European windstorm risk at the regional scale under recent and future climate conditions

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IMPACT FORECASTING — Powered by Aon

1 Motivation

- **EU windstorms** are among hazard with the **highest** economic **loss** [1].
- In future climate, there is an **increase in storm loss** over **Core Europe** [2].

2 Advantages of this study

- **Estimate risks** of windstorms at the **regional scale**.
- **Estimate the loss** using Aon **Impact Forecasting** (IF) **storm loss model**.

3 Data

- **ERA5** reanalysis hourly surface wind speed and gust speed at 30 km resolution Oct-Mar (1959-2021).
- **Aon Impact Forecasting** storm loss model (ELEMENTS).
- **Euro-CORDEX (EUR-11)** 3-hourly surface wind speed (30 models) and daily maximum surface gust speed (20 models) at 12.5 km resolution (Oct-Mar) from historical (1976-2005) to future period (*GWL+2°C and +3°C).
  *GWL : global warming level

4 Methods

Loss was calculated using **Meteorological index** (MI) and **Loss index** (LI) [2].

$$LI = \sum_{i=1}^{N} \sum_{j=1}^{M} \left(\frac{v_{ij}}{v_{98ij}} \right)^3 . I\left(v_{ij}, v_{98ij} \right) . \boldsymbol{P_{i,j}} . \boldsymbol{L_{i,j}}$$

*discarded in MI

Vij: maximum wind speed within 72 hours
V98th ij: 98th percentile of daily maximum wind speed
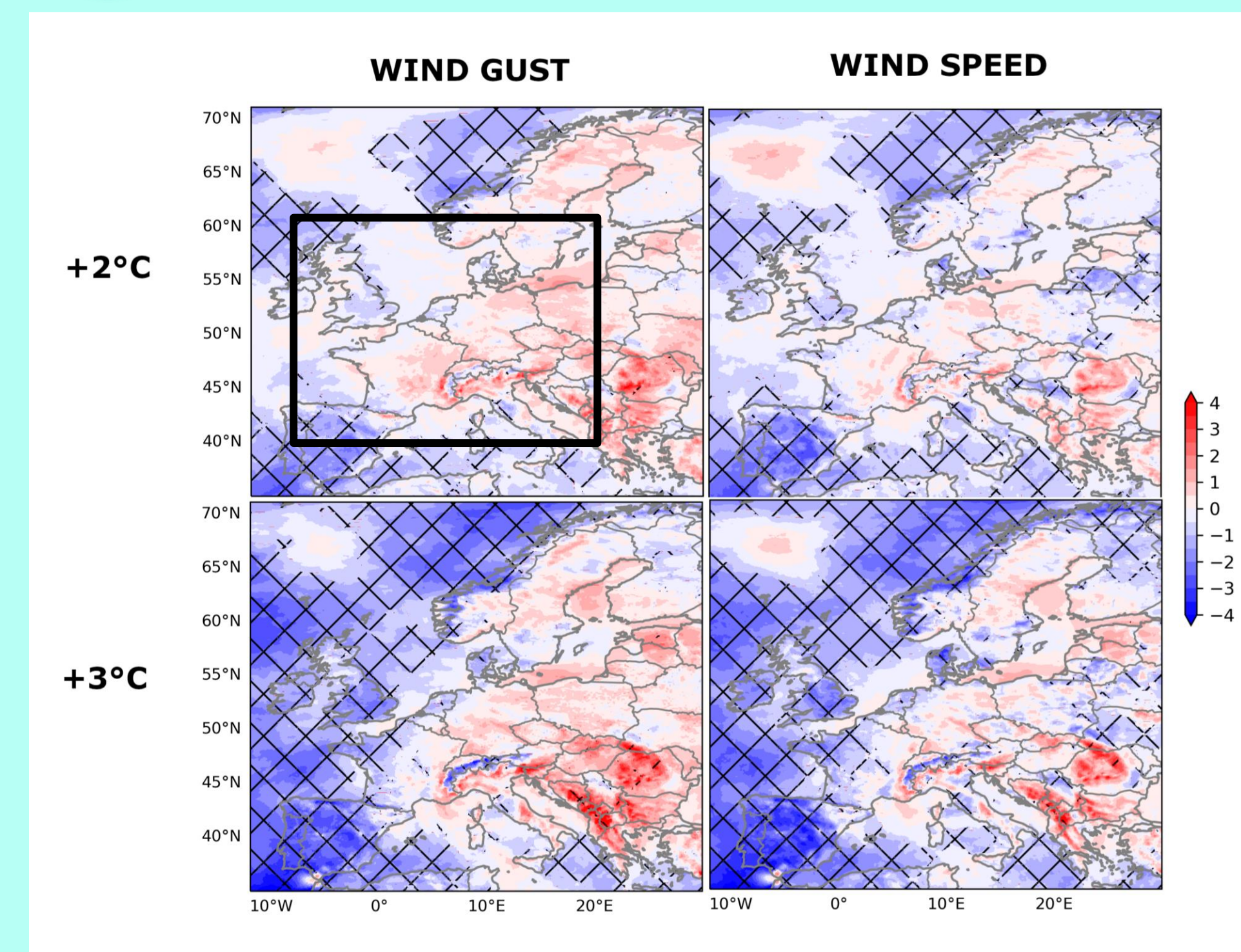*I (Vij.V98th): 0 if vij<v98th and 1 if vij>v98th*
P ij : population density
L ij : 0 if seas and 1 if land

" Section 6 : We only show loss based on LI"

EUR-11 MODEL CHAINS :

Global Climate Model (GCM) :
NorESM1-M **(2031 – 2060)** **(2057 – 2086)**
EC-EARTH **(2026 – 2055)** **(2051 – 2080)**
HadGEM2-ES **(2016 – 2045)** **(2037 – 2066)**
CNRM-CM5, and MPI-ESM-LR **(2029 – 2058)** **(2052 – 2081)**

*GWL +2°C
*GWL +3°C

Regional Climate Model (RCM) :
HIRHAM5
*COSMO-crCLIM-v1-1
*RACMO22E
*HadREM3-GA7-05
*RCA4
RegCM4-6

*Windgust data were used

5 How do the *winds change* between *future* and *current climates* ?

*Mean differences of 98th percentile of daily maximum wind **CORDEX RCP8.5 minus historical**.*
Cross lines: statistically significant change at 95 % confidence interval from t-test. Box : CORE EUROPE.

- The **changes in wind gust and speed** between future (*RCP 8.5) and historical periods are **small**.
- There is a **non-significant increase** of wind gust and speed over **part of Core Europe**.
- Under *GWL +3°C, there is statistically **significant decrease** of winds gust and speed over **Mediterranean, the UK**, and part of **France**.
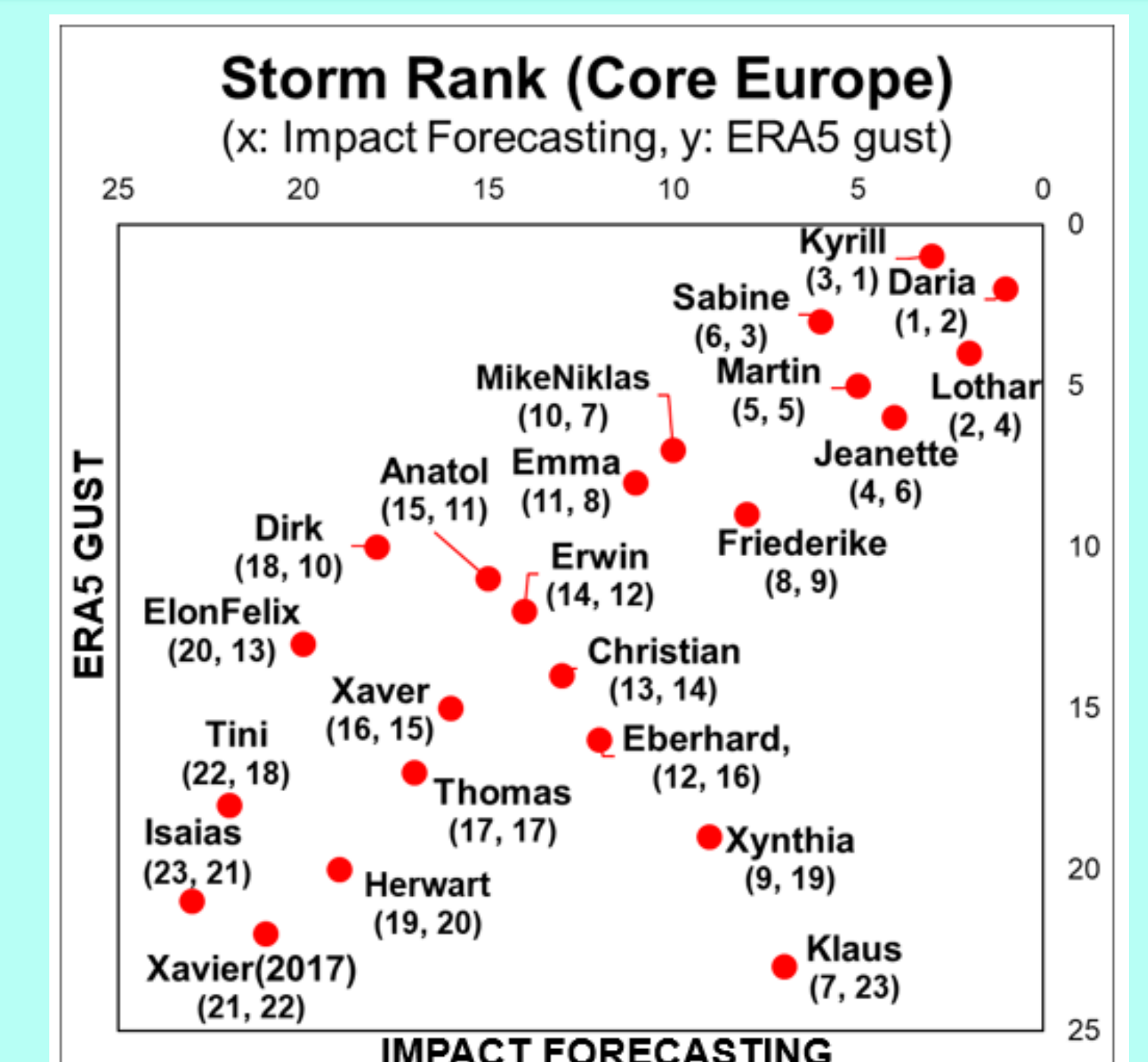
*RCP : Representative Concentration Pathway

6 How are the *windstorm losses* based on ERA5 gust and *IF model* ?

Losses (Core Europe)
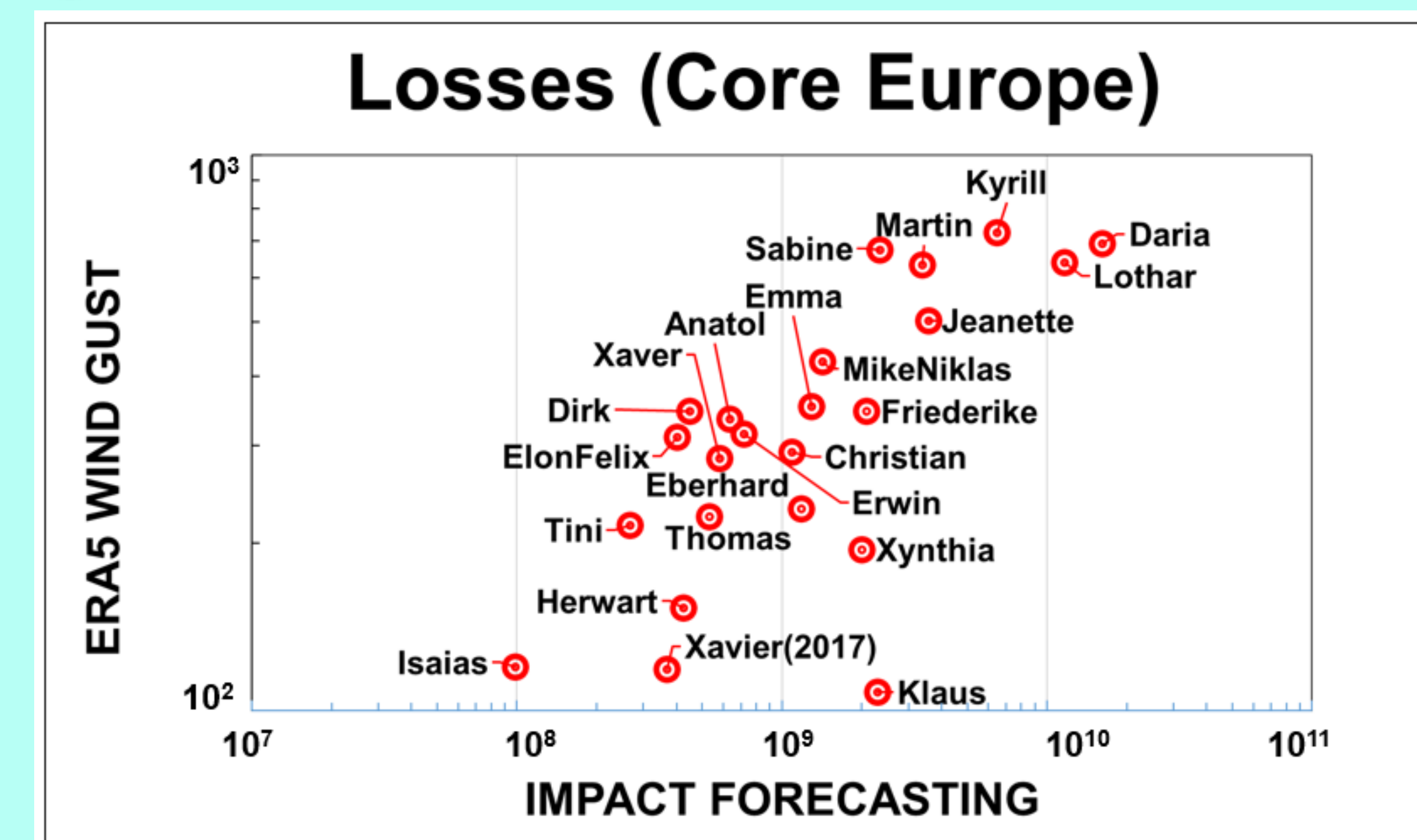
*Comparison between **losses of ERA5 wind gust** and **losses** of Impact Forecasting.*

Ratio between **big storms** (Daria, Kyrill, Lothar) and **weak storm** (Isaias) are **larger in IF** than ERA5.

Storm Rank (Core Europe)
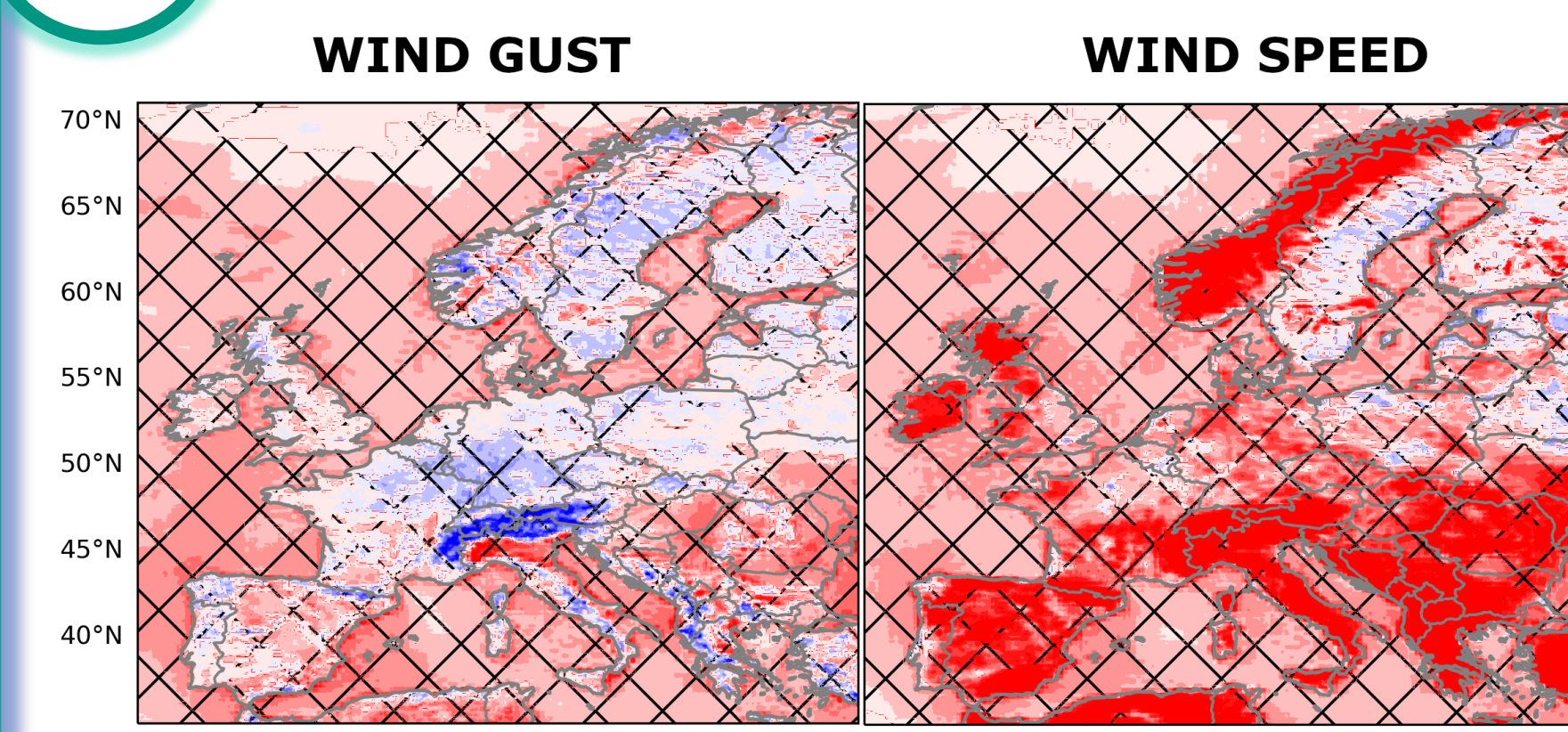(x: Impact Forecasting, y: ERA5 gust)

*Comparison of **storm rank** from **losses of ERA5 wind gust** and **losses of Impact Forecasting**.*

Storm rank shows **consistency**, especially for **big storms**.

7 OUTLOOK

*Mean differences of 98th percentile of daily maximum wind **CORDEX minus ERA5**.*
Cross lines: statistically significant change at 95 % confidence interval from t-test.

- ✓ Euro-CORDEX **bias correction**.
- ✓ Estimate the **windstorm damage** using **convection-permitting regional climate model** simulations.
- ✓ Calculate the **return levels** and **return periods** of European windstorms.

References

[1] Aon. 2023. 2023 Weather, Climate and Catastrophe Insight. https://www.aon.com/weather-climate-catastrophe/index.html.
[2] Pinto JG, Karremann MK, Born K, Della-Marta PM, Klawa M. 2012. Loss potentials associated with European windstorms under future climate conditions. Clim Res 54:1-20. https://doi.org/10.3354/cr01111

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