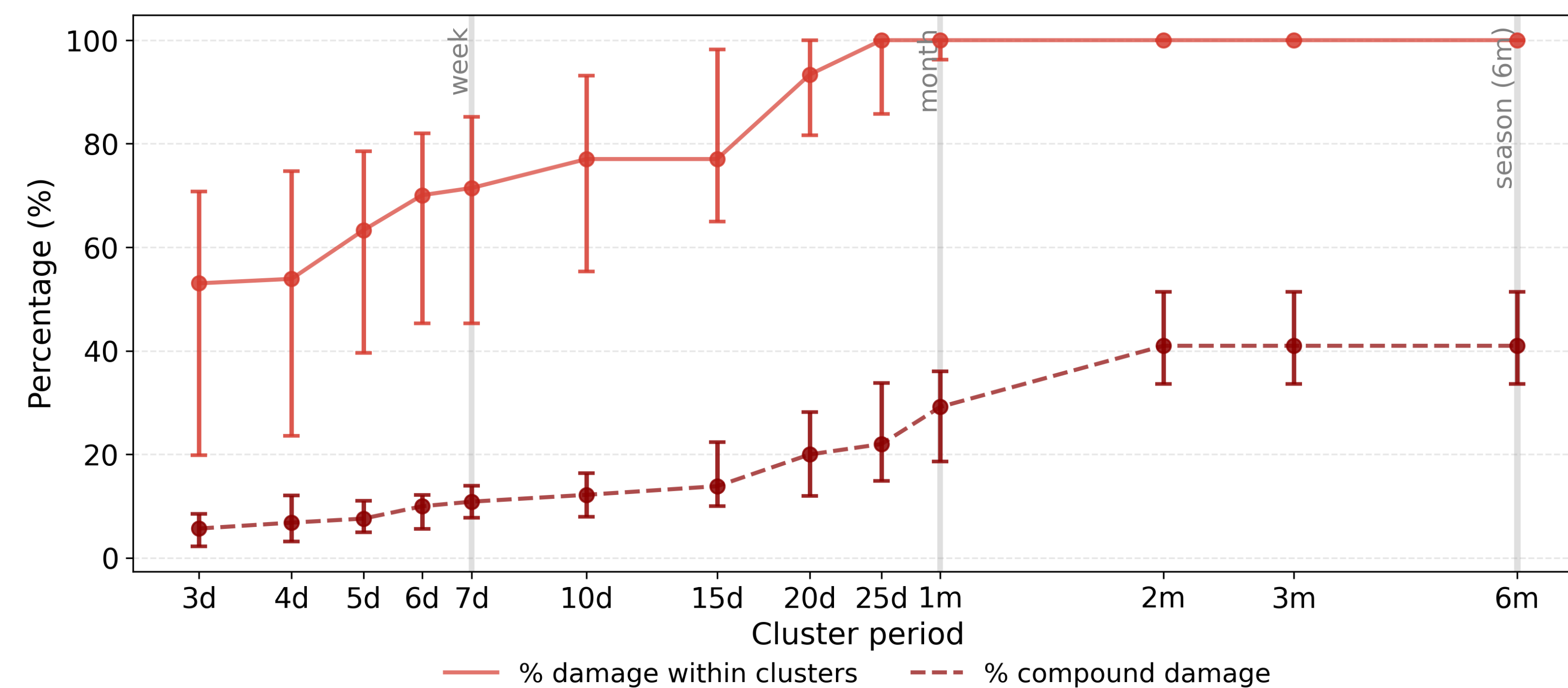
Generali IARD, Houses, Gather ERA5-res



3 Temporally compounded damage

Compound damage = damage associated with successive wind events locally

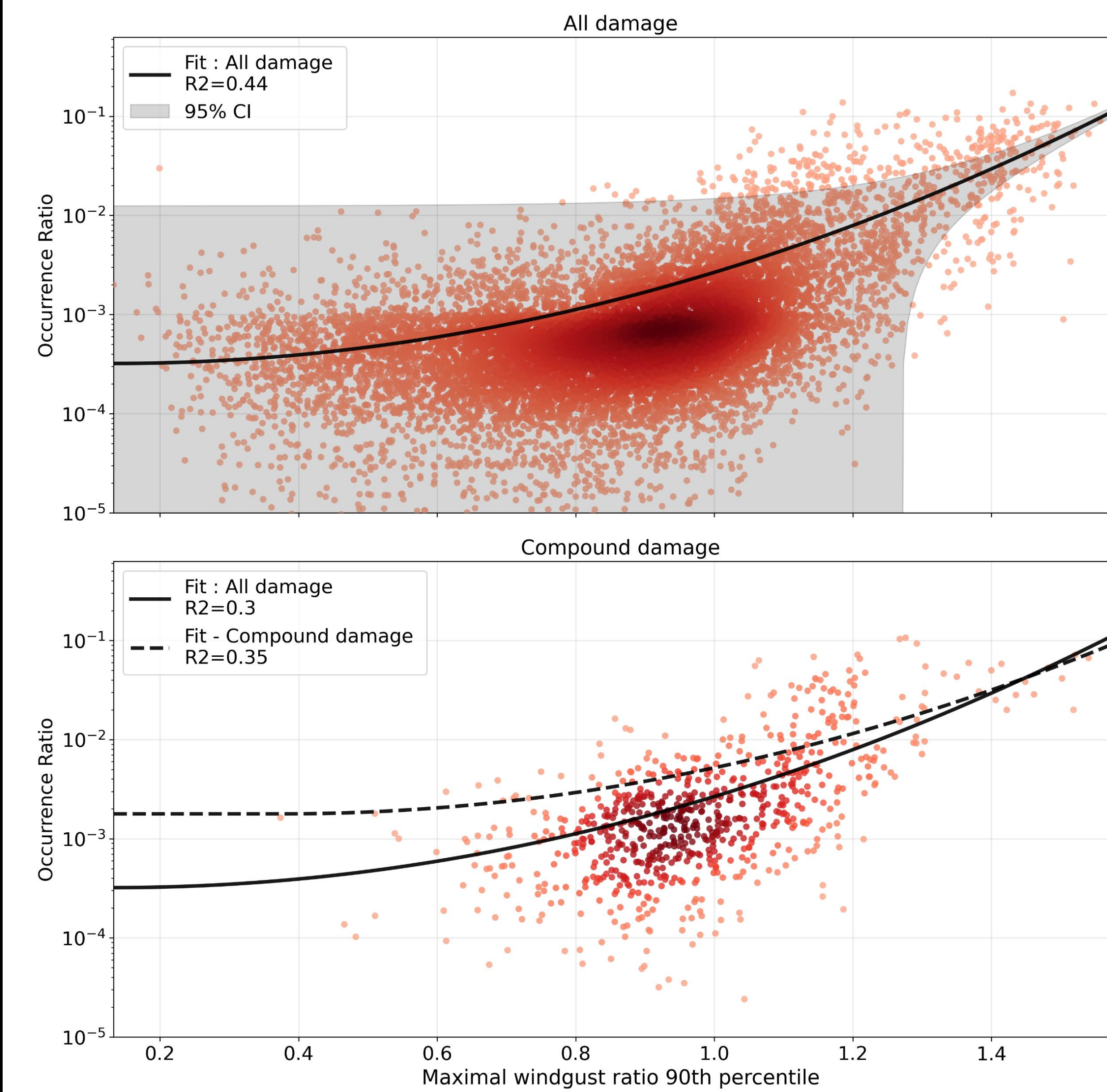
- Most of the damage is associated with cluster of storms but subject to important seasonal variability
- Few damage present temporally compounding of the windgusts



4 Methods – Vulnerability curves

Focus 4d clusters

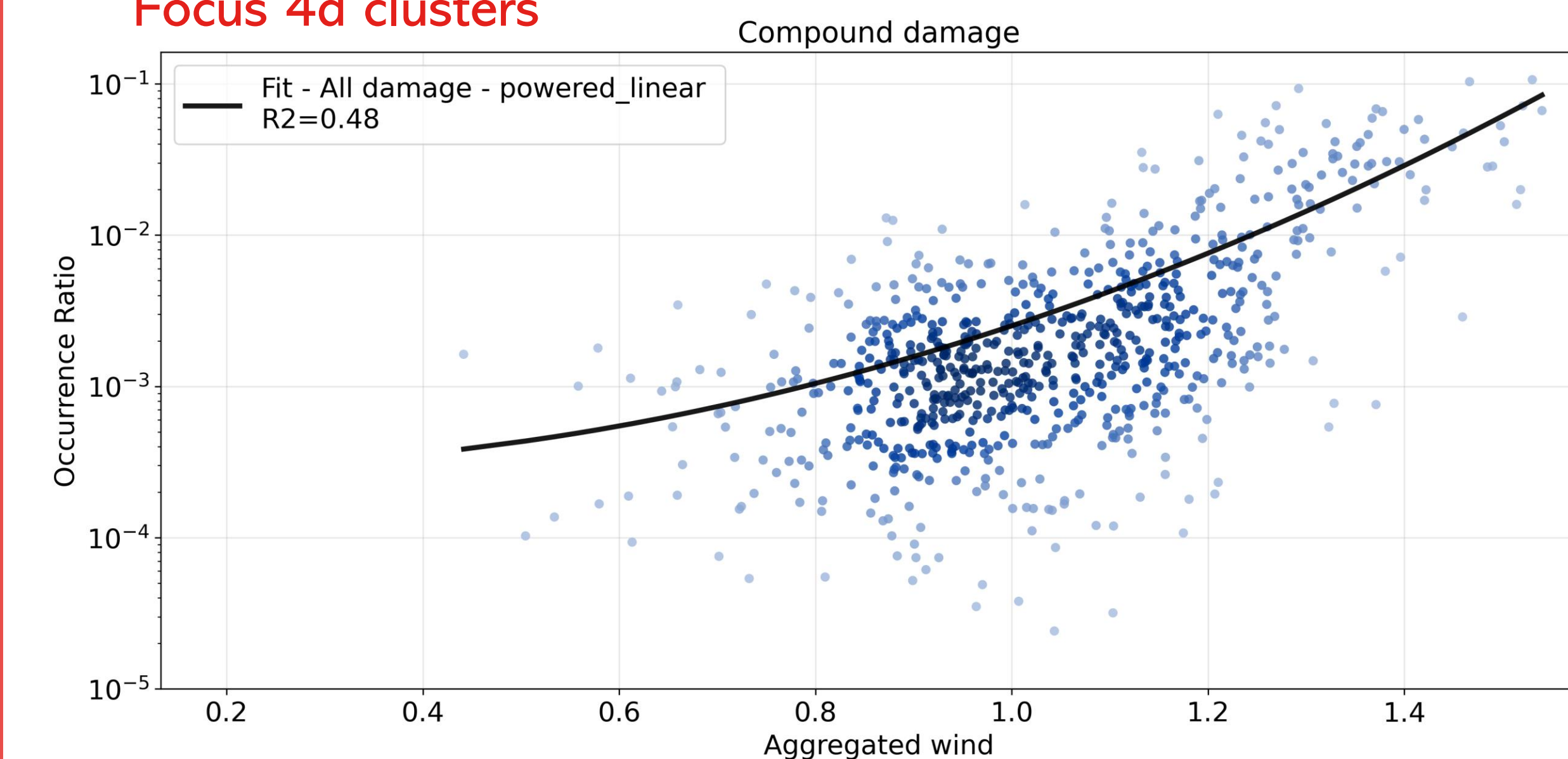
$$\text{Occurrence Ratio}(x, v) = \frac{\#Claims(x, v)}{\#Policies(x, v)} = \begin{cases} e^{\alpha v^2 + b v + c} & \text{if } v \geq v_{min} = \frac{-b}{2a} \\ e^{\alpha v_{min}^2 + b v_{min} + c} & \text{otherwise} \end{cases}$$



- Important variability in the occurrence ratio
- Bad performances over compound damage points
- Higher expected occurrence ratio over temporally-compounded damage

7 Results – Vulnerability curves

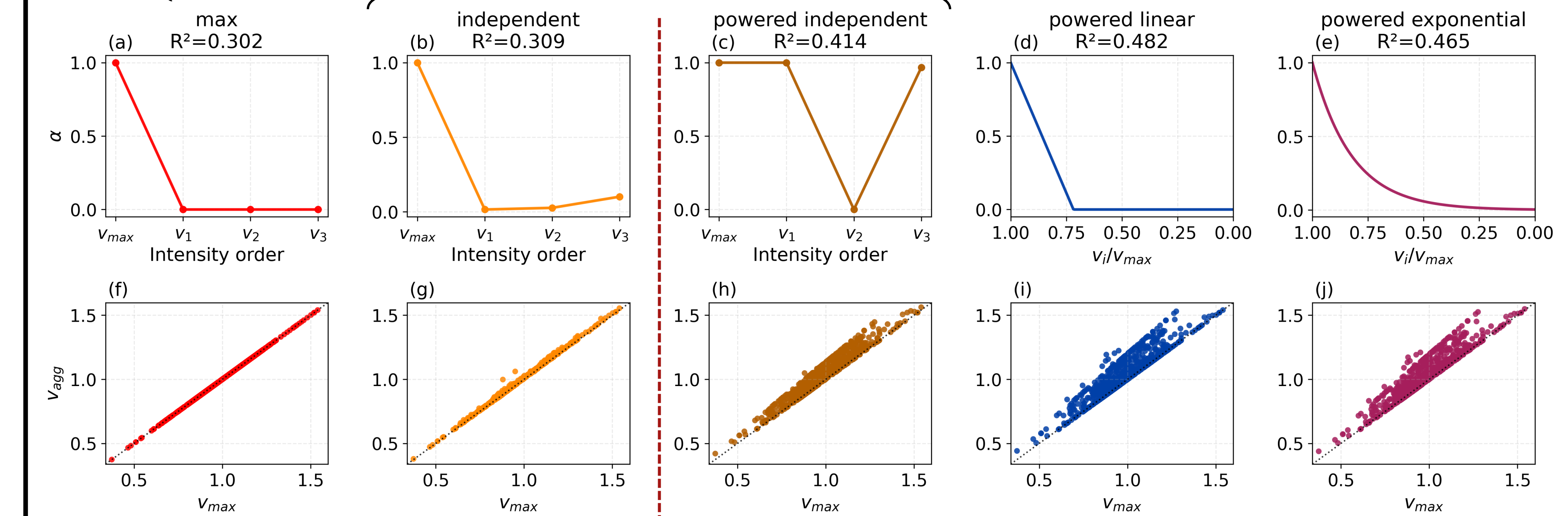
Focus 4d clusters



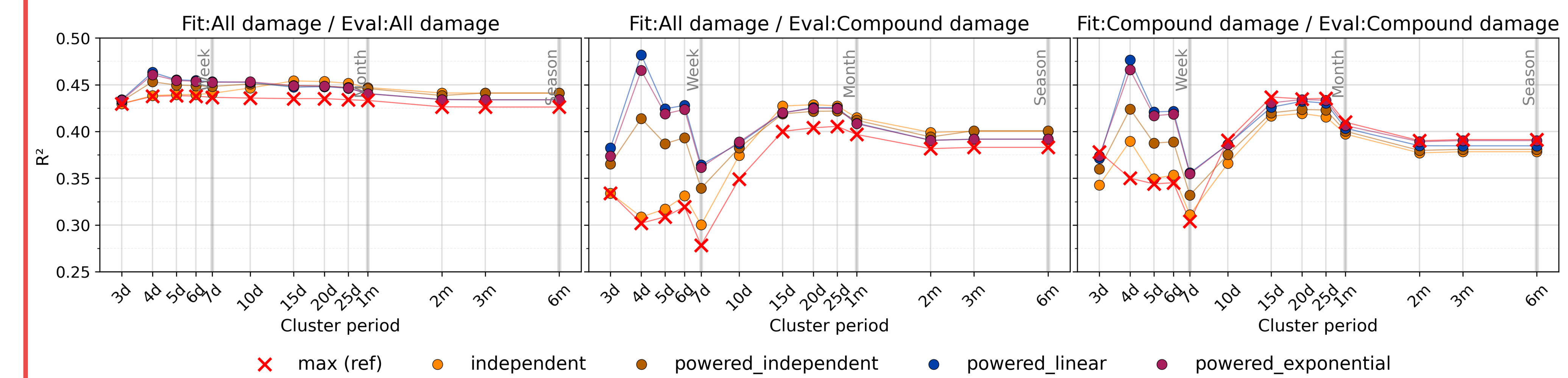
5 Methods – Wind aggregation

$$V_x^{agg} = \sum_{i=0}^n \alpha_i v_i$$

$$\alpha_i = \begin{cases} 1 & \text{if } v_i = v_{max} \\ 0 & \text{otherwise} \end{cases}$$



6 Results – Scores



- Increase of the performances of the all-damage fit when adding with the aggregated wind models
- Performances equivalents to the compound-damage fit when changing the wind aggregation method

8 Conclusion

- For short-duration clusters (<7 days):
At most 15% of damage arise from temporally compounded wind
Damage from temporally compound wind events is greater than what is expected from the observed local maximum
Performances are improved by aggregating wind not only on the maximal wind gust
- For longer-duration clusters (>1 month):
Alternative aggregation methods offer less improvement.
Total seasonal damage is primarily driven by the maximum wind event within the season.

[1] Fédération France Assureurs, 2024
[2] Hasbini, L., Yiu, P. (2025) NHESS <https://doi.org/10.5194/egusphere-2025-3138>
[3] Fédération France Assureurs, 2000
[4] Dacre, H.F., Pinto, J.G. (2020) NPJ Clim. Atmos. Sci. 3, 48. <https://doi.org/10.1038/s41616-020-00152-9>
[5] van Ederen, D., Fonseca-Cerda, M.d.S., Botzen, W.J.W. et al. (2025) npj Nat. Hazards 2, 43 <https://doi.org/10.1016/j.wace.2024.100661>