• Met Office Models Performance in 2020 (Paulette, Eta, Laura)
• Cyclogenesis (Gulf/Caribbean v. open Atlantic)
• Rapid intensification (Laura, Delta)
• Wind-Pressure relationship and drag over the ocean (Paulette)
• Atmosphere-Ocean coupled model trial (Teddy)

• Additional slides including GloSea Seasonal Forecast 2020
• 2020 Atlantic track errors good at short lead times, but large at longer lead times.
• Active season, but dominated by relatively short storms – except Paulette and Eta.
• Paulette and Eta dominated longer lead time errors (as Joaquin did in 2015)
• Met Office models poor handling in the Gulf
• 00UTC 9 Nov 48h MOGM-ECMWF difference plot
• Initial investigation into small differences in position/depth of low near Cuba and handling of trough which lifts Eta northwards

• MOGEPS-G ensemble spread did not capture second Florida landfall
• Feeding into wider research work into the ensemble being underspread
The most skilful individual ensemble can vary from storm to storm and basin to basin.

Additional skill can be gained by using a multi-model ensemble.

Titley and Bowyer (2019)
Cyclogenesis – Hurricane Hanna

• All forecasts verifying just before landfall as a hurricane shown

• Little indication of formation until 60 hours before landfall

• Very little to suggest hurricane intensity possible
Cyclogenesis – Hurricane Zeta

- All forecasts verifying at time just before landfall over Yucatan.
- Hint of formation 84 hours in advance, but still weak up to 24 hours ahead.
### Cyclogenesis – Hurricane Eta

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Map 1</th>
<th>Map 2</th>
<th>Map 3</th>
<th>Map 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>T=240 (10 days)</td>
<td><img src="image1.png" alt="Map 1" /></td>
<td><img src="image2.png" alt="Map 2" /></td>
<td><img src="image3.png" alt="Map 3" /></td>
<td><img src="image4.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=228 (9.5 days)</td>
<td><img src="image5.png" alt="Map 1" /></td>
<td><img src="image6.png" alt="Map 2" /></td>
<td><img src="image7.png" alt="Map 3" /></td>
<td><img src="image8.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=216 (9 days)</td>
<td><img src="image9.png" alt="Map 1" /></td>
<td><img src="image10.png" alt="Map 2" /></td>
<td><img src="image11.png" alt="Map 3" /></td>
<td><img src="image12.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=204 (8.5 days)</td>
<td><img src="image13.png" alt="Map 1" /></td>
<td><img src="image14.png" alt="Map 2" /></td>
<td><img src="image15.png" alt="Map 3" /></td>
<td><img src="image16.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=192 (8 days)</td>
<td><img src="image17.png" alt="Map 1" /></td>
<td><img src="image18.png" alt="Map 2" /></td>
<td><img src="image19.png" alt="Map 3" /></td>
<td><img src="image20.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=180 (7.5 days)</td>
<td><img src="image21.png" alt="Map 1" /></td>
<td><img src="image22.png" alt="Map 2" /></td>
<td><img src="image23.png" alt="Map 3" /></td>
<td><img src="image24.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=166 (7 days)</td>
<td><img src="image25.png" alt="Map 1" /></td>
<td><img src="image26.png" alt="Map 2" /></td>
<td><img src="image27.png" alt="Map 3" /></td>
<td><img src="image28.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=156 (6.5 days)</td>
<td><img src="image29.png" alt="Map 1" /></td>
<td><img src="image30.png" alt="Map 2" /></td>
<td><img src="image31.png" alt="Map 3" /></td>
<td><img src="image32.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=144 (6 days)</td>
<td><img src="image33.png" alt="Map 1" /></td>
<td><img src="image34.png" alt="Map 2" /></td>
<td><img src="image35.png" alt="Map 3" /></td>
<td><img src="image36.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=132 (5.5 days)</td>
<td><img src="image37.png" alt="Map 1" /></td>
<td><img src="image38.png" alt="Map 2" /></td>
<td><img src="image39.png" alt="Map 3" /></td>
<td><img src="image40.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=120 (5 days)</td>
<td><img src="image41.png" alt="Map 1" /></td>
<td><img src="image42.png" alt="Map 2" /></td>
<td><img src="image43.png" alt="Map 3" /></td>
<td><img src="image44.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=108 (4.5 days)</td>
<td><img src="image45.png" alt="Map 1" /></td>
<td><img src="image46.png" alt="Map 2" /></td>
<td><img src="image47.png" alt="Map 3" /></td>
<td><img src="image48.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=96 (4 days)</td>
<td><img src="image49.png" alt="Map 1" /></td>
<td><img src="image50.png" alt="Map 2" /></td>
<td><img src="image51.png" alt="Map 3" /></td>
<td><img src="image52.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=84 (3.5 days)</td>
<td><img src="image53.png" alt="Map 1" /></td>
<td><img src="image54.png" alt="Map 2" /></td>
<td><img src="image55.png" alt="Map 3" /></td>
<td><img src="image56.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=72 (3 days)</td>
<td><img src="image57.png" alt="Map 1" /></td>
<td><img src="image58.png" alt="Map 2" /></td>
<td><img src="image59.png" alt="Map 3" /></td>
<td><img src="image60.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=60 (2.5 days)</td>
<td><img src="image61.png" alt="Map 1" /></td>
<td><img src="image62.png" alt="Map 2" /></td>
<td><img src="image63.png" alt="Map 3" /></td>
<td><img src="image64.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=48 (2 days)</td>
<td><img src="image65.png" alt="Map 1" /></td>
<td><img src="image66.png" alt="Map 2" /></td>
<td><img src="image67.png" alt="Map 3" /></td>
<td><img src="image68.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=36 (1.5 days)</td>
<td><img src="image69.png" alt="Map 1" /></td>
<td><img src="image70.png" alt="Map 2" /></td>
<td><img src="image71.png" alt="Map 3" /></td>
<td><img src="image72.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=24 (1 day)</td>
<td><img src="image73.png" alt="Map 1" /></td>
<td><img src="image74.png" alt="Map 2" /></td>
<td><img src="image75.png" alt="Map 3" /></td>
<td><img src="image76.png" alt="Map 4" /></td>
</tr>
<tr>
<td>T=12 (0.5 days)</td>
<td><img src="image77.png" alt="Map 1" /></td>
<td><img src="image78.png" alt="Map 2" /></td>
<td><img src="image79.png" alt="Map 3" /></td>
<td><img src="image80.png" alt="Map 4" /></td>
</tr>
</tbody>
</table>

- All forecasts verifying at time just after Eta became a hurricane.
- An indication of formation 108 hours ahead, but very weak circulation.
- Other cases of poor cyclogenesis prediction (see additional slides): Marco, Nana, Delta.
All forecasts verifying at first main hour after storm formation

Good forecast of tropical storm formation at least 7 days ahead

Cyclogenesis handled better for larger storms and those in the MDR/open ocean

Possible research: impact of observations on the periphery of TC development in western Caribbean and Gulf of Mexico.
Ensembles Cyclogenesis

Tropical cyclone genesis in 2020 Atlantic hurricane season

- The storms that developed from African Easterly Waves were generally well forecast by MOGREPS-G, and the other global ensembles.

- The formation of some of the storms that formed in the Caribbean and Gulf were less well predicted by the global ensembles.

- Forecast from DT 00UTC 6th September.
- Formations of Paulette, Rene and Teddy in open ocean all well predicted.
- Formation of Sally near Florida not well predicted
Rapid Intensification

- Rapid intensification of Laura reasonably well captured
- Rapid intensification of Delta not captured
- Second peak in intensity of Delta handled well
Convection Permitting Ensemble (4.4 km) – Hurricane Sally

- CP ensemble tracks similar to MOGREPS-G
- CP ensemble much better for intensity

Forecast 80-90% prob of 600 mm in 96h

- Observed:
  - Pensacola 610 mm
  - AL/FL border 750 mm

- CP ensemble also captured second intensification of Delta well (additional slides)
Wind-Pressure Relationship Update

- Capped drag at high wind speeds to be introduced in Global Model in December
- Trials show improvement in wind-pressure relationship (Control red, Trial green)
- Example forecast for Hurricane Paulette
- Control left, Trial right
- Winds 18 knots stronger with no difference in central pressure
• Planned introduction 2021
• Central pressure over-deepening bias much reduced
  • Hurricane Teddy example
• Low bias in 10m winds made worse
• Combined impact of drag over the ocean and coupling yet to be tested.
The End

Additional slides available including seasonal forecast assessment
Additional slides
# Atlantic Seasonal Forecast 2020

## Forecast Values

<table>
<thead>
<tr>
<th>Storm Type</th>
<th>May-October</th>
<th>June-November*</th>
<th>July-December*</th>
<th>August-January*</th>
<th>Observed to 17 November</th>
<th>1981-2010 Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical storms</td>
<td>13</td>
<td>9-17</td>
<td>15</td>
<td>11-19</td>
<td>19</td>
<td>15-23</td>
</tr>
<tr>
<td>Hurricanes</td>
<td>7</td>
<td>5-9</td>
<td>7</td>
<td>5-9</td>
<td>8</td>
<td>5-11</td>
</tr>
<tr>
<td>Major hurricanes</td>
<td>3</td>
<td>2-4</td>
<td>3</td>
<td>2-4</td>
<td>4</td>
<td>3-5</td>
</tr>
<tr>
<td>ACE index</td>
<td>115</td>
<td>66-164</td>
<td>112</td>
<td>68-156</td>
<td>150</td>
<td>108-192</td>
</tr>
</tbody>
</table>

* Forecast values include data for storms which occurred before the forecast start date.
* Public forecast
Atlantic Seasonal Forecast 2020

- Forecast track spatial anomaly from August onwards gave good guidance
Atlantic Seasonal Forecast 2020

- Forecasts late March to early April called for high activity
- Forecast activity reduced mid-April to late May when public forecast issued
- From June onwards forecast activity increased again

- Currently only one public forecast issued (late May)
- May consider issuing a late July update as done by other agencies

- GloSea6 to be implemented February 2021 based on GC3.2
- No assessment or hindcasts yet available
Cyclogenesis – Hurricane Marco

- All forecasts verifying at time Marco became a hurricane
- Very weak circulation forecast on and off from day 5
- Barely discernible even in the analysis
• All forecasts verifying just before landfall as a hurricane shown

• Hint of formation 7 days out, but too far east and lost after that

• Barely discernible even in the analysis
Cyclogenesis – Hurricane Delta

• All forecasts verifying at time of landfall over Yucatan

• Early forecasts too strong for Gamma and missed Delta

• Eventually captured Delta two days before landfall
Wind-Pressure Relationship Update

- Prior to implementation of GA6 in 2014, global model rarely simulated tropical cyclones stronger than 65 knots or 960 hPa.
- Under GA6/GA7 central pressure can go as low as 880 hPa, but rarely above 110 knots.

- Contributor to poor Wind-Pressure relationship at high wind speeds is the model’s linearly increasing drag over the ocean.
- Theory and experimental work suggests drag does not continue increasing at higher wind speeds.
- Extensive trials undertaken with drag capped and then reduced at high wind speeds.
MOGREPS-G - Hurricane Laura

- Laura 00Z forecast tracks (left), 12Z tracks (right)
- A left-of-track bias in some early forecasts (slight wind shield wiper effect)
- Ensembles captured uncertainty as in this example from 00Z 23 August.
MOGREPS-G and Convection Permitting Ensemble – Hurricane Delta

MOGREPS-G

8.8km GA7 ensemble

8.8km CP ensemble

4.4km CP ensemble
• MOGREPS-G and 4.4km ensemble both capture track well

• MOGREPS-G good for intensity timing, but not absolute value

• 4.4km ensemble excellent for intensity