GROOT* User's Guide

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

Created by Sarah D. Ditchek^{1,2}

¹Cooperative Institute for Marine and Atmospheric Studies (CIMAS) | University of Miami (UM) ²Hurricane Research Division (HRD) | Atlantic Oceanographic and Meteorological Laboratory (AOML)



GROOT User's Guide

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/)

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/)

Verification Capability

Capability

GRB

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

<u>RUN OVERVIEW (runverif.ksh – edit this)</u> 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 \rightarrow NHC verification \rightarrow 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

<u>NAMELIST OVERVIEW (editgrb.m – edit this)</u>

SECTION 1: Choose storm, experiments, and associated colors SECTION 2: Set directories SECTION 3: Set switches SECTION 4: Choose variables <u>RUN OVERVIEW (rungrb.ksh – edit this)</u> SECTION 1: Account Information

Usage

0000

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



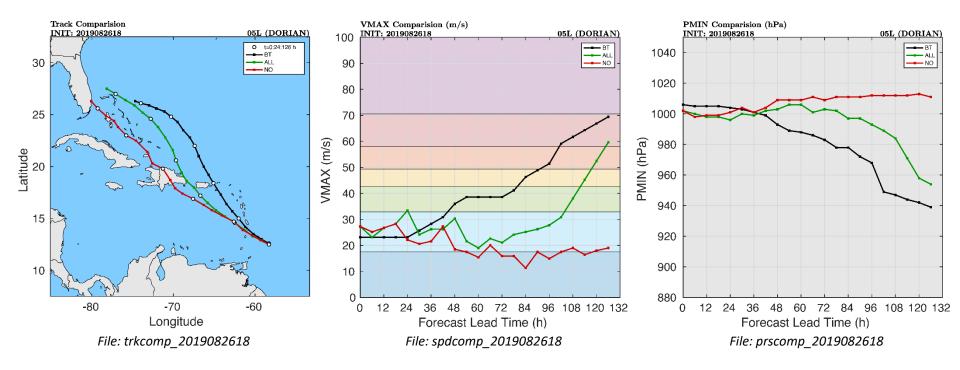
*Generation of these graphics can be turned off in the namelist by setting identgraphicsbycycle=0

One Storm: Each Cycle

es Composite Graphics

Raw Value Graphics

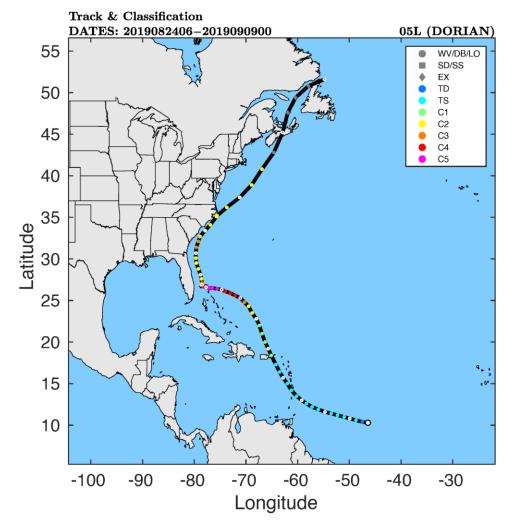
The below graphics as well as graphics for Along-Track Error, Across-Track Error, R34/R50/R64 (for the NE, SE, SW, and NW quadrants), PO, RO, and RMW are generated* for each cycle.





Composite Graphics

Best Track Graphic



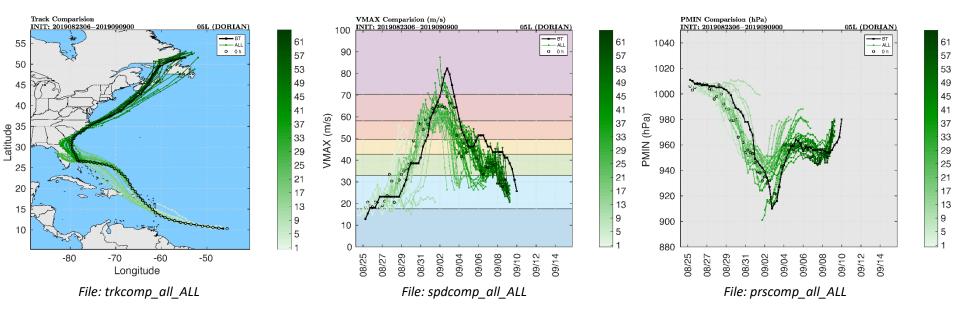
File: DORIAN19_track



Composite Graphic

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.

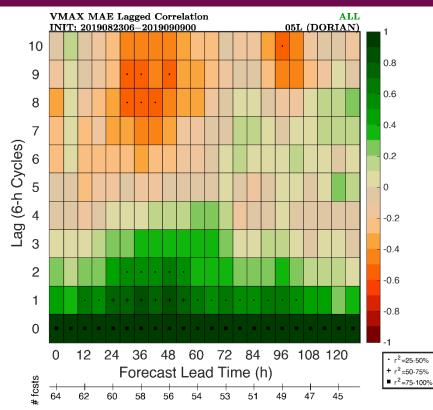




Composite Graphics

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, 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



One Storm: All Cycles

Mean Bias

VMAX Mean Bias (m/s)

Ton East

Too Slow

0

64 62 60

12 24

36 48

Forecast Lead Time (h)

58 56 54 53 51 49 47

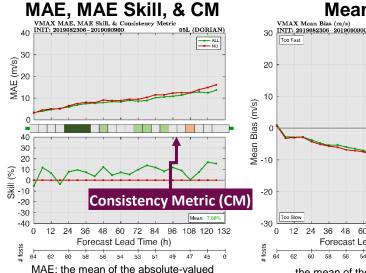
time

File: DORIAN19 spdbias

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

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.



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

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

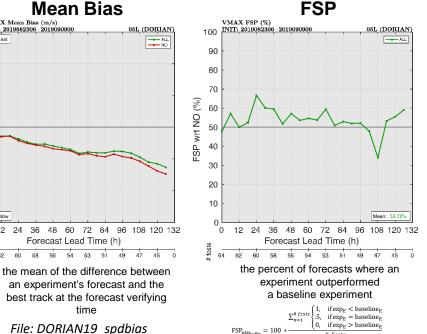
File: DORIAN19 spderrskill mean

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**.

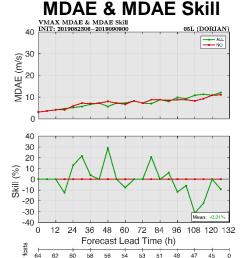
45

GROOT User's Guide

Last Updated: November 21, 2022



File: DORIAN19 spdfsp



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



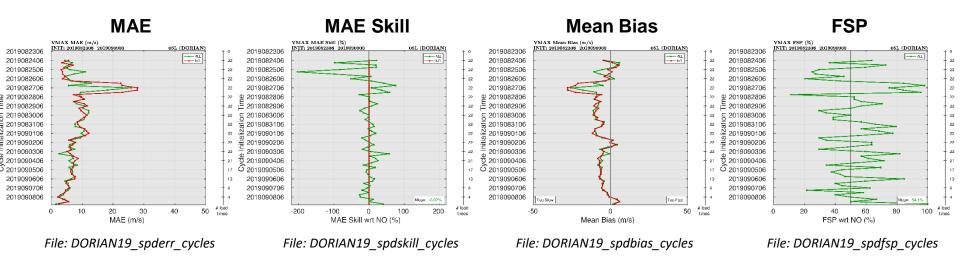
One Storm: Each Cycle One S

One Storm: All Cycles Composi

omposite Graphics

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.

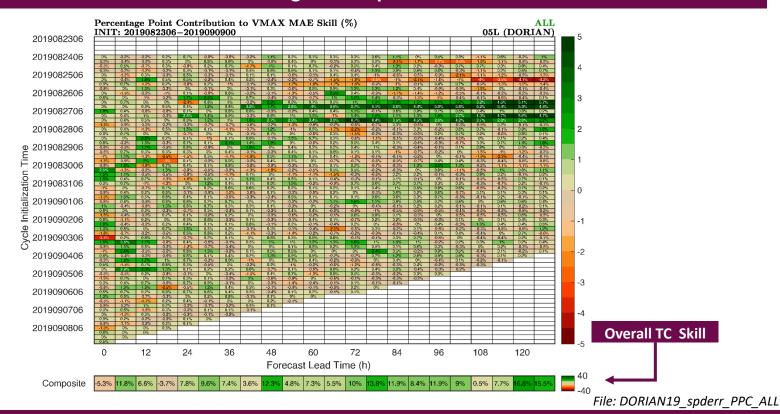




One Storm: Each Cycle One Storm: All Cycles Composite Gra

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.



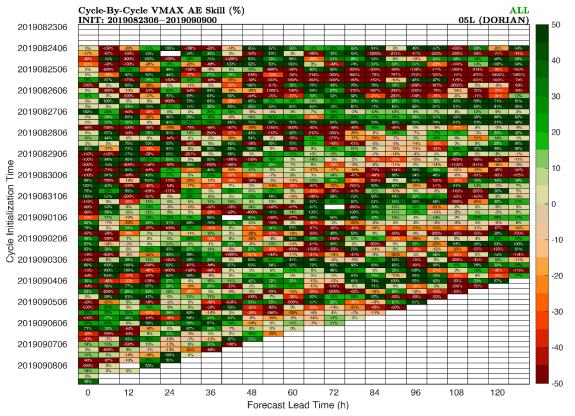
GROOT User's Guide



One Storm: All Cycles

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

Last Updated: November 21, 2022

GROOT User's Guide



One Storm: Each Cycle

One Storm: All Cycles

Composite Graphics

Scorecard Graphic

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

	Score INIT:		08230)6-20	19090	900														05L	(DOR	ALL LIAN)
MAE (km) MAE Skill (%) FSP (wrt 50%) MDAE (km)	10.1 1 10.3 1.7% 0.8% 101 10.7	24.8 25.7 3.5% 6.3% 20.2 22.7	40.3 1 40.6 0.9% -2.4% 32.2 1 33.4	52.4 54.3 3.4% 6.6% 38.8 41.6	65 67.1 3.1% 3.3% 53 52.4	77.3 82.1 5.8% 3.4% 60 66.6	881 93.1 5.5% 10.3% 65.3 1 72.7	99.9 104.1 4.1% 5.3% 81.3 82.3	111.8 119.7 6.6% 0.9% 91.3 86.5	123.2 130.4 5.6% 0.9% 100.6 95.6		125.5 139.4 10% 9.4% 111.7 107.7	133.3 148.9 10.5% 12.3% 119.1 115.8	142.9 161.7 11.7% 2.9% 134.8 123.2	158 176.8 10.6% 1% 164.5 157.6	171.1 188.5 9.2% 10% 171.1 179.1	198.3 215.5 8% -1% 192.4 193.5	221.8 1237.3 6.5% 3.1% 222.2 1222.4	248.4 1 259.7 4.3% 5.3% 243.5 1 254.9	281.5 294.1 4.3% 10.9% 284.6 287.1	314 324.3 3.2% 5.6% 318.9 317.6	353.2 356 0.8% 0% 334.2 364.2
MDAE Skill`(%) AT Mean Bias (km) XT Mean Bias (km) # fcsts	6.8% NaN I NaN NaN I NaN 64	11.2% -7.61-7.5 -5.21-4.6 63	3.4% -6.71-6.1 -7.71-8 62	6.7% -6.31-8 -10.41-12.4 61	-1.1% -5.41-7.7 -17.61-18.6 60	9.9% -3.11-5.7 -24.81-27.7 59	10.2% -31 -8.2 -28.9 1 -30.9 58 Cl	1.2% -3.81-9.8 -321-35.3 57	-5.6% -4.21-11.1 -32.51-41 56	-5.3% -5.31-12.5 -34.31-43.6 55	1.6% -1.71-6 -37.41-43.2 54	-3.7% 4.811.3 -36.51-48.7 53	-2.8% 12.1 10.3 -37.8 -53.2 53	-9.5% 13.8 15.5 -41.8 -59.9 52	-4.4% 14.9 15.5 -45.5 -64.8 51	4.5% 10.5 15.3 -46.9 -66.6 50 Cl	0.6% 6.3 13.6 -44.1 - 64.1 49	0.1% 5.9 11.1 -40.5 -61.8 48	4.5% 8.8 11.1 -37.2 -56.3 47	0.9% 20124.4 -311-51.2 46	-0.4% 35.7 41.4 -22.7 -43.2 45	8.2% 54.7 58.1 -18.1 -41.1 44
MAE (m/s) MAE Skill (%) FSP (wrt 50%) MDAE (km)	3.313.2 -5.3% -2.3% 3.113.1	414.5 11.8% 7.1% 3.613.6	4.715 6.6% 0% 4.114.1	5.315.1 -3.7% 2.5% 4.614.1	5.916.4 7.8% 16.7% 5.115.9	6.8 7.5 9.6% 10.2% 5.7 7.2	7.418 7.4% 9.5% 6.716.9	7.617.9 3.6% 1.8% 7.217.2	7.919 12.3% 7.1% 5.718	8.418.8 4.8% 3.6% 7.217.2	8.318.9 7.3% 4.6% 7.216.7	919.5 5.5% 3.8% 8.218.2	8.519.4 10% 9.4% 7.217.2	8.9110.3 13.8% 1% 6.918.7	10.2 11.5 11.9% 2.9% 8.7 8.7	10.5 11.5 8.4% 2% 8 8,5	10.8 12.3 11.9% 2% 9.8 8.7	11.4 12.5 9% -2.1% 9.3 8.7	12.4 12.5 0.5% -16% 10.8 8.2	12.8 13.9 7.7% 3.3% 11.3 9.3	12.4 14.9 16.8% 5.6% 10.8 10.8	13.6 16.1 15.5% 9.1% 12.1 11.1
MDAE Skill (%) Mean Bias (m/s) # fcsts CM	0% 110.7 64	0% -2.71-3.1 63	0% -2.81-3 62	-12.5% -2.81-2.8 61	13% -3.71-4.2 60 CI	21.4% -4.7 -5.1 59 Cl	3.7% -5.41-5.6 58 Cl	0% -5.31-6 57	29% -5.91-6.8 56 MCI	0% -6.51-7.1 55	-7.7% -71-7.4 54	0% -8.21-8.6 53	0% -7.81-8.3 53 MCI	20.6% -81-9 52 MCI	0% -81-9.3 51	6.1% -7.61-8.5 50 MCI	-11.8% -7.61-9.2 49	-5.9% -8.21-9.7 48	-31.3% -9.4 I -10.8 47 MCD	-22.2% -111-12.2 46	0% -11.5 -13.8 45	-9.3% -12.6 -14.7 44
MAE (m/s) MAE Skill (%) FSP (wrt 50%) MDAE (km) MDAE Skill (%)	2.512.5 -1.9% -3.9% 212	515.7 12.8% 4% 415	5.316.1 12.7% 8.9% 3.514	6.417 9.1% 8.2% 415	6.917.4 7.6% 5.8% 515	8.2 8.4 2.4% 0% 7 6	8.718.8 0.2% 4.3% 617	9.3 9.4 1.1% -2.6% 7 6	8.619.6 9.7% 8.9% 6.517	9.2110.1 9.5% 10.9% 717	91 10.7 16.1% 9.3% 618	91 10.8 16.9% 7.5% 51 8	9110.5 14.9% 6.6% 717	10.1 1 11.6 13.3% 6.7% 71 7	10.8 12.6 14.2% 10.8% 7 7	11.7 14 16.3% 10% 719	12.3 14.7 16% 2% 9 8	13.3 15.2 13% 1% 9.5 9	14115.6 10.4% -5.3% 1119	14.5 17 14.8% -1.1% 10.5 9	14.6 17.9 18% 0% 13 12	16.5 19.7 16.5% -6.8% 15.5 13
Mean Bias (m/s) # fcsts CM	0% -1.3 -1.4 64	20% -3.71-4.3 63 MCI	12.5% -3.4 -3.6 62 C 24.9 24.9	20% -3.4 -3.5 61 Cl 31.1 29.8	0% -21 -1.9 60 28.8 1 28.8	-16.7% 010 59 29.1 131.6	14.3% 1.7 1.6 58 34.7 37.4	-16.7% 2.312.4 57	7.1% 2.913.4 56 Cl 35.6139.2	0% 3.714.4 55 MCI	25% 4.615.4 54 Cl 39.2136.8	37.5% 616.8 53 MCI 37140.1	0% 6.517.4 53 44.3142.3	0% 6.517.8 52 47.1142.1	0% 6.417.8 51 MCI 42141.1	22.2% 6.1 17.6 50 Cl 47.6 145.7	-12.5% 618.5 49 50.1 148.8	-5.6% 6.7 9.6 48 48.4 49.8	-22.2% 8.3 10.9 47 53.4 51.3	-16.7% 10.3 12.5 46 54.7 61.2	-8.3% 12.2 15 45	-19.2% 13.9 17.1 44
MAE (m/s) MAE Skill (%) FSP (wrt 50%) MDAE (km) MDAE Skill (%)	30.7 1 28 -9.6% -1.6% 24.1 1 18.5 -30%	28.6 27.2 -5.2% 0.6% 24.1 22.2 -8.3%	0.2% 3.9% 20.4 18.5 -10%	-4.4% 5.7% 22.2 25.9 14.3%	20.5 1 25.5 0% 2.2% 22.2 1 22.2 0%	8.1% 10.2% 27.8 27.8 0%	7.2% 6.2% 31.5 31.5 0%	2.4% 1.1% 31.5 33.3 5.6%	9.2% 1.9% 31.5 37 15%	35136.6 4.3% 2.9% 33.3133.3 0%	-6.6% -4.4% 35.2 33.3 -5.6%	7.7% 7% 35.2137 5%	-4.8% -7.4% 37135.2 -5.3%	-11.8% -7.7% 37133.3 -11.1%	-2.2% -2.8% 37135.2 -5.3%	-4.3% -2.8% 37142.6	-2.6% 0.9% 48.2 42.6 -13%	40.4 1 49.0 2.9% -3.1% 40.7 1 44.4 8.3%	-4.1% -7.7% 50150 0%	10.6% 3.9% 51.9 53.7 3.4%	10.1% 10.8% 53.7 1 57.4 6.5%	10.9% -4.3% 52.8156.5 6.6%
Mean Bias (m/s) # fcsts CM MAE (m/s)	12.3 11.2 183 MCD 15.8 16.7	-11.6 -13.3 164 MCD 18.3 19.1	-14.8 -12.3 153 19.1 19.5	-10.8 -14.9 175 20122.4	-12.2 -12.7 162 21.5 23.1	-19.3 -20.3 137 MCI 21.1 23.6	-21.8 -22.8 130 MCI 23.6 24.7	-22.1 -24.7 138 MCI 25.4 26.8	-25.1 -23.1 131 MCI 24.8 25.9	-26.4 -26.4 140 26.2 26.7	-29.5 -28.6 126 CD 26.4 27.9	-28.8 -31.6 115 Cl 25.8 26.9	-32.9 -32.4 121 CD 27.6 28	-31.2 -25 123 CD 25.6 26.4	-33.7 -33.6 108 MCD 24.6 26.1	-36.9 -35.5 125 28 27.8	-41.4 -40.9 115 MCD 28.3 27.8	-41.1 -41.4 113 30131	-49.3 -47.8 124 MCD 37.1 35.9	-50.6 -55.4 115 MCI 36.9 37.1	-54.1 -62.3 111 Cl 41.1 40.5	-50.8 1 -57.7 82 331 33.8
MAE Skill (%) FSP (wrt 50%) MDAE (km) MDAE Skill (%)	5.3% -1.1% 13113 0%	4.3% 2% 14.8 14.8 0%	2.3% 4.3% 16.7 16.7 0%	10.4% 11.5% 16.7 20.4 18.2%	7.1% 6.4% 16.7 19.4 14.3%	10.4% 5.9% 18.5 22.2 16.7%	4.3% 1.9% 22.2 22.2 0%	5.3% 4.4% 22.2 22.2 0%	4.5% 4.5% 20.4122.2 8.3%	1.8% -0.4% 20.4 22.2 8.3%	5.3% 7.4% 22.2 21.3 -4.3%	4.2% 3.5% 22.2 22.2 0%	1.3% 2.8% 20.4 19.4 -4.8%	3% -3.9% 22.2 22.2 0%	5.5% 5.3% 18.5 20.4 9.1%	-0.6% 5.9% 23.2 122.2 -4.2%	-1.6% 5.3% 22.2 22.2 0%	3.4% -3.8% 22.2 24.1 7.7%	-3.4% -3.4% 35.2127.8 -26.7%	0.5% -1.2% 33.3 31.5 -5.9%	-1.5% -8.2% 35.2135.2 0%	2.1% -2.6% 27.8 31.5 11.8%
Mean Bias (m/s) # fcsts CM MAE (m/s)	-1.41-0.7 138 19.7120.4	-13.3 -14.8 126 12.8 12.2	-161 -16.2 128 MCI 11.3 11.2	-16.1 -17.8 144 Cl 13.2 12.8	-17.7 -19.3 132 Cl 13.6 12.8	-19.8 -22.1 111 Cl 10.6 9.6	-19.9 -21.4 105 10.1 11.3	-22.5 -24.5 113 MCI 11110.1	-23.5 -24.6 101 MCI 9.8 10.1	-23.8 -24.7 116 MCI 8.1 8.1	-24.3 -26 102 9.5 10.2	-23.8 -25.8 86 9.3 9.1	-25.6 -26.5 90 10.9 10.9	-23.5 -23.4 90 9.918.7	-23.7 -24.8 85 MCI 10.4 9.8	-26.5 -26.9 110 11 10.6	-26.5 -26.4 94 10.8 10.4	-26.9 -28.5 93 9.9 11	-35.1 -33.8 103 MCD 12.2 10.4	-34.8 1-35.2 84 9.218.3	-39.1 -38.9 85 MCD 10.7 9	-31.5 -33.2 57 10.2 9.4
MAE Skill (%) FSP (wrt 50%) MDAE (km) MDAE Skill (%) Mean Bias (m/s)	3.4% 0.8% 18.5 16.7 -11.1% 18.5 18.5	-4.8% 1.4% 11.1 9.3 -20% 10.2 9.6	-0.7% 1.7% 9.318.3 -11.1% 6.516	-2.9% -4.7% 11.1 9.3 -20% 8.2 8	-6.2% -8% 11.1 8.3 -33.3% 7.4 5.1	-9.9% -5.2% 7.417.4 0% 7.414.3	10.5% 6.7% 7.417.4 0% 5.315.2	-8.3% -1.6% 7.417.4 0% 4.214.2	2.7% 0.6% 7.417.4 0% 614.4	-0.2% 2.5% 7.417.4 0% 4.413.5	7.2% 3.8% 7.417.4 0% 5.616.3	-2.1% 1.3% 9.317.4 -25% 5.413.9	0.4% 4.5% 7.419.3 20% 5.315.3	-14.1% -10% 7.417.4 0% 4.415.3	-5.9% -3.9% 8.317.4 -12.5% 5.415.4	-3.6% -1.9% 9.319.3 0% 3.813	-3.2% -4.2% 9.317.4 -25% 2.112	9.7% 0% 9.319.3 0% 2.813.3	-17.6% -6% 9.317.4 -25% 0.110.9	-11.2% -6.5% 7.417.4 0% 1.912.2	-18.1% -3.8% 9.317.4 -25% 1.41-0.4	-8.5% 1.4% 5.617.4 25% 2.812.1
MAE (m/s) # fcsts CM MAE (m/s) MAE Skill (%)	126 17.7 17.9	110 18.1 120.3 10.7%	116 191 18.2 -4.8%	129 CD 21.6 18 -20.1%	112 CD 19.1 118.8	97 MCD 18.3 18.7 2.3%	89 MCI 19.7 16.8 -17.5%	95 20120.7 3.5%	19.2120 4,1%	100	93 21.8 1 30.6 28.6%	76 23.5 21.7 -8.4%	22.3 126.9	65 MCD	64 MCD 22.4132.5 30.9%	78	2.112 71 MCD 20.7126.3	66	67 MCD 24.9128.9 13.6%	54 21.6 125.1 13.9%	52 MCD 18.6 1 26.1	37 21.3 1 23.4 9.2%
FSP (wrt 50%) MDAE (km) MDAE Skill (%) Mean Bias (m/s)	11.7% 9.3112 23.1% -5.31-3.1	5.6% 11.1 13 14.3% -4.1 -3.9	-3.2% 11.1 12 7.7% -7.6 -7	-1.6% 13113 0% -3.61-4.2	-0.8% 13111.1 -16.7% -6.51-5.2	0.8% 9.3111.1 16.7% -1.41-2.7	-7.8% 131 11.1 -16.7% -0.5 -0.8	1.8% 13 13 0% -1.5 2.1	2.7% 10.2 11.1 8.3% -5.5 2.3	3.6% 9.3113 28.6% -1.512.1	13% 12113 7.1% -0.317.4	-7.5% 14.8 14.8 0% 6.2 6.2	3.8% 11.1 13 14.3% -4.2 10.4	11.5% 11.1 13 14.3% -2.5 10.5	5.9% 11.1 13 14.3% -2.5 11.1	-13% 14.8 13 -14.3% -6 3.6	6.1% 13113 0% -5.210.6	4.2% 11.1 14.8 25% -4.4 -1	0% 14.8 14.8 0% -4.4 -0.7	-1.1% 12110.2 -18.2% -2.412.5	8.9% 11.1 11.1 0% -0.4 2.2	11.4% 12113 7.1% -211.9
# fcsts CM	64 Cl	63 MCI	62	61	60 MCD	59 MCI	58 MCD	57	56 MCI	55 MCI	54 Cl	53	53 MCI	52 CI	51 MCI	50	49	48 MCI	47	46	45	44 CI

Credit: Idea & Base Code by Dr. Peter Marinescu

GROOT User's Guide

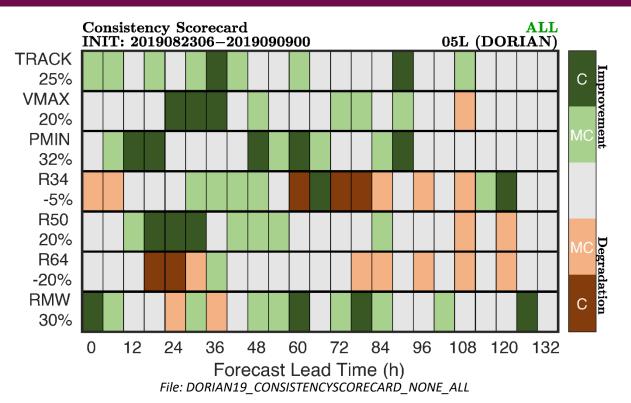
File: DORIAN19_SCORECARD_NONE_ALL



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.**





Verification: Consistent with NHC

: 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 1 st 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 ± 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: $x \ge 15$ kt IN: $5 < x < 15$ kt SS: $-5 \le x \le 5$ kt WK: $-15 < x < -5$ kt RW: $x \le -15$ 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 (\geq 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 <u>only if</u> 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

Overview	Error Statistics	Asm. Obs: CONV	Asm. Obs: SAT	GRB Graphics	Usage
0000	000000000000000000000000000000000000000	00000	000000	0000000	0000

Basin: Individual | Verification: Consistent with NHC

ch Cuala Como Starma All Cualas Composi

Composite Graphics

NHC Verification & Stratifications

I	#	STRATIFICATION	DEFINITION
	0	NONE	Perform no subsets other than NHC verification
ЦS	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 1 st cycle where the obs in question was assimilated to the (end beginning) of the storm
S	5-8	TD TS H12 H345	cycles with best track intensity of (TD TS H12 H345) at t=0
S(9-13	RI IN SS WK RW	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 -15<x<-5="" kt="" kt)<="" rw:="" sc:~5≤x<5="" td="" wk:="" x≤-15="" =""></x<15>
0	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 (\geq 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
	23	YYYY	cycles that occur in a single year (only runs if >1 year)

NOTE: #1-4 are run, and #5-8, #15-17, #18-19, & 20-21 are further subset into OBS and NOOBS <u>only if</u> 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 glo	bal
domain. Other than OBS-G, any OBS-related subset considers only the near-storm environment (R<2000 km)	

ن للل			
	#	STRATIFICATION	DEFINITION
S	1	OBS-I	cycles from storms with obs, where that storm was the only one with obs in the parent domain
S	2	OBS-T	cycles from storms with obs, where that storm was not the only one with obs in the parent domain
Ο	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)
<u>e</u>	5	NOOBS-P	cycles where there were no obs in any storm anywhere in the parent domain
ភ្ល	6	RECON-I	cycles from storms with recon, where that storm was the only one with recon in the parent domain
ы	7	RECON-T	cycles from storms with recon, where that storm was not the only one with recon in the parent domain
1	8	RECON-O	cycles from storms without recon, where there were other storms with recon in the parent domain
Ē	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)
as	10	PRERECON-P	cycles where there were no recon anywhere in the parent domain
m			

NOTE: #1-10 are run <u>only if</u> 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



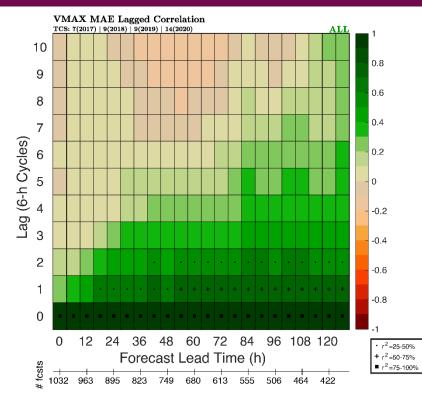
Basin: Individual | Verification: Consistent with NHC

e 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

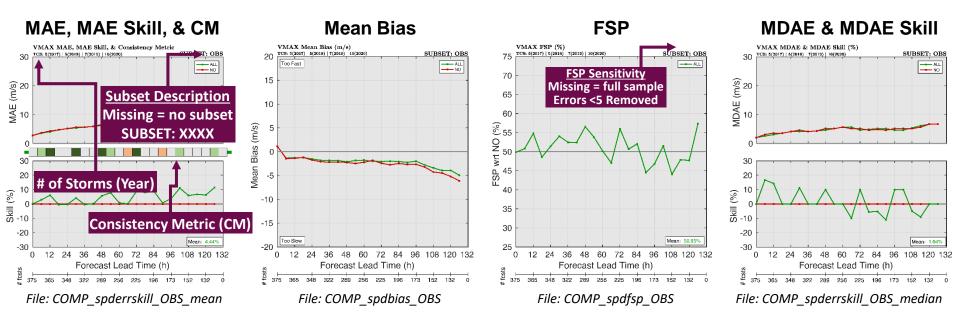
Asm. Obs: CONV Overview **Error Statistics** Asm. Obs: SAT **GRB** Graphics Usage 00000 000000 0000000 0000 0000 *For track, both the along-track and across-track bias are generated

Basin: Individual | Verification: Consistent with NHC

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.



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)

GROOT User's Guide

 Overview
 Error Statistics
 Asm. Obs: CONV
 Asm. Obs: SAT
 GRB Graphics
 Usage

 OOOO
 OOOOOOOOOOOOOOOOOOOOOOOO
 OOOOOO
 OOOOO
 OOOOOOO
 OOOOO
 OOOOOO
 OOOOOOO
 OOOOOOOOOOOOO
 <td

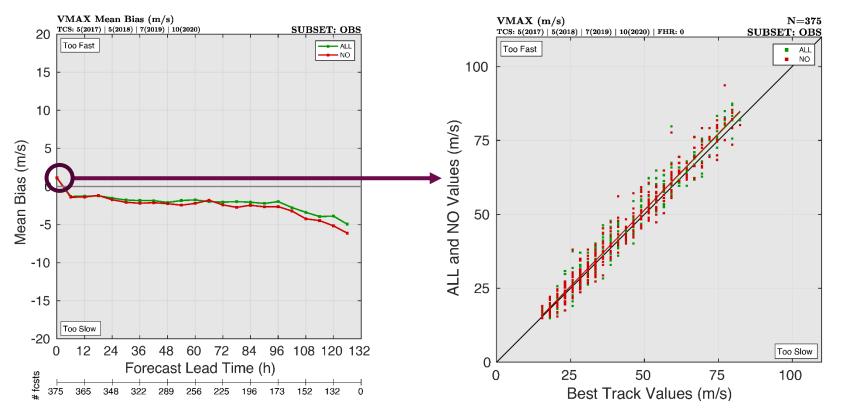
Basin: Individual | Verification: Consistent with NHC

ne Storm: Each Cycle One Storm: All Cycles Cor

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

e 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.

		nber (5(2017)						ing te	o VN	IAX	MA	E					_		• •	UDG	ET:	ODG		
09L (Harvey)	18	17	17	17	16	15	15	14	13	13	12	12	12	12	12	12	11	13	13	14	15	15	100	
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	00	
13L (Katia)	6	6	5	5	5	4	4	3	3	2	1	1	0	0	0	0	0	0	0	0	0	0	90	
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	80	
07L (Gordon)	7	7	7	7	7	7	6	5	4	3	Su	bset	: De	scri	ptic	on	0	0	0	0	0	0		
09L (Isaac)	6	6	5	5	5	5	5	4	3	2		ssin					0	0	0	0	0	0		
12L (Kirk)	10	9	8	7	6	6	5	4	3	2						ser	0	0	0	0	0	0	- 70	
14L (Michael)	13	13	13	13	13	12	11	10	9	8		SUB	SET	: XX	XX		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	- 60	
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	- 50	
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	- 40	
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	- 30	
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	- 20	
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	- 10	
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		
hen by #	0		12		24		36		48		60		72		84		96		108		120		ĩ	Files COMP and any fact OPC
									⊢or	ecas	t Lea	ad Tir	ne (n)										File: COMP_spderr_fcst_OBS

Number of Forecasts Contributing to VMAX MAE

GROOT User's Guide

Sorted by Year 1

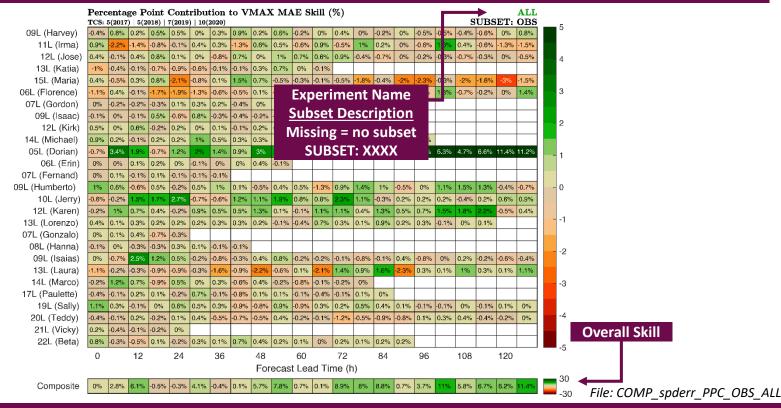
Overview	Error Statistics	Asm. Obs: CONV	Asm. Obs: SAT	GRB Graphics	Usage
0000	000000000000000000000000000000000000000	00000	000000	0000000	0000

Basin: Individual | Verification: Consistent with NHC

ne 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.



GROOT User's Guide

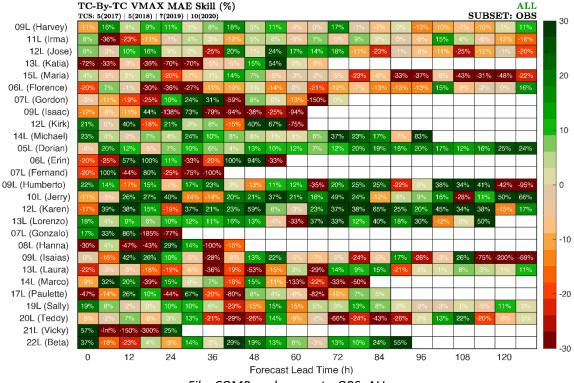
Basin: Individual | Verification: Consistent with NHC

ne Storm: Each Cycle One Storm: All Cycles Composit

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)!

GROOT User's Guide

Overview	Error Statistics	Asm. Obs: CONV	Asm. Obs: SAT	GRB Graphics	Usage
0000	000000000000000000000000000000000000000	00000	000000	0000000	0000

Basin: Individual | Verification: Consistent with NHC

Storm: Each Cycle One Storm: All Cycle

Composite Graphics

Scorecard Graphic

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

Scorecard

ALL

		TCS: 5	(2017)	5(2018)	7(201	9) 10(3	2020)														SUE	BSET:	OBS	50
	MAE (km) MAE Skill (%)	10.7 10.5 -2.5%	25.2124.7	39.1 39.2 0.2%	52.6 52.4 -0.5%	64.2 164.5 0.4%	75.8 76.8	87.2 87.7 0.5%	99.5 100.9 1.4%	110.3 113.3 2.6%	24.4 124.2	132 133.9 1.5%	144.1 147 2%	156.9 163 3.7%	166.5 173.6 4.1%	182.6 190.5 4.1%	201.2 1207.4	215.6 222.4	229.4 238.2 3.7%	250.1 257.7 2.9%	271.3 1281.8 3.7%	294.3 303.8 3.1%	333.1 337.4 1.3%	50
Я	FSP (wrt 50%) MDAE (km)	-0.8%	-4.3% 22121.4	-0.3% 33,4 133,4	-1.7% 45.5 45.7	-1% 58.4 158.3	-0.5% 68.4 71.7	1.9% 79.3 79	1.5% 89.6 92.7	4.5% 97.4 102.6	1.1%	5.7% 111.2 110.1	5.4% 119.2 117.2	5.1% 138.6 126.7	2.4%	3.6%	3% 161,4 157,8	1.4% 171.9 173.7	3.4% 200.4 199.3	5.6% 221 224.7	5.3% 248.7 1246.8	2.7% 282 281.4	0.8% 817.7 321.6	
Ψ	MDAE Skill`(%)	0.1%	-3.2%	0%	0.3%	-0.2%	4.6%	-0.3%	3.3%	5.1%	6.4%	-1%	-1.6%	-9.4%	-5.8%	0.2%	-2.3%	1.1%	-0.5%	1.7%	-0.7%	-0.2%	1.2%	
R	AT Mean Bias (km) XT Mean Bias (km)	NaN I NaN NaN I NaN	-51-5.3 4.413	-3.21-3.5 7.514.6	-2.91-4.6 9.216.3	-2.21-4.7 7.213.4	-0.21-2.6 2.21-1.8	-11-3.5 2.31-2.4	-4.11-7.1 -0.91-5.9	-81-9.9 -4.61-8.9	-10.8 -12.3 -6.8 -12.5	-9.91-11.8 -10.21-13.8	-11.1 -9.2 -13.7 -18.3	-5.11-7.4 -8.61-13.9	-2.61-3.9 -0.71-7.8	-0.41-3.9 9.512.1	2.81-2.2 15.217.2	11 11.2 25.4 13.2	241 21.8 28.8 11.3	20.7 13.4 28.3 15.4	11.2 7.7 25.1 13.7	4.61-0.6 14.910.8	-1.51-6.1	40
H	# fcsts	375	370 CD	365	358	348	333 MCI	322	306	289 CI	273	256 MCI	241	225	210	196 MCI	184	173 MCI	161 MCI	152 Cl	142 MCI	132	123 MCI	
	MAE (m/s)	2.812.8	3.613.7	4.114.3	4.814.7	5.215.2	5.415.6	5.715.7	5.915.9	6.216.6	6.417	6.816.9	7.117.2	6.417	6.316.8	6.316.9	7.117.2	7.517.8	7.318.2	8.118.6	8.819.5	9.319.9	9.31 10.5	
×	MAE Skill (%) FSP (wrt 50%)	0% -0.1%	2.8% 0.8%	6.1% 4.8%	-0.5% -1.4%	-0.3% 1.4%	4.1% 4.1%	-0.4% 2.5%	0.1%	5.7% 6.6%	7.8%	0.7%	0.1%	8.9% 6%	8% 0.7%	8.8%	0.7%	3.7%	11% 1.6%	5.8% -5.9%	6.7% -2.1%	6.2% -2.3%	11.4% 7.3%	- 30
ΨV	MDAE (km) MDAE Skill (%)	2.1 2.1 0%	2.613.1	3.1 3.6 14.3%	3.613.6 0%	4.1 4.1 0%	4.1 4.6 11.1%	4.1 4.1 0%	4.4 4.4	4.615.1 10%	5.1 5.1 0%	5.715.7 0%	5.715.1 -10%	4.615.1 10%	4.914.6 -5.6%	5.114.9 -5.3%	5.1 14.6 -11.1%	4.615.1 10%	4.6 5.1 10%	5.415.1 -5%	6.215.7 -9.1%	6.716.7 0%	6.716.7 0%	
5	Mean Bias (m/s)	1.1 1.1 375	-1.3 -1.4 370	-1.3 -1.4 365	-1.2 -1.2 358	-1.5 -1.7 348	-1.8 -2.1 333	-1.91-2.2 322	-1.91-2.1 306	-2.1 -2.3 289	-1.91-2.5 273	-1.81-2.2 256	-21-1.8 241	-2.1 -2.4 225	-21 -2.7 210	-2.11-2.5 196	-2.21-2.7 184	-21 -2.7 173	-2.8 -3.2 161	-3.4 -4.3 152	-41-4.5 142	-3.9 -5.2 132	-51-6.1 123	
	#`fcsts CM	375	MCI	CI			CI		306	CI	MCI		MCD	CI			MCD		MCI				MCI	- 20
	MAE (m/s) MAE Skill (%)	-2.3%	4.615	5.315.7 6.9%	5.8 6.1 4.8%	6.416.6 2.4%	6.8 6.9 1.6%	7.1 7.1	7.7 7.8	8.218.2	8.518.7	8.819	8.819.4 6.8%	8.619.2 7%	8.418.8 4.5%	8.519 6.1%	8.819.3 5.5%	9.2110 7.5%	9.5 10.9 12.6%	10.1 11.4 11.2%	10.2 11.5	11 12.6	12.2 14.1 13.1%	20
E	FSP (wrt 50%) MDAE (km)	-2%	4.7% 314	3.3% 414	4.3% 414	3.2% 515	3.6% 515	2.8%	1.8%	1.6% 616	4% 617	0.2%	4.4% 617	5.1% 616	1% 616	2.3%	1.6%	1.4% 716	5.9% 617	3% 6.517	0.4%	1.9% 7.5 8.5	3,3% 10 10	
Σ	MDAE Skill`(%)	0%	25%	0%	0%	0%	0%	0%	0%	0%	14.3%	14.3%	14.3%	0%	0%	0%	0%	-16.7%	14.3%	7.1%	0%	11.8%	0%	
Р	Mean Bias (m/s) # fcsts	-0.81-0.7 375	-2.51-2.5 370	-2.4 -2.1 365	-2.5 -2.5 358	-2.11-1.8 348	-1.2 -0.8 333	-0.91-0.4 322	-0.91-0.5 306	-0.81-0.5 289	-0.81-0.1 273	-0.71-0.1 256	-0.31-0.1 241	0.110.6 225	0.211 210	0.511.3 196	1 1.8 184	1.3 2.5 173	2.5 3.5 161	3.2 4.2 152	3.9 4.7 142	4.6 6.3 132	5.717.5 123	- 10
	CM MAE (m/s)	MCD 51.5 51.3	CI 36.4 1 36.2	MCI 34.7 136.5	MCI 37137.9	MCI 36.5 136.8	MCI 37.6 40.2	40.1 41.1	MCI 40.8 42.5	40.3 42.5	Cl 40.2 42.8	MCI 45.5 1 45.9	CI 45.8 47.5	MCI 49.1 48.5	53.6 52.3	50150.8	52151,4	56.3 56.4	CI 56.7 58.7	MCI 58.2 57.4	62.1 66.6	MCI 69.7 1 72.8	69.9 175.6	
	MAE Skill (%)	-0.3%	-0.4%	4.9%	2.5%	0.7%	6.3%	2.4%	4.1%	5.3%	5.9%	0.9%	3.4%	-1.3%	-2.5%	1.6%	-1.2%	0.3%	3.4%	-1.4%	6.8%	4.2%	7.5%	
34	FSP (wrt 50%) MDAE (km)	1.1% 35.2 37	1.3% 27.8 27.8	5.5% 25.9 1 29.6	3% 27.8 29.6	1.3% 27.8 27.8	5.8% 29.6 33.3	2.2% 33.3 31.5	5.4% 33.3 35.2	6.4% 33.3 37	5.2% 31.5 35.2	2.3% 35.2 38.9	5.8% 37137	-0.9% 40.7 42.6	0% 44.4 42.6	5.9% 44.4 42.6	0.7% 40.7 144.4	3.2% 48.2 48.2	6.9% 46.3 50	0.5% 501 50	2.2% 54.6 53.7	5% 59.3 61.1	3.8% 59.3 1 68.5	- 0
R	MDAE Skill`(%) Mean Bias (m/s)	5% 34.7 1 33.9	0%	12.5% -6.1 -5.6	6.2%	0%	11.1% -13.6 -16.5	-5.9% -17.5 -19.8	5.3%	10% -18.5 -23	10.5%	9.5% -24.8 1-28.5	0% -20.5 1 -27.4	4.3% -25.5 -32.7	-4.3% -31.2 -33.7	-4.3% -29.21-30.5	8.3% -33.5 1-35.4	0% -40.2 -39,1	7.4%	0% -44.4 1-46.4	-1.7% -491-53.4	3% -60.8 -63.5	13.5% -58.2 -62.7	
	# fcsts	1152	1080	1021 CI	980 CI	910	792 Cl	733	653 CI	632 CI	588 Cl	549	477	458	451	373	363	348	299 CI	307	270	221 CI	197 CI	
	MAE (m/s)	26.6 125.9	21.5 21.9	221 22.5	21.5 22.9	21.9 22.3	21.9 23.2	22.4 23.2	23.6124.3	24.6 1 26.1	24.5 126.4	25.8127.5	26.5 127.2	29.2 29.1	30.1 1 30.5	28.4 29.9	30130.3	31 31.6	29.9 132.2	33.9134.8	34.1 135.8	36137.1	33.3134.4	10
	MAE Skill (%) FSP (wrt 50%)	-2.8% -3.2%	1.7% 0.7%	2.4% 2.7%	6.3% 4.8%	1.8% 2.8%	5.6% 3.4%	3.8% 0.4%	2.8% 2%	5.8% 6.1%	7.2% 6.2%	6.2% 6.3%	2.6% 2%	-0.3% 2.7%	1.3% 1.7%	4.9% 8.1%	1%	2.1% 1.7%	6.9% 6.8%	2.6% 4.8%	4.7% 5.4%	3.1% 4.2%	3.1% 1.3%	-10
150	MDAE (km) MDAE Skill (%)	18.5 18.5 0%	16.7 18.5 10%	18.5 18.5 0%	16.7 18.5 10%	18.5 18.5 0%	16.7 18.5 10%	18.5 18.5 0%	20.4 20.4 0%	20.4 22.2 8.3%	20.4 22.2 8.3%	20.4 1 20.4 0%	20.4 1 20.4 0%	24.1 22.2 -8.3%	24.1 24.1 0%	24.1 25.9 7.1%	24.1 25.9 7.1%	25.9 25.9 0%	24.1 25.9 7.1%	27.8 25.9 -7.1%	27.8 129.6 6.3%	29.6 33.3 11.1%	25.9 29.6 12.5%	
μ,	Mean Bias (m/s)	11.6 10.7	-41-6	-6.41-8.8	-7.51-9.3	-10.2 -11.6	-11.4 -13.4	-10.6 -13.1	-121-14	-11.8 -15.5	-131-16.1	-16.7 -18.7	-15.3 -18.4	-191-21.5	-20.1 -21.1	-20.6 -23	-20.4 1-21.5	-22.9 -23.4	-21.5 -23.2	-27.51-27.3	-27.1 1-28.4	-29.5 -29.4	-26.4 1-26.1	
	#ˈfcsts CM	883 MCD	792 MCI	771 MCI	746 CI	708 MCI	640 CI	593	533 MCI	518 Cl	492 Cl	461 MCI	394 MCI	375	372 MCI	321 CI	314 MCI	291	263 CI	259	213 CI	179 CI	158 MCI	-20
	MAE (m/s) MAE Skill (%)	23.8 22.5	17.6 16.3 -8.4%	16.6 15.8 -5%	16.4 15.7 -4.4%	15.5 14.8	15.7 14.3	15.6 14.9 -4.5%	15.7 15	15.7 15.2 -2.9%	14.8 13.9 -6.1%	16 16 0.1%	15.4 15.1 -2.1%	16.2 16.2 -0.1%	16.7 16.3	17115.6 -9%	16.8 16.8	18.2 17.8	19.4 19 -2.2%	19.6 19.8 0.7%	19.6 20.1 2.5%	20.5 19.6	21.7 21.7	
4	FSP (wrt 50%) MDAE (km)	-4% 18.5 18.5	-6.7% 13113	-3.2% 14.8 13	-0.5%	-3.1% 13 11.1	-5.9%	-2.7%	-0.8%	-0.2%	-0.6%	-0.4%	1.6% 9.3 11.1	-0.3%	-2%	-6.3% 131 13	1.2%	0.6%	-4.4% 16.7 16.7	2.3% 16.7 16.7	-0.3% 14.8 16.7	0.8%	-0.9% 18.5 16.7	
R6	MDAE Skill (%)	0%	0%	-14.3%	0%	-16.7%	0%	0%	-16.7%	-8.3%	-20%	0%	16.7%	14.3%	0%	0%	14.3%	0%	0%	0%	11.1%	-11.1%	-11.1%	-30
	Mean Bias (m/s) # fcsts	17.8 15.7 643	1018.4 561	7.515.4 571	8.4 6.3 568	7.615.9 551	8 5.6 519	7.615.8 466	7.816.1 442	7.815	7.915.8 394	615 403	7.616.5 322	7.316.5 315	4.614.4	6.815.6 261	6.815 250	5.614.4 240	5.6 4.5 217	3.9 3.4 195	4.914.2 163	7.8 5.5 129	4.4 4.8	
	CM	MCD	MCD 22.4 121.1	CD 24.8 125.8	27.5 25.1	CD	MCD 28.4 129	MCD 29.5 1 29.3	MCD 31.2 29.9	MCD 30.6 132.4	MCD	35.6135.6	34.2 134.5	34.9 36	MCD 33,5137,5	MCD	37,9137,8	34.9 37.7	MCD 37.4 141.7	40.5141,9	MCI 40,9 140,9	MCD 45146,2	44.5 45.5	
7	MAE (m/s) MAE Skill (%)	-6.8%	-5.8%	4%	-9.6%	-12.4%	2.1%	-0.5%	-4.4%	5.7%	4.6%	-0.1%	1%	2.9%	10.5%	-1.8%	-0.3%	7.4%	10.4%	3.3%	0%	2.7%	2.1%	40
ĭ.	FSP (wrt 50%) MDAE (km)	0.8%	-1.4% 11.1 11.1	1.1% 14.8 14.8	-4.3% 14.8 14.8	-2.6% 16.7 13	-2.6% 16.7 14.8	-1.7% 16.7 16.7	1.3% 18.5 18.5	2.4% 16.7 18.5	-2.4% 18.5 18.5	2% 20.4 18.5	2.5% 20.4 120.4	0.2%	4% 20.4 20.4	-0.5% 23.2 24.1	-0.8% 23.2 122.2	-0.3% 22.2 25.9	0.9% 27.8 27.8	-0.3% 26.9 1 33.3	-4.2% 25.9 126.9	-0.8% 28.7 31.5	6.1% 31.5 31.5	-40
2	MDAE Skill (%) Mean Bias (m/s)	0% 5.412.7	0% 2.211.5	0% 2.814.4	0% 4.6 2.5	-28.6% 6.5 1.8	-12.5% 3.918.6	0% 5.915	0%	10% 6.211.6	0% 717.8	-10% 7.416.7	0% 4.915.3	8.3% 7.1 10.9	0% 7.518.2	3.8% 4.515.5	-4.2% 4.415.4	14.3% 5.714	0% 2.216.5	19.4% 6.315.4	3.4% 2.513.6	8.8% 3.3 3.8	0% 5.817	
щ	# fcsts	375	370	365	358	348	333	322	306	289	273	256	241	225	210	196	184	173	161	152	142	132	123	
	CM	<u> </u>	MCD	10	MCD	CD		26		CI		60		70	MCI			MCI		MCI 100		MCI	MCI	-50
		0		12		24		36		48	F	60	d Timer (1	72		84		96		108		120		
											Fore	ecast Lea	d Time (I	n)										

Credit: Idea & Base Code by Dr. Peter Marinescu

GROOT User's Guide

File: COMP_SCORECARD_OBS_ALL



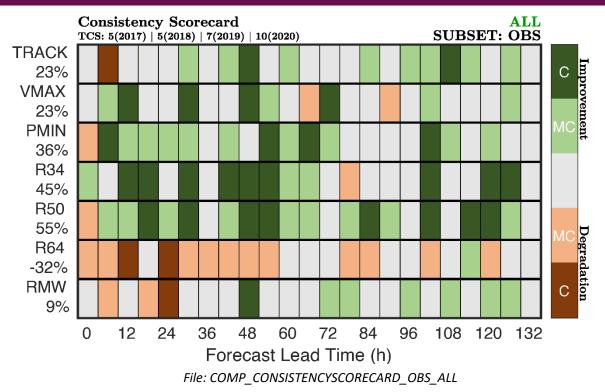
Basin: Individual | Verification: Consistent with NHC

ne Storm: Each Cycle | One Storm: All Cycles | 0

Composite Graphics

Consistency Scorecard By Forecast Lead Time

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





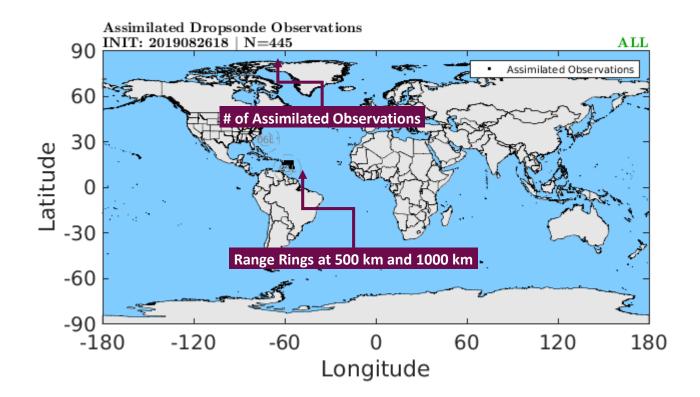
*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle One Storm: All Cycles Compo

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.





 Error Statistics

 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O

Asm. Obs: CONV Asm. Obs: SAT

GRB Graphics

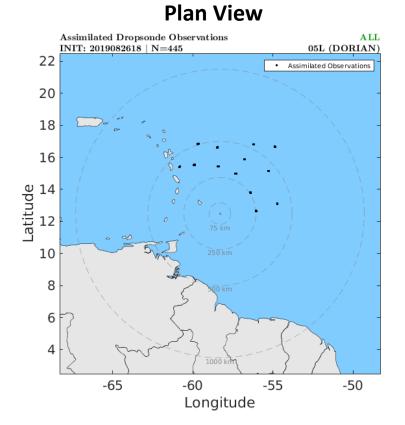
*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle One

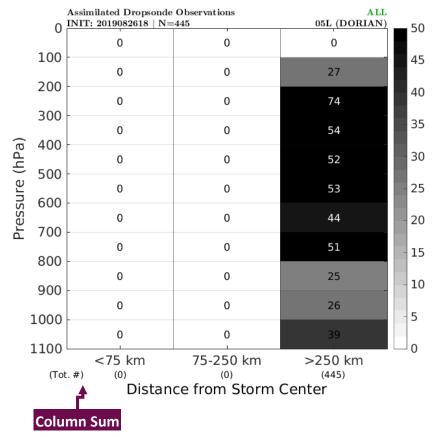
Composite Graphics

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.



Radial View



GROOT User's Guide



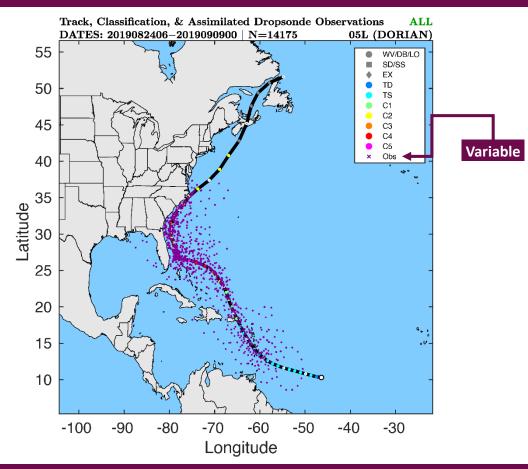
*Works with observation subtypes – each get their own color/name in namelist!

One Storm: Each Cycle One Storm: All Cycles Cor

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.



GROOT User's Guide

Last Updated: November 21, 2022



One Charmer All Cueles

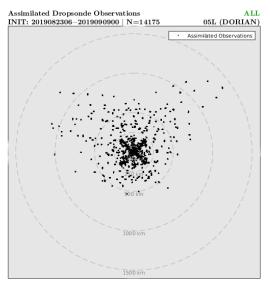
Dine Storm: Each Cycle One Storm: All Cycles

Composite Graphics

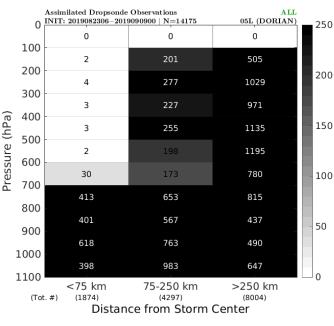
Plan, Radius-Pressure, & Radial View

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.

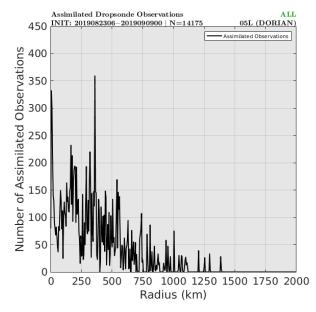
Plan View



Radius-Pressure View



Radial View



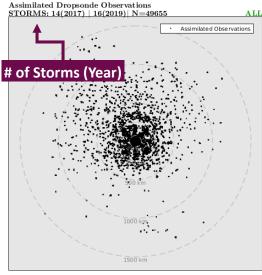


Composite Graphics

Plan, Radius-Pressure, & Radial View

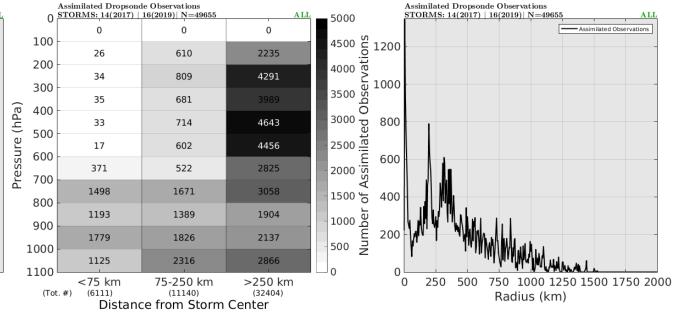
The below graphic is generated for each experiment. For OBS-related subsets in GROOT-G (other than OBS-G) it will take into account observations within 2000 km of the storm – this will be indicated on the graphic.

Plan View



Radius-Pressure View

Radial View

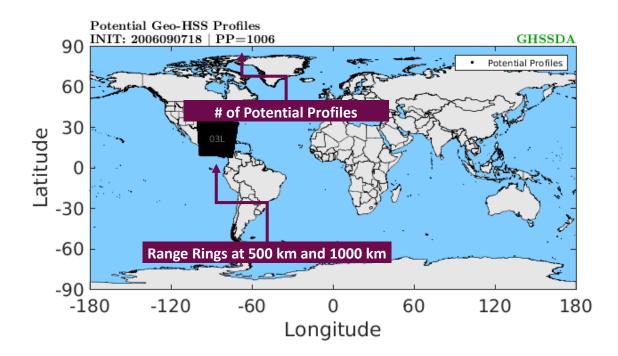




One Storm: Each Cycle One Storm: All Cycles Composite Graphic

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.

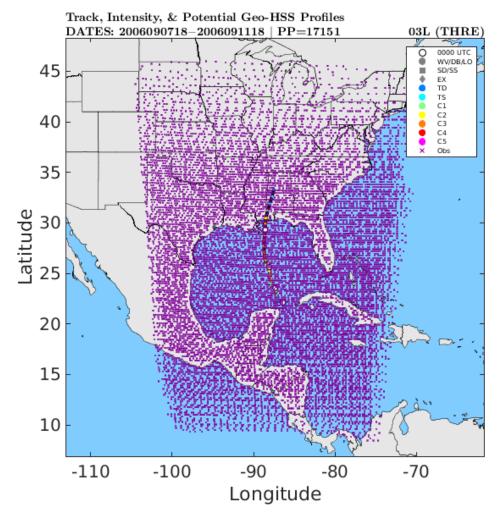




One Storm: Each Cycle

Composite Graphics

Best Track Graphic

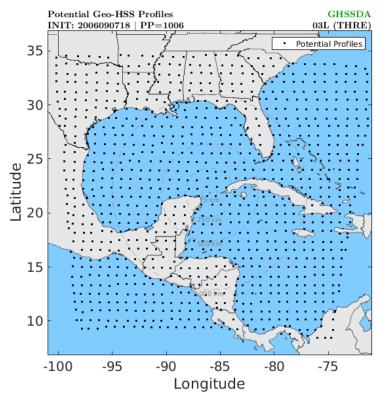




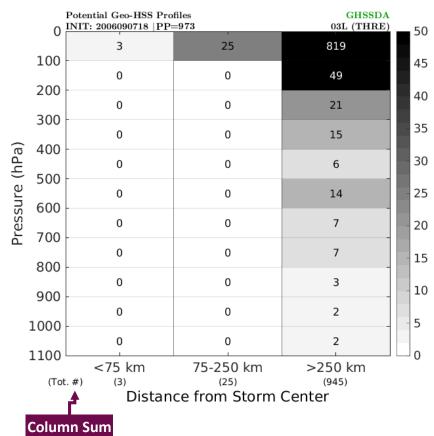
One Storm: Each Cycle

Plan View & Radial View

Plan View

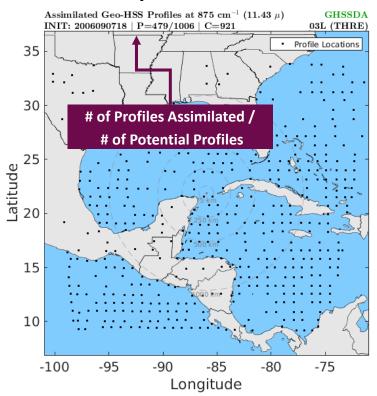


Radial View



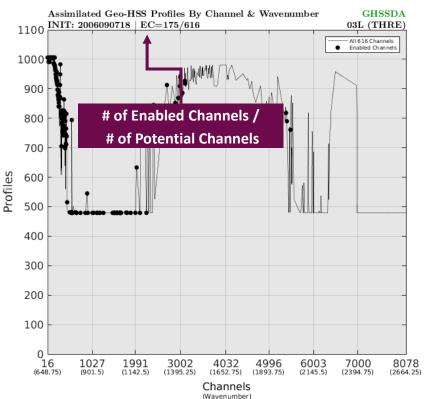


Specific Channel & Profiles by Channel



Specific Channel

Profiles by Channel

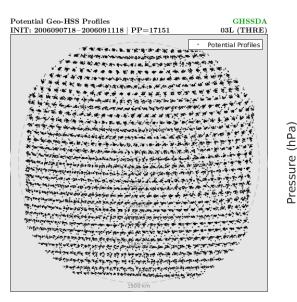




Composite Graphics

Plan, Radius-Pressure, & Radial View

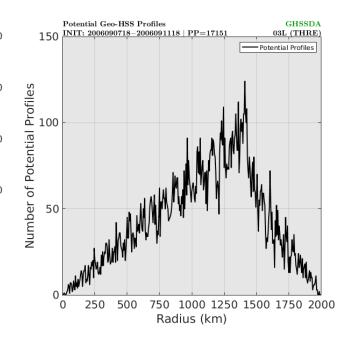
Plan View



Radius-Pressure View

Potential Geo-HSS Profiles GHSSDA O INIT: 2006090718-2006091118 PP=17151 03L (THRE) <75 km 75-250 km >250 km (380) (15698) (Tot. #) (42) Distance from Storm Center

Radial View





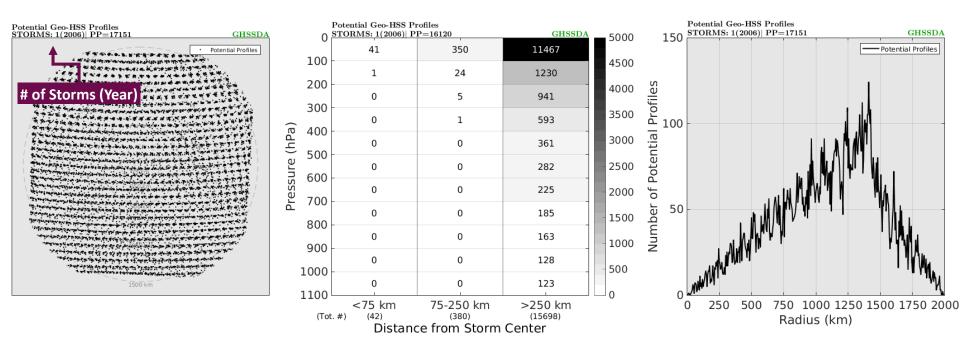
Composite Graphics

Plan, Radius-Pressure, & Radial View

Plan View

Radius-Pressure View

Radial View



Overview

Error Statistics

Asm. Obs: CONV

Asm. Obs: SAT GRB Graphics

*Only for GROOT-H

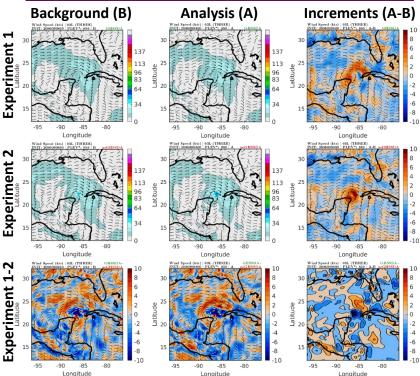
Usage

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.

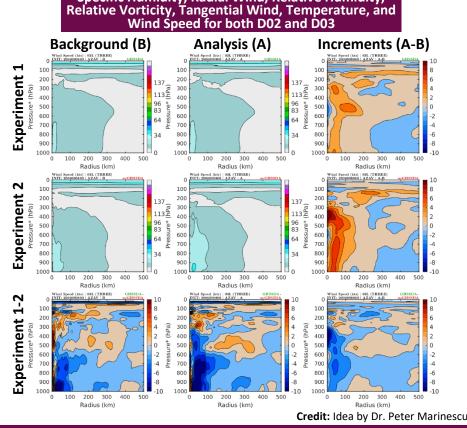
Plan View

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,



Last Updated: November 21, 2022

GROOT User's Guide

Asm. Obs: SAT

000000

Usage

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

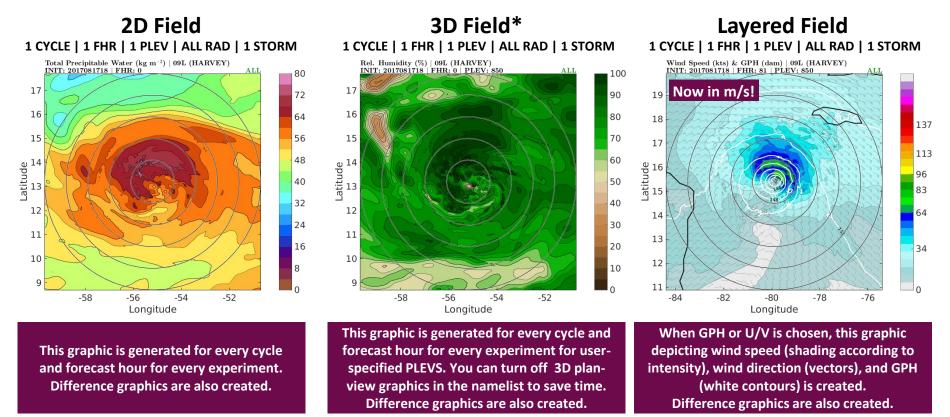
Absolute Vorticity (Isobaric) | Geopotential Height (Isobaric) | Precipitable Water (2D) Pressure Reduced to MSL (Surface) | Relative Humidity (Isobaric) | U/V Component of Wind (Isobaric)

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.

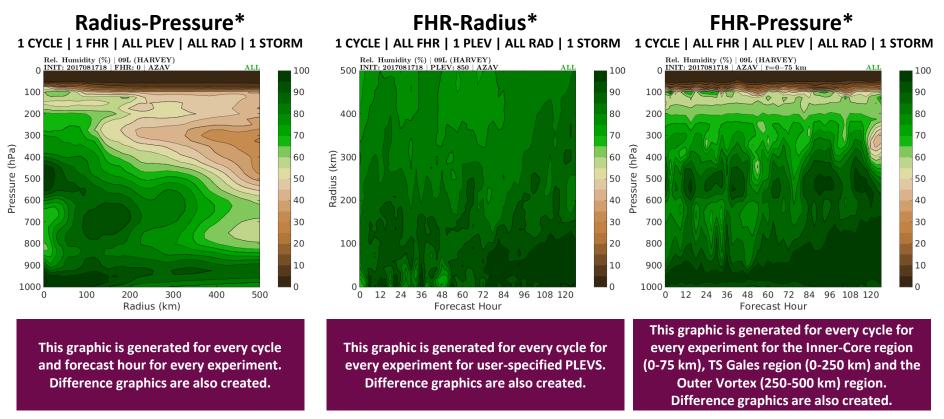
Storm Grid Plan View



Range Rings: every 100 km from 100-500 km

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

Storm Grid Azimuthal Averages



Range Rings: every 100 km from 100-500 km

GROOT User's Guide

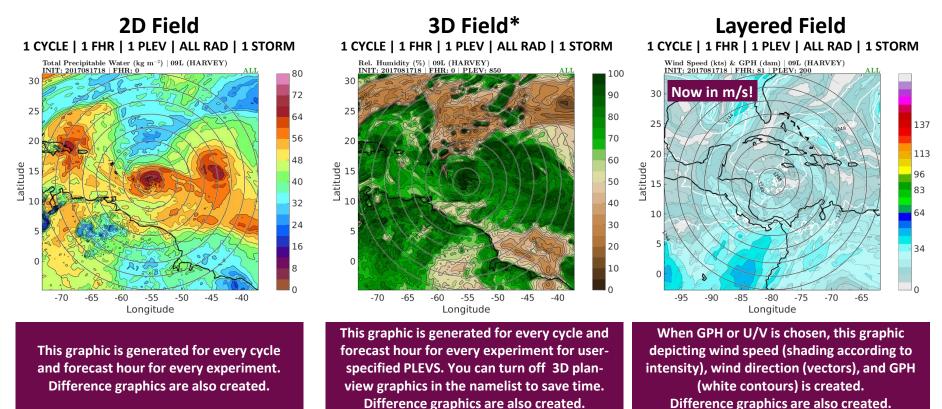
GRB Graphics

Usage

0000

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

Synoptic Grid Plan View



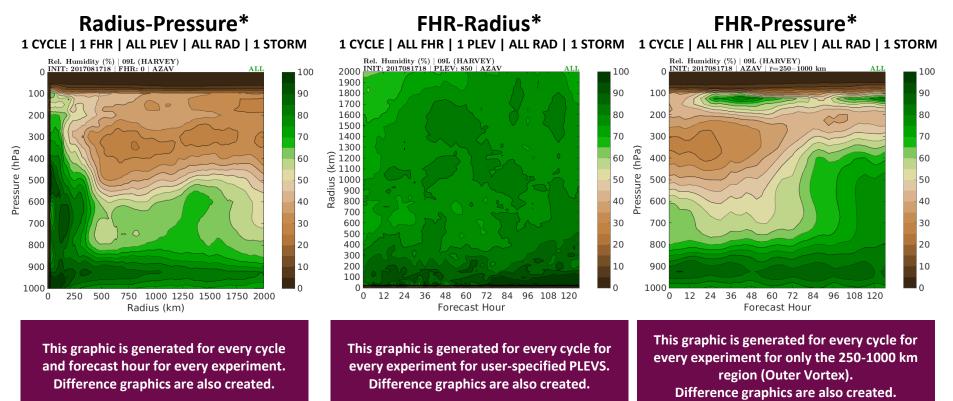
Range Rings: every 250 km from 250-2000 km

Overview

0000

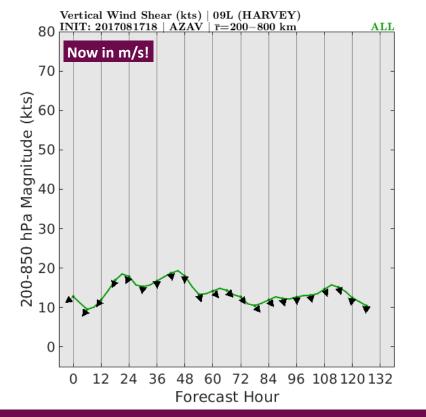
*These graphics are not generated for zonal or meridional wind.

Synoptic Grid Azimuthal Averages



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).

Overview

 Error Statistics

 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O
 O

Asm. Obs: CONV Asm. Obs: SAT

00000

GRB Graphics

Usage

*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.

000000

Getting Started

Follow Along

Step 1: Checkout the code from GitHub				
You can checkout the code from GitHub (<u>https://github.com/sditchek/GROOT</u>)				
Not in GROOT-G ↓	G Step 2: View Your Files Not in GROOT-G			
README bdeck editgrb.m	n editverif.m nctoolbox-1.1.3 retrievalscripts rungrb.ksh runverif.ks	n 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!

GROOT User's Guide

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!
CPP Craphics	*hwrfprs.storm.0p015.f*.grb2	*hwrfprs.storm.0p015.f*.grb2
GRB Graphics	*hwrfprs.synoptic.0p125.f*.grb2	*hwrfprs.synoptic.0p125.f*.grb2

Usage

Acknowledgements

Publications

If using output from this graphics package in <u>PUBLICATIONS</u>, 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 <u>PRESENTATIONS</u>, 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 <u>Email:</u> sarah.d.ditchek@noaa.gov

GROOT User's Guide

Last Updated: November 21, 2022