Statistical Rapid Intensity Prediction: Implications of Recent Model Results

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Outline

• Background on the RI problem
• Analysis of RI prediction skill of recent deterministic model forecasts
• Description of the statistical RI models
• Verification of statistical RI model performance
• Overview of shear distributions of RI and non-RI cases
• Summary
Background

• Predicting RI using deterministic intensity prediction models has proven to be very difficult (Elsberry et al. 2007)

• ~80% of Atlantic MH undergo RI (30-kt/24-h) (Kaplan and DeMaria 2003)

• Model forecasting difficulties due to the multi-scale nature of RI:
  ➢ Environment (e.g. Molinari and Volleraro 1989; Kaplan and DeMaria 2003)
  ➢ Inner-core (Kossin and Schubert 2001, Kieper and Jiang 2012; Rogers et al. 2015)
  ➢ Ocean (Shay et al. 2000)

• 2004-SHIPS-RII - Statistical model for estimating probability of RI (30-kt/24-h) using SHIPS( GFS-based) environmental predictors becomes operational (Kaplan and DeMaria 2003)

• 2008- More sophisticated versions of SHIPS-RII based upon linear discriminant analysis are developed (Kaplan et al. 2010)

• 2016- SHIPS-RII and new probabilistic Logistic regression, Bayesian, and Consensus RI models (Rozoff and Kossin 2011) developed for 12-h, 24-h, 36-h, and 48-h lead times (Kaplan et al. 2015)

• 2017 – RI models for 65kt/72-h lead-time added (HFIP)
Percentiles of over-water tropical cyclone intensity change (1995-2016)

<table>
<thead>
<tr>
<th>dv/dt (kt h⁻¹)</th>
<th>Atlantic</th>
<th>E. Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-kt/12h</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>25-kt/24h</td>
<td>89</td>
<td>85</td>
</tr>
<tr>
<td>30-kt/24-h</td>
<td>93</td>
<td>90</td>
</tr>
<tr>
<td>35-kt/24-h</td>
<td>96</td>
<td>93</td>
</tr>
<tr>
<td>40-kt/24-h</td>
<td>97</td>
<td>95</td>
</tr>
<tr>
<td>45-kt/36-h</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>55-kt/48-h</td>
<td>95</td>
<td>93</td>
</tr>
<tr>
<td>65-kt/72-h</td>
<td>94</td>
<td>94</td>
</tr>
</tbody>
</table>
POD, FAR, and Frequency of RI (30-kt/24-h) of 2014-2016 Atlantic operational model forecasts (N=470, NRI=32)
POD, FAR and Frequency of RI (30-kt/24h) of 2014-2016 E. Pacific operational model forecasts (N=929, NRI=115)
POD, FAR, and Frequency of RI (25-kt/24-h) of 2014-2016 Atlantic operational model forecasts (N=470, NRI=46)
POD, FAR and Frequency of RI (25-kt/24h) of 2014-2016 E. Pacific operational model forecasts (N=929, NRI=159)
POD, FAR, and Frequency of RI (55-kt/48-h) for 2014-2016 Atlantic operational model forecasts (N=361, NRI=17)
POD, FAR, and Frequency of RI (55-kt/48-h) for 2014-2016 E. Pacific operational model forecasts (N=725, NRI=68)
2016 Operational Statistical RI models

• Predict RI probability for 7 RI thresholds at 4 lead times (20-kt/12-h, 25-kt/24-h, 30-kt/24-h, 35-kt/24-h, 40-kt/24-h, 45-kt/36-h and 48-h/55-kt) for the Atlantic and E. Pacific (Kaplan et al. 2015).

• Multi-lead time RI models developed include the following:
  - SHIPS-RII – Based upon linear discriminant analysis
    - 10 SHIPS environmental predictors utilized in both the Atlantic and E. Pacific basins (Kaplan et al. 2015)
  - Logistic regression and Bayesian RI models (Rozoff and Kossin 2011; Kaplan et al. 2015)
    - Logistic regression/Bayesian RI models employ the SHIPS predictors that maximized cross-validated model skill at each forecast lead time
  - Consensus RI model is the arithmetic average of SHIPS, Logistic, and Bayesian model forecasts
Predictors used in operational SHIPS-RII

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Definition</th>
<th>More Favorable</th>
</tr>
</thead>
<tbody>
<tr>
<td>PER</td>
<td>Previous 12-h intensity change</td>
<td>Larger</td>
</tr>
<tr>
<td>VMAX</td>
<td>Maximum sustained wind (t=0 h)</td>
<td>Avg. of RI sample</td>
</tr>
<tr>
<td>IRSD</td>
<td>Std. dev. of 50-200 km GOES-IR brightness temperatures (t= 0 h)</td>
<td>Smaller</td>
</tr>
<tr>
<td>IRPC</td>
<td>2nd principle component of GOES-IR image (0-440 km radius) (t= 0 h)</td>
<td>Front left quadrant</td>
</tr>
<tr>
<td>SHEAR</td>
<td>850-200-hPA shear 0-500 km radius (time-avg.)</td>
<td>Smaller</td>
</tr>
<tr>
<td>D200</td>
<td>200-hPA divergence from 0-1000 km radius (time-avg.)</td>
<td>Larger</td>
</tr>
<tr>
<td>TPW</td>
<td>Percent area with TPW &lt; 45 mm within 500 km 90 deg. up-shear (t=0 h)</td>
<td>Smaller</td>
</tr>
<tr>
<td>CFLX</td>
<td>Inner-core dry-air predictor/flux (time-avg.)</td>
<td>Smaller</td>
</tr>
<tr>
<td>POT</td>
<td>Potential intensity (Current intensity – MPI) (time-avg.)</td>
<td>Larger</td>
</tr>
<tr>
<td>OHC</td>
<td>Oceanic heat content (time-avg.)</td>
<td>Larger</td>
</tr>
</tbody>
</table>
Sample TPW predictor for Hurricane Isabel (2003)

Source: Kaplan et al. 2015
Sample IRPC predictor for Hurricane Wilma (2015) at 1800 UTC on October 17

Source: Kaplan et al. 2015
Statistical operational RI model skill in 2016 Hurricane Season

Skill evaluated for all tropical and subtropical over-water cases relative to the climatological RI probabilities based upon NHC best tracks as of Feb 2017

Consensus Model- Average of SHIPS-RII, Bayesian, and Logistic regression RI probabilistic forecasts

Atlantic

E. Pacific
POD, FAR of RI (30-kt/24-h) of 2016 operational forecasts

Atlantic (N=206, NRI=15)

E. Pacific (N=246, NRI=28)
2017 Operational RI models

-GFS model-derived TPW used in place of satellite-based values

-Slight modification to methodology used to derive GOES IR principle-component predictor

-GFS CSR reanalysis fields used in place of operational GFS analyses for cases from 1995-1999

-SHIPS-RII predictors same as 2016 version but Logistic and Bayesian models predictors slightly different

-2017 RI models include RI probabilities for 72-h/65-kt threshold (HFIP)
Relative weights of the 2017 SHIPS-RII

(for 24-h/30-kt, 48-h/55-kt and 72-h/65-kt RI thresholds based upon 1995-2016 developmental data)
Comparison of Skill of the 2016 and 2017 SHIPS-RII for the 2014-2016 re-run forecasts

Atlantic

E. Pacific

![Comparison of Skill of the 2016 and 2017 SHIPS-RII for the 2014-2016 re-run forecasts](image_url)
Skill of the 2016 and 2017 Consensus RI models for the 2014-2017 re-run forecasts

![Brier skill relative to climatology](chart1.png)

- **Forecast Lead time (hr):** 12, 24, 36, 48, 72
- **RI threshold (kt):** 20, 25, 30, 35, 40, 45, 55, 65

![Brier skill relative to climatology](chart2.png)

- **Forecast Lead time (hr):** 12, 24, 36, 48, 72
- **RI threshold (kt):** 20, 25, 30, 35, 40, 45, 55, 65

Legend:
- **Consensus_2016**
- **Consensus_2017**
Reliability of the 2017 SHIPS-RII forecasts for the 2014-2016 rerun cases

Atlantic

E. Pacific
Reliability of 2017 Consensus RI model forecasts for the 2014-2016 rerun cases

Atlantic

E. Pacific
SHIPS-RII and Consensus RI model forecast frequency distributions

Atlantic

E. Pacific

SHIPS

Consensus
SHIPS-RII 2017 model rerun and HWFI operational forecasts for Hurricane Patricia (2015)
SHIPS-RII 2017 rerun and HWFI operational forecasts for Hurricane Matthew (2016)
Atlantic basin 850-200 mb observed SHIPS shear distributions for the 1995-2016 developmental sample

30kt/24h

55kt/48h

65kt/72h

Cumulative Frequency

Frequency (%)
E. Pacific basin 850-200 mb observed SHIPS shear distributions for the 1995-2016 developmental sample

30kt/24h

55kt/48h

65kt/72h

Cumulative Frequency
Probability of RI based upon 850-200mb observed SHIPS shear for the 1995-2016 developmental samples

Atlantic

E. Pacific
Summary

- Deterministic model forecasts exhibited a low POD and moderate FAR for the 2014-2016 Atlantic and E. Pacific samples.

- Statistical operational RI models showed a small (modest) degree of skill in the Atlantic (E. Pacific) for the 2016 season. New 2017 RI models showed improvements over 2016 versions for the 2014-2016 reruns.

- Consensus of SHIPS, Logistic, and Bayesian RI models generally provided increased reliability and skill over SHIPS-RII for the 2014-2016 reruns forecasts (particularly in E. Pacific).

- Study results underscore the importance of accurately measuring and predicting the large-scale environment.

- Additional research is needed to better understand the processes that govern RI to ultimately improve RI prediction.