

WindBorne Global Sounding Balloon Observations: Forecast impacts during the 2022 and 2023 tropical seasons

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14 November 2024



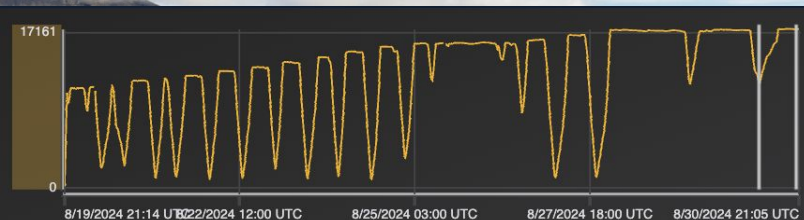
WindBorne

Global sensing for better weather forecasts

Global Sounding Balloon (GSB)

Sensing:

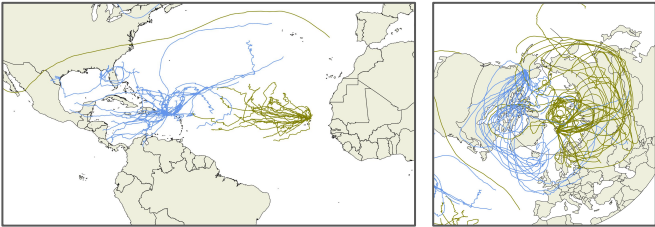
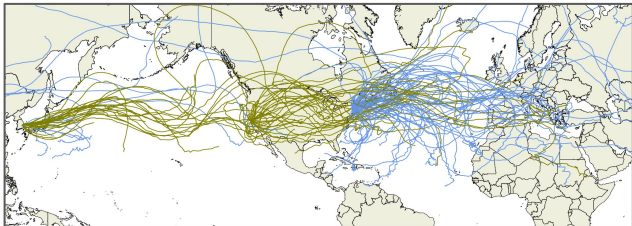
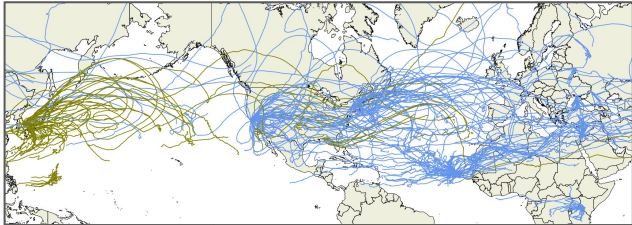
Temperature
Humidity
Wind
Pressure



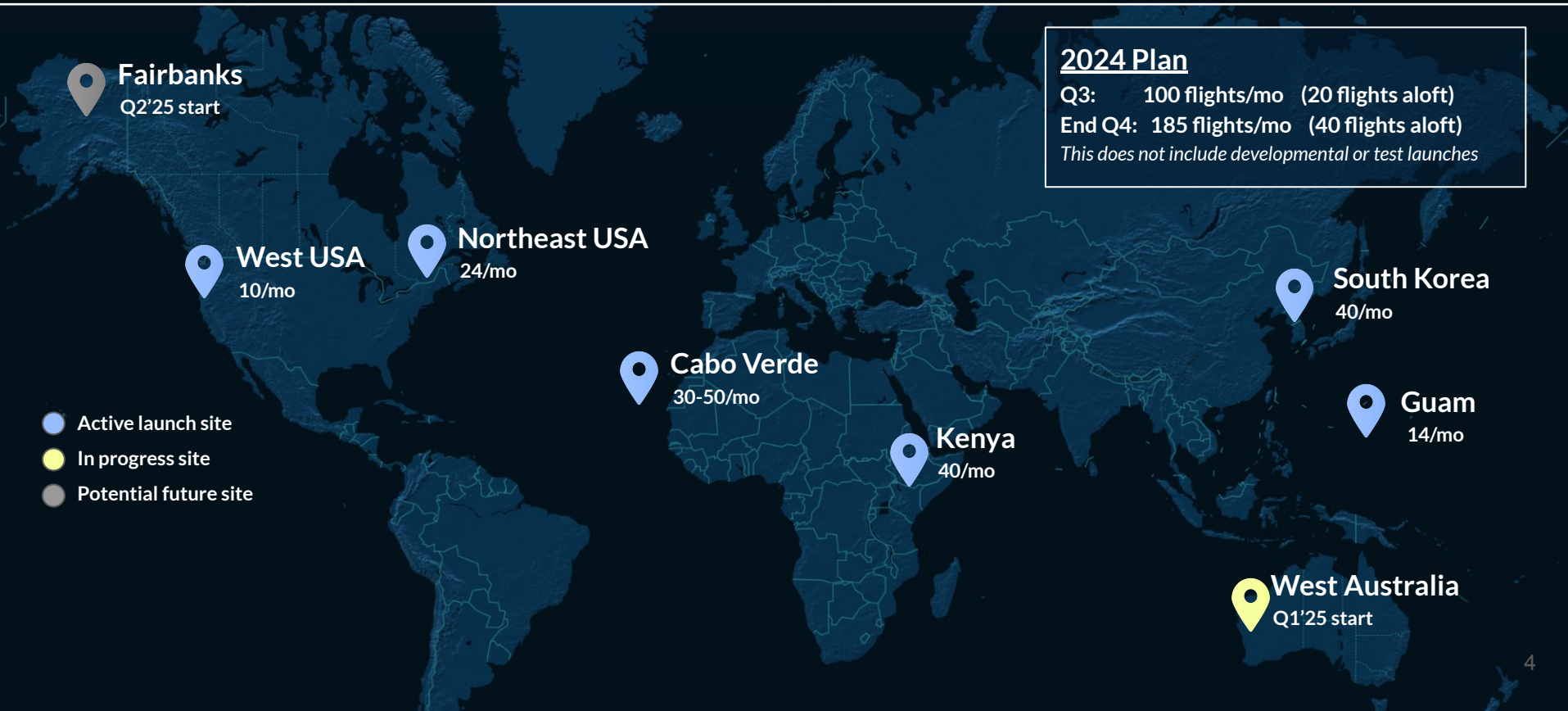
The GSB is a highly cost-effective platform that can reach data-sparse and -void regions, supplementing existing collection methods and **closing the existing in-situ data gap.**

- In situ observations from surface to stratosphere
- **Longer duration now: up to 53 days**
- **Long range:** able to circumnavigate the globe
- **Real-time, full-range altitude control**
- Can **target areas of interest** using wind
- Observations available within **10 minutes**
- **AI-powered** autonomous flight control
- **New: Lightweight Dropsondes being tested**

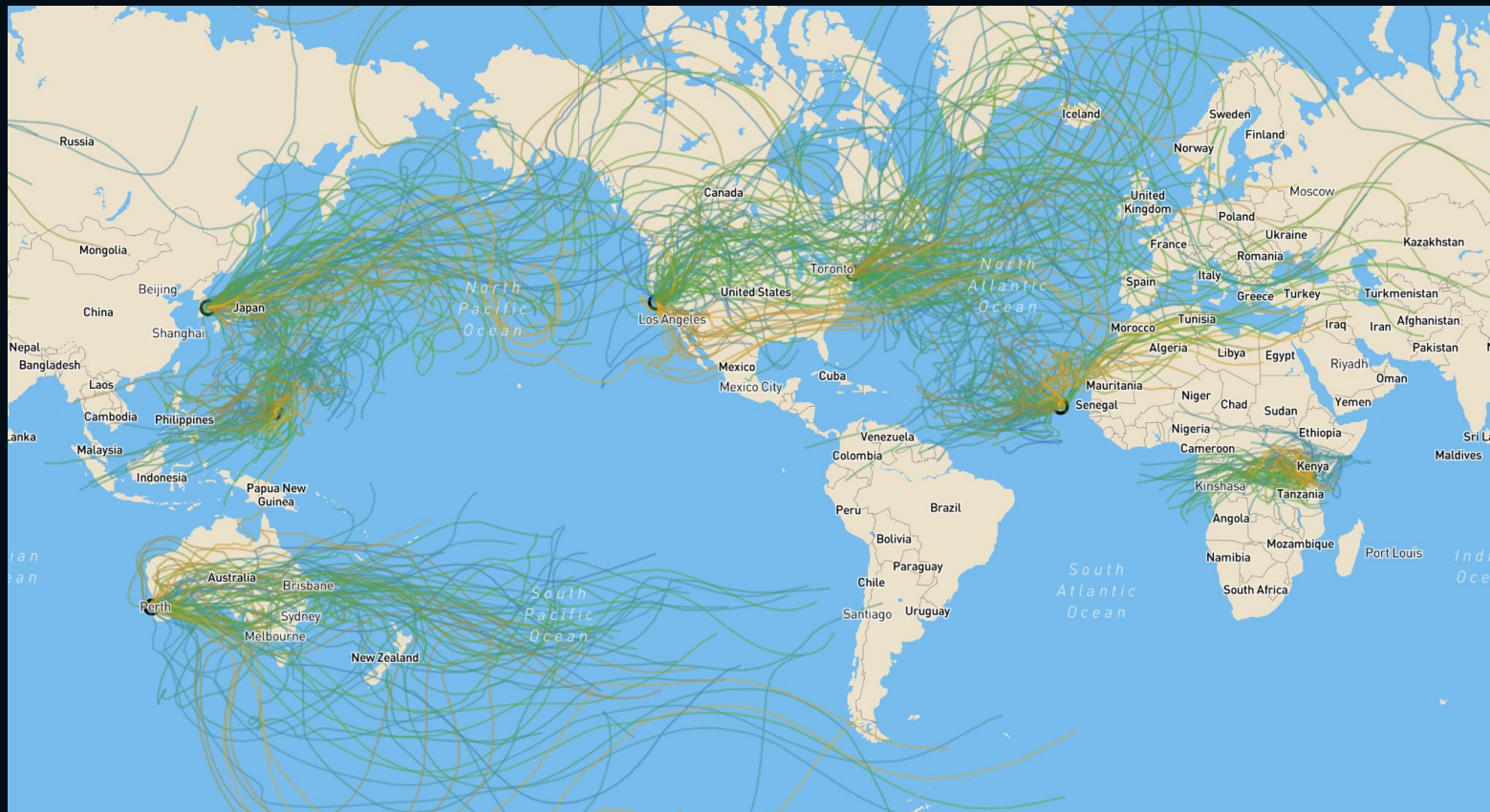
WindBorne Flights by Tropical Season

Period	Data	Coverage
6 Aug - 9 Oct 2022	167 flights 1892 soundings (27/day) 353955 total obs (5056/day) Field Campaign	
1 Aug - 30 Oct 2023	134 flights 1477 soundings (16/day) 353868 total obs (3889/day) Continuous Operations	
1 Aug - 30 Oct 2024	367 flights 3611 soundings (40/day) ~900,000 total obs (9900/day) Continuous Operations	

WindBorne Current and Planned Launch Locations



Typical Flight Paths in Aug/Sep/Oct



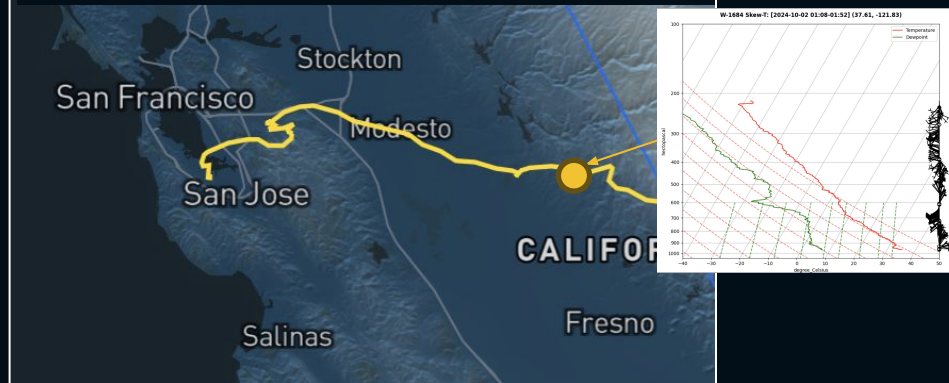
Dropsonde from Balloons

Provide soundings:

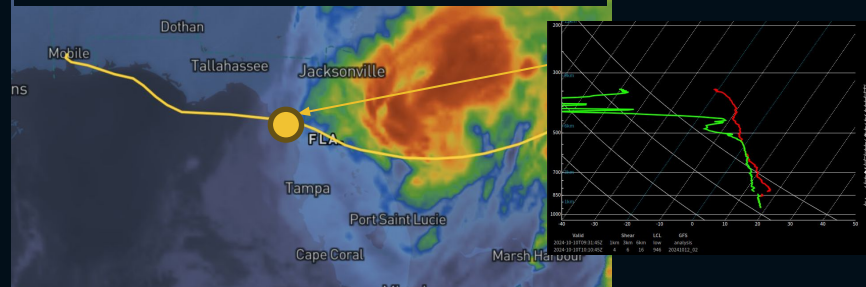
1. From ~100 mb to sfc
2. Within precipitation
3. One per flight now, multiple in future

During 2025 Tropical Season, many flights will have 1 or more dropsondes

Sonde dropped on 2 Oct 2024



Sonde dropped on 10 Oct 2024



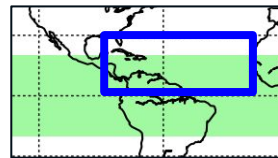
Summer 2022: Forecast Impact: Tropics



NOAA/EMC has run GFS retrospectively with and without WindBorne Observations

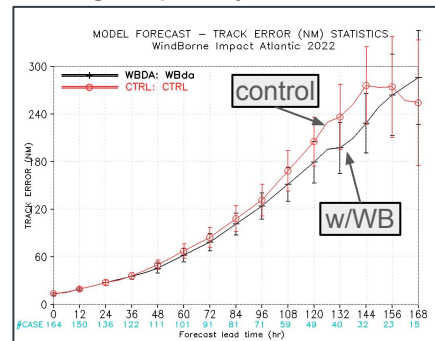
- Runs with obs yielded improved skill:
 - 1-3% reduction in 500 mb GPH errors 96-168 hour forecasts
 - Statistically significant reduction in forecast track; up to 18% at 132h
 - Large forecast track improvement for Hurricane Fiona

Bulk Statistics over tropical Atl.

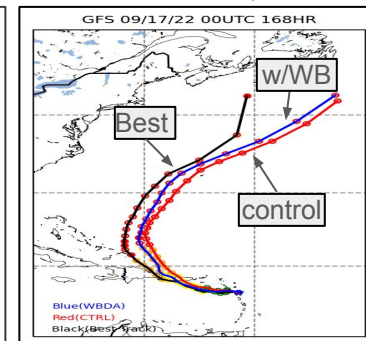


	168 h	120 h	96 h	72 h	midatl_hr	144 h	120 h
Height							
All Levels	-0.01 (-0.13)	-0.10 (-1.43)	-0.23 (-2.30)	-0.09 (-0.43)	-0.32 (-1.75)	-0.07 (-2.90)	-0.55 (-2.70)
50 - 250 mb	-0.03 (-0.29)	-0.13 (-1.29)	-0.13 (-0.89)	0.02 (0.43)	-0.32 (-0.90)	-0.05 (-2.29)	-0.97 (-2.29)
300 - 500 mb	-0.01 (-0.46)	-0.01 (-0.29)	0.10 (-1.90)	-0.02 (0.13)	-0.21 (0.26)	-0.40 (-0.90)	-0.97 (-2.90)
550 - 750 mb	0.01 (1.13)	-0.00 (-0.40)	-0.30 (-2.30)	-0.01 (-0.13)	-0.31 (-1.00)	-0.30 (-1.30)	-0.20 (-1.30)
800 - 1000 mb	0.01 (0.70)	-0.00 (-0.20)	-0.20 (-1.90)	-0.20 (-2.10)	-0.33 (-1.80)	-0.34 (-1.30)	-0.21 (-1.20)
Temperature							
All Levels	-0.00 (-0.20)	-0.00 (-0.40)	0.00 (0.40)	-0.00 (-0.40)	-0.01 (-0.70)	-0.02 (-1.40)	-0.02 (-1.40)
50 - 250 mb	-0.00 (-0.40)	-0.00 (-0.20)	0.00 (0.20)	-0.00 (-0.10)	-0.01 (-0.70)	-0.02 (-1.20)	-0.02 (-1.20)
300 - 500 mb	-0.00 (0.30)	0.00 (0.40)	0.00 (0.20)	-0.00 (-0.10)	-0.01 (-0.80)	-0.03 (-2.20)	-0.05 (-2.90)
550 - 750 mb	0.00 (0.13)	0.00 (0.40)	0.00 (0.13)	-0.00 (-0.20)	-0.00 (0.20)	-0.02 (-1.20)	-0.02 (-1.40)
800 - 1000 mb	-0.00 (-0.20)	-0.00 (-0.20)	0.00 (0.10)	-0.01 (-0.70)	-0.01 (-0.80)	-0.00 (0.20)	0.00 (0.20)
U wind							
All Levels	-0.01 (-0.50)	-0.02 (-0.60)	-0.02 (-0.60)	-0.04 (-0.90)	-0.09 (-1.70)	-0.08 (-1.50)	-0.08 (-1.40)
50 - 250 mb	-0.01 (-0.20)	-0.01 (-0.60)	0.03 (0.60)	-0.03 (-0.20)	-0.10 (-1.10)	-0.10 (-1.10)	-0.10 (-1.10)
300 - 500 mb	-0.00 (-0.10)	-0.00 (-0.60)	-0.02 (-0.40)	-0.04 (-0.60)	-0.09 (-1.50)	-0.08 (-1.00)	-0.09 (-1.50)
550 - 750 mb	-0.02 (-1.00)	-0.05 (-2.10)	-0.08 (-2.10)	-0.08 (-2.10)	-0.10 (-2.20)	-0.09 (-2.00)	-0.04 (-0.50)
800 - 1000 mb	-0.02 (-1.00)	-0.05 (-2.10)	-0.08 (-2.10)	-0.08 (-2.10)	-0.09 (-1.50)	-0.09 (-1.20)	-0.01 (-0.20)
V wind							
All Levels	-0.02 (-0.60)	-0.01 (-0.20)	-0.01 (-0.20)	-0.04 (-0.70)	-0.07 (-1.20)	-0.07 (-1.20)	-0.07 (-1.20)
50 - 250 mb	-0.02 (-0.60)	-0.01 (-0.20)	0.00 (0.10)	-0.04 (-0.60)	-0.02 (0.10)	-0.07 (-0.70)	-0.09 (-0.80)
300 - 500 mb	-0.01 (-0.20)	0.01 (0.10)	-0.01 (-0.20)	-0.01 (-0.20)	-0.01 (-0.60)	-0.03 (-0.60)	-0.04 (-0.60)
550 - 750 mb	-0.02 (-0.60)	-0.02 (-0.40)	-0.04 (-0.90)	-0.04 (-0.60)	-0.05 (-1.00)	-0.08 (-1.50)	-0.08 (-1.50)
800 - 1000 mb	-0.01 (-0.60)	-0.01 (-0.20)	-0.02 (-0.50)	-0.03 (-0.60)	-0.09 (-2.00)	-0.09 (-2.00)	-0.04 (-0.40)
Relative Humidity							
All Levels	-0.04 (-0.20)	-0.04 (-0.10)	-0.02 (-0.10)	-0.02 (-0.40)	0.04 (0.20)	-0.03 (-0.10)	-0.14 (-0.50)
50 - 250 mb	-0.04 (-0.20)	-0.07 (-0.20)	-0.00 (0.10)	0.02 (0.10)	-0.02 (-0.40)	-0.11 (-0.50)	-0.09 (-0.20)
300 - 500 mb	-0.07 (-0.20)	0.01 (0.10)	-0.08 (-0.20)	0.01 (0.10)	0.20 (0.70)	0.11 (0.30)	-0.21 (-0.50)
550 - 750 mb	-0.04 (-0.20)	-0.06 (-0.20)	-0.01 (-0.60)	-0.07 (-0.20)	-0.03 (-0.60)	-0.09 (-0.50)	-0.09 (-0.50)
800 - 1000 mb	-0.05 (-0.20)	-0.06 (-0.40)	0.00 (0.10)	-0.04 (-0.20)	-0.07 (-0.40)	-0.08 (-0.40)	-0.07 (-0.20)

Average tropical cyclone track error



Fiona track comparison



Summer 2023: Forecast Impact: Tropics

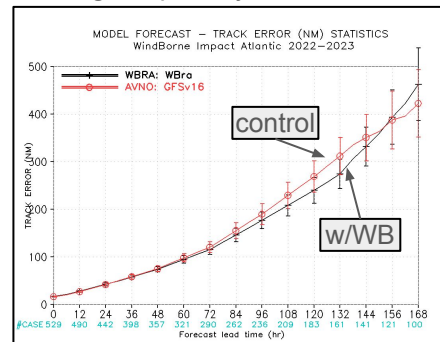


NOAA/EMC has run GFS retrospectively with and without WindBorne Observations

- Runs with obs yielded improved skill:
 - 1-3% reduction in 500 mb GPH errors 96-168 hour forecasts
 - Statistically significant reduction in forecast track; up to 15% at 132h
 - Case study results ongoing
- Second year with statistically significant positive impact in forecast tracks



Average tropical cyclone track error

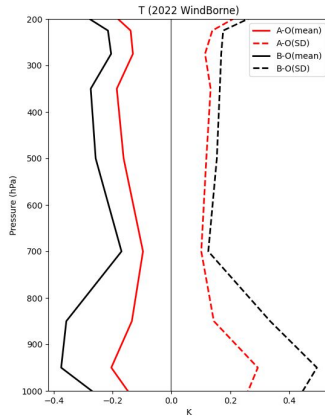


GFS Forecast Impact Studies

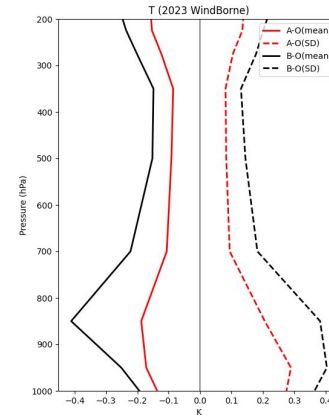
Data Assimilation Cycles: are reducing A-O smaller than B-O



2022 Season

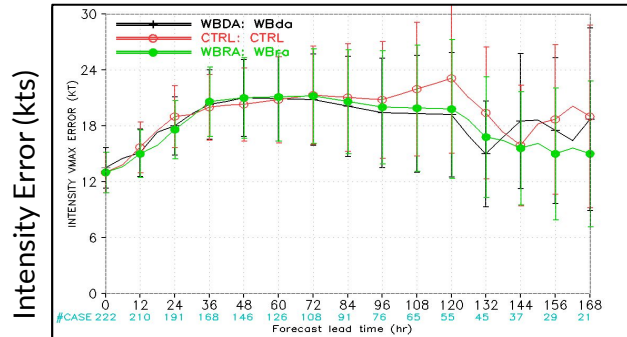
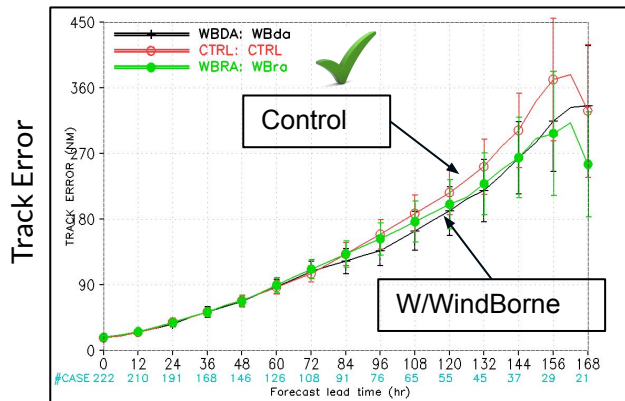


2023 Season

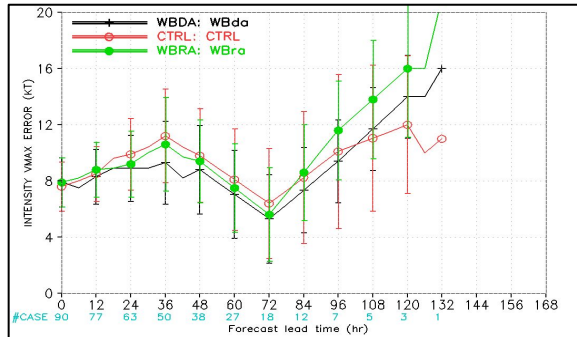
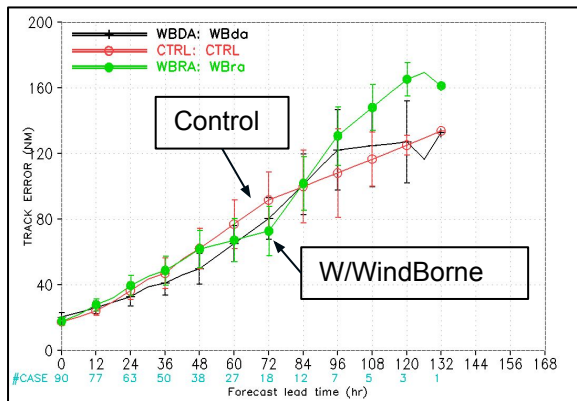


GFS Forecast Impact Studies: 2022

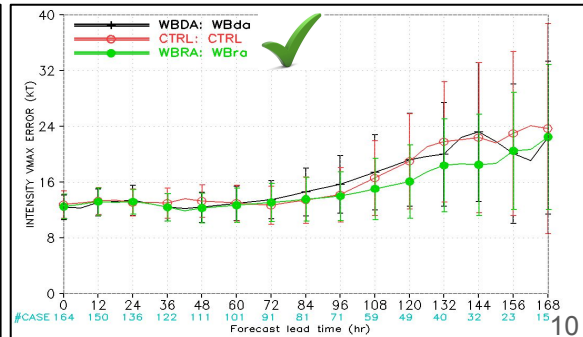
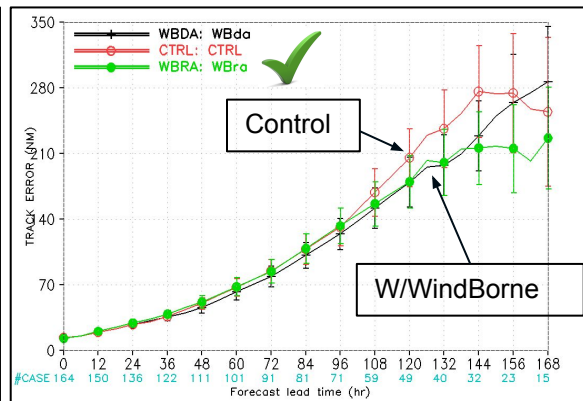
West Pac



East Pac

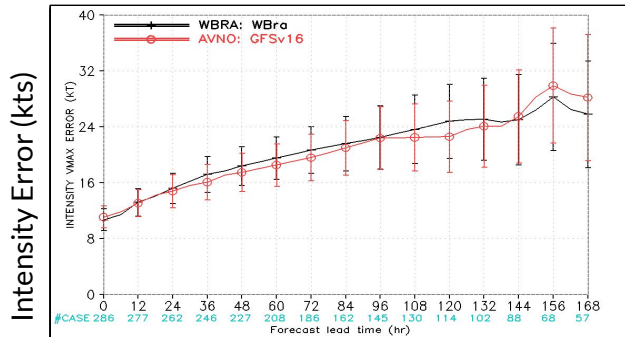
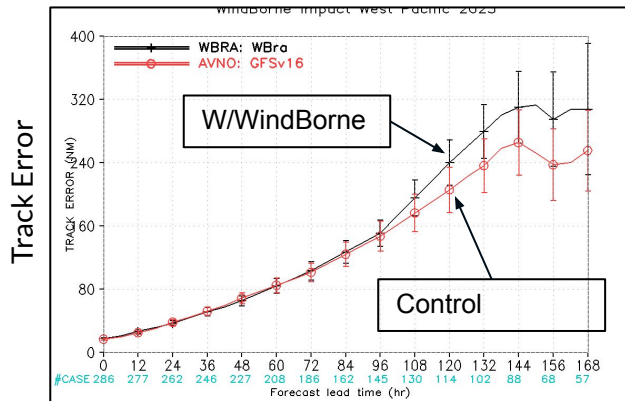


Atlantic

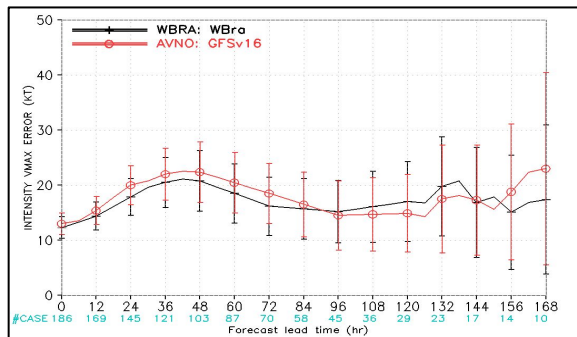
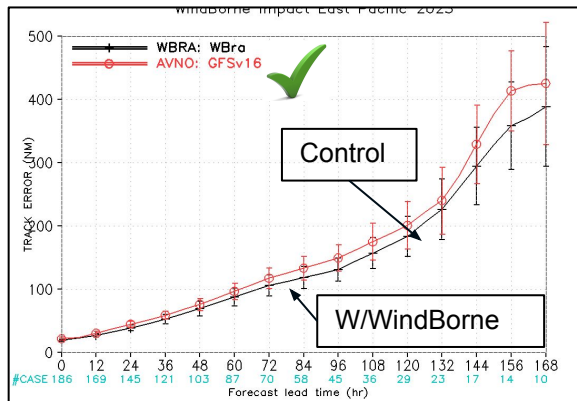


GFS Forecast Impact Studies: 2023

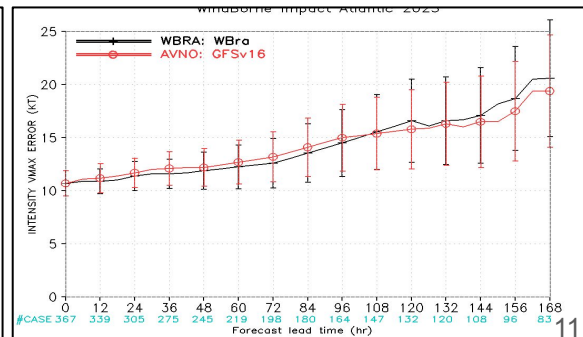
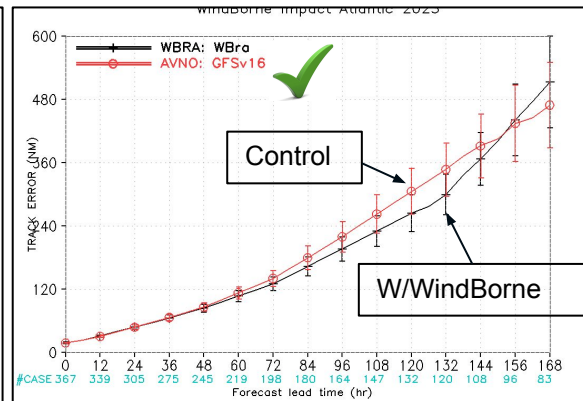
West Pac



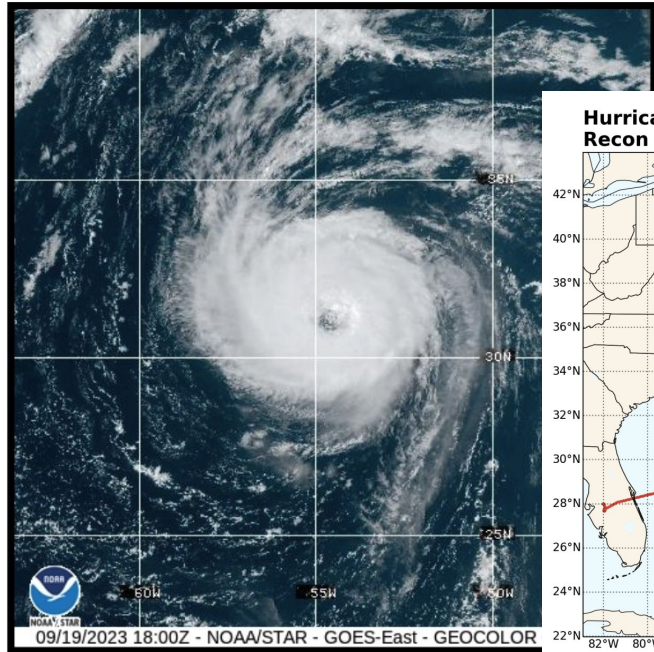
East Pac



Atlantic

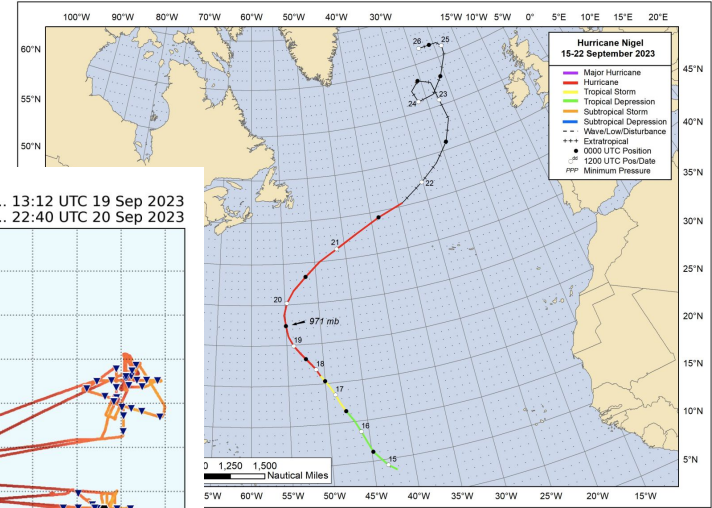
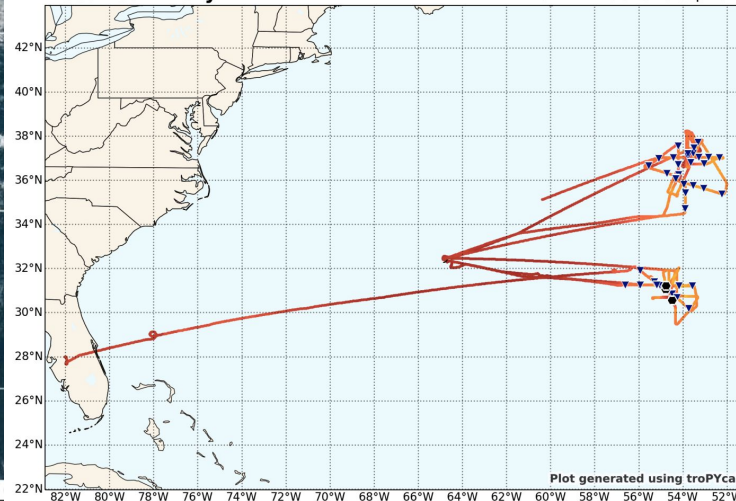


Hurricane Nigel Analysis

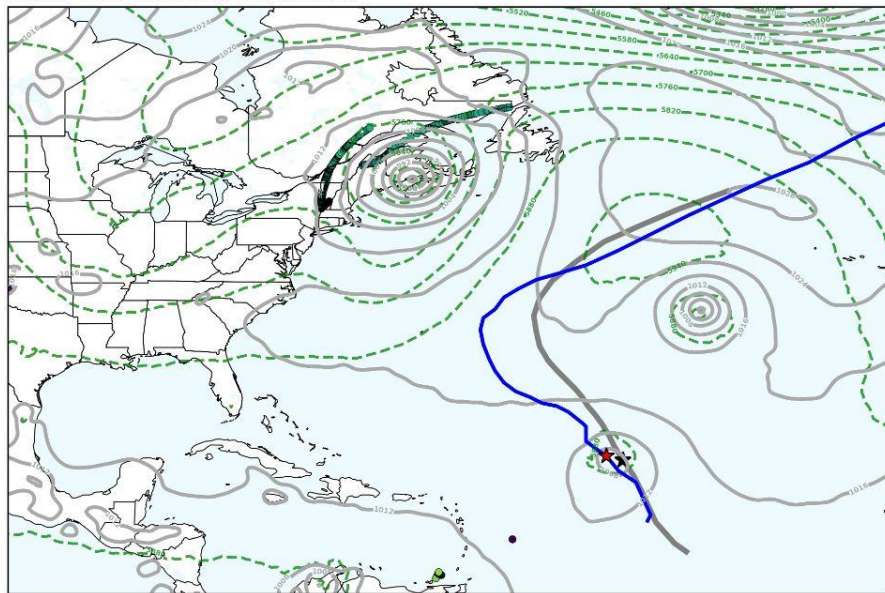


Hurricane NIGEL Recon summary

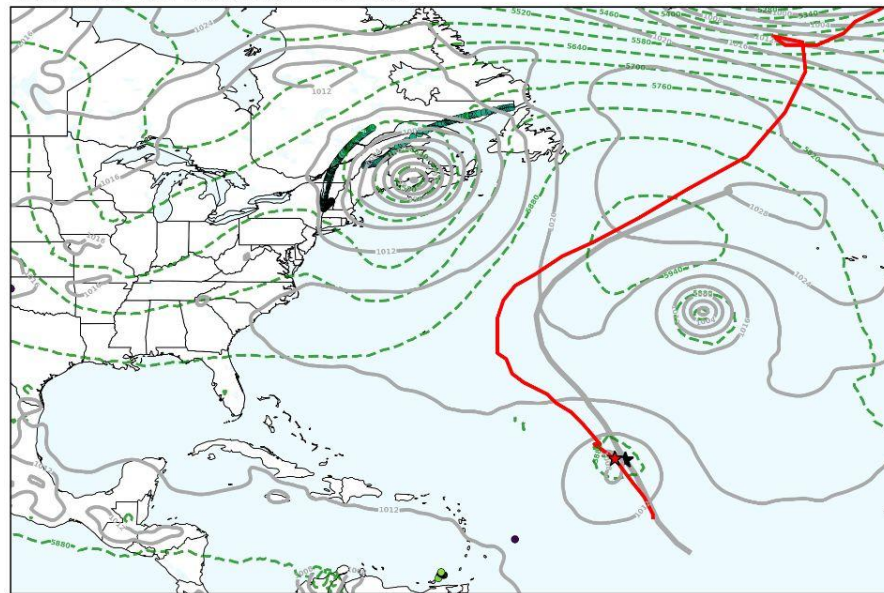
Start ... 13:12 UTC 19 Sep 2023
End ... 22:40 UTC 20 Sep 2023



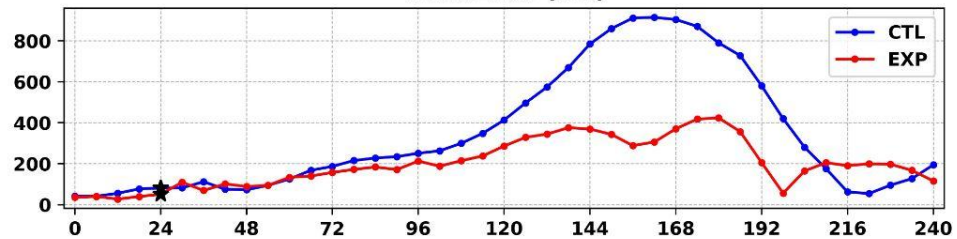
Control - MSLP and precip(mm/6h,shaded)



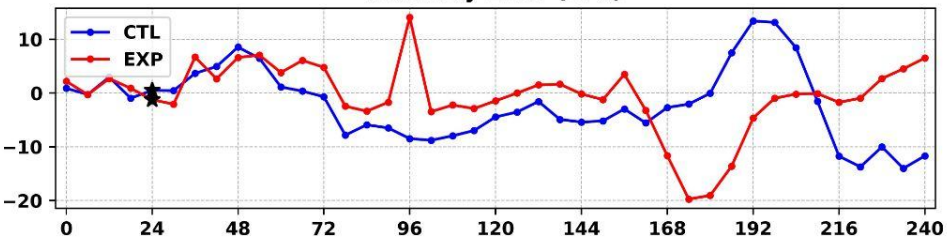
Experimental - MSLP and precip(mm/6h,shaded)



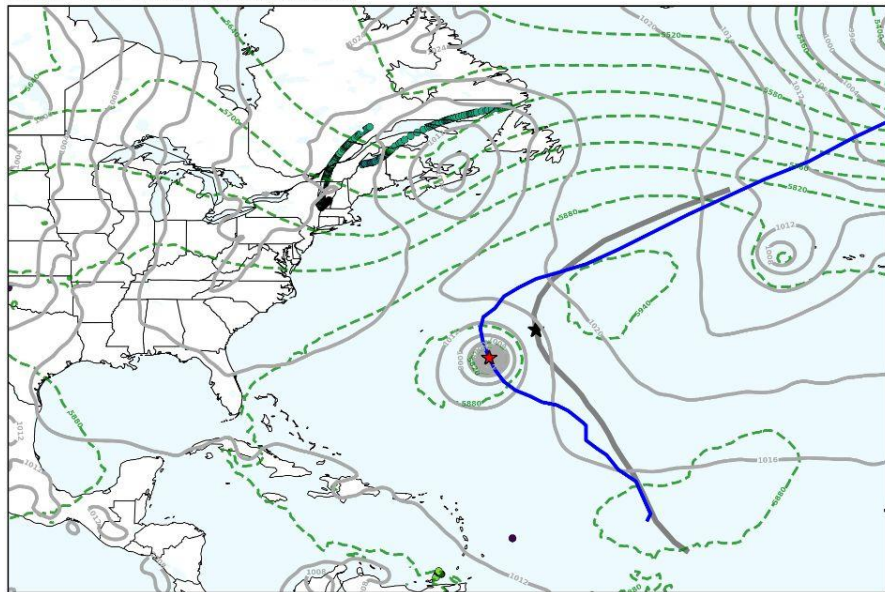
Track Error (NM)



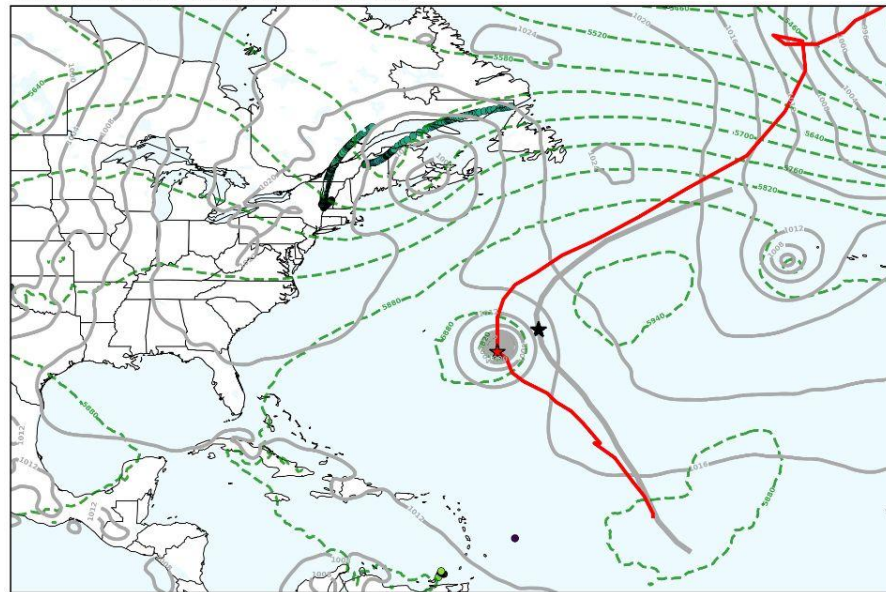
Intensity Error (hPa)



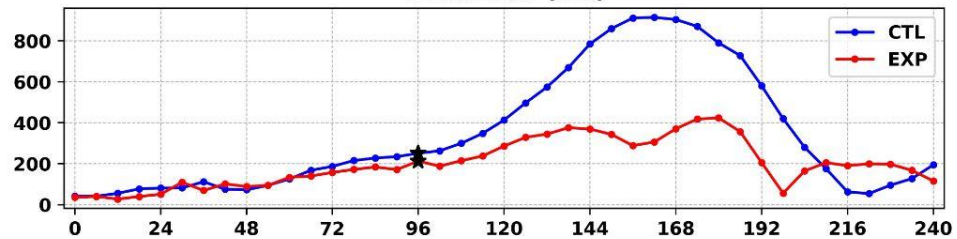
Control - MSLP and precip(mm/6h,shaded)



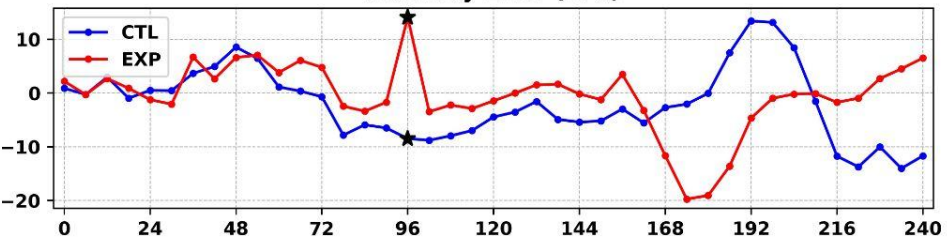
Experimental - MSLP and precip(mm/6h,shaded)



Track Error (NM)

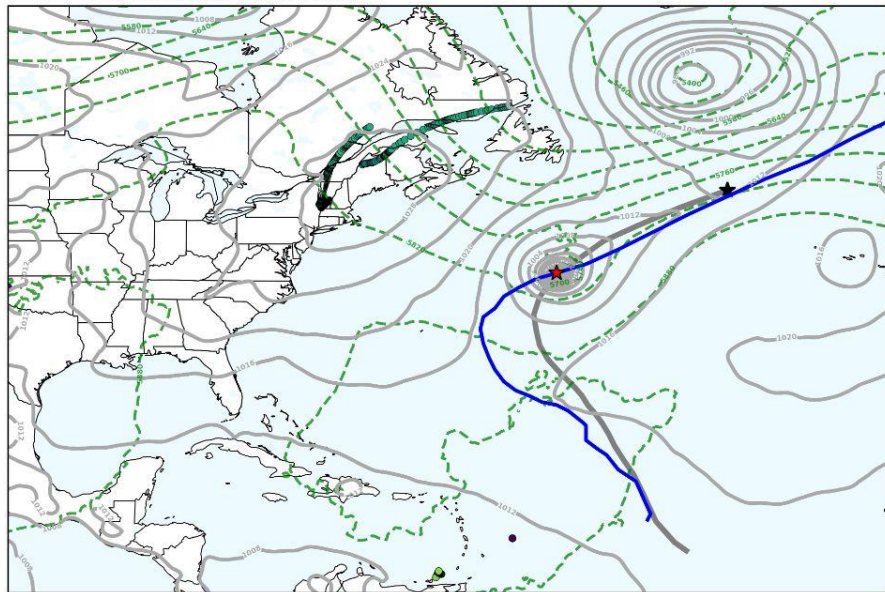


Intensity Error (hPa)

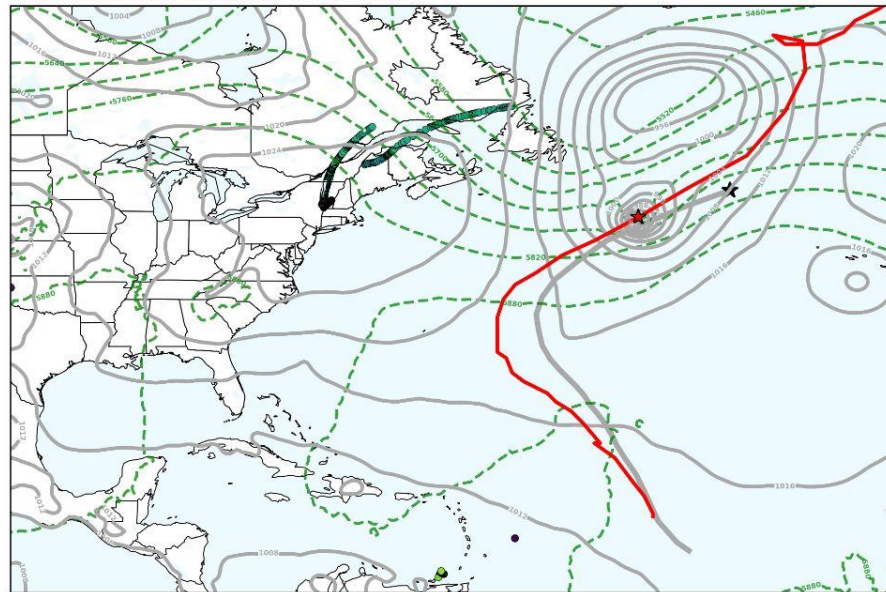


Hurricane Nigel - Initialization Date: 2023091600 - Fhr: 144 - Valid Date: 2023091600

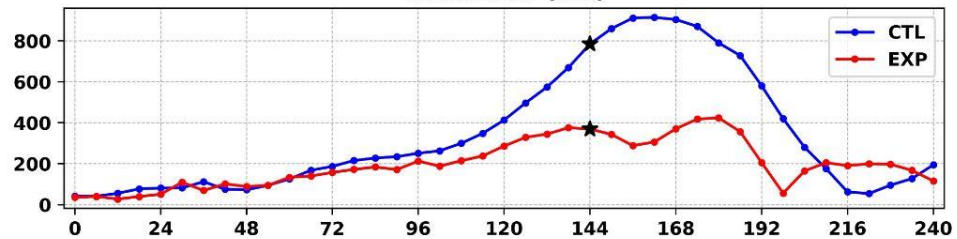
Control - MSLP and precip(mm/6h,shaded)



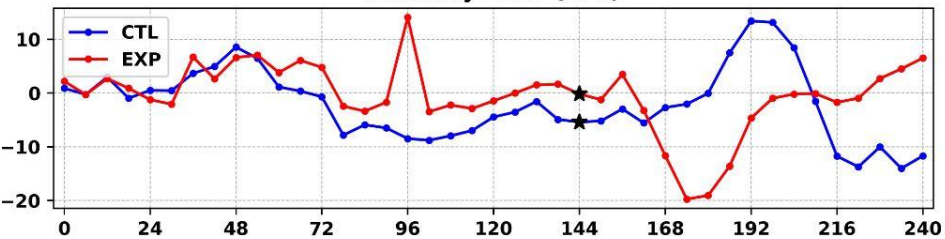
Experimental - MSLP and precip(mm/6h,shaded)



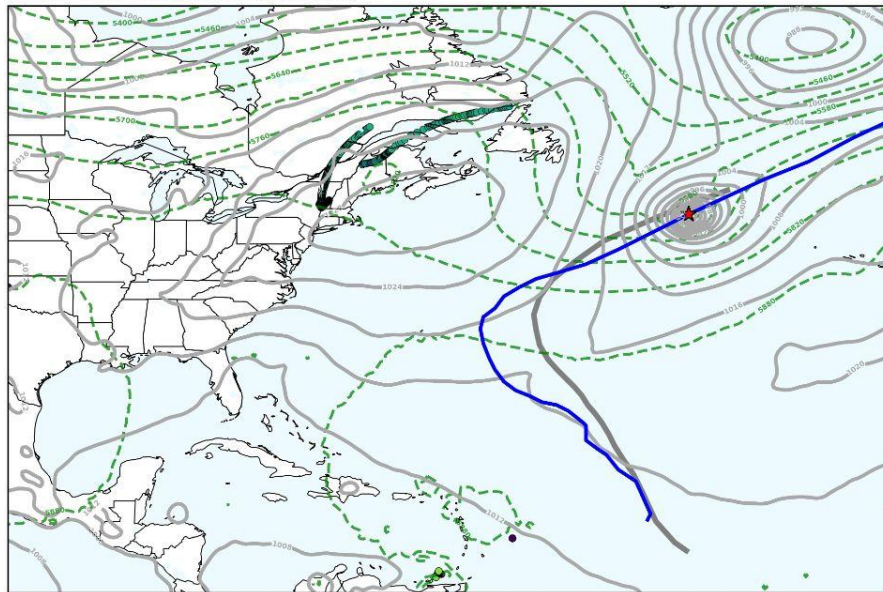
Track Error (NM)



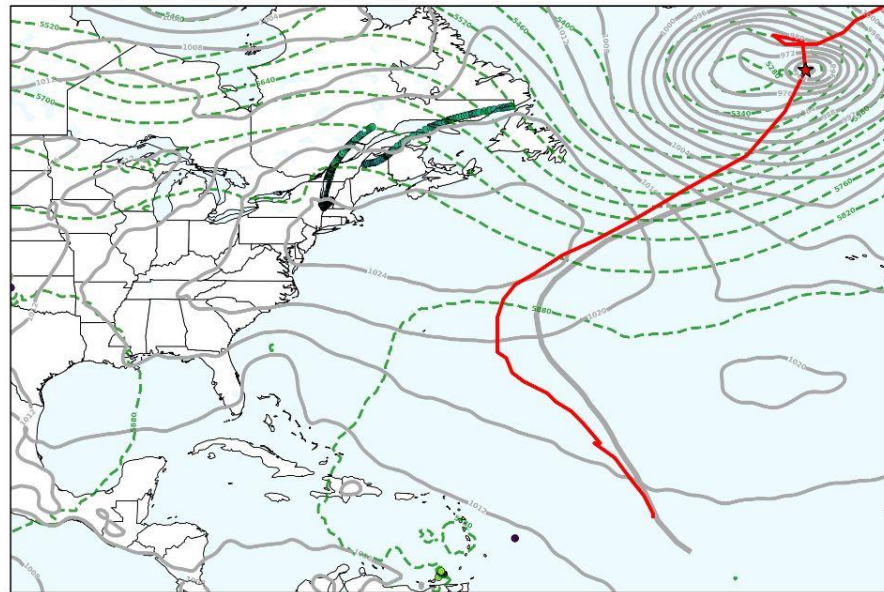
Intensity Error (hPa)



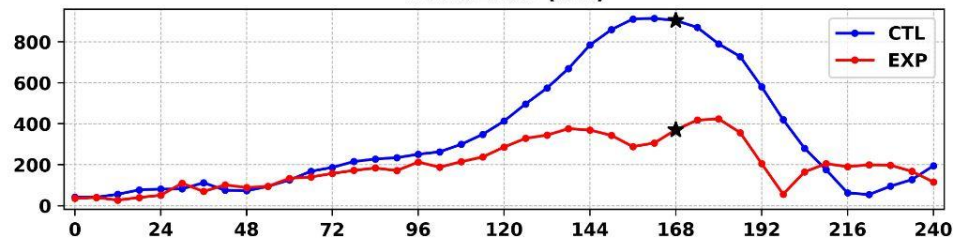
Control - MSLP and precip(mm/6h,shaded)



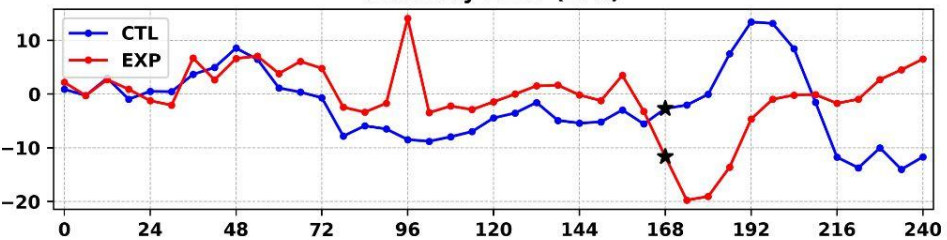
Experimental - MSLP and precip(mm/6h,shaded)



Track Error (NM)

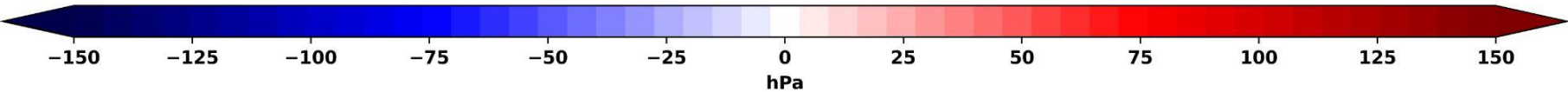
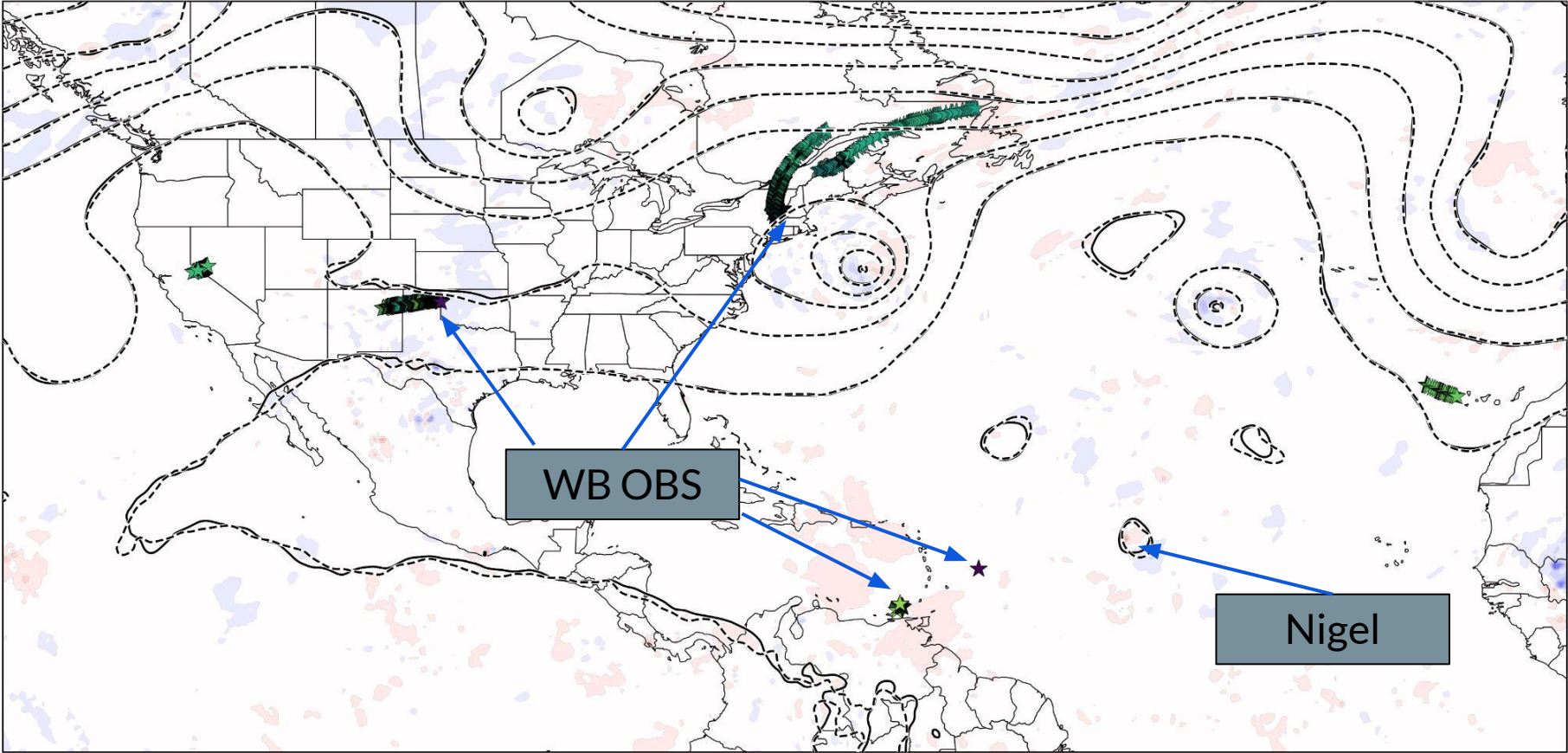


Intensity Error (hPa)

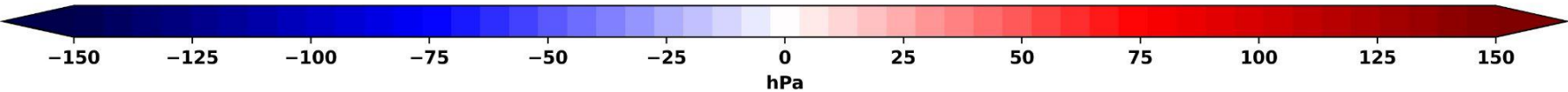
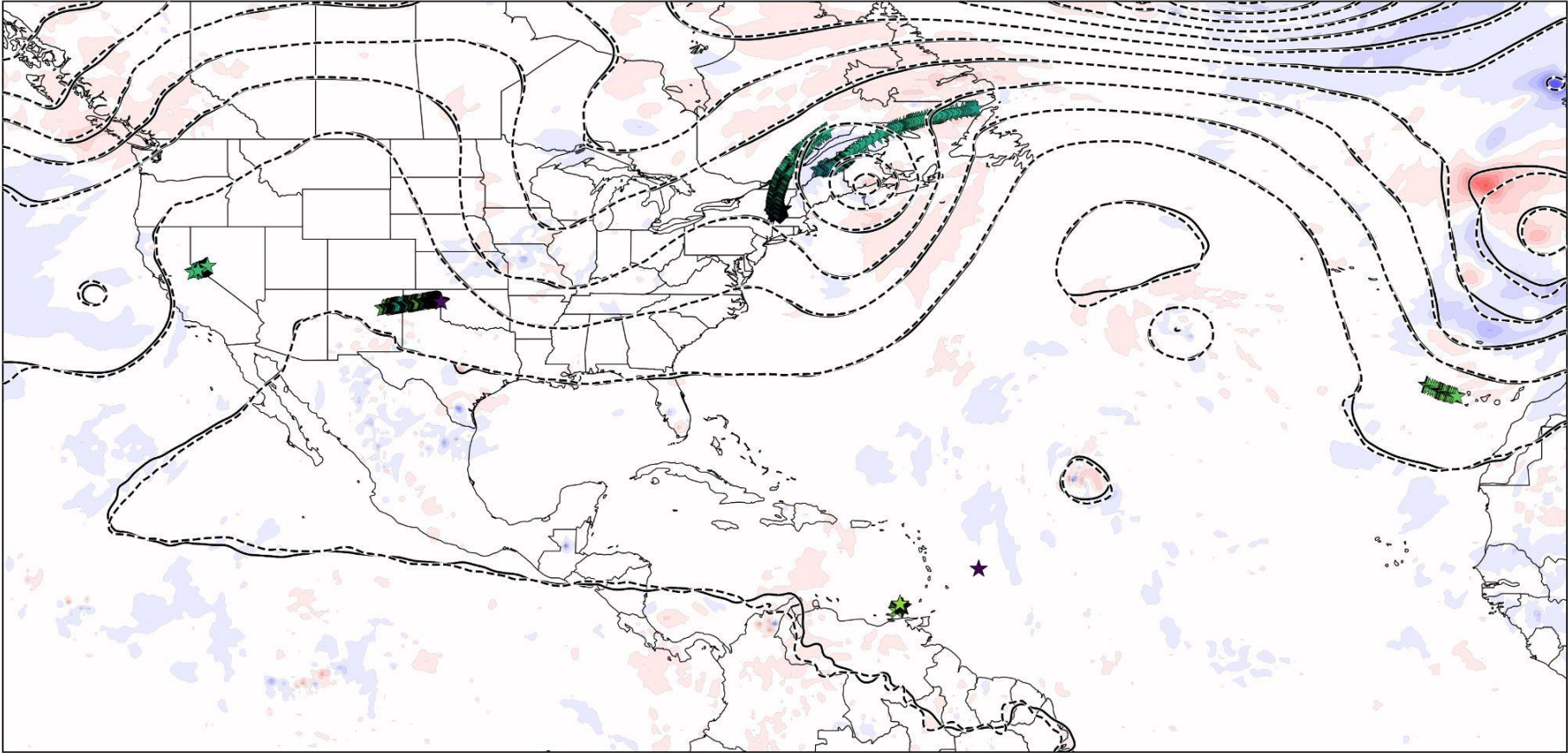


500 mb

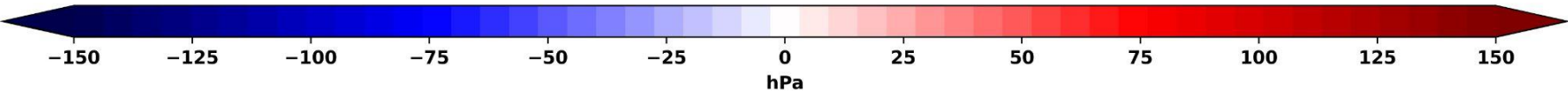
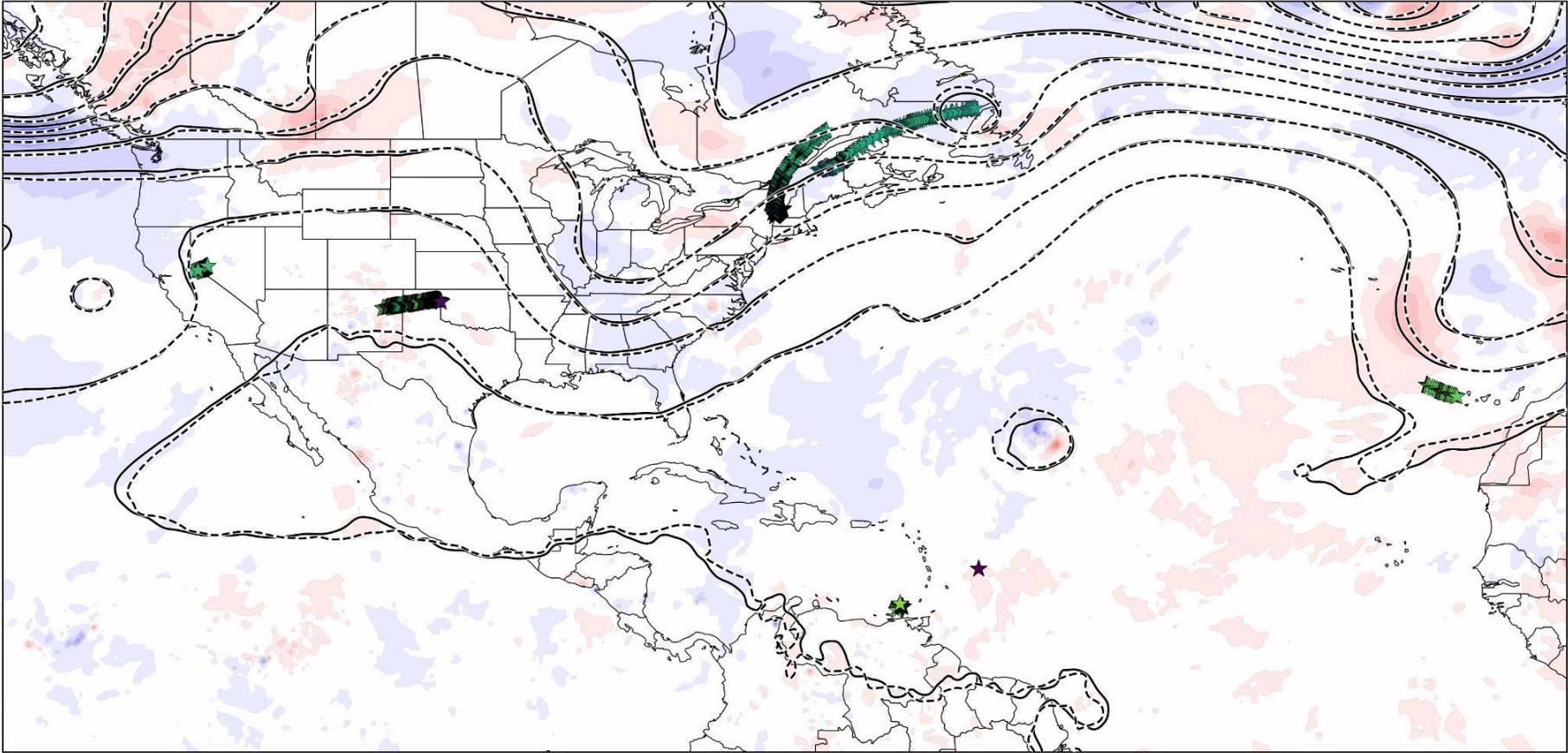
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 0 - Valid: 20230916 00z



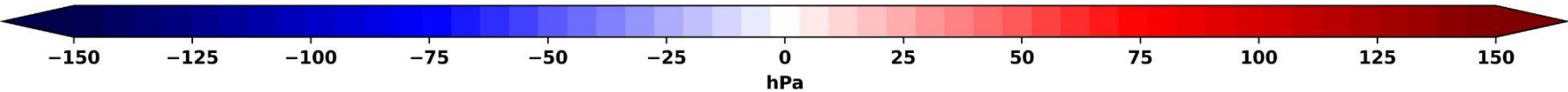
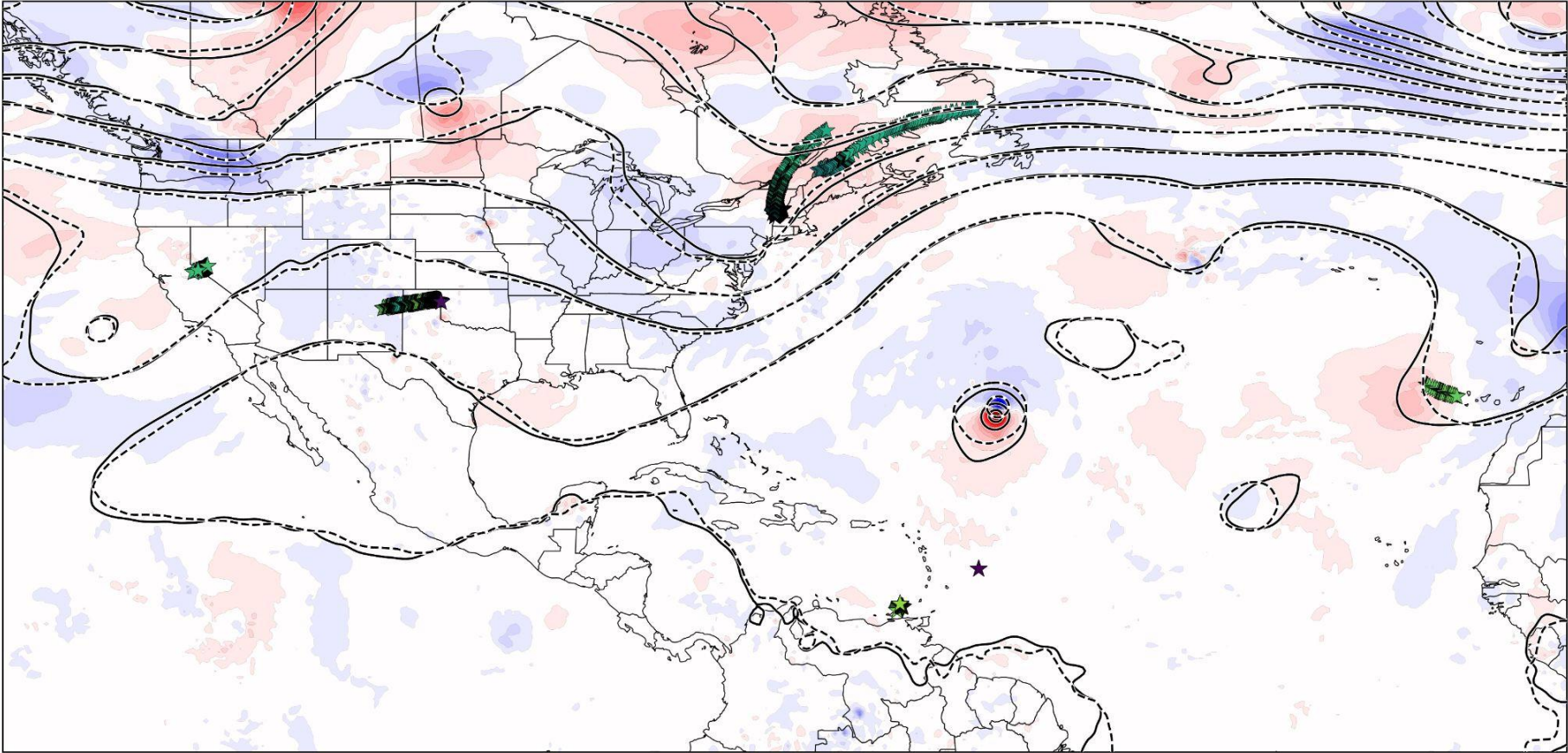
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 24 - Valid: 20230917 00z



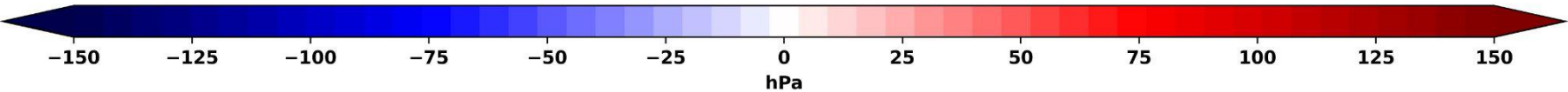
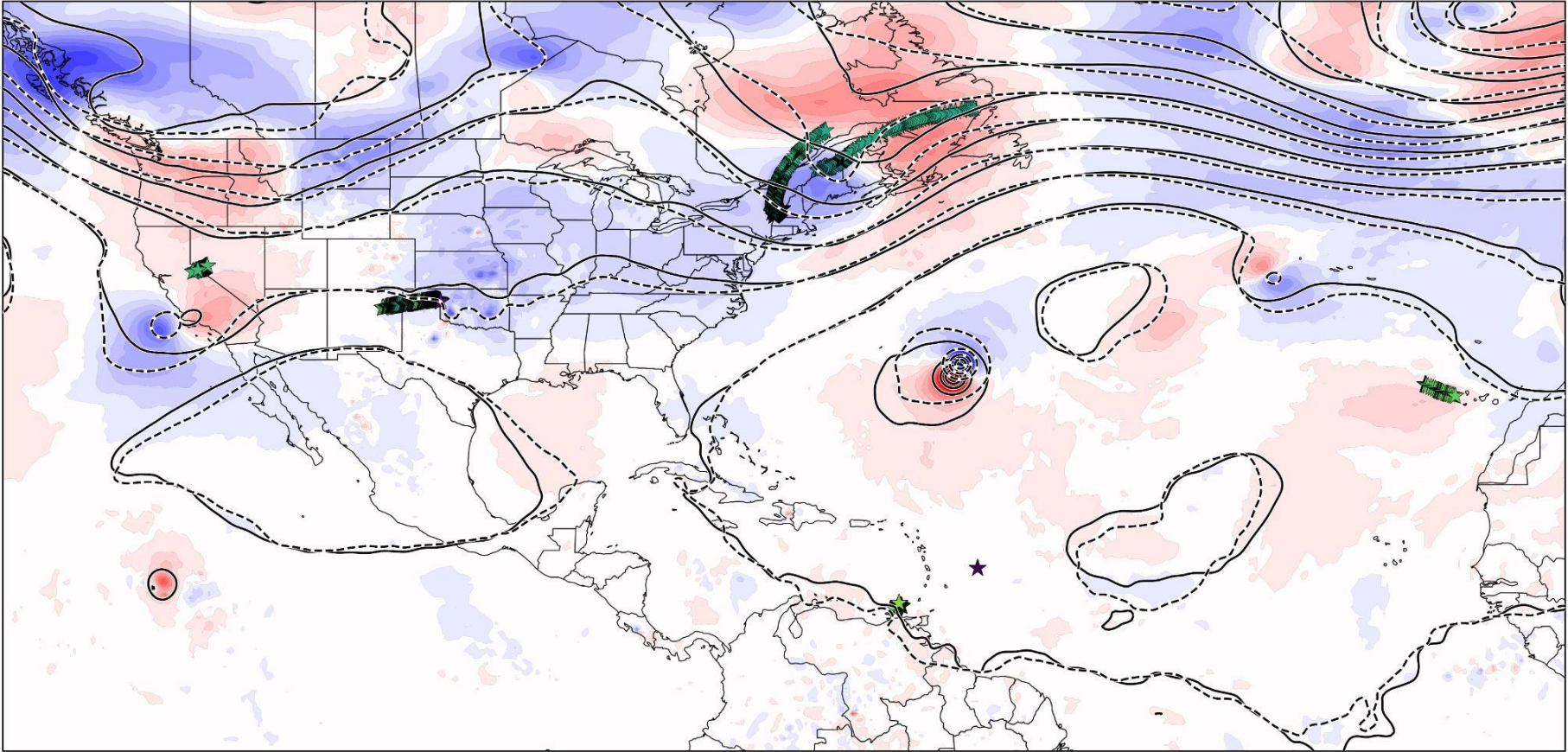
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 48 - Valid: 20230918 00z

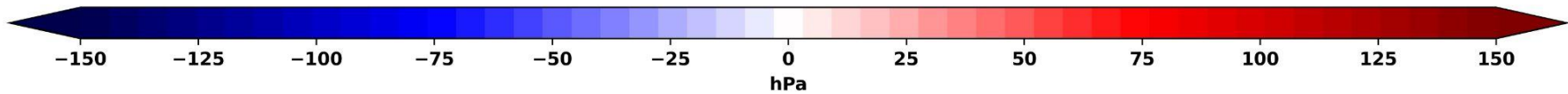


500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 72 - Valid: 20230919 00z

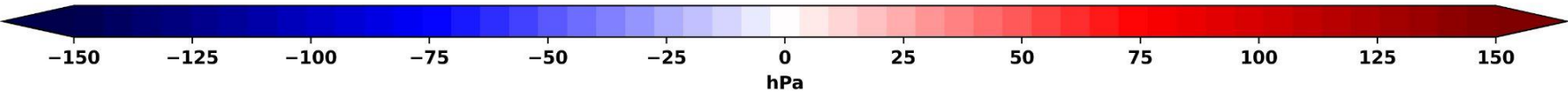
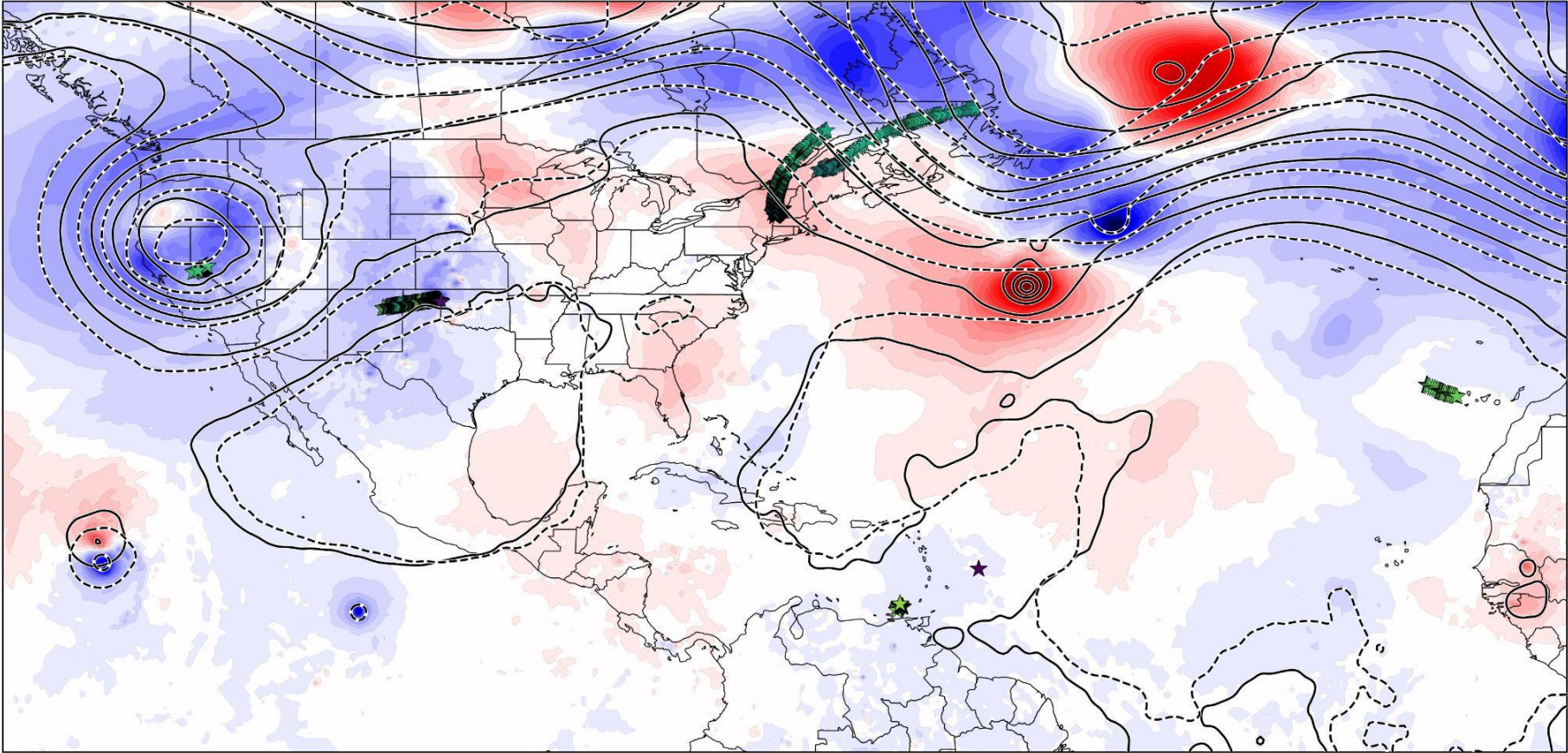


500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 96 - Valid: 20230920 00z

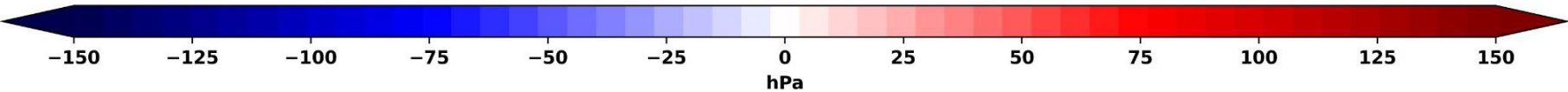
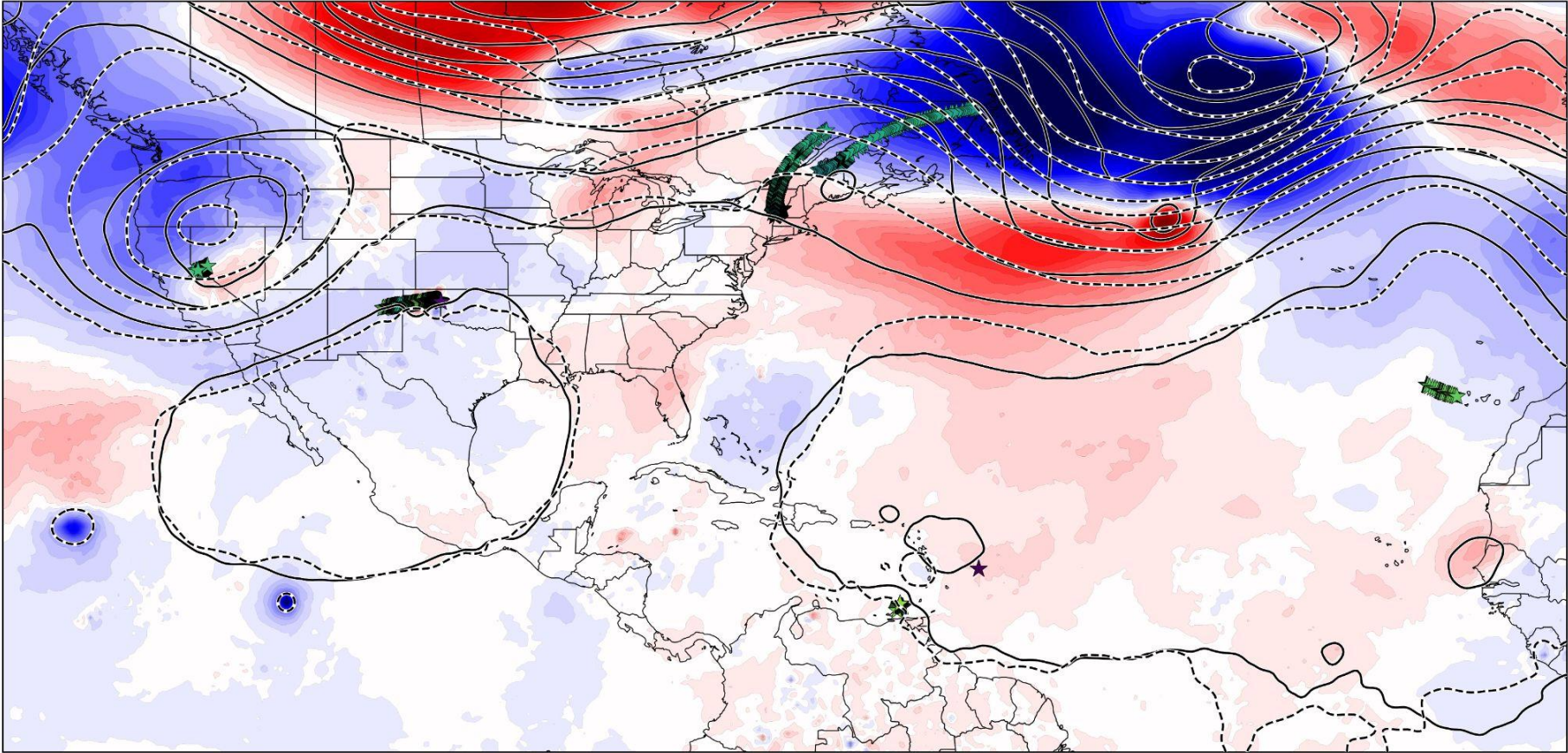




500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 144 - Valid: 20230922 00z



500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 168 - Valid: 20230923 00z



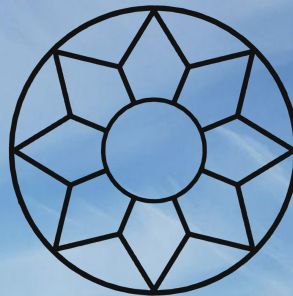
Data Availability

WindBorne web site access and data is available upon request:

todd@windbornesystems.com

bufr, netcdf, textual, skew-T images available

Some data available over WMO Global
Telecommunication System



Thank you