National Hurricane Center Forecast Verification: Quantifying Forecast Uncertainty

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NHC Forecast Verification

• NHC verifies all official tropical cyclone track and intensity forecasts each year

• Why verify forecasts?
  1. Monitor performance and progress
     • Government Performance and Results Act (GPRA)
  2. Understanding forecast errors help forecasters and modelers to reduce them
  3. Identify critical issues for the research community
  4. Basis for the development of certain products
     • Wind speed and storm surge probabilities
  5. Helps decision makers use NHC products more effectively
NHC Forecast Verification

• System must be a tropical or subtropical cyclone at both forecast initial time and verification time

• Special advisories ignored (original advisory is verified instead)

• Definitions:
  • Track error: great-circle distance between the forecast location and the actual location of the storm center (n mi)
  • Intensity error: difference between the forecast and actual intensity (kt)
  • Forecast SKILL is computed by comparing forecast error to the error from a Climatology-Persistence model (CLIPER, Decay-SHIFOR)
Track Error Definition
2011 Atlantic Verification

Values in green exceed all-time records

48-hour GPRA error targets
Track: 87 n mi (met)
Intensity: 13 kt (missed)
Nothing new here...

Two records set for track and 48-h track error was near 70 n mi
No change in intensity error, still grows quickly through 2-3 days and levels off
Track errors increase 40-50 n mi per day, 5-day errors approaching 200 n mi.
Atlantic Track Error Trends

Errors have been cut in half over the past 15 years.
Bret, Don, Irene, Katia, Lee, Rina, and Sean were successes. Struggled with Maria, Ophelia.
NHC Forecast Cone

- Represents probable track of tropical cyclone center – but does not tell you anything about impacts!
- Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- Size of the circles determined so that, for example, the actual storm position at 48 h will be within the 48-h circle 67% of the time
# Atlantic Cone Radii – 2012 vs. 2011

<table>
<thead>
<tr>
<th>Forecast Period (h)</th>
<th>2011 Circle Radius (n mi) (’06 – ’10 errors)</th>
<th>2012 Circle Radius (n mi) (’07 – ’11 errors)</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>36</td>
<td>36</td>
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<tr>
<td>24</td>
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<tr>
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<td>190</td>
<td>180</td>
<td>-5%</td>
</tr>
<tr>
<td>120</td>
<td>239</td>
<td>236</td>
<td>-1%</td>
</tr>
</tbody>
</table>
Along- and Cross-Track Errors (Timing vs. Location)
Along- and Cross-Track Errors

Cross-Track Error
(Forecast too far to the right)

Along-Track Error
(Forecast too slow)
Along- and Cross-Track Errors

Differences largely negligible at shorter time periods, but at longer ranges there is more difficulty with timing than direction.

Wind speed and storm-surge probability products use along-track and cross-track errors.
Intensity errors increase quickly at first, but then level off at 15-20 kt after 48 h.
No progress with intensity

24-48 h intensity forecasts likely to be off by one SSHS category, and off by two SSHS categories perhaps 5-10% of the time
Atlantic forecasts well calibrated throughout – much improved this year
5-year Atlantic Genesis Forecast Verification

5-year sample shows good reliability through the probability range, with a slight under-forecast bias at 70% and above
Verification Web Page

NHC Data Archive

Contents
- Tropical Cyclone Reports
- Tropical Cyclone Advisories
- Graphical Tropical Weather Outlook (GTWO)
- Marine & Advisory Text Products
- Best Track Data (HURDAT)
- Past Track Seasonal Maps
- Past Track Maps of U.S. Landfalls
- Tropical Cyclone GIS Data
- Storm Weather Scanning Project
- Tropical Cyclone Monthly Summaries
- Tropical Cyclone Annual Summaries (Atlantic)
- Tropical Cyclone Seasonal Outlooks
- Tropical Cyclone Climatology
- Tropical Cyclone Forecast Verification
- Aircraft Reconnaissance Archive
- Deadliest, Costliest, Most Intense Atlantic Storms
- Central Pacific Hurricane History

Tropical Cyclone Reports

The National Hurricane Center's Tropical Cyclone Reports (formerly called Preliminary Reports) contain comprehensive information on each storm, including synoptic history, meteorological statistics, casualties and damages, and the post-analysis best track (six-hourly positions and intensities).

Atlantic, Caribbean, and the Gulf of Mexico

2011

Eastern Pacific (out to 140°W)

2011


An XML index file is also available for all the Tropical Cyclone Reports.
Summary

• Atlantic basin track errors increase by 40–50 n mi each day
  • Forecasts have been steadily getting better over the past two decades (and longer)

• NHC uncertainty cone made up of circles that enclose actual storm position about two-thirds of the time
  • Error cone will be only about 5% smaller in 2012, so little perceivable change
  • However, as the cone has shrunk over the years, impacts become more likely to occur outside the cone!

• Actual track forecast errors aren’t quite circular about the forecast point
  • Along-track (timing) errors tend to be larger than cross-track (directional) errors at 48 h and beyond
Summary

• Intensity errors 24-48 h in advance are regularly off by one Saffir-Simpson category
• Intensity errors begin to level off around 72 h
• No appreciable change in intensity forecast error over the past two decades
• 48-h genesis forecasts show ability to distinguish between systems that clearly will or will not develop
  • Genesis forecasts struggle with systems in the 30-70% probability ranges, but have shown signs of improvement