Forcing Data at WRF lateral Boundary Corner and its Impact on Storm Intensification - a Case Study through mid-latitude Cyclone Christian

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Forcing data at WRF lateral boundary corner and its impact on storm intensification – a case study through mid-latitude cyclone Christian

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About me

- 1st year PhD student (Sep. 2017), Technical University of Denmark (DTU Wind Energy)

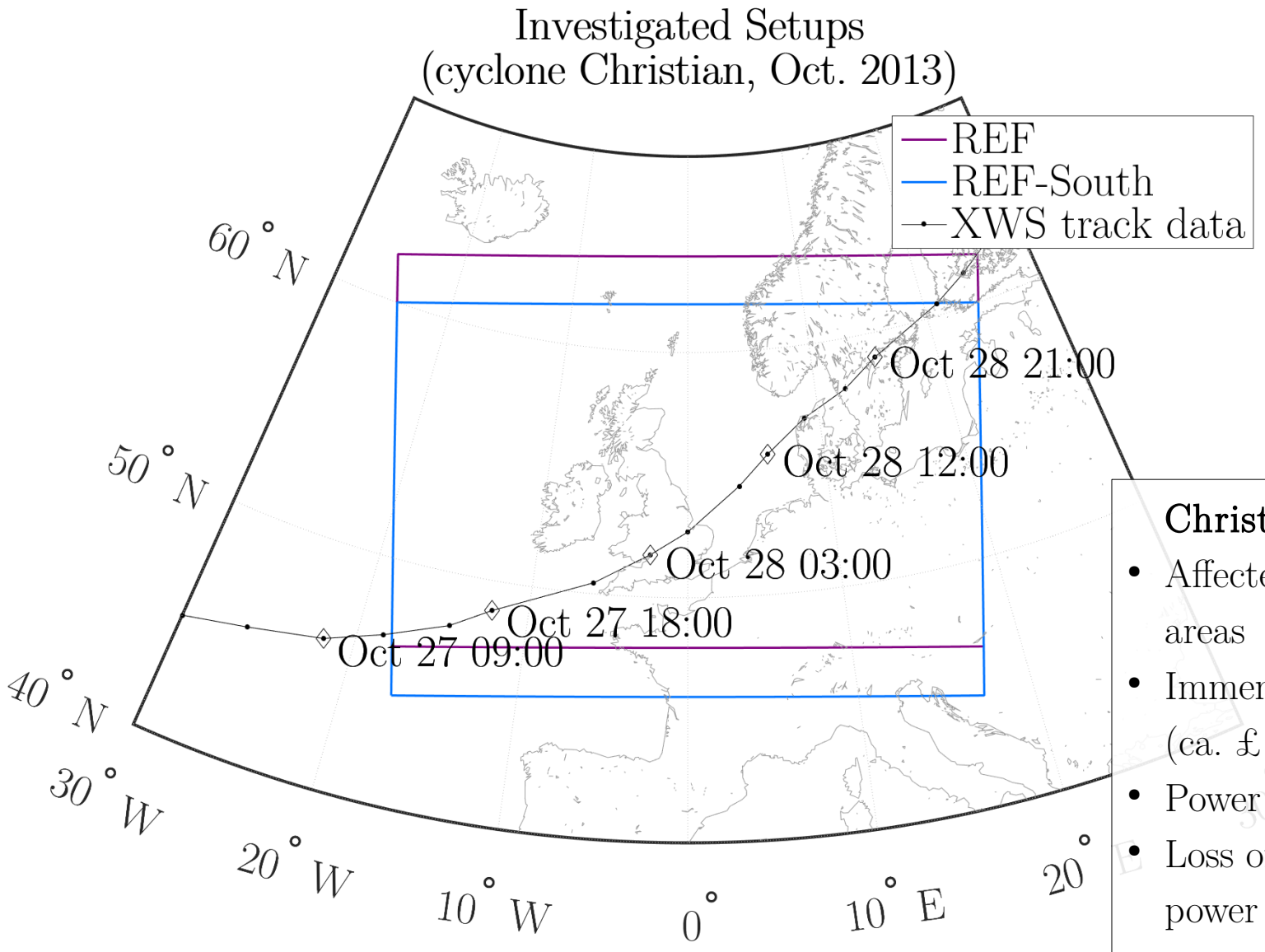
  "Advanced meteorological modeling across scales – MPAS for wind energy applications"

- Focus on mid-latitude storms influencing the North Sea

- Comparisons with currently used method

  (WRF nesting)

WRF “Corner Issue”: Motivation



Christian / St. Jude

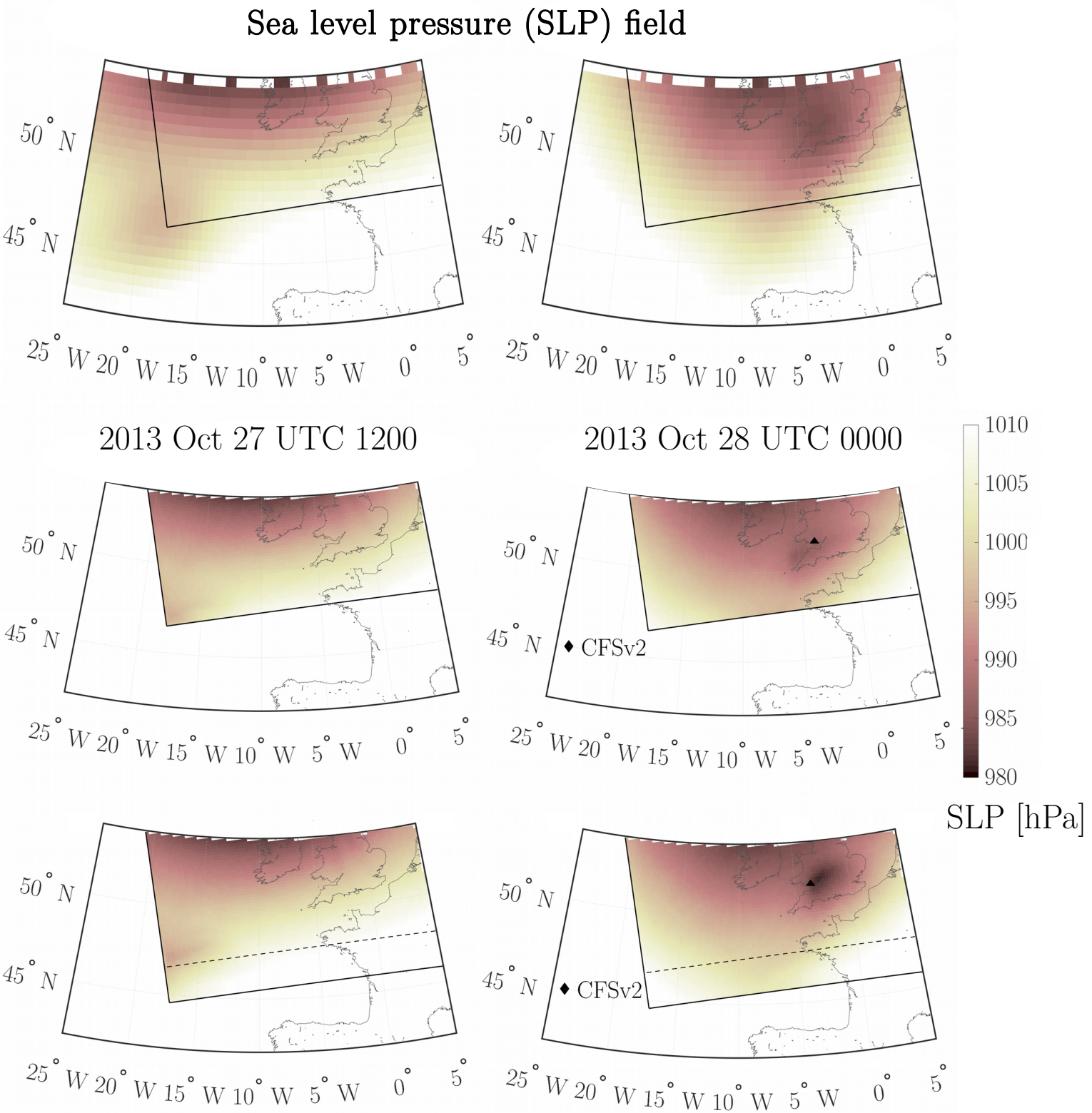
- Affected densely populated areas
- Immense insurance losses (ca. £ 1 billion)
- Power cuts
- Loss of approx. 2GW of wind power within 24h of storm

Forcing data
(CFSv2)

WRF (18km resolution)

- Reference

- Southwards shifted
  domain



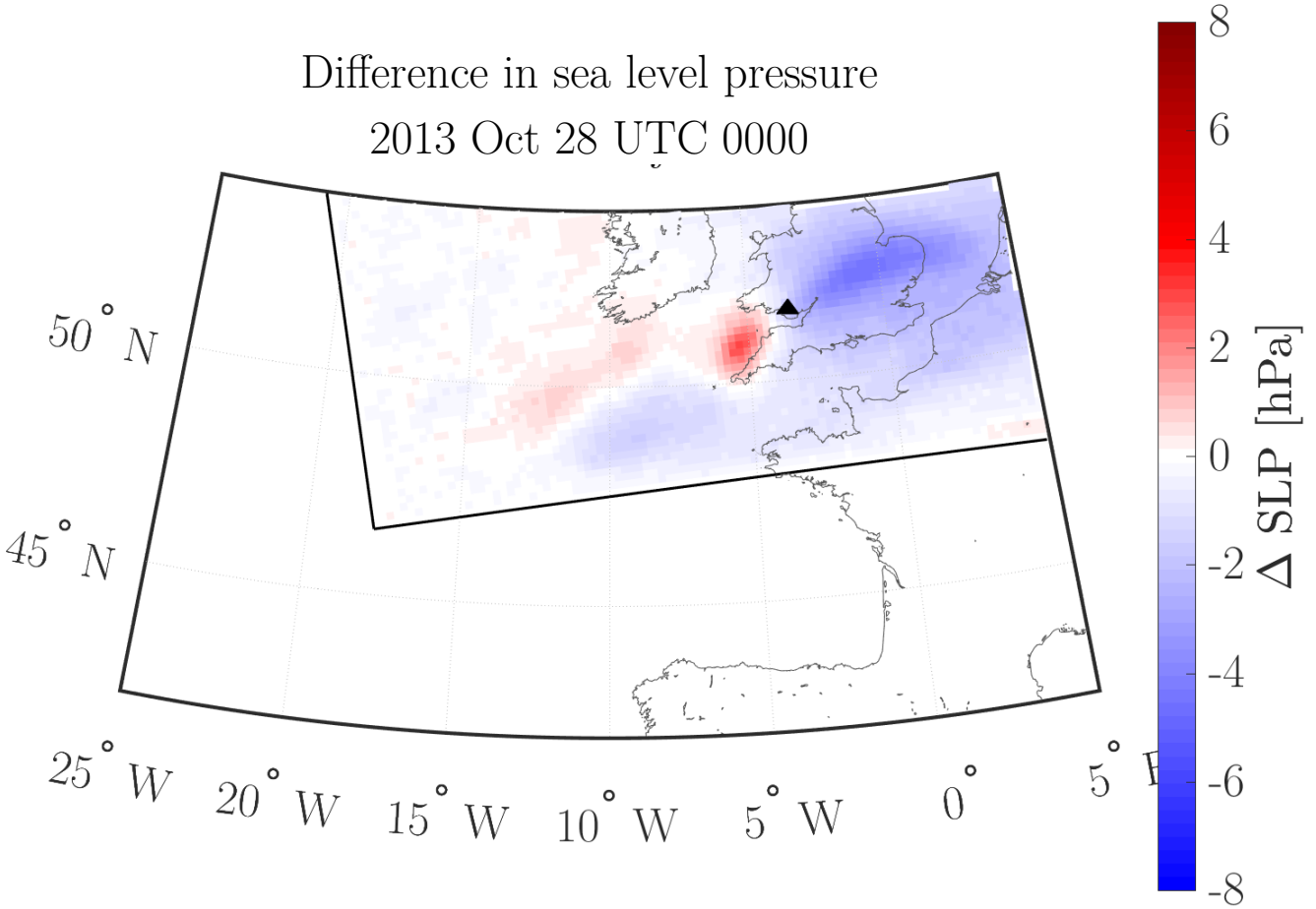
Investigated Settings

Reference case	Applied changes
18km horizontal resolution	
51 vertical layers	
12h spin-up + 24h simulation time	
Forcing data: CFSv2	ERA5
6-hourly update	3-hourly, hourly
No nudging	Spectral and analysis nudging
4 layer relaxation zone	2 layer / 8 layer

Physics: New Thompson (microphysics), RRTMG (radiation), MYNN (surface layer), Noah Land Surface Model (land surface), MYNN Level 3 (PBL scheme), Kain-Fritsch (cumulus)
Land cover: USGS (24 categories)
WRF version: WRF Model Version 3.7.1

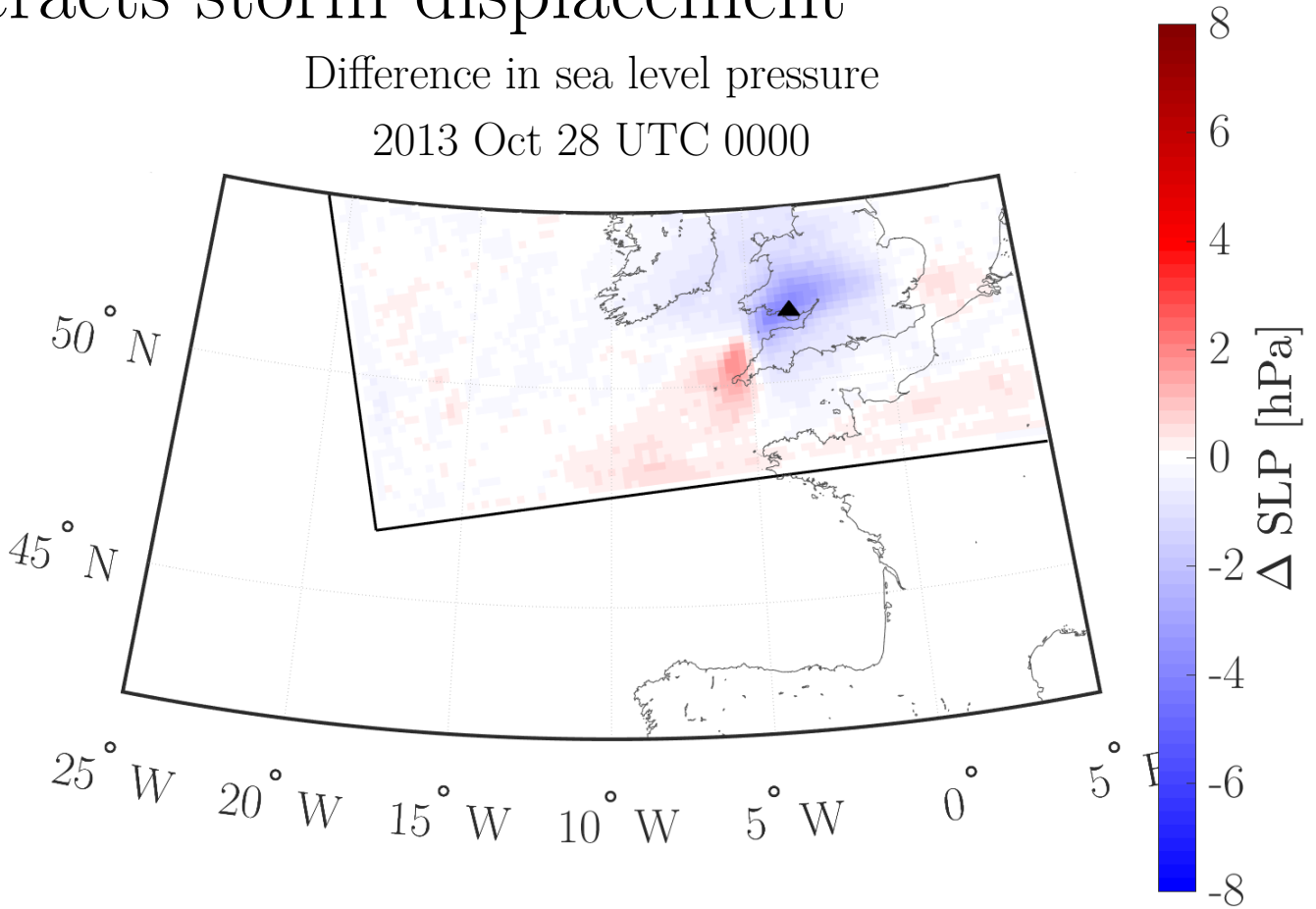
Results: Nudging

- Spectral nudging enhances storm intensity slightly
- Strongest: high wave numbers (nudging above 100km), nudging in all layers



Results: Relaxation Zone

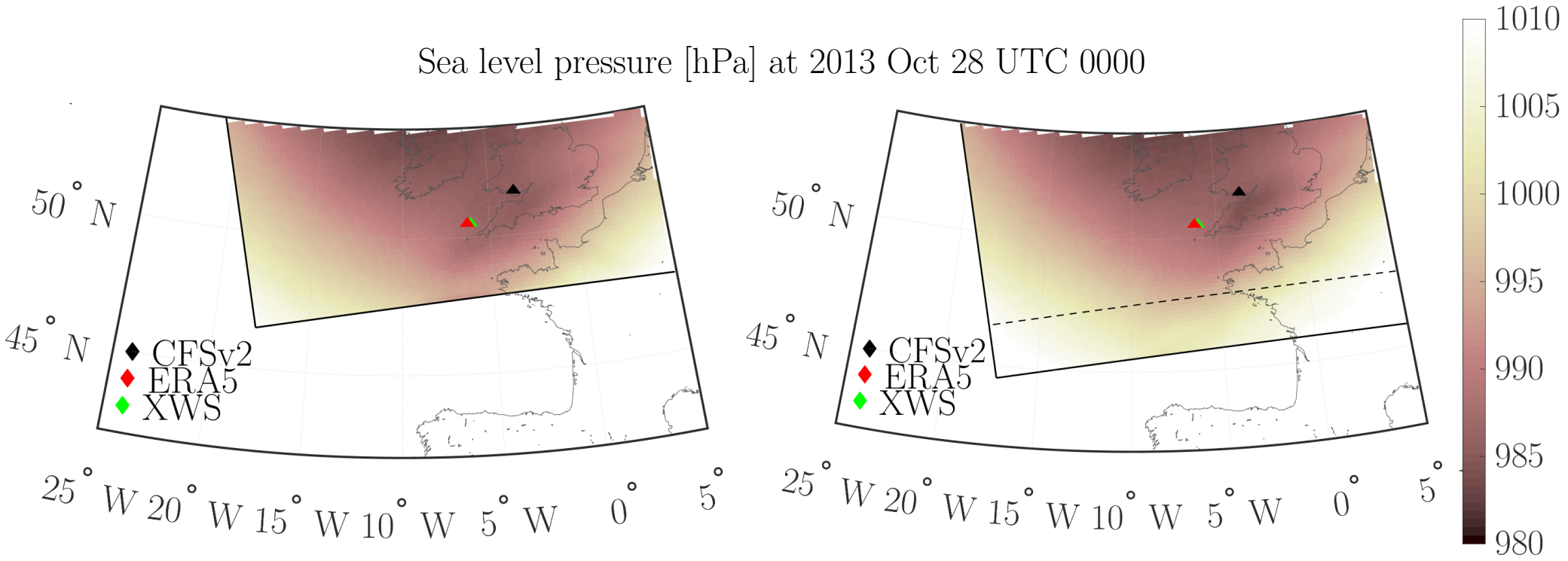
- Reduced relaxation zone brought biggest enhancement
- Surroundings of storm center less influenced
- Counteracts storm displacement



Results: Forcing Data Change

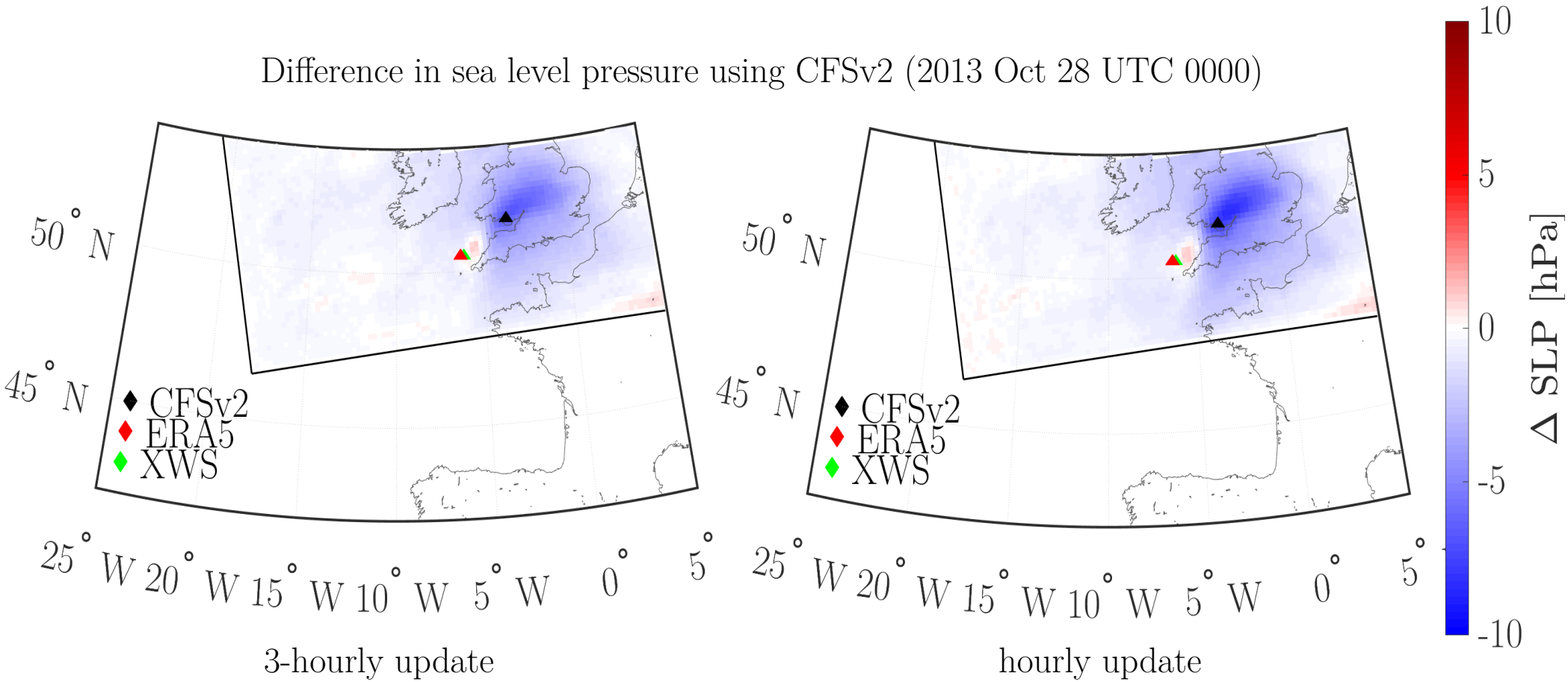
- Disagreement on storm location (at same time)
- Spec. nudging necessary in both domains

  $\rightarrow$ corner issue less pronounced
- No intensification



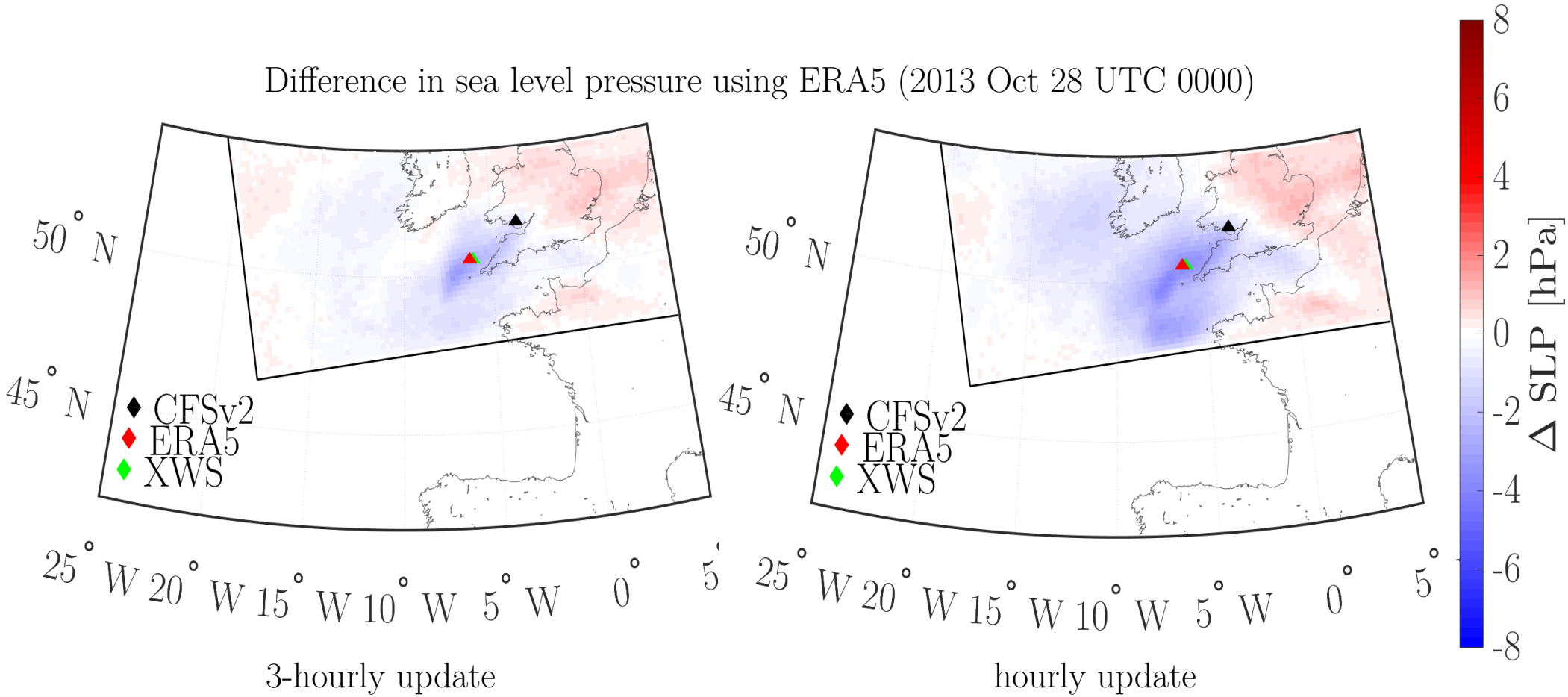
Results: Update Frequency

- Higher decrease of SLP in expected area and surrounding with increased frequency



Results: Update Frequency (Boundary Forcing)

- Enhancement also visible using ERA5
- Absolute decrease less pronounced



Conclusion

Approach	Effect on storm location	Effect on storm intensification
Reference	Displacement of storm center	Marginal intensification
Nudging technique	Corrected location	Moderate, also in surroundings
Relaxation width	Corrected location	Weak, concentrated on storm center
Forcing data	different storm center location (at same time)	Not comparable without bias
Update frequency	Corrected location	Strong enhancement

→ Methods tackle crucial points

(1) Correct information from large scale forcing

(2) Reduce smoothing effect

→ Compromises

→ Biggest improvement: Update frequency

Work in progress:

Plan:

Run WRF with MPAS output

to test LBC update frequency of

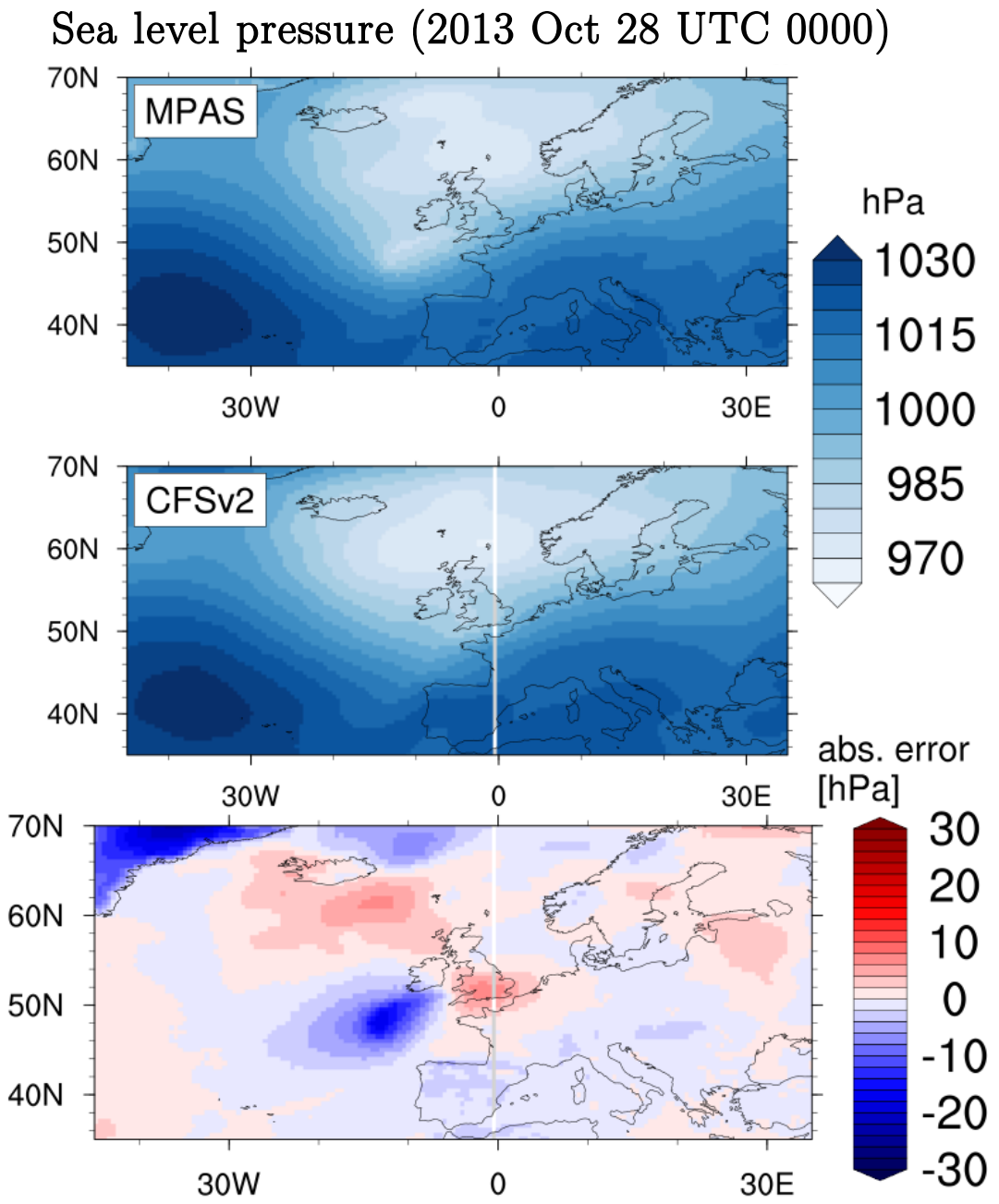
30min and 10min

Current status:

Analysis of MPAS output

Faced issue:

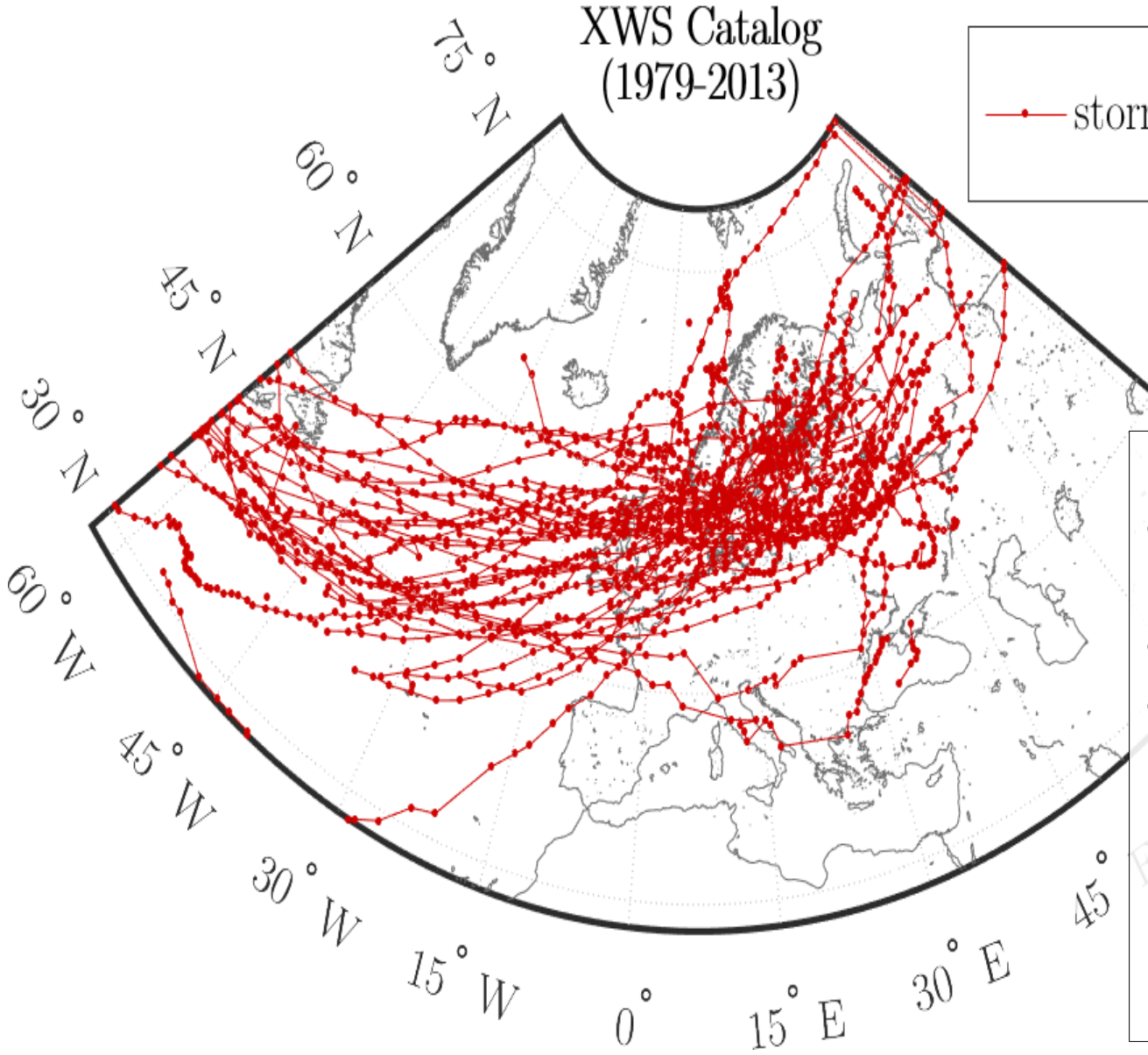
SLP field: cyclone center



Thanks!

Cyclone Christian, 1214 UTC 28 Oct 2013 (© NERC Satellite Receiving Station / University of Dundee)

XWS Extreme Wind Storm Catalogue



XWS

- Met Office, University of Reading & Exeter
- 50 + 2 storms
- Collection of most intense* winter storms affecting Europe

*based on damaging area of the storm (insurance losses)