(Image from Marvel's Guardians of the Galaxy Vol. 2)

GROOT* User's Guide

*Graphics for OS(S)Es and Other modeling applications on TCs

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If using this graphics package in publications or presentations, please see the last slide for acknowledgement wording.

Capabilities Overview

GROOT

Hurricane Component: GROOT-H

Use this component if you are running HWRF, the basin-scale HWRF, or HAFS that do not use ADECKS.

Error Statistics
individual storms, composites, various subsets
(editverif.m, runverif.ksh)

Assimilated Observations
individual storms, storm-centered composites
(editverif.m, runverif.ksh)

GRB Graphics
plan-view and azimuthally-averaged graphics for individual storms for each experiment and difference graphics between experiments
(editgrb.m, rungrb.ksh)

Retrieval Scripts
all required files for error statistics, assimilated observations, and GRB graphics
(retrievalscripts/)

Verification Capability

GRB Capability

Global Component: GROOT-G

Use this component if you are running the FV3GFS or any output using ADECKS (even if from HWRF/basin-scale HWRF/HAFS).

Error Statistics
individual storms, composites, various subsets
(editverif.m, runverif.ksh)

Assimilated Observations
individual storms, storm-centered composites
(editverif.m, runverif.ksh)

GRB Graphics (FUTURE WORK)
plan-view and azimuthally-averaged graphics for individual storms for each experiment and difference graphics between experiments
(editgrb.m, rungrb.ksh)

Retrieval Scripts (FUTURE WORK)
all required files for error statistics, assimilated observations, and GRB graphics
(retrievalscripts/)

Why Use GROOT?

Benefits
Comprehensive
• results for both individual storms and composite studies are generated • retrieval scripts to grab GROOT-required files from HPSS are provided • capabilities are continuously being added
Project Flexibility
• user input is confined to a brief namelist • any number of experiments can be compared (recommended maximum: 6) • customization of colors and of baseline model available in the namelist • it works with model output from HWRF, the basin-scale HWRF, and FV3GFS • user can switch between GROOT-H and GROOT-G with ease – same way to run both components!
Uniformity
• uniform, publication-ready graphics are generated • graphics generated are those that are often needed in OS(S)E studies that evaluate TC performance

WHAT WILL THIS USER'S GUIDE GO OVER?

Graphics types created by GROOT-H for experiments run with the basin-scale HWRF and HWRF, followed by step-by-step instructions of how to get and run the package. Again, all graphics shown will eventually be generated by GROOT-G unless otherwise indicated, but currently only error statistics and assimilated observations graphics are available for GROOT-G.

*For GROOT-G, for each experiment, place your atcf files for all cycles desired in 1 folder, named according to the experiment run.

High-Level Verification Capability Overview

NAMELIST OVERVIEW (*editverif.m – edit this*)

SECTION 1: Set directories of the package, where the graphics go, and model properties
SECTION 2: Identify experiments and associated colors
SECTION 3: Case Study Options
SECTION 4: Error Graphics Options
SECTION 5: Conventional Graphics Options
SECTION 6: Satellite Graphics Options

RUN OVERVIEW (*runverif.ksh – edit this*)

SECTION 1: Set Folders
SECTION 2: Identify Experiments
SECTION 3: Account Information
SECTION 4: Date Range of Files

MAIN VERIFICATION SCRIPT OVERVIEW (*scripts/runverif.m – no need to edit*)

load namelist settings
for run the package
  for each individual storm *(each storm submitted as separate batch scripts so clock won't run out)*
    set up directories and naming conventions; find common cycles across experiments
    grabs and processes the bdeck
    plots the track of the storm
    runs assimilated obs capability script – conv: processes files and makes graphics *(namelist switch)*
    runs assimilated obs capability script – sat: processes files and makes graphics *(namelist switch)*
    runs error statistics capability script: processes files and makes graphics – full storm → NHC verification → subsets
  end
  for all storms combined - only if there is more than 1 storm in your sample! *(submitted as separate batch scripts)*
    identify how many basins are in the sample & get stratifications and consistent y-axes for each graphic
    run error statistics capability script: processes files and makes graphics – NHC verification → subsets
    runs assimilated obs capability script – conv: processes files and makes graphics
    runs assimilated obs capability script – sat: processes files and makes graphics
  end
end *(batch script cleans up files created and emails you when it's done – SUBMISSION_FINISHED.txt appears in your directory)*

High-Level GRB Capability Overview

NAMELIST OVERVIEW *(editgrb.m – edit this)*

SECTION 1: Choose storm, experiments, and associated colors
SECTION 2: Set directories
SECTION 3: Set switches
SECTION 4: Choose variables

RUN OVERVIEW (*rungrb.ksh – edit this)*

SECTION 1: Account Information

MAIN GRB SCRIPT OVERVIEW *(scripts/rungrb.m – no need to edit)*

for run the package *(submits various batch scripts to ensure the clock doesn't run out)*
- **set up directories and naming conventions; find common cycles across experiments**
- **grabs and processes the bdeck**
- **runs the HWRFDA component *(storm and synoptic grids; namelist switch)***
- **generates error statistics for later use *(no graphics are generated – this is all done in the verification capability)***
- **creates .mat files of chosen variables *(storm and/or synoptic grids; namelist switch)***
- **if selected in namelist, converts u/v to radial/tangential wind and windspeed *(storm and synoptic grids; namelist switch)***
- **if selected in namelist, converts absolute vorticity to relative vorticity *(storm and synoptic grids; namelist switch)***
- **creates storm-centered graphics and difference graphics *(storm and synoptic grids; namelist switch)***
- **creates shear graphics *(for synoptic grid, only; only if corresponding u/v files are generated)***
- **clean up .mat files to save space**

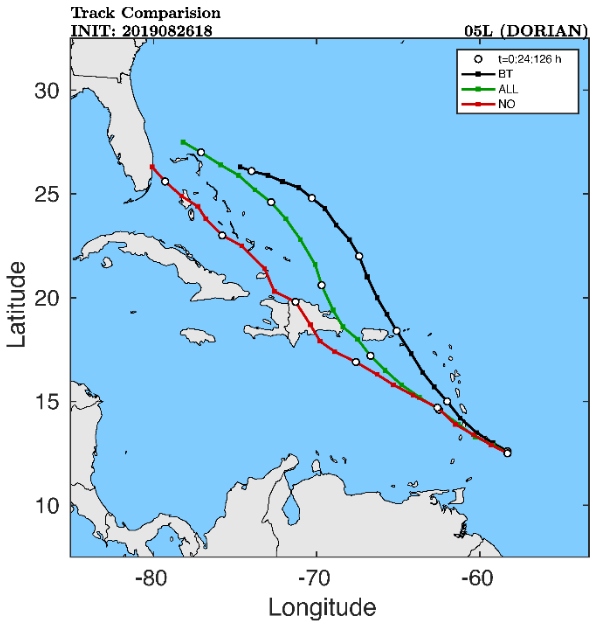
end

*Generation of these graphics can be turned off in the namelist by setting identgraphicsbycycle=0

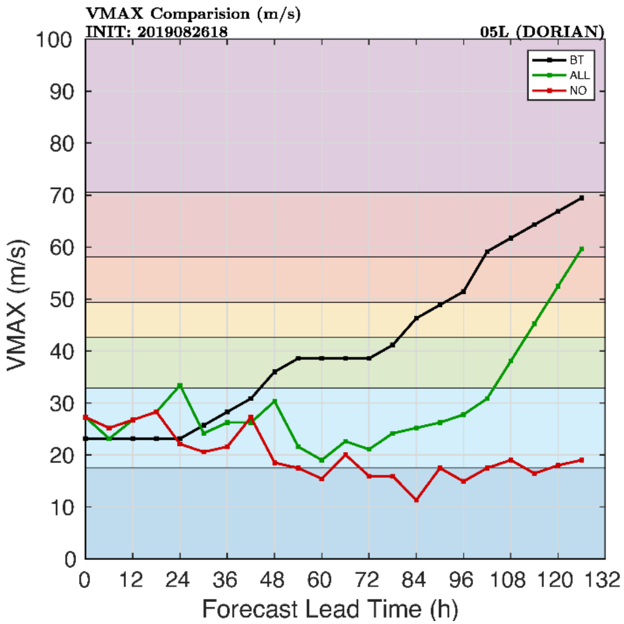
One Storm: Each Cycle | One Storm: All Cycles | Composite Graphics

Raw Value Graphics

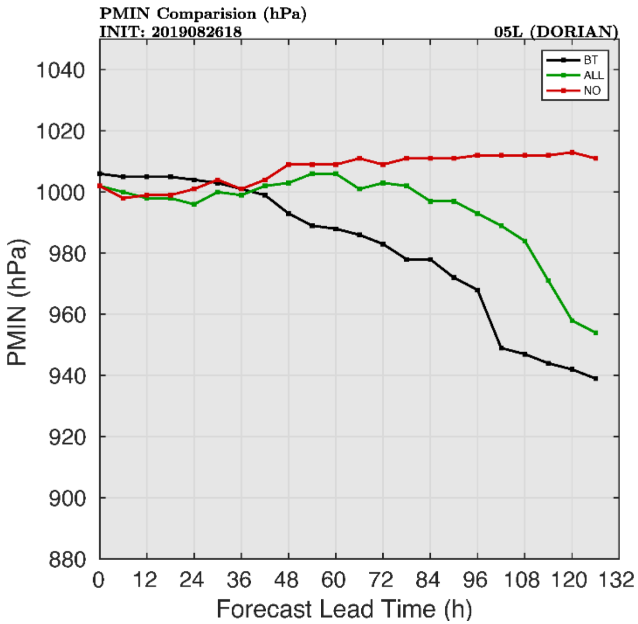
The below graphics as well as graphics for Along-Track Error, Across-Track Error, R34/R50/R64 (for the NE, SE, SW, and NW quadrants), PO, RO, and RMW are generated* for each cycle.



File: trkcomp_2019082618



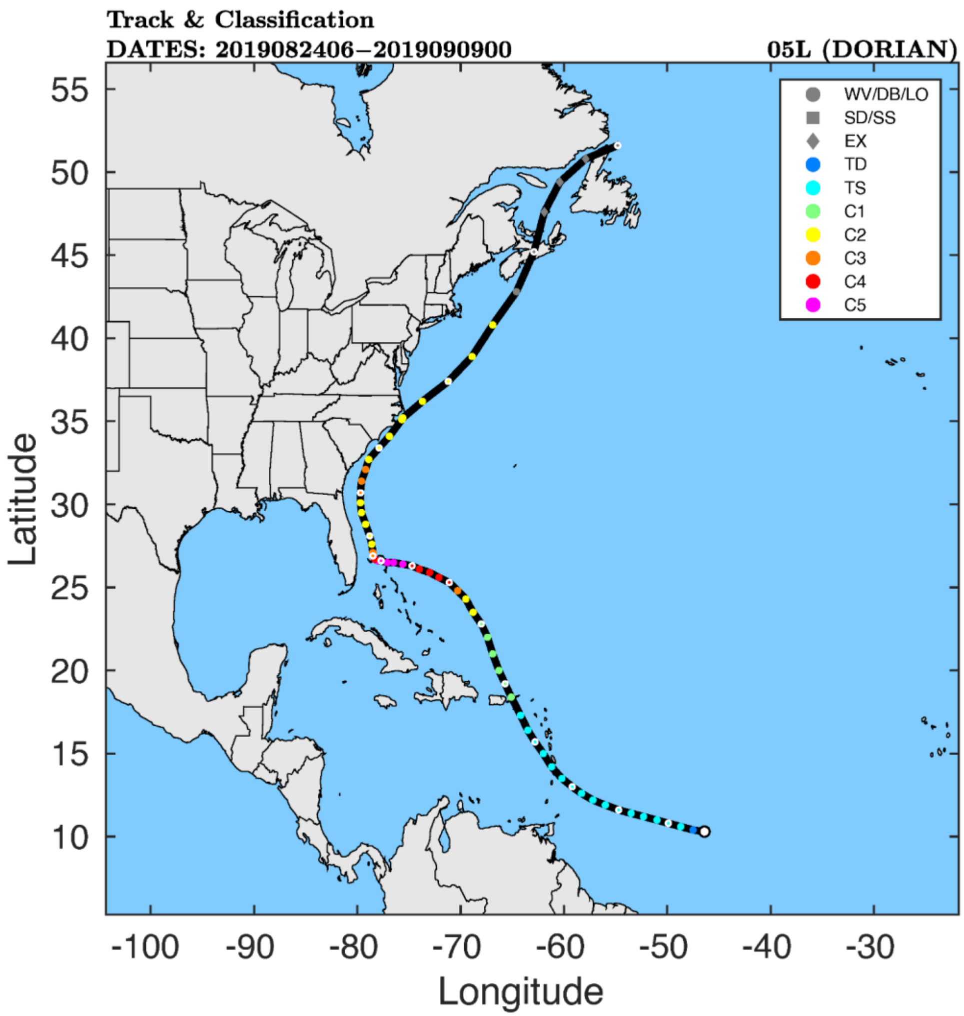
File: spdcomp_2019082618



File: prscomp_2019082618

One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

Best Track Graphic

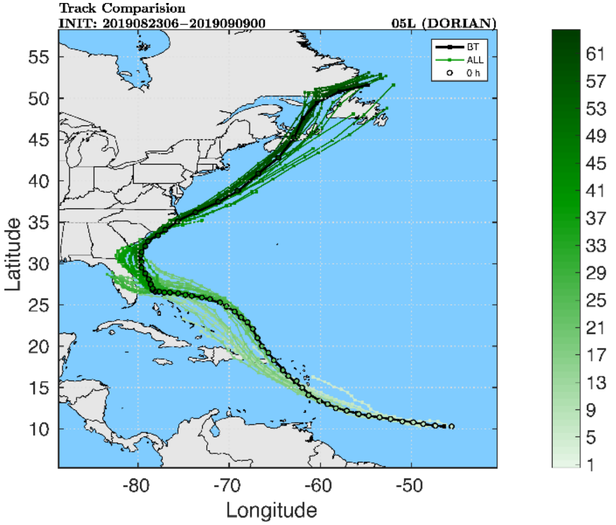


File: DORIAN19_track

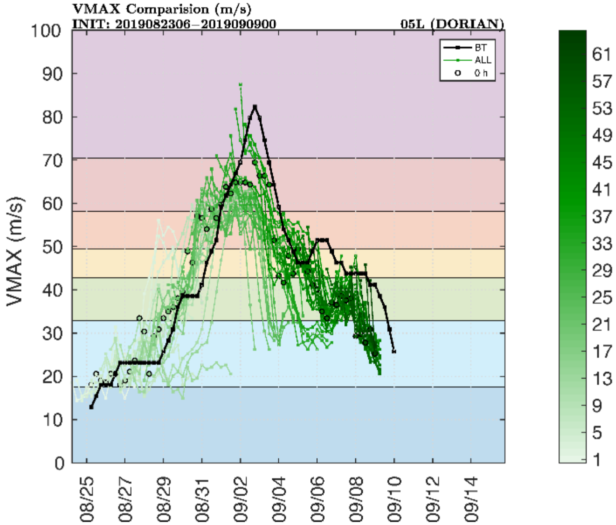
One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

Raw Value Graphics

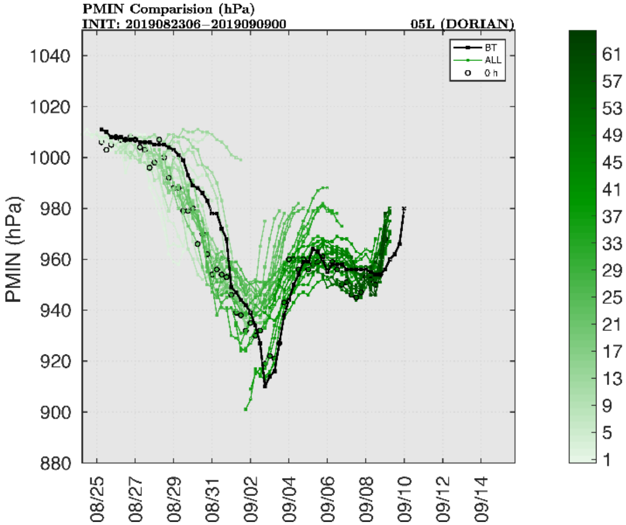
The below graphics as well as graphics for Along-Track Error, Across-Track Error, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants), PO, RO, and RMW are generated for each experiment.



File: trkcomp_all_ALL



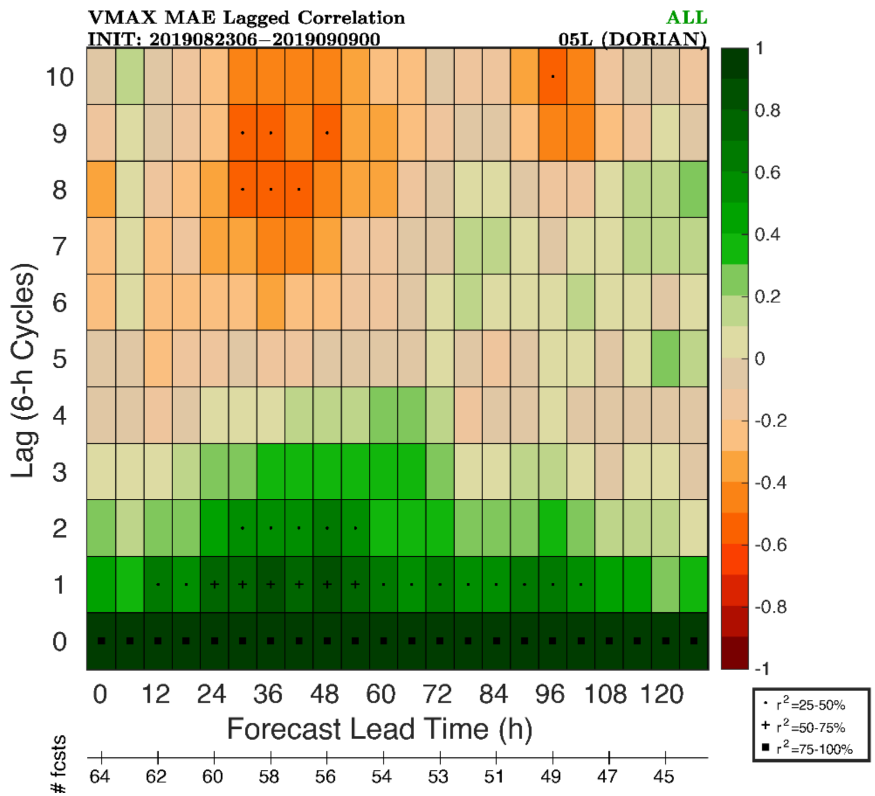
File: spdcomp_all_ALL



File: prscomp_all_ALL

Lagged Correlation

The below graphic is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment so the user can gauge how many cycles it takes for errors to decorrelate in the full sample. (It was previously used to calculate the effective sample size for statistical significance tests through a user-defined variance and lag threshold in the namelist (*editverif.m*). Divisors were calculated from the first experiment listed in the namelist. For example, DORIAN19_scfactor.txt includes details on the divisors for each variable. Due to the introduction of the consistency metric, statistical significance is no longer needed/used. Thus this feature is no longer active.)



File: DORIAN19_spderr_LAGCORR_ALL

*For track, both the along-track and across-track bias are generated.

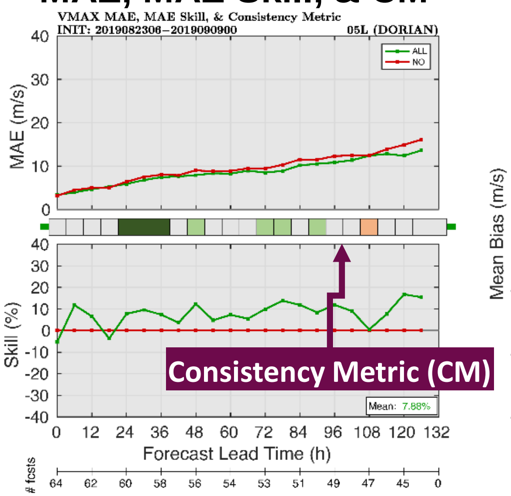
One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

Verification Metrics

By Forecast Lead Time

The below graphics are generated for Track*, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW.

MAE, MAE Skill, & CM

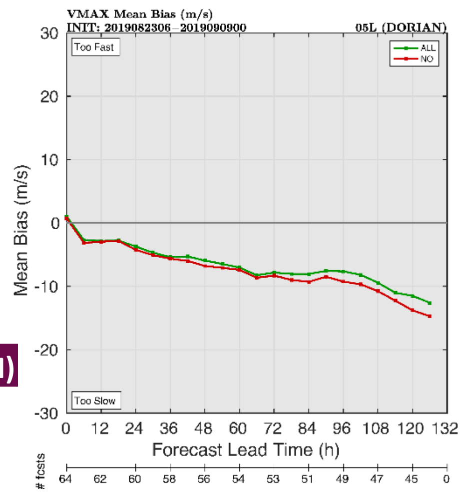


MAE: the mean of the absolute-valued difference between an experiment's forecast and the best track at the forecast verifying time.
MAE Skill: on average how much better or worse an experiment performed over a baseline experiment using the MAE

$$I = 100 * \left(1 - \frac{\overline{\text{exp}}}{\overline{\text{baseline}}}\right)$$

File: DORIAN19_spderrskill_mean

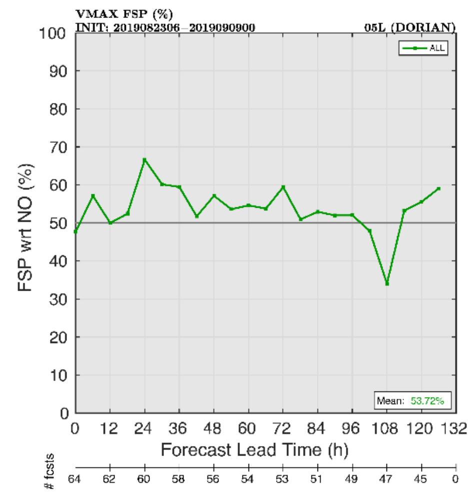
Mean Bias



the mean of the difference between an experiment's forecast and the best track at the forecast verifying time

File: DORIAN19_spdbias

FSP

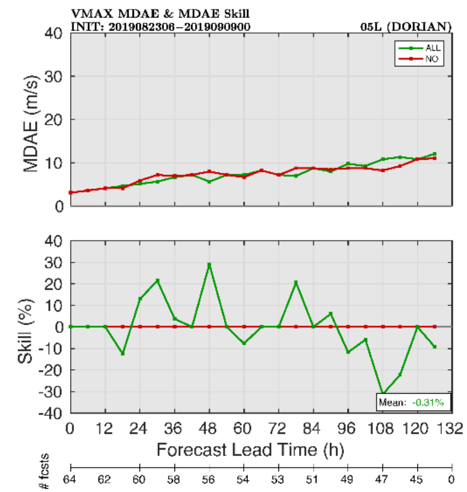


the percent of forecasts where an experiment outperformed a baseline experiment

$$FSP_{exp_{t=fhr}} = 100 * \frac{\sum_{n=1}^{\#\,fcsts} \begin{cases} 1, & \text{if } exp_E < baseline_E \\ .5, & \text{if } exp_E = baseline_E \\ 0, & \text{if } exp_E > baseline_E \end{cases}}{\#\,fcsts}$$

File: DORIAN19_spdfsp

MDAE & MDAE Skill



the median of the absolute-valued difference between an experiment's forecast and the best track at the forecast verifying time and on average how much better or worse an experiment performed over a baseline experiment using the MDAE

File: DORIAN19_spderrskill_median

Details on the consistency metric will be provided in Ditchek et al. (2022, *in review at WAF*). For now, details can be found on the README within the Post-TC Verification Tab of the AOML Hurricane Model Viewer.

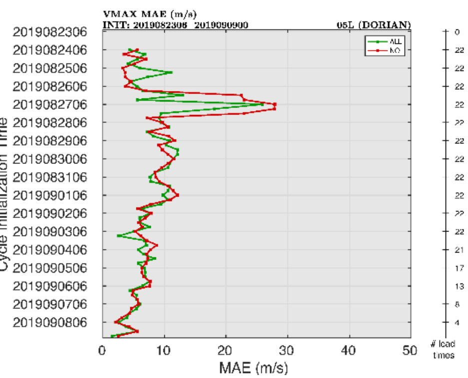
*For track, both the along-track and across-track bias are generated.

Verification Metrics

By Cycle

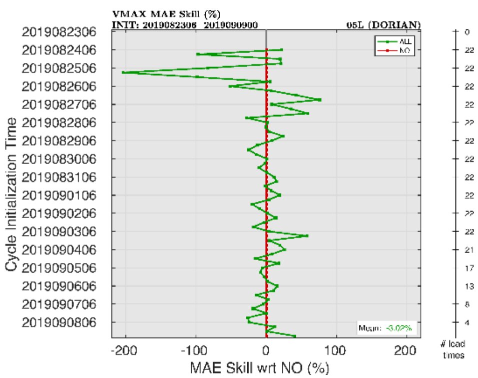
The below graphics are generated for Track*, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW.

MAE



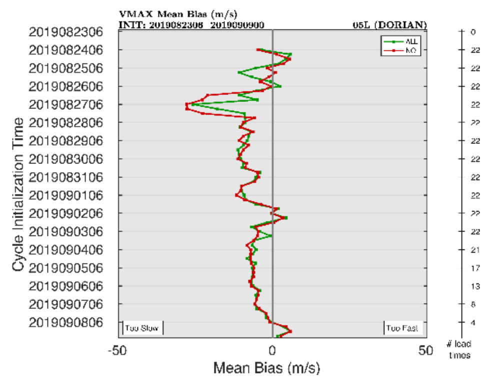
File: DORIAN19_spderr_cycles

MAE Skill



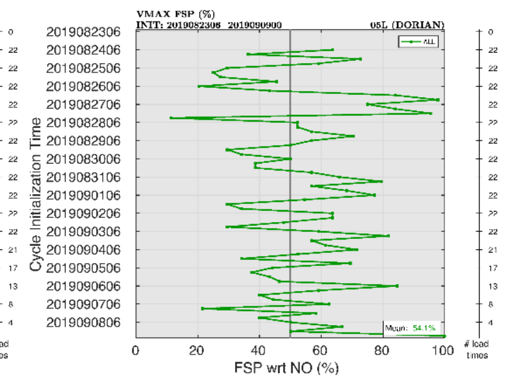
File: DORIAN19_spdskill_cycles

Mean Bias



File: DORIAN19_spdbias_cycles

FSP

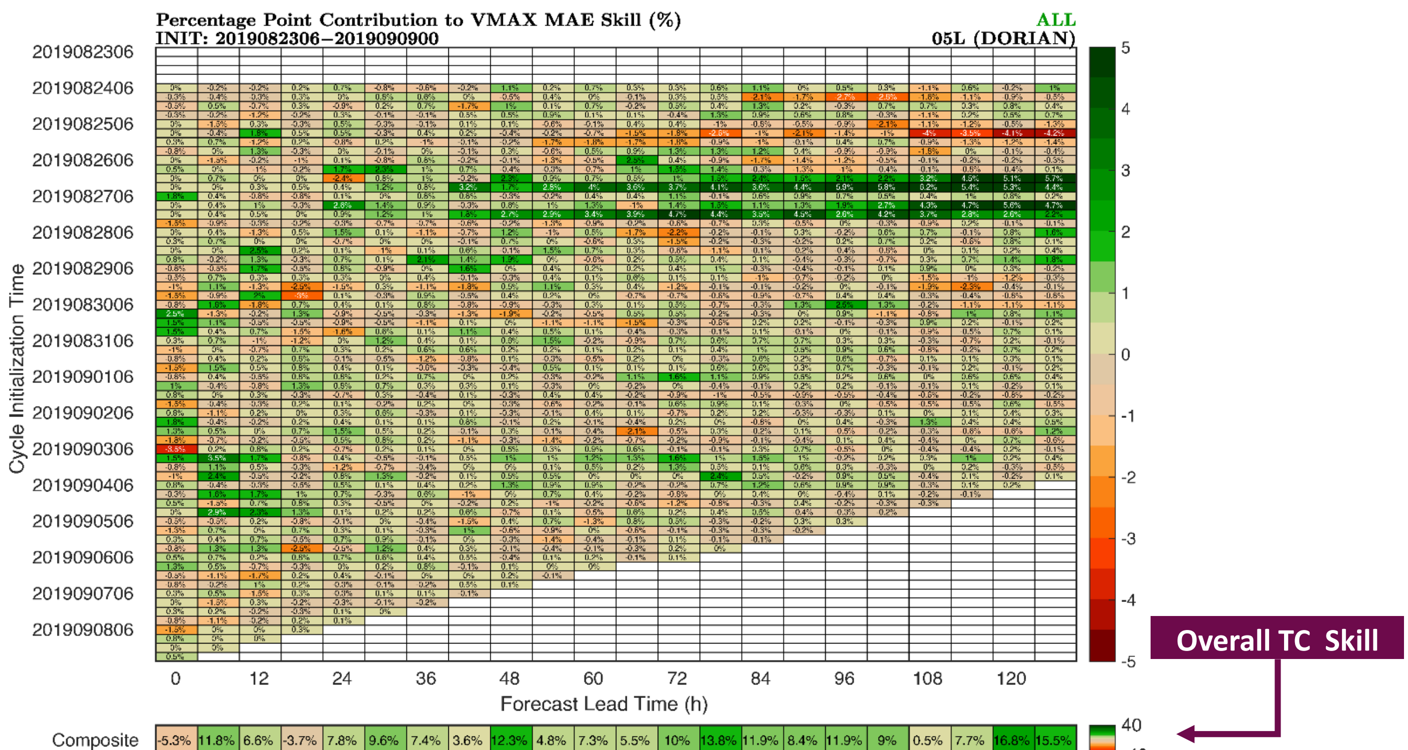


File: DORIAN19_spdfsp_cycles

PPC to MAE Skill

By Forecast Lead Time

The below graphic is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment so the user can gauge each cycle's percentage point contribution (PPC) to the MAE skill and, therefore, which cycles might be dominating the sample.



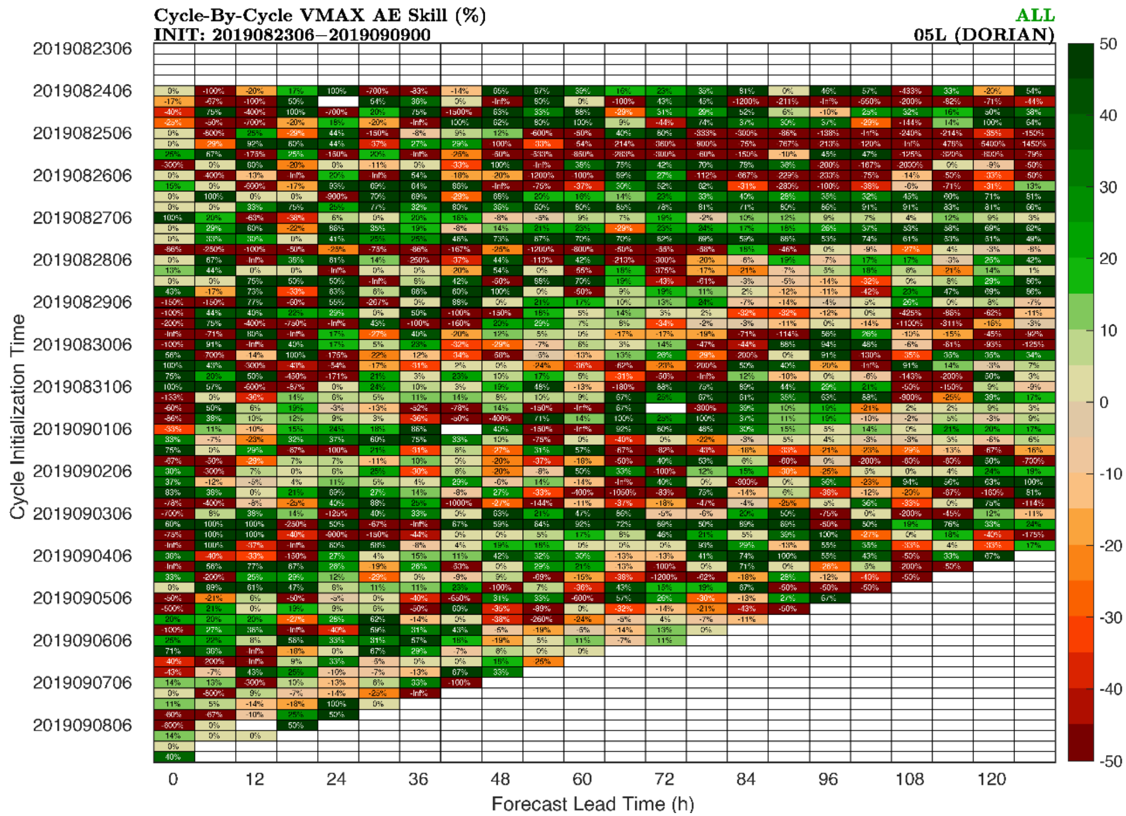
File: DORIAN19_spderr_PPC_ALL

One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

Cycle-By-Cycle AE Skill

By Forecast Lead Time

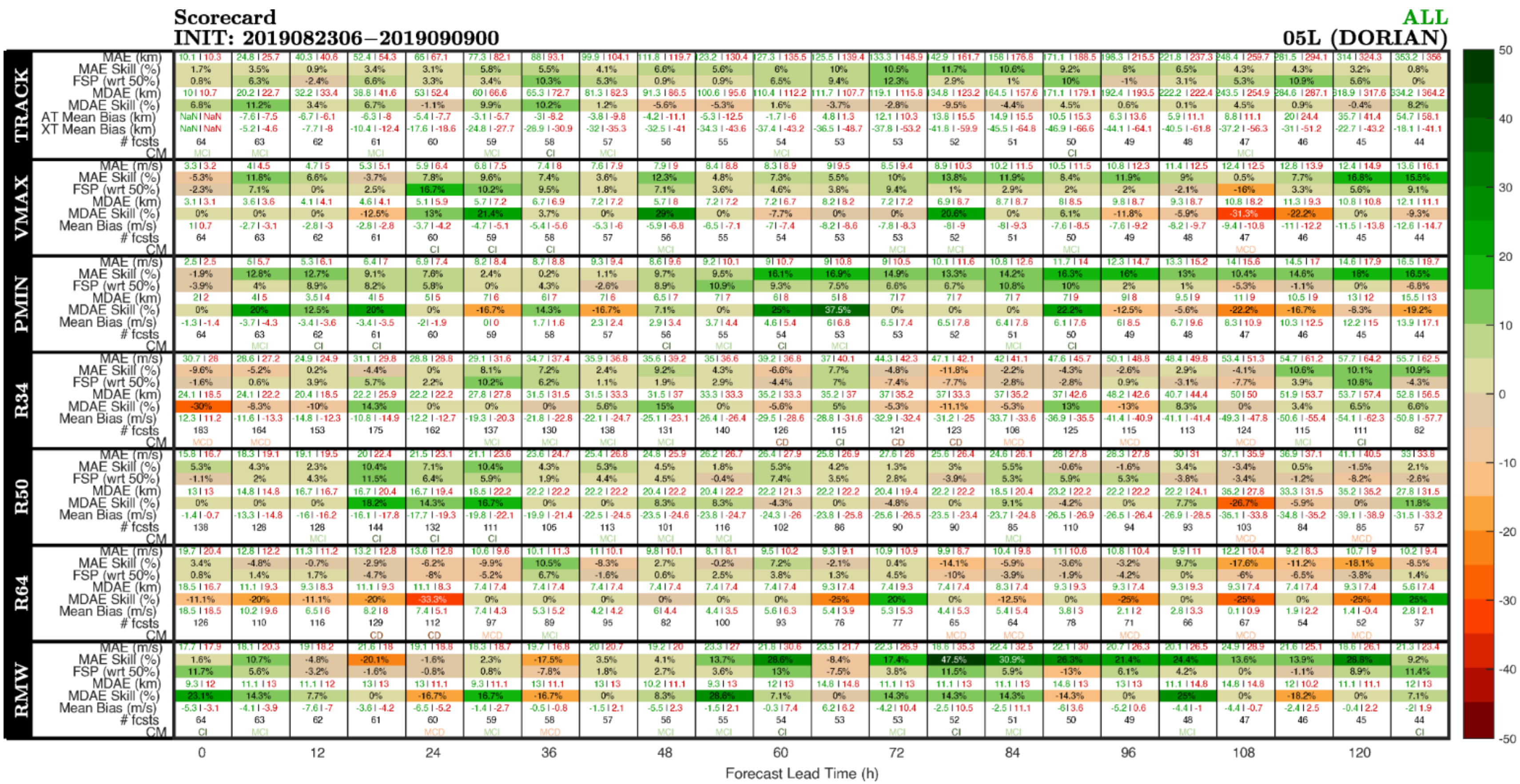
The below graphic is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment so the user can see each cycle's actual skill based on the absolute errors (AE).



File: DORIAN19_spderr_contr_ALL

Scorecard Graphic

The below graphic is generated for each experiment to give an overall snapshot of the model performance.



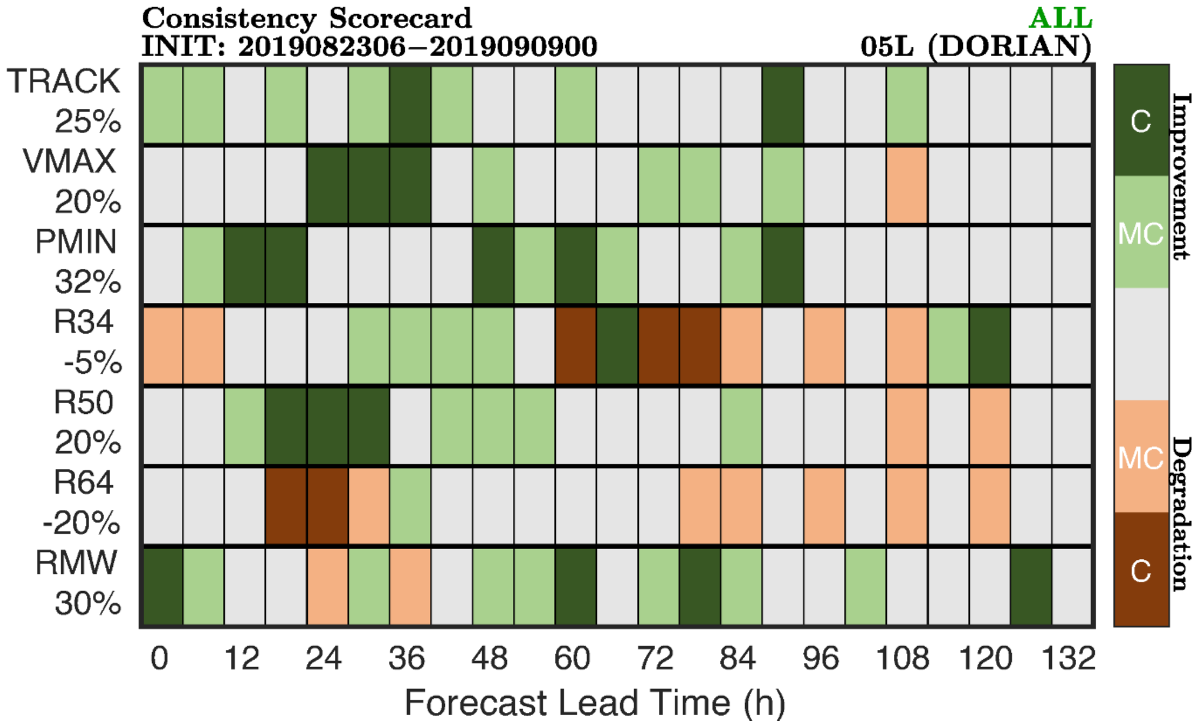
Credit: Idea & Base Code by Dr. Peter Marinescu

File: DORIAN19_SCORECARD_NONE_ALL

Consistency Scorecard

By Forecast Lead Time

This graphic is generated for each experiment and stratification. details can be found on the README within the Post-TC Verification Tab of the AOML Hurricane Model Viewer.



File: DORIAN19_CONSISTENCYSCORECARD_NONE_ALL

One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

NHC Verification & Stratifications

Graphics on the last 7 slides are also generated for an NHC-Verification-Rules sample (NONE) and the stratifications below based on switches in the namelist.

#	STRATIFICATION	DEFINITION
0	NONE	Perform no subsets other than NHC verification
1-2	OBS | NOOBS	keeps only the cycles where the obs in question (was | was not) assimilated in a storm
3-4	RECON | PRERECON	keeps (from | before) the 1st cycle where the obs in question was assimilated to the (end | beginning) of the storm
5-8	TD | TS | H12 | H345	cycles with best track intensity of (TD | TS | H12 | H345) at t=0
9-13	RI | IN | SS | WK | RW	For the best track of a storm, calculate the running $\pm$6 h intensity change to capture what type of intensity change the storm is currently undergoing. Then, for cycles t=0, categorize as follows: (RI: $x \geq 15$ kt | IN: $5 < x < 15$ kt | SS: $-5 \leq x \leq 5$ kt | WK: $-15 < x < -5$ kt | RW: $x \leq -15$ kt)
14	HFIP-RI	Using the definition found in section 3.3 of https://www.mdpi.com/2073-4433/12/6/683/htm
15-17	LOW | MOD | HIGH	cycles with SHIPS shear* of (LOW | MOD | HIGH) at t=0
18-19	N30 | S30	cycles with best track latitude (≥30 N | <30 N) at t=0
20-21	ENKF | GDAS	Cycles that used ENKF or GDAS covariances on D03 (for HWRF and basin-scale HWRF, only)
22	CUSTOM	you can input a list of cycles for your own custom subset in the namelist

NOTE: #1-4 are run, and #5-8, #15-17, #18-19, & #20-20 are further subset into OBS and NOOBS *only if* identconv=1 or identsatobs=1 in the namelist which lets the package know that you retrieved the required files and are running the assimilated obs component of the package.

FOR GROOT-G, ONLY

- **An additional subset called OBS-G is included that includes cycles where the obs in question was assimilated anywhere in the global domain**
- **Other than OBS-G, any OBS-related subset considers only the near-storm environment (R<2000 km)**

* Shear: 850-200 hPa mag (kt) | vortex removed | averaged 0-500 km relative to 850 hPa center

Basin: Individual | Verification: Consistent with NHC

* There is a switch in the namelist to indicate if the model is a basin-scale model.

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

NHC Verification & Stratifications

All OS(S)Es

<table>
<tr><th>#</th><th>STRATIFICATION</th><th>DEFINITION</th></tr>
<tr><td>0</td><td>NONE</td><td>Perform no subsets other than NHC verification</td></tr>
<tr><td>1-2</td><td>OBS | NOOBS</td><td>keeps only the cycles where the obs in question (was | was not) assimilated in a storm</td></tr>
<tr><td>3-4</td><td>RECON | PRERECON</td><td>keeps (from | before) the 1st cycle where the obs in question was assimilated to the (end | beginning) of the storm</td></tr>
<tr><td>5-8</td><td>TD | TS | H12 | H345</td><td>cycles with best track intensity of (TD | TS | H12 | H345) at t=0</td></tr>
<tr><td>9-13</td><td>RI | IN | SS | WK | RW</td><td>For the best track of a storm, calculate the running ±6 h intensity change to capture what type of intensity change the storm is currently undergoing. Then, for cycles t=0, categorize as follows:
(RI: x≥15 kt | IN: 5<x<15 kt | SS:−5≤x≤5 kt | WK: −15<x<−5 kt | RW: x≤−15 kt)</td></tr>
<tr><td>14</td><td>HFIP-RI</td><td>Using the definition found in section 3.3 of https://www.mdpi.com/2073-4433/12/6/683/htm</td></tr>
<tr><td>15-17</td><td>LOW | MOD | HIGH</td><td>cycles with SHIPS shear* of (LOW | MOD | HIGH) at t=0</td></tr>
<tr><td>18-19</td><td>N30 | S30</td><td>cycles with best track latitude (≥30 N | <30 N) at t=0</td></tr>
<tr><td>20-21</td><td>ENKF | GDAS</td><td>Cycles that used ENKF or GDAS covariances on D03 (for HWRF and basin-scale HWRF, only)</td></tr>
<tr><td>22</td><td>CUSTOM</td><td>you can input a list of cycles for your own custom subset in the namelist</td></tr>
<tr><td>23</td><td>YYYY</td><td>cycles that occur in a single year (only runs if >1 year)</td></tr>
</table>

Same as "One Storm: All Cycles" other than this additional subset!

NOTE: #1-4 are run, and #5-8, #15-17, #18-19, & 20-21 are further subset into OBS and NOOBS *only if* identconv=1 or identsatobs=1 in the namelist which lets the package know that you retrieved the required files and are running the assimilated obs component of the package.

For GROOT-G, an additional subset called OBS-G is included that includes cycles where the obs in question was assimilated anywhere in the global domain. Other than OBS-G, any OBS-related subset considers only the near-storm environment (R<2000 km)

Basin-Scale* OS(S)Es

#	STRATIFICATION	DEFINITION
1	OBS-I	cycles from storms with obs, where that storm was the only one with obs in the parent domain
2	OBS-T	cycles from storms with obs, where that storm was not the only one with obs in the parent domain
3	OBS-O	cycles from storms without obs, where there were other storms with obs in the parent domain
4	OBS-P	cycles where there were obs in a storm somewhere in the parent domain (OBS-P=OBS-I+OBS-T+OBS-O / OBS-P=OBS+OBS-O)
5	NOOBS-P	cycles where there were no obs in any storm anywhere in the parent domain
6	RECON-I	cycles from storms with recon, where that storm was the only one with recon in the parent domain
7	RECON-T	cycles from storms with recon, where that storm was not the only one with recon in the parent domain
8	RECON-O	cycles from storms without recon, where there were other storms with recon in the parent domain
9	RECON-P	cycles where there were recon somewhere in the parent domain (RECON-P=RECON-I+RECON-T+RECON-O / RECON-P=RECON+RECON-O)
10	PRERECON-P	cycles where there were no recon anywhere in the parent domain

NOTE: #1-10 are run *only if* identconv=1 or identsatobs=1 in the namelist which lets the package know that you retrieved the required files and are running the assimilated obs component of the package. Also, #1-5 are further subset by year (YYYY).

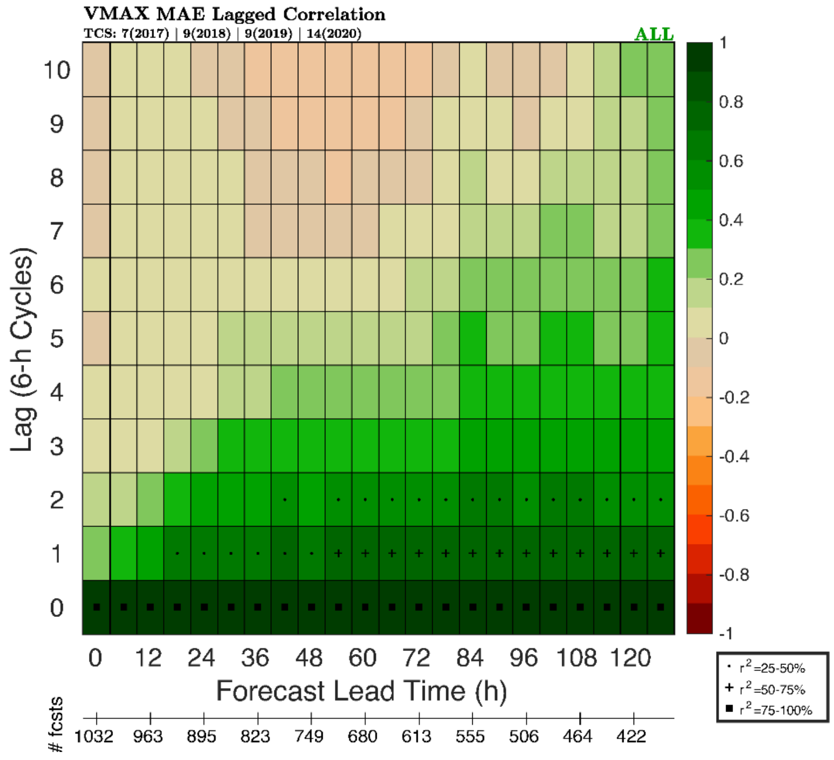
* Shear: 850-200 hPa mag (kt) | vortex removed | averaged 0-500 km relative to 850 hPa center

Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

Lagged Correlation

The below graphic is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment so the user can gauge how many cycles it takes for errors to decorrelate in the full sample. **(It was previously used to calculate the effective sample size for statistical significance tests through a user-defined variance and lag threshold in the namelist (*editverif.m*). Divisors were calculated from the first experiment listed in the namelist. For example, COMP_scfactor.txt includes details on the divisors for each variable. Due to the introduction of the consistency metric, statistical significance is no longer needed/used. Thus this feature is no longer active.)**



File: COMP_spderr_NONE_LAGCORR_ALL

Basin: Individual | Verification: Consistent with NHC

*For track, both the along-track and across-track bias are generated.

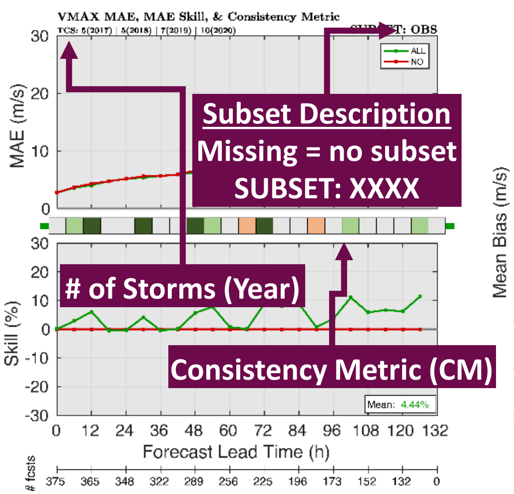
One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

Subsets of Error, Improvement, Bias, & FSP

By Forecast Lead Time

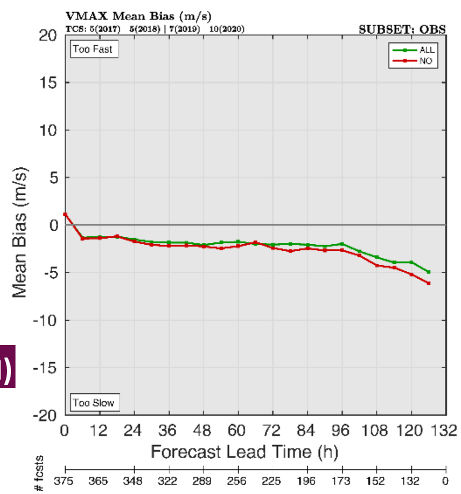
The below graphics are generated for Track*, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each stratification.

MAE, MAE Skill, & CM



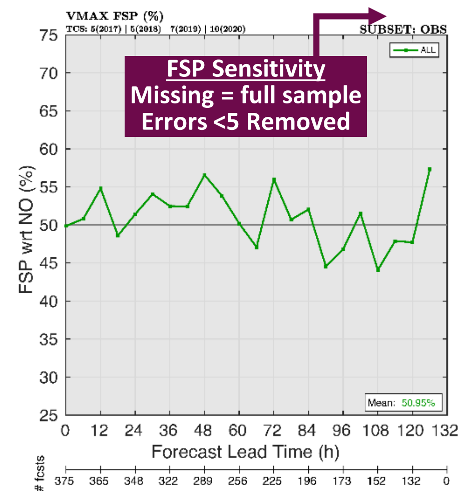
File: COMP_spderrskill_OBS_mean

Mean Bias



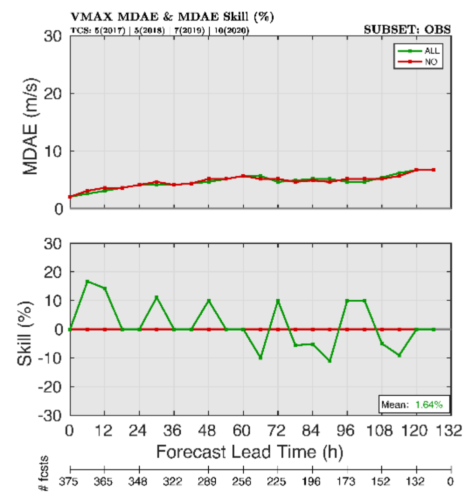
File: COMP_spdbias_OBS

FSP



File: COMP_spdfsp_OBS

MDAE & MDAE Skill



File: COMP_spderrskill_OBS_median

Details on the consistency metric will be provided in Ditchek et al. (2022, *in review at WAF*). For now, details can be found on the README within the Post-TC Verification Tab of the AOML Hurricane Model Viewer.

Not shown: Separate graphics for MAE (File: COMP_spderr_OBS) and MAE Skill (File: COMP_spdskill_OBS)

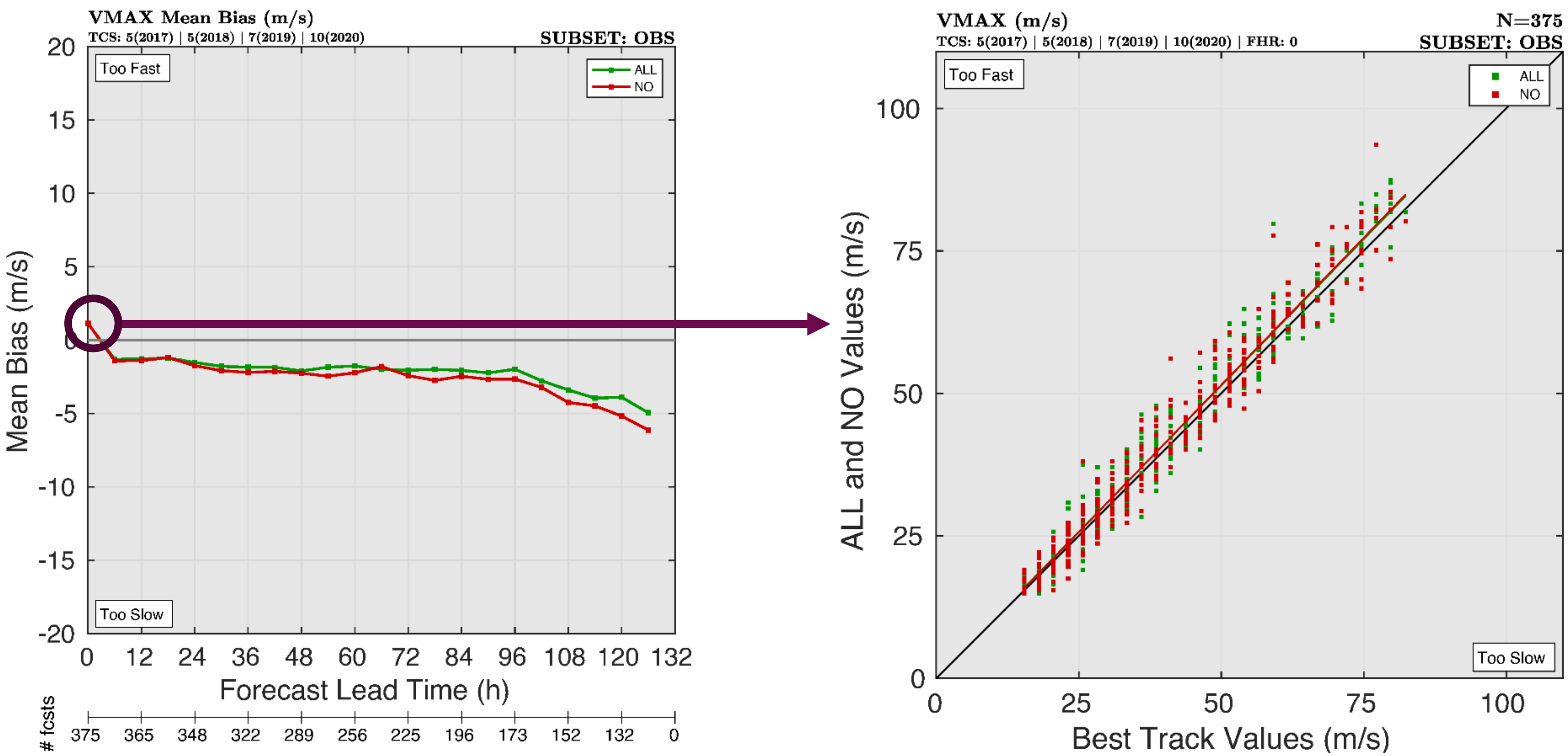
Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

Raw Value Comparison

At Forecast Initialization

The below graphics are generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each stratification.



File: COMP_spdval_OBS

Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

Number of Forecasts Contributing to The Error

By Forecast Lead Time

The below graphic is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment and stratification so the user can know how many cycles/TC are contributing to the errors.

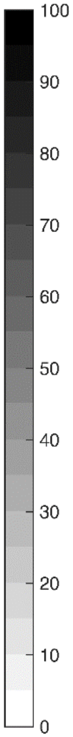
Number of Forecasts Contributing to VMAX MAE

TCS: 5(2017) | 5(2018) | 7(2019) | 10(2020)

SUBSET: OBS

	0		12		24		36		48		60		72		84		96		108		120	
09L (Harvey)	18	17	17	17	16	15	15	14	13	13	12	12	12	12	12	12	13	13	13	14	15	15
11L (Irma)	29	29	29	29	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12
12L (Jose)	18	18	18	18	18	17	16	15	14	13	13	12	11	10	9	8	8	7	7	6	5	4
13L (Katia)	6	6	5	5	5	4	4	3	3	2	1	1	0	0	0	0	0	0	0	0	0	0
15L (Maria)	39	39	39	39	39	39	39	39	39	39	39	39	38	37	36	35	34	33	32	31	30	29
06L (Florence)	23	23	23	23	23	23	23	23	23	23	23	23	22	21	20	19	18	17	16	15	14	13
07L (Gordon)	7	7	7	7	7	7	6	5	4	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0
09L (Isaac)	6	6	5	5	5	5	5	4	3	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0
12L (Kirk)	10	9	8	7	6	6	5	4	3	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0
14L (Michael)	13	13	13	13	13	12	11	10	9	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	0	0	0	0	0
05L (Dorian)	46	46	46	46	45	44	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29
06L (Erin)	2	2	2	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
07L (Fernand)	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09L (Humberto)	17	17	17	16	15	15	14	14	13	13	12	12	11	10	9	9	8	7	6	5	4	3
10L (Jerry)	19	18	18	17	17	16	16	15	14	13	13	12	11	10	9	8	7	6	5	4	3	2
12L (Karen)	10	10	10	10	9	9	9	9	8	8	7	6	5	4	4	4	4	3	3	3	2	1
13L (Lorenzo)	6	6	6	6	6	6	6	6	6	6	6	5	4	4	4	3	2	2	2	1	0	0
07L (Gonzalo)	2	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08L (Hanna)	3	3	3	3	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09L (Isaias)	18	18	18	17	16	15	14	13	12	11	10	10	9	8	7	6	5	4	3	2	1	1
13L (Laura)	21	21	21	21	21	21	21	21	20	19	18	17	16	15	14	13	12	11	10	9	8	8
14L (Marco)	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	0	0	0	0	0	0	0
17L (Paulette)	5	5	5	5	5	5	5	5	5	4	3	2	2	2	1	0	0	0	0	0	0	0
19L (Sally)	15	15	15	15	14	13	12	11	10	9	8	7	6	5	4	3	2	2	2	1	1	1
20L (Teddy)	15	14	13	12	12	11	11	10	10	9	9	9	9	8	8	8	8	7	6	6	6	5
21L (Vicky)	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22L (Beta)	11	11	11	11	10	9	8	7	6	5	4	3	2	2	1	1	0	0	0	0	0	0

Forecast Lead Time (h)



Subset Description
Missing = no subset
SUBSET: XXXX

Sorted by Year then by #

File: COMP_spderr_fcst_OBS

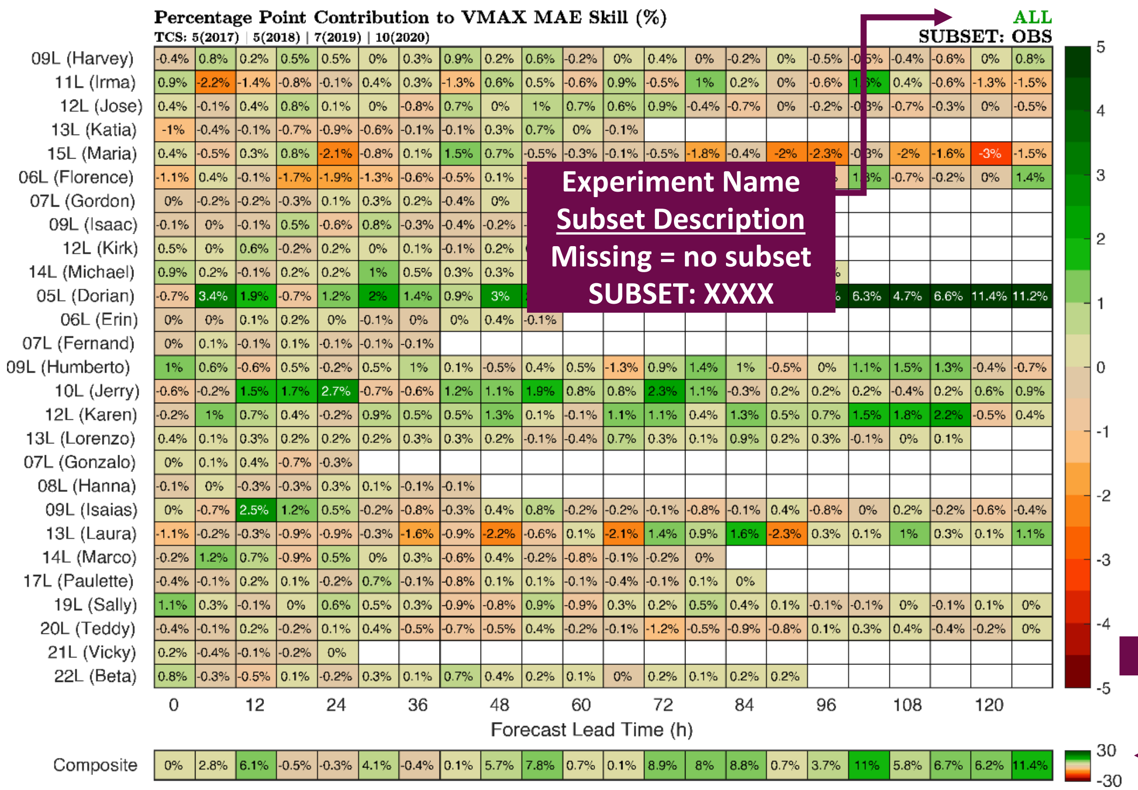
Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

PPC to MAE Skill

By Forecast Lead Time

The below graphic is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment and stratification so the user can gauge each TC's percentage point contribution (PPC) to the MAE skill and, therefore, which TCs might be dominating the sample.



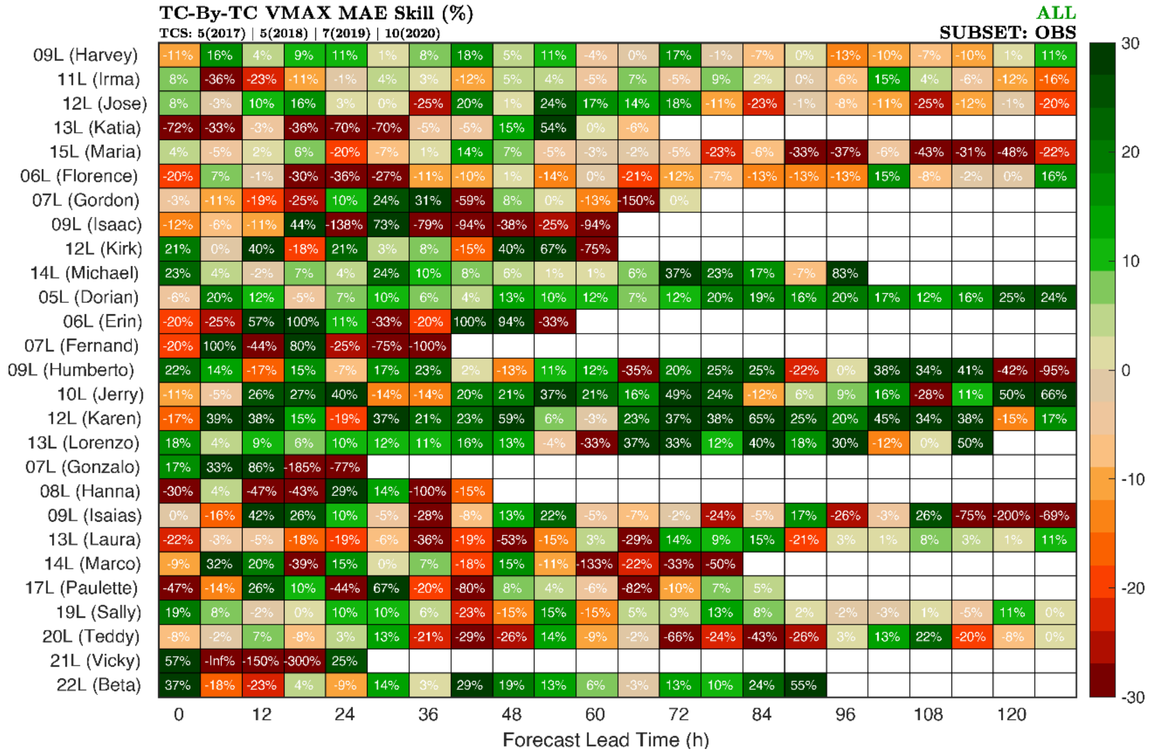
Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

TC-by-TC MAE Skill

By Forecast Lead Time

The below graphic* is generated for Track, VMAX, PMIN, R34/R50/R64 (for each the NE, SE, SW, and NW quadrants as well as overall), PO, RO, and RMW for each experiment, and stratification so the user can see each TC's actual skill based on the absolute errors (AE).



File: COMP_spderr_contr_OBS_ALL_mean

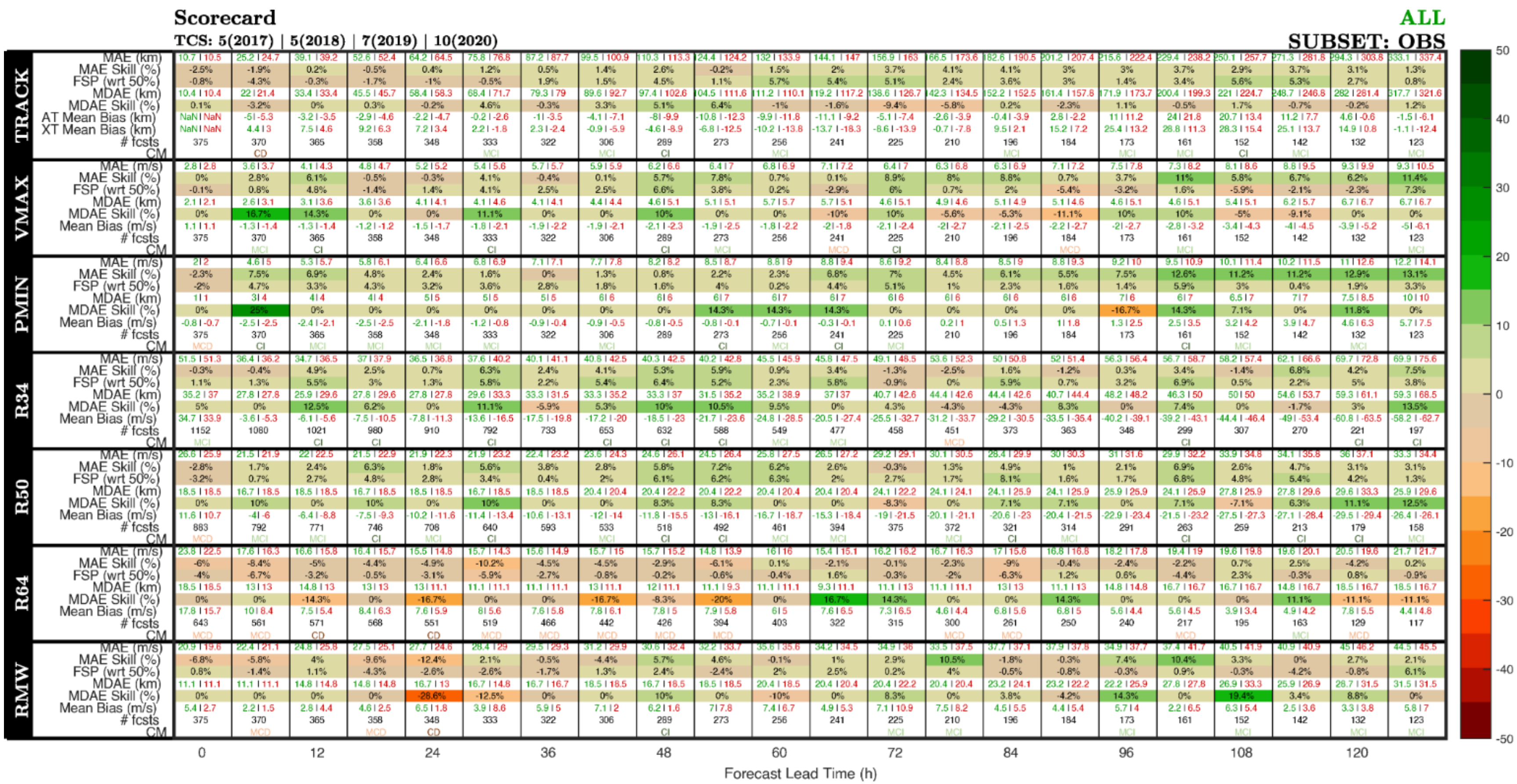
*Not Shown: also generated for TC-by-TC MDAE Skill (*File: COMP_spderr_contr_OBS_ALL_median*), FSP (*File: COMP_spderr_contr_OBS_ALL_fsp*), and CM (*File: COMP_spderr_contr_OBS_ALL_conmetric*)!

Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

Scorecard Graphic

The below graphic is generated for each experiment and stratification to give an overall snapshot of the model performance.



Credit: Idea & Base Code by Dr. Peter Marinescu

File: COMP_SCORECARD_OBS_ALL

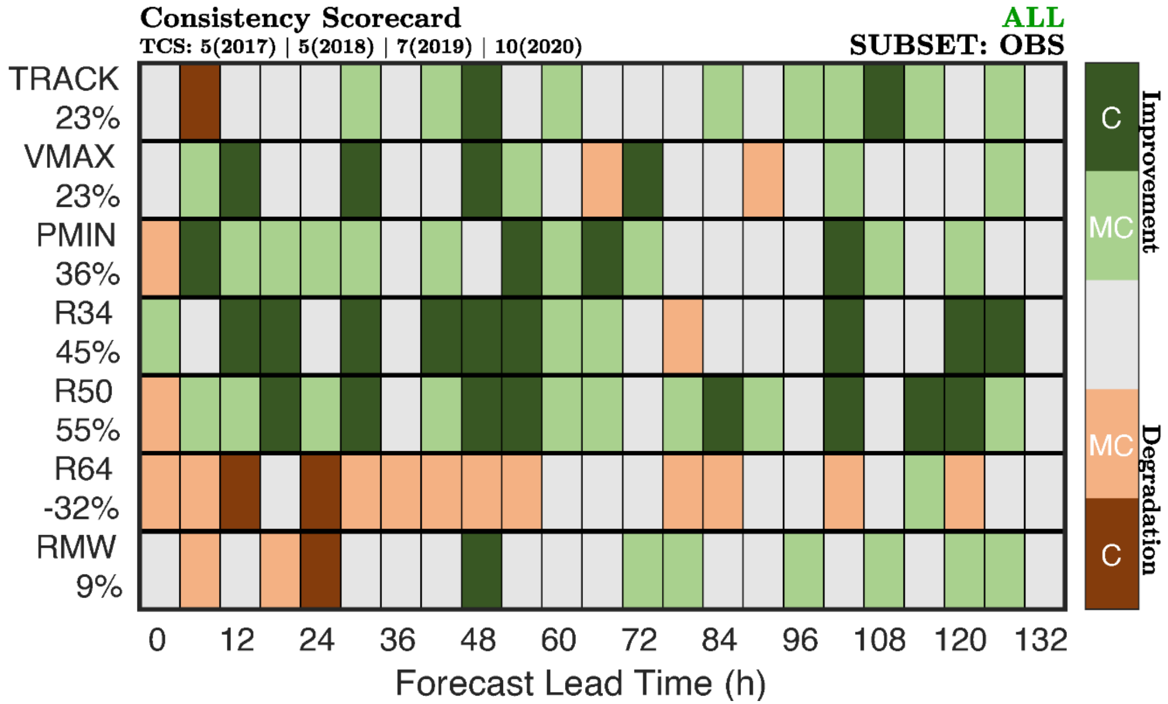
Basin: Individual | Verification: Consistent with NHC

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

Consistency Scorecard

By Forecast Lead Time

This graphic is generated for each experiment and stratification. details can be found on the README within the Post-TC Verification Tab of the AOML Hurricane Model Viewer.



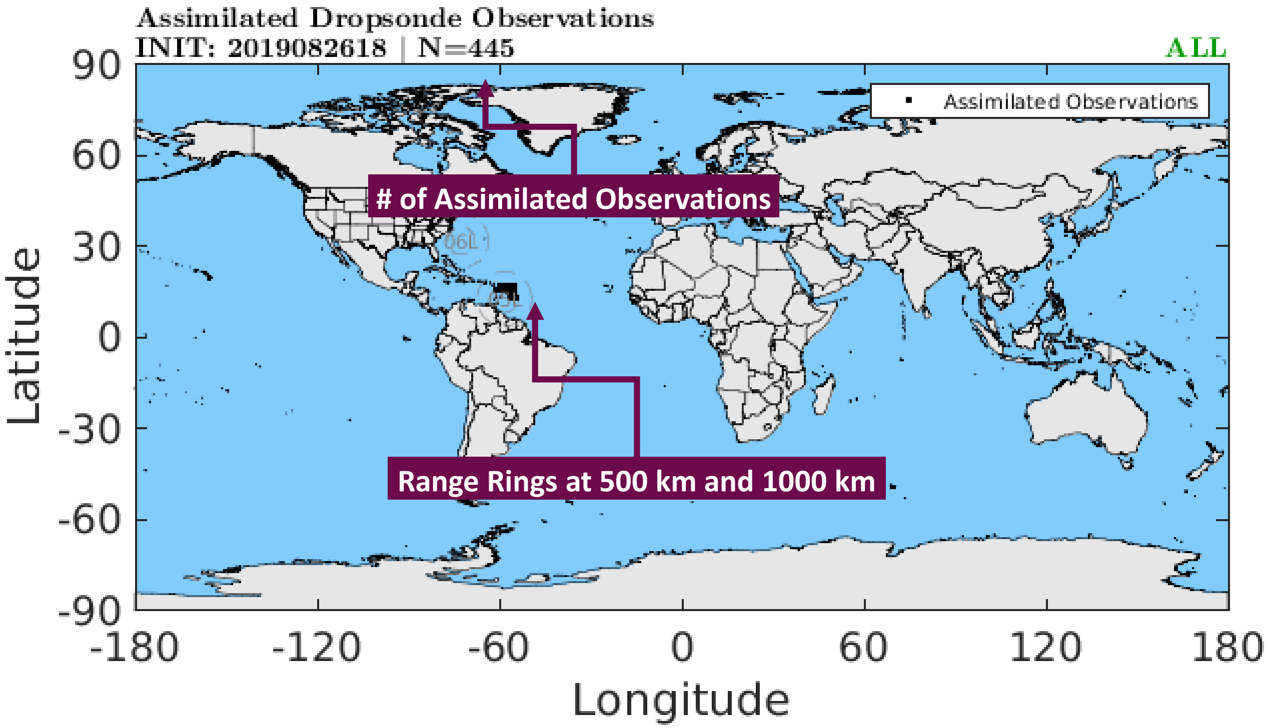
File: COMP_CONSISTENCYSCORECARD_OBS_ALL

*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle | One Storm: All Cycles | Composite Graphics

Basin View

The below graphic is generated for each experiment. It shows the number of storms run at each cycle time. For HWRF, this graphic will show only 1 storm. For the basin-scale HWRF and the global component, this graphic will show all storms run at this cycle time.



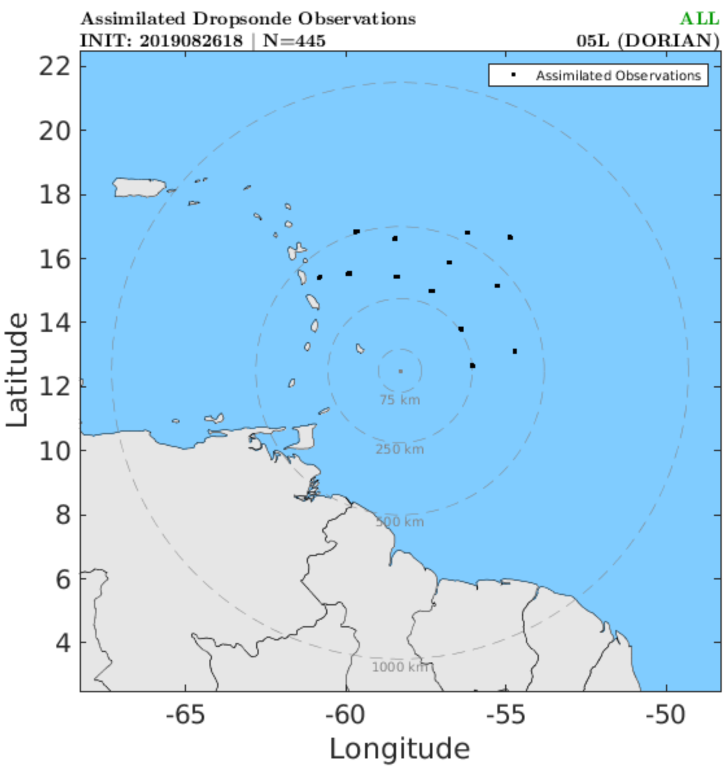
*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle | One Storm: All Cycles | Composite Graphics

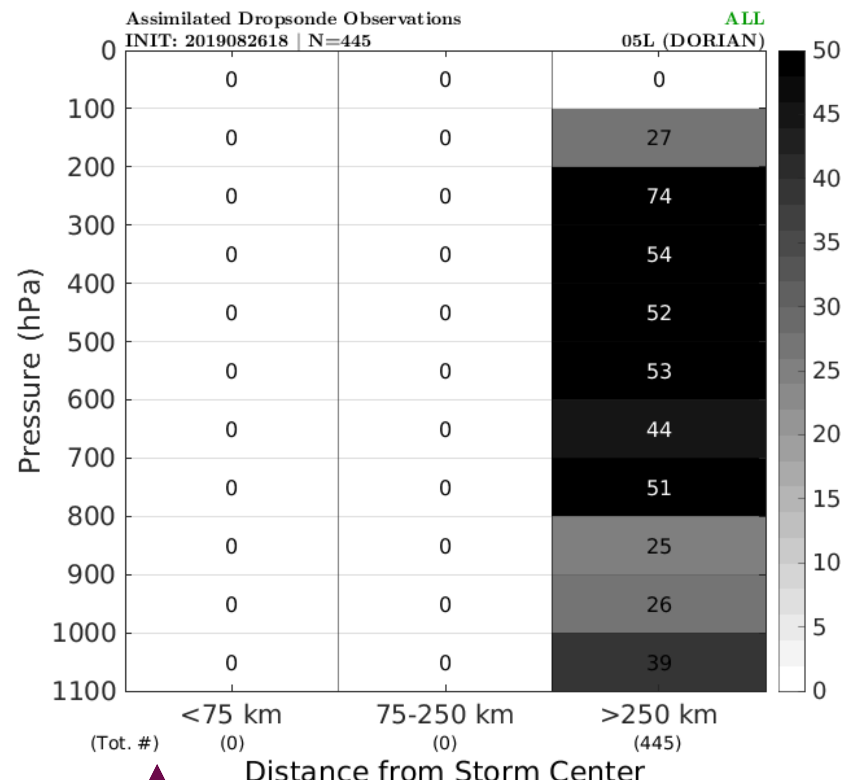
Plan View & Radial View

The below graphics are generated for each experiment and each storm. For OBS-related subsets in GROOT-G (other than OBS-G) it will take into account observations within 2000 km of the storm – this will be indicated on the graphic.

Plan View



Radial View



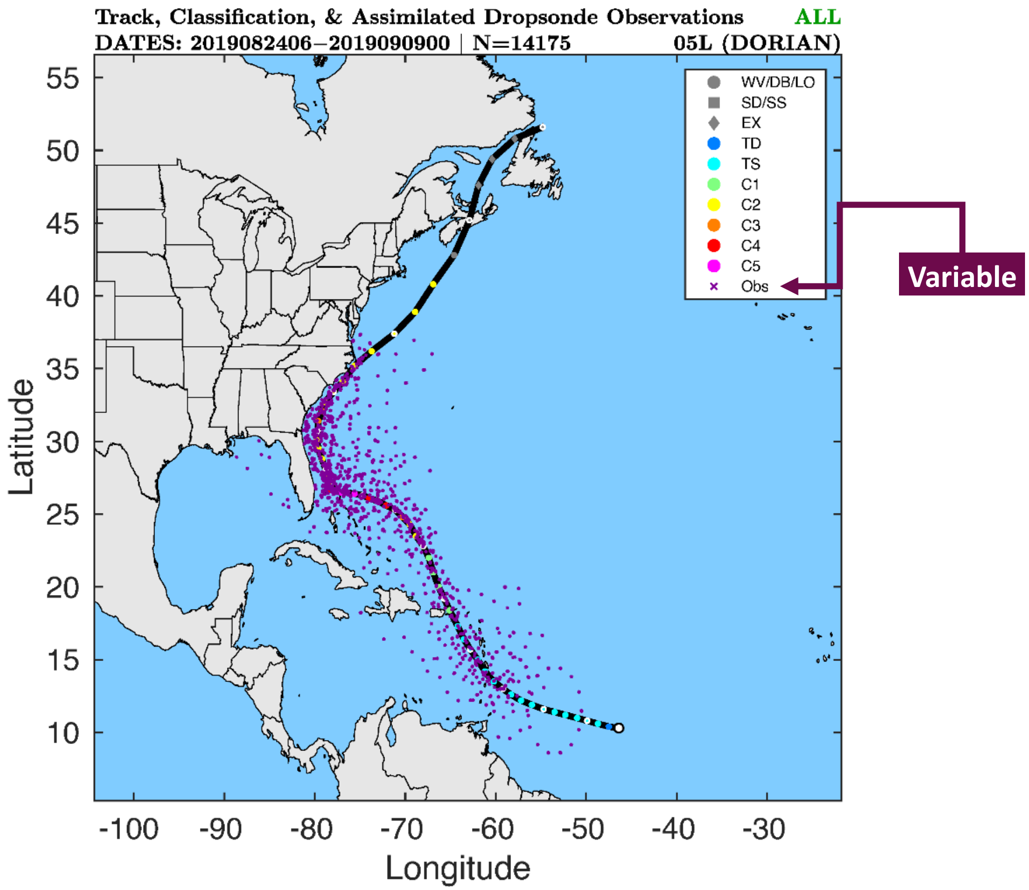
Column Sum

*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

Best Track Graphic

The below graphic is generated for each experiment and shows the along-track assimilated observations. For OBS-related subsets in GROOT-G (other than OBS-G) it will take into account observations within 2000 km of the storm – this will be indicated on the graphic.



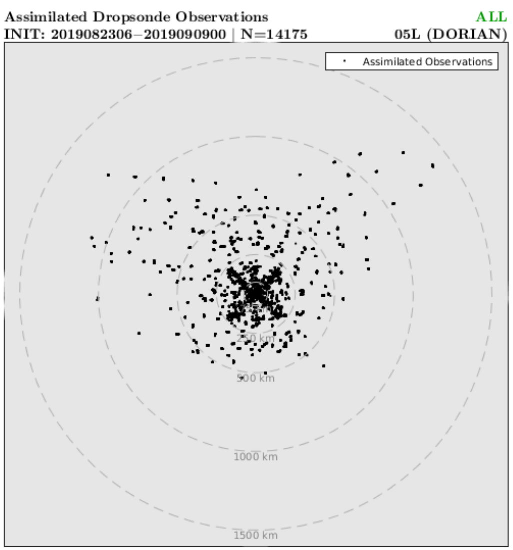
*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle | **One Storm: All Cycles** | Composite Graphics

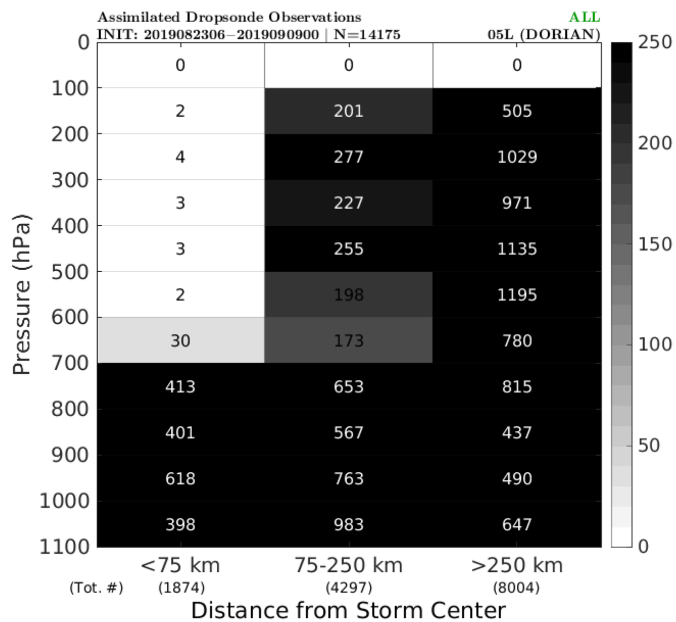
Plan, Radius-Pressure, & Radial View

The below graphic is generated for each experiment. For OBS-related subsets in GROOT-G (other than OBS-G) it will take into account observations within 2000 km of the storm – this will be indicated on the graphic.

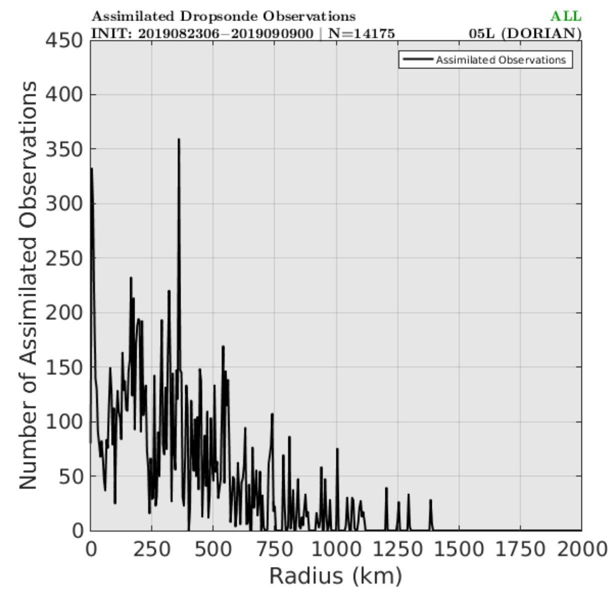
Plan View



Radius-Pressure View



Radial View



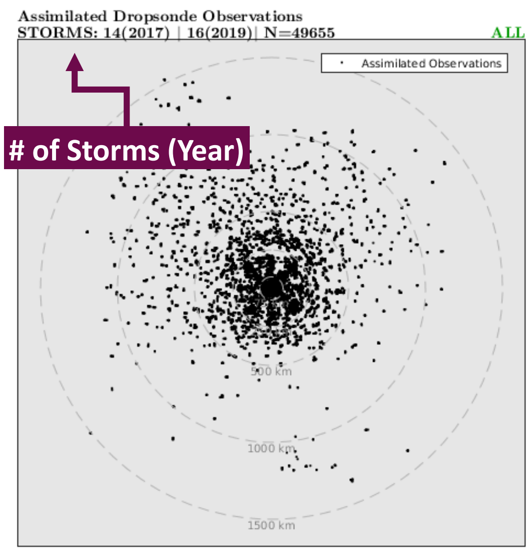
*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle | One Storm: All Cycles | **Composite Graphics**

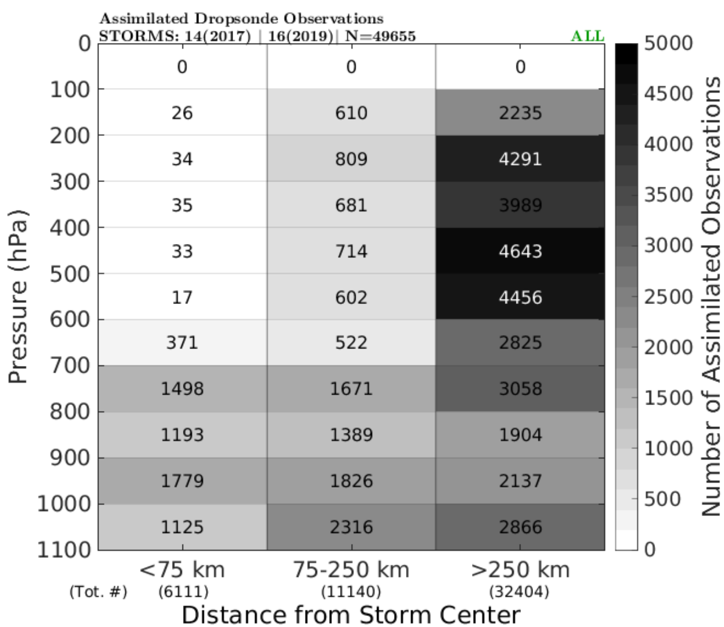
Plan, Radius-Pressure, & Radial View

The below graphic is generated for each experiment. For OBS-related subsets in GROOT-G (other than OBS-G) it will take into account observations within 2000 km of the storm – this will be indicated on the graphic.

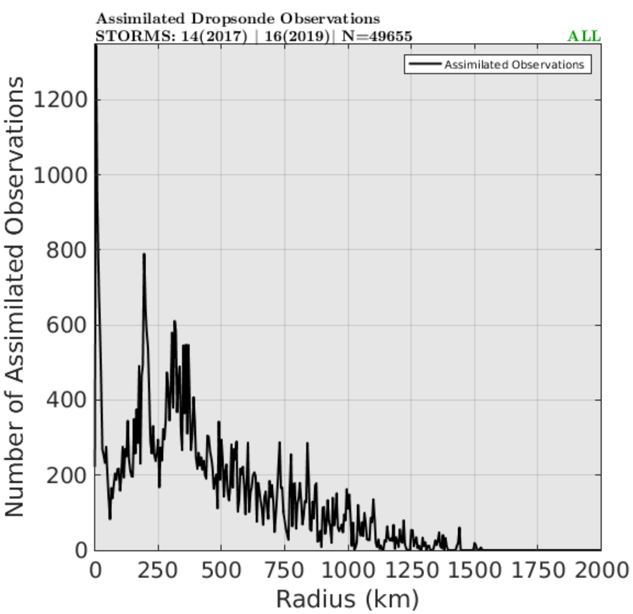
Plan View



Radius-Pressure View



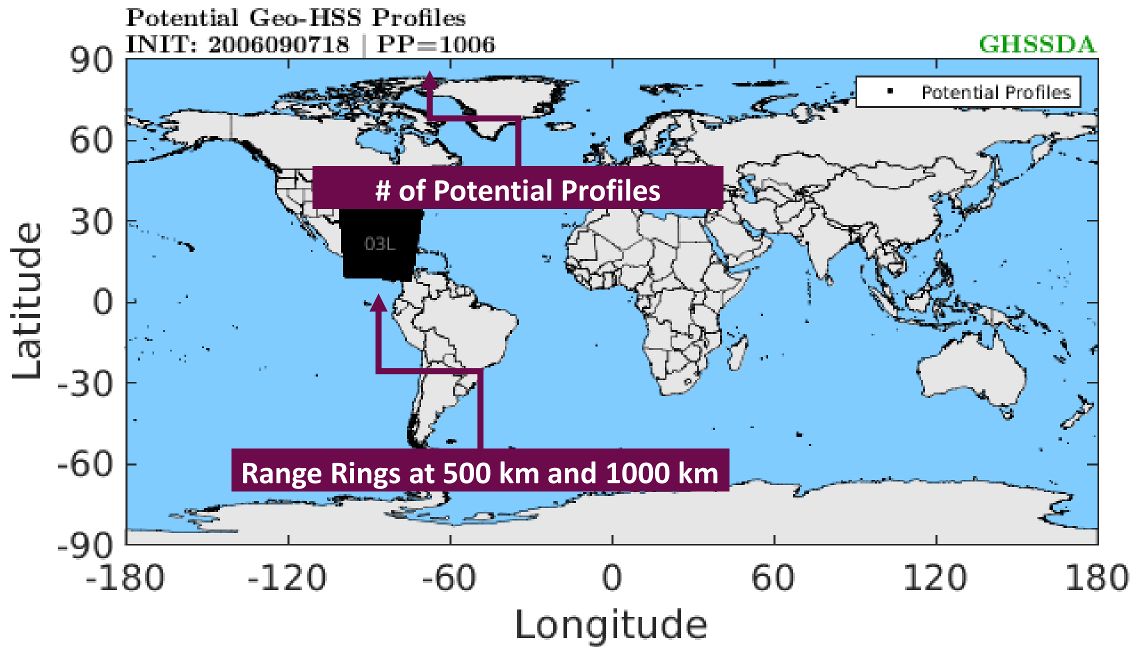
Radial View



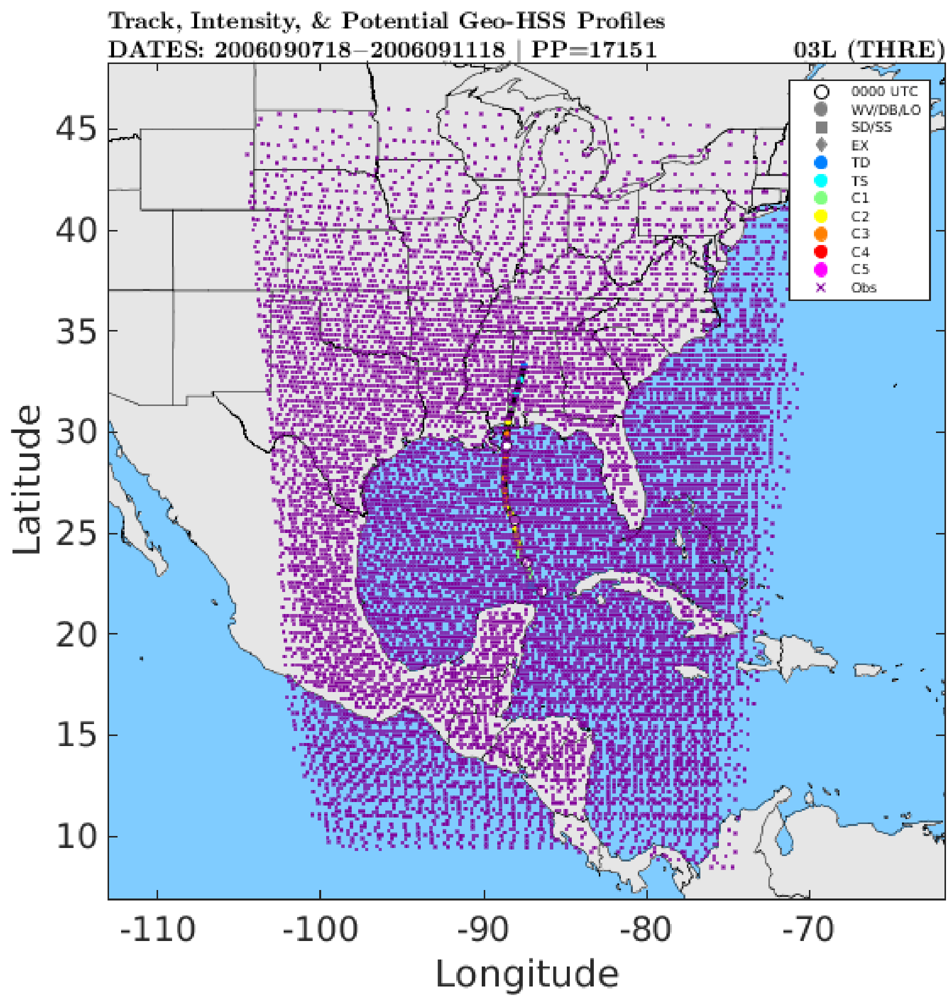
One Storm: Each Cycle | One Storm: All Cycles | Composite Graphics

Basin View

The below graphic is generated for each experiment. It shows the number of storms run at each cycle time. For HWRF, this graphic will show only 1 storm. For the basin-scale HWRF and the global component, this graphic will show all storms run at this cycle time.



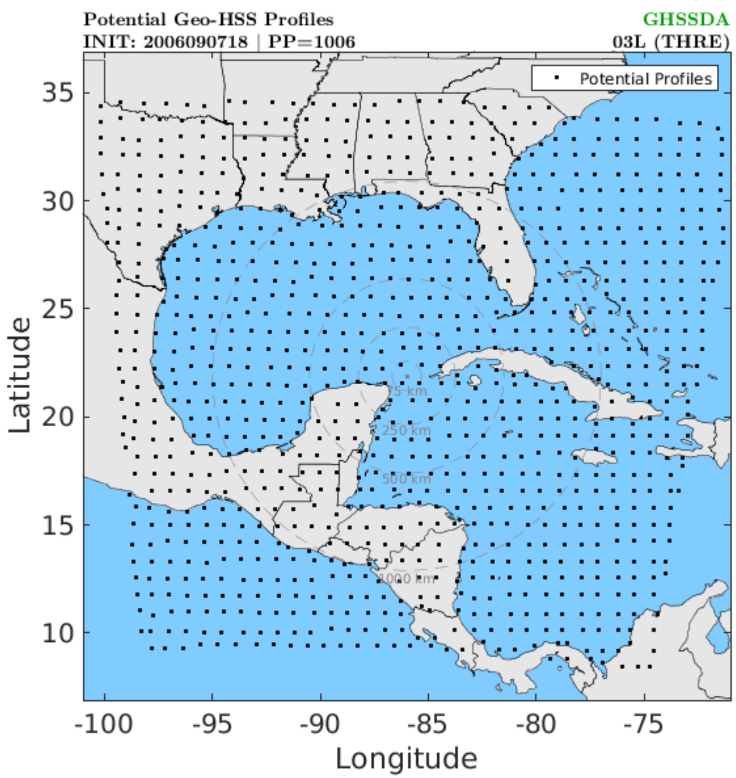
Best Track Graphic



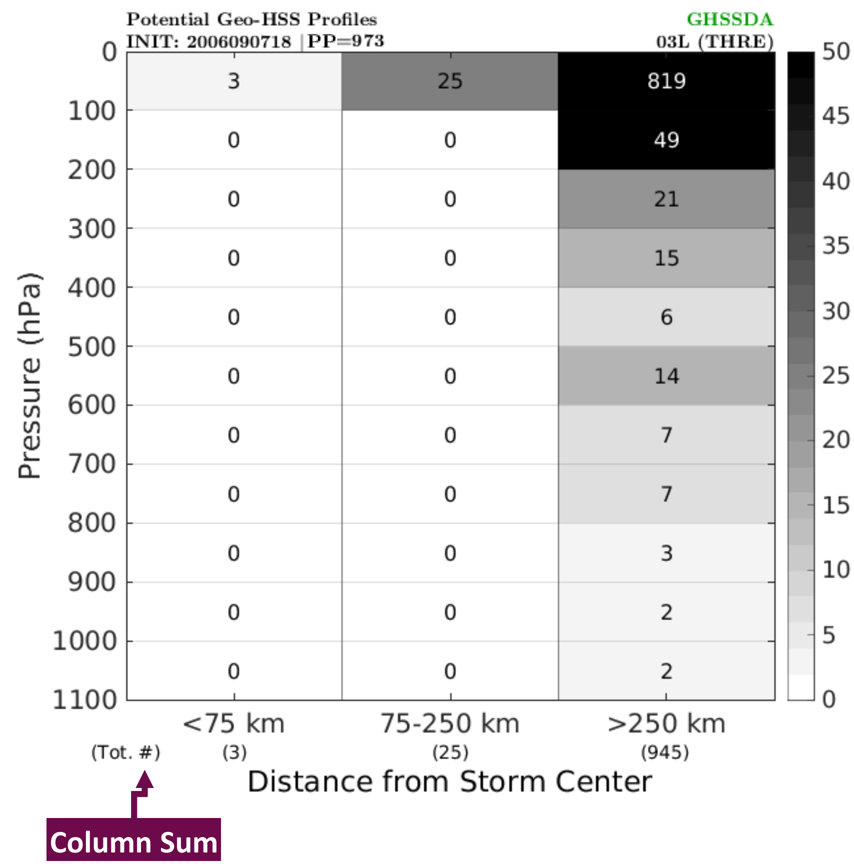
One Storm: Each Cycle | One Storm: All Cycles | Composite Graphics

Plan View & Radial View

Plan View



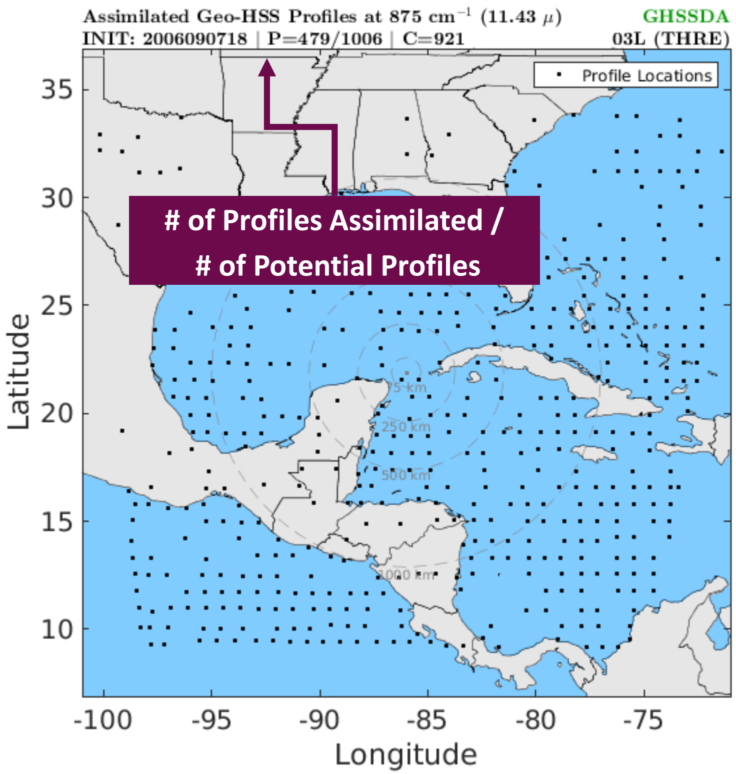
Radial View



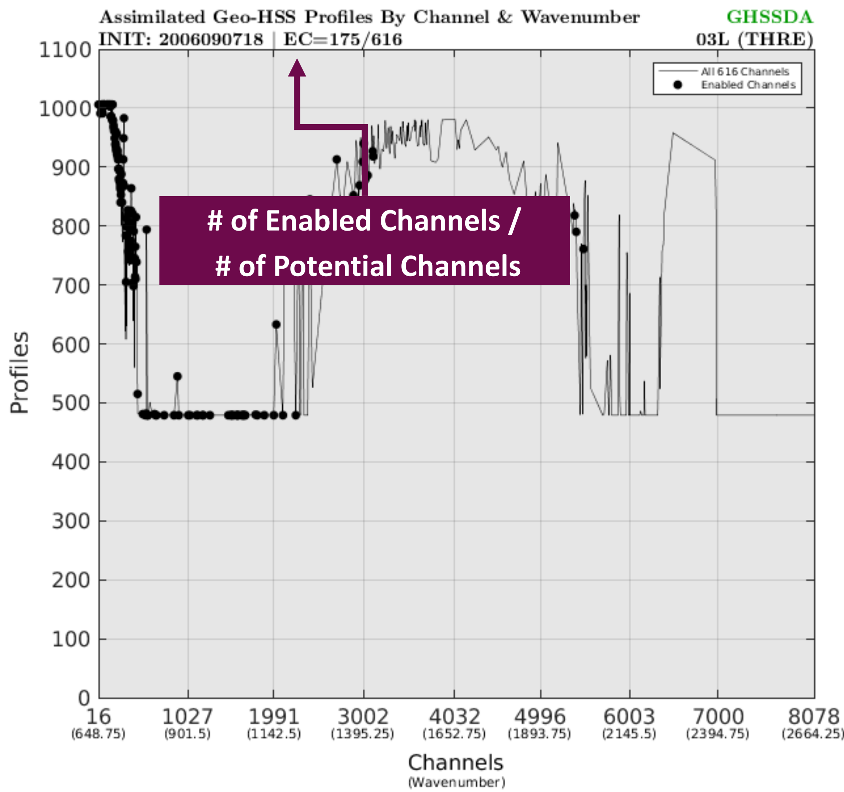
One Storm: Each Cycle | One Storm: All Cycles | Composite Graphics

Specific Channel & Profiles by Channel

Specific Channel

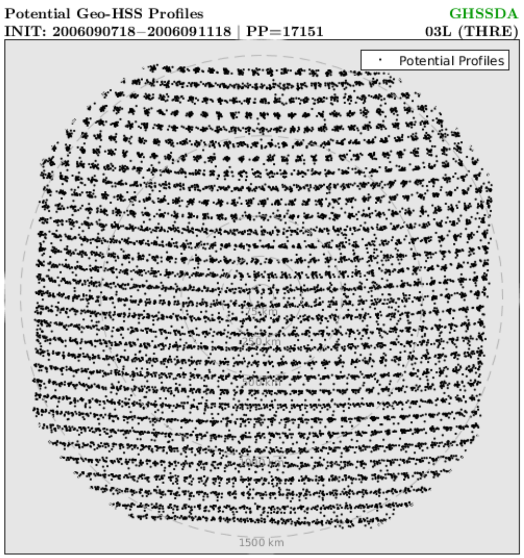


Profiles by Channel

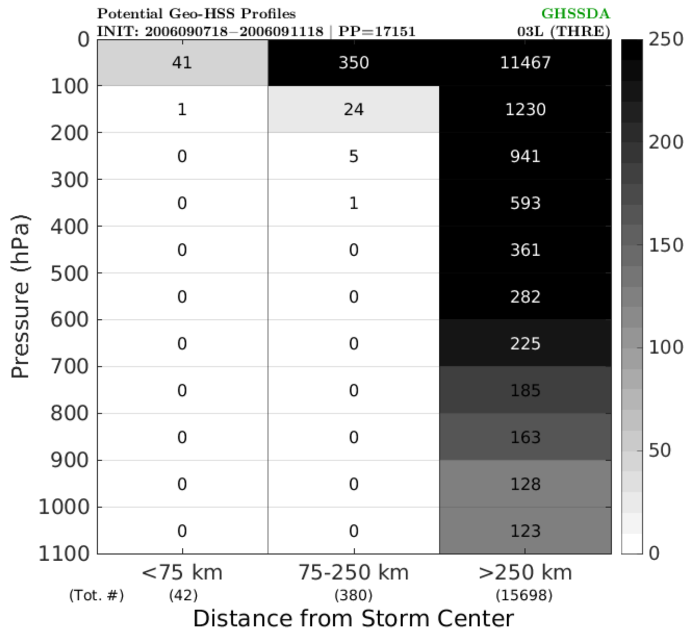


Plan, Radius-Pressure, & Radial View

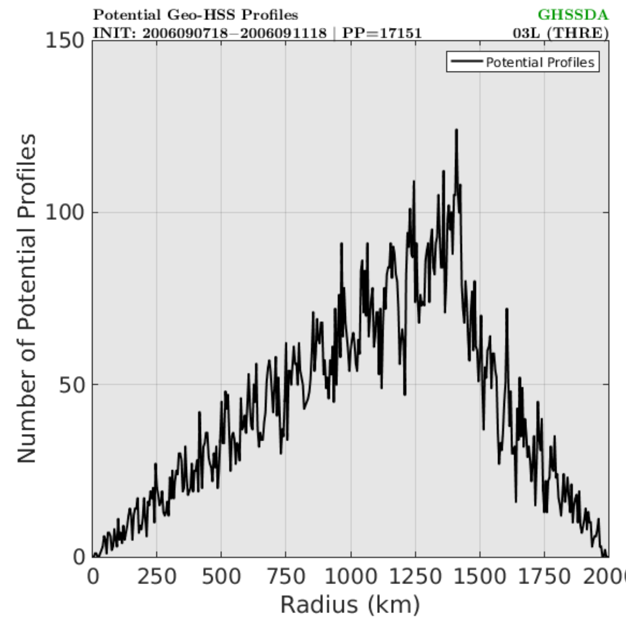
Plan View



Radius-Pressure View

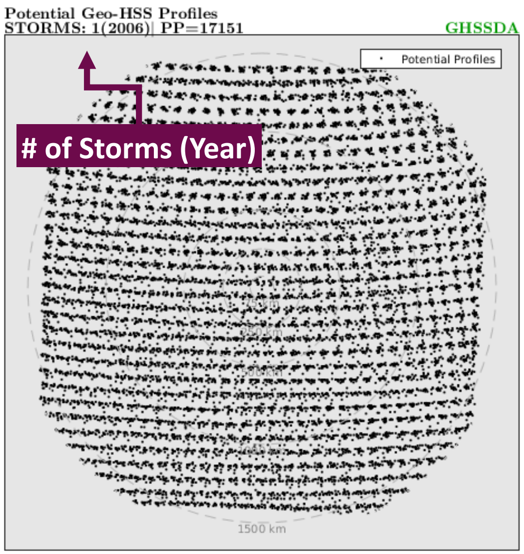


Radial View

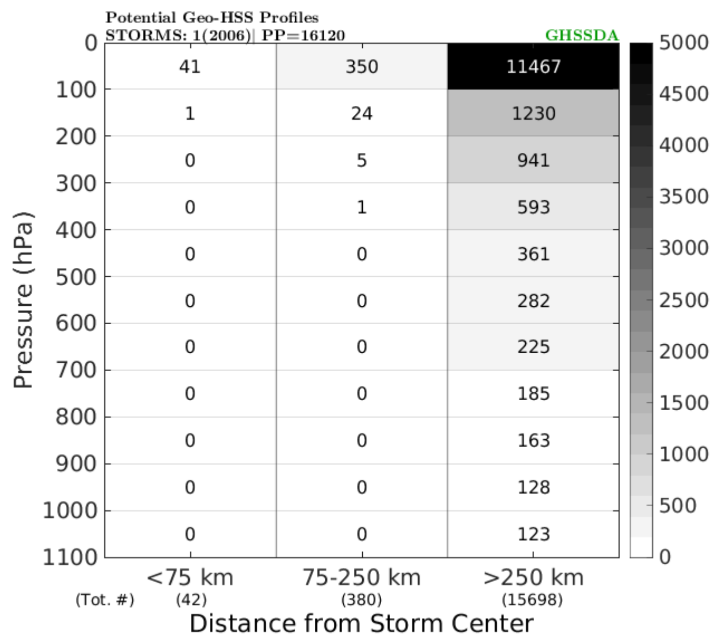


Plan, Radius-Pressure, & Radial View

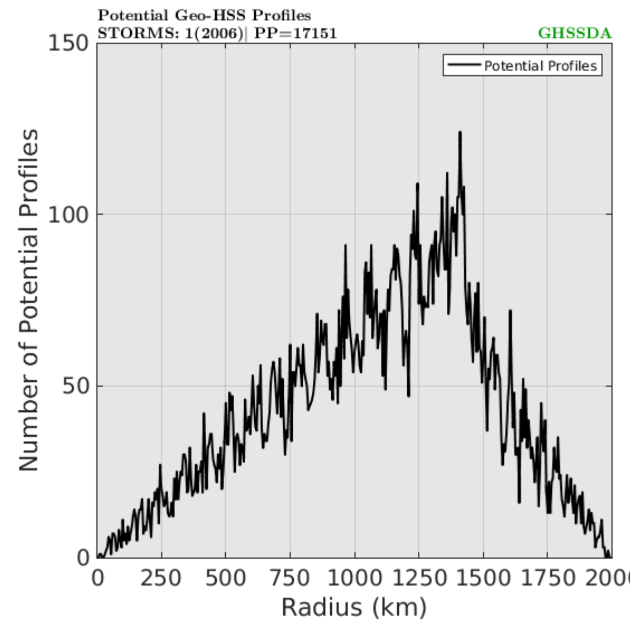
Plan View



Radius-Pressure View



Radial View



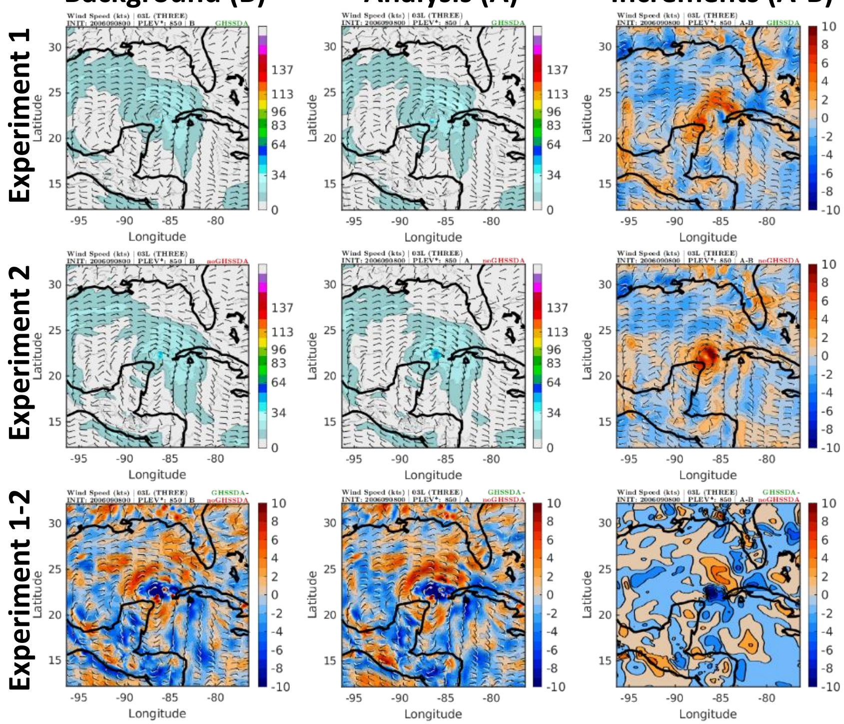
*Only for GROOT-H

Pre- and Post- GSI Graphics*

If you want to plot pre- and post- GSI fields to further understand the impact of your observations, you need to setup the HWRFDA.ksh script in the retrievalscripts/ folder *before* starting your experiments, since HWRF doesn't save the pre- and post- GSI files.

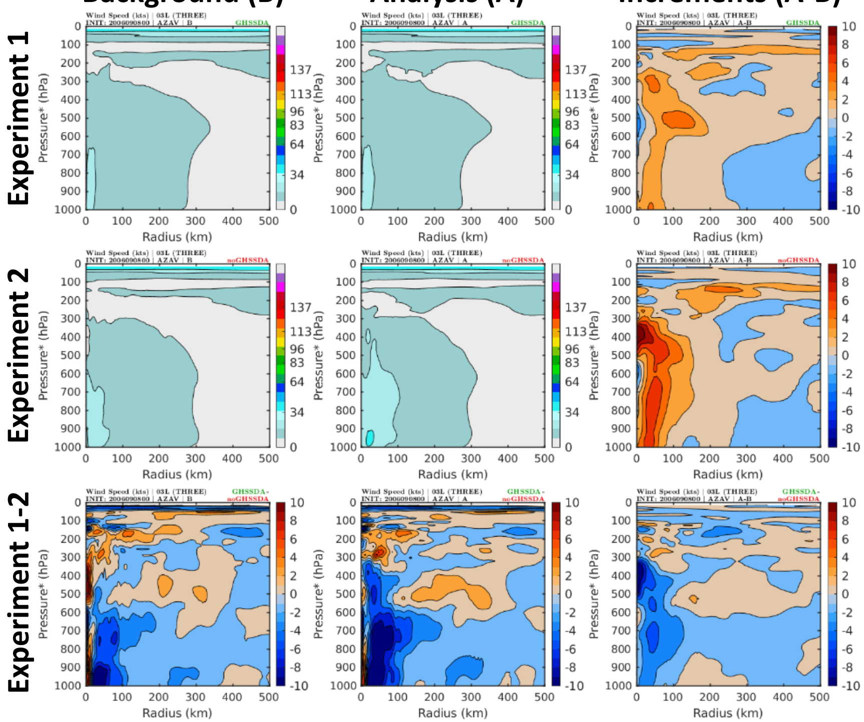
Plan View

The below graphics are generated for Divergence, Pressure, Specific Humidity, Relative Humidity, Relative Vorticity, Temperature, Zonal Wind, Meridional Wind, and Wind Speed at 850 hPa, 500 hPa, and 200 hPa for both D02 and D03.



Azimuthal Averages

The below graphics are generated for Divergence, Specific Humidity, Radial Wind, Relative Humidity, Relative Vorticity, Tangential Wind, Temperature, and Wind Speed for both D02 and D03



Credit: Idea by Dr. Peter Marinescu

Storm Grid & Synoptic Grid Graphics

Variables Available

User Options & Guidance

Full List of Available Variables

Absolute Vorticity (Isobaric) | Cloud Ice (Isobaric) | Cloud Mixing Ratio (Isobaric) | Maximum/Composite Radar Reflectivity (2D) | Convective Available Potential Energy (Surface) | Convective Inhibition (Surface) | Convective Accumulated Precipitation (Water; Surface) | 2 Metre Dewpoint Temperature (2D) | Dew Point Temperature (Isobaric) | Downward Long-Wave Radiation Flux (Surface) | Downward Long-Wave Radiation Flux Hour Average (Surface) | Downward Short-Wave Radiation Flux (Surface) | Downward Short-Wave Radiation Flux Hour Average (Surface) | Drag Coefficient | Geopotential Height (Isobaric) | Geopotential Height (Surface) | Orography (2D) | Land-Sea Mask (Surface) | Non-Convective Accumulated Precipitation (Large-Scale; Surface) | Latent Heat Net Flux (Surface) | Momentum Flux, U Component (Surface) | Momentum Flux, V Component (Surface) | Planetary Boundary Layer Height (2D) | Potential Temperature (Tropopause) | Precipitable Water (2D) | Precipitation Rate (Surface) | Pressure Reduced To MSL (Surface) | Surface Pressure (Surface) | Pressure (Tropopause) | Rain Mixing Ratio (Isobaric) | Radar Reflectivity (Isobaric), | Relative Humidity (2D) | Relative Humidity (Isobaric) | Rime Factor (Isobaric) | Sensible Heat Net Flux (Surface) | Snow Mixing Ratio (Isobaric) | Specific Humidity (2D) | Specific Humidity (Isobaric) | Storm Relative Helicity (2D) | Surface Roughness (Surface) | Temperature (2D) | Temperature (Isobaric) | Temperature (Surface) | 2 Metre Temperature (2D) | Total Column Integrated Rain (2D) | Total Column Integrated Snow (2D) | Total Column-Integrated Cloud Ice (2D) | Total Column-Integrated Cloud Water (2D) | Total Column-Integrated Condensate (2D) | Total Condensate (Isobaric) | Total Accumulated Precipitation (Surface) | Upward Long-Wave Radiation Flux (Surface) | Upward Long-Wave Radiation Flux Hour Average (Surface) | Upward Short-Wave Radiation Flux (Surface) | Upward Short-Wave Radiation Flux Hour Average (Surface) | Heat Exchange Coefficient (2D) | Vertical Speed Shear (Tropopause) | Vertical Velocity (Isobaric) | Sea Surface Temperature (Surface) | 10 Metre U/V Wind Component (2D) | U/V Component Of Wind (Isobaric) | U/V Component Of Wind (Tropopause)

Commonly-Selected Variables

Absolute Vorticity (Isobaric) | Geopotential Height (Isobaric) | Precipitable Water (2D)
Pressure Reduced to MSL (Surface) | Relative Humidity (Isobaric) | U/V Component of Wind (Isobaric)

Additional Variables Computed

Relative Vorticity (Isobaric): from absolute vorticity, if selected
Radial & Tangential Wind (Isobaric): from u/v component of wind, if selected
Wind Speed (Isobaric): from u/v component of wind, if selected

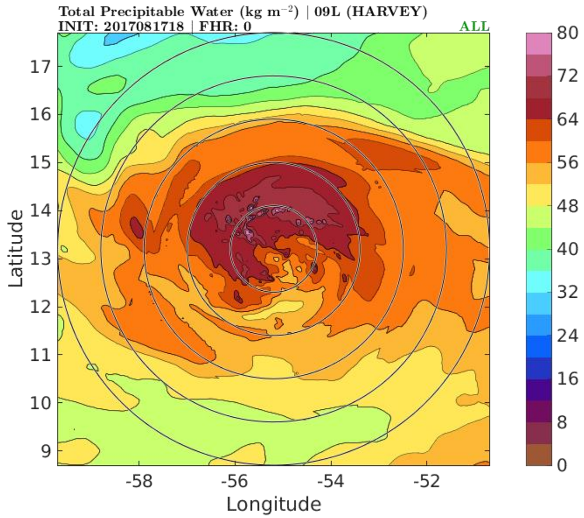
*These graphics are not generated for zonal, meridional, radial, or tangential wind.

Storm Grid

Plan View

2D Field

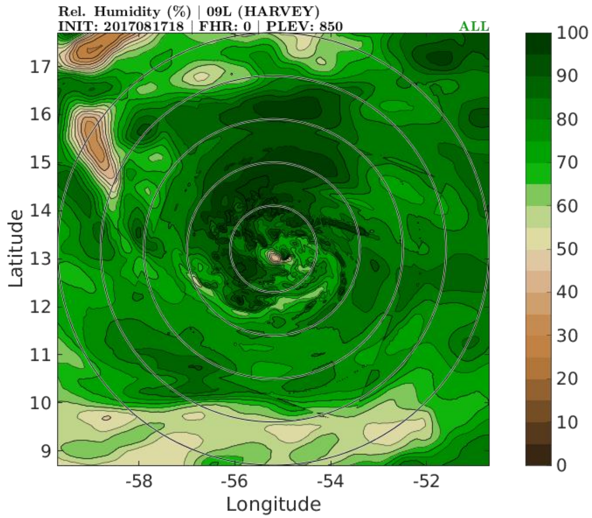
1 CYCLE | 1 FHR | 1 PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle and forecast hour for every experiment. Difference graphics are also created.

3D Field*

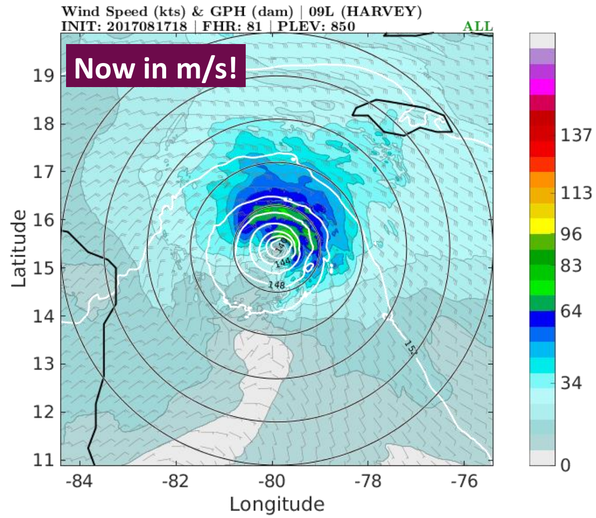
1 CYCLE | 1 FHR | 1 PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle and forecast hour for every experiment for user-specified PLEVS. You can turn off 3D plan-view graphics in the namelist to save time. Difference graphics are also created.

Layered Field

1 CYCLE | 1 FHR | 1 PLEV | ALL RAD | 1 STORM



When GPH or U/V is chosen, this graphic depicting wind speed (shading according to intensity), wind direction (vectors), and GPH (white contours) is created. Difference graphics are also created.

Range Rings: every 100 km from 100-500 km

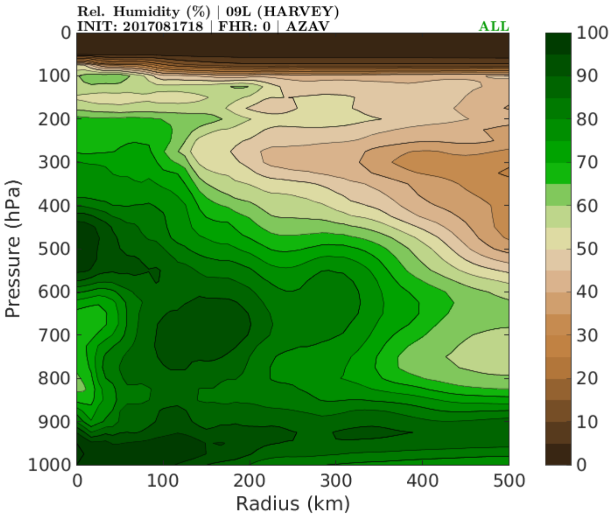
*These graphics are not generated for zonal or meridional wind.

Storm Grid

Azimuthal Averages

Radius-Pressure*

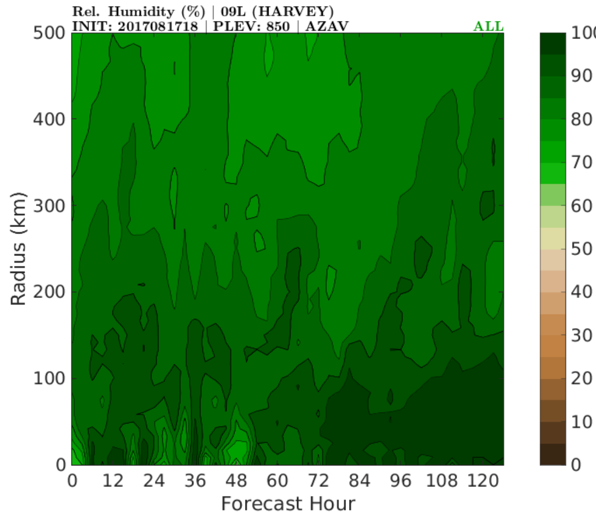
1 CYCLE | 1 FHR | ALL PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle and forecast hour for every experiment. Difference graphics are also created.

FHR-Radius*

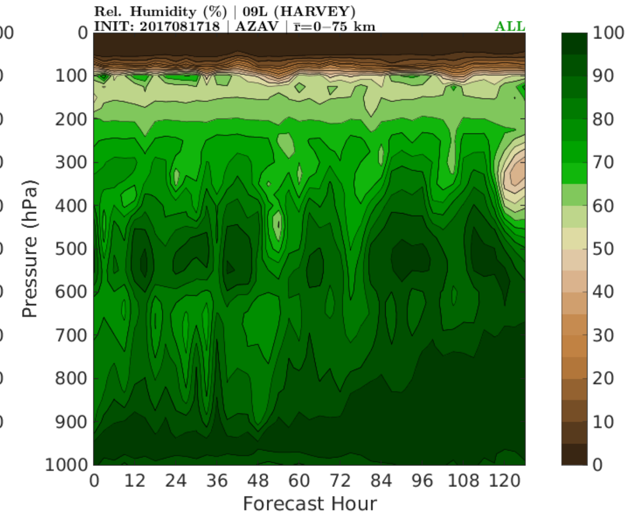
1 CYCLE | ALL FHR | 1 PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle for every experiment for user-specified PLEVS. Difference graphics are also created.

FHR-Pressure*

1 CYCLE | ALL FHR | ALL PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle for every experiment for the Inner-Core region (0-75 km), TS Gales region (0-250 km) and the Outer Vortex (250-500 km) region. Difference graphics are also created.

Range Rings: every 100 km from 100-500 km

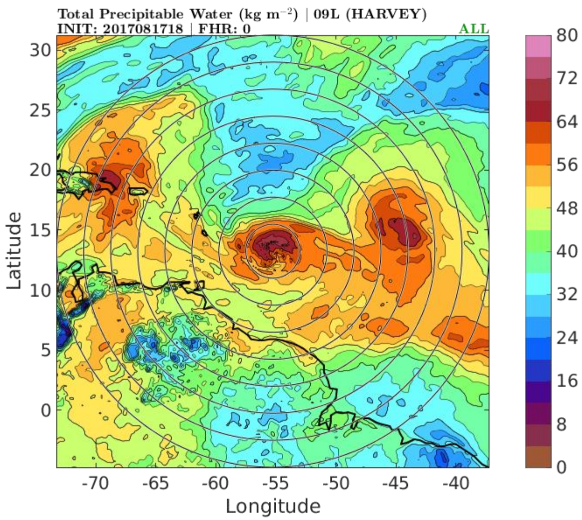
*These graphics are not generated for zonal, meridional, radial, or tangential wind.

Synoptic Grid

Plan View

2D Field

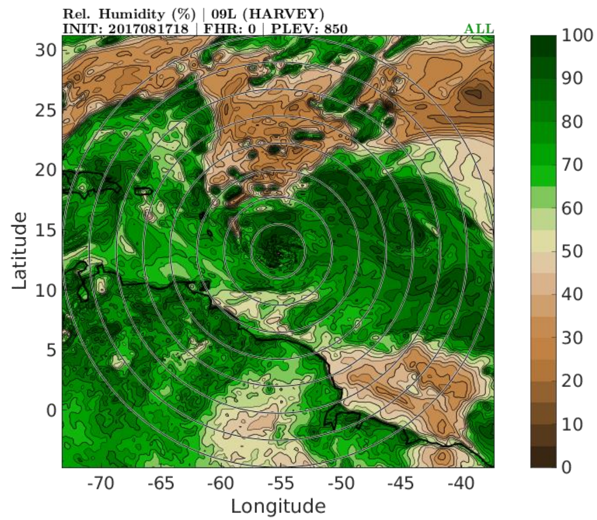
1 CYCLE | 1 FHR | 1 PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle and forecast hour for every experiment. Difference graphics are also created.

3D Field*

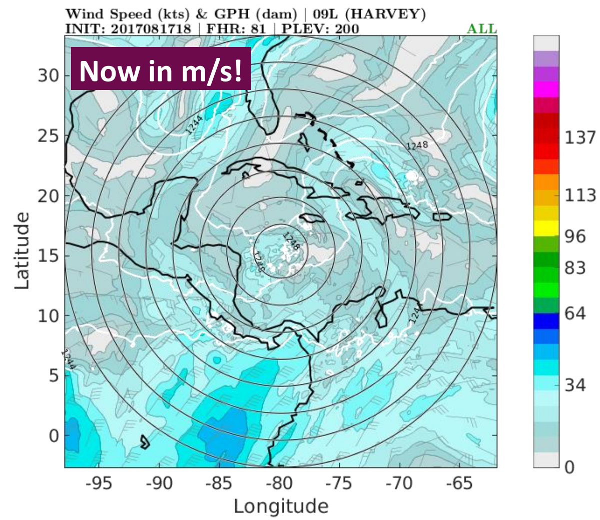
1 CYCLE | 1 FHR | 1 PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle and forecast hour for every experiment for user-specified PLEVS. You can turn off 3D plan-view graphics in the namelist to save time. Difference graphics are also created.

Layered Field

1 CYCLE | 1 FHR | 1 PLEV | ALL RAD | 1 STORM



When GPH or U/V is chosen, this graphic depicting wind speed (shading according to intensity), wind direction (vectors), and GPH (white contours) is created. Difference graphics are also created.

Range Rings: every 250 km from 250-2000 km

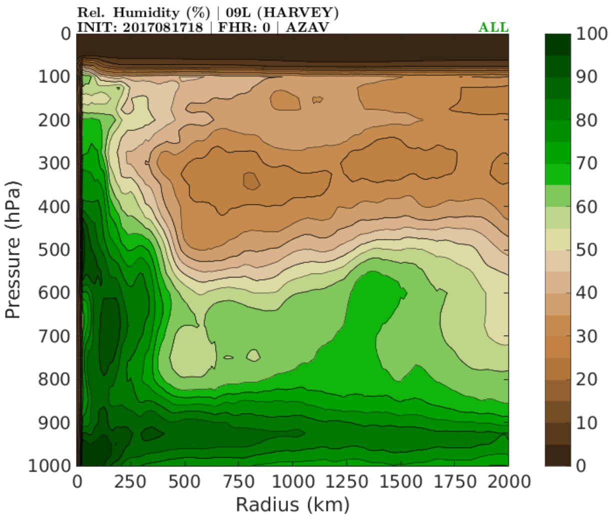
*These graphics are not generated for zonal or meridional wind.

Synoptic Grid

Azimuthal Averages

Radius-Pressure*

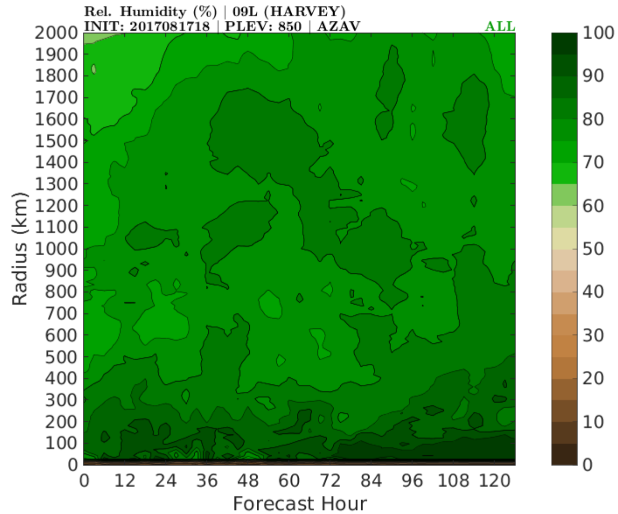
1 CYCLE | 1 FHR | ALL PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle and forecast hour for every experiment. Difference graphics are also created.

FHR-Radius*

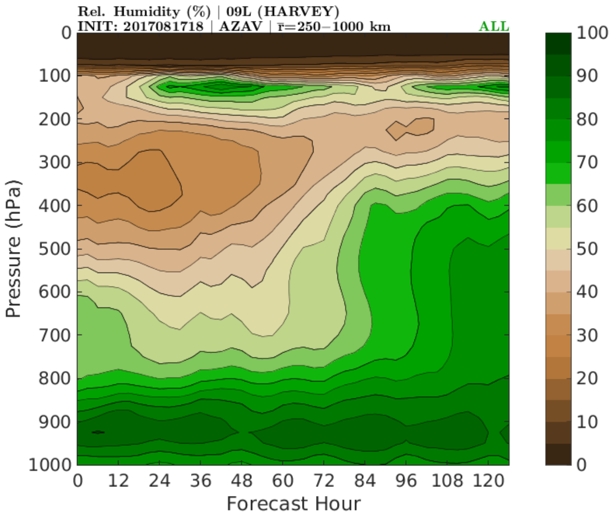
1 CYCLE | ALL FHR | 1 PLEV | ALL RAD | 1 STORM



This graphic is generated for every cycle for every experiment for user-specified PLEVS. Difference graphics are also created.

FHR-Pressure*

1 CYCLE | ALL FHR | ALL PLEV | ALL RAD | 1 STORM

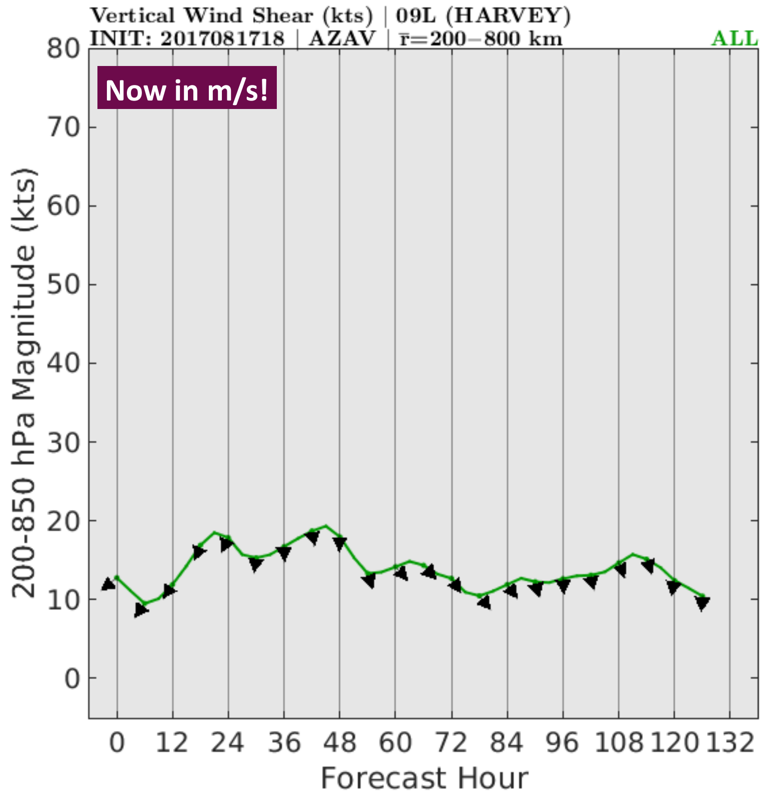


This graphic is generated for every cycle for every experiment for only the 250-1000 km region (Outer Vortex).
Difference graphics are also created.

Synoptic Grid

Vertical Wind Shear

1 CYCLE | ALL FHR | 200-850 hPa PLEV | 200-800 km RAD | 1 STORM



This graphic is generated for every cycle for every experiment. It depicts the vertical wind shear magnitude (line) and direction (arrow).

*For GROOT-G, place your atcf files for all cycles desired in 1 folder, named according to the experiment run. Do the same treatment for all assimilated observations files for the variable you're testing.

Getting Started

Follow Along

Step 1: Checkout the code from GitHub

You can checkout the code from GitHub (https://github.com/sditchek/GROOT)

Step 2: View Your Files

Not in GROOT-G (editgrb.m) — Not in GROOT-G (rungrb.ksh)

```
README  bdeck  editgrb.m  editverif.m  nctoolbox-1.1.3  retrievalscripts  rungrb.ksh  runverif.ksh  scripts
```

Step 3: Read the README!

Step 4: Steps to Run

VERIFICATION CAPABILITY: FULL-STORM GRAPHICS & GRAPHICS THAT ARE CONSISTENT WITH NHC VERIF | VARIOUS STRATIFICATIONS ARE ALSO TAKEN.

1) For GROOT-H: If you had scrubbing ON, run retrieval scripts in retrievalscripts/ directory to download files needed by the package (read the README)
2) Edit the user settings section of editverif.m for the cases you want to include - follow the instructions carefully or it won't run
3) Edit the user settings section of runverif.ksh - follow the instructions carefully or it won't run
4) Load the matlab module (module load matlab) - this isn't included in the batch scripts in case there is an issue/conflict with your other loaded modules
5) Submit runverif.ksh to batch: sbatch ./runverif.ksh

Step 5: Be Patient!

Kick back and relax – a watched script never finishes! Thousands (tens of thousands if many storms) of graphics are being generated.
If something is not working, do a cat slurm* in your GROOT-H/ or GROOT-G/ directory. Failures typically occur due to user errors in the namelist or since the required files were not retrieved. These slurm files will be deleted next time you run the code so you can start fresh.

Step 6: View Your Results

When the package finishes, you'll receive an email. Go to your directory and there will be a new text file pointing you to the finished results!

NOTE: Script Updates/Bugs

When there are major script updates, I'll push them to GitHub, so be sure to check for updates before running!

The README

Sections
Summary Description of the package
Files and Directories Describes the files included in the package
How To Run The Package Description of the steps you need to take to run the package
Location and Description of Various Results Details the directory structure of where results are located
Key Points A few key points that you should be aware of
New Additions A history of new additions to the package starting from the first internal release to my group
Issues My contact information in case you have difficulty running or find any bugs!

Required Files By Component

GROOT-H: scripts in the retrievalscripts/ directory are set up to retrieve all required files
GROOT-G: only the Error Statistics and Assimilated Observations component are available currently; ATCF files for all cycles should be placed in 1 folder, named according to the experiment run, which you will point to in runverif.ksh; do the same treatment for all assimilated observations files for the variable you're testing.

Component	GROOT-H (for each cycle)	GROOT-G (for each cycle)
Error Statistics	*atcfunix* *(Note: atcf files must have this text in the file name for GROOT to grab it)*	*atcfunixp.gfs* *(Note: if you run your global experiments without archiving *atcfunixp.gfs* files, you will not be able to run this component)*
Assimilated Observations	*storm_vit	*storm_vit *(Note: GROOT-G has code to extract tcvitals files since some global workflows do not archive *storm_vit files – so if you don't have these, don't worry, GROOT will still work!)*
	*gsi_d02.diag_conv_anl.gz	*anl*.gz or already-unzipped *anl*.nc4 files – either work!
GRB Graphics	*hwrfprs.storm.0p015.f*.grb2	*hwrfprs.storm.0p015.f*.grb2
	hwrfprs.synoptic.0p125.f.grb2	*hwrfprs.synoptic.0p125.f*.grb2

Acknowledgements

Publications

If using output from this graphics package in PUBLICATIONS,
please include the following in the acknowledgements section:

"The "Graphics for OS(S)Es and Other modeling applications on TCs" verification package developed by Dr. Sarah Ditchek and funded by the Quantitative Observing System Assessment Program (QOSAP) and the FY18 Hurricane Supplemental (NOAA Award ID #NA19OAR0220188) was used to generate graphics for this publication."

Presentations

If using output from this graphics package in PRESENTATIONS,
please indicate the following verbally:

"Graphics were made using GROOT – a verification package developed by Dr. Sarah Ditchek and funded by QOSAP and the FY18 Hurricane Supplemental."

THANK YOU FOR YOUR INTEREST IN GROOT!

Dr. Sarah D. Ditchek
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