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

- 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

2013 Oct 27 UTC 1200

2013 Oct 28 UTC 0000

Sea level pressure (SLP) field

SLP [hPa]
# Investigated Settings

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

**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

Difference in sea level pressure
2013 Oct 28 UTC 0000
Results: Relaxation Zone

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

Difference in sea level pressure
2013 Oct 28 UTC 0000
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

Difference in sea level pressure using CFSv2 (2013 Oct 28 UTC 0000)
Results: Update Frequency (Boundary Forcing)

- Enhancement also visible using ERA5
- Absolute decrease less pronounced
Conclusion

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

→ 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

Sea level pressure (2013 Oct 28 UTC 0000)
Thanks!
XWS Extreme Wind Storm Catalogue

XWS Catalog (1979-2013)

- Storm track XWS

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)