Use of the AOML Hurricane Model Viewer for Understanding Hurricane Analysis and Forecast System (HAFS) Forecasts

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Major: Meteorology
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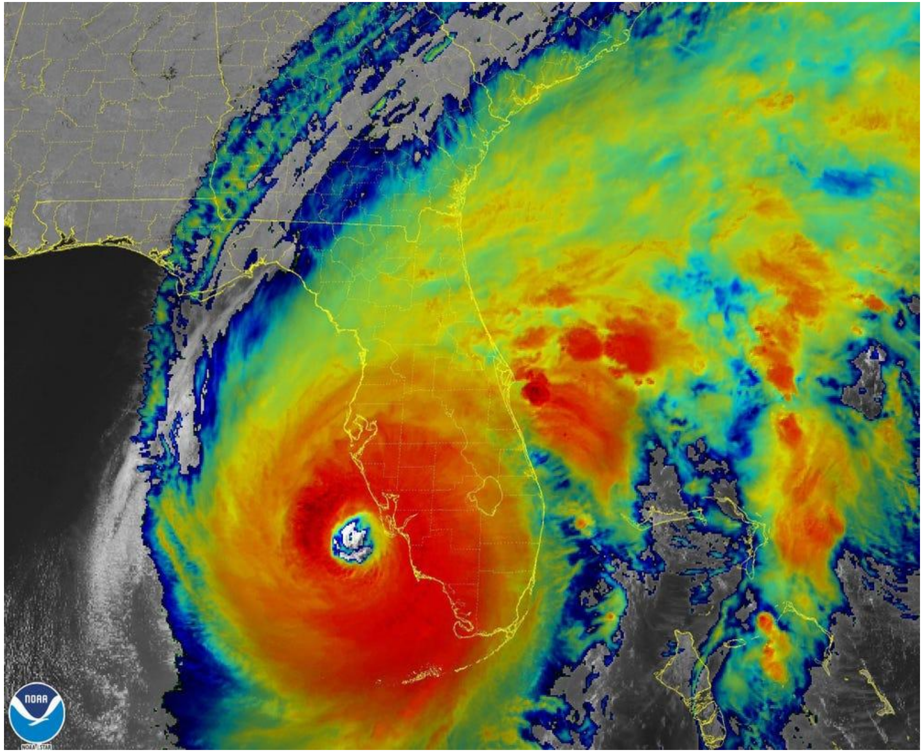
OUTLINE

- Objectives and Background
- Methodology
- Hurricane Ian (Analysis)
- Summary and Next Steps
- Acknowledgments



OBJECTIVE & BACKGROUND

- Hurricanes have caused over $1 trillion in damage and taken nearly 6,900 lives in the US between 1980 and 2023.
- Tropical weather systems are very hard to predict, because the atmosphere and ocean are changing all the time.
- The goal of this research is to help improve NOAA forecasting by identifying cases in which the HAFS-B forecast model were unable to correctly predict the storm's intensification.

**** Some preliminary results show that air-to-sea interaction is one reason for rapid storm intensification; others may indicate the temperature of the ocean has a significant effect on a storm's intensification.***

OBJECTIVE & BACKGROUND (cont'd)

Meteorologists working within the National Oceanic and Atmospheric Administration (NOAA) use forecast models to inform and protect people around the world. More specifically, NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) uses different models to conduct research on the storm's track, intensity, and sea-to-atmosphere interactions. These include global (e.g., European model, NOAA's Global Forecast System) and high-resolution hurricane models, including the Hurricane Analysis and Forecast System (HAFS) jointly developed by the NWS/Environmental Modeling Center and AOML.

The Hurricane Research Division, in particular, completed real-time experiments with the HAFS-B configuration spanning the years 2020-2022, using AOML's Hurricane Model Viewer. This summer, I worked to identify 4 cases in which the HAFS-B forecast model was unable to correctly predict storm intensification, and reported my research findings on how this differed from the forecast.

My research goal is to help improve NOAA forecasting, to save lives and protect property.

HURRICANE ANALYSIS FORECAST SYSTEM (HAFS)

- Became operational in June 2023
- Next generation hurricane model, to replace the HWRF (Hurricane Weather and Research Forecast) model
- Part of the Unified Forecast System (UFS) - a community-based coupled Earth modeling system, designed to support the Weather Enterprise

METHODOLOGY

1. Select a historic hurricane event and present a comparison between models using the AOML Hurricane Model Viewer, to understand forecast from Hurricane Analysis and Forecast System (HAFS).
2. Examine multiple parameters and products for the selected storm at three (3) hour intervals, to assess the viability of HAFS in the context of today's forecasting environment.
3. Generate a presentation comparing the performance of hurricane models using a test case, providing insight into visualization best practices to help NOAA create useful and usable products.
4. Become familiar with using NOAA Research & Development High Performance Computing System (RDHPCS) Orion resources.

KEY TERMS AND DEFINITIONS

- **Vertical Wind Shear**: The difference in wind speed and/or direction with height.
- **Rapid Intensification**: An increase in the maximum sustained winds of a tropical cyclone of 35 mph or greater in a 24 hour period.
- **Relative Humidity:** The amount of moisture in the atmosphere.
- **Latent Heat**: Heat derived from the evaporated liquid water from the ocean.
- **Ocean Heat Content**: Total amount of heat stored in the ocean.

IDEAL CONDITIONS FOR HURRICANE INTENSIFICATION

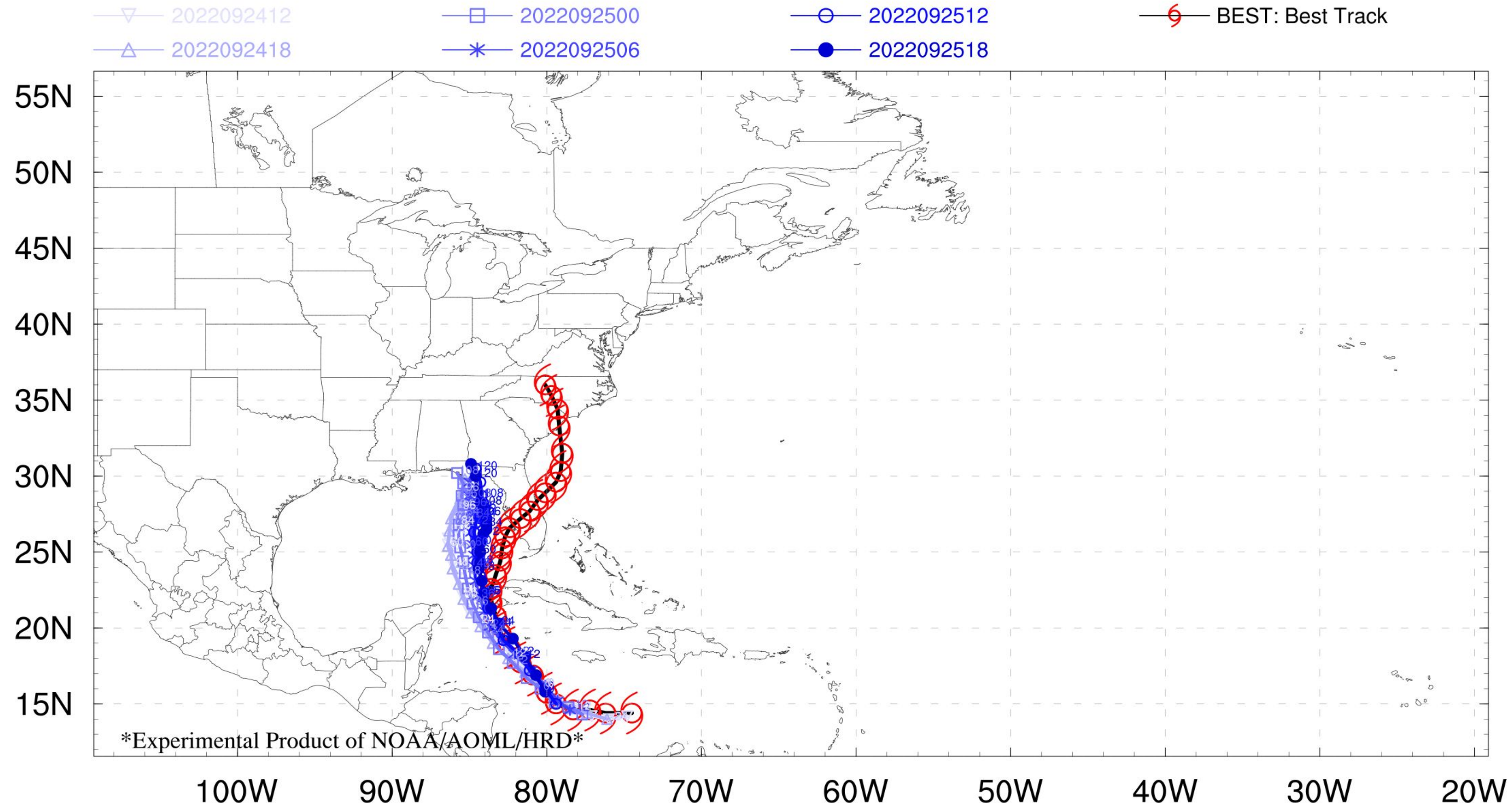
- Low vertical wind shear
- Moist air in the middle atmosphere
- Warm ocean surface
- Deep heat in the ocean

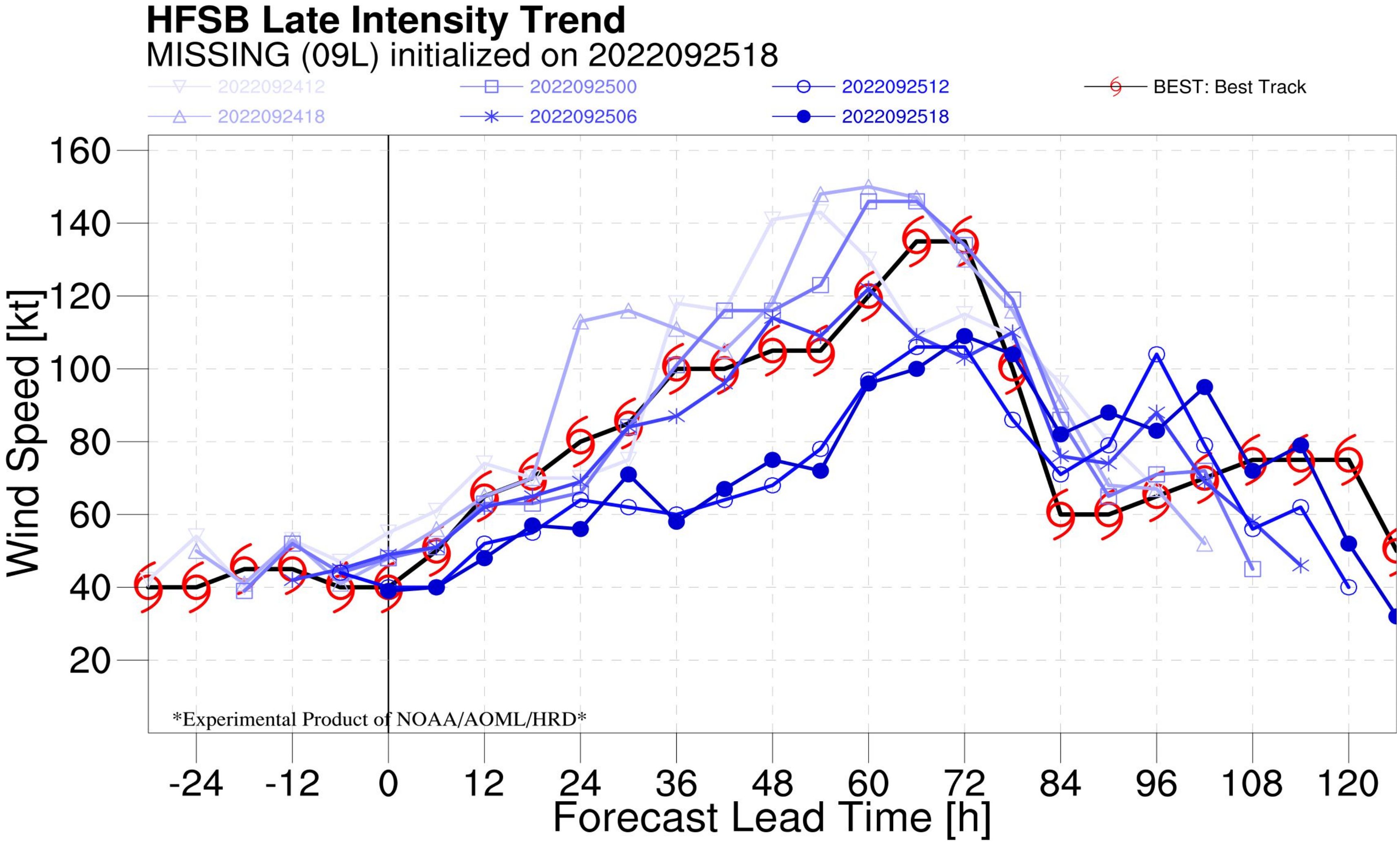
HURRICANE IAN (2022)

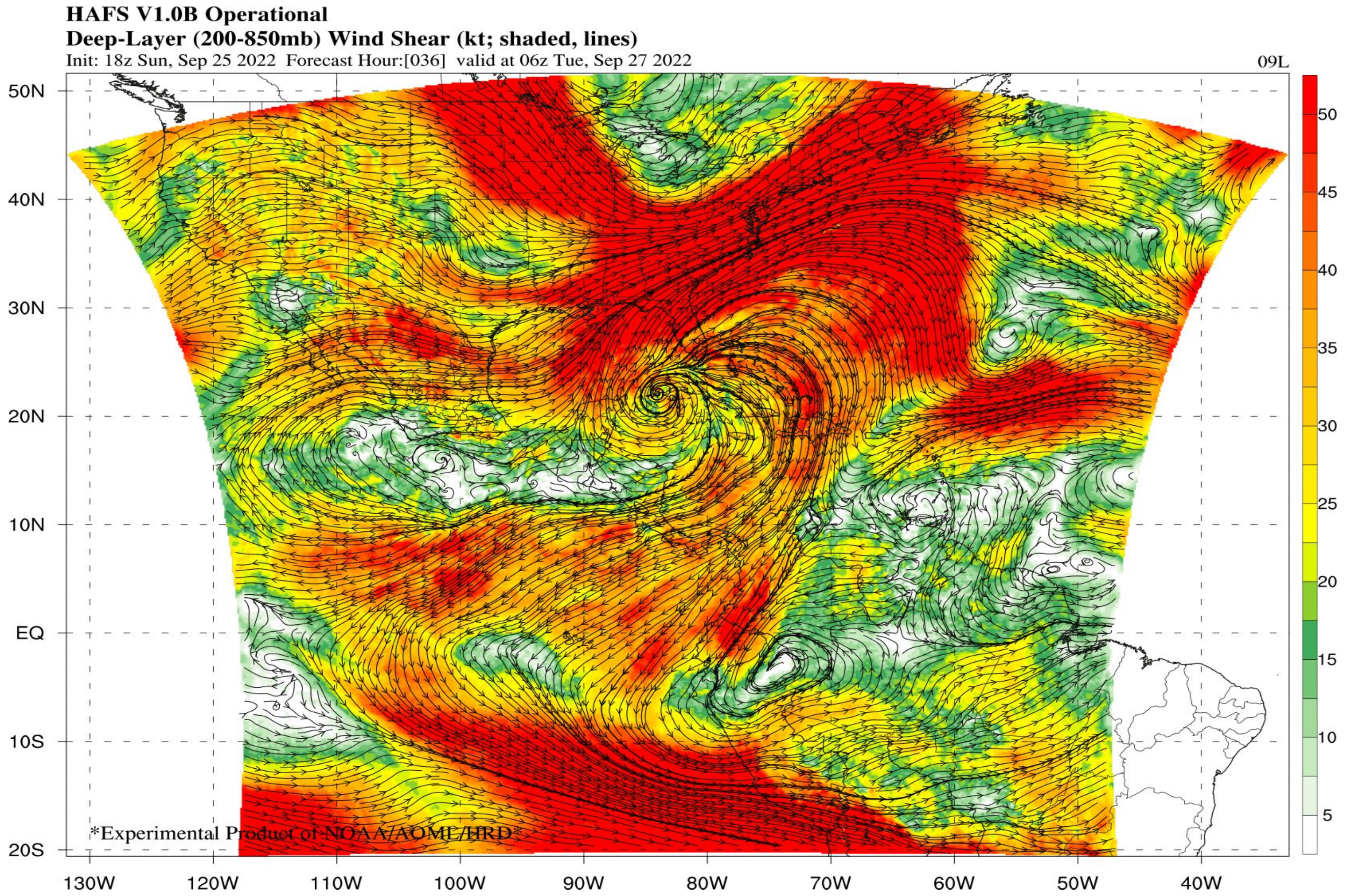
- **September 14-15** - Ian forms from a tropical wave that moved off the West African coast
- **September 24** - Ian becomes a tropical storm
- **September 26** - Ian officially becomes a hurricane
- **September 28** - Ian makes landfall in southwestern Florida as a Category 4 hurricane

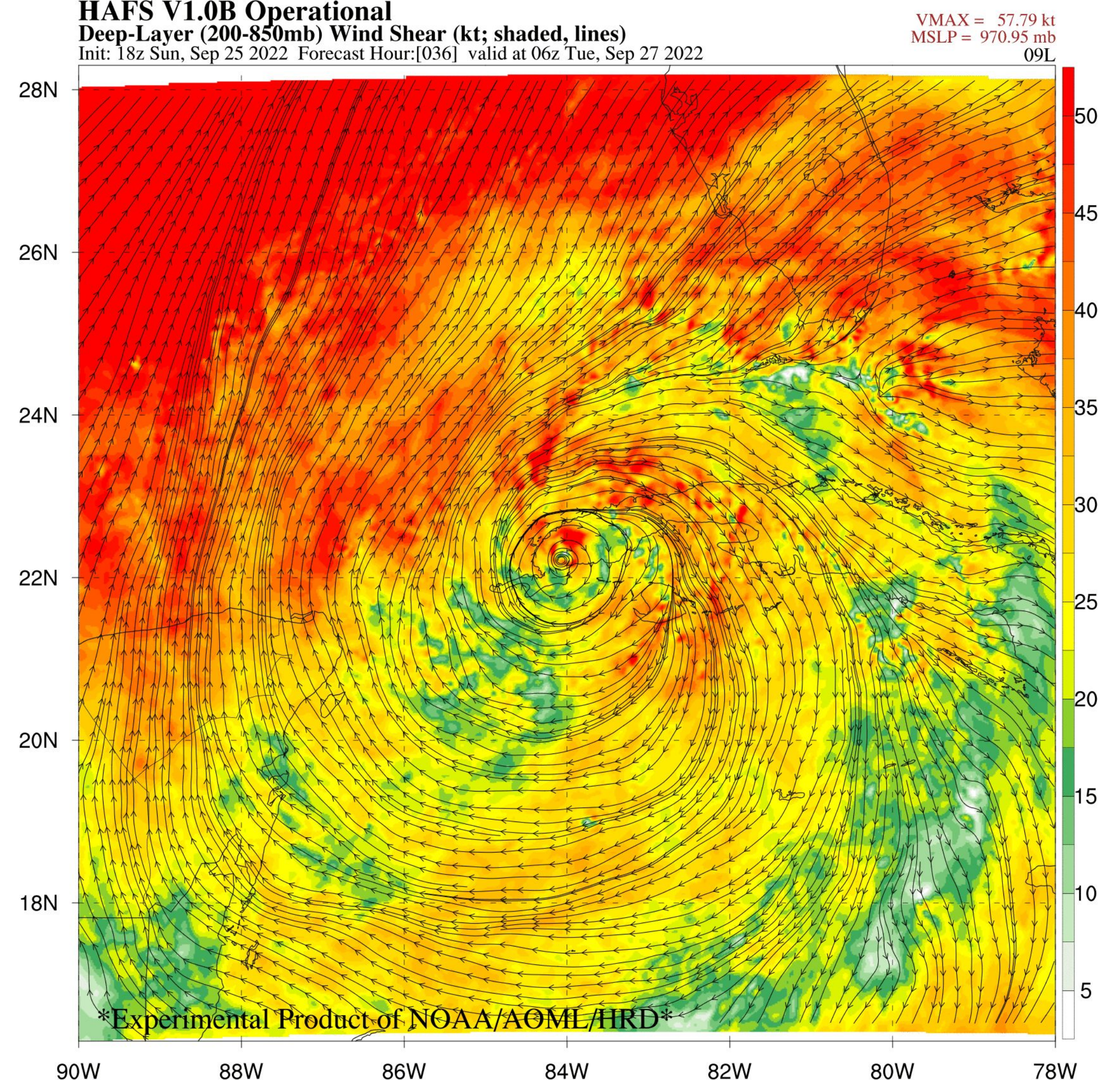
**** Hurricane Ian was one of the costliest storms in U.S. history - around $112.9 billion, and resulted in 149 fatalities***

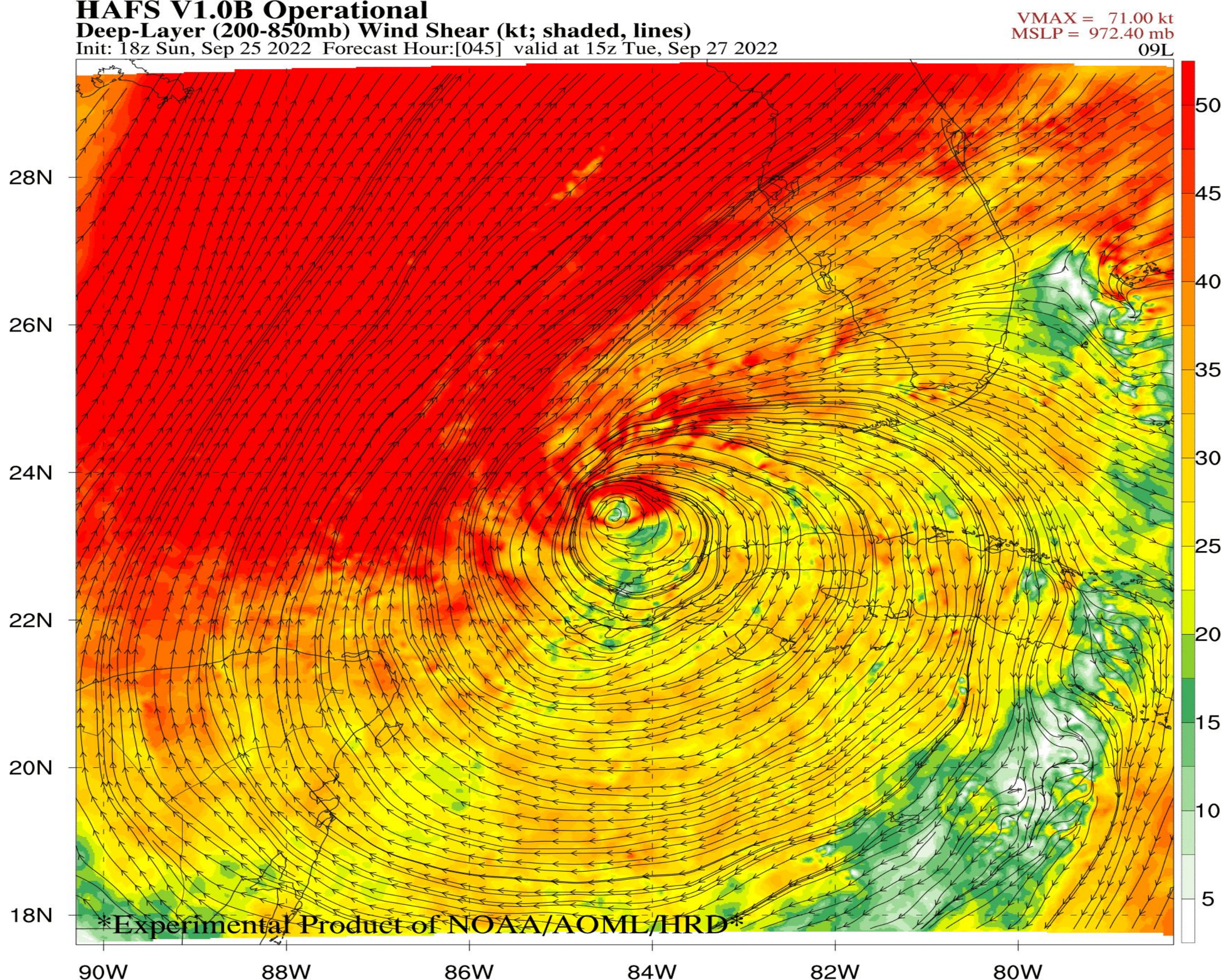
HFSB Late Track Trend
MISSING (09L) valid on 2022092518




HFSB Late Intensity Trend
MISSING (09L) initialized on 2022092518
2022092412
2022092500
2022092512
BEST: Best Track
2022092418
2022092506
2022092518
Wind Speed [kt]
160
140
120
100
80
60
40
20
-24
-12
0
12
24
36
48
60
72
84
96
108
120
Forecast Lead Time [h]
Experimental Product of NOAA/AOML/HRD


HAFS V1.0B Operational
Deep-Layer (200-850mb) Wind Shear (kt; shaded, lines)
Init: 18z Sun, Sep 25 2022 Forecast Hour:[036] valid at 06z Tue, Sep 27 2022
09L
50N
40N
30N
20N
10N
EQ
10S
20S
130W
120W
110W
100W
90W
80W
70W
60W
50W
40W
50
45
40
35
30
25
20
15
10
5
Experimental Product of NOAA/AOML/HRD


HAFS V1.0B Operational
Deep-Layer (200-850mb) Wind Shear (kt; shaded, lines)
Init: 18z Sun, Sep 25 2022 Forecast Hour:[036] valid at 06z Tue, Sep 27 2022
VMAX = 57.79 kt
MSLP = 970.95 mb
09L
28N
26N
24N
22N
20N
18N
90W
88W
86W
84W
82W
80W
78W
50
45
40
35
30
25
20
15
10
5
Experimental Product of NOAA/AOML/HRD

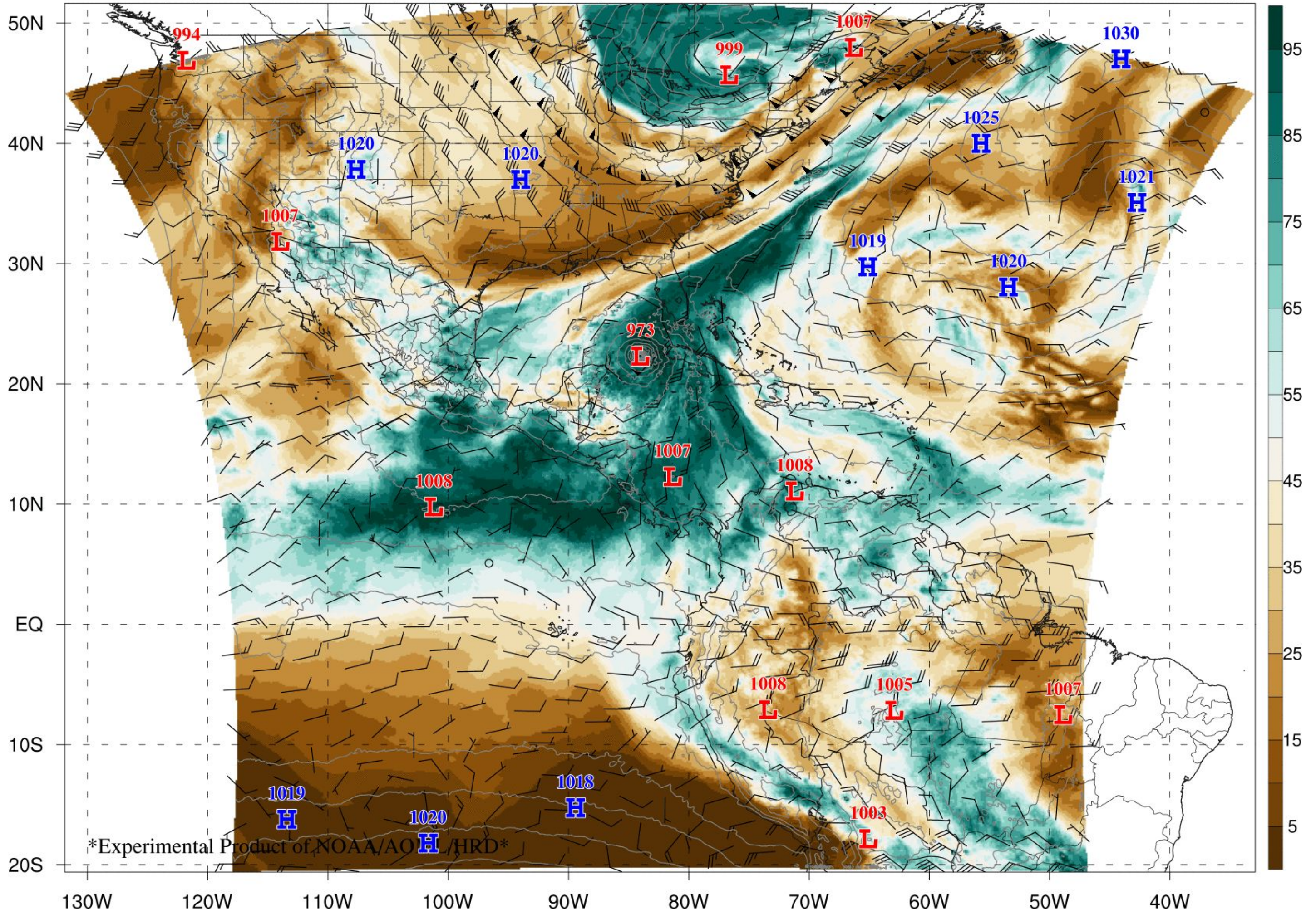


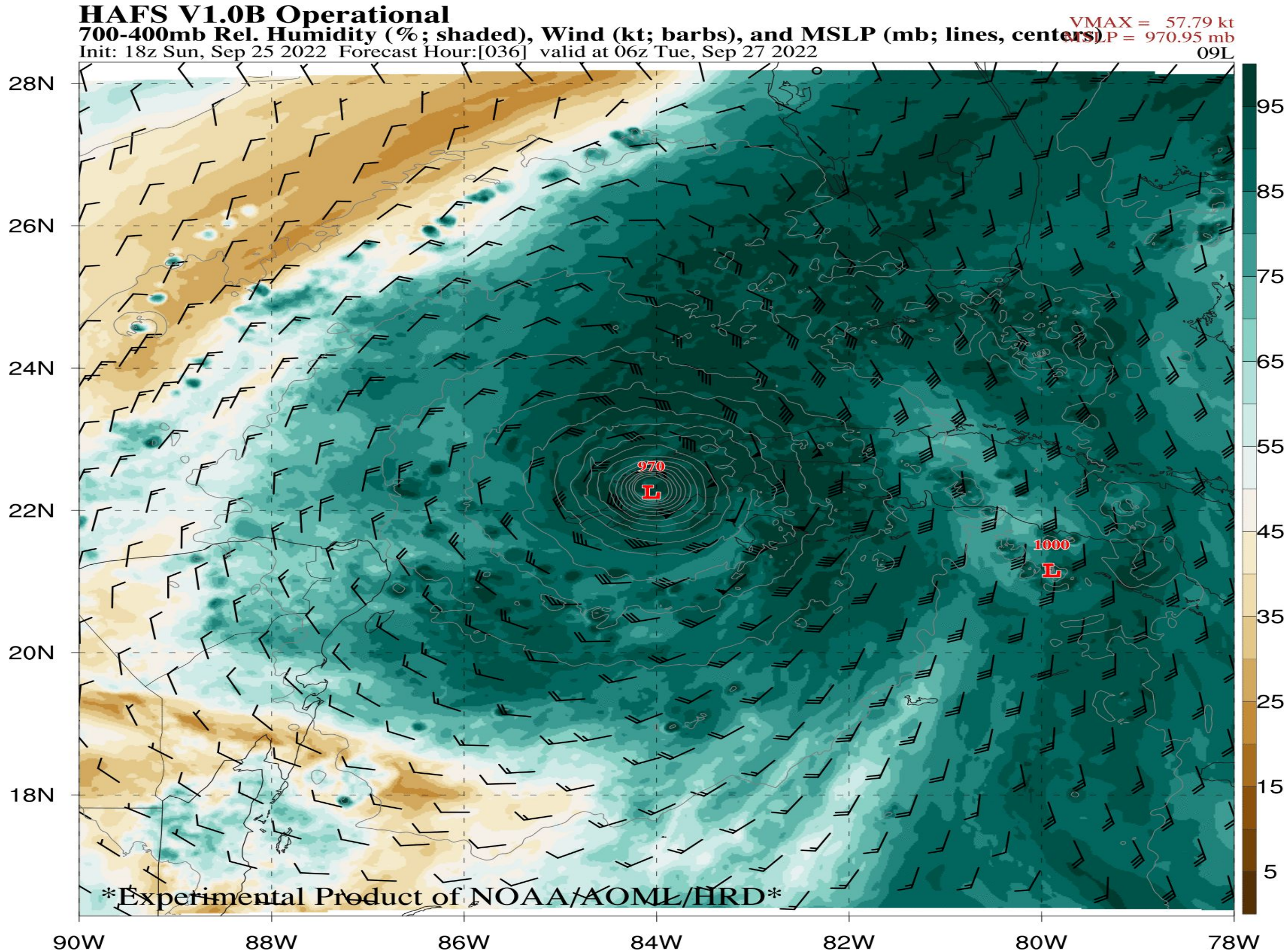
HAFS V1.0B Operational
Deep-Layer (200-850mb) Wind Shear (kt; shaded, lines)
Init: 18z Sun, Sep 25 2022 Forecast Hour:[045] valid at 15z Tue, Sep 27 2022
VMAX = 71.00 kt
MSLP = 972.40 mb
09L
28N
26N
24N
22N
20N
18N
90W
88W
86W
84W
82W
80W
50
45
40
35
30
25
20
15
10
5
Experimental Product of NOAA/AOML/HRD

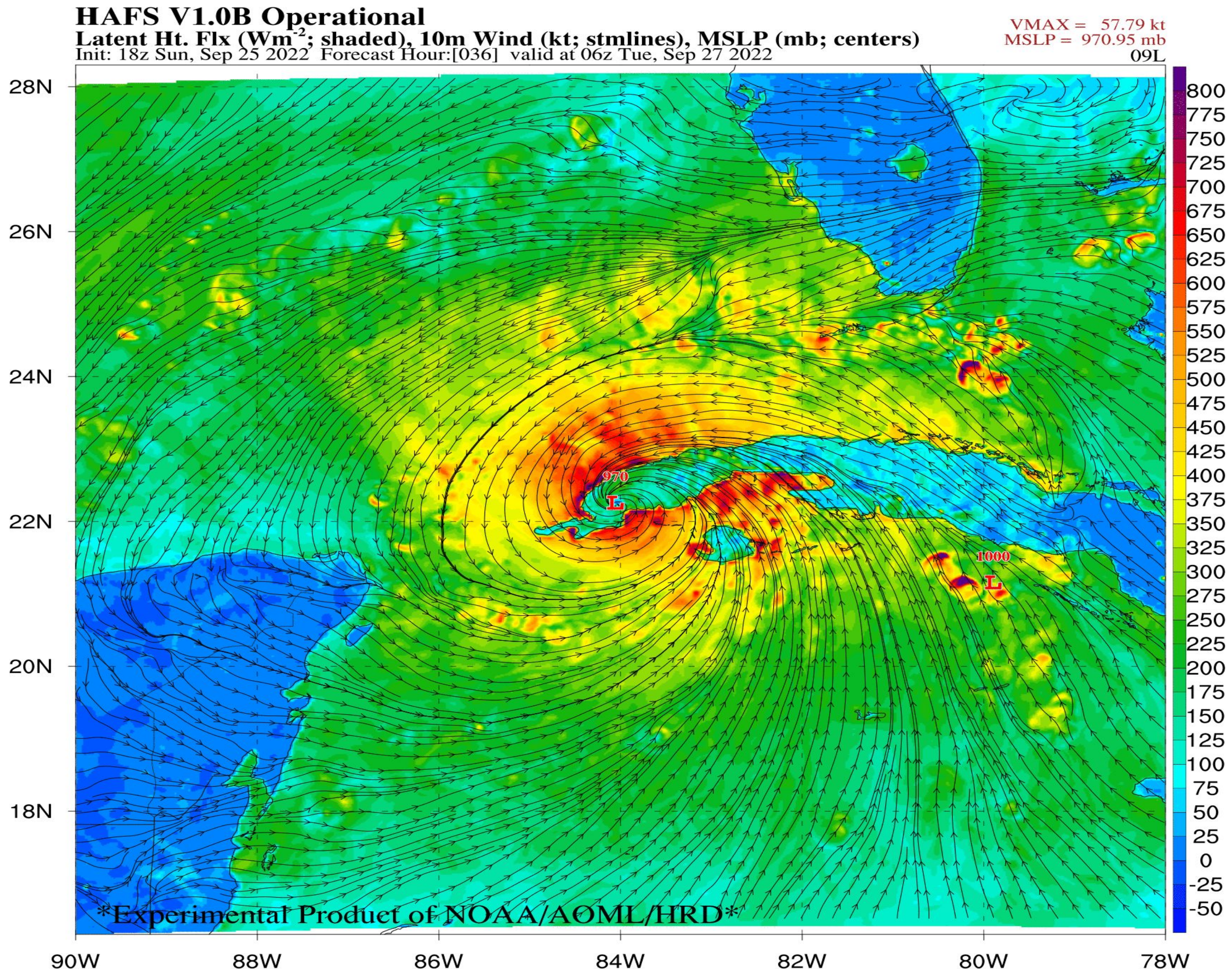
HAFS V1.0B Operational

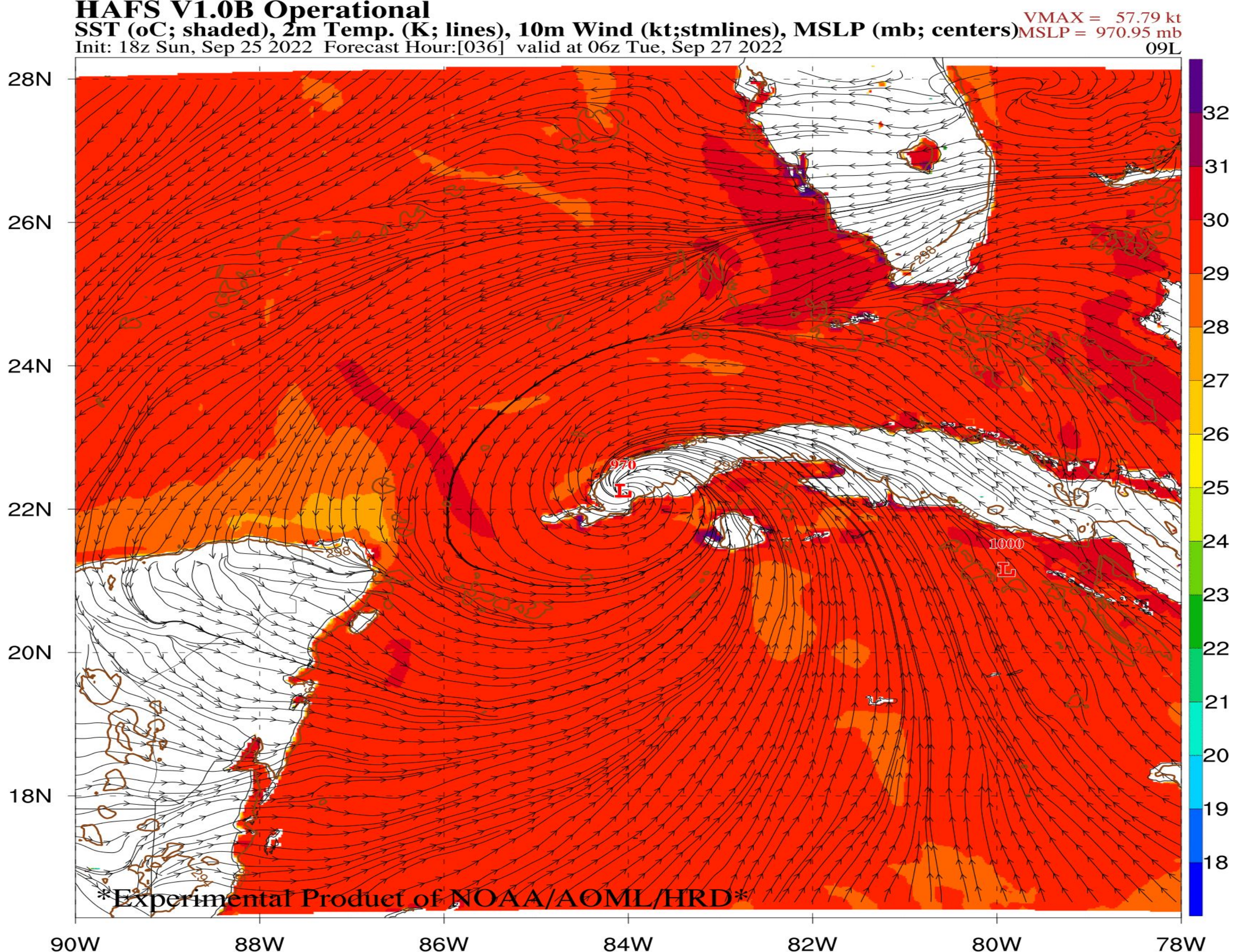
700-400mb Rel. Humidity (%; shaded), Wind (kt; barbs), and MSLP (mb; lines, centers)

Init: 18z Sun, Sep 25 2022 Forecast Hour:[036] valid at 06z Tue, Sep 27 2022

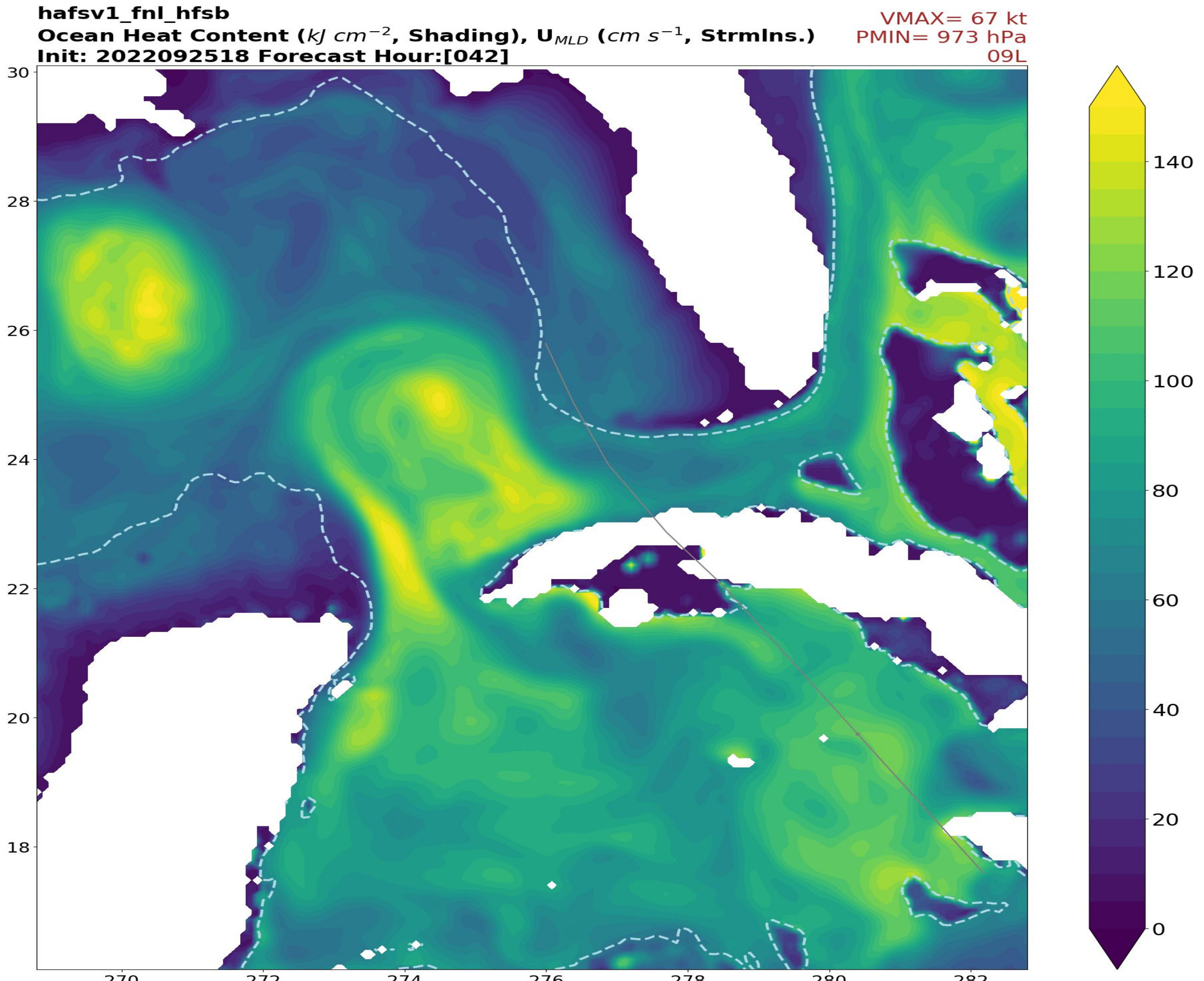



HAFS V1.0B Operational
700-400mb Rel. Humidity (%; shaded), Wind (kt; barbs), and MSLP (mb; lines, centers)
Init: 18z Sun, Sep 25 2022 Forecast Hour:[036] valid at 06z Tue, Sep 27 2022
VMAX = 57.79 kt
MSLP = 970.95 mb
09L
28N
26N
24N
22N
20N
18N
970
L
1000
L
95
85
75
65
55
45
35
25
15
5
Experimental Product of NOAA/AOML/HRD
90W
88W
86W
84W
82W
80W
78W


HAFS V1.0B Operational
Latent Ht. Flx (Wm-2; shaded), 10m Wind (kt; stmlines), MSLP (mb; centers)
Init: 18z Sun, Sep 25 2022 Forecast Hour:[036] valid at 06z Tue, Sep 27 2022
VMAX = 57.79 kt
MSLP = 970.95 mb
09L
28N
26N
24N
22N
20N
18N
90W
88W
86W
84W
82W
80W
78W
970
L
1000
L
800
775
750
725
700
675
650
625
600
575
550
525
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
-25
-50
Experimental Product of NOAA/AOML/HRD



HAFS V1.0B Operational
SST (oC; shaded), 2m Temp. (K; lines), 10m Wind (kt;stmlines), MSLP (mb; centers)
VMAX = 57.79 kt
MSLP = 970.95 mb
Init: 18z Sun, Sep 25 2022 Forecast Hour:[036] valid at 06z Tue, Sep 27 2022
09L
28N
26N
24N
22N
20N
18N
90W
88W
86W
84W
82W
80W
78W
970
L
1000
L
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
Experimental Product of NOAA/AOML/HRD



hafsv1_fnl_hfsb
Ocean Heat Content (kJ cm^-2, Shading), U_MLD (cm s^-1, Strmlns.)
Init: 2022092518 Forecast Hour:[042]
VMAX= 67 kt
PMIN= 973 hPa
09L
30
28
26
24
22
20
18
270
272
274
276
278
280
282
140
120
100
80
60
40
20
0

SUMMARY AND NEXT STEPS

- The conditions for Hurricane Ian were ideal for rapid intensification. However, this did not occur as expected, due to the limited ocean heat content.

- Identifying errors in the HAFS-B forecasts will help to improve outcomes in the future. This is important for saving lives, since an incorrect forecast may result in misinterpretation of risk communication from storms.

- Next steps for this research include using Orion in conjunction with the AOML Hurricane Model viewer, to analyze more storms to identify potential errors in model forecasts.

ACKNOWLEDGEMENTS

AOML Hurricane Model Viewer - https://storm.aoml.noaa.gov/viewer/

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THANK YOU

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