NESDIS/CIRA Activities & Plans

HFIP Diagnostics Workshop

08/10/2012

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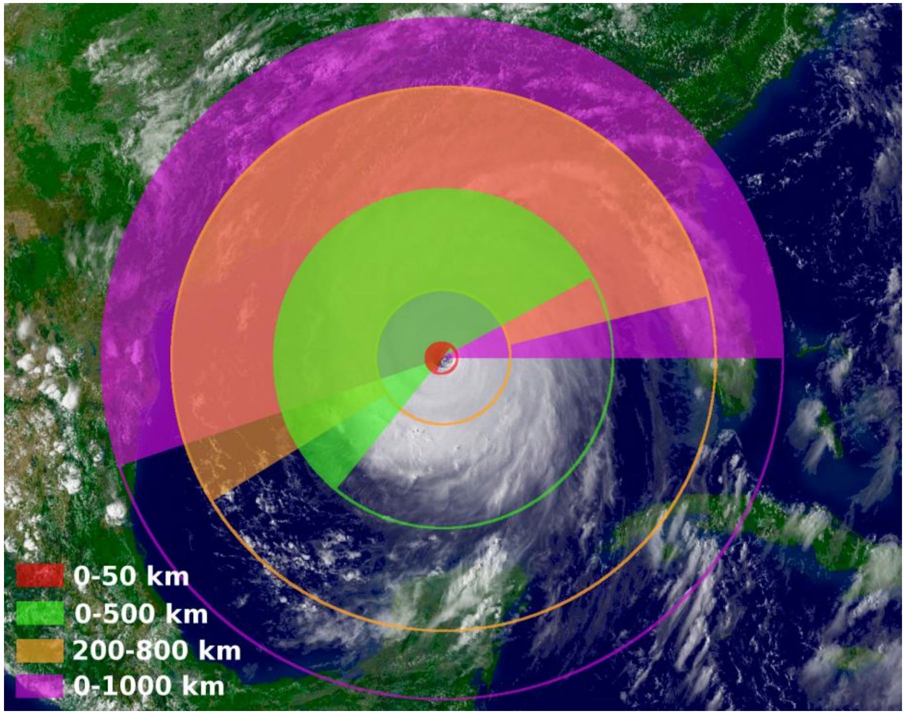
Outline

- SHIPS Diagnostic Files and Verification
- SPICE
- Global Ensemble Diagnostic Files and SPICE
- Balanced Vortex Model
- Verification of HWRF synthetic GOES imagery
- Hybrid Statistical-Dynamical Wind Speed Probabilities

SHIPS Diagnostic Files

- Simple ASCII file with SHIPS model predictors
- Input required
  - Model grib files
    - u, v, T, RH, Z at mandatory levels 1000 to 100 hPa
    - SST field if available
  - Model storm track (A-deck format)
- Output
  - ~20 kbyte ASCII file per 126 hr forecast
- Code available from CIRA
  - Currently used by: EMC; GFDL; NRL; ESRL; NCAR; SUNY-Albany; UWisc
- *Much easier to generate in real time than from archived data*
  - e.g., Difficult to extract and read ~500 gbyte FIM tar files
- Verification
  - HWRF and GFDL diagnostic files (against GFS analysis) monthly during 2012 season



Key parameters are calculated in prescribed areas...

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)

Diagnostic File Example

```
          *   HWRF  2011091018   *
          *   AL14       MARIA   *

           ------------------------------------------------------   STORM DATA   ------------------------------------------------------

NTIME 022   DELTAT 006
TIME     (HR)         0     6    12    18    24    30    36    42    48    54    60    66    72    78    84    90    96   102   108   114   120   126
LAT      (DEG)     17.5  18.3  19.0  20.1  21.0  21.7  22.2  22.8  23.4  23.9  24.3  24.9  25.7  26.6  27.8  29.3  30.8  32.4  34.1  36.0  38.2  40.9
LON      (DEG)    298.1 297.3 296.7 296.1 295.6 294.9 294.4 294.0 293.4 292.7 292.1 291.8 291.4 291.3 291.1 291.1 291.2 291.7 292.4 293.8 295.9 299.0
MAXWIND  (KT)        41    45    41    42    44    49    52    56    63    71    76    83    83    93    91    93    92    91    95    99    98    91
RMW      (KM)       164   142   152   147   132    89    48    49    51    38    41    41    46    52    52    53    56    59    64    67    66    74
MIN_SLP  (MB)      1006  1005  1003  1004  1001   997   990   987   979   970   962   956   951   951   945   945   942   942   943   946   946   951
SHR_MAG  (KT)        18    19    19    20    18    17    16    16    16    14    11    12    17    20    22    25    28    27    26    32    39    44
SHR_DIR  (DEG)      237   229   235   244   246   248   260   246   254   253   246   227   221   223   209   190   180   183   180   180   189   202
STM_SPD  (KT)        11     9    12    10    10     7     7     8     8     7     7     9     9    12    15    15    17    18    22    28    36  9999
STM_HDG  (DEG)      316   321   333   333   317   317   328   317   308   306   336   336   354   352     0     3    15    19    31    37    42  9999
SST      (10C)      294   291   291   291   290   292   291   290   290   289   288   285   285   284   283   282   278   275   273   275   258   250
OHC      (KJ/CM2)  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999
TPW      (MM)      9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999  9999
LAND     (KM)       412   316   264   275   324   368   413   478   529   538   551   604   680   776   906   941   837   780   775   730   601   453
850TANG  (10M/S)    104   108   107   102   109   116   114   117   122   130   134   142   148   154   151   157   168   170   170   177   177   180
850VORT  (/S)        18    15     8    -1     3     9     5     2    11    19    16    26    49    66    61    68    80    77    72    91    98   113
200DVRG  (/S)        90    61    34    48    71    64    50    39    39    31    29    29    57    48    62    77   107   106   105   138   145   137

           ------------------------------------------------------   SOUNDING DATA   ------------------------------------------------------

NLEV 020 SURF 1000 0950 0900 0850 0800 0750 0700 0650 0600 0550 0500 0450 0400 0350 0300 0250 0200 0150 0100
TIME     (HR)         0     6    12    18    24    30    36    42    48    54    60    66    72    78    84    90    96   102   108   114   120   126
T_SURF   (10C)      287   286   286   285   284   284   284   283   283   282   282   281   280   279   277   274   271   267   261   249   233   209
R_SURF   (%)         79    79    79    79    78    78    78    78    78    78    78    78    78    79    79    78    78    78    78    78    76    74
P_SURF   (MB)      1012  1013  1013  1015  1015  1016  1015  1017  1014  1016  1013  1014  1012  1013  1010  1011  1009  1010  1008  1009  1008  1009
U_SURF   (10KT)    -117  -121  -121  -112  -105  -102   -85   -85   -85   -82   -68   -65   -68   -75   -59   -37   -13    -2    39    60    85   106
V_SURF   (10KT)      11    -5    13    17    19     9    28    12    22    15    29    19    23    26    35    25    26    31    48    30    24    26
T_1000   (10C)      277   277   274   270   269   269   266   264   266   267   266   265   268   269   267   265   265   264   257   242   229   210
R_1000   (%)         73    73    75    77    78    79    80    81    81    81    81    81    80    79    79    78    76    75    78    80    80    81
Z_1000   (DM)        11    12    11    13    13    14    13    15    12    14    11    13    10    11     9    10     8     9     7     8     7     7
U_1000   (10KT)    -141  -143  -142  -132  -124  -122  -101  -102  -101   -99   -81   -78   -80   -89   -68   -43   -14    -1    45    70    96   121
V_1000   (10KT)      14    -5    17    23    24    13    35    17    27    19    35    25    29    34    44    32    32    40    58    39    32    35
T_0950   (10C)      235   235   232   228   228   227   225   223   225   226   225   224   226   227   226   224   224   223   217   204   192   175
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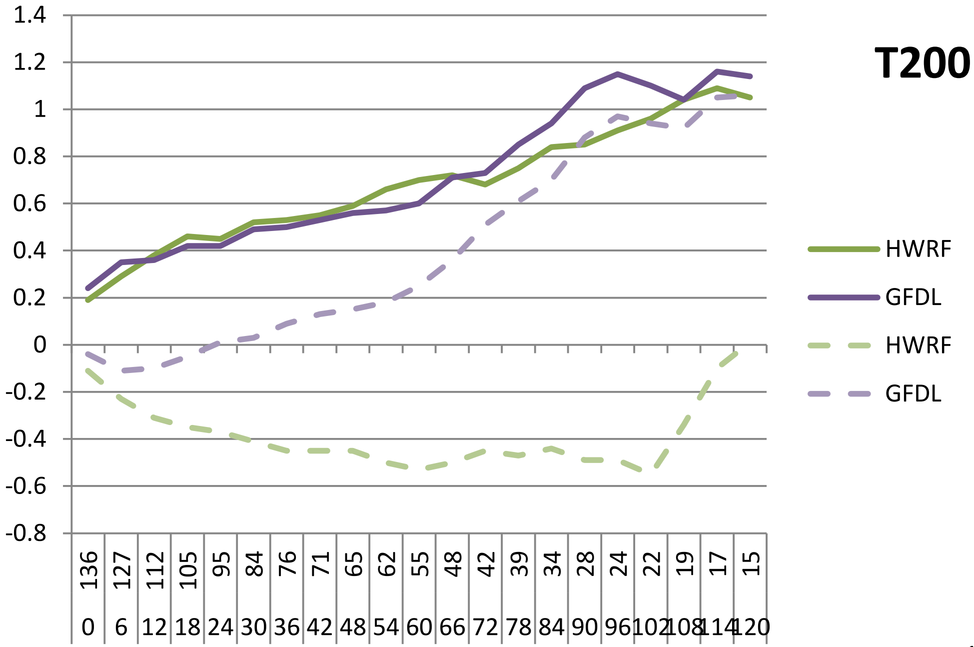
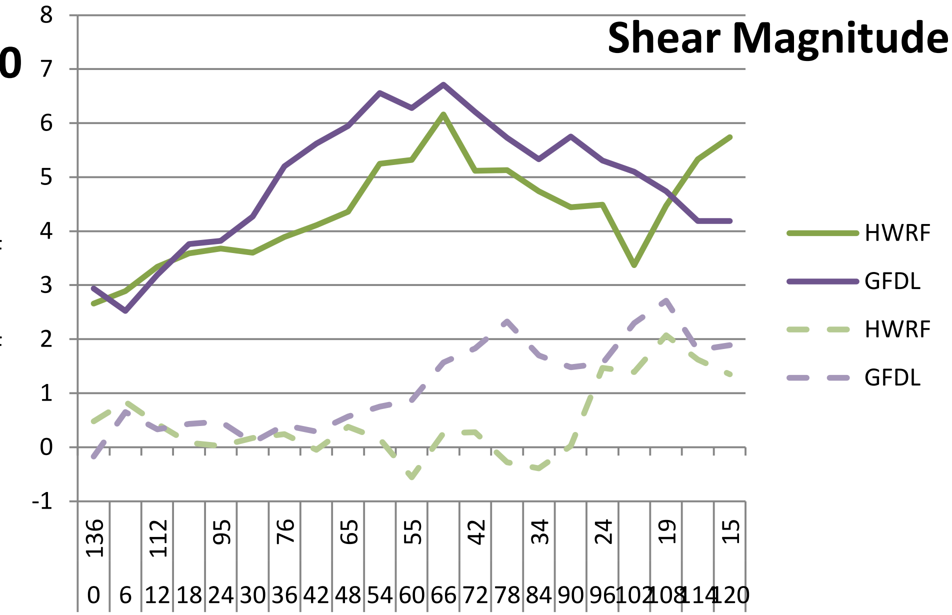
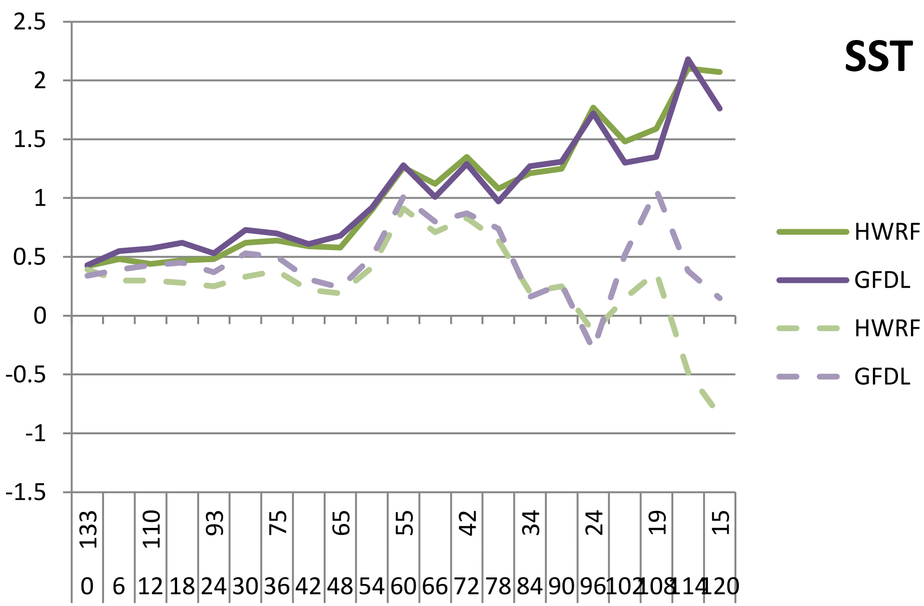
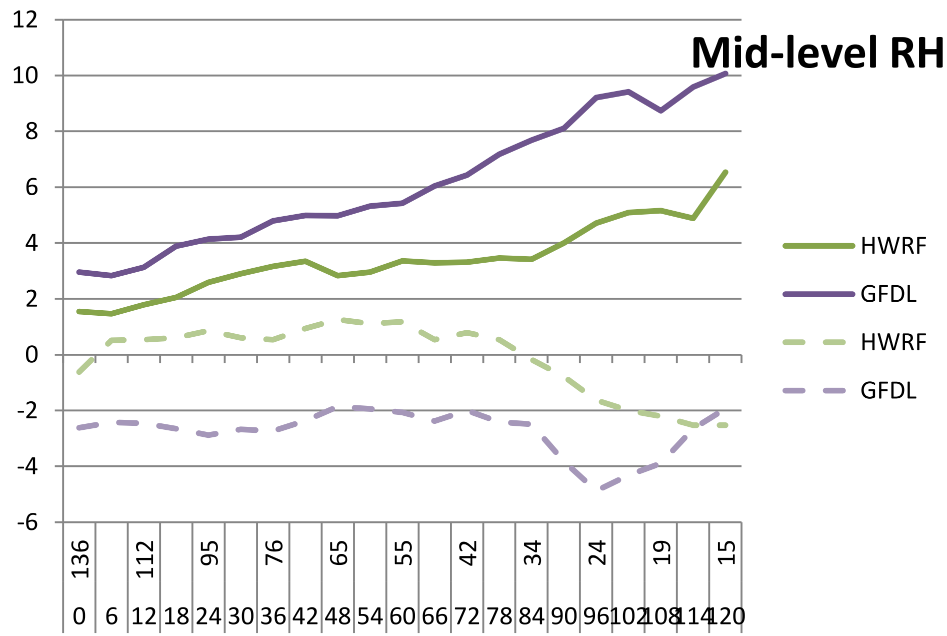
⋮

Diagnostic Verification – HWRF and GFDL 2012 AL

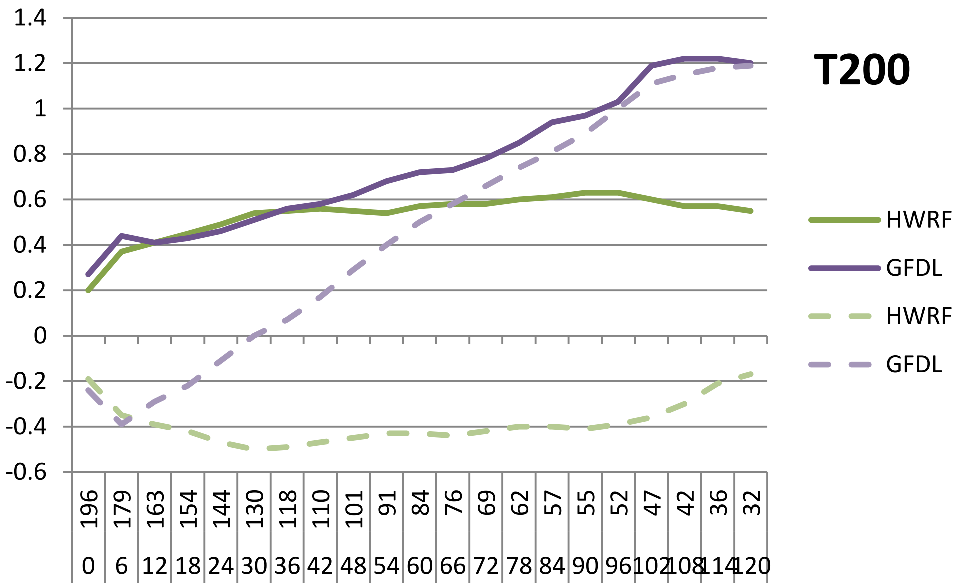


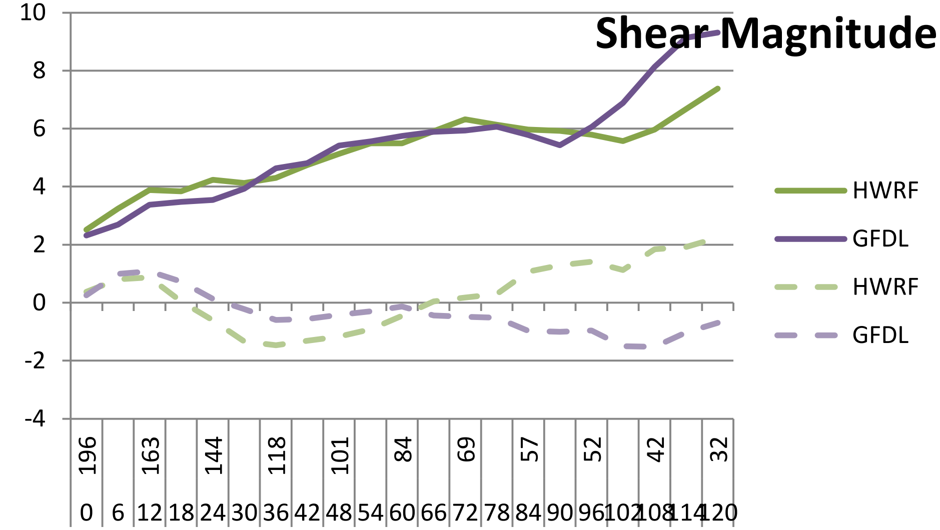


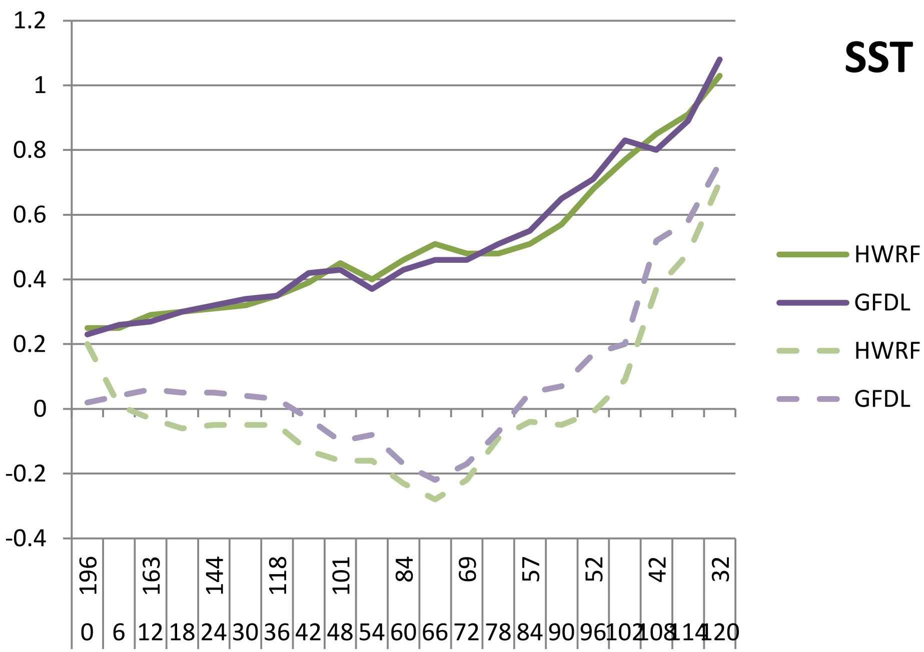


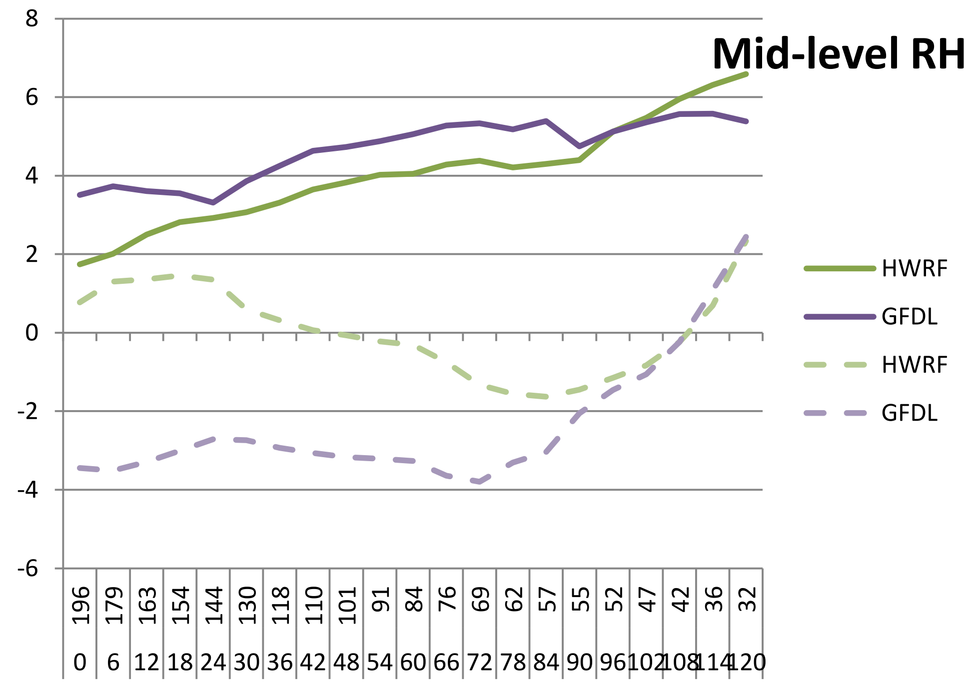


Diagnostic Verification – HWRF and GFDL 2012 EP



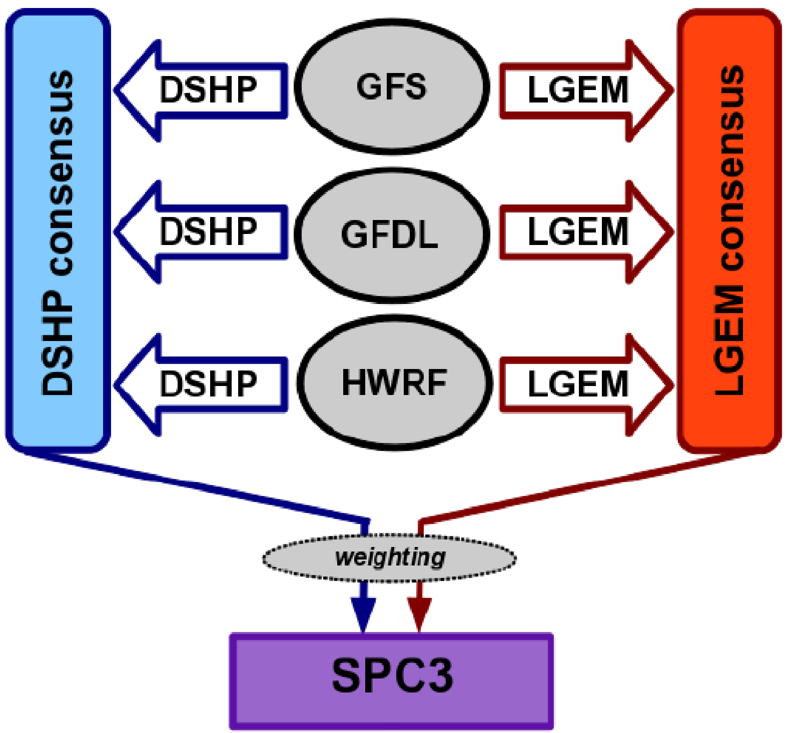






SPICE (Statistical Prediction of Intensity from a Consensus Ensemble)

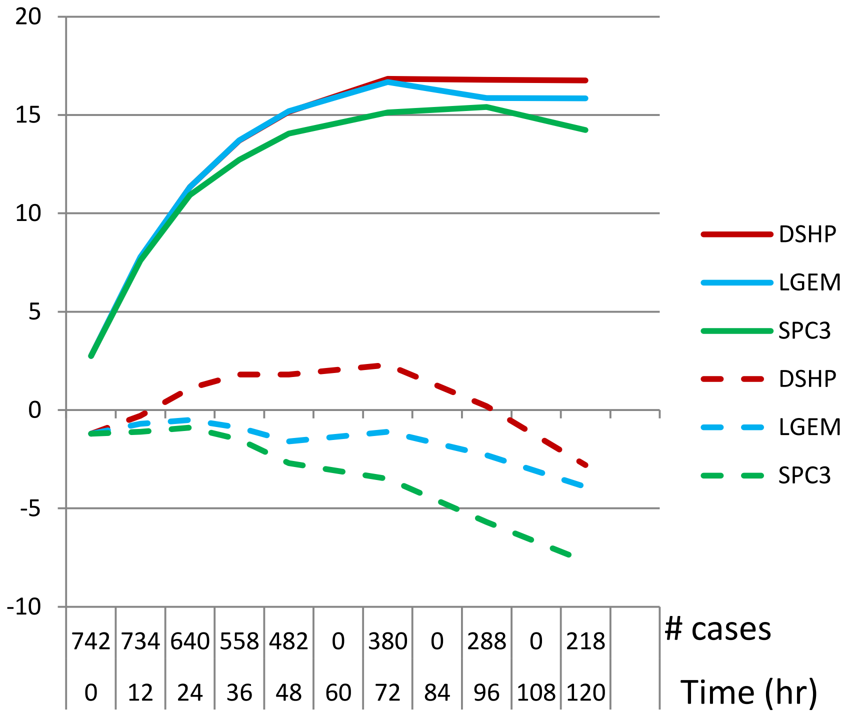
Model Configuration for Consensus



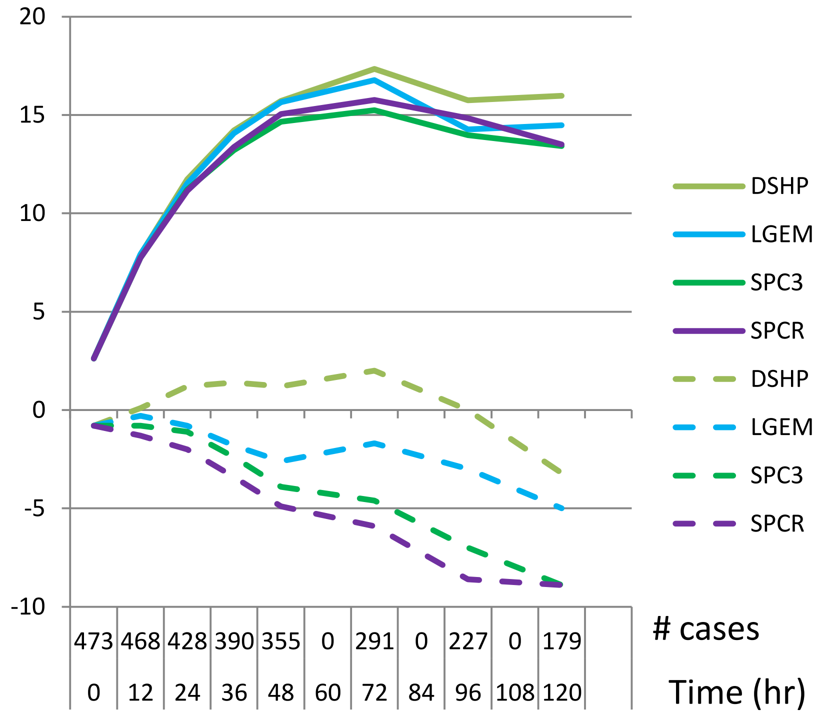
- SPICE forecasts TC intensity using a combination of parameters from:
  - Current TC intensity and trend
  - Current TC GOES IR
  - TC track and large-scale environment from GFS, GFDL, and HWRF models
- These parameters are used to run DSHP and LGEM based off each dynamical model
- The forecasts are combined into two unweighted consensus forecasts, one each for DSHP and LGEM
- The two consensus are combined into the weighted SPC3 forecast

Verification of SPICE – 2012 HFIP Stream 1.5 (SPC3)

SPC3 – 2009-2011 Retrospective Runs



SPCR – 2009-2011 Retrospective Runs



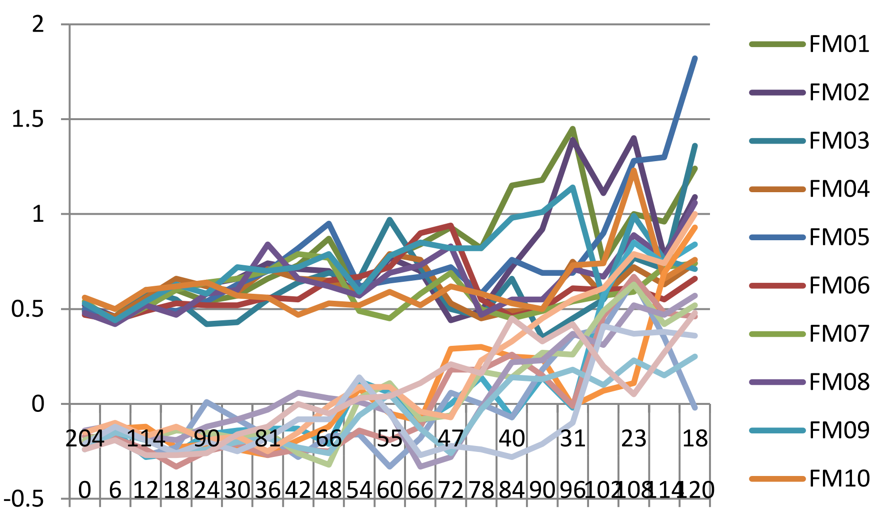
Average Intensity Error (solid) and bias (dashed) (kt)

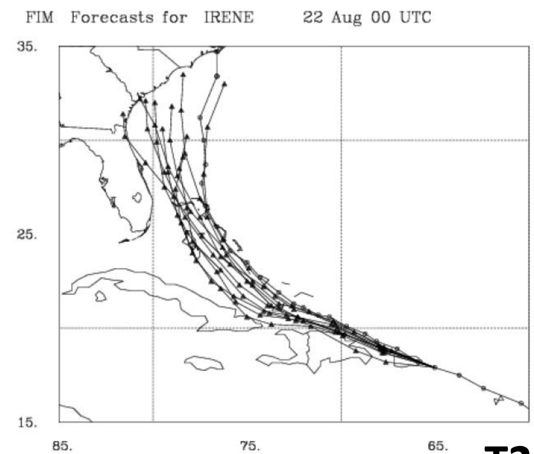
Global Ensemble Diagnostic Files and SPICE

- In August 2012 CIRA will begin producing diagnostic files from the GFS and FIM global ensembles
  - Verification of diagnostic files
  - Input to SPCG (Stream 2 configuration of SPICE using global model ensembles)

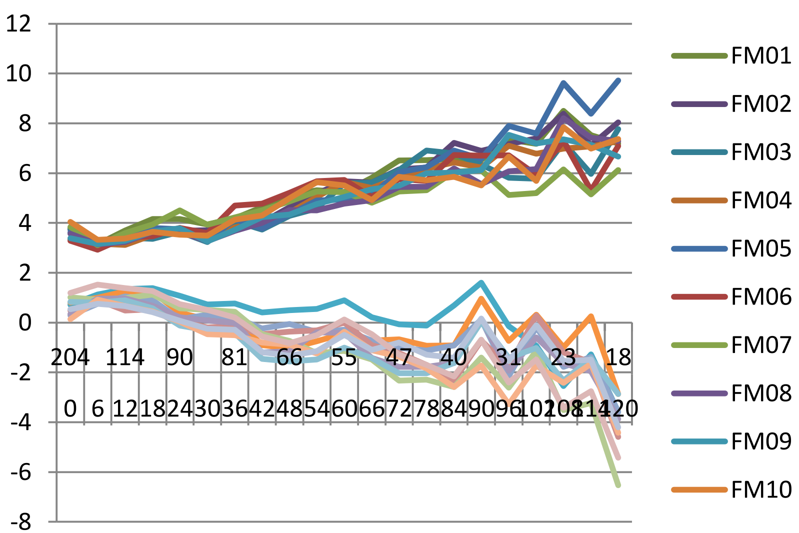
FIM 10-member Ensemble

SST

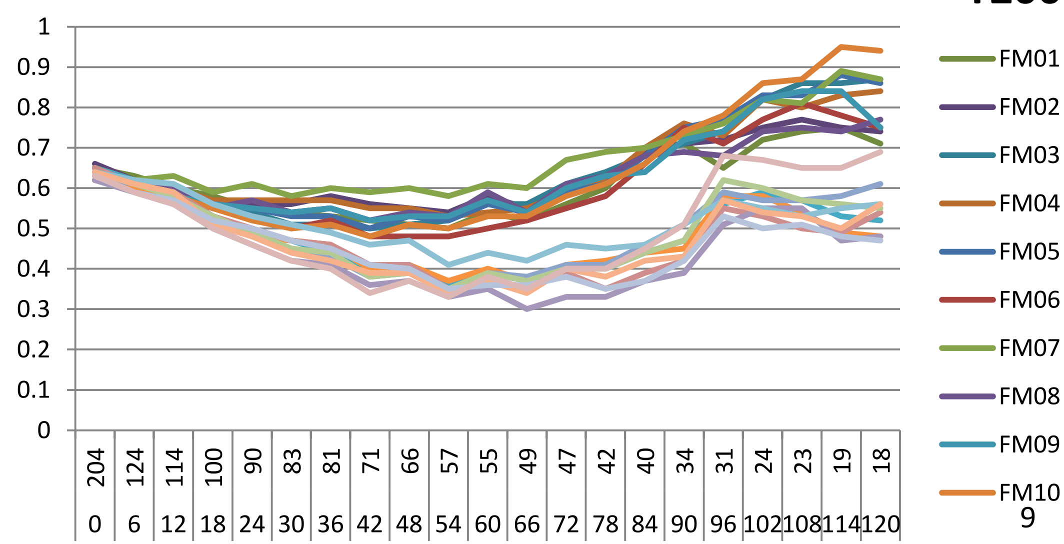




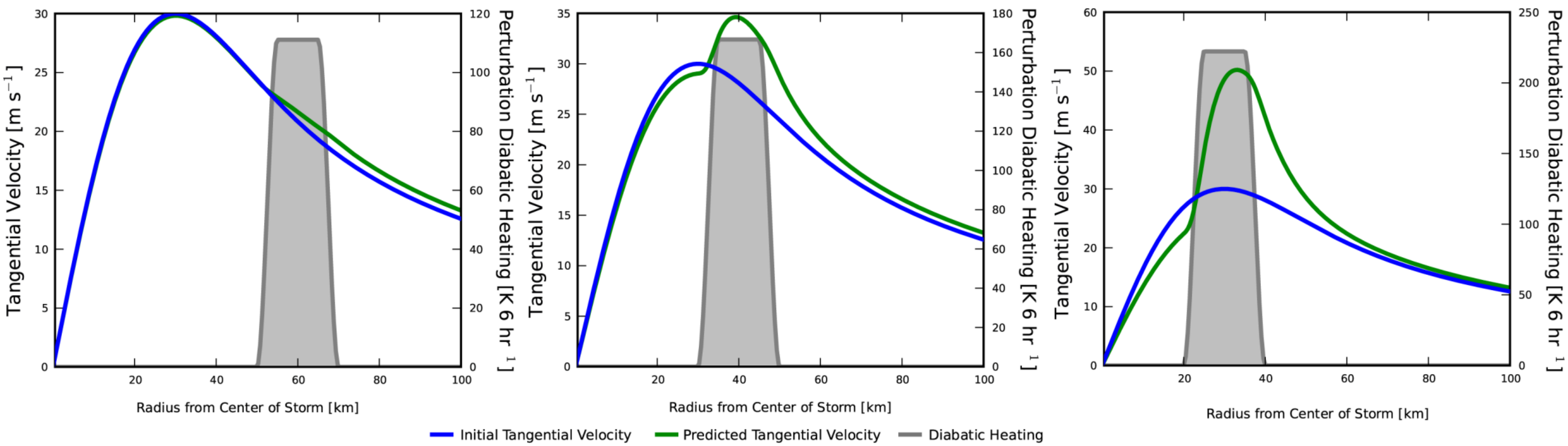
Shear Magnitude



T200



Determining Tropical Cyclone Intensity Change through Balanced Vortex Model (BVM) Applications



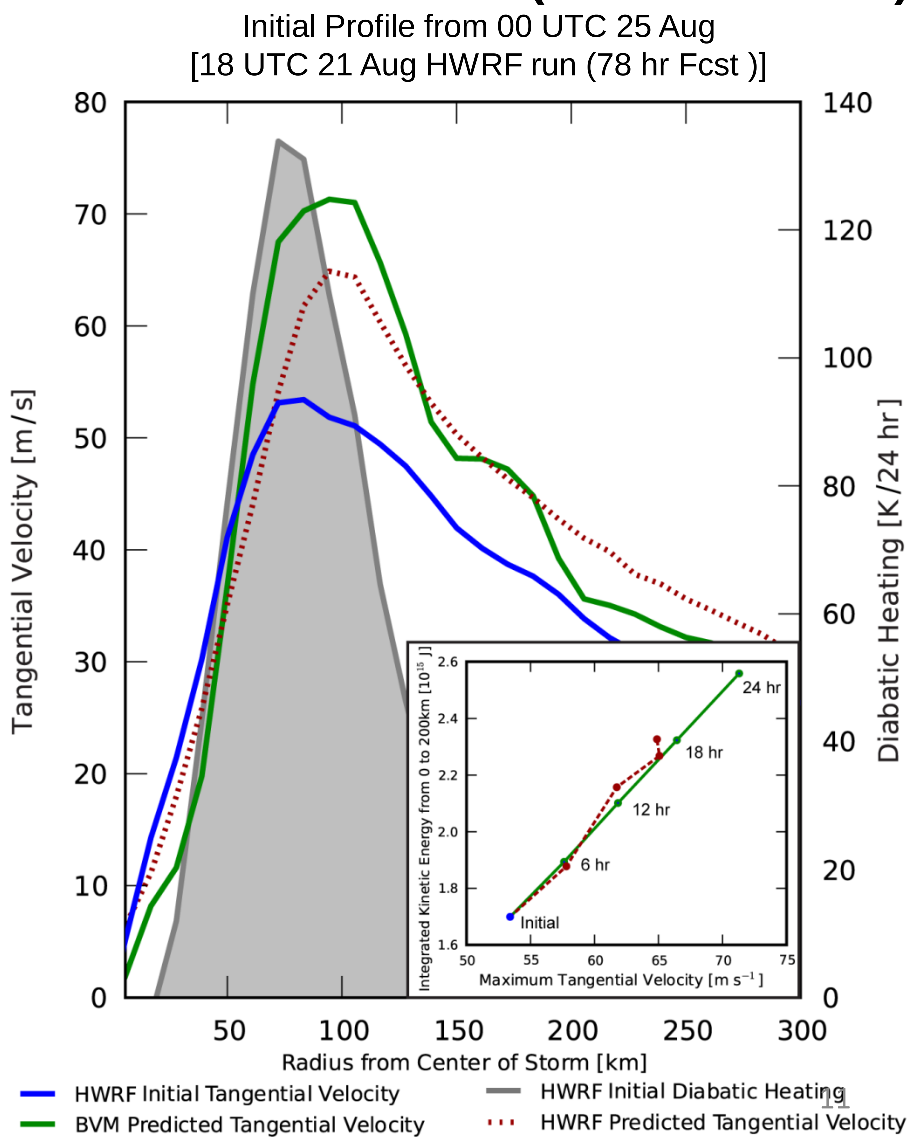
- Based on Eliassen's (1951) work but solves for the geopotential tendency equation.
- Assumes: Inviscid, Axisymmetric, Quasistatic, Gradient Balanced, Stratified, *f*-plane.

- Location of the diabatic heating in relation to the profile of inertial stability (IS) indicates BVM response.
  - Outside the high IS region
  - Near the high IS region
  - Inside the high IS region

Diagnosing the Influence of Diabatic Heating on HWRF Intensity Change Using a Balanced Vortex Model (BVM)

- HWRF flight level (700 hPa) wind and diabatic heating (DH) are applied to balanced vortex theory.
- The tangential velocity tendency is computed from HWRF's DH using the geopotential tendency equation.
- The HWRF and BVM intensity changes are compared showing the influence of DH on HWRF's intensity change.
- The intensity change from HWRF relates well to the theory which shows that the BVM can be used as a fast and elegant diagnostic tool.

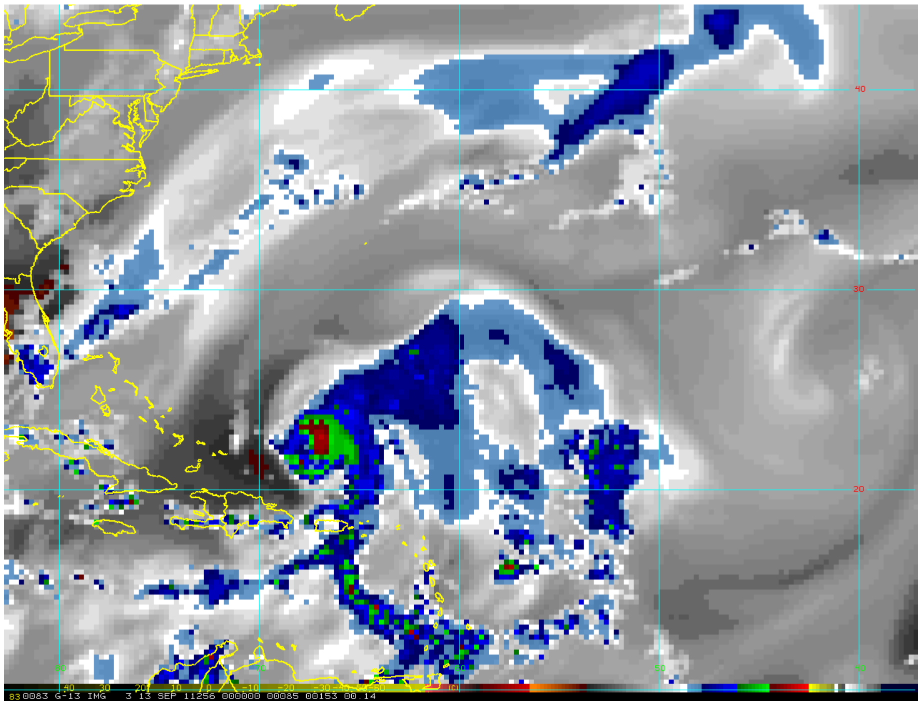
Hurricane Irene 2011 (24hr Prediction)

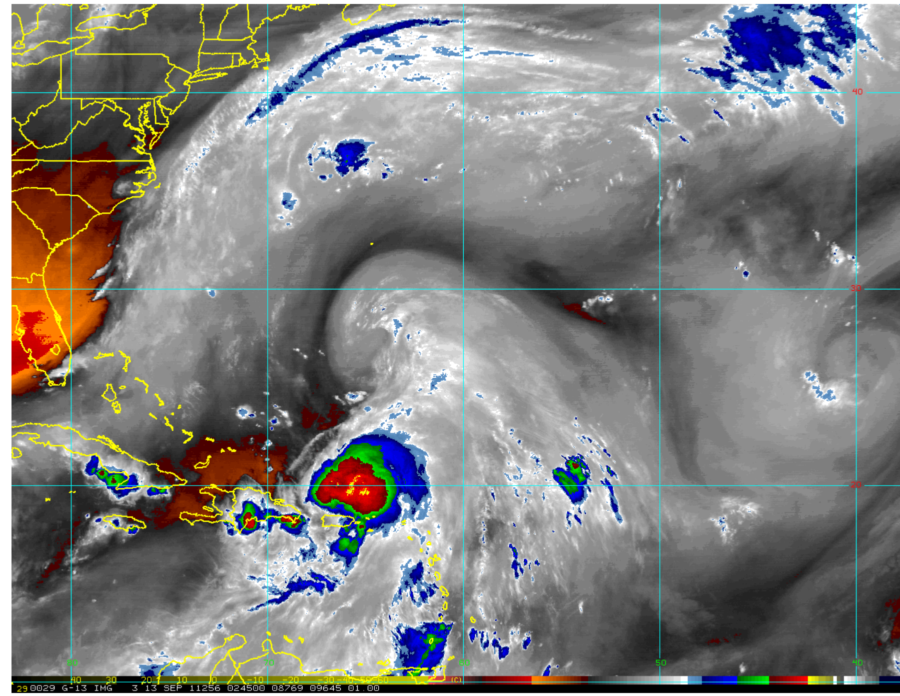


Infrared T_B Verification

- Use radiative transfer code to calculate synthetic infrared (IR) data from HWRF output
  - GOES channel 3 (water vapor) and 4 (window channel)
- Compare synthetic IR with real GOES data
- Mean absolute error, bias, brightness temperature histograms
- Compare verification for H212 and 2011 operational HWRF
- Preliminary tests with Irene and Maria(2011) cases

Comparison of Operational HWRF and H212 for 2010-2011 East Pacific Cases

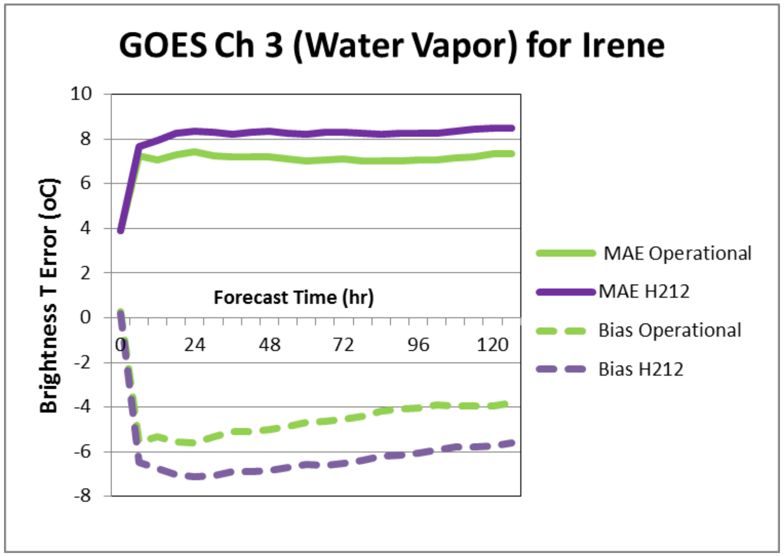


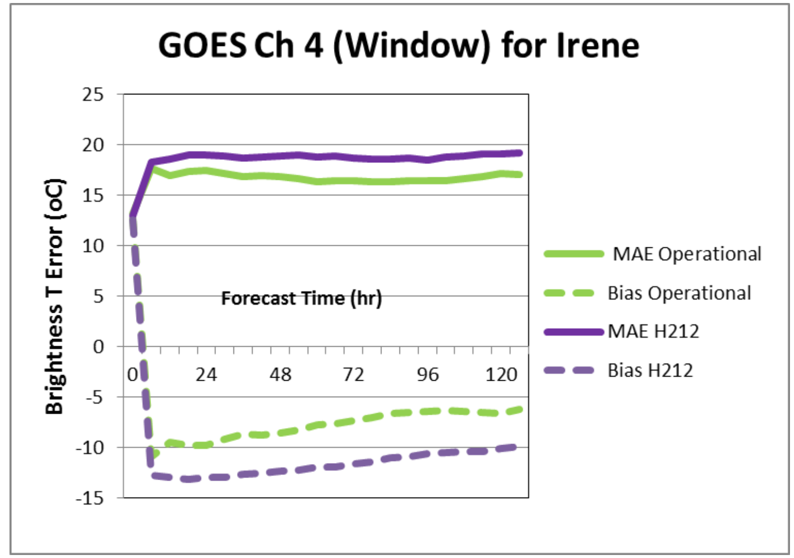


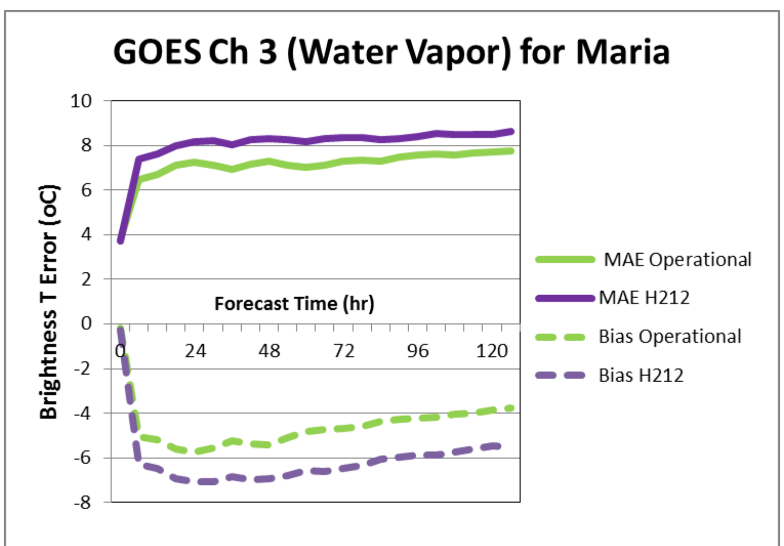
Synthetic GOES WV Image
24 hr HWRF Forecast valid
at 00 UTC on 13 Sept 2011

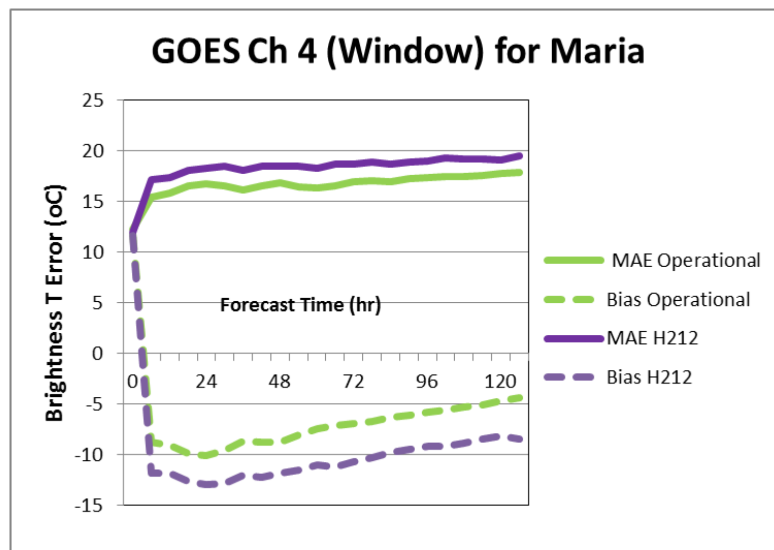
Real GOES WV Image
at 00 UTC on 13 Sept 2011

Validation of GOES Ch3 and Ch4 for Hurricane Irene and Maria Forecasts

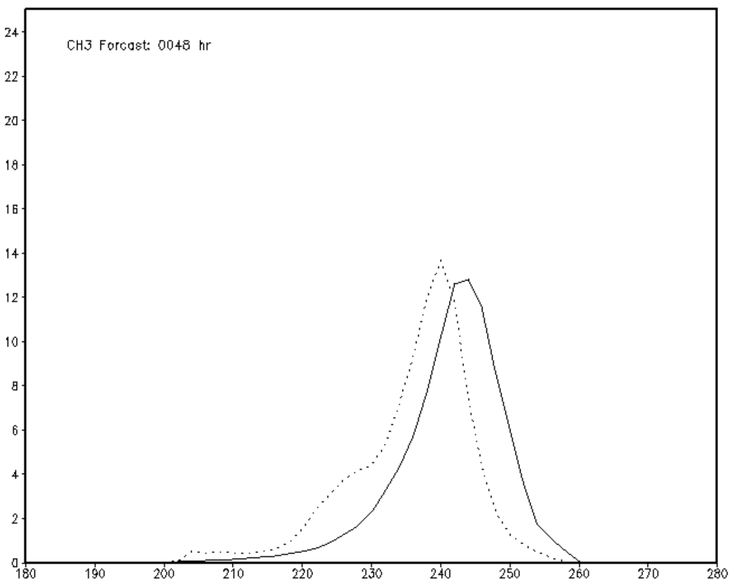




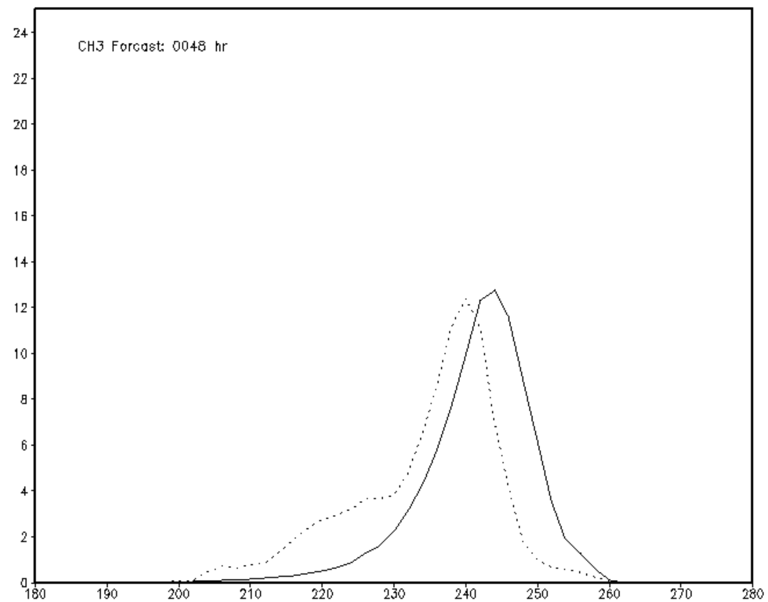




GOES Water Vapor T_B Histograms for 48 h Maria Forecasts



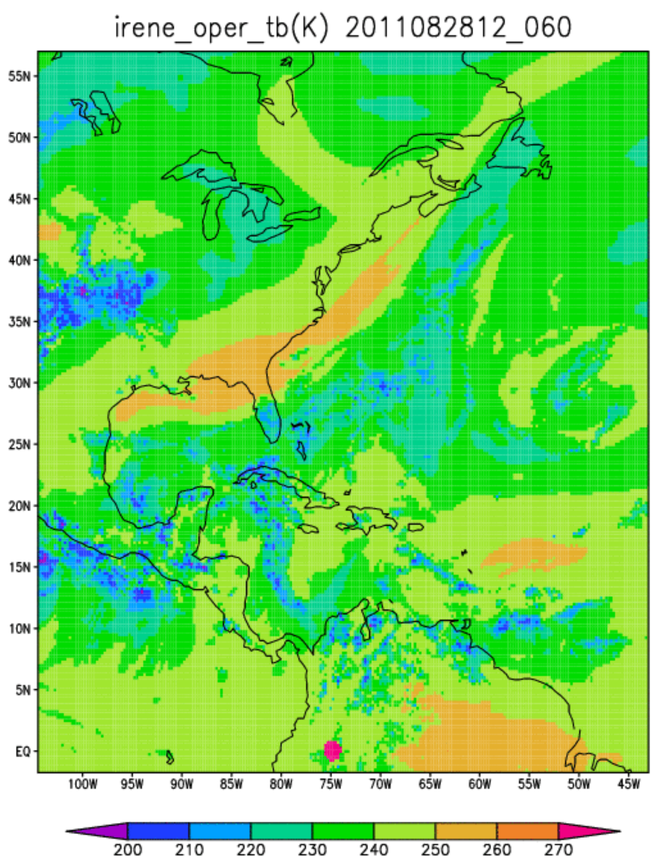
HWRF Operational

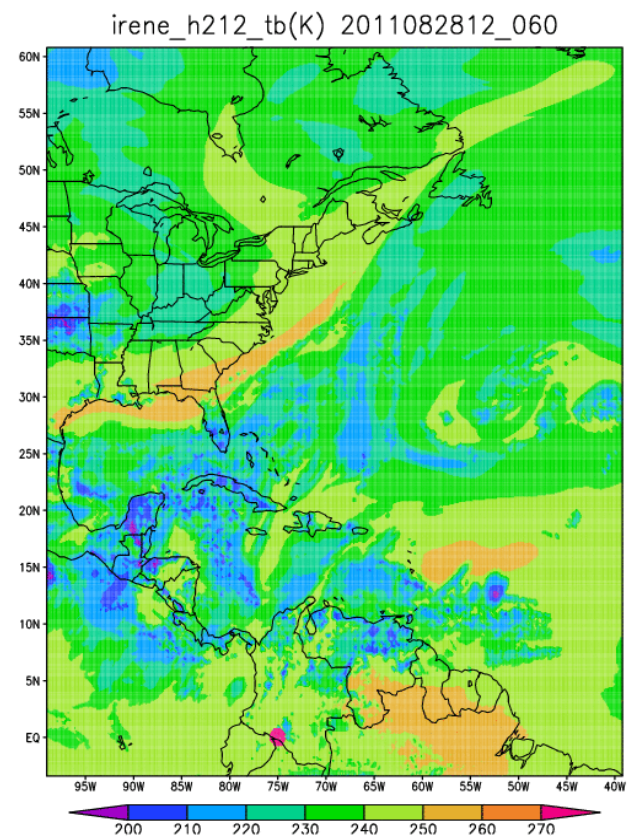


HWRF H212

(Dashed= Model, Solid=Observed)

HWRF Operational and H212 GOES WV Imagery Comparison





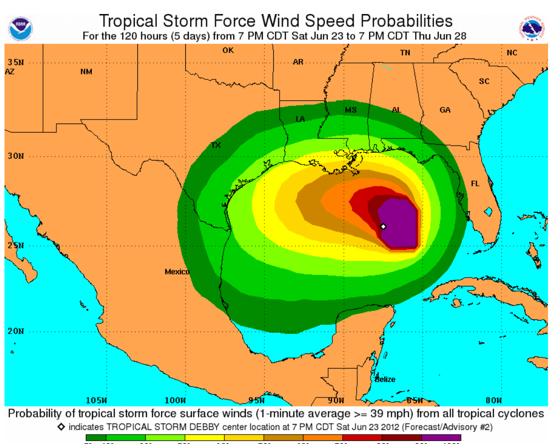
Hybrid Statistical-Dynamical Wind Speed Probabilities

- Methodology similar to NHC's operational wind speed probability algorithm
  - 1000 forecast realizations generated by sampling from NHC track and intensity distributions, using radii CLIPER model
  - Serial correlation of errors included
  - Probability at a point from counting number of realizations passing within the wind radii of interest
- Hybrid uses nearly the same methodology except: *realization tracks are replaced with global model ensemble tracks*
- Uses up to 93* global model ensemble track forecasts used
  - GFS (control + 20 perturbations)
  - CMC (control + 20 perturbations)
  - ECMWF (control + 50 perturbations)

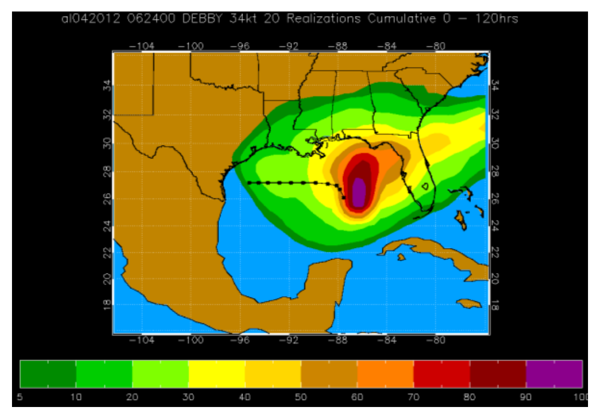
**Not all ensembles available each forecast time*

Hybrid Statistical-Dynamical Wind Speed Probabilities (cont…)

- CIRA will test prototype in real-time beginning in August 2012
- Will provide diagnostic of global model ensemble TC track forecasts
  - Graphical output displayed on HFIP prototype web page for evaluation
  - 2012 validation will compare Hybrid with Operational WSP
- Example: Tropical Storm Debby, 6/24/12 0Z (below)
  - GFS ensembles were split between two types of track; WNW or NE
  - Hybrid WSP (right) capable of representing split track scenario whereas operational WSP cannot – potential benefit of using ensembles



WSP model



Hybrid WSP model (GFS only)

Summary

- SHIPS diagnostic files provide easy way to inter-compare model forecasts
  - Provides additional forecast metrics
  - Currently being produced by several model groups
- SPICE had better error statistics than SHIPS and LGEM in the Atlantic basin
  - Consistent in 2008-2010 Retrospective Runs, 2011 Demonstration, and 2009-2011 Retrospective Runs
  - SPC3 showed skill improvements of up to 5-10% over SHIPS and LGEM
- SPICE model should benefit from greater diversity of input models
  - SPCR and SPCG will be generated starting August 2012, from additional regional models and global model ensembles, respectively
  - Use model forecast intensity changes and diagnostic files to fit SHIPS coefficients for examination of model TC behavior in relation to environment
- Balanced vortex model being applied to diagnose effect of diabatic heating on tropical cyclone intensification in HWRF model
- Cold bias in HWRF synthetic GOES data
  - Upper tropospheric moist bias
  - More active deep convection
- Hybrid Statistical-Dynamical Wind Speed Probabilities will be generated starting August 2012, available on hfip.org
  - Shows ability to represent bifurcating track forecasts compared to statistical wind speed probabilities