Diagnostics and Verification of the Tropical Cyclone Environment in Regional Models

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Also a special thanks to the COAMPS-TC modeling team at NRL for extensive collaboration and feedback
Diagnostic Files

- Condense model run down to 20 kb text file
- Contains analysis and forecast of key vortex-scale data as well as a vertical profile of large-scale environmental data
- Produced and made available in near-real-time since 2008 at CIRA for HWRF and GFDL
- Five-page document made available that details file naming convention, field calculations, etc.
- Uniform format across all models, flexible enough to accommodate different temporal and vertical resolutions, and to include additional custom fields
Diagnostic Files, con't

- From 2008-2011, code only existed in IDL
- In mid 2011, CIRA developed and shared Fortran code with interested modeling groups who also produced these files (NRL-Monterey, Univ at Albany, EMC, GFDL, ESRL, DTC, Univ of Wisconsin)
  - Part of HFIP Stream 1.5 effort... SPICE (SPC3) utilizes these files in real-time
- Updated versions of this code are easy to distribute and implement
- Multi-model collection of these files facilitates convenient comparison of track, intensity, environment over a storm or entire season
  - ~8 Mb / model / season
Standard SHIPS Parameters

Key parameters are calculated in prescribed areas from regional model...

This is already done with GFS output to create SHIPS “predictor” files available on NHC's FTP server

- Sea surface temp (RSST)
- 850-200 mb shear (SHDC)
- 200 mb zonal wind (U20C)
- 200 mb temp (T200)
- 850-700 mb RH (RHLO)
- 700-500 mb RH (RHMD)
- 500-300 mb RH (RHHI)
- 200 mb divergence (D200)
- 850 mb vorticity (Z850)
### Storm Data

**AL09**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>STORM DATA</td>
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<td>LAT (DEG)</td>
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<td>SHR_MAG (KT)</td>
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**Sounding Data**

**AL09**

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<td>GRD_V (dm)</td>
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<td>GRD_Z (dm)</td>
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**Custom Data**

**AL09**

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<td>GRIDWIND (KT)</td>
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<td>GRID_SLP (MB)</td>
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<td>CAFE (3/7KG)</td>
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<tr>
<td>VERT (100M/S)</td>
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**Comments**

- SST, OHC averaged in five closest points under storm center [x10 C, kJ/cm²] *
- RMW, TPW, GRIDWIND, GRID_SLP within 0-200km around storm center [km, mm, kt, mb] *
- U, V, SHR averaged from 0-500km around storm center [x10 kt, x10 kt, km] *
- 850VORT averaged from 0-100km around storm center [x10⁻⁷ rad/s, x10⁻⁷ rad/s] *
- 850TANG is 0-600km average symmetric wind [x10 m/s] *
- T, R, Z, P averaged from 200-800km around storm center [x10 C, %, dm, mb] *
Post-season Environmental Verification

- 2011 Atlantic season
- Storms of at least TD intensity
- Bias (dotted) and MAE (solid) plotted as function of forecast hour
- Homogeneous sample size shown below forecast hour
- 308 HWRF/GFDL/COTC cases at t=0 (60 at t=120h)
For intensity, “BTRK” is NHC's best-track… But in the remainder of fields, “BTRK” refers to GFS analysis.
Sea Surface Temperature

- Slight cool bias, more so in COTC (2 deg by 120h)
- Intimately linked to track errors
Vertical Shear

- ~5kt error at 36h, then GFS reaches 11kt at 120h while GFDL reaches 6.5kt at 120h
850mb Vorticity

- Similar errors among all models, most bias in HWRF
Fairly persistent and constant low-level RH errors

GFDL too dry (3-7%)
700-500mb RH

- Mid-level RH errors increase slightly with time
- GFDL drier again (5-13%)
500-300mb RH

- Persistent dry bias in HWRF & GFDL upper-level RH
- GFDL 7-14% too dry
200mb Zonal Wind

- Similar errors among all models, most bias in COTC
200mb Divergence

- Significant error in COTC
200mb Temperature

- Significant error (all positive) in GFDL's 200mb temp
  - This can have large impact on intensity
Real-time Environmental Diagnostics

- **10m Max Wind Speed (kts)**
  - GFDM
  - HWRF
  - DSMPR
  - LCEM
  - SPC3
  - 21Aug 00Z - 30Aug 00Z

- **200–850hPa Shear (kts)**
  - GFDM
  - HWRF
  - GFS
  - 21Aug 00Z - 30Aug 00Z

- **Sea Surface Temp (C)**
  - GFDM
  - HWRF
  - GFS
  - 21Aug 00Z - 30Aug 00Z

- **700–500hPa humidity (%)**
  - GFDM
  - HWRF
  - GFS
  - 21Aug 00Z - 30Aug 00Z

**±5d Intensity Comparisons for AL09**

**±5d Deep-Layer Shear Comparisons for AL09**

**±5d Track Comparisons for AL09**

**±5d SST Comparisons for AL09**

**±5d Mid-Level RH Comparisons for AL09**
Real-time Environmental Diagnostics

±5d Intensity Comparisons for AL09

±5d Deep-Layer Shear Comparisons for AL09

±5d Track Comparisons for AL09

±5d SST Comparisons for AL09

±5d Mid-Level RH Comparisons for AL09
HWRF 2011 vs HWRF 2012

- Pre-implementation evaluation of model environment

Sample of results from retrospective 2010-2011 Atlantic storms
Wrap-Up & Future Plans

- Create uniform summaries of model runs that contain key vortex and environmental data, including full vertical profile
  - Easy to compare different models, different versions of same model, impact of model upgrades
  - Allows for pre-implementation, real-time, and post-season evaluation of significant environmental parameters beyond intensity and track
- Improve efficiency of code, involve more modelers
- Allow for wider range of input data formats
- Centrally house files from many models/groups at DTC