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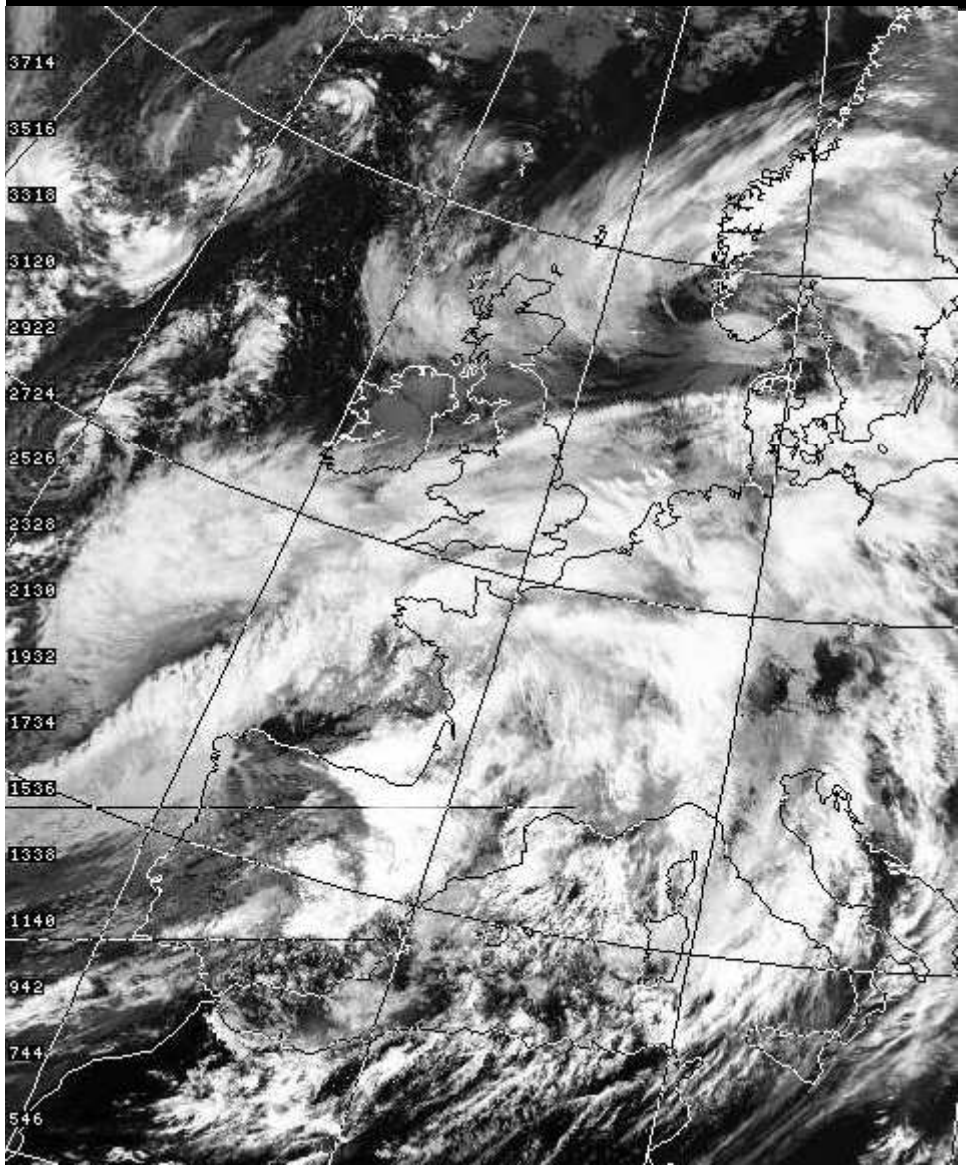
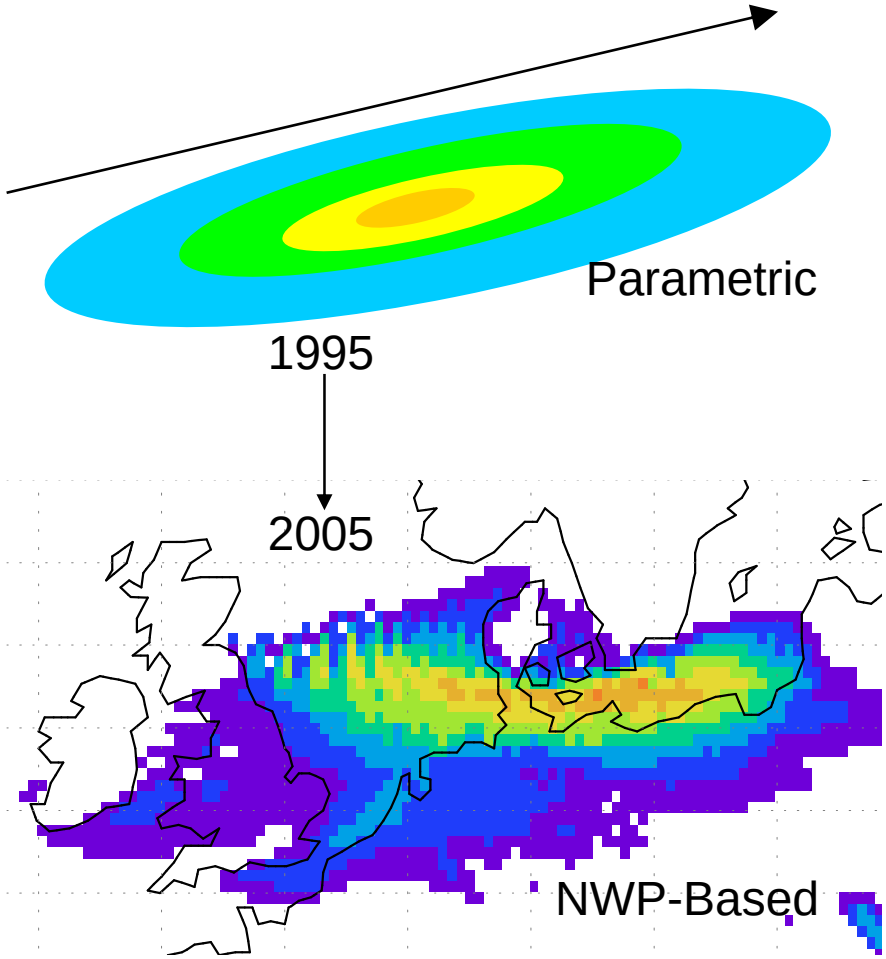


Estimating the damage potential of extra-tropical cyclones using the WRF model: is there an ideal resolution?

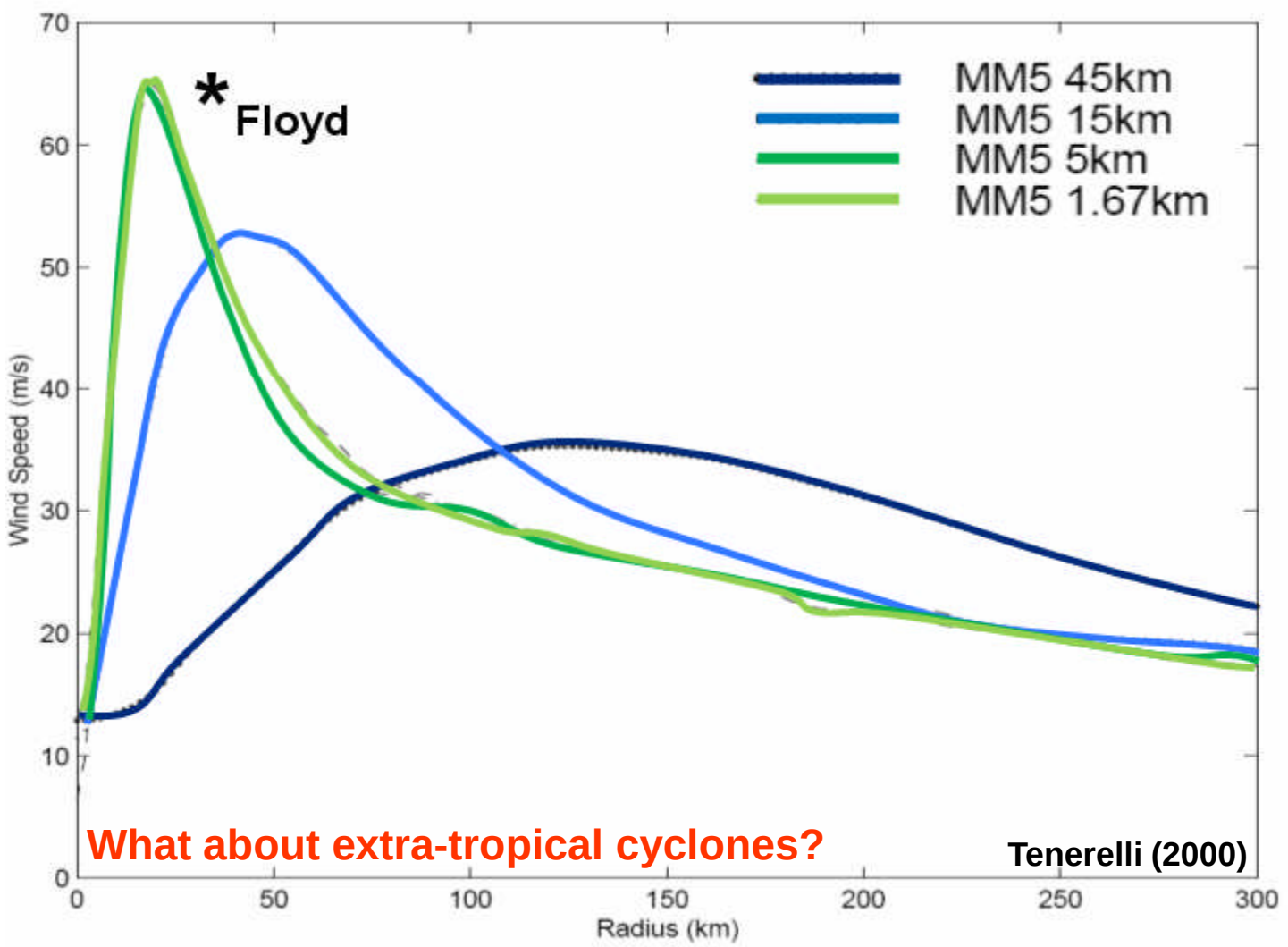
Richard Dixon

Catastrophe Modelling and NWP

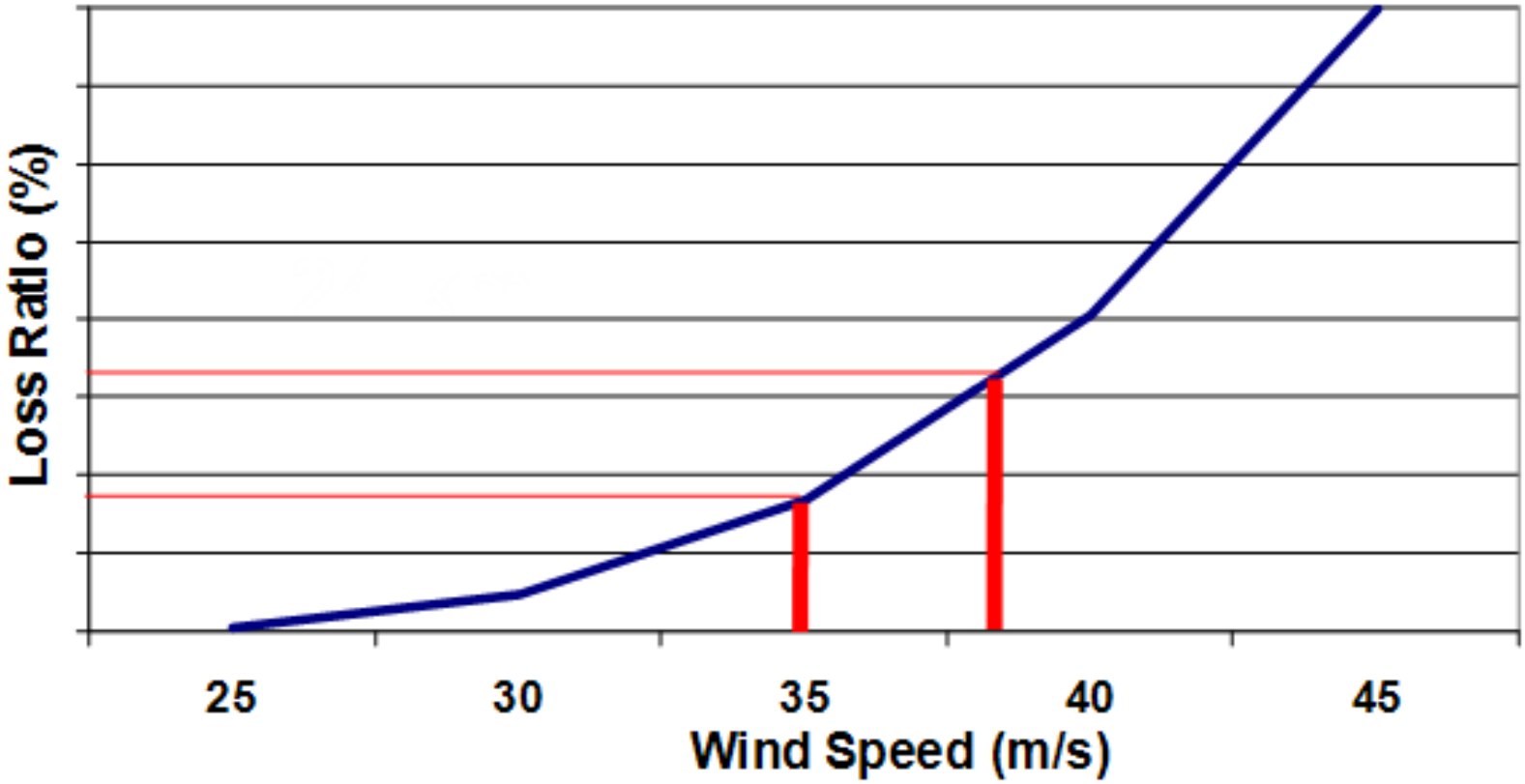
- Insurance companies are regular users of “catastrophe models”
- Effectively attempting to simulate 10,000 years+ of extra-tropical cyclones (windstorms)
- Simple “parametric models” have given way to more sophisticated Numerical Weather Prediction (NWP)-based models
- Keen to understand if existing models are at a “fair” resolution for damage estimation



Motivation 1: NWP Resolution for Resolving Hurricanes

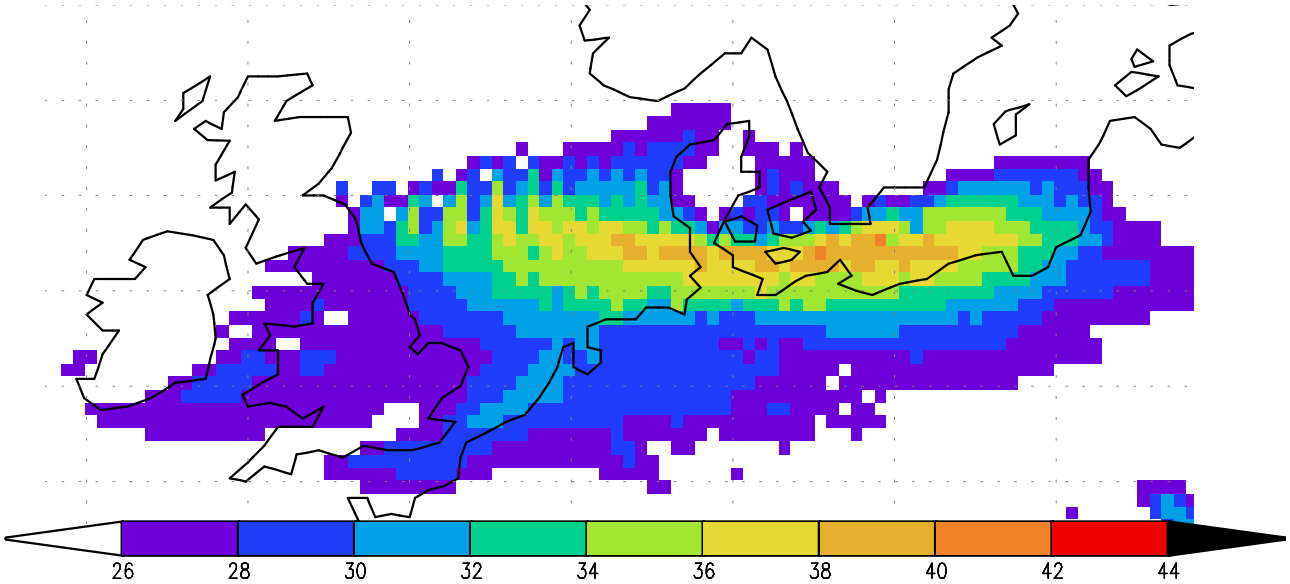


Motivation 2: Sensitivity of Damage to Windspeed



- **How does the sensitivity to NWP resolution affect damage for extra-tropical cyclones?**

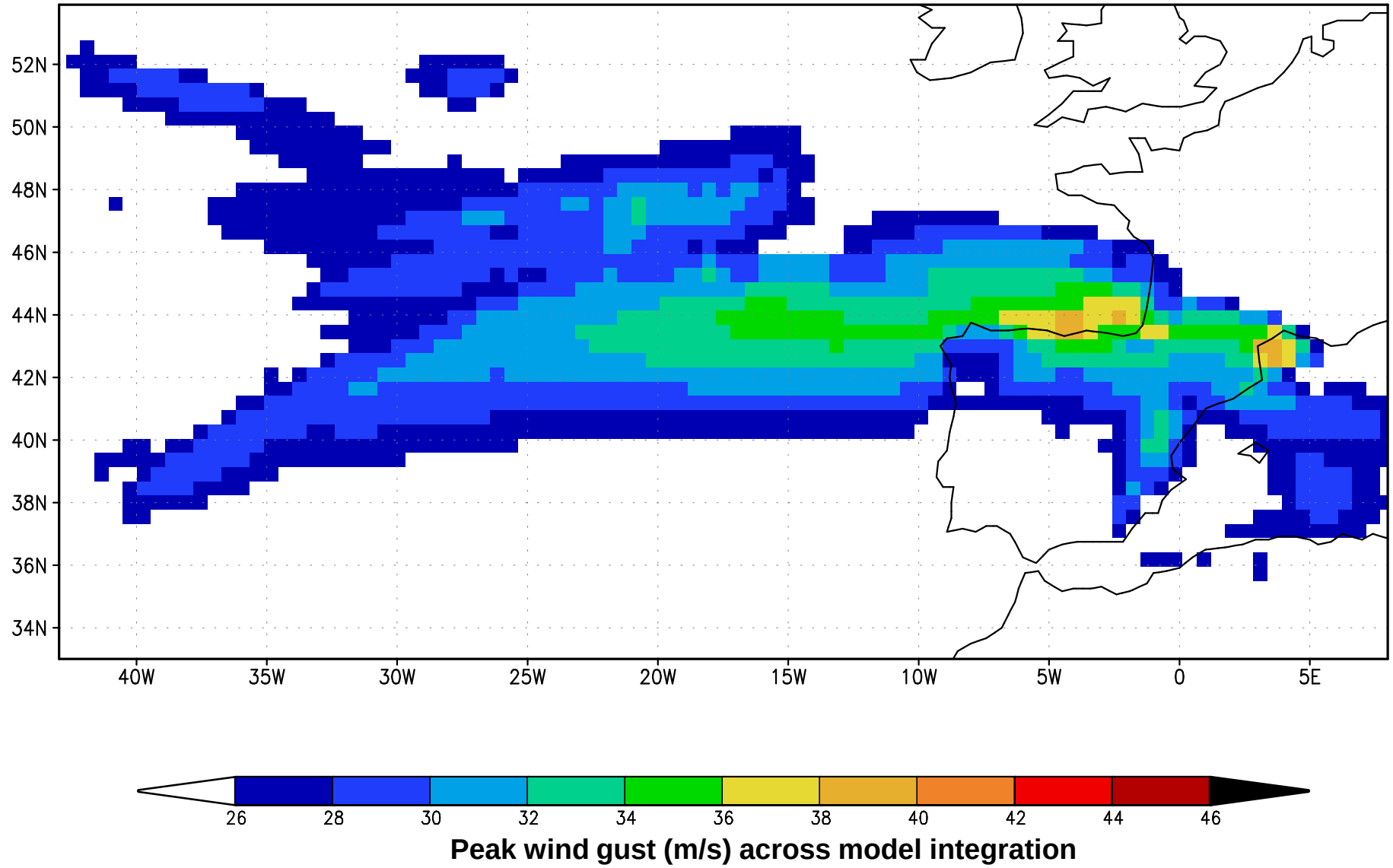
Experimental Design



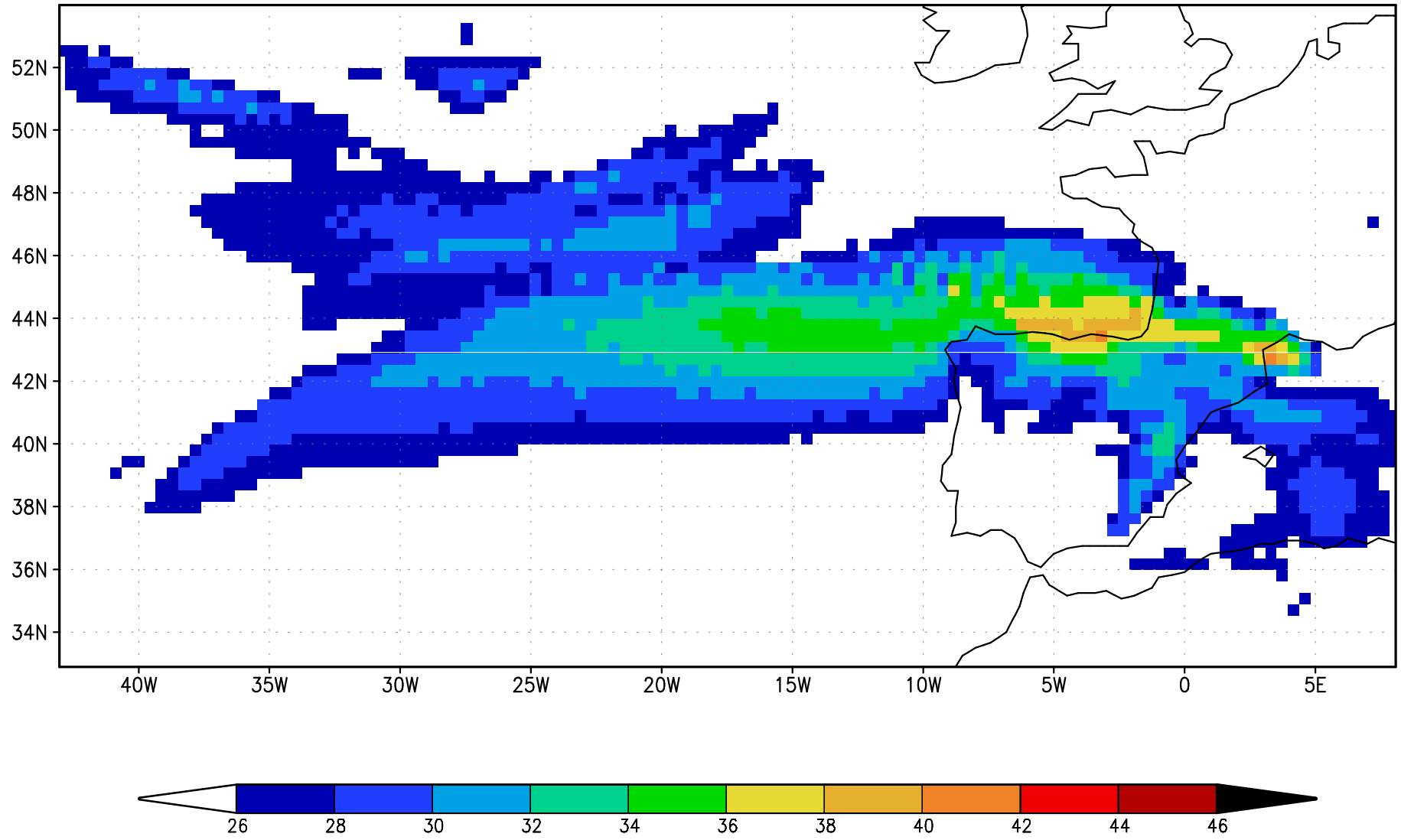
Peak wind gust (m/s) across model integration

- WRF EMS on 4x2.83 GHz, 8Gb RAM Linux box
- ARW configuration
- Multiple runs with varying resolution
  - 50, 40, 30, 20, 15, 12km
  - 45, 90 vertical levels
- Simulation domain of 4800 x 2400 km
- Use of the modelled “peak gust” calculation
- Straight “out of the box” simulation

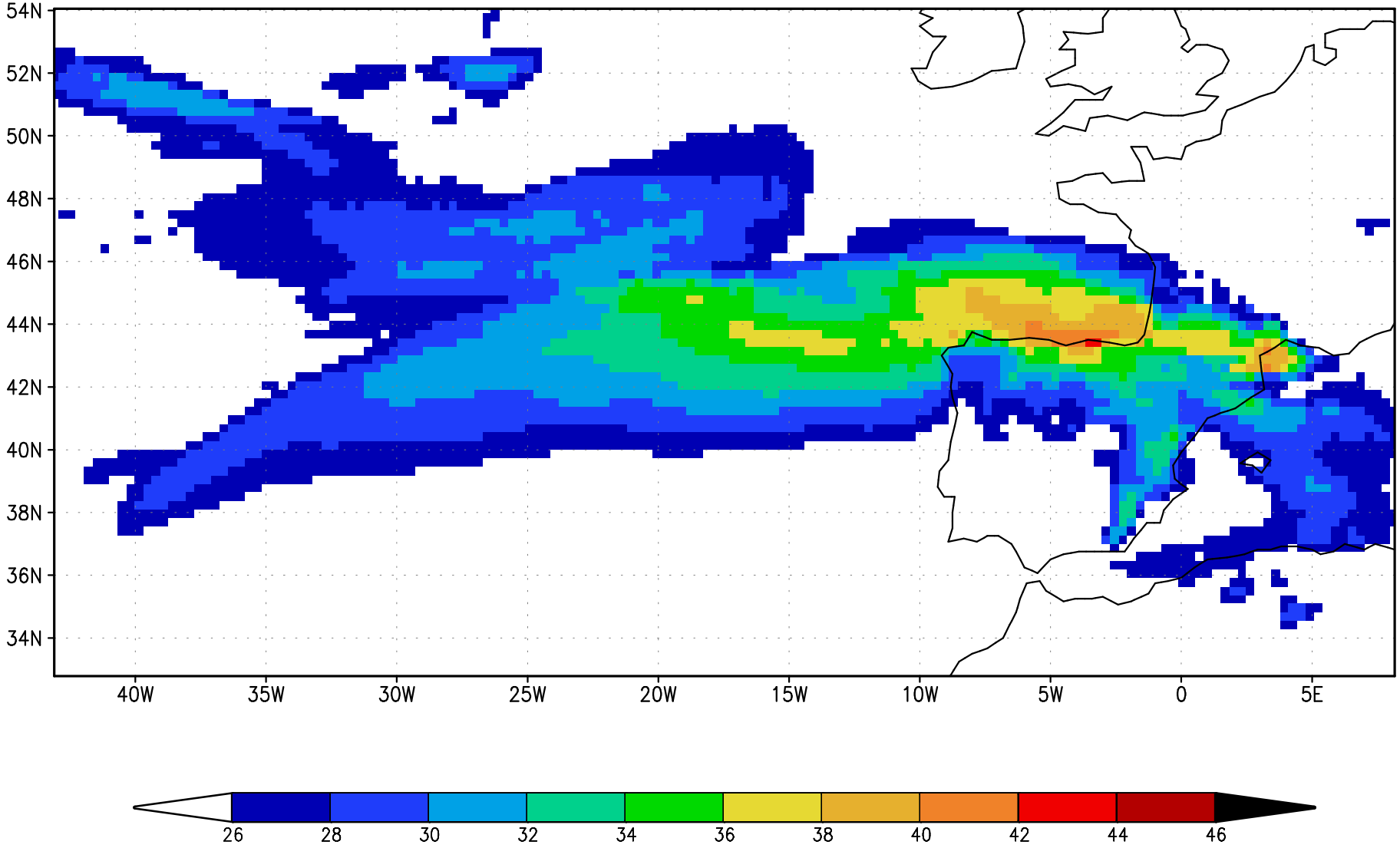
Windstorm Klaus: 50km, 45 levels



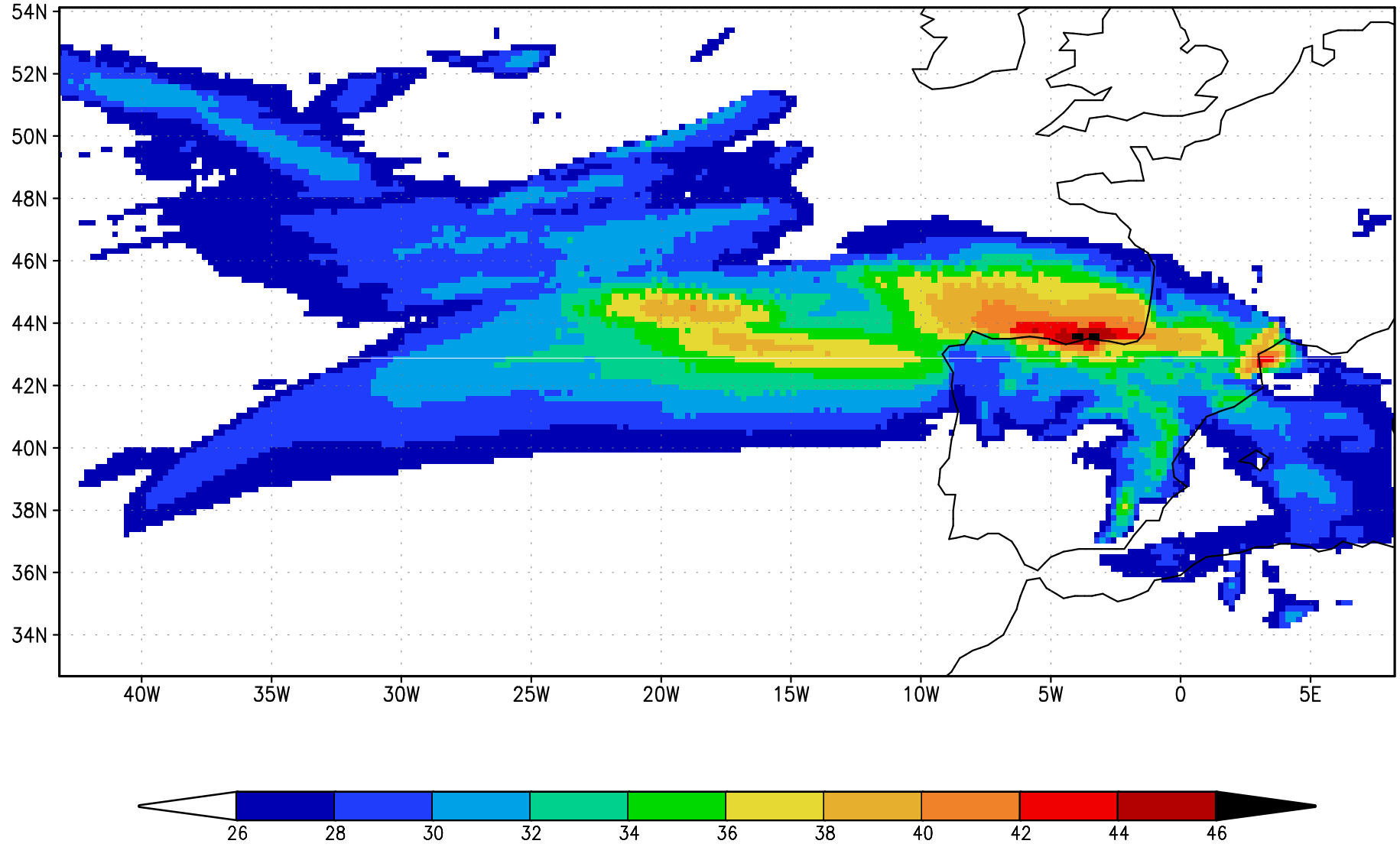
Windstorm Klaus: 40km, 45 levels



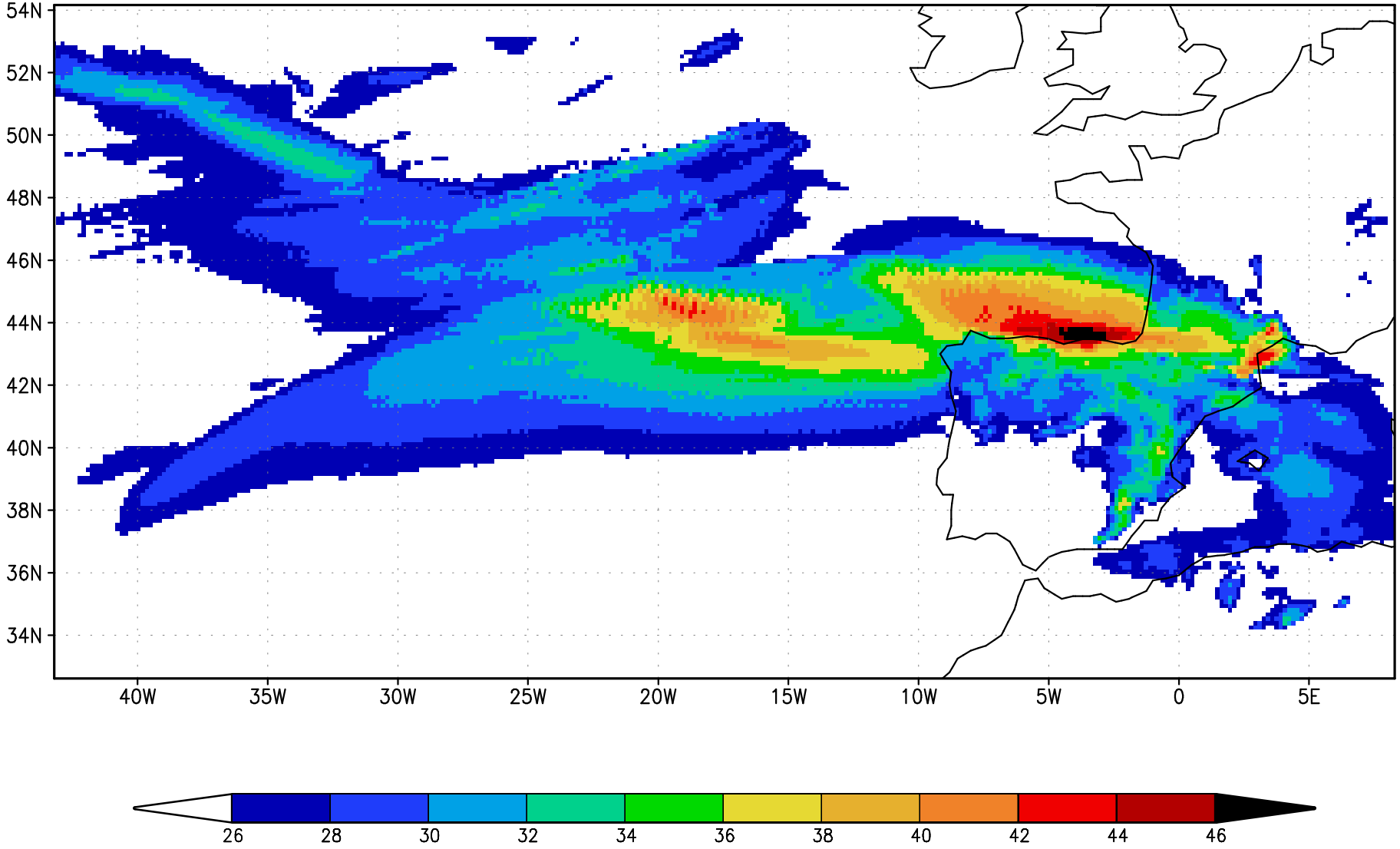
Windstorm Klaus: 30km, 45 levels



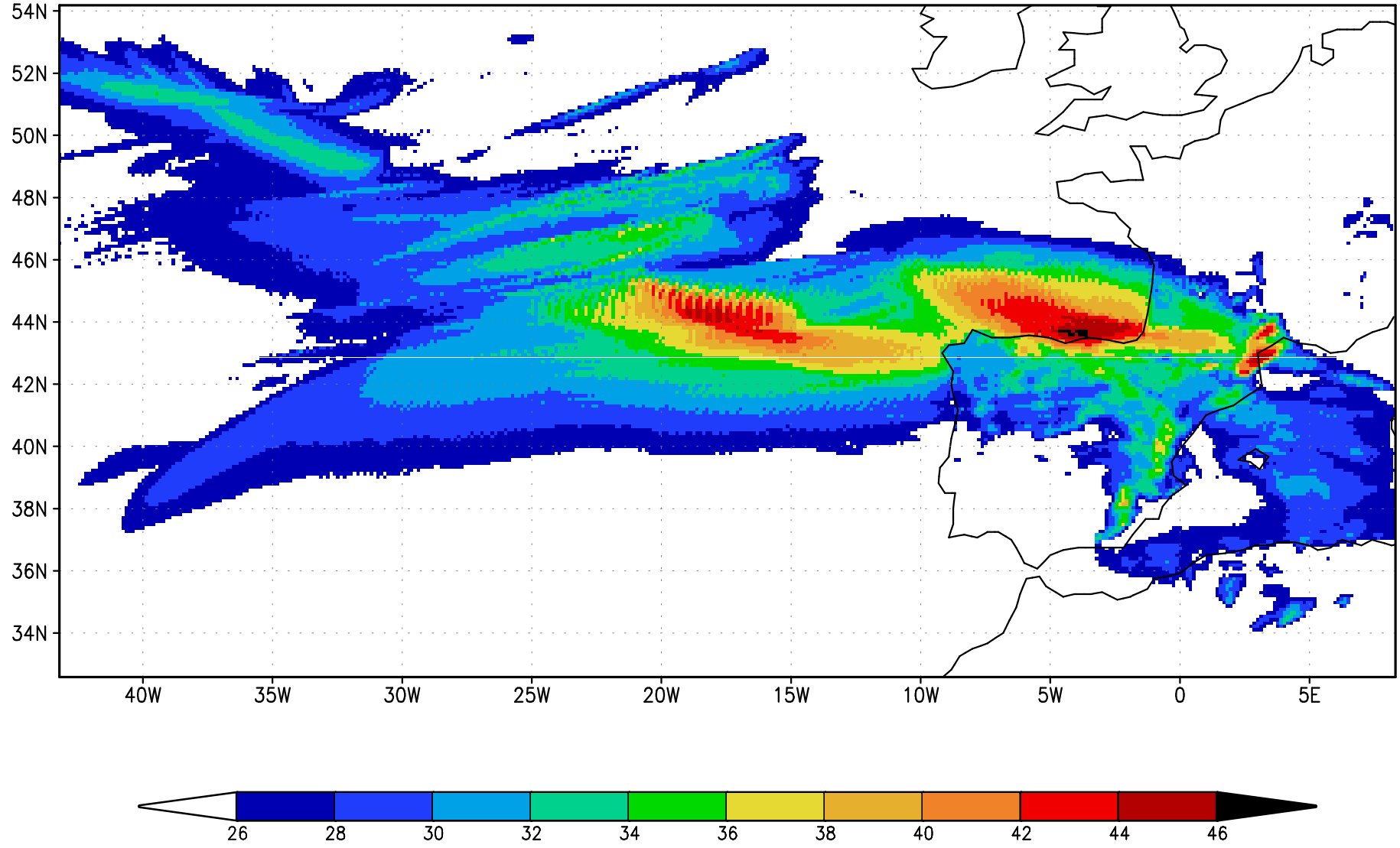
Windstorm Klaus: 20km, 45 levels



Windstorm Klaus: 15km, 45 levels



Windstorm Klaus: 12km, 90 levels



Wind vs. Damage

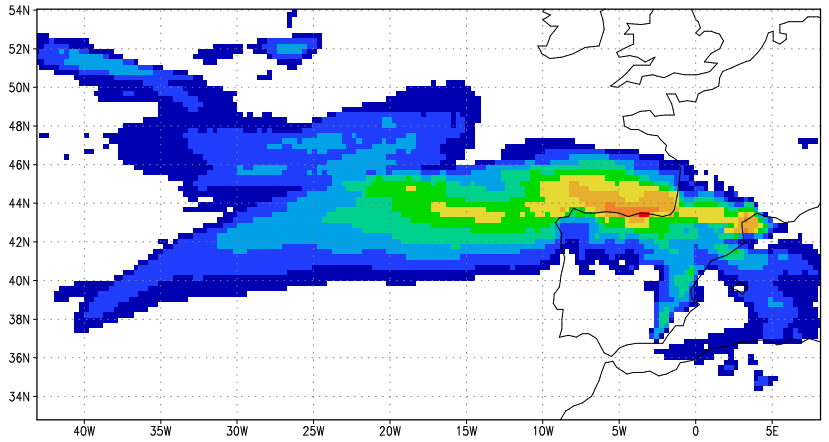
- Wind damage can be simply estimated where **V** = gridpoint peak gust as:

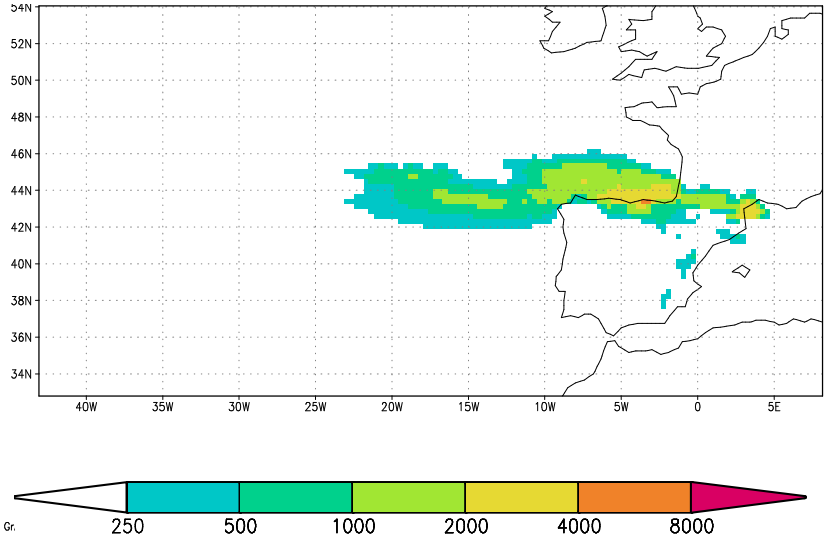
$$D = (V-26)^3$$

- Convert peak wind footprint into a “damage” footprint

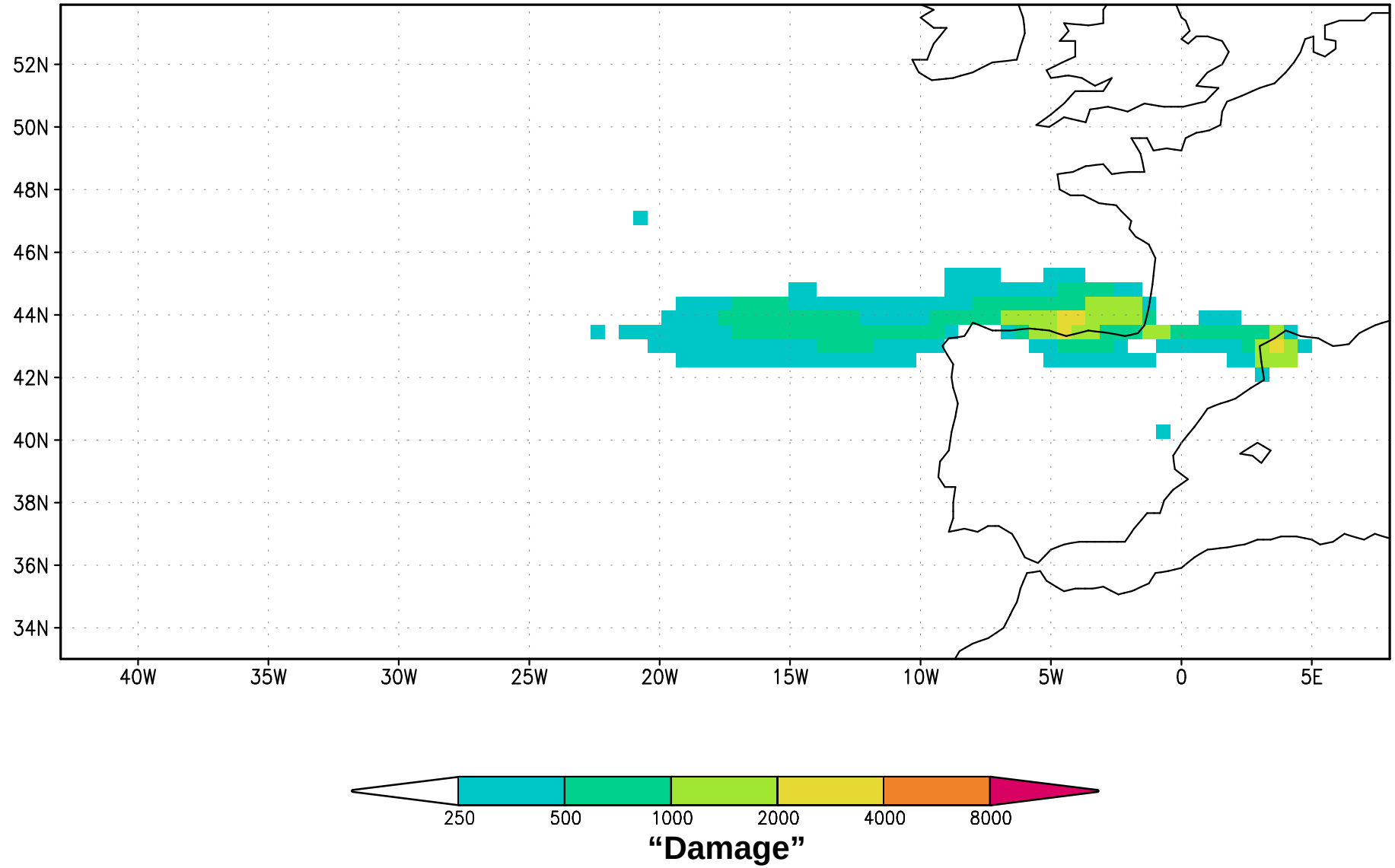
- Storm damage index

$$DI = \sum D_{domain} * resolution^2$$

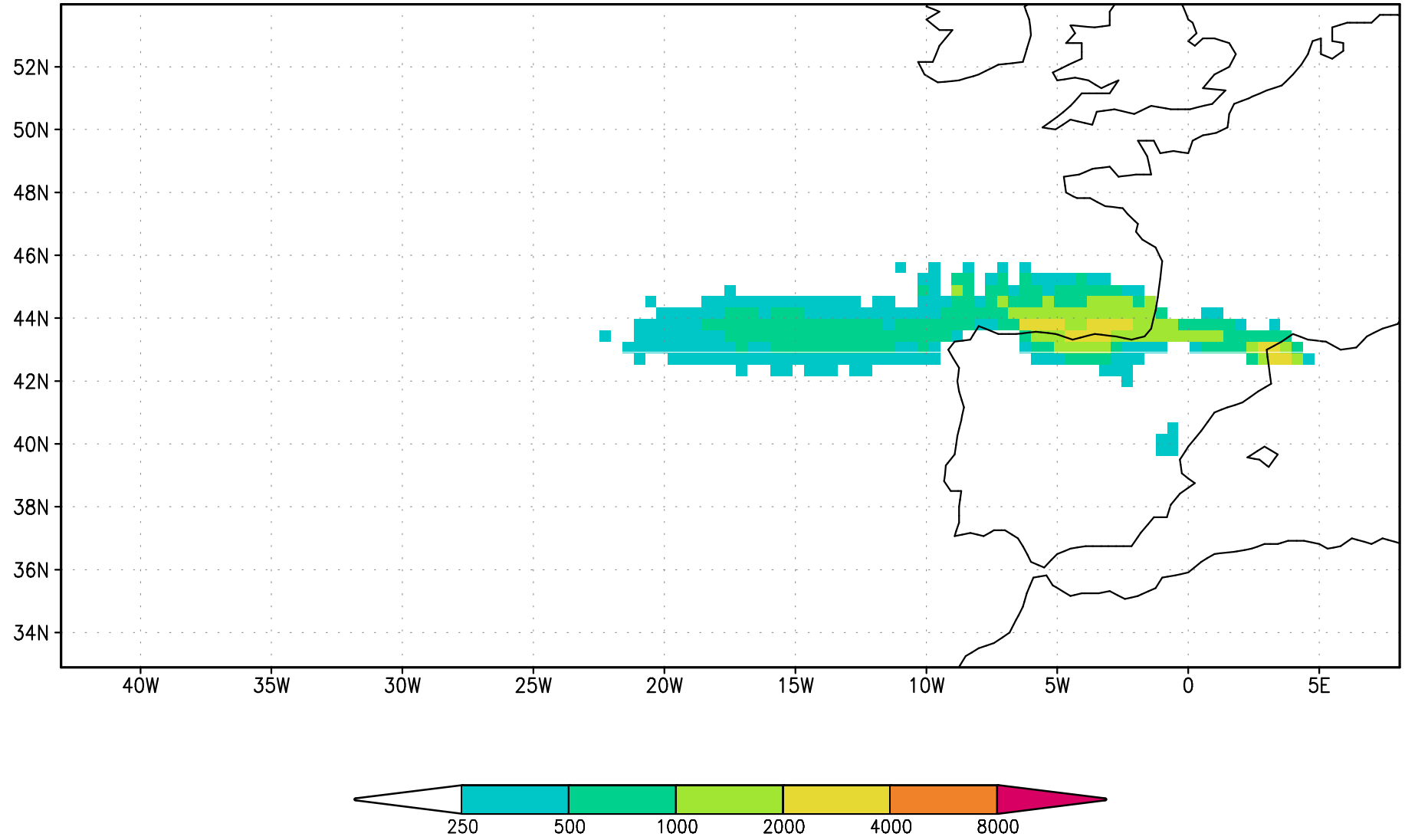




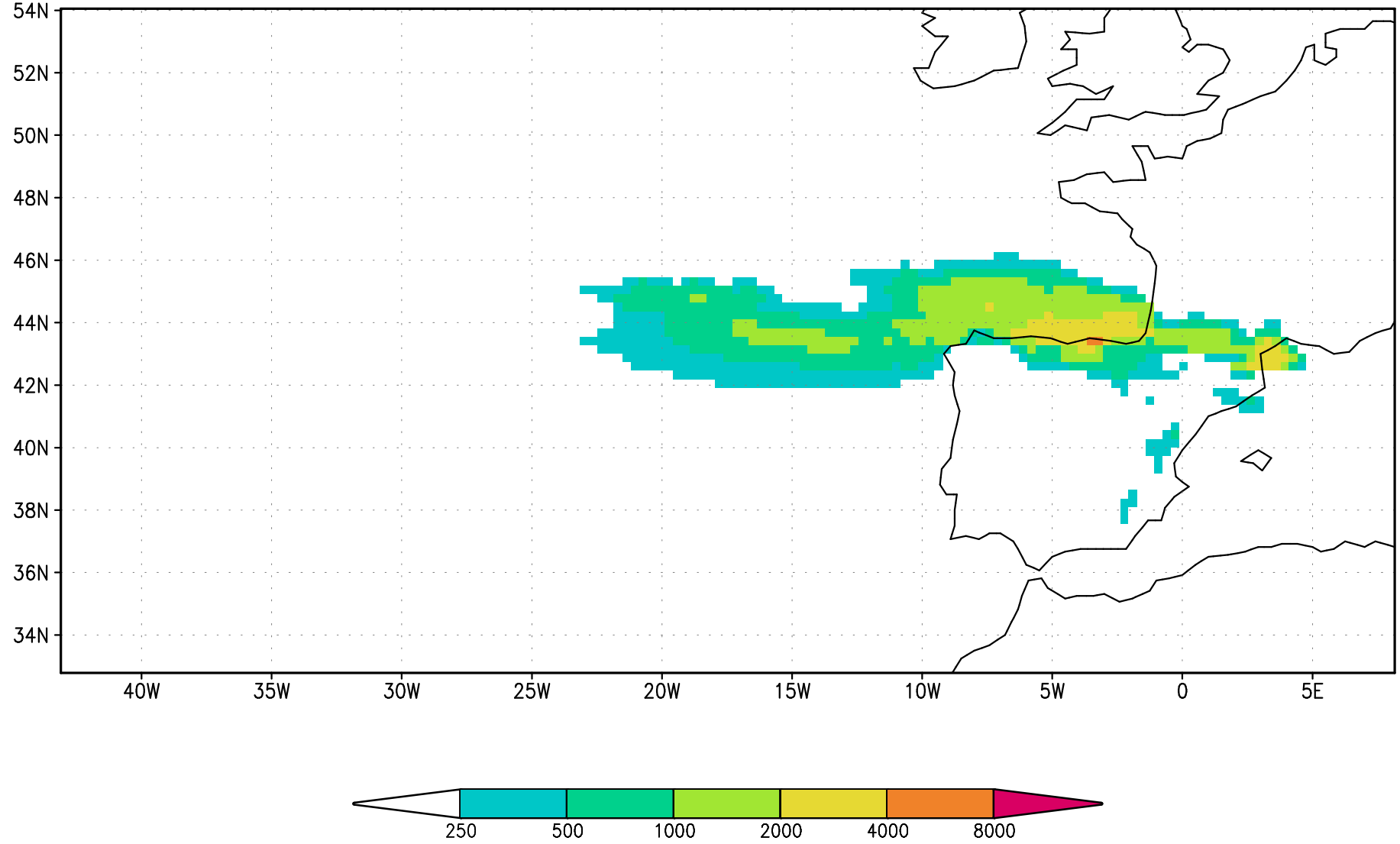
Windstorm Klaus: 50km: Damage



Windstorm Klaus: 40km: Damage

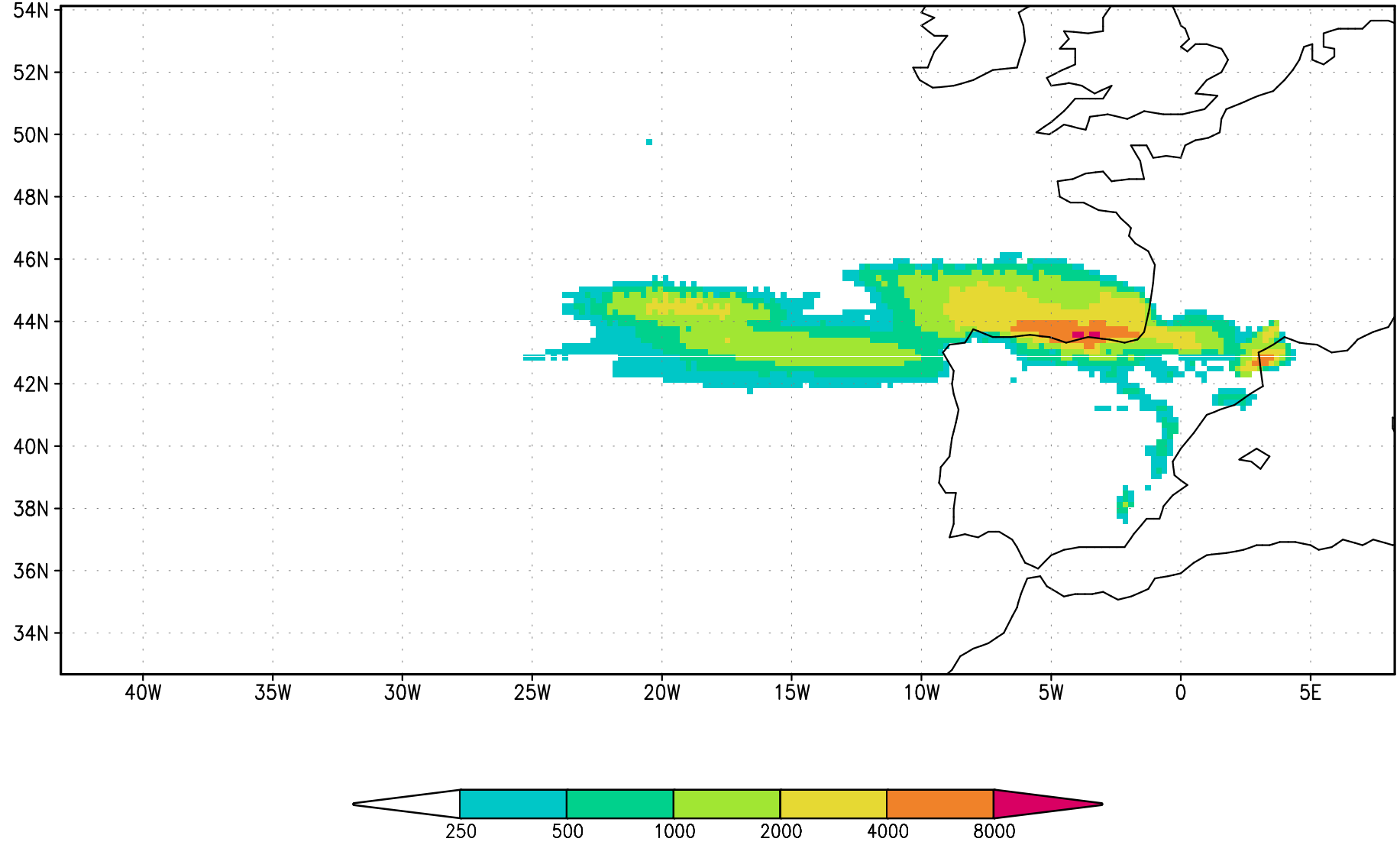


Windstorm Klaus: 30km: Damage



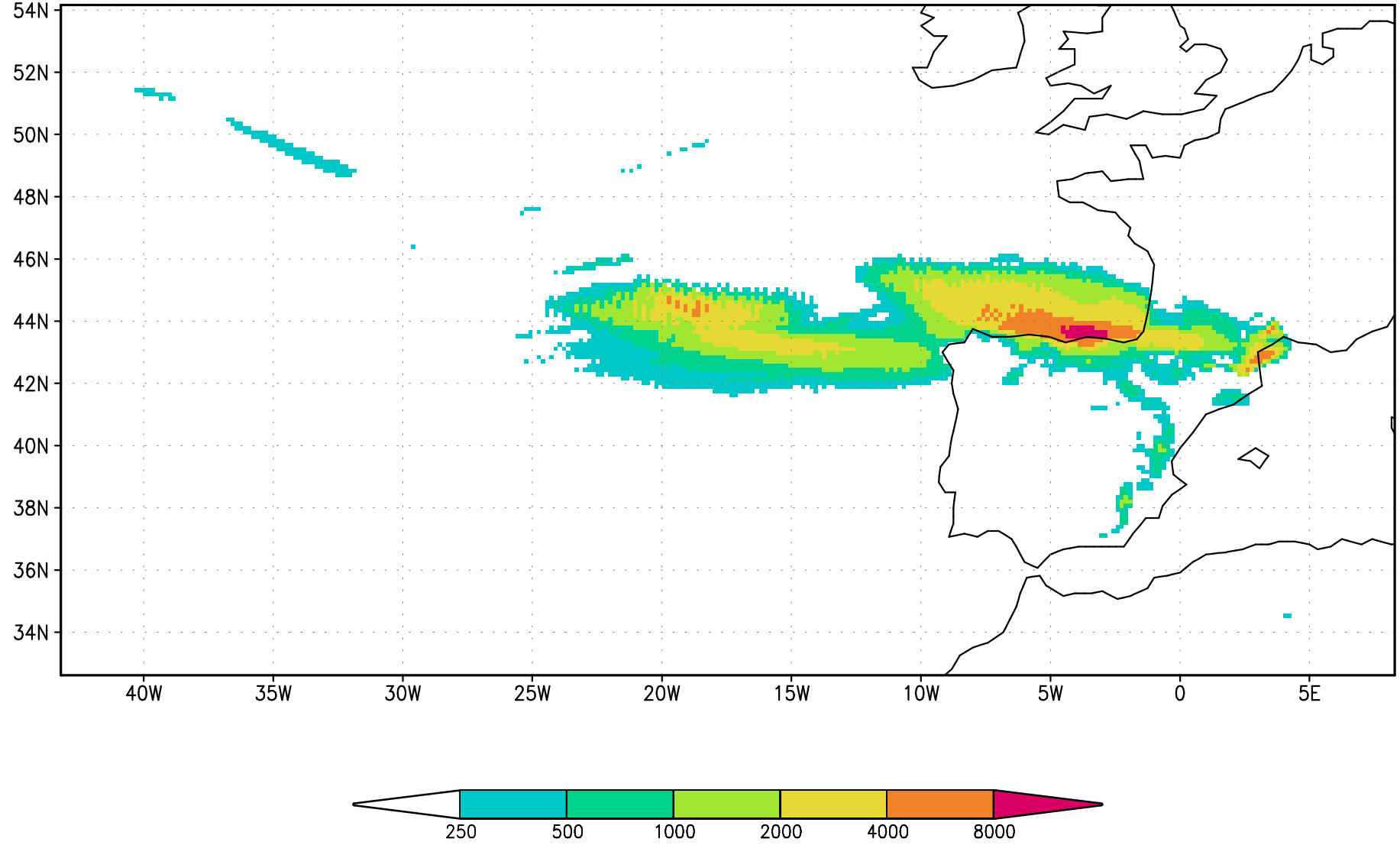
GrADS: COLA/IGES

Windstorm Klaus: 20km: Damage

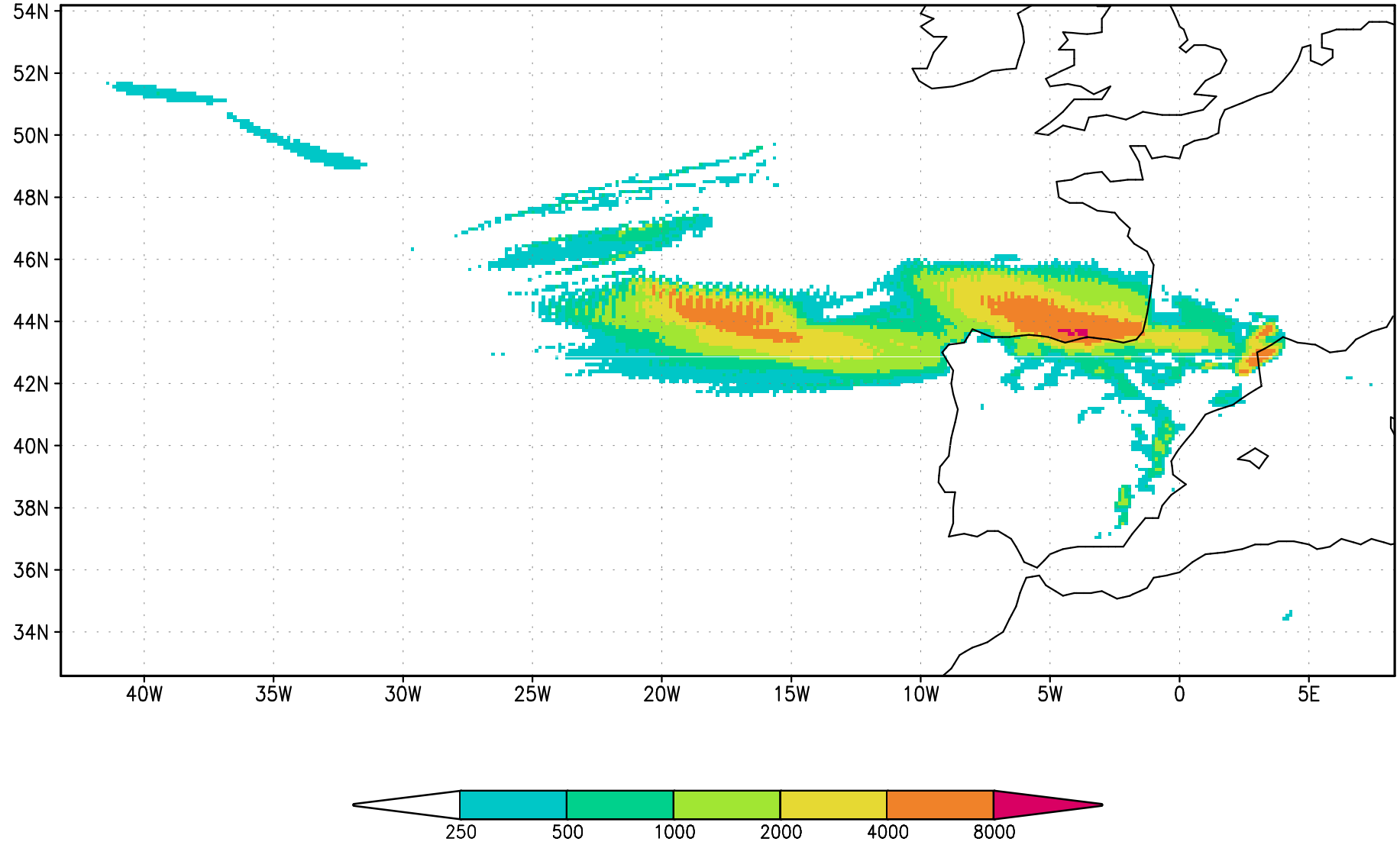


GrADS: COLA/IGES

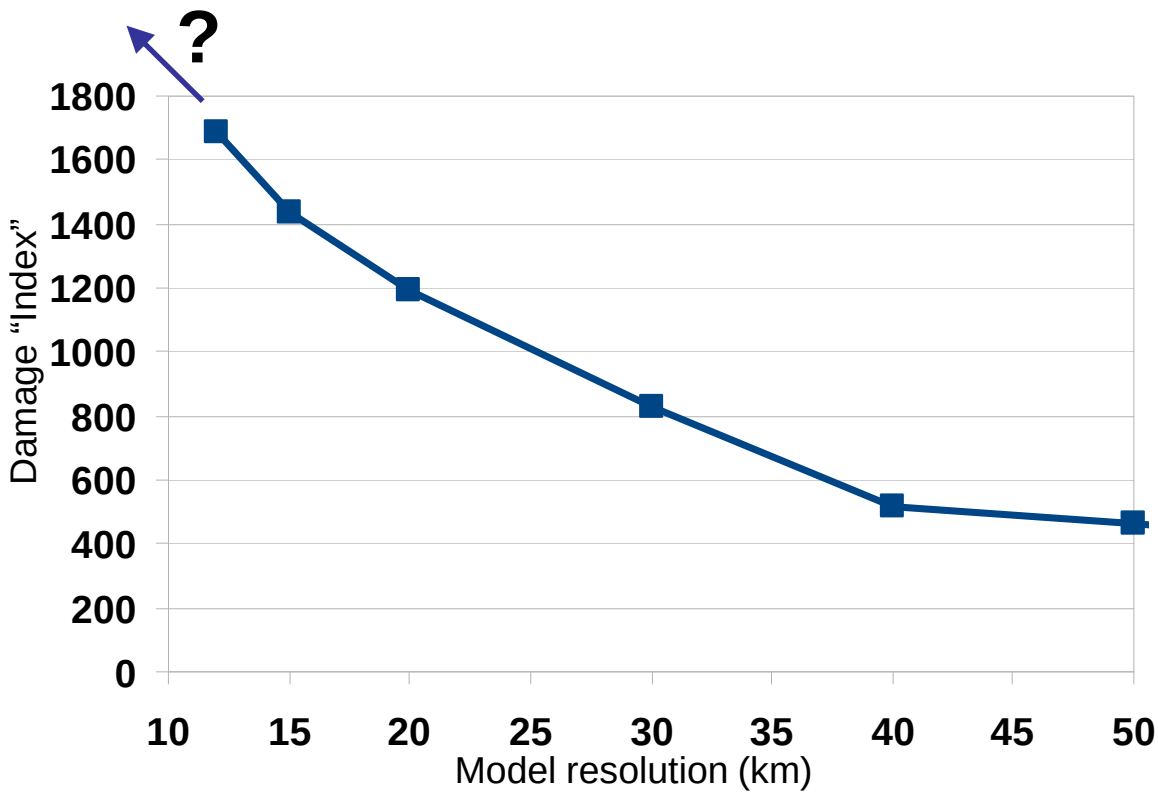
Windstorm Klaus: 15km: Damage



Windstorm Klaus: 12km: Damage

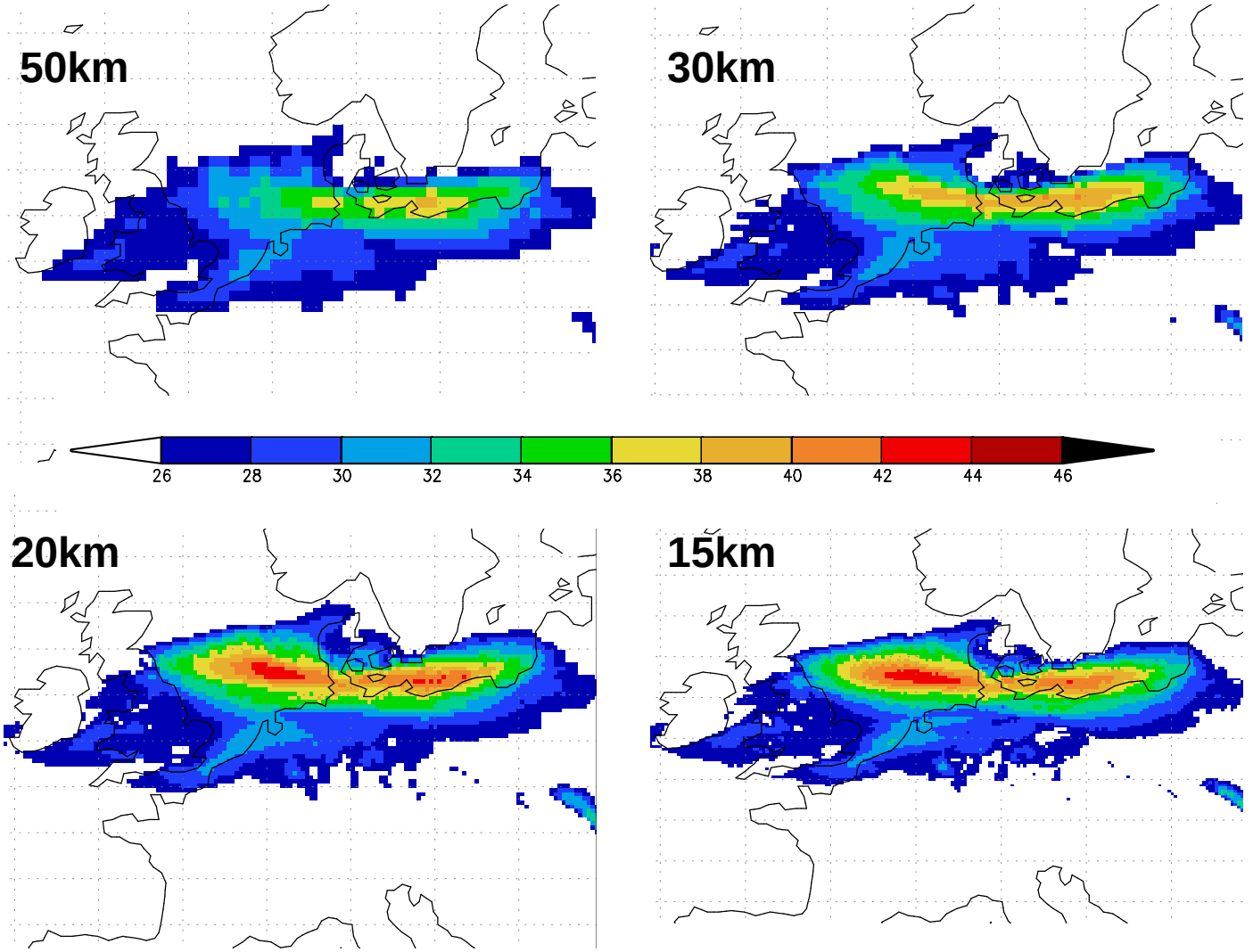


“Damage Index”



- **DI = $\sum D_{domain}$ * resolution^2**
- Gradual increase as model resolution increases
- Where is the asymptote?
- 10km? 5km? 2km?
  - Beyond my Linux box !!

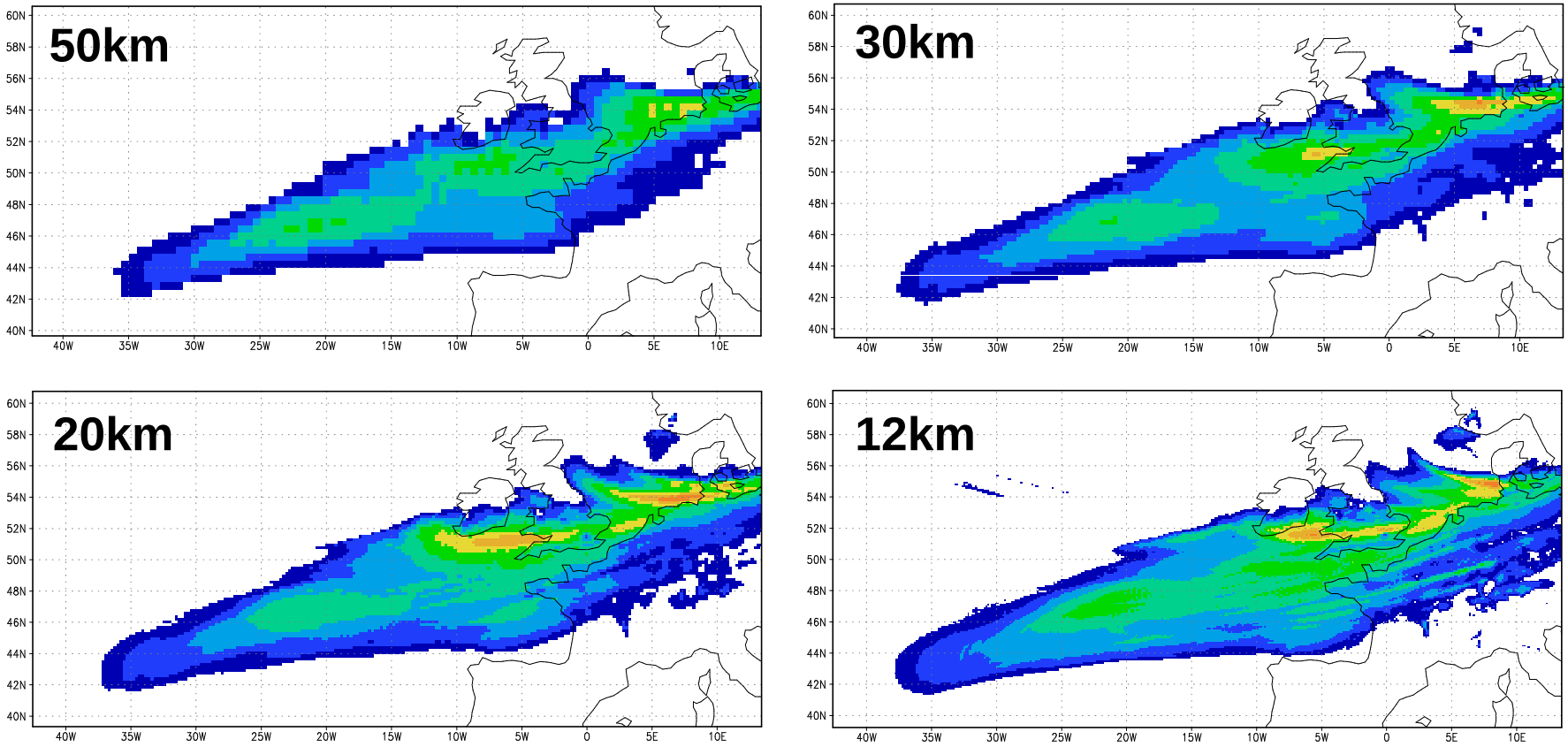
Other Examples: 1: Anatol (1999): Gusts



- Wind maximum “sharpens up” with increased resolution

Other Examples: 2: Daria (1990): Gusts

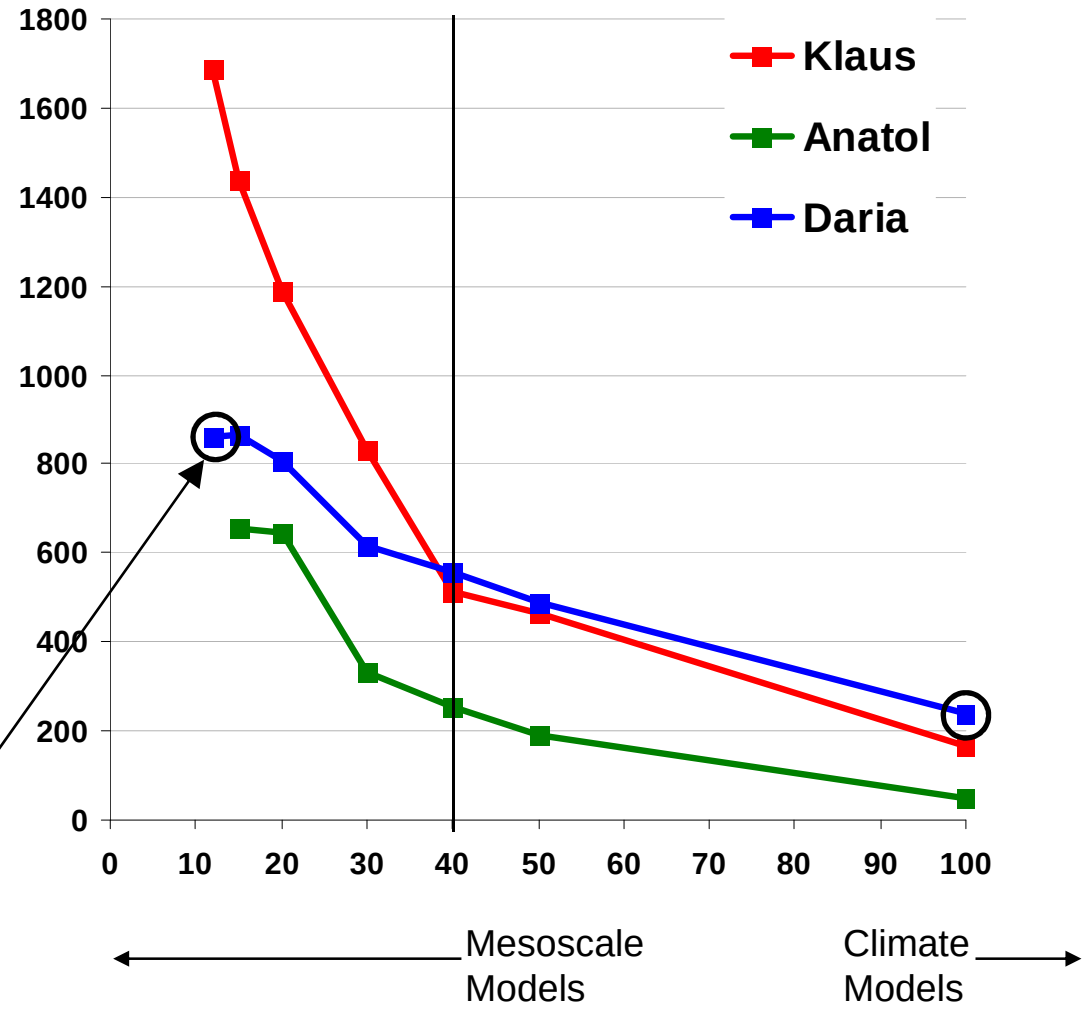
(Burns Day Storm)



- **Less “sharpening up” with increased resolution than previous examples**

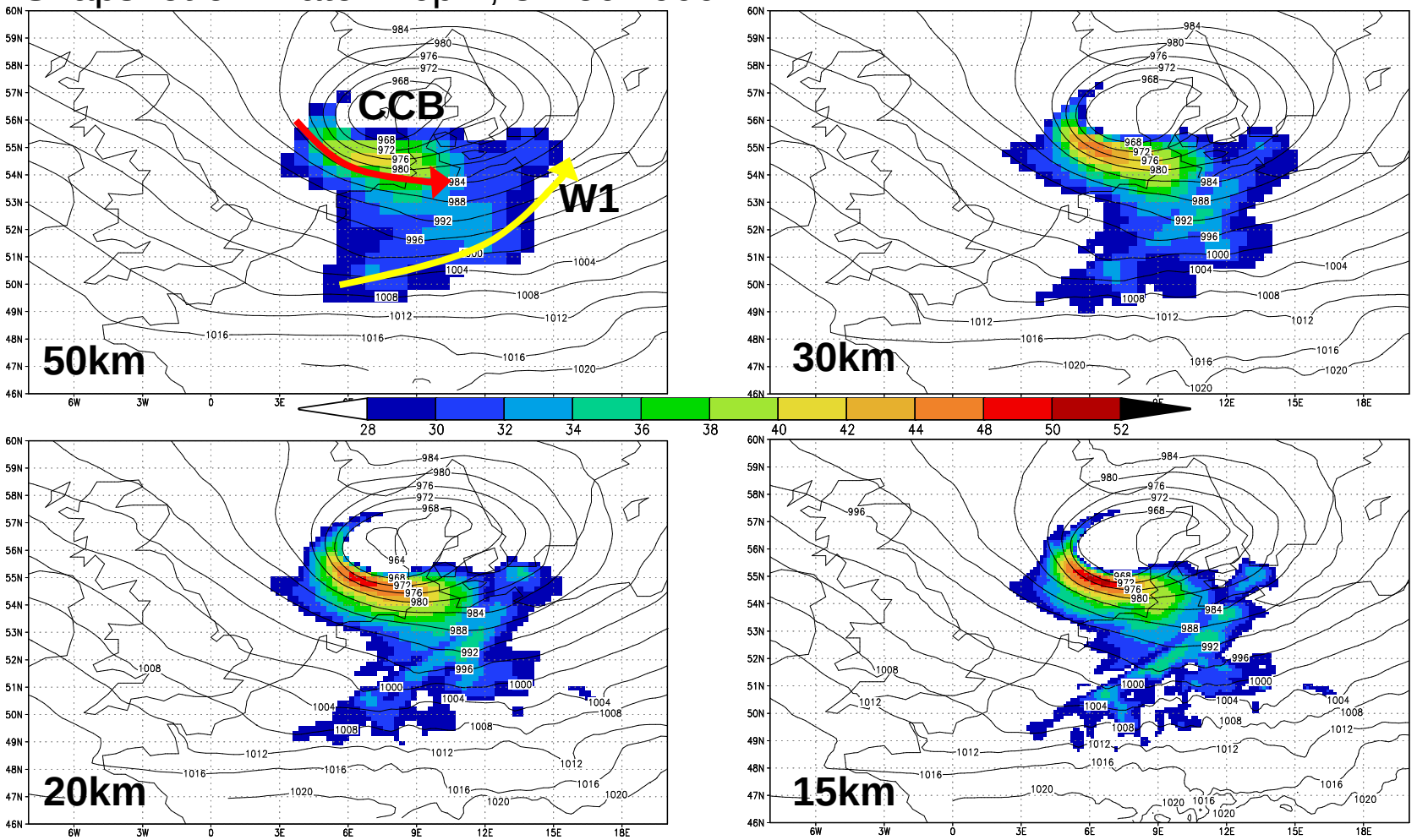
Damage Potential for 3 Storms

- Clearly increase in model resolution increases “damageability”
- Divergence in damageability above 40km
- Anatol, Klaus simulations “benefit” from greater resolution more than Daria
- Why?
- Storm that is most damaging at 100km needn’t be the most damaging at 15km…



How Resolvable are Storm Features?

- Snapshot of Anatol – 6pm, 3 Dec 1999



- Resolution-dependency of flows – CCB, W1, (sting jet)

Future Work

Shapiro-Keyser “Frontal Fracture” type-storms Anatol Klaus

Narrow, intense, high wind-speeds?

Difficult to resolve at low resolution?

Norwegian School “Occlusion” type-storms Daria

Broad, “flatter” wind footprints?

Easier to resolve at low resolution?

- What’s the ideal resolution for simulating windstorms? 5km? 20km?
- Is the “resolvability” a function of the key damaging flows
  - CCB jet, “W1” WCB flow, Sting-jet ?
- For climate-modelling studies, how good is 100km/200km resolution predictor of a storm’s “true” intensity at 10-20km resolution?
- **Hints and tips to improve the model set-up?**
  - Surface gust? 1km winds?


UCL
Thanks for listening
Acknowledgements:
David Smart (UCL)
Robert Rosumalski (NWS)