Enhancement of SHIPS Using Passive Microwave Imager Data—2005 Testing

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Ty Martin (UAH)
Outline

I. Intro - Components of SHIPS-MI forecast

II. Results from 1988-2004 training sample

III. Results from 2005

IV. Webpage examples
**SHIPS-MI**

Forecast Intensity Change (DELV)

=  

Sample Mean  +  

**Climatological and Persistence**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSW0</td>
<td>Initial Max Sustained Winds</td>
</tr>
<tr>
<td>PER</td>
<td>Persistence (previous 12-h intensity change)</td>
</tr>
<tr>
<td>VPER</td>
<td>MSW0 x Persistence</td>
</tr>
</tbody>
</table>

**Environmental Terms**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POT</td>
<td>MPI - MSW0 (Potential for further intensification)</td>
</tr>
<tr>
<td>POT2</td>
<td>POT squared</td>
</tr>
<tr>
<td>SHRD</td>
<td>200-850 hPa wind shear</td>
</tr>
<tr>
<td>SHRDLAT</td>
<td>SHRD x LAT</td>
</tr>
<tr>
<td>MSWSHRD</td>
<td>MSW0 x SHRD</td>
</tr>
<tr>
<td>EPOS</td>
<td>$\theta_E$ excess of a lifted parcel</td>
</tr>
<tr>
<td>T200</td>
<td>200 hPa temperature</td>
</tr>
<tr>
<td>Z850</td>
<td>850 hPa vorticity</td>
</tr>
<tr>
<td>PSLV</td>
<td>Pressure at the Steering Level</td>
</tr>
</tbody>
</table>

**Microwave Terms**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEANH19</td>
<td>0-100 km Mean 19 GHz Horizontal TB</td>
</tr>
<tr>
<td>MAXH19</td>
<td>0-100 km Maximum 19 GHz Horizontal TB</td>
</tr>
</tbody>
</table>

In E. Pacific:

Latitude and 200 hPa Divergence added

PSLV and VPER removed
Recent Progress

Training sample size expanded substantially

Now 1988-2004 (~1600 24-h forecasts)
Previously 1995-2003 (~900 24-h forecasts)

Code tested at NHC

Ingest TMI and SSM/I near real time TBs
Read SHIPS predictors from lsdiag.dat file
Compute microwave predictors
Generate SHIPS-MI forecast
Write text output
Results from Training Sample

MI training sample now goes back to 1988
IR+OHC adjustment in SHIPS goes back to 1995
Comparisons between SHIPS-MI and SHIPS use 1995-2004 subset of training sample
- homogeneous, dependent sub-sample
- landfall cases are excluded
SHIPS-E is the 2005 operational model without IR or Oceanic Heat Content adjustment. BASE has the same predictors as SHIPS-MI, except microwave predictors are excluded.

Sample size is small at 60 h and beyond; improvement there is not meaningful. Improvement due to MI is greater than improvement due to IR and OHC.

Normalized relative to errors from the 2005 operational SHIPS coefficients.
1995-2004 Mean Absolute Errors

Same data as previous plot, except errors are not normalized.

Sample size is small at 60 h and beyond; improvement there is not meaningful.

SHIPS-MI improves over SHIPS through 48 h, essentially matches SHIPS after that.
1995-2004 homogeneous sample size

Sample size for a *homogeneous, dependent* sample 1995-2004 (no jack-knifing applied)

1995-2004 includes the IR+OHC adjustment to the operational SHIPS (only IR in E. Pacific)
Normalized relative to errors from the 2005 operational SHIPS coefficients

SHIPS-E is the 2005 operational model without IR adjustment
BASE has the same predictors as SHIPS-MI, except microwave predictors are excluded

Sample size is small at 60 h and beyond; improvement there is not meaningful
Improvement due to MI is greater than improvement due to IR
Same data as previous plot, except errors are not normalized.

Sample size is small at 60 h and beyond; improvement there is not meaningful.

SHIPS-MI improves over SHIPS through 48 h, essentially matches SHIPS after that.
Mean Absolute Errors for a *homogeneous, dependent* sample 1988-2004 (no jack-knifing applied)
Mean Absolute Errors for a *homogeneous, dependent* sample 1988-2004 (no jack-knifing applied)

SHIPS-E is the 2005 operational model *without* IR or Oceanic Heat Content adjustment

**BASE** has the same predictors as SHIPS-MI, except microwave predictors are excluded

Note that this is the entire SHIPS-MI training sample, but SHIPS uses a larger training sample, so SHIPS-MI (and **BASE**) has an unfair advantage in computing errors from this sample; this especially matters at long forecast periods where sample size is small
Mean Absolute Errors for a *homogeneous, dependent* sample 1991-2004 (no jack-knifing applied)

SHIPS-E is the 2005 operational model *without* IR adjustment

**BASE** has the same predictors as SHIPS-MI, except microwave predictors are excluded

Note that this is the entire SHIPS-MI training sample, but SHIPS uses a larger training sample, so SHIPS-MI (and **BASE**) has an unfair advantage in computing errors from this sample; this especially matters at long forecast periods where sample size is small
Microwave and Sea Surface Temperature predictors are most important through 24 h

Contribution from microwave decreases rapidly after 36 h

SST contribution increases with time

Shear terms are second most important (behind SST) after 36 h
SST and CLIPER terms (primarily LATITUDE) are most important in E. Pac.; LAT is not included in Atlantic version

Persistence especially important for short range, Latitude especially important for long range

Shear much less important than in Atlantic

Microwave has less impact at 18-54 h than in Atlantic
2005 Atlantic Results

Data collected in real time
Forecasts re-generated in 2006, after expanding training sample back to 1988
Verification based on operational intensities, *not* best tracks
Some scripting and network issues caused missing forecasts
- Should have had fcsts at 30-40% of synoptic times
- Instead had fcsts at 25% of synoptic times
### 2005 RMS Errors (ATL)

<table>
<thead>
<tr>
<th></th>
<th>12-h</th>
<th>24-h</th>
<th>36-h</th>
<th>48-h</th>
<th>72-h</th>
<th>96-h</th>
<th>120-h</th>
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<tbody>
<tr>
<td>#fcsts</td>
<td>115</td>
<td>103</td>
<td>94</td>
<td>85</td>
<td>71</td>
<td>58</td>
<td>45</td>
</tr>
<tr>
<td>SHIPS-MI</td>
<td>8.5</td>
<td>12.4</td>
<td>16.0</td>
<td>19.3</td>
<td>21.9</td>
<td>22.5</td>
<td>27.7</td>
</tr>
<tr>
<td>SHIPS</td>
<td>8.7</td>
<td>12.6</td>
<td>16.4</td>
<td>18.7</td>
<td>21.3</td>
<td>21.7</td>
<td>26.3</td>
</tr>
<tr>
<td>OFCL</td>
<td>7.4</td>
<td>11.1</td>
<td>14.6</td>
<td>17.7</td>
<td>20.9</td>
<td>22.9</td>
<td>28.4</td>
</tr>
<tr>
<td>SHIFOR</td>
<td>9.2</td>
<td>14.0</td>
<td>18.8</td>
<td>21.0</td>
<td>24.8</td>
<td>25.4</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Landfalls excluded

Operational estimates used for verification
## 2005 Bias (ATL)

<table>
<thead>
<tr>
<th></th>
<th>12-h</th>
<th>24-h</th>
<th>36-h</th>
<th>48-h</th>
<th>72-h</th>
<th>96-h</th>
<th>120-h</th>
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</thead>
<tbody>
<tr>
<td>SHIPS-MI</td>
<td>-0.1</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SHIPS</td>
<td>-0.9</td>
<td>-1.1</td>
<td>-0.6</td>
<td>-2.1</td>
<td>-3.7</td>
<td>-3.2</td>
<td>-3.4</td>
</tr>
<tr>
<td>OFCL</td>
<td>0.2</td>
<td>-0.5</td>
<td>0.0</td>
<td>-2.7</td>
<td>-4.9</td>
<td>-5.1</td>
<td>-4.9</td>
</tr>
<tr>
<td>SHIFOR</td>
<td>-0.8</td>
<td>-1.6</td>
<td>-2.1</td>
<td>-5.0</td>
<td>-6.6</td>
<td>-6.3</td>
<td>-6.7</td>
</tr>
</tbody>
</table>

Landfalls excluded

Operational estimates used for verification

Negligible bias

In 2005, SHIPS-MI tended to nudge forecasts a few kt in the right direction, compared to SHIPS
Individual 2005 Storms

36-h RMS errors for those storms that had at least ten SHIPS-MI forecasts:

<table>
<thead>
<tr>
<th>Storm</th>
<th># fcsts</th>
<th>SHIPS-MI</th>
<th>SHIPS</th>
<th>OFCL</th>
<th>SHIFOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emily</td>
<td>13</td>
<td>24.9</td>
<td>27.3</td>
<td>18.5</td>
<td>33.5</td>
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<tr>
<td>Irene</td>
<td>15</td>
<td>12.3</td>
<td>8.6</td>
<td>8.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Maria</td>
<td>12</td>
<td>8.7</td>
<td>9.9</td>
<td>12.3</td>
<td>10.5</td>
</tr>
<tr>
<td>Epsilon</td>
<td>13</td>
<td>15.2</td>
<td>17.6</td>
<td>17.1</td>
<td>15.1</td>
</tr>
</tbody>
</table>

For various reasons, only a few storms had 10+ SHIPS-MI 36-h forecasts

- scripting or network problems at UAH
- SSM/I at bad time in GOM / W. Carrib, too late for fcsts
For 24-h fcsts:

SHIPS-MI is better ~60% of time

SHIPS is better ~40% of time

Usually only a few kt difference

Most improvement is for large underforecasts
Webpage Examples

Page is under development, hope to have it online with real time forecasts in 2006

User capable of altering input predictor values, generate new forecast

Example:
  If you don’t believe the shear is accurate, input a new value

Test to see how much impact an extreme predictor value will have
A) User can change any of the input predictor values

In this example, the user increases SHEAR by 10 kt

For reference, the:

B) original forecast value

C) training sample mean

D) standard deviation are listed
The extra 10 kt Shear causes extra 37 kt weakening by 72-h
Impact from MI predictors

Changing from common values for microwave predictors to the maximum reasonable values:

<table>
<thead>
<tr>
<th>TIME</th>
<th>BEST TRACK</th>
<th>SHIPS</th>
<th>SHIPS-MI</th>
<th>SHIPS-MI(user)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>12</td>
<td>45</td>
<td>43</td>
<td>52</td>
<td>54</td>
</tr>
<tr>
<td>24</td>
<td>35</td>
<td>52</td>
<td>62</td>
<td>76</td>
</tr>
<tr>
<td>36</td>
<td>0</td>
<td>59</td>
<td>71</td>
<td>93</td>
</tr>
<tr>
<td>48</td>
<td>0</td>
<td>67</td>
<td>77</td>
<td>102</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>72</td>
<td>77</td>
<td>104</td>
</tr>
<tr>
<td>72</td>
<td>0</td>
<td>77</td>
<td>83</td>
<td>103</td>
</tr>
</tbody>
</table>

Increases forecast by:

- ~10 kt at 12 h
- ~25 kt at 24 h
- ~30 kt at 36-48 h
Example Strong Positive Microwave Signal

Hurricane Frances, 31 August 2004

MEANH19 = 259 K
Impact from MI predictors

Changing from common values for microwave predictors to the minimum reasonable values:

Decreases forecast by:
- ~10 kt at 12 h
- ~20 kt at 24 h
- ~25 kt at 36-48 h

<table>
<thead>
<tr>
<th></th>
<th>00</th>
<th>12</th>
<th>24</th>
<th>36</th>
<th>48</th>
<th>60</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST TRACK</strong></td>
<td>35</td>
<td>45</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>SHIPS</strong></td>
<td>35</td>
<td>43</td>
<td>52</td>
<td>59</td>
<td>67</td>
<td>72</td>
<td>77</td>
</tr>
<tr>
<td><strong>SHIPS-MI</strong></td>
<td>35</td>
<td>43</td>
<td>52</td>
<td>62</td>
<td>71</td>
<td>77</td>
<td>83</td>
</tr>
<tr>
<td><strong>SHIPS-MI(user)</strong></td>
<td>35</td>
<td>33</td>
<td>34</td>
<td>38</td>
<td>45</td>
<td>49</td>
<td>58</td>
</tr>
</tbody>
</table>

**Comparison of Forecasts**

Original SHIPS-MI

SHIPS

User-adjusted SHIPS-MI

Best Track