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

Todd Hutchinson[*], Chris Riedel[*], Andrey Sushko[*], Xingren Wu[+], Vijay Tallapragada[+], Michael Mueller[^], Lidia Cucurull[^]

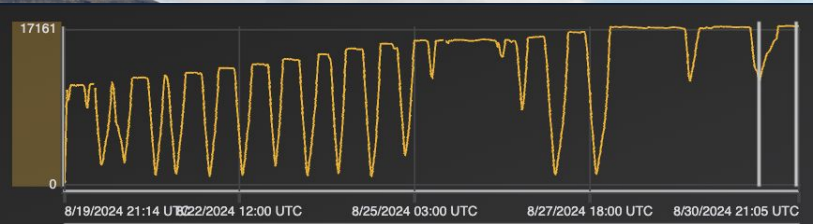
[*]WindBorne Systems
[+]NOAA Environmental Modeling Center
[^]NOAA QOSAP

14 November 2024

WindBorne

Global sensing for better weather forecasts

Global Sounding Balloon (GSB)

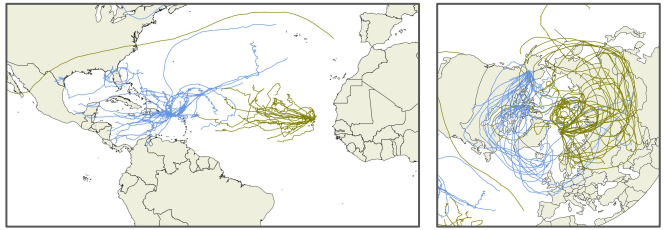
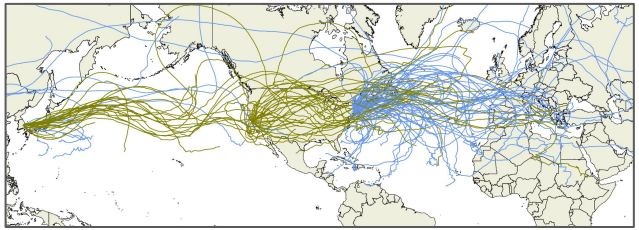
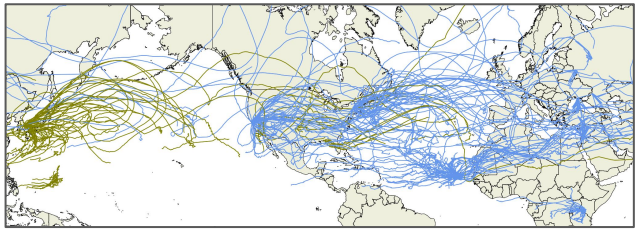


WindBorne

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

WindBorne

2024 Plan

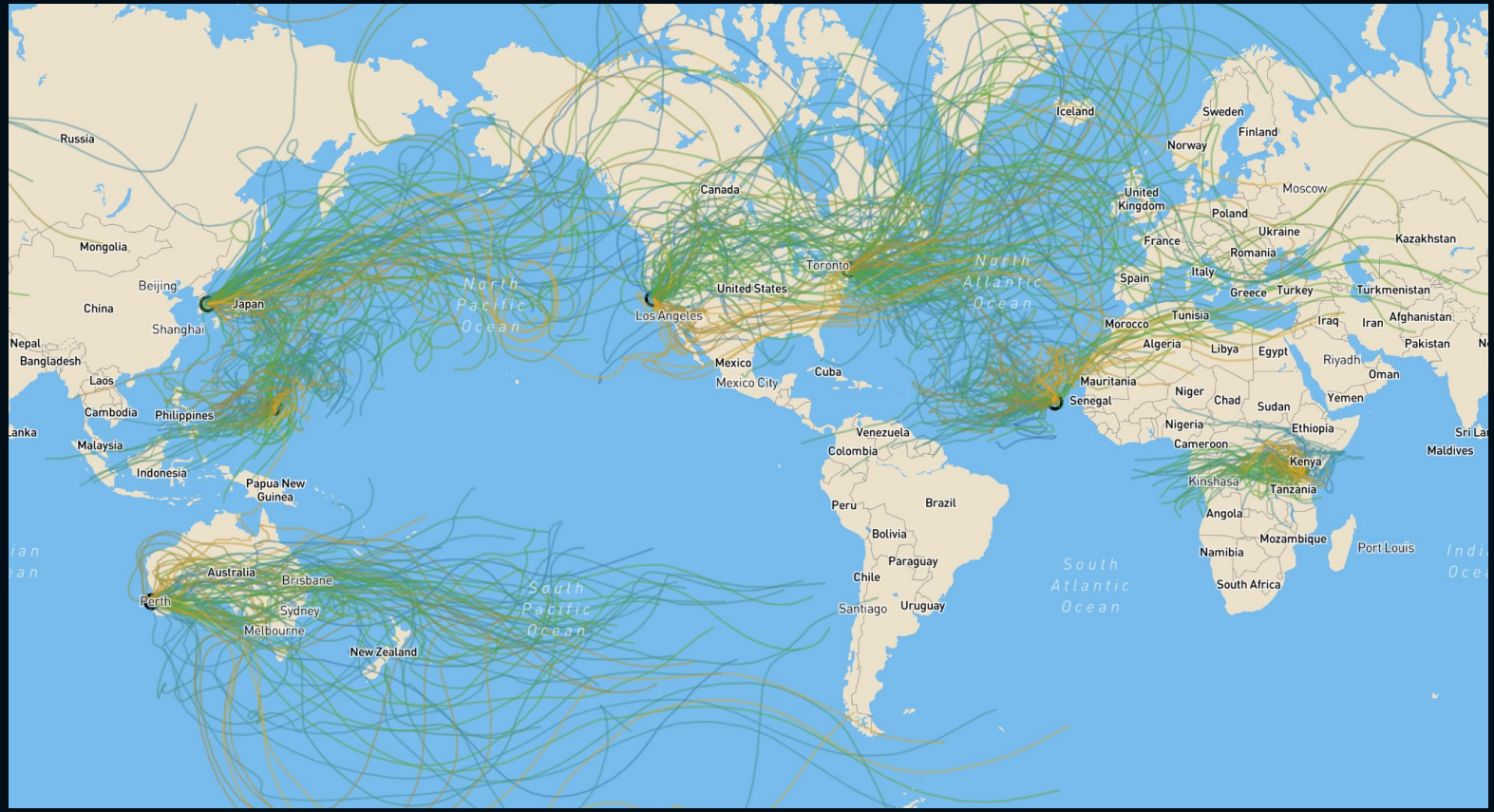
Q3: 100 flights/mo (20 flights aloft)

End Q4: 185 flights/mo (40 flights aloft)

This does not include developmental or test launches

Typical Flight Paths in Aug/Sep/Oct

WindBorne



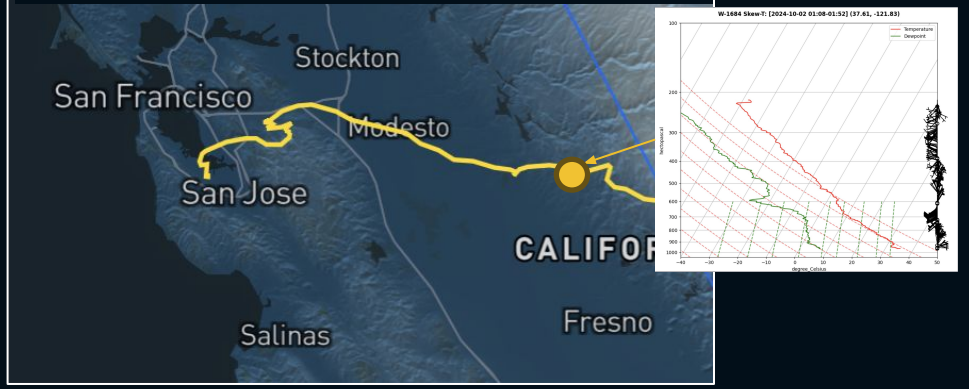
Dropsonde from Balloons

WindBorne

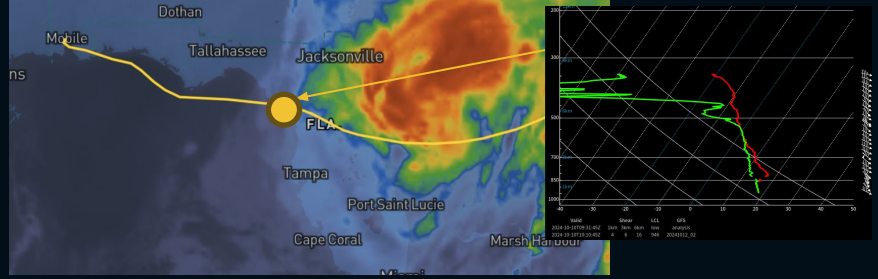
Provide soundings:
1. From ~100 mb to sfc
2. Within precipitation
3. One per flight now, multiple in future

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

Sonde dropped on 2 Oct 2024



Sonde dropped on 10 Oct 2024

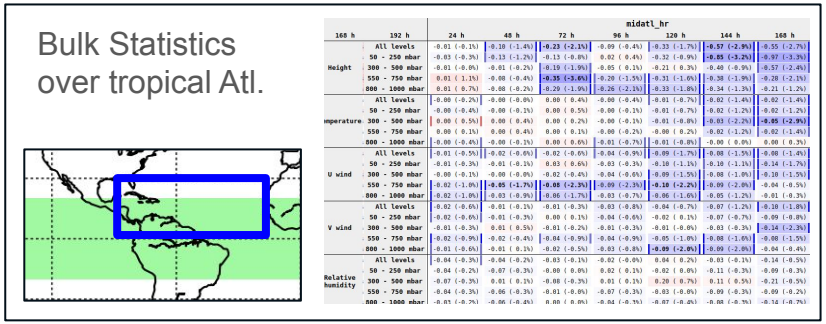


Summer 2022: Forecast Impact: Tropics

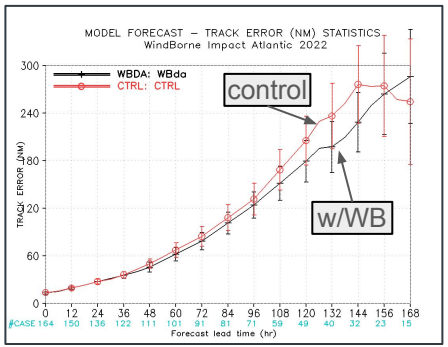
WindBorne

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

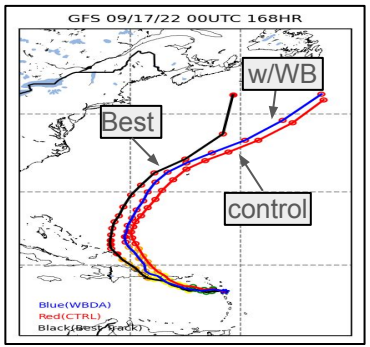
- Runs with obs yielded improved skill:
  - 1-3% reduction in 500 mb GPH errors 96-168 hour forecasts
  - Statistically significant reduction in forecast track; up to 18% at 132h
  - Large forecast track improvement for Hurricane Fiona



Average tropical cyclone track error



Fiona track comparison

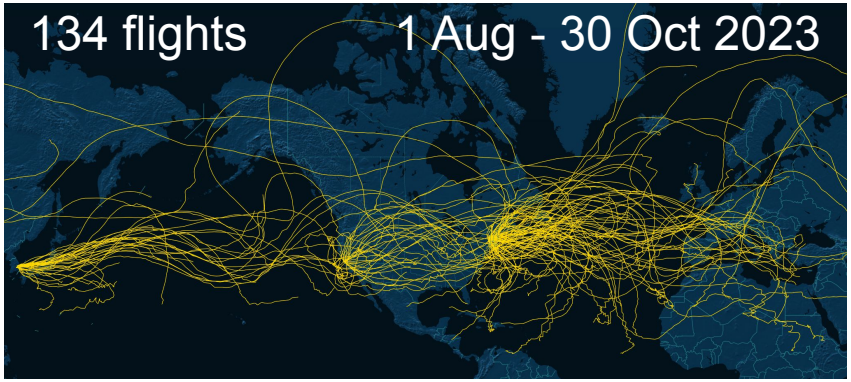


Summer 2023: Forecast Impact: Tropics

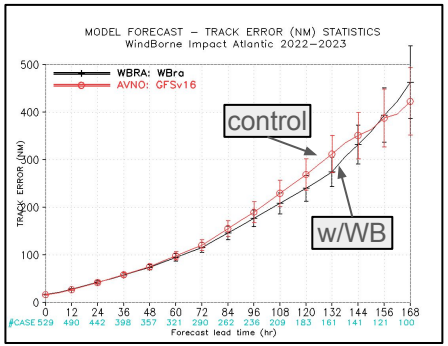
WindBorne

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



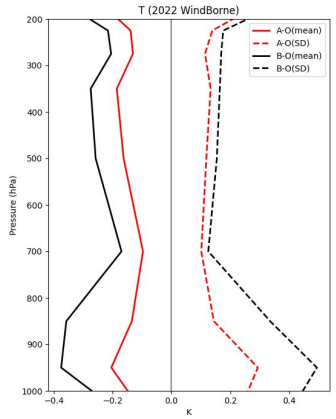
Average tropical cyclone track error



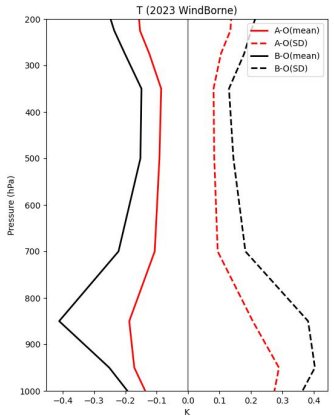
GFS Forecast Impact Studies

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

2022 Season



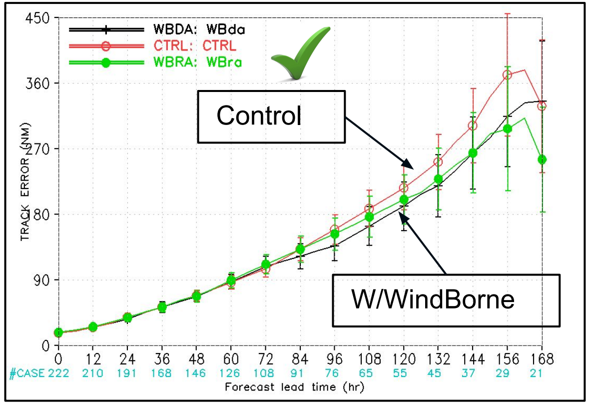
2023 Season

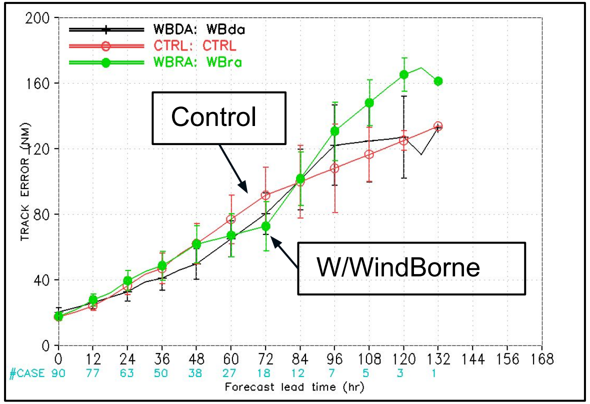


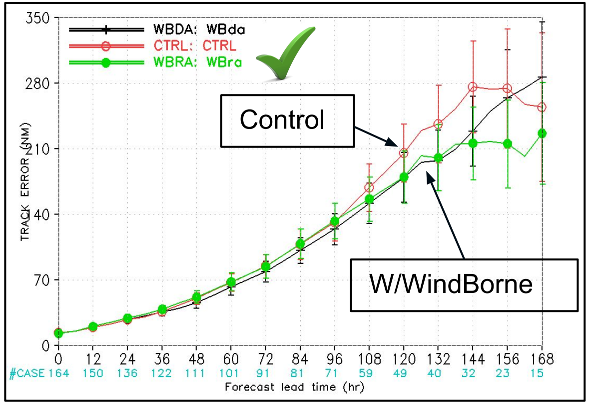
GFS Forecast Impact Studies: 2022

West Pac | East Pac | Atlantic

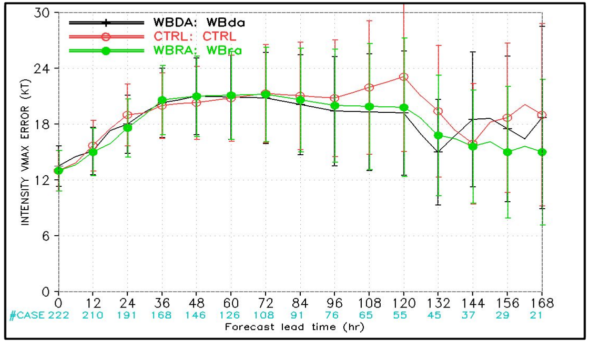
Track Error

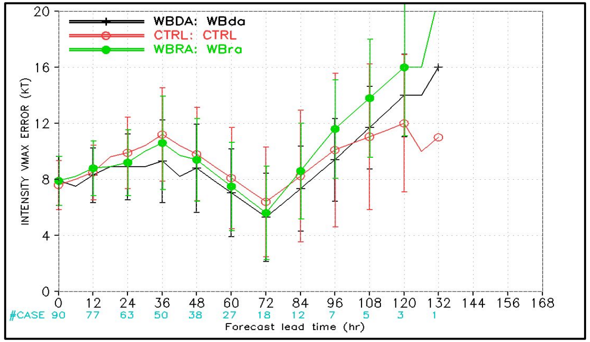


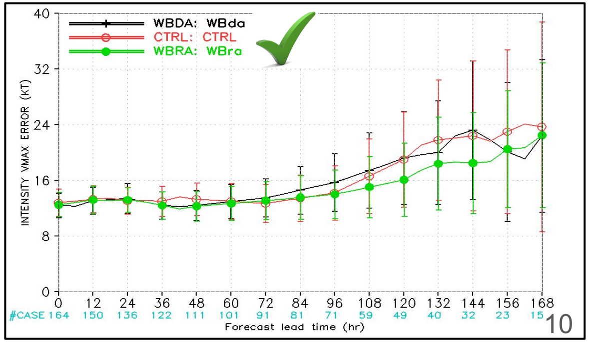




Intensity Error (kts)



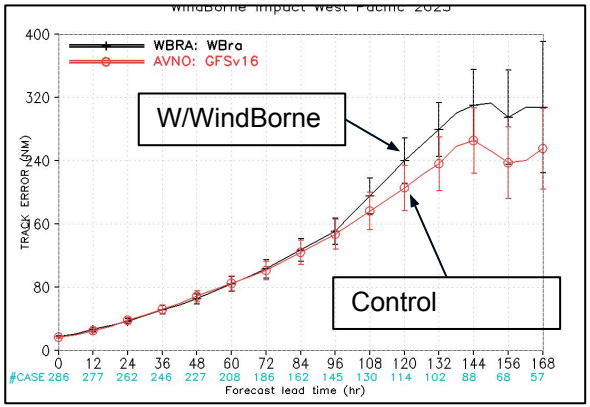


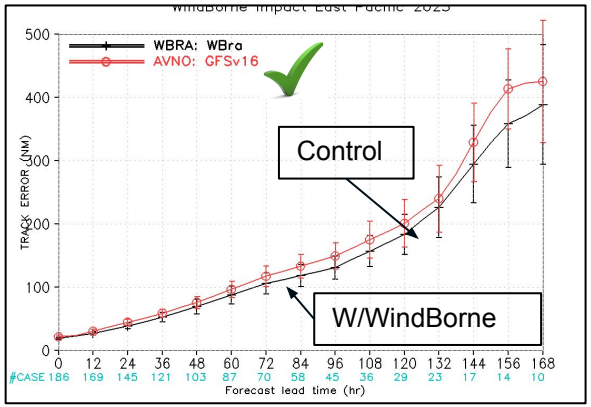


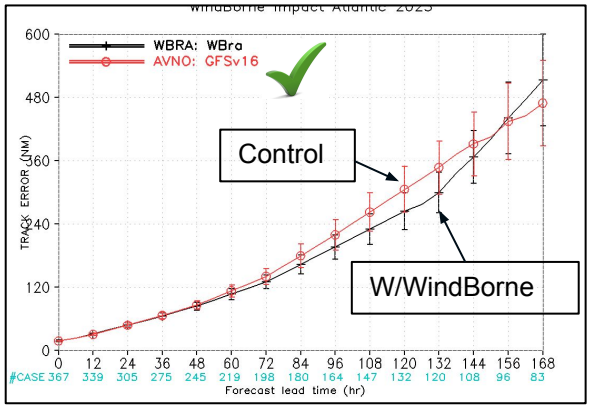
GFS Forecast Impact Studies: 2023

West Pac | East Pac | Atlantic

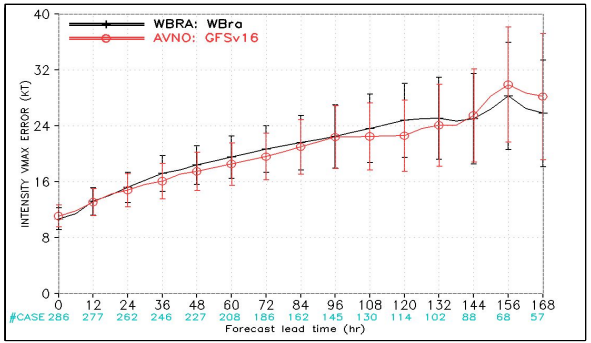
Track Error

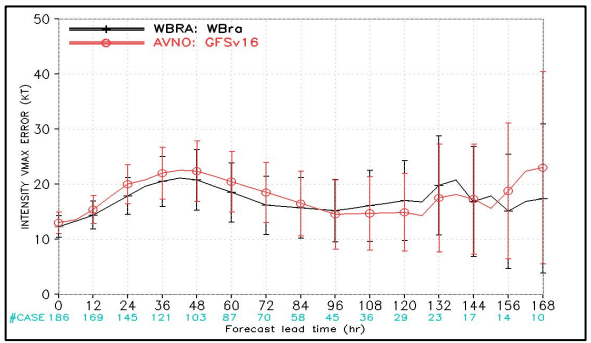


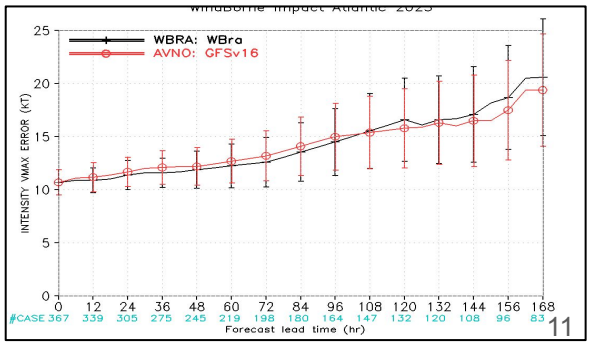




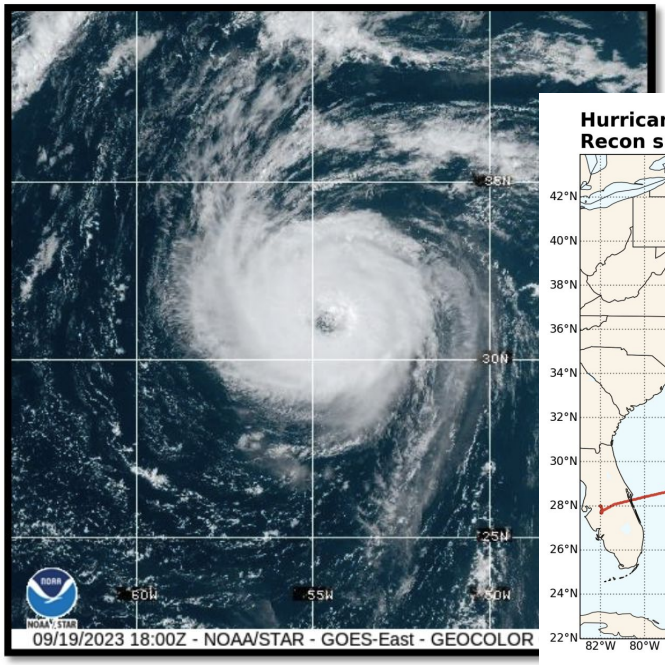
Intensity Error (kts)

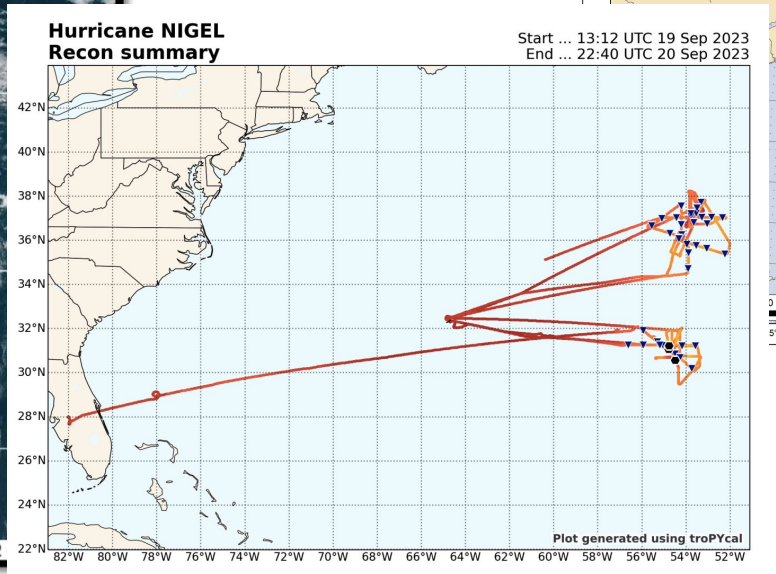


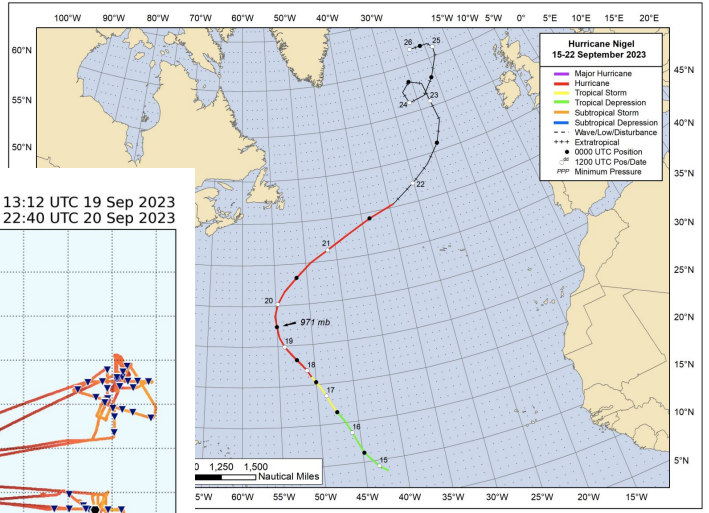




Hurricane Nigel Analysis



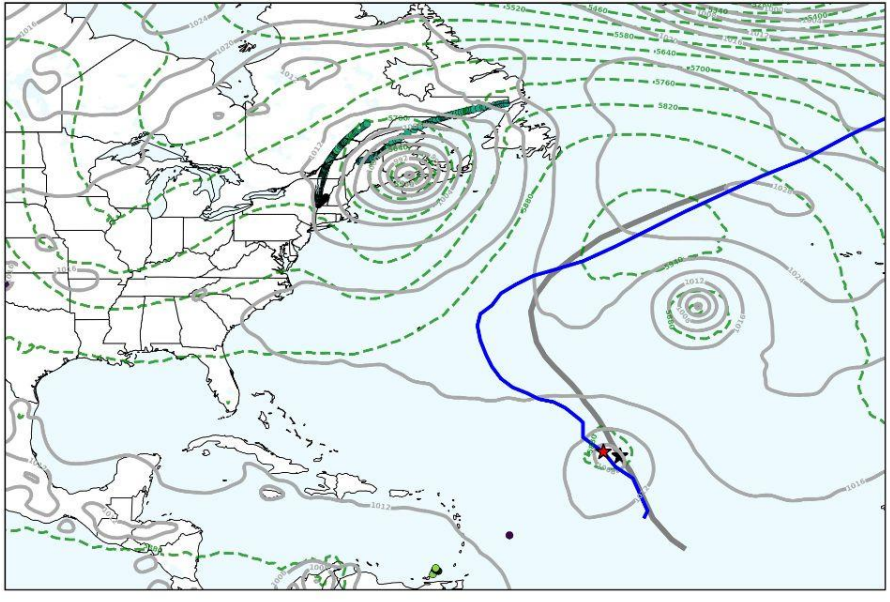




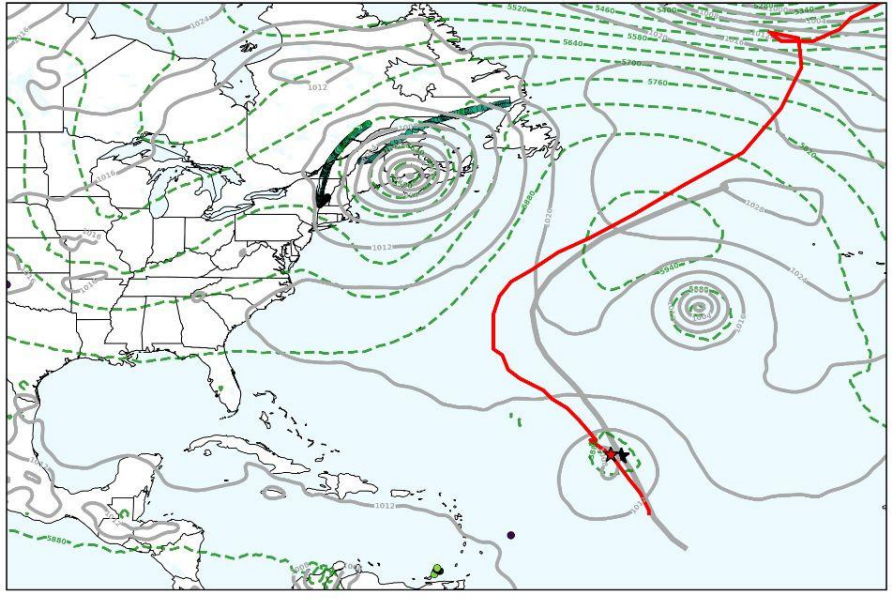
GOES-16 GEOCOLOR IMAGE OF HURRICANE NIGEL AT 1800 UTC19 SEPTEMBER 2023.
IMAGE COURTESY OF NOAA/NESDIS/STAR.

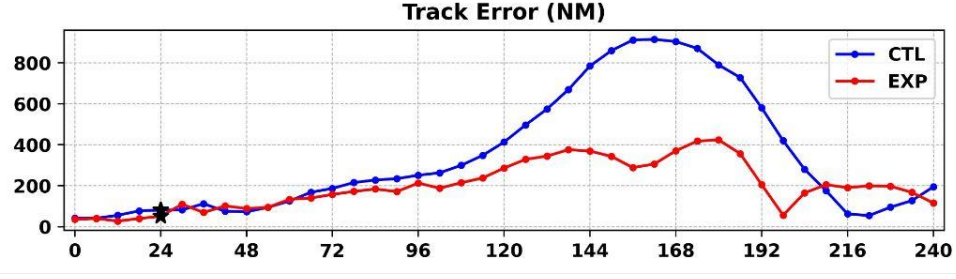
Hurricane Nigel - Initialization Date: 2023091600 - Fhr: 024 - Valid Date: 2023091600

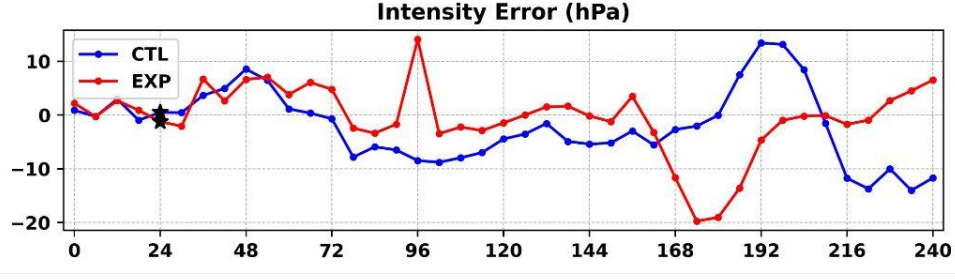
Control - MSLP and precip(mm/6h,shaded)



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

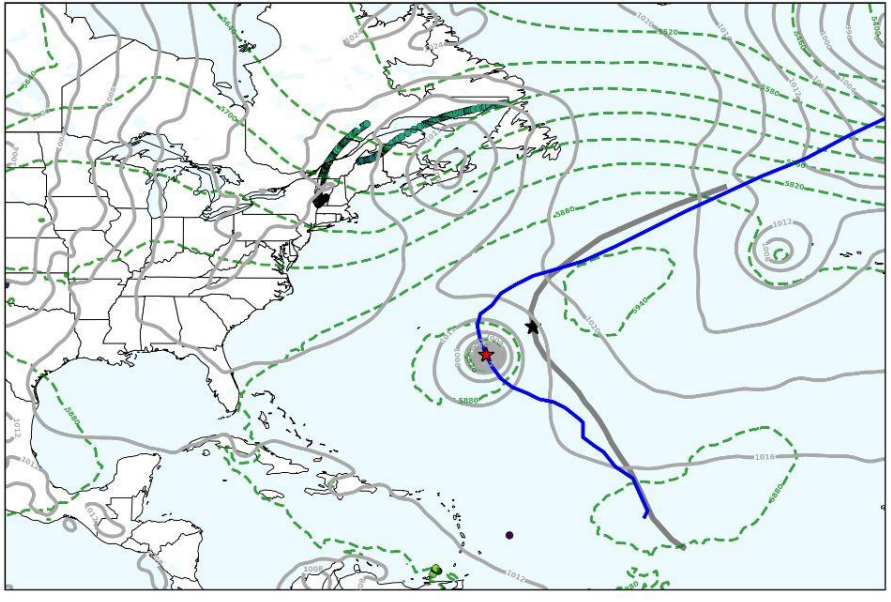




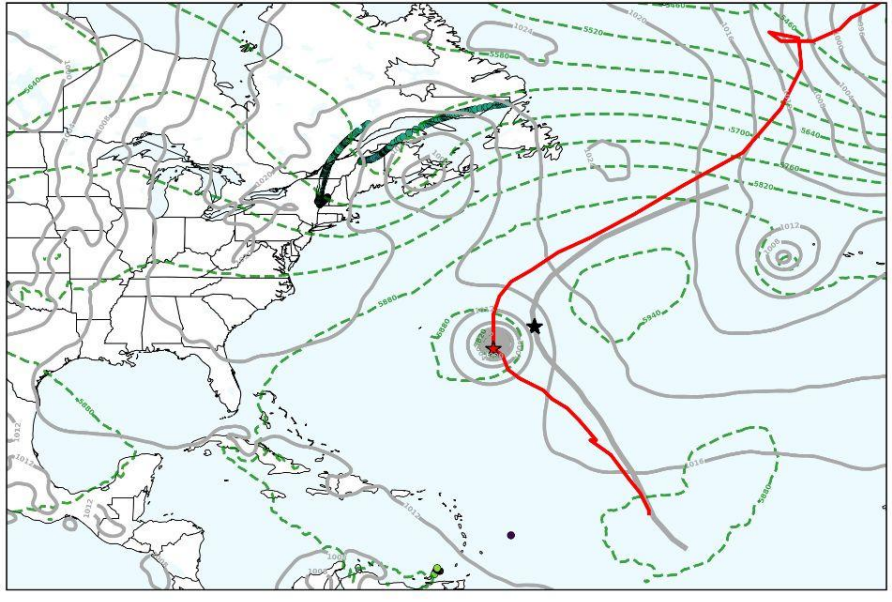


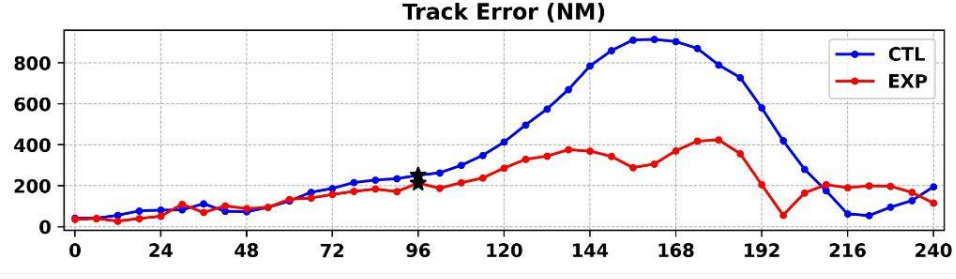
Hurricane Nigel - Initialization Date: 2023091600 - Fhr: 096 - Valid Date: 2023091600

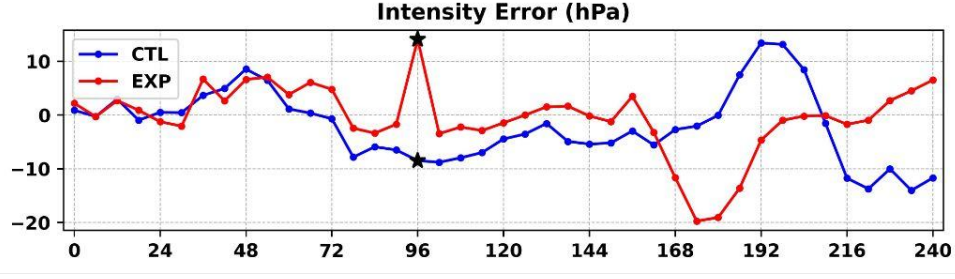
Control - MSLP and precip(mm/6h,shaded)



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

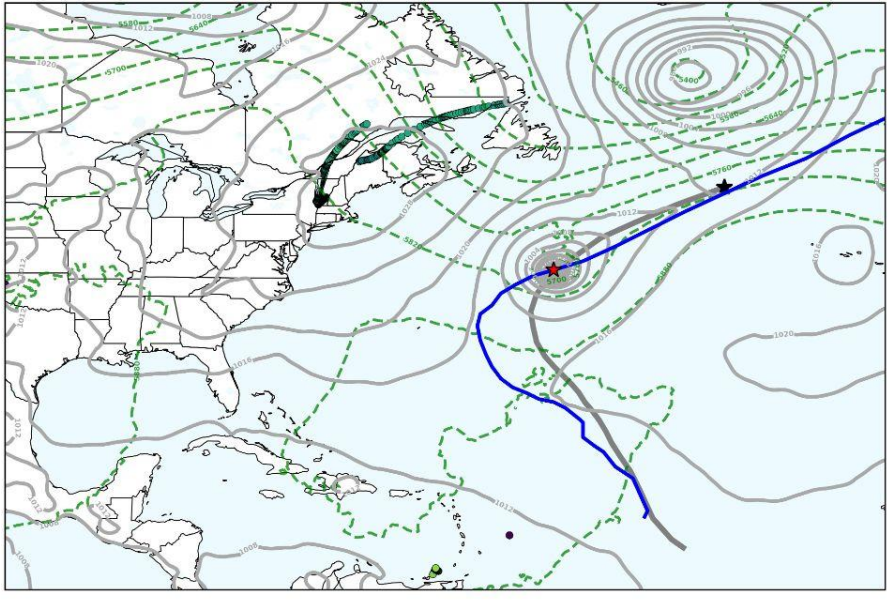




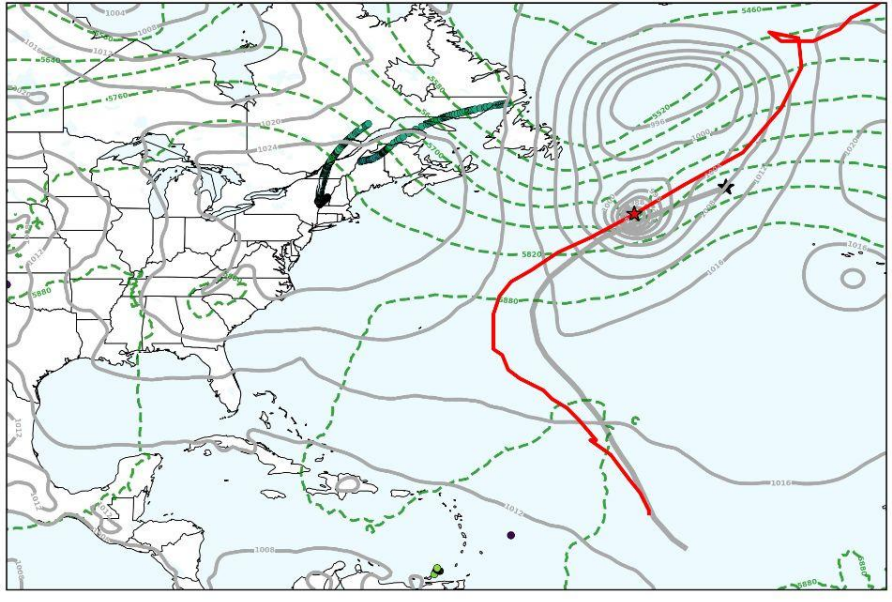


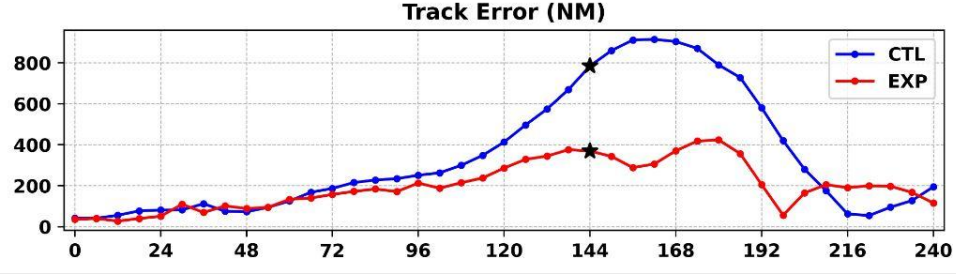
Hurricane Nigel - Initialization Date: 2023091600 - Fhr: 144 - Valid Date: 2023091600

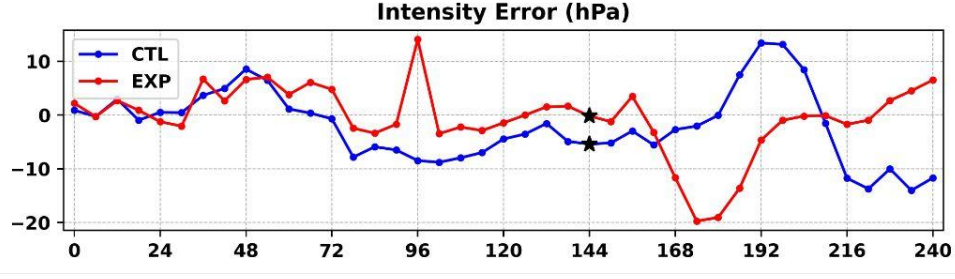
Control - MSLP and precip(mm/6h,shaded)



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

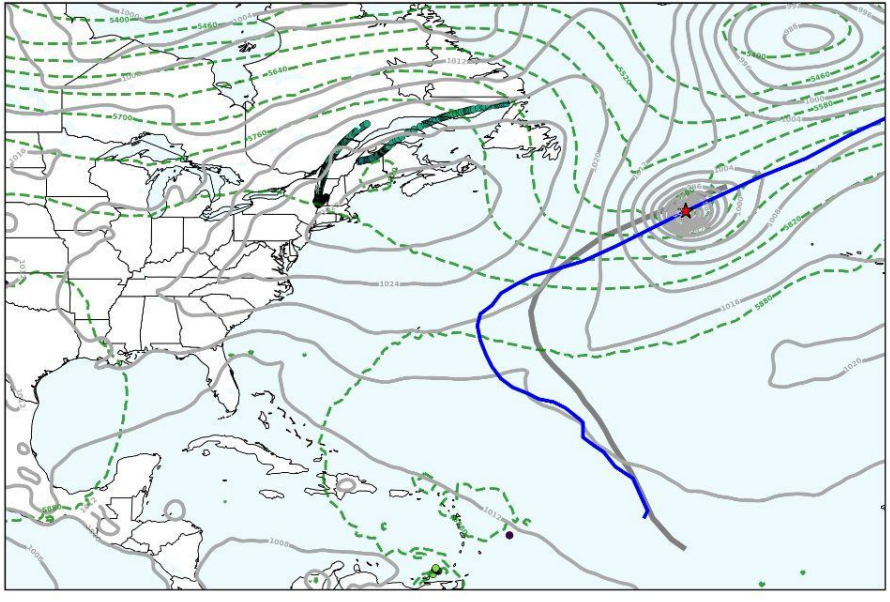




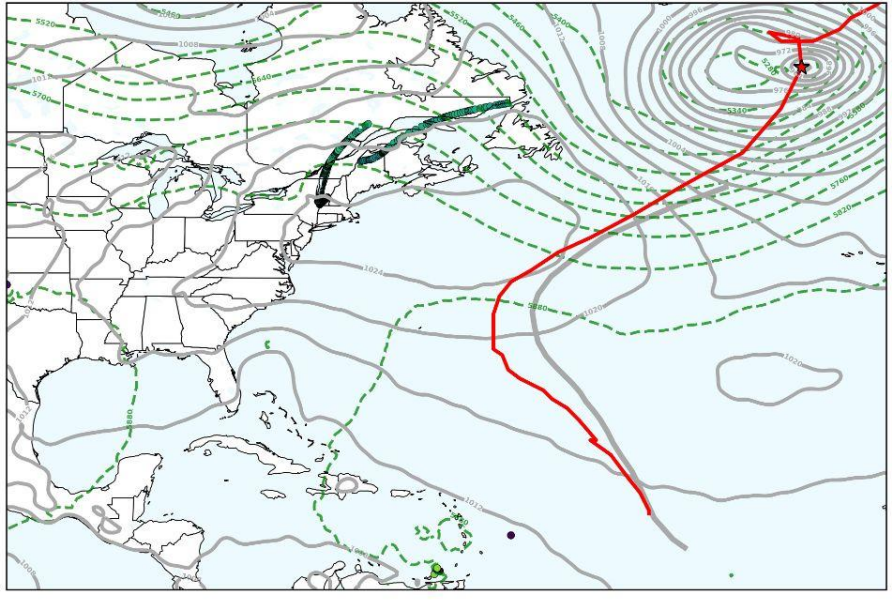


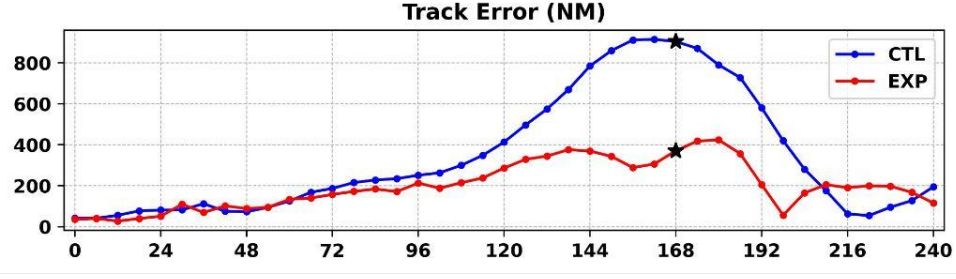
Hurricane Nigel - Initialization Date: 2023091600 - Fhr: 168 - Valid Date: 2023091600

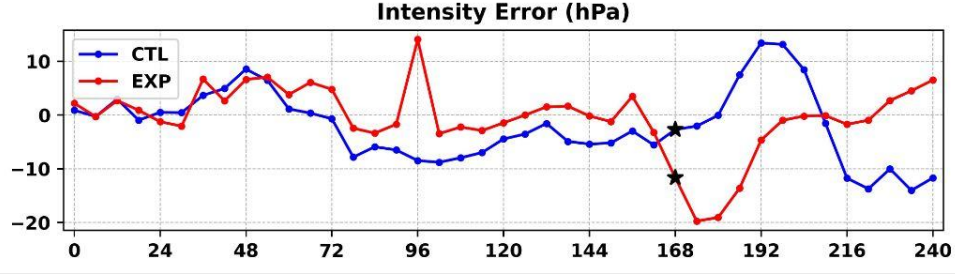
Control - MSLP and precip(mm/6h,shaded)



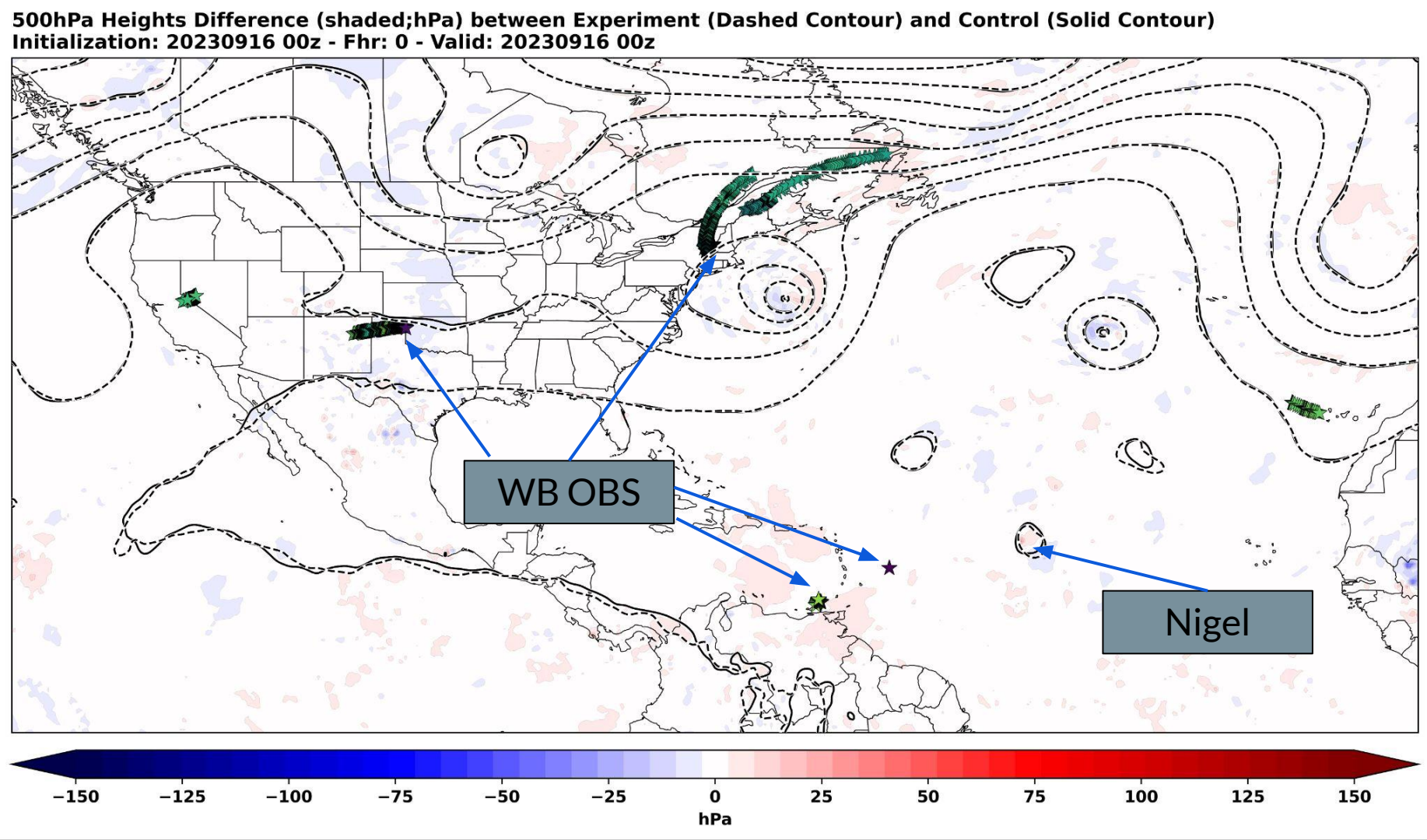
Experimental - MSLP and precip(mm/6h,shaded)



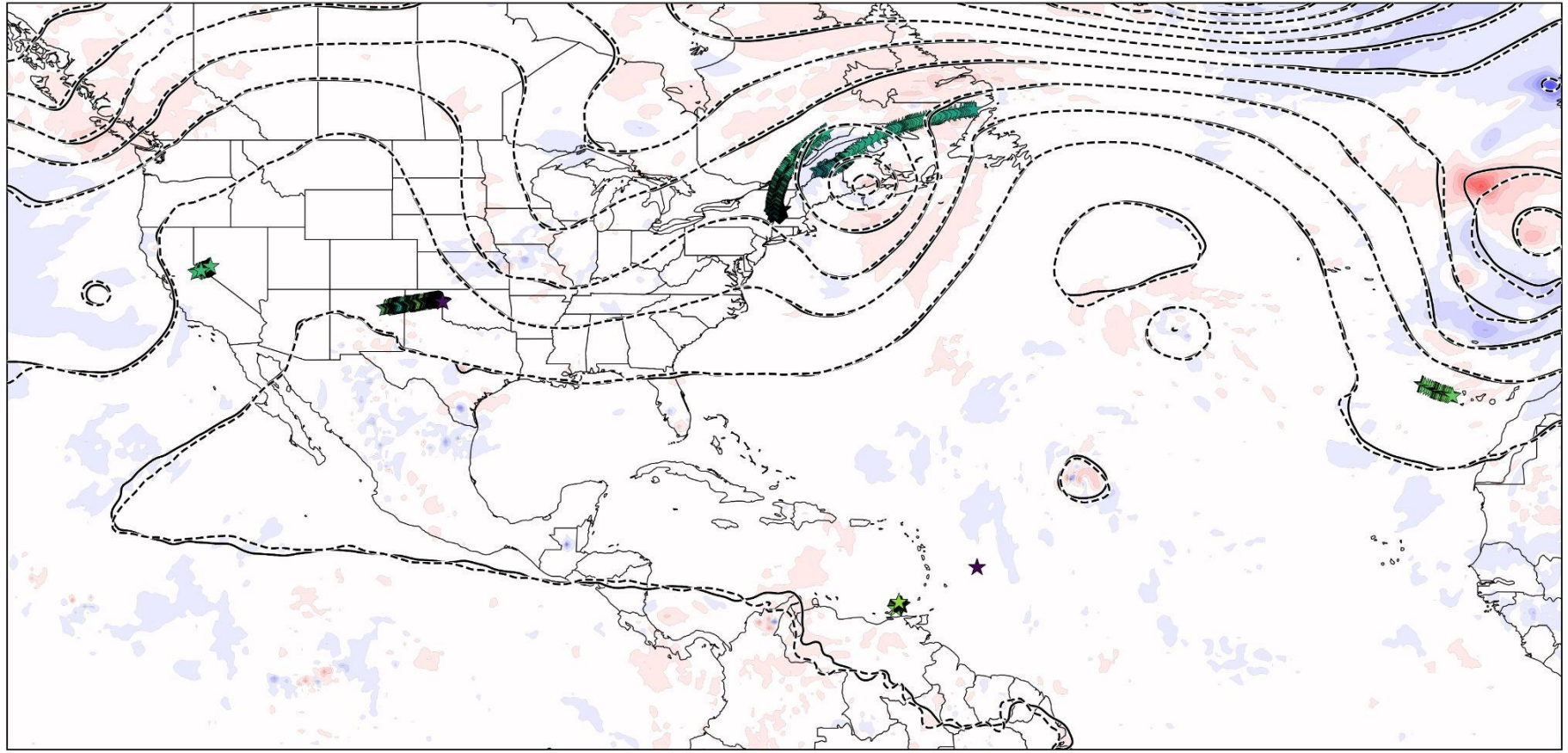




500 mb


500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 0 - Valid: 20230916 00z
WB OBS
Nigel
−150
−125
−100
−75
−50
−25
0
25
50
75
100
125
150
hPa

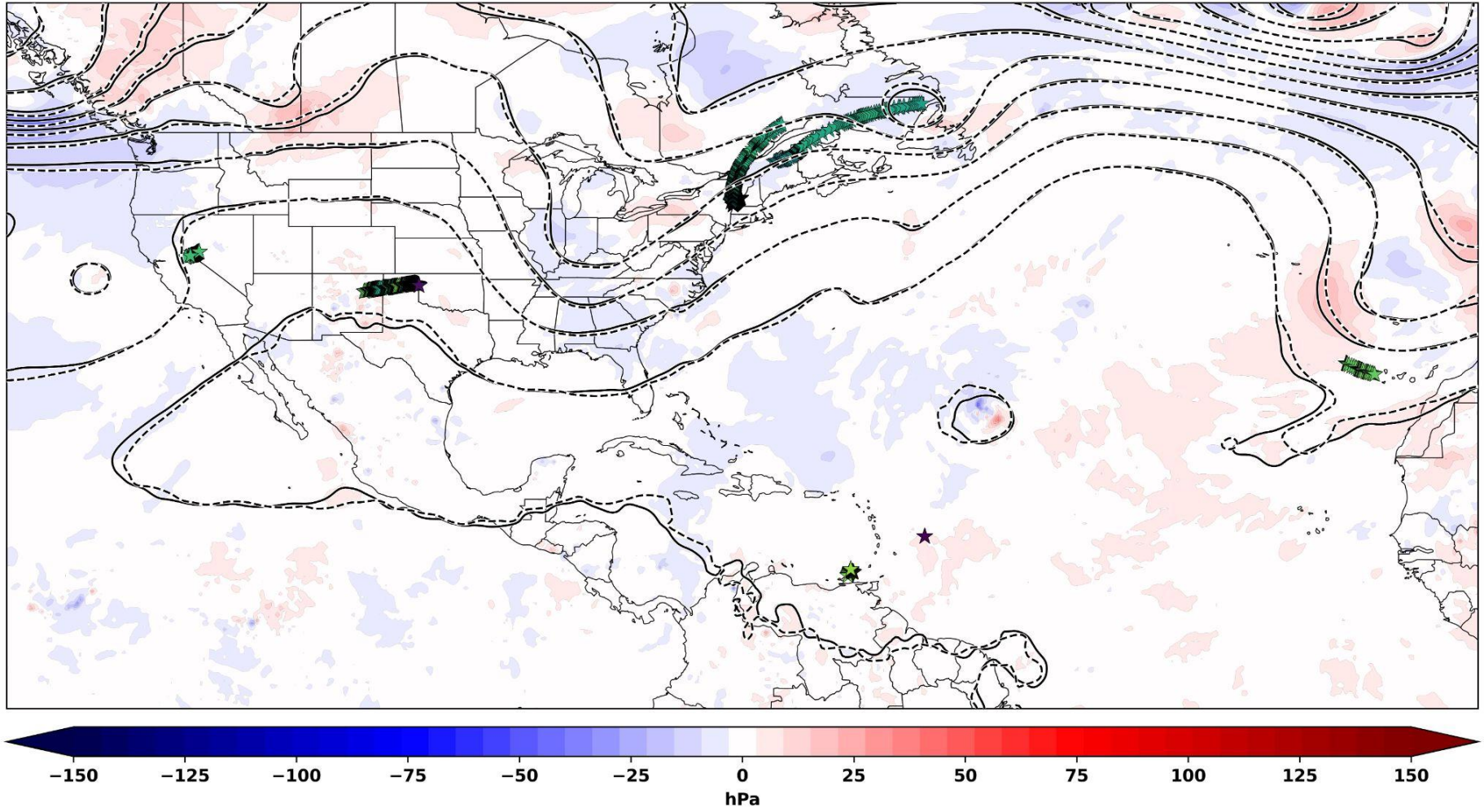
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 24 - Valid: 20230917 00z



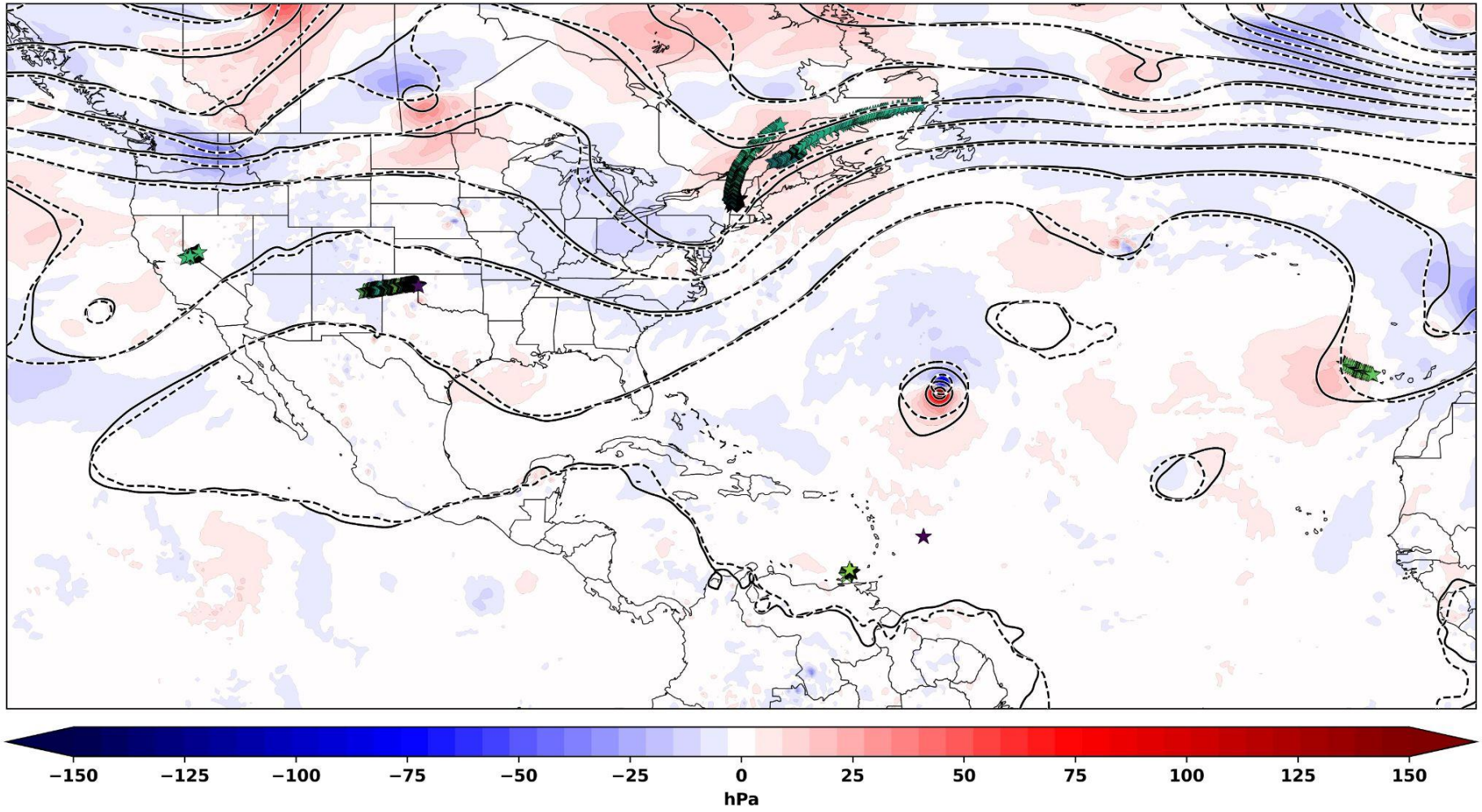
−150 −125 −100 −75 −50 −25 0 25 50 75 100 125 150

hPa

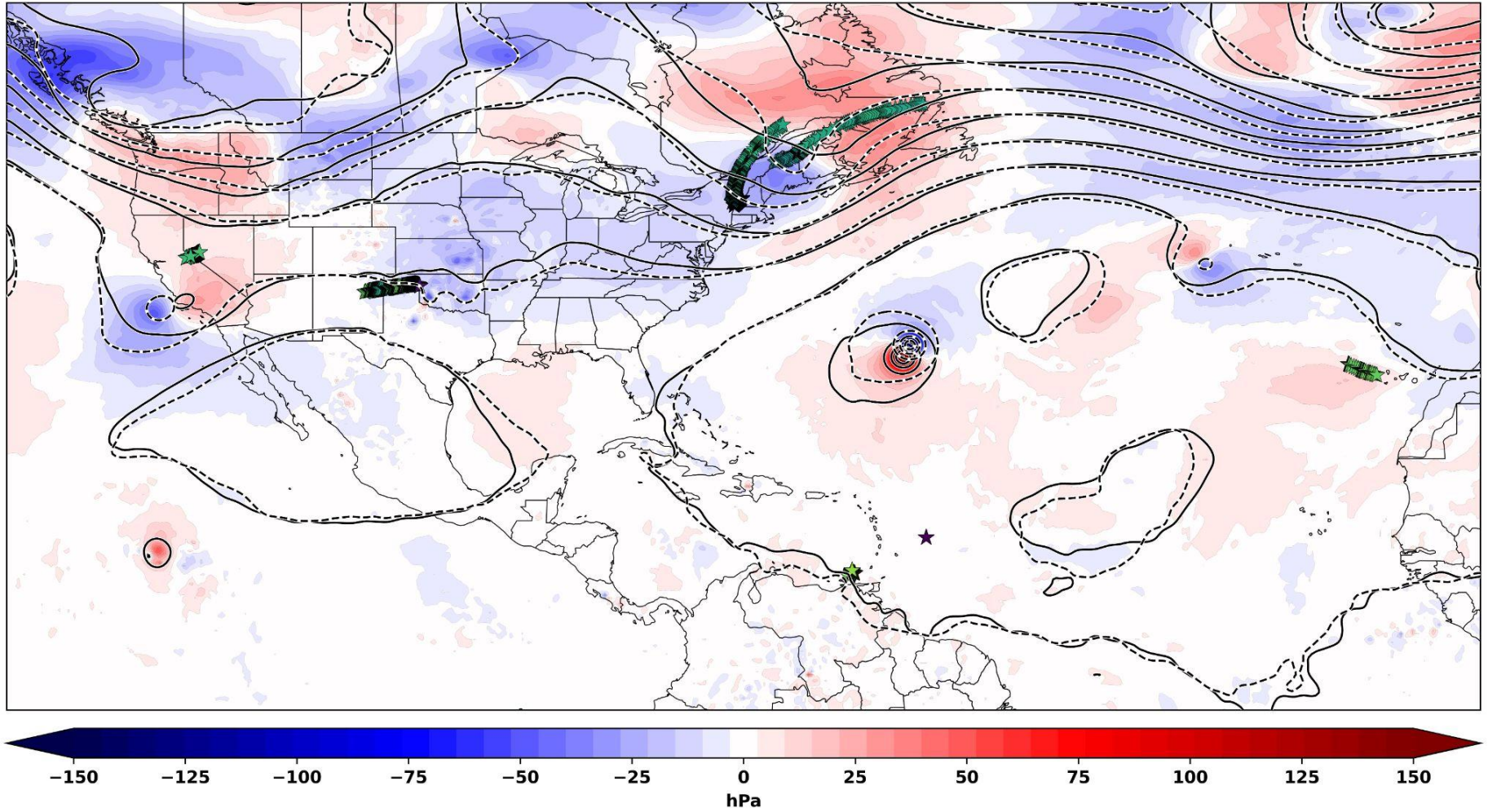
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 48 - Valid: 20230918 00z



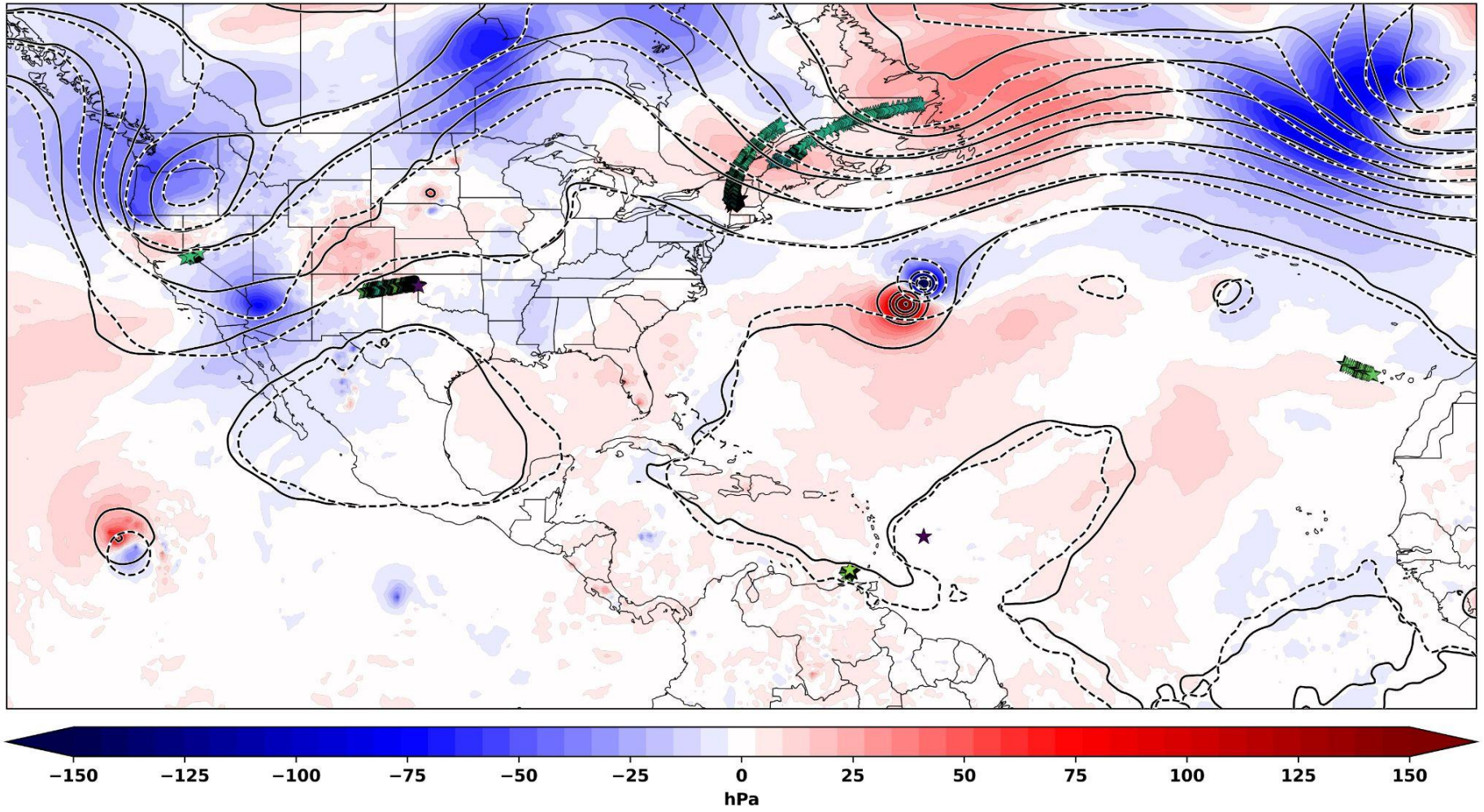
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 72 - Valid: 20230919 00z



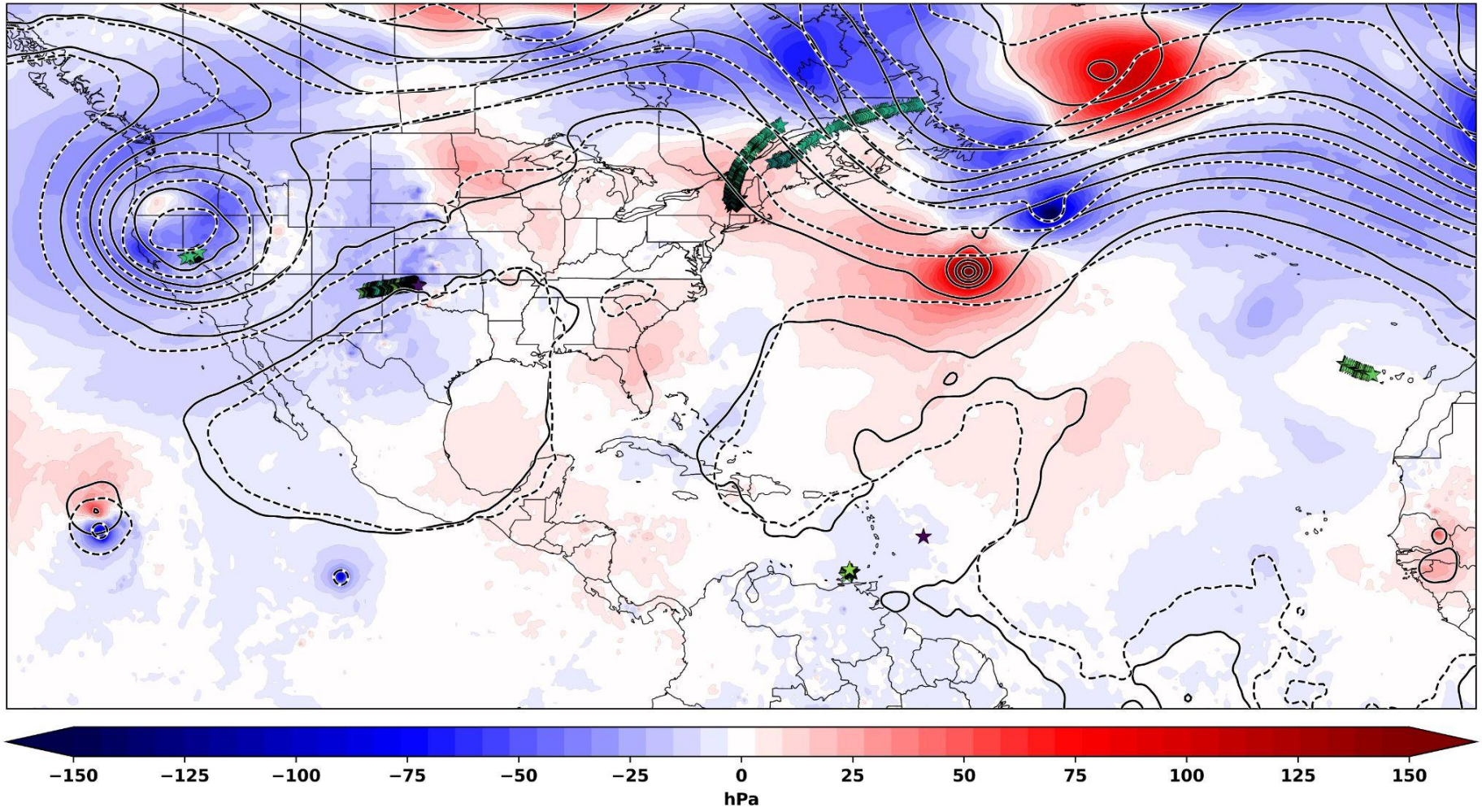
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 96 - Valid: 20230920 00z



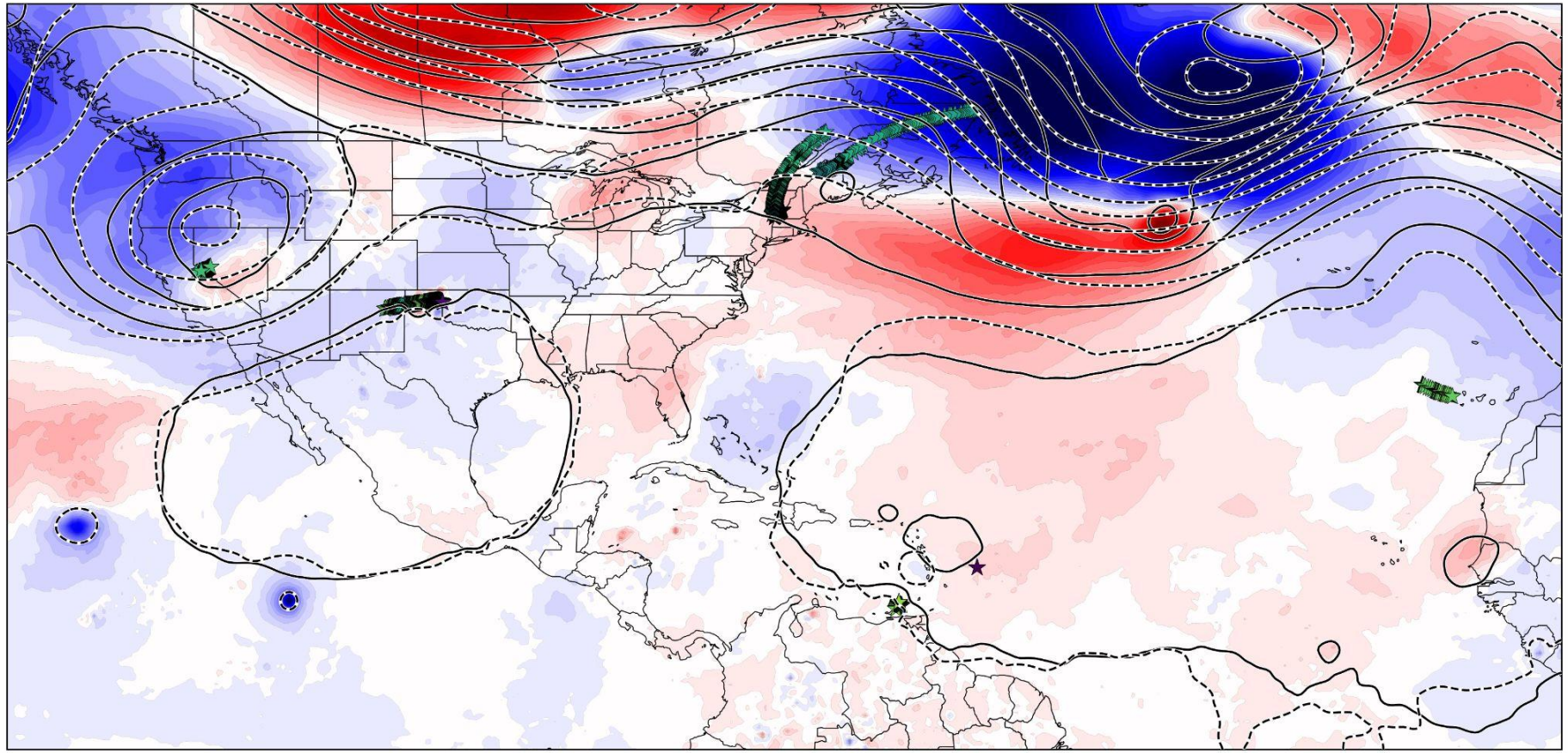
500hPa Heights Difference (shaded;hPa) between Experiment (Dashed Contour) and Control (Solid Contour)
Initialization: 20230916 00z - Fhr: 120 - Valid: 20230921 00z



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



−150 −125 −100 −75 −50 −25 0 25 50 75 100 125 150

hPa

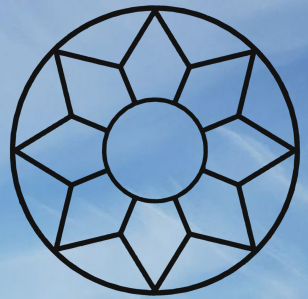
Data Availability

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