

Spatial decoupling of wind-solar production and system efficiency in Europe

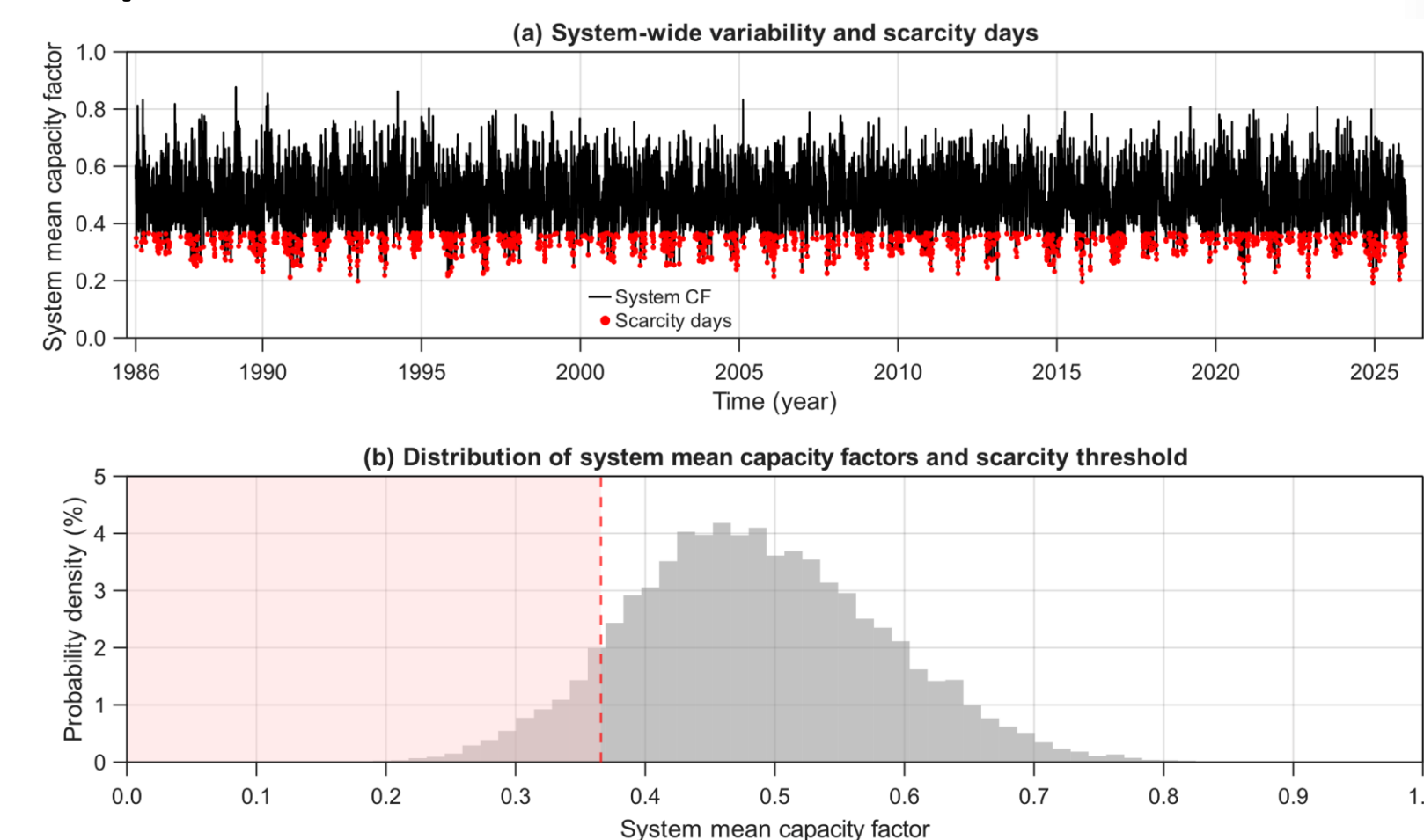
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Introduction

- Current deployment strategies prioritize regions with the highest average wind and solar resources.
- Assumption: Maximizing generation automatically improves system performance.
- But: Break down under system-critical low-supply conditions. Mismatch between deployment strategies and system-level resilience requirements.

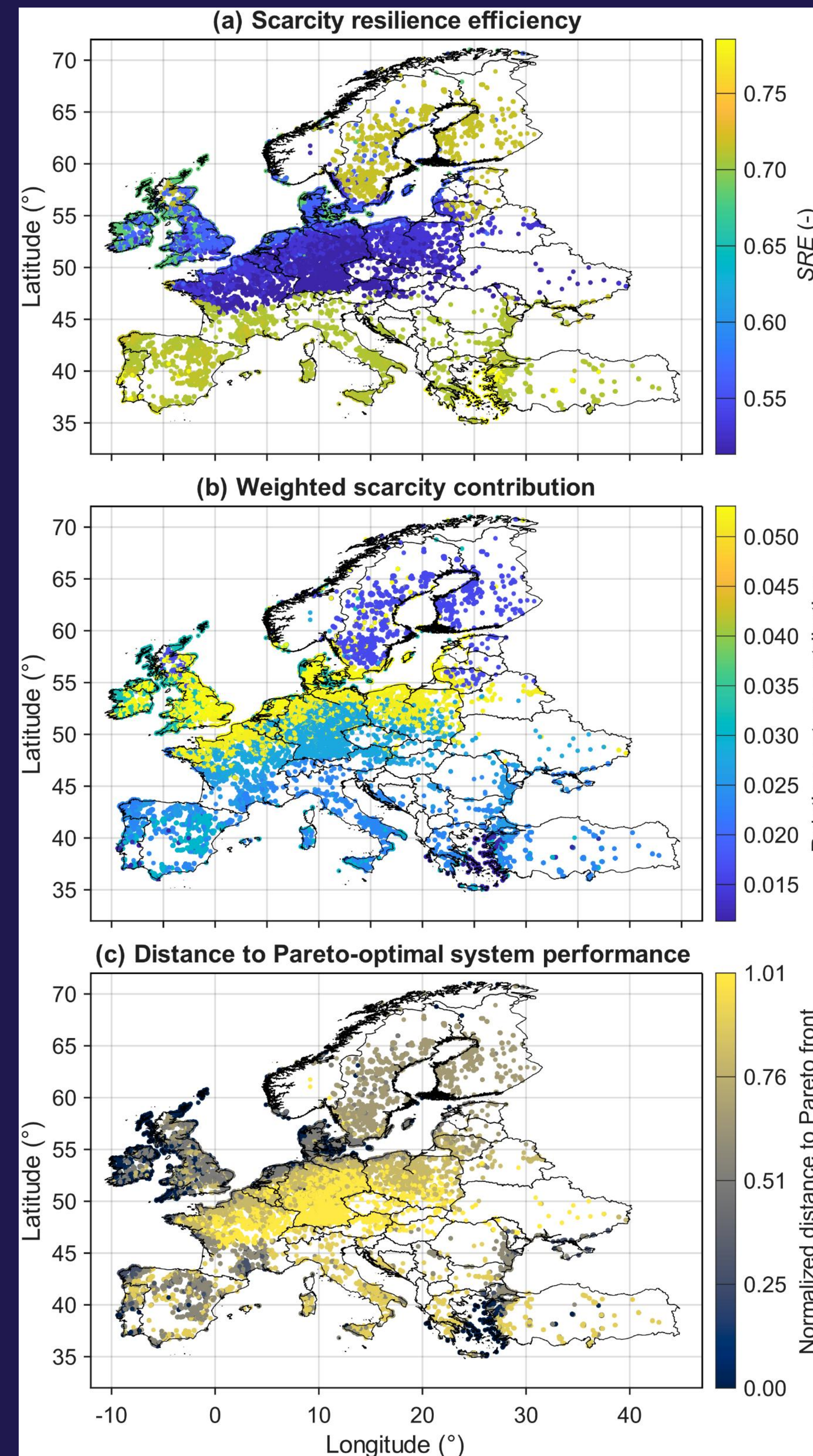
Methods

- Dimensionality reduction to extract dominant wind-solar variability structures.
- Clustering to identify coherent renewable generation regimes.
- Capacity factors evaluate contributions during low-supply periods.



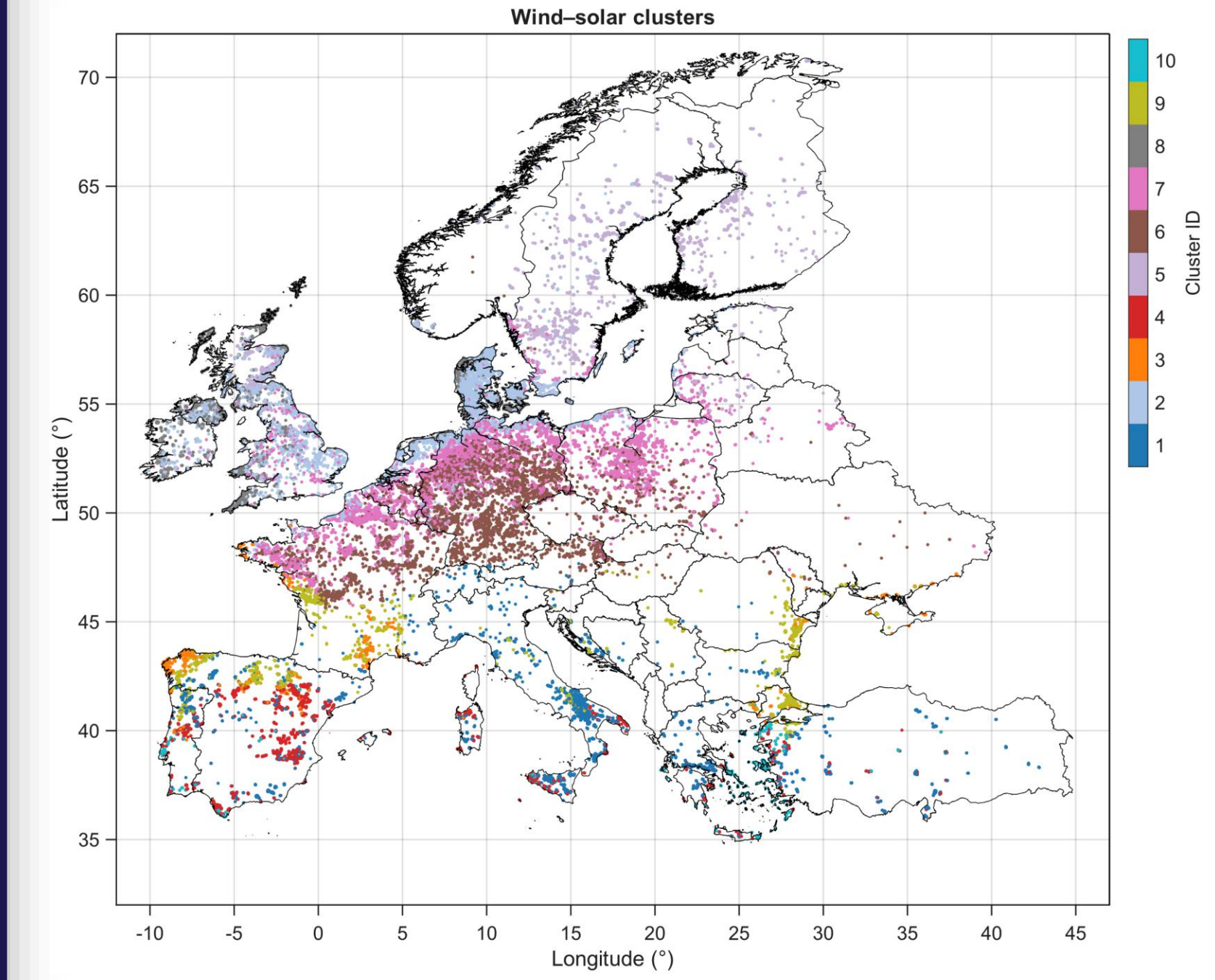
- Scarcity resilience efficiency compares generation during generation periods with long-term mean generation.

Performance of wind-solar clusters under scarcity conditions

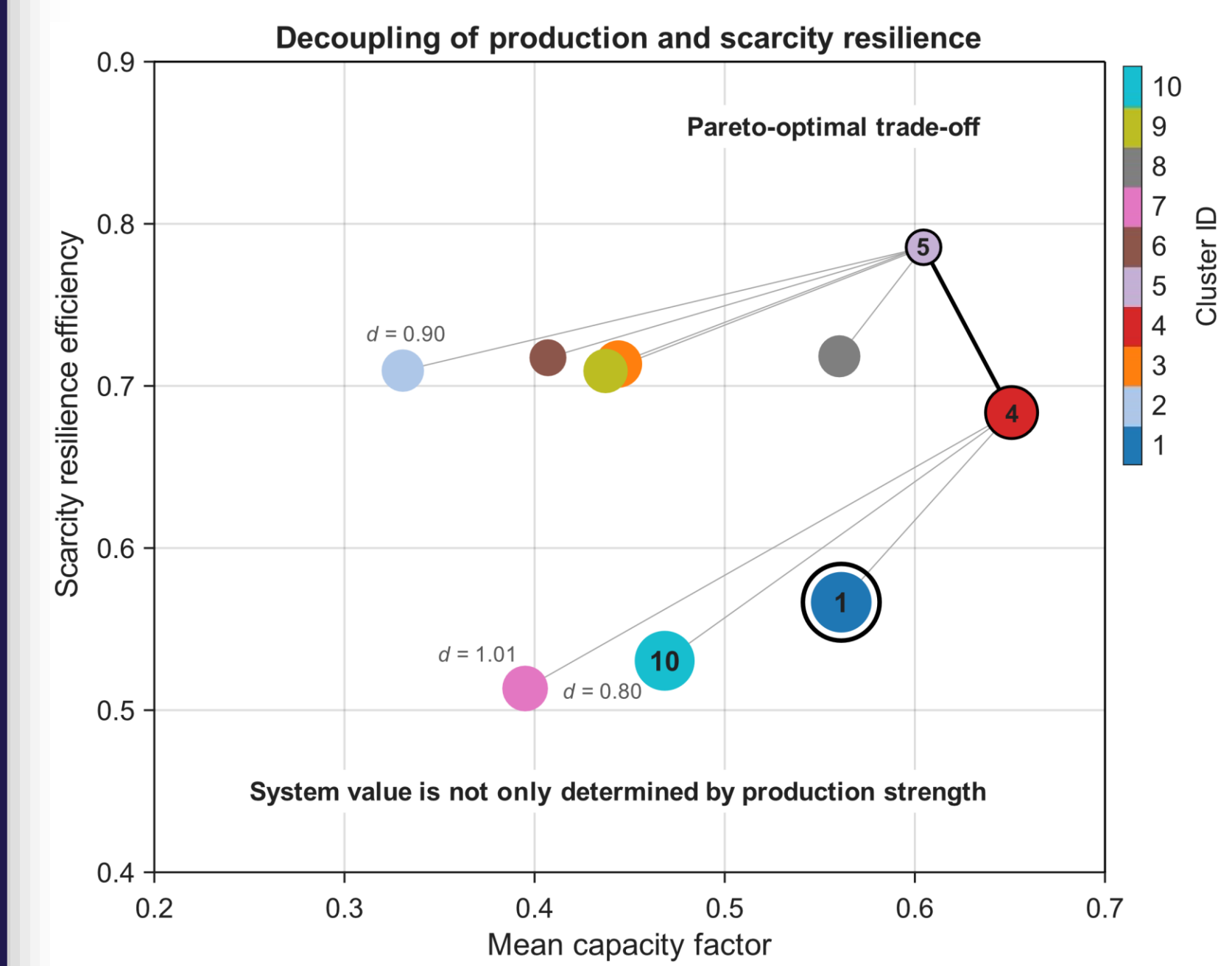


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Organization of wind-solar generation regimes across Europe



Decoupling of production strength and scarcity resilience efficiency



Conclusions

- Production strength and scarcity resilience efficiency are spatially decoupled across Europe.
- High renewable energy yield does not necessarily increase system resilience.
- Resilient energy systems require system-oriented rather than resource-oriented planning.

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