Performance and Evaluation of HWRF-based Ensemble Prediction System for 2018 Hurricane Season

Zhan Zhang\textsuperscript{1,2}, Weiguo Wang\textsuperscript{1,2}, Lin Zhu\textsuperscript{1,2}, Bin Liu\textsuperscript{1,2}, Avichal Mehra\textsuperscript{2} and Vijay Tallapragada\textsuperscript{2}

\textsuperscript{1}IMSG, Rockville, MD 20842
\textsuperscript{2}EMC/NCEP/NWS/NOAA, College Park, MD 20740

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Outline

- Configuration of 2018 HWRF-base Ensemble Prediction System (HWRF-EPS)
- Comparison of verification of HWRF-EPS with its own deterministic control member (HWoo)
- Comparison of verification of HWRF-EPS with the 2018 operational HWRF
- Posterior analysis and HWRF-EPS Statistical Characteristics
- Conclusion and Future Work
2018 HWRF ensemble Configuration

- Use 2018 operational deterministic HWRF model except for
  - Less horizontal resolution: 14.5/4.5/1.5km vs. 18/6/2km (27/9/3km, in 2017)
  - Less vertical resolution: L75 vs. L61 (L43)
  - No GSI due to lack of GDAS data;

- IC/BC Perturbations (large scale): 20 member GEFS, 0.5x0.5 degree GRIB2 (1x1deg.)

- Model Physics Perturbations (vortex scale):
  - Stochastic Convective Trigger Perturbations in SAS: -50hPa to +50hPa white noise;
  - Stochastic boundary layer height perturbations in PBL scheme, -20% to +20%;
  - Stochastic Cd perturbation;

- Situation-appropriate perturbations to the initial time position and intensity in TCVital.

- Initial ocean SST perturbations (Xiao Hui & Ryan Torn)
  - Climatological (2012-2016), GFS surface analysis
  - Remove climatological mean, scale to 0.5K standard deviation.
  - Mix the initial SST perturbation downward into upper ocean (150 m).

- Use values of coac and codamp for 2km resolution
## Storm List conducted in 2018 Hurricane Season

### North Atlantic Basin (total sample: 187)

<table>
<thead>
<tr>
<th>Storm Name</th>
<th>Start Cycle</th>
<th>End Cycle</th>
<th>No. of Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florence 06L</td>
<td>2018083018</td>
<td>2018091500</td>
<td>61</td>
</tr>
<tr>
<td>Gordon 07L</td>
<td>2018090212</td>
<td>2018090500</td>
<td>11</td>
</tr>
<tr>
<td>Isaac 09L</td>
<td>2018090712</td>
<td>2018091706</td>
<td>35</td>
</tr>
<tr>
<td>Kirk 12L</td>
<td>2018092106</td>
<td>2018092812</td>
<td>30</td>
</tr>
<tr>
<td>Leslie 13L</td>
<td>2018092318</td>
<td>2018101000</td>
<td>30</td>
</tr>
<tr>
<td>Michael 14L</td>
<td>2018100718</td>
<td>2018101112</td>
<td>20</td>
</tr>
</tbody>
</table>

### East Pacific Basin (total sample: 88)

<table>
<thead>
<tr>
<th>Storm Name</th>
<th>Start Cycle</th>
<th>End Cycle</th>
<th>No. of Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hector 10E</td>
<td>2018080400</td>
<td>2018081318</td>
<td>40</td>
</tr>
<tr>
<td>Lane 14E</td>
<td>2018081612</td>
<td>2018082806</td>
<td>48</td>
</tr>
</tbody>
</table>
Track and Intensity Verification for NATL/EPAC (HWMN vs HWoo)

~20% track improvement after day 1

~10% improvement for day 1 neutral afterward

~5% improvement at all time levels

~13% improvement at all time levels
Track and Intensity Verification
(HWMN vs HWRF)

AL-Track
Improved at all time levels

AL-Intensity
Improved before day 1 and after 60h

EP-Track

EP-Intensity

Improved at all time levels
1. All three systems missed westward turning point;
2. HWoo/HWMN have southward track bias following GEFS.
Composite Intensities for Florence 06L

Improved compared with HWoo

Improved compared with HWRF
Posterior Analysis on Track/Intensity forecasts

MPTE: Minimum Potential Track Error
MPIE: Minimum Potential Intensity Error

The track/intensity forecasts in MPTE/MPIE consist of the ensemble member that is closest to the observed track/intensity in the best track at each cycle.

Potential applications of MPTE/MPIE:
1. Verify/validate ensemble system by checking equal chance of being best forecast for each individual ensemble member (next slide);
2. Select best ensemble member by using available model/obs. Information;
3. Investigate best forecast member to understand model physics;
4. Study the predictability of current dynamic model, intrinsic forecast limit.
Statistical Features of HWRF-EPS

Probability of individual ensemble member being best track/intensity

Track

1/20 or 5% line

Intensity

Ratio of Forecast Error to Ensemble Spread

Improved over H217
Conclusion

- HWRF EPS produced lower track/intensity forecast errors, compared to its deterministic control run at both AL and EP basins in 2018;
- Although HWRF-EPS uses lower resolution and no DA, it outperformed the operational HWRF in terms of intensity forecasts at NATL basin, track forecast is still behind (partially followed its parent model, GEFS);
- HWRF-EPS has its desired feature that each member has equal chance to be closest to best track obs., and the ensemble spread and forecast error ratio of HWRF-EPS is improved compared to 2017 version;

Future Work

- Further improve the ratio of ensemble spread and forecast error
- Develop better track/intensity post-process based on MPTE/MPIE
Thank You!

HWRF-EPS:
http://www.emc.ncep.noaa.gov/HWRF/HWRFEPS/index.php
Additional Slides
Highlights for HWRF's FY2018 implementation --related to HWRF-based ensemble

HWRF Infrastructure Enhancements:

- Upgrade dynamic core from WRF3.8.1a to WRF3.9.1
- Test and evaluation with 2017 4D-Hybrid GDAS/GFS initial and boundary conditions
- Increase horizontal resolution from (18/6/2-km) to (13.5/4.5/1.5-km), with slightly reduced domain sizes for the two nested domains

HWRF Physics Advancements:

- Upgrade the RRTMG scheme with a modified cloud overlap method
- Adjust the horizontal diffusion and convergence damping coefficients
Individual Storm Track Improvement for NATL (HWMN vs HWoo)

Florence, 06L
Gordon, 07L
Isaac, 09L
Kirk, 12L
Michael, 14L
Leslie, 13L
Individual Storm Intensity Improvement for NATL (HWMN vs HWoo)

Florence, 06L
Gordon, 07L
Isaac, 09L
Kirk, 12L
Michael, 14L
Leslie, 13L
Individual Storm Track/Intensity Improvement, EPAC (HWMN vs HWoo)

- **Track**: Hector, 10E
- **Intensity**: Lane 14E

- **Track**: Lane, 14E
- **Intensity**: Lane 14E
Larger Ensemble Spread indicates larger Forecast Errors
Smaller Ensemble Spread indicates Smaller Forecast Errors
RI Probability Forecast from HWRF-EPS

Florence 06L

![Bar chart showing observed RI cycles for Florence 06L with probability (%) on the y-axis and dates on the x-axis.]

Michael 14L

![Bar chart showing observed RI cycles for Michael 14L with probability (%) on the y-axis and dates on the x-axis.]

\[ P_{RI} = \frac{N_{RI}}{N_{total}} \]

- \( N_{RI} \) is the max No of ensemble members that predicted RI event in 96h;
- \( N_{total} \) equals 20, the total No. of ensemble numbers.