THE STORM CLUSTER OF FEBRUARY 2022 SEEN THROUGH SPECTRALLY NUDGED STORYLINES

Felipe de Luca Lopes de Amorim, Frauke Feser, Elke M. I. Meyer, Lidia Gaslikova, Ralf Weisse

Helmholtz-Zentrum Hereon, Institute of Coastal Systems – Analysis and Modeling, Geesthacht, Germany.

4TH INTERNATIONAL WORKSHOP ON WAVES, STORM SURGES, AND COASTAL HAZARDS
Incorporating the 18th International Waves Workshop

Image Source: https://www.dlr.de/eoc/;
Mühr et al. (2022) DOI: 10.5445/IR/1000143470

CONTEXT

- In February 2022, Europe experienced a cluster of extratropical storms — Dudley, Eunice, and Franklin — impacting the region in rapid succession.

Timeline:

- Feb 16: Storm Dudley (Ylenia)
- Feb 18: Storm Eunice (Zeynep)
- Feb 20: Storm Franklin (Antonia)
- Impacts: Winds >130 km/h in Germany; 196 km/h record in UK; heavy rain
- 16 fatalities, EUR 3.8 billion insured loss

- Goal: show event-based storylines and regional climate simulations with COSMO-CLM to evaluate the extreme event attribution to climate change — and what it could mean for coastal risk.

Source: dpa

Source: Matthias Bein/dpa-Zentralbild/ZB

Source: Kai Osthoff/dpa

Source: imago images/Hanno Bode

MOTIVATION

- This storm sequence was characterized by intense wind speed, coastal surge, and damage. But could climate change have amplified it?

STORYLINES

- Storylines = physically consistent versions of past or plausible events
- Keep event structure (storm track, sequence) constant
- Modify boundary conditions (GHG, SST)
- Rather than estimating probabilities, we ask: How would this storm cluster play out in a warmer world?

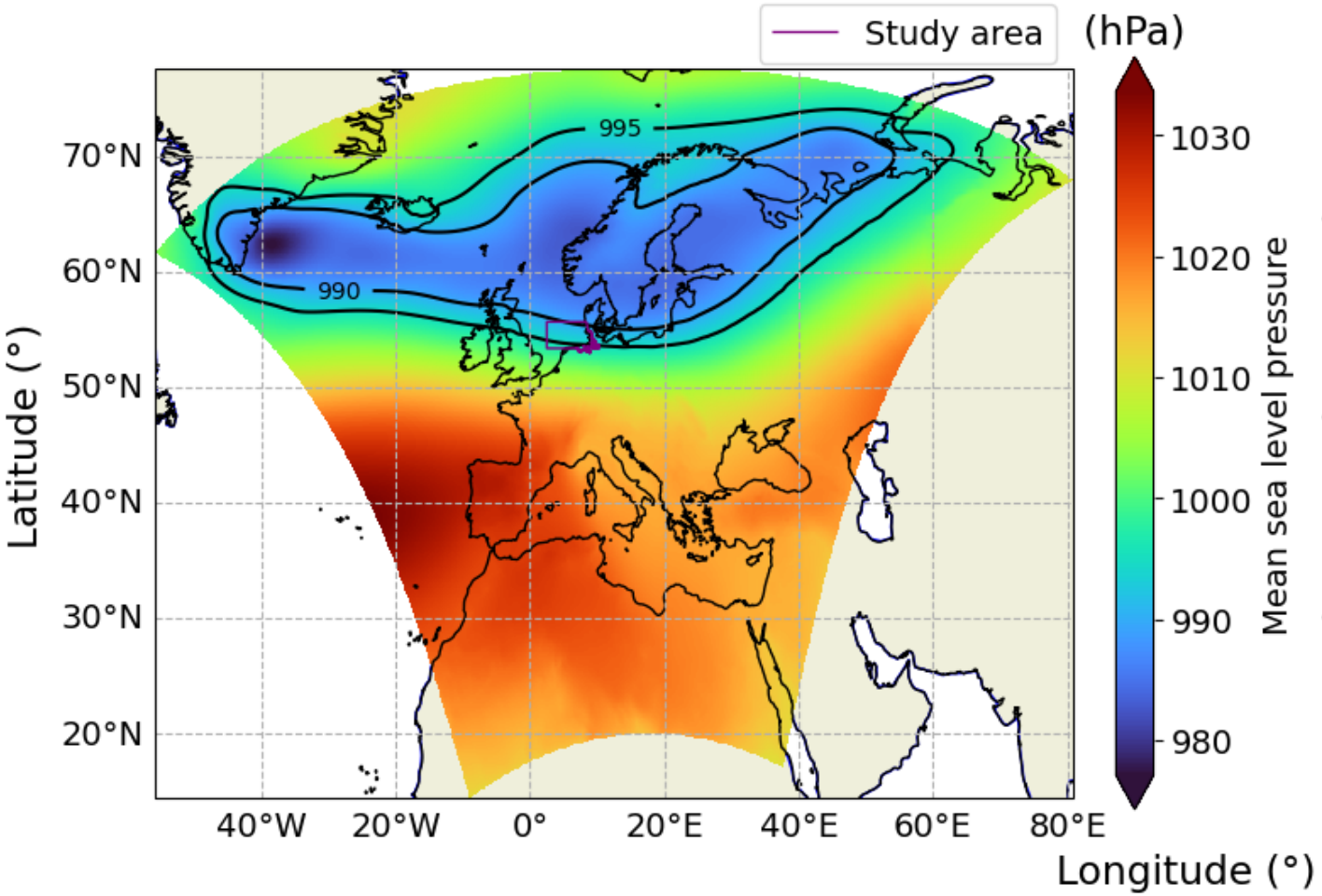
SIMULATIONS

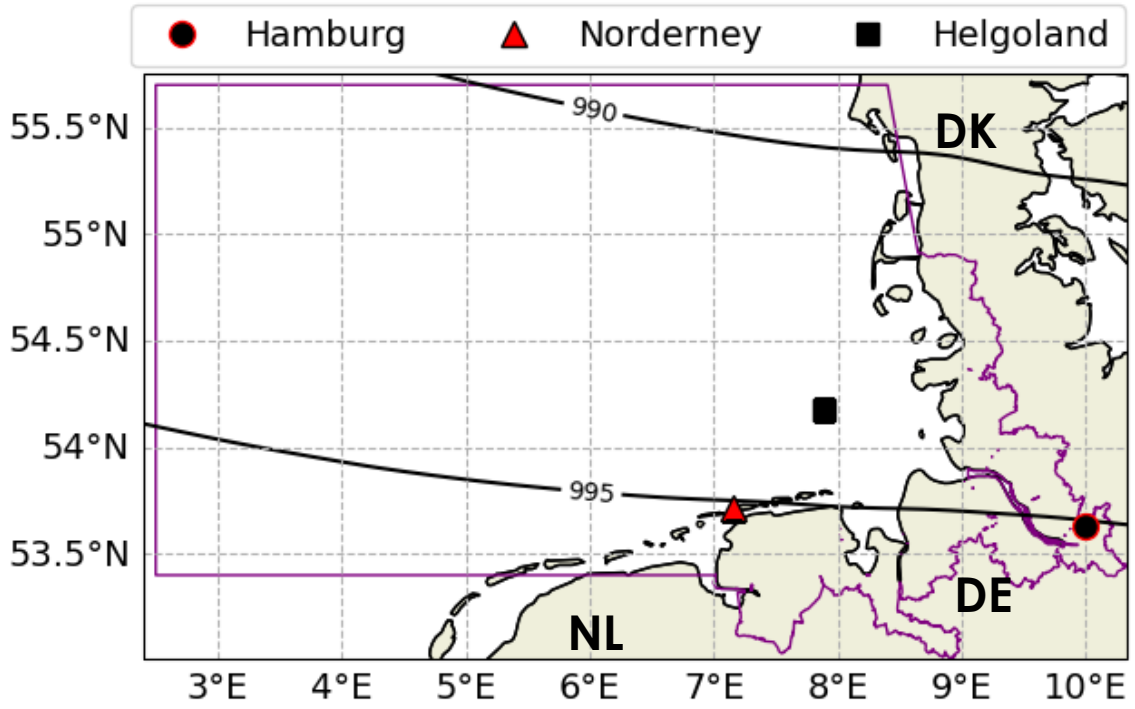
- COSMO-CLM: Regional climate model at ~0.11° (~12 km) resolution – forced by global ECHAM fields
- Spectral Nudging: Keeps large-scale circulation aligned with forcing fields – thermodynamic climate change (e.g., preserving synoptic-scale dynamics while changing thermodynamic background)
- Ideal for reconstructing observed events under alternate climates
- This approach preserves realism while testing climate-driven sensitivities.

- 5 simulations per storyline
- Mean and median ensemble
- 0.11° - EURO-CORDEX domain

Storyline	Forcing	Description
Pre-industrial	Pre-industrial SST/ GHGs	No climate change
Present	NCEP ECHAM	Present
+2°C, +3°C, +4°C	increased SSTs/GHGs	Warming scenarios

MODEL DOMAIN AND STUDY AREA





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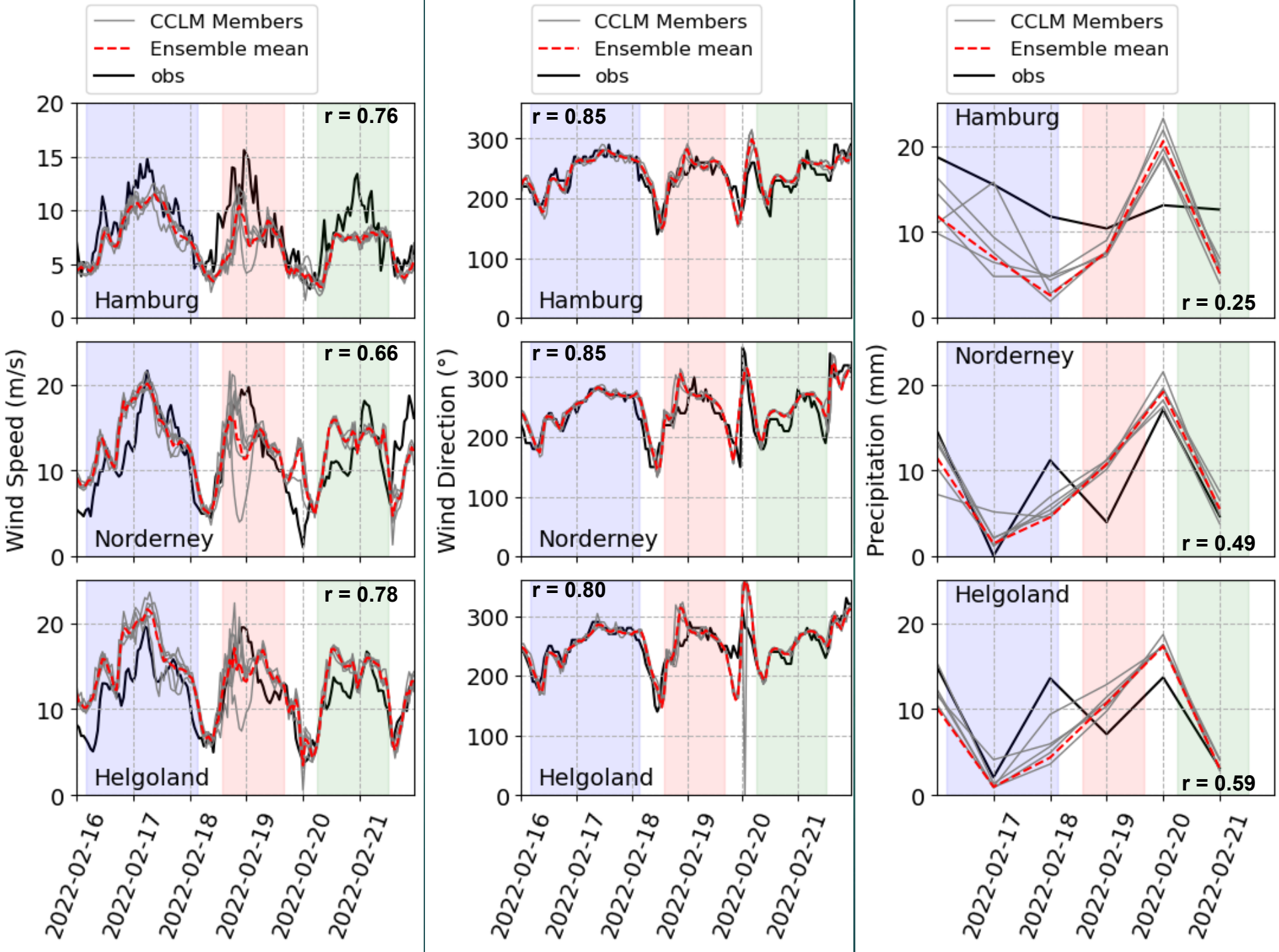
Water on the East Frisian Coasts

- Protection against natural hazards
- What happens if … extreme events / climate change

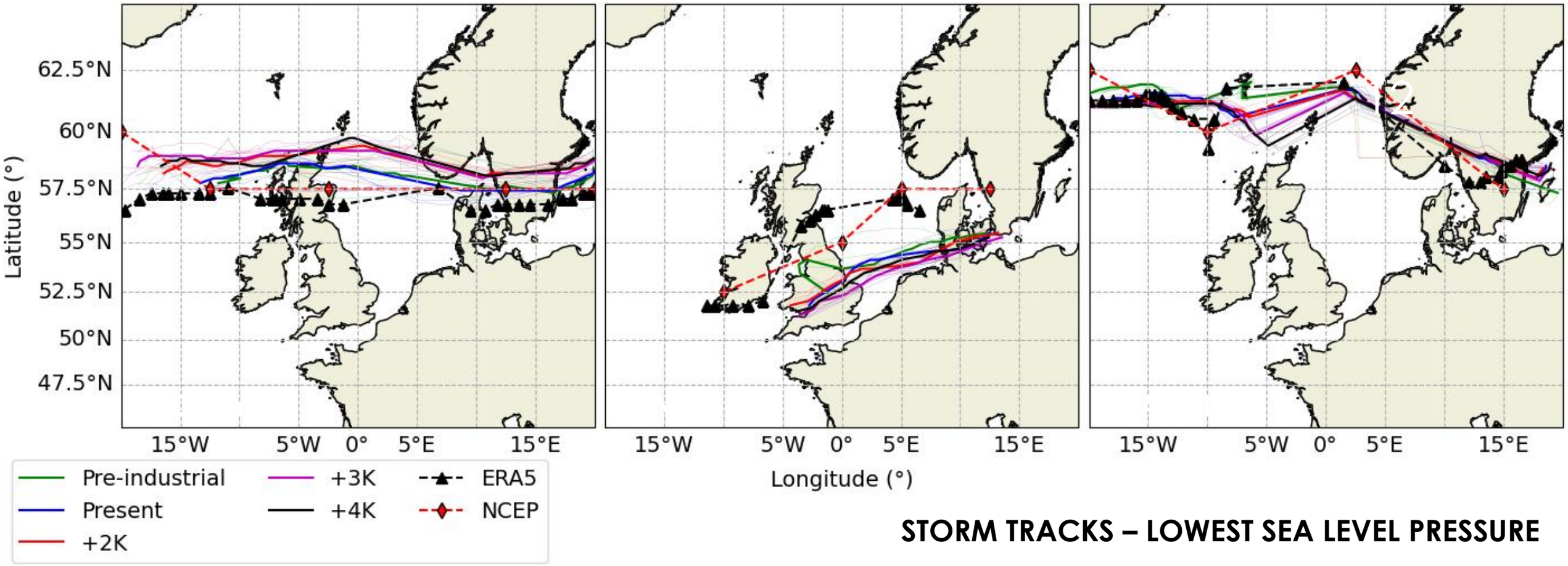
MODEL AND OBSERVATIONS

- Comparison of observed vs simulated wind speed and direction, precipitation and storm tracks

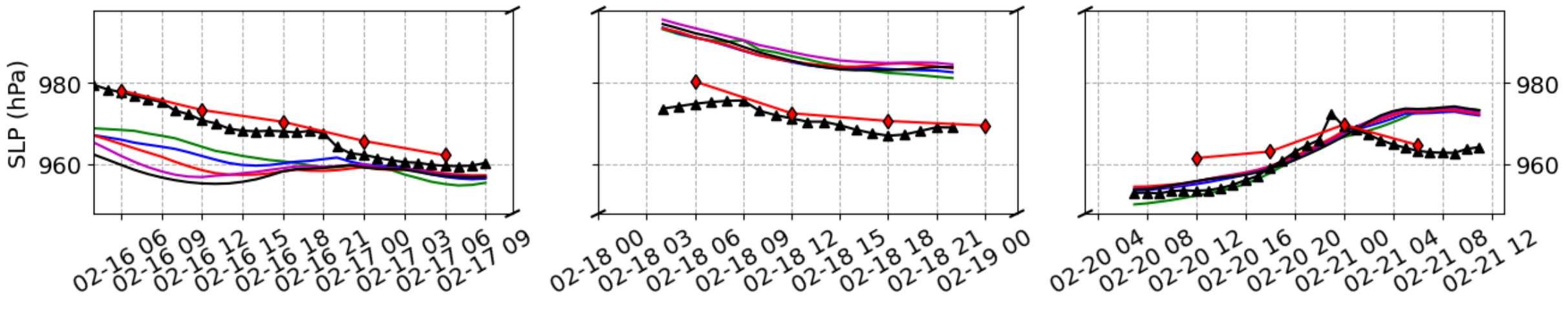


Storm
Dudley (1st storm)
Eunice (2nd storm)
Franklin (3rd storm)

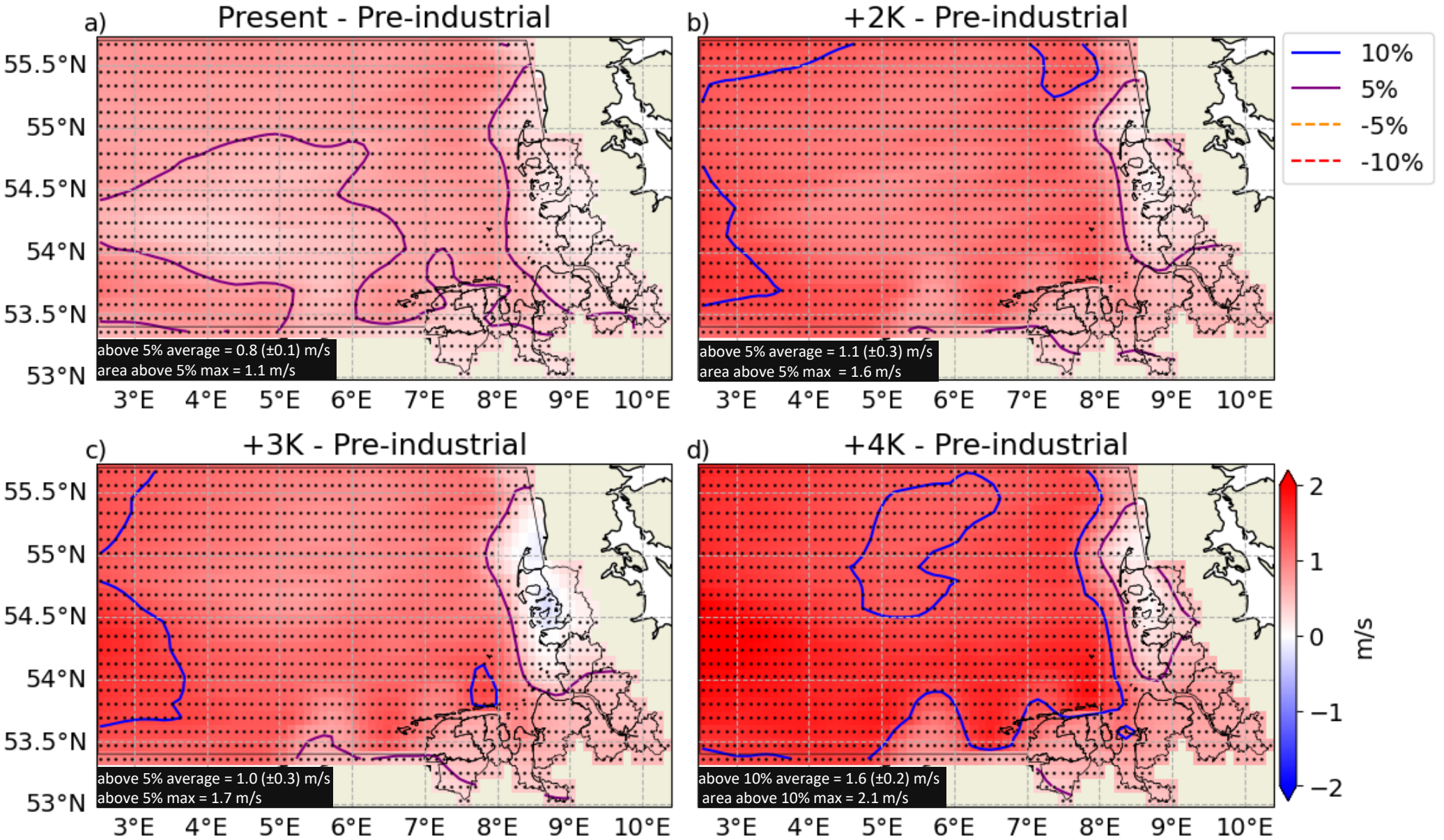
RESULTS



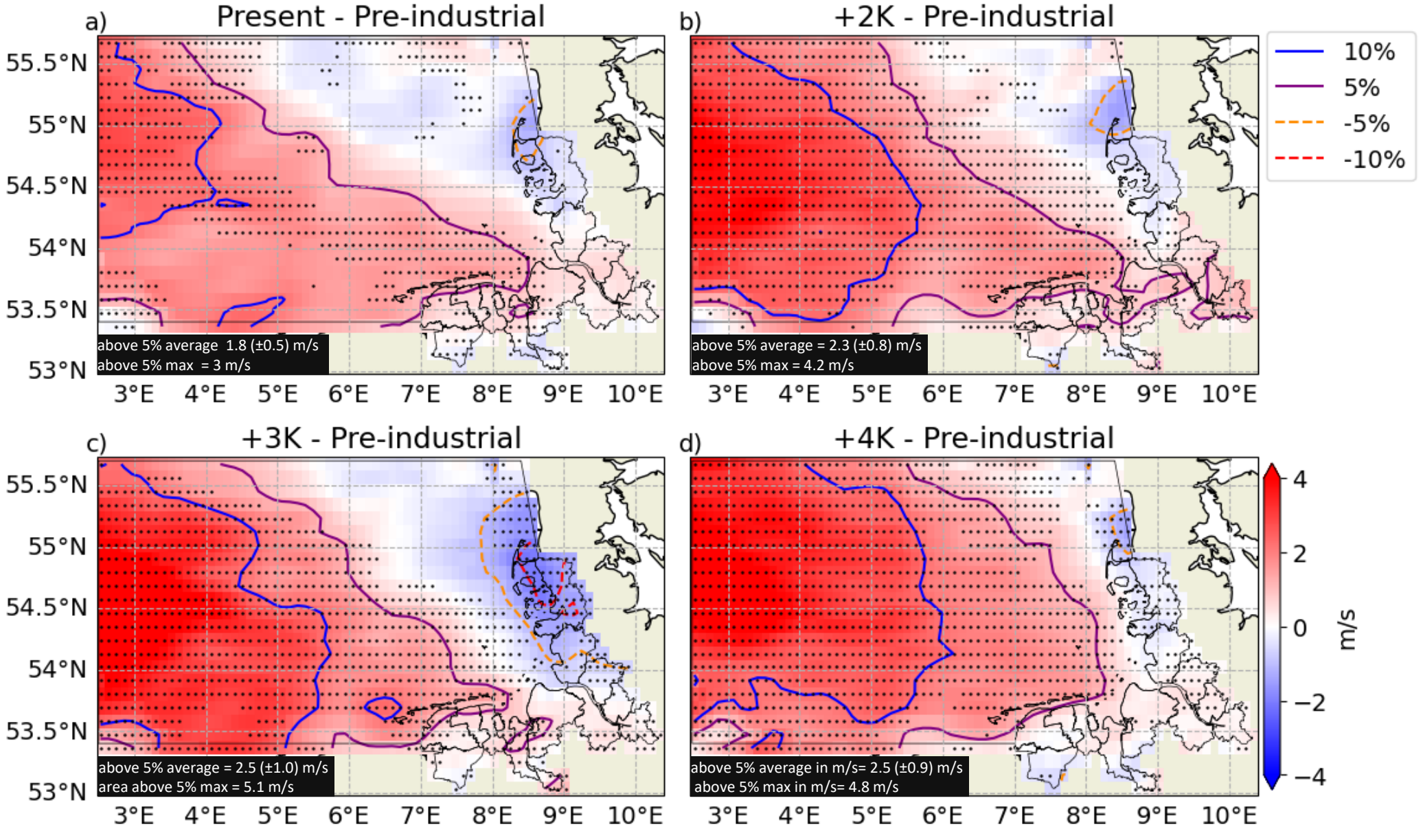
STORM TRACKS – LOWEST SEA LEVEL PRESSURE



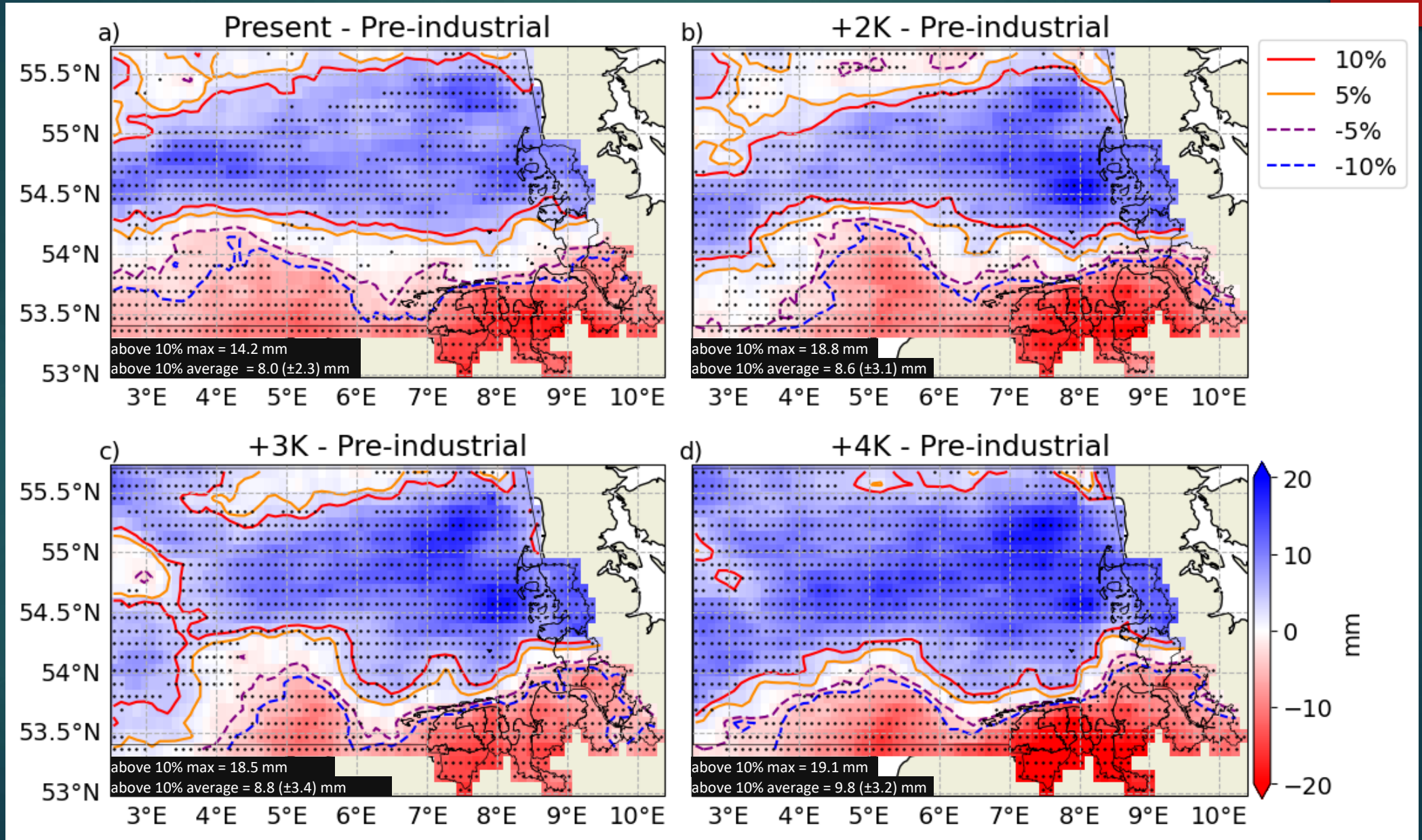
AVERAGED WIND SPEED (m/s)



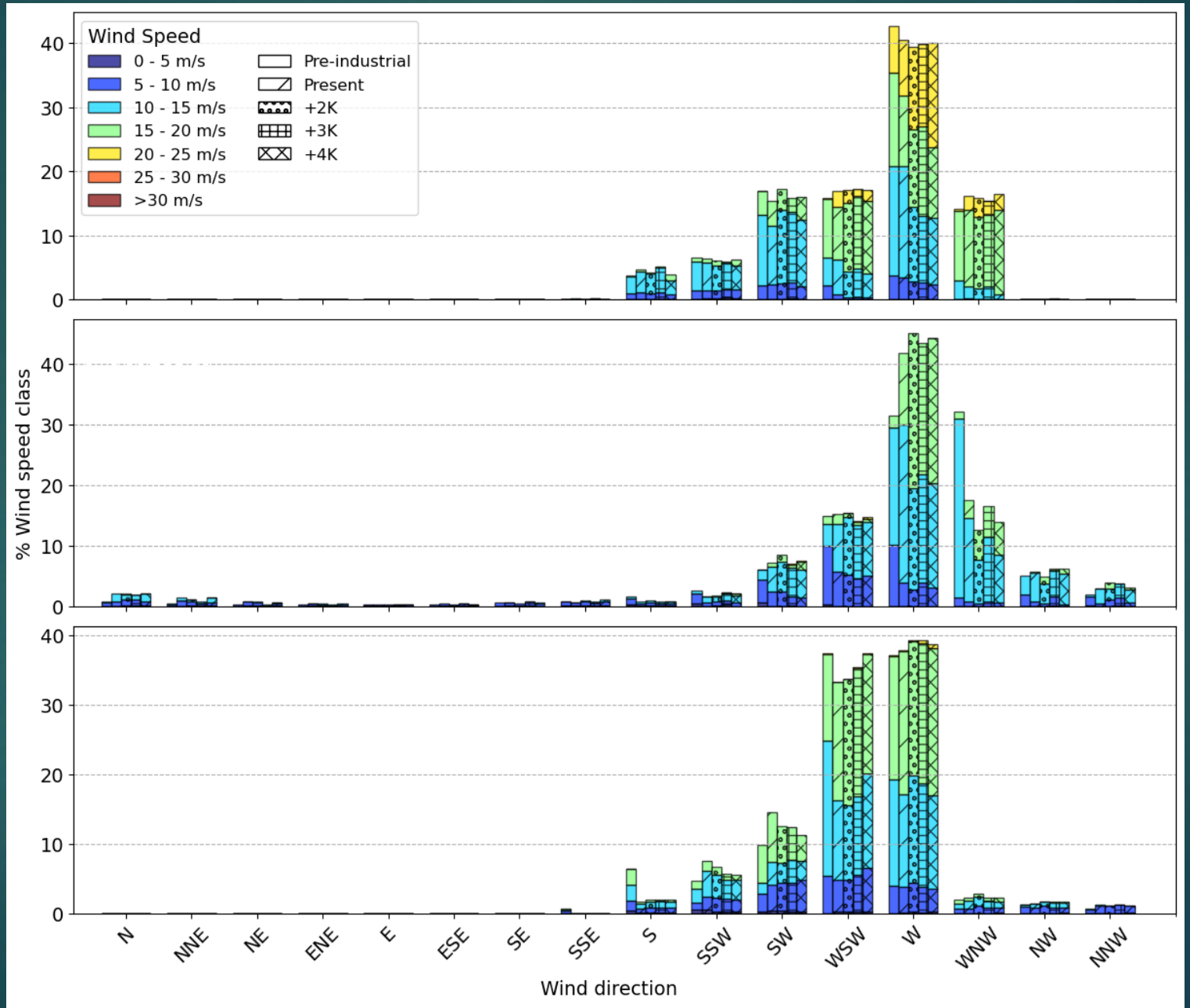
MAXIMUM WIND SPEED (m/s)



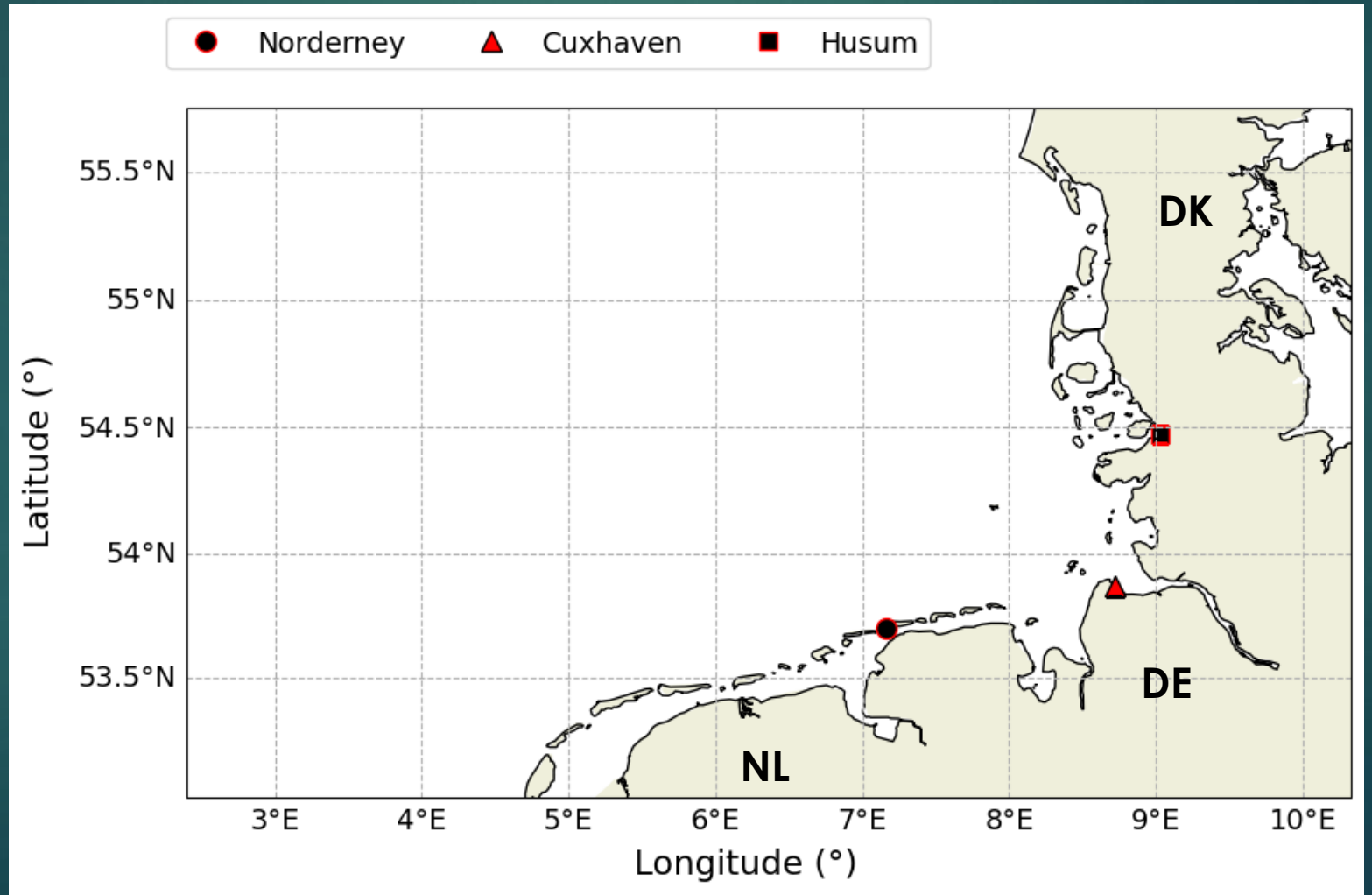
ACCUMULATED TOTAL PRECIPITATION (mm)

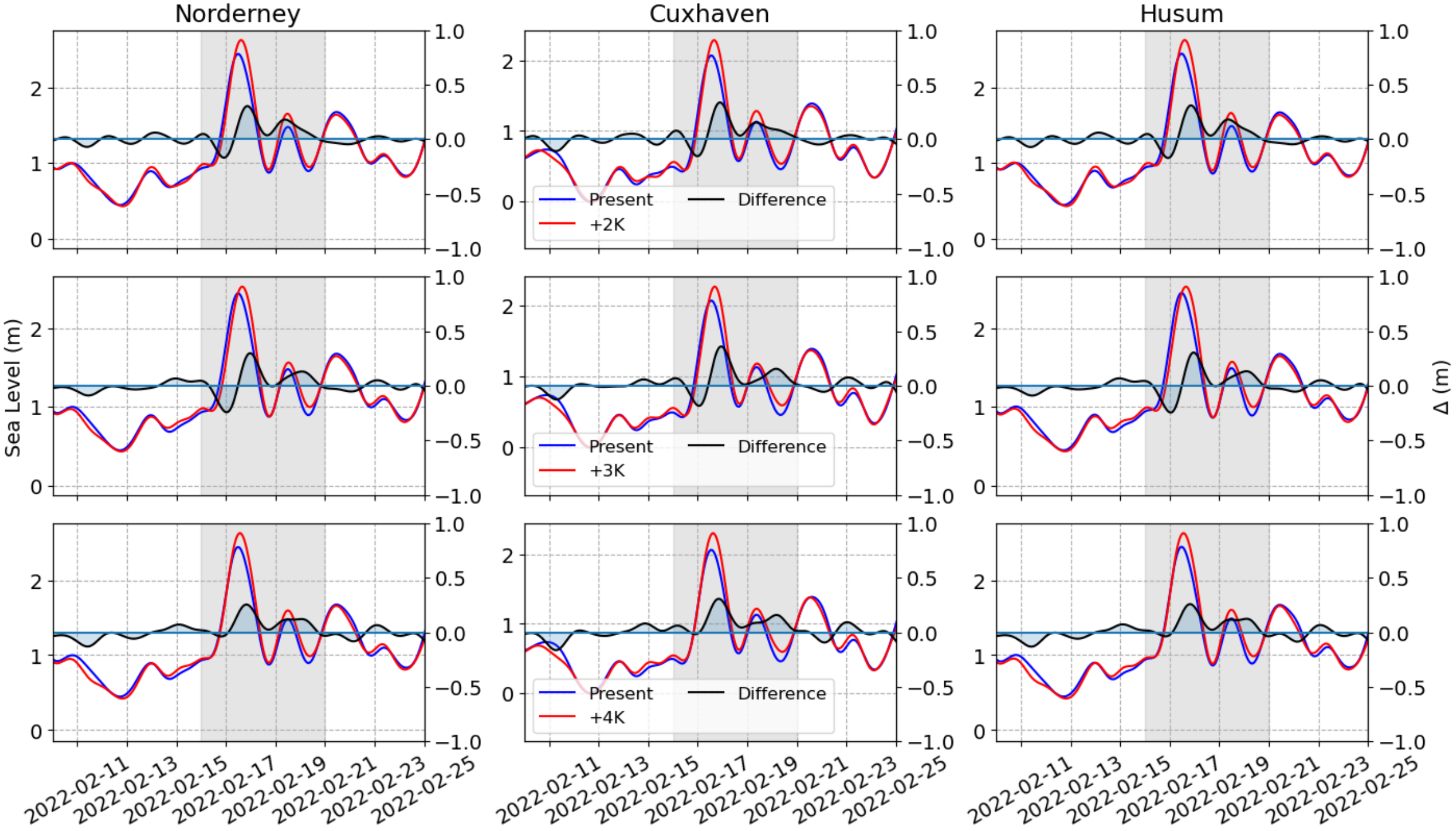


WIND SPEED CLASSES AND DIRECTION



SEA LEVEL SIMULATIONS WITH TRIM




Norderney
Cuxhaven
Husum
Sea Level (m)
Δ (m)
Present
+2K
Difference
Present
+3K
Difference
Present
+4K
Difference
2022-02-11
2022-02-13
2022-02-15
2022-02-17
2022-02-19
2022-02-21
2022-02-23
2022-02-25

Physical Climate Storyline

- is directly targeted at people's perception and response to risk;
- explore boundaries of plausibility - complementing approaches -> statistical analyses of model output.
- Planning emergency response scenarios under plausible worst cases
- Communicating climate risk without relying on abstract probabilities

- The February 2022 storm cluster offers a real-world testbed for climate attribution.
- COSMO-CLM with spectral nudging enables plausible, regional scale, event-focused storyline simulations.
- Climate change intensified overall storm events – **a small shift in wind intensity** could matter for coastal impact (wind-induced damage increases exponentially)

🔭 Future Directions:

- Extend to compound flood + wind damage simulations
- Integrate social vulnerability for actionable planning
- Coupling with surge models
- Exploring thermodynamic vs dynamic drivers separately

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THANK YOU!!!

- felipe.amorim@hereon.de