HFIP HWR4

- Configuration
- Horrible Forecasts
- Possible Reasons
- HFIP Re-Runs
  - Faster simulations
  - Different configuration
- Speedup Needed for Hi-Res Operational Runs

High-Res Setup

- HWRF 13.5:4.5 km res
- Gravity Wave Drag (GWD)
- POM coupling at regular operational resolution
- 18 second outer domain timestep, necessary to prevent model from going unstable (27:9 uses 54 second timestep)
- 6-hour cycling

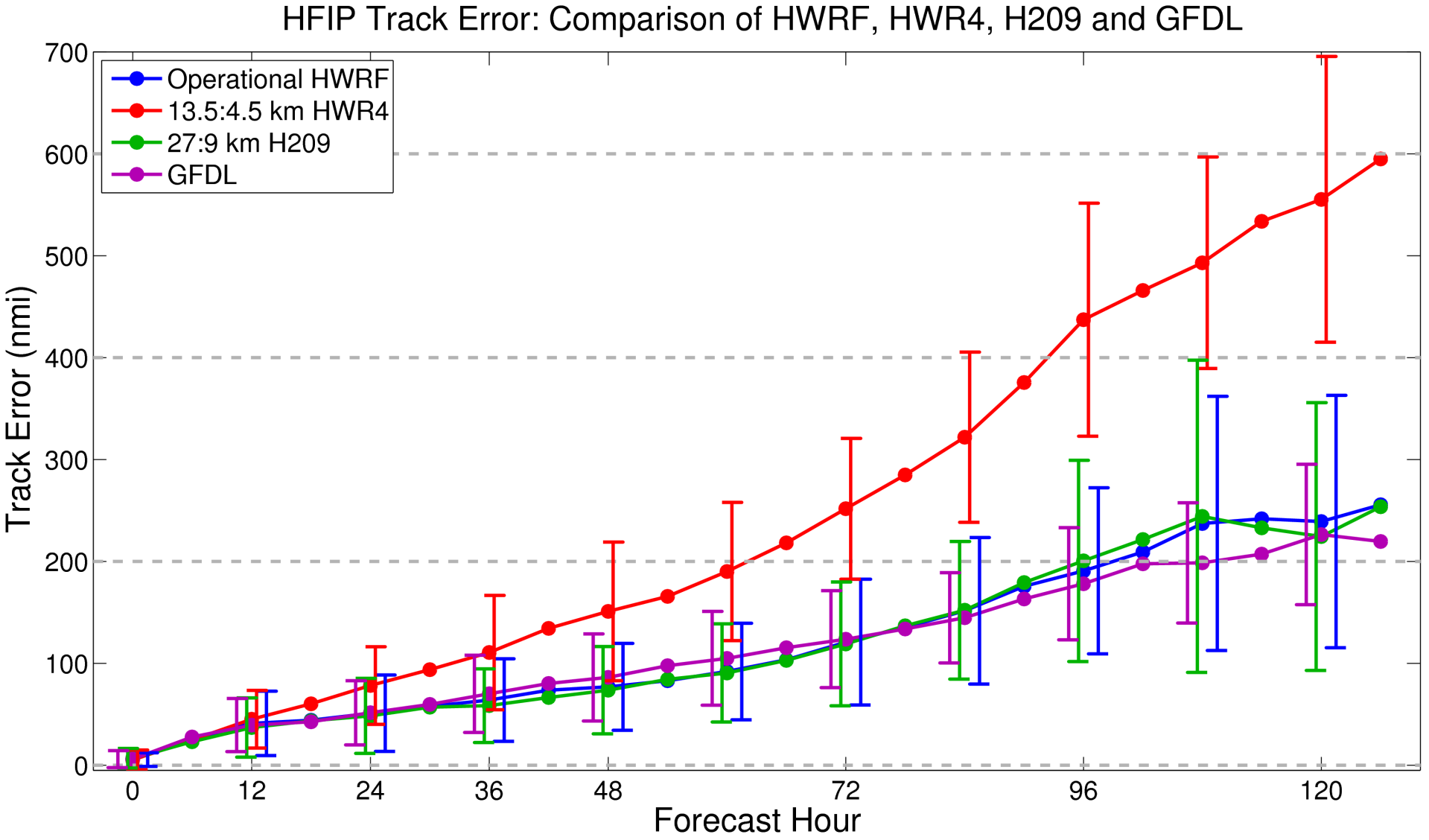
- 4 hrs for init, 8-9 for forecast (wallclock limit is 9hrs)
- 1600-1900 CPU-hrs/run

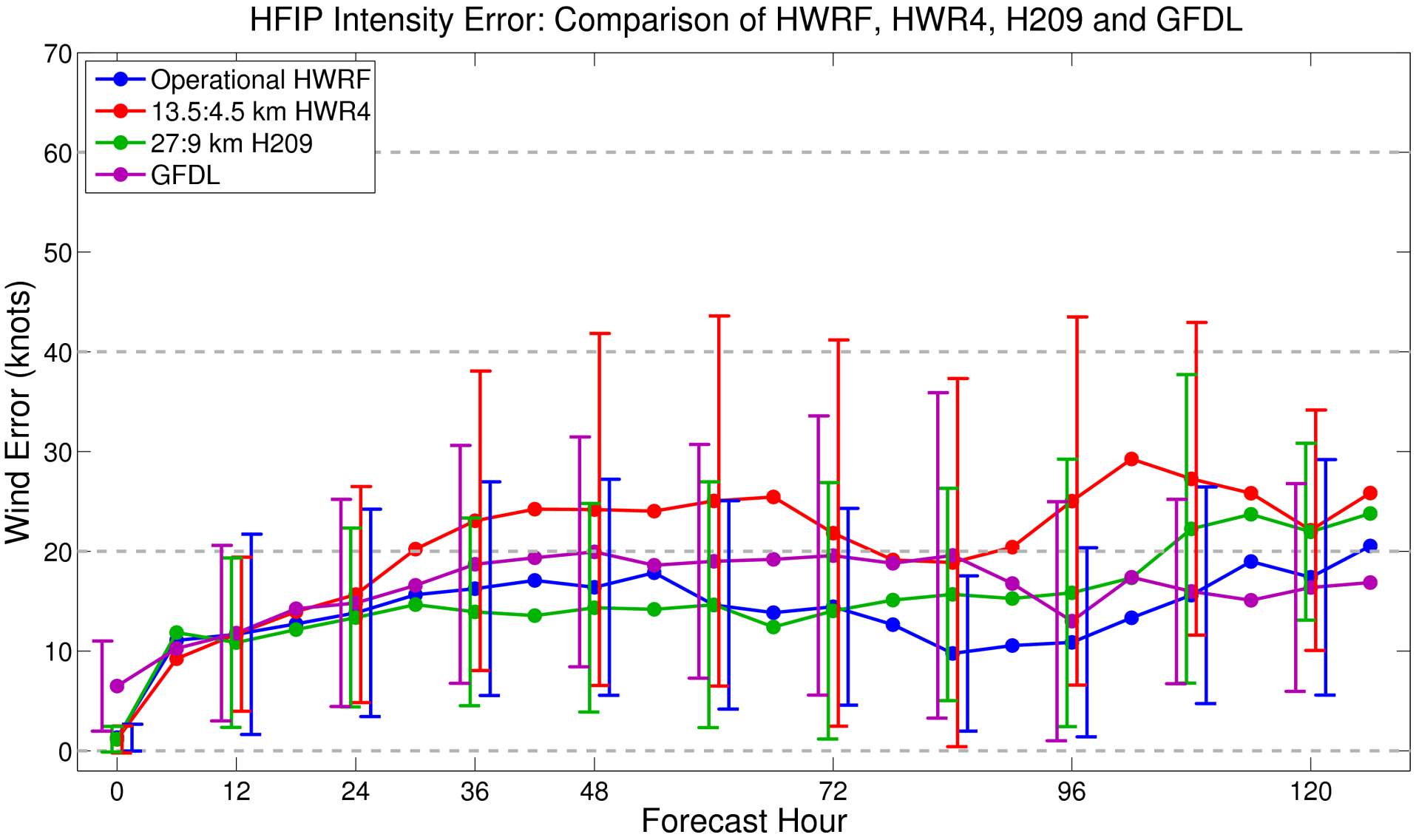
Summary of Performance

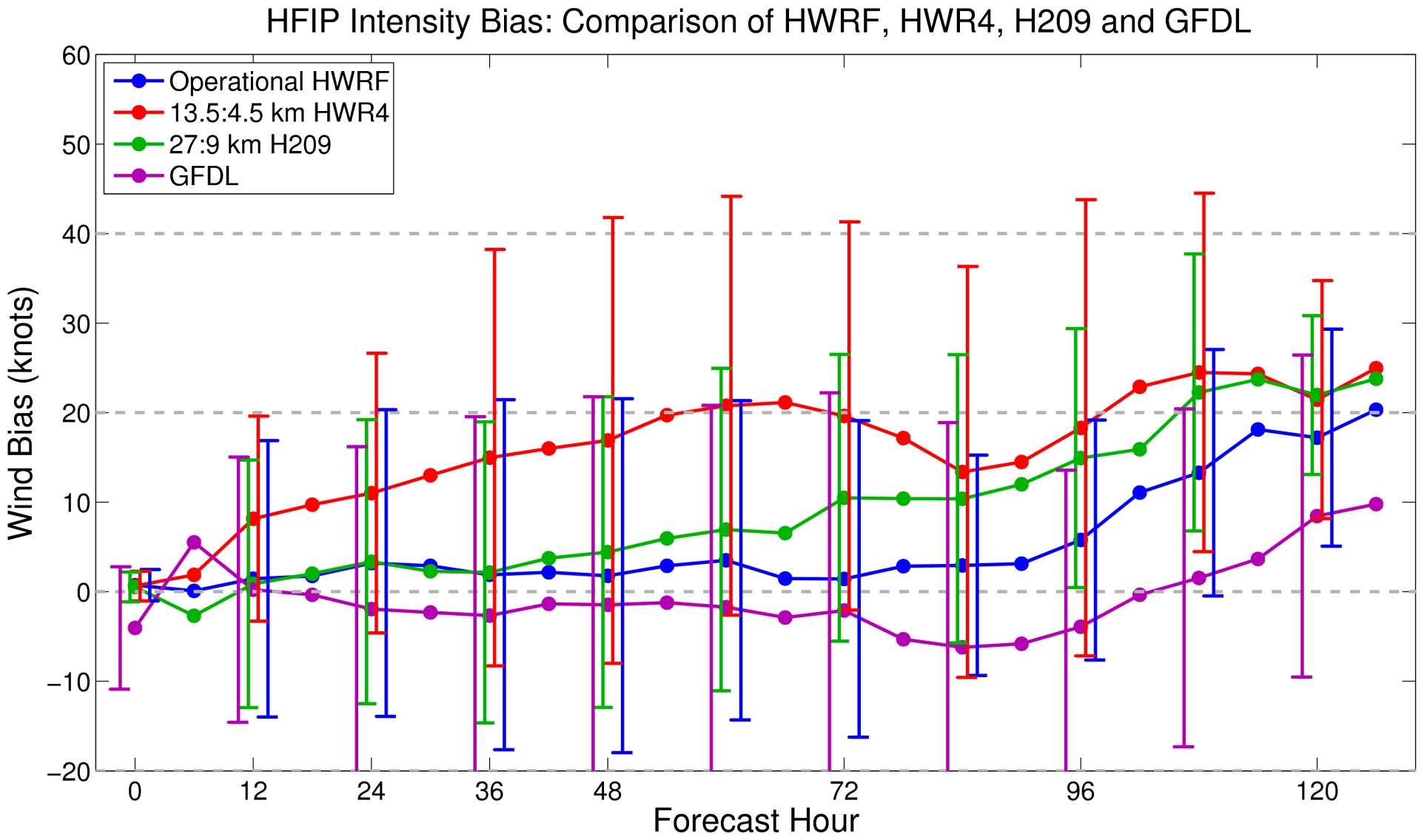
- Small sample set: mostly just Bill 03L and Fred 07L.
- Track prediction is essentially worthless
- Intensity prediction is almost reasonable, but tends to have positive bias.
- Strong positive intensity bias (~23 knots).
- Storm moves too rapidly, typically N or NE.

Comparison of Models

- Models
  - Operational HWRF
  - HFIP HWR4 (13.5:4.5 km)
  - H209 (27:9 km) – basis of HWR4
  - Operational GFDL
- Only cycles used are ones run by all four models.
  - HWR4 Invest cases were often not run by one or more model.
- Error bars at +/- one standard deviation.


HFIP Track Error: Comparison of HWRF, HWR4, H209 and GFDL
Operational HWRF
13.5:4.5 km HWR4
27:9 km H209
GFDL
Track Error (nmi)
700
600
500
400
300
200
100
0
0
12
24
36
48
72
96
120
Forecast Hour


HFIP Intensity Error: Comparison of HWRF, HWR4, H209 and GFDL
Operational HWRF
13.5:4.5 km HWR4
27:9 km H209
GFDL
Wind Error (knots)
Forecast Hour
0
10
20
30
40
50
60
70
0
12
24
36
48
72
96
120


HFIP Intensity Bias: Comparison of HWRF, HWR4, H209 and GFDL
Operational HWRF
13.5:4.5 km HWR4
27:9 km H209
GFDL
Wind Bias (knots)
60
50
40
30
20
10
0
−10
−20
0
12
24
36
48
72
96
120
Forecast Hour

Vapor Issues

- FairShare: 7680 CPU-hrs/day allowed
  - Max ~4.2 runs/day, so re-running was usually not possible
  - 8-9 hrs for 126 hr forecast, 9 hr wallclock limit
- Vapor has serious problems
  - Filesystem issues: 100x-300x slowdown for hours at a time. Happened every week or so.
  - Network issues: 1.5x-2.5x slowdown. Starting run over on different nodes fixed problem. Happened to ~1/5 of runs.
- **End result: at least 1/3 of cycles had to be re-run, some could not be.**

Issues: Physics, Ocean and Init

- Vapor only has past 24-48 hours of forecast data.
- HISTORY cases (all of Bill) were run with limited data assimilation due to HPSS permission issues
  - HISTORY cases had better track & intensity predictions though.
- /nwprod out of date (same issue as with HWRF V3 on Vapor)
  - Ocean init usually failed (61 out of 95 cases)
- GWD used – is this really appropriate for 4.5 km? - Vijay
- POM run at operational resolution, should be run at 2x resolution. - Dmitiri

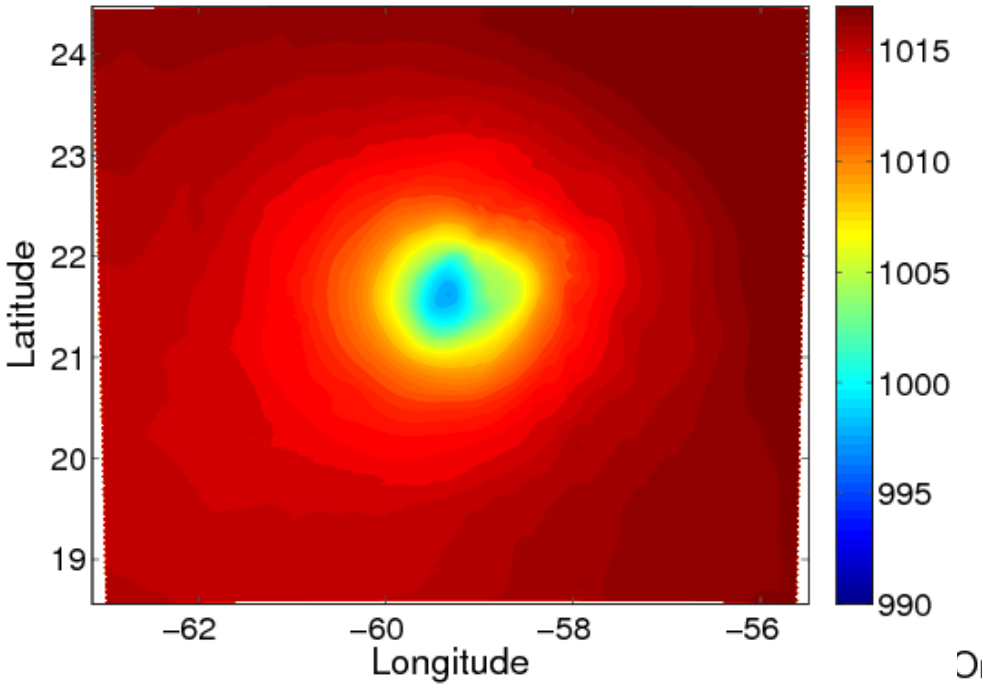
Failure Summary

- Excluding 05L (run by Vijay)
- Total: 95 cycles
  - 20 cold starts, 12 should not have been
  - 50 history runs (missing some obs. due to HPSS permissions.)
  - 45 forecast runs (some files missing from /com/gfs/prod/*/)
  - 61 runs had ocean init fail

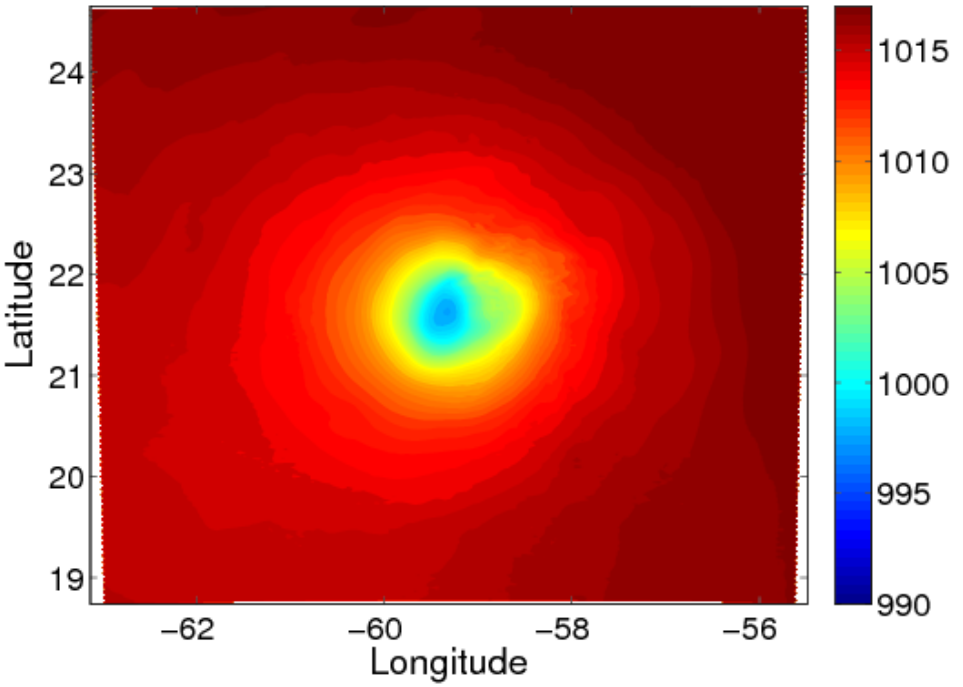
Issues: Nest Movement Implementation

- Non-hydrostatic domains, but
- nest's non-hydrostatic state is discarded after nest move.
- Not doing that results in non-physical waves due to terrain change in leading portion of nest. -- Gopal
- Non-hydr. more important as resolution increases.
- Maybe reason for 18 s. timestep necessity?
- 9:3 runs (IU BigRed) required 12 s timestep, displayed sudden bursts of convection after each nest move

Henri 2009100712: Pres. On Lowest Model Level 6 sec.
Before 10/08 12:27 Nest Move

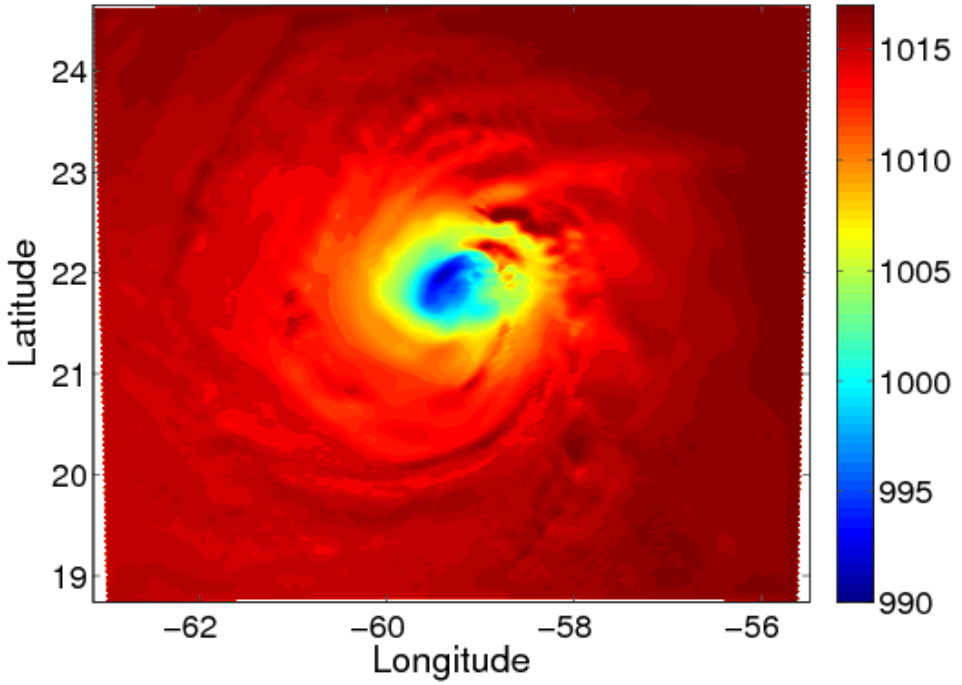


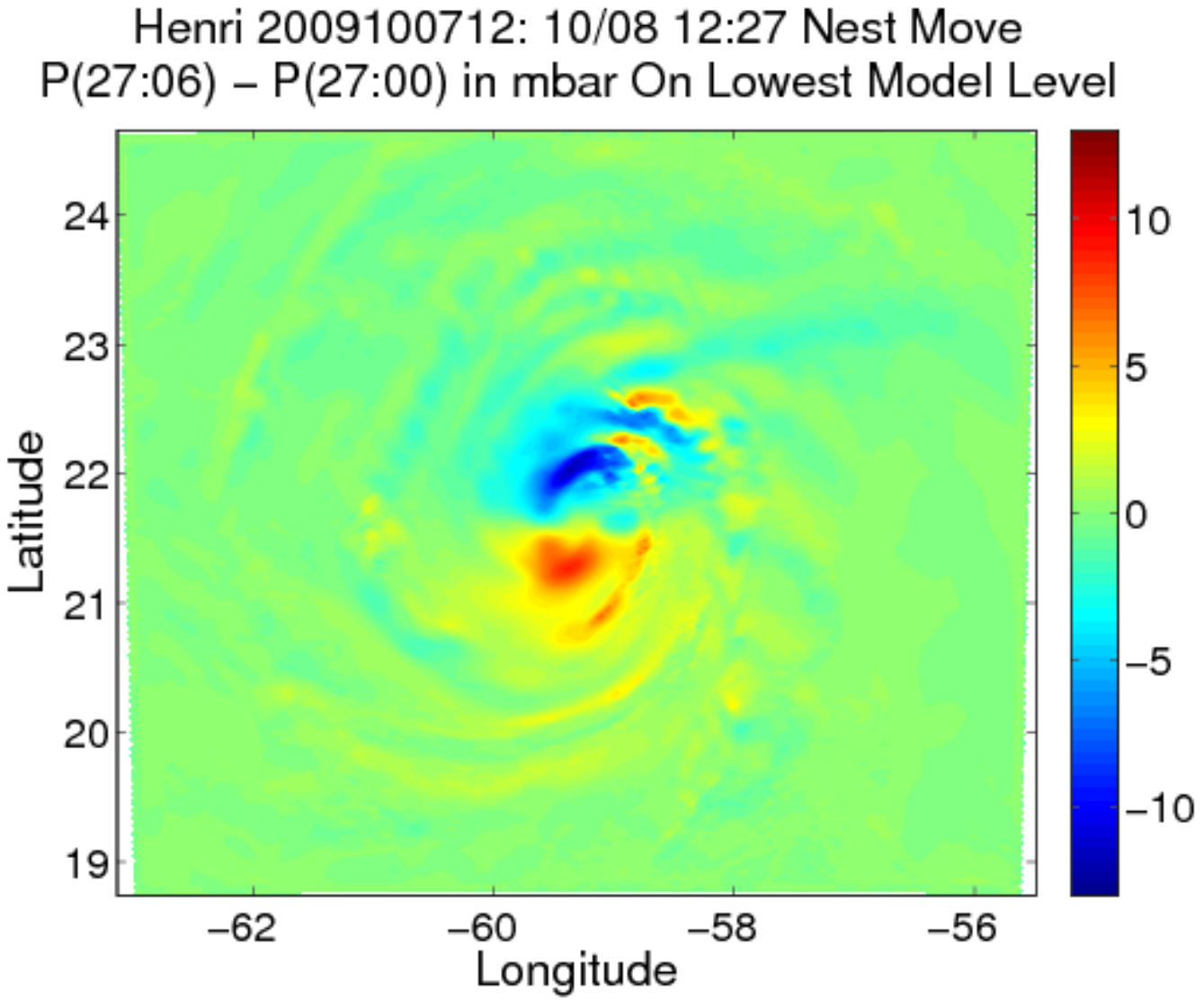
Henri 2009100712: Pres. On Lowest Model Level
Immediately After 10/08 12:27 Nest Move

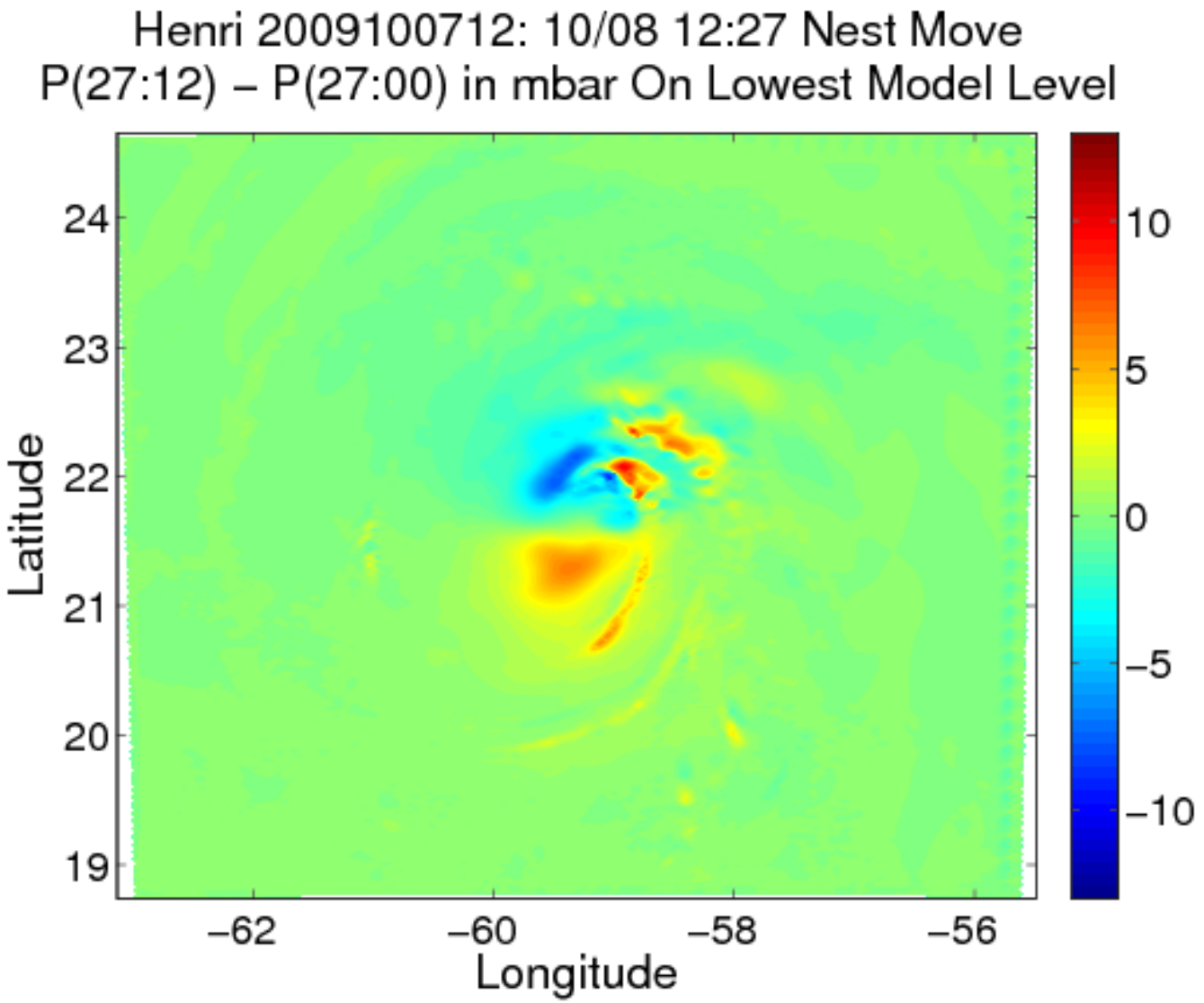


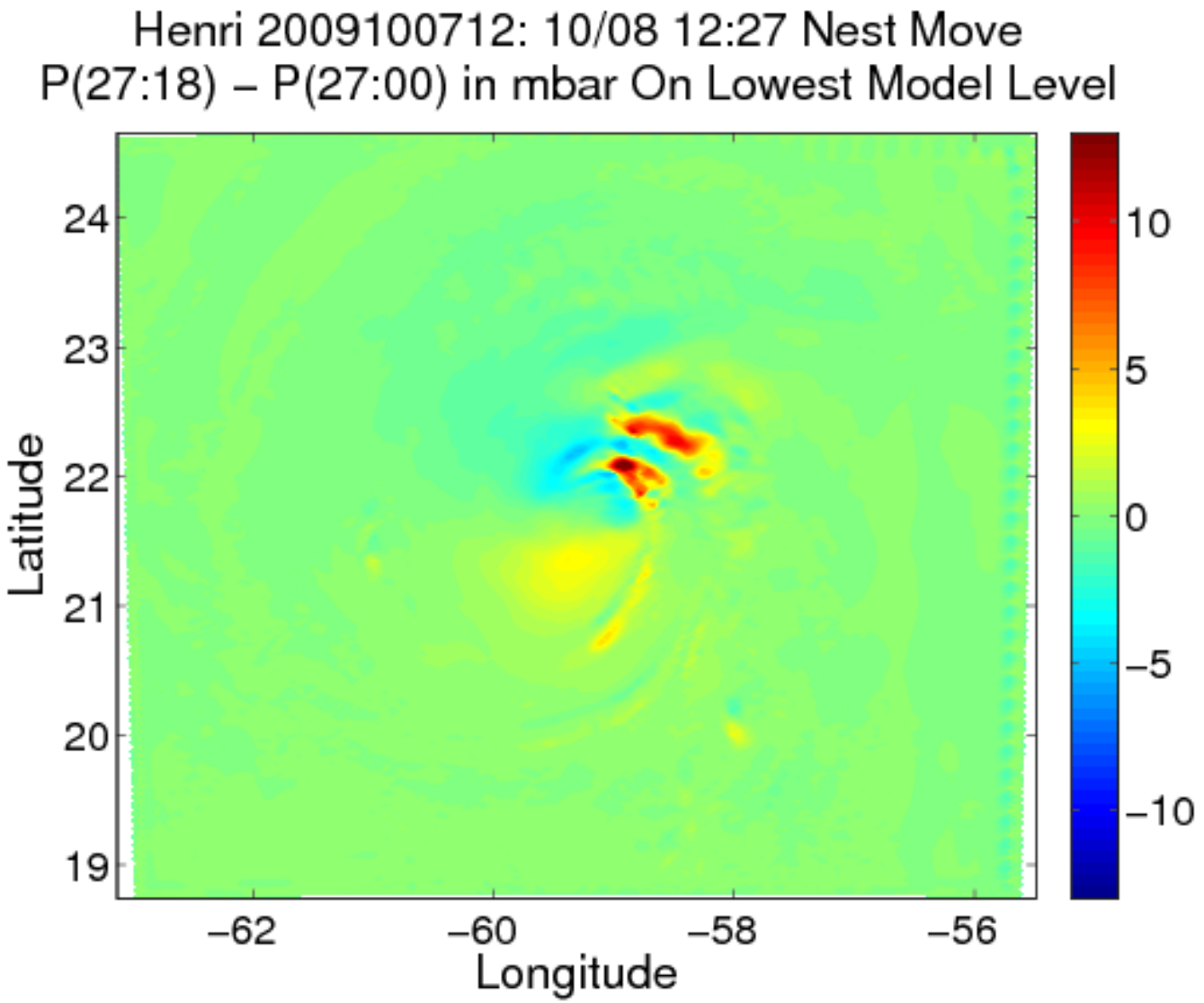
On Lc

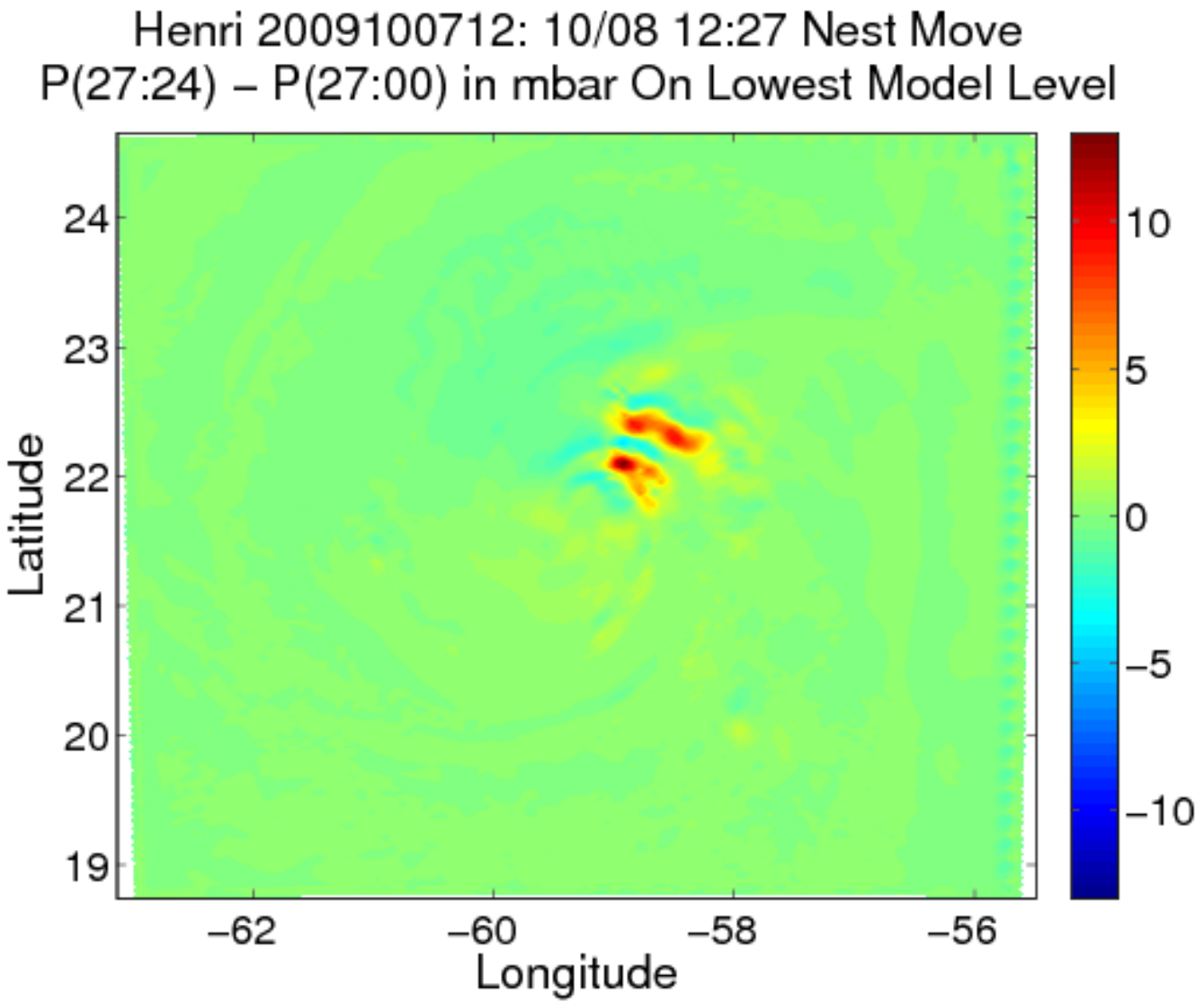
6 Seconds After 10/08 12:27 Nest Move

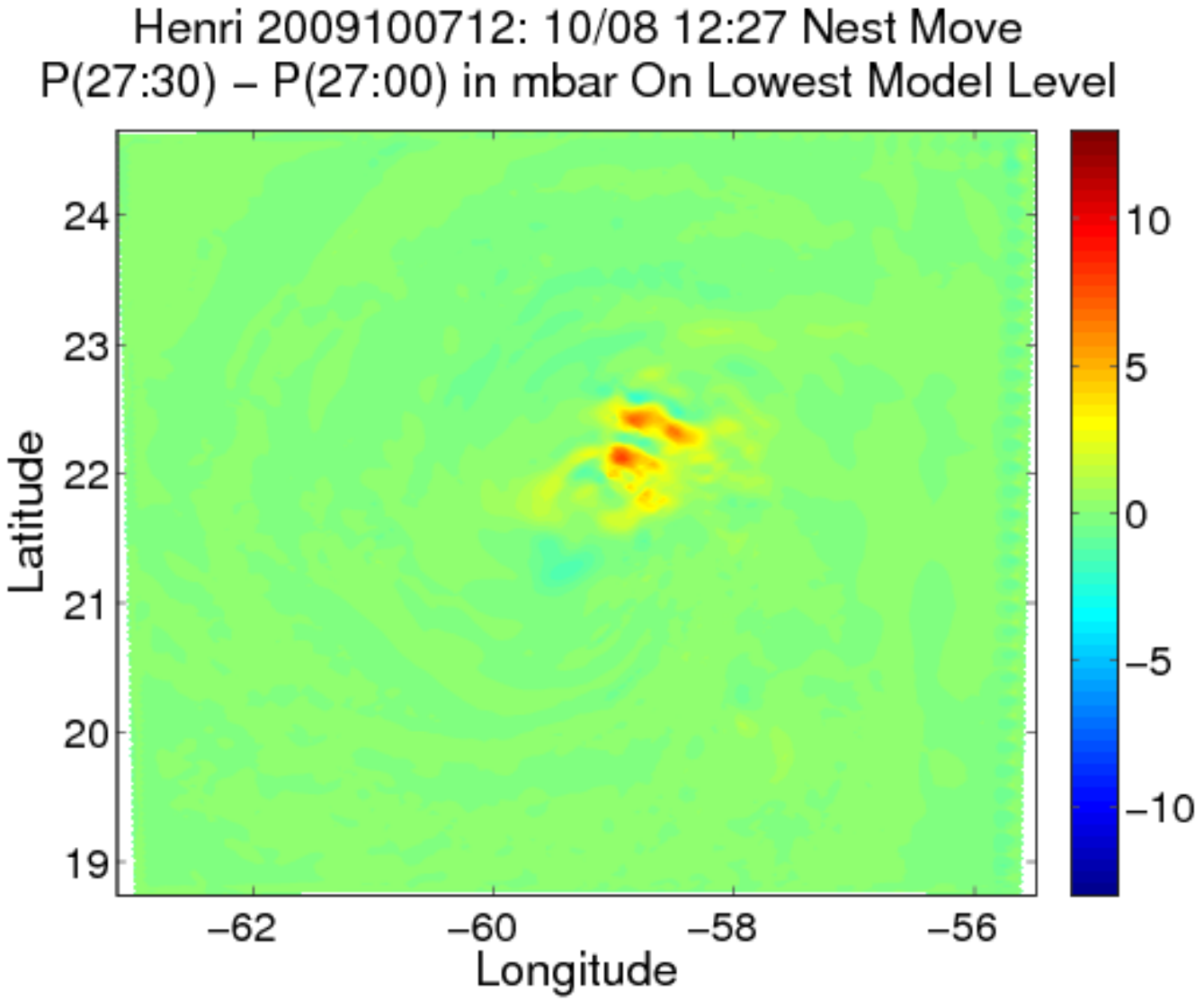


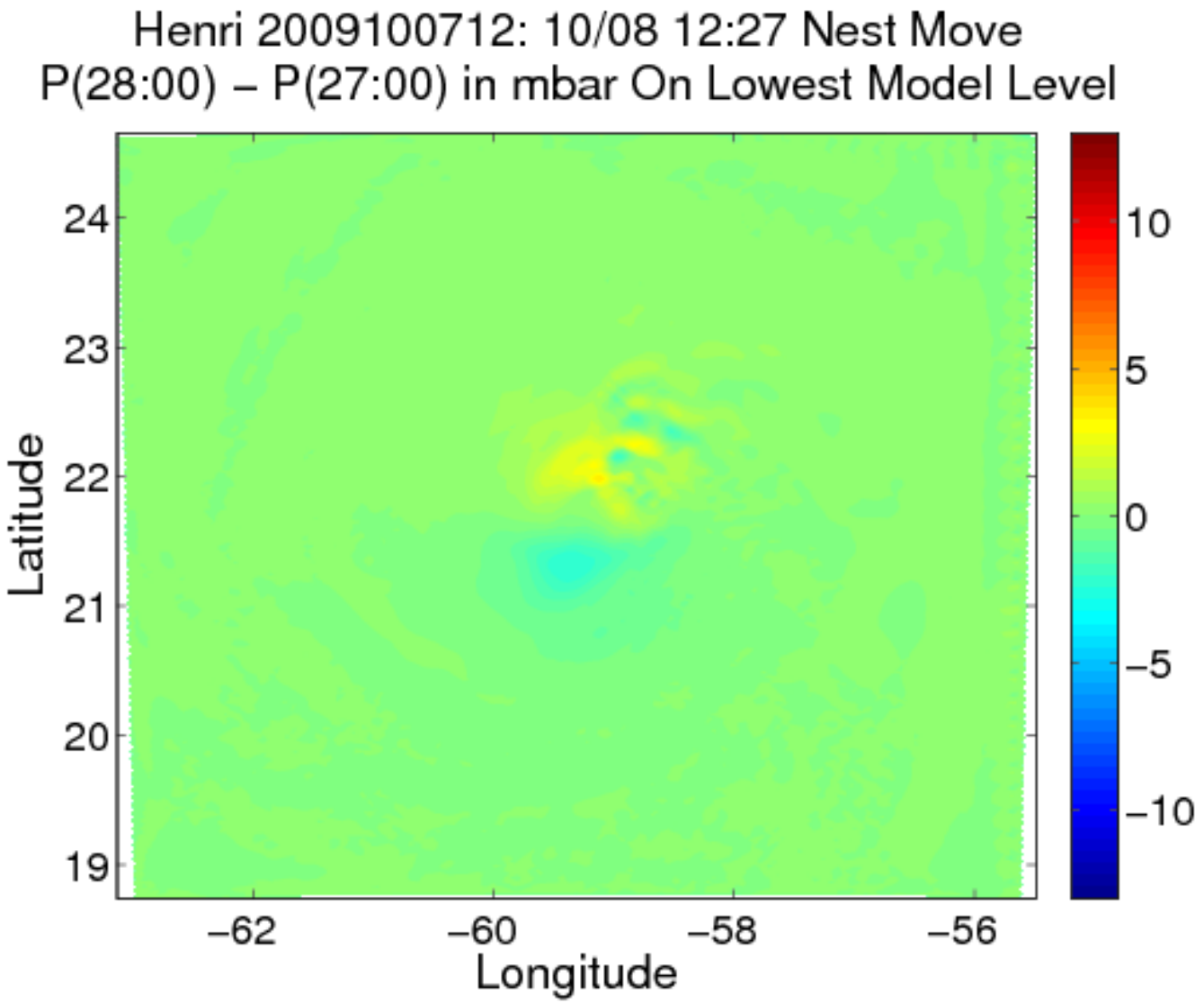

Henri 2009100712: 10/08 12:27 Nest Move
P(27:06) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10

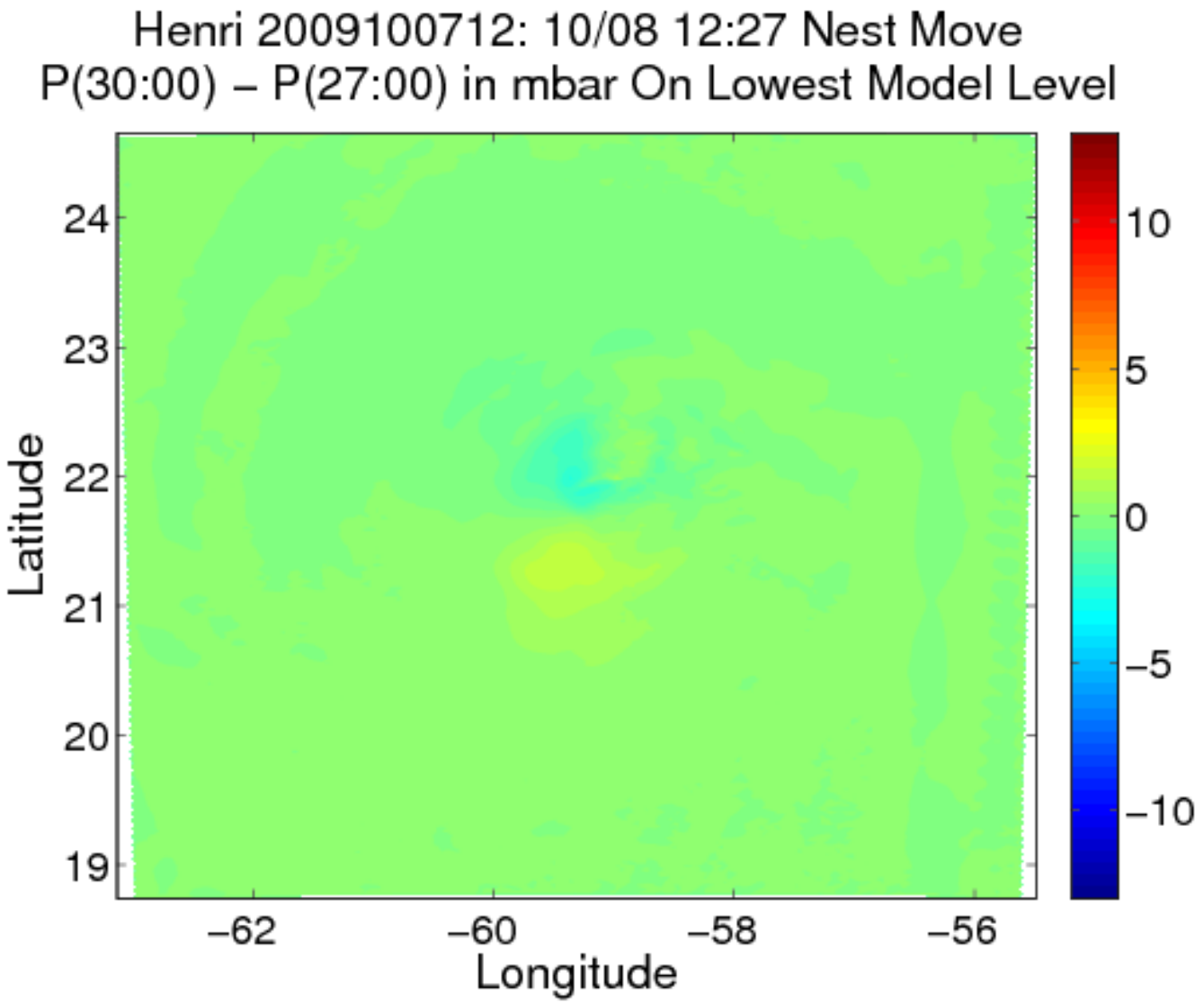

Henri 2009100712: 10/08 12:27 Nest Move
P(27:12) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10

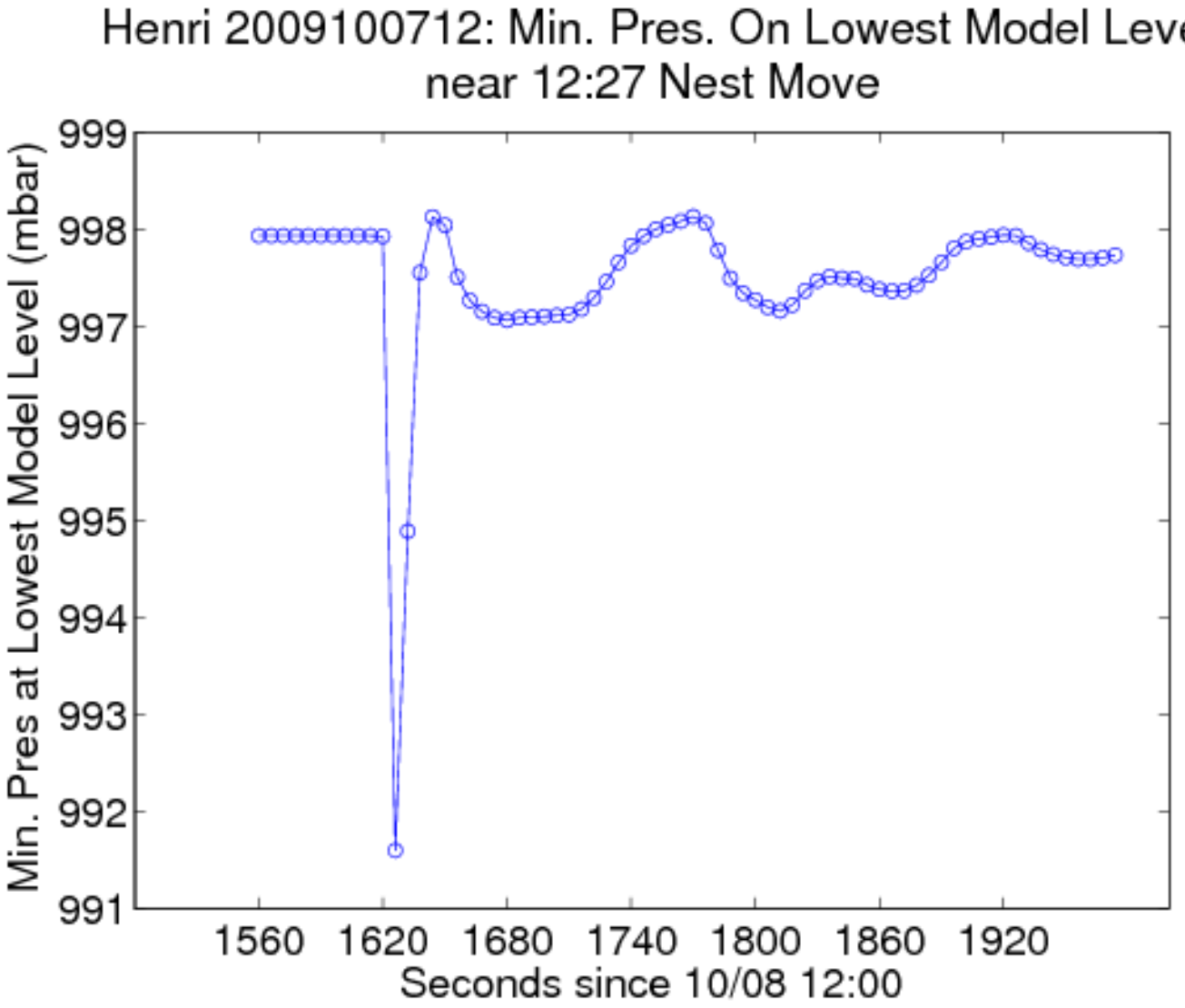

Henri 2009100712: 10/08 12:27 Nest Move
P(27:18) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10

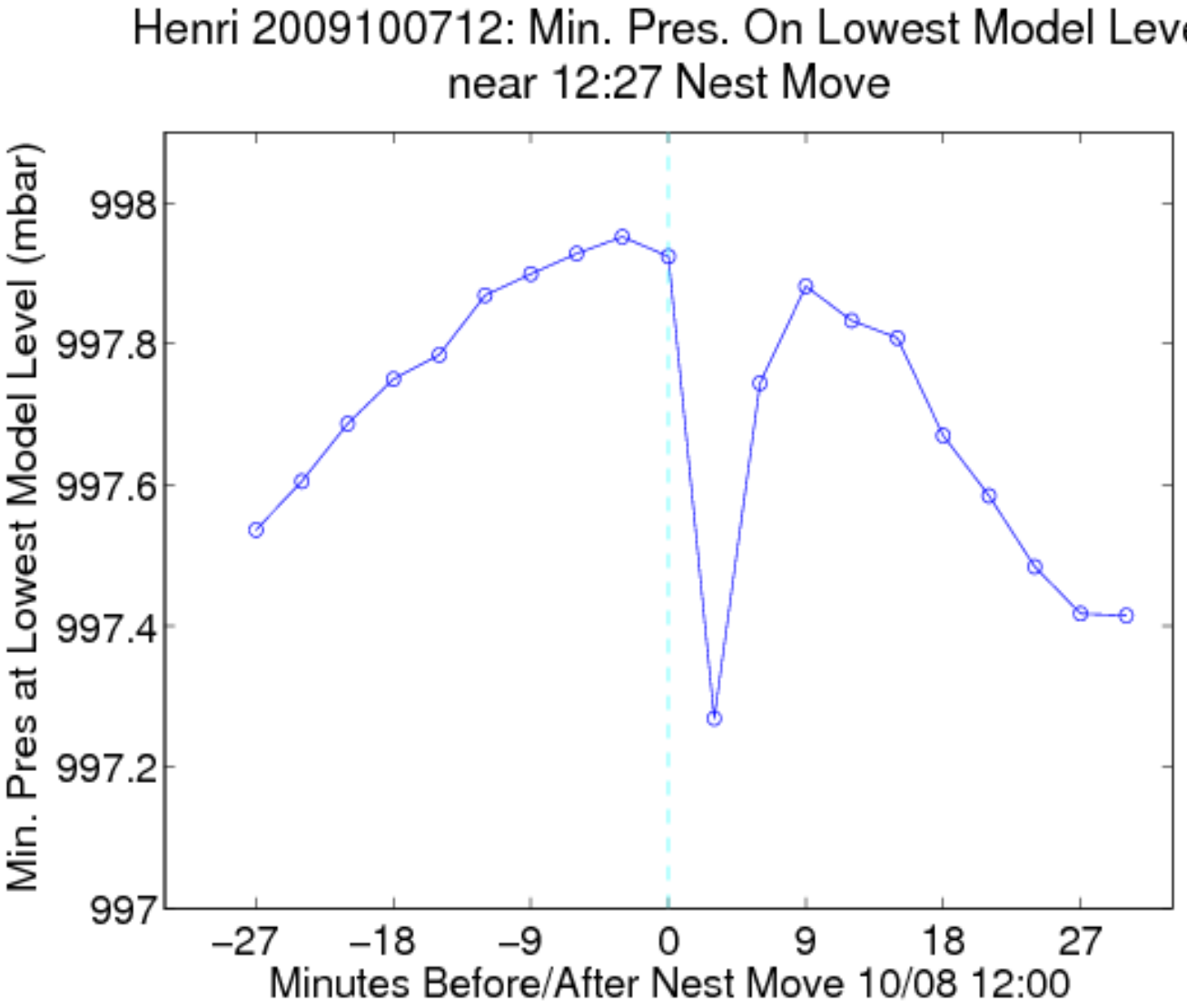

Henri 2009100712: 10/08 12:27 Nest Move
P(27:24) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10


Henri 2009100712: 10/08 12:27 Nest Move
P(27:30) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10


Henri 2009100712: 10/08 12:27 Nest Move
P(28:00) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10


Henri 2009100712: 10/08 12:27 Nest Move
P(30:00) – P(27:00) in mbar On Lowest Model Level
Latitude
24
23
22
21
20
19
–62
–60
–58
–56
Longitude
10
5
0
–5
–10


Henri 2009100712: Min. Pres. On Lowest Model Level
near 12:27 Nest Move
Min. Pres at Lowest Model Level (mbar)
999
998
997
996
995
994
993
992
991
1560
1620
1680
1740
1800
1860
1920
Seconds since 10/08 12:00


Henri 2009100712: Min. Pres. On Lowest Model Level
near 12:27 Nest Move
Min. Pres at Lowest Model Level (mbar)
998
997.8
997.6
997.4
997.2
997
−27
−18
−9
0
9
18
27
Minutes Before/After Nest Move 10/08 12:00

Issues: Convection Issues

- 200 mb cloud tops in simulation
- Actual hurricanes reach 100 mb regularly.
- Isolated ”hot towers”
  - some can puncture tropopause, pass 20km
  - Critical for strengthening pot.temp. inversion in eye
  - Important in climate research and stratospheric transport as mechanism for transporting matter from troposphere to stratosphere.
- Actual hurricane convective scale is 1.5-6 km. Grid scale is 4.5 km. Can SAS handle that?
- Higher resolution: NMM may be explicitly resolving small amount of convection on its own.

Fixed So Far

- Copy all GFS input data to Vapor.
- Use updated GFDL executables (done late in HFIP runs)
- Not real-time, so re-running cycles is not a problem.
- HWRF autosubmission script
  - detects whether ocean init worked.
  - detects cold starts.
  - launches next cycle after previous cycle's 12hr track is done.
  - handles deletion of data.
  - emails results.

Hi-Res Reruns: Speed

- Current speed test:
  - Original HWR4 physics, dynamics but with correct input data and coupling to low-res POM.
  - 21.6 second timestep (25 timesteps per coupling interval)
  - Optimize NMM_NEST_UTILS1.F (base_state_parent)
  - Use -O3 instead of -O2
  - Run 60 processes on ONE MACHINE
- Speed: ~11-12 machine-hours per cycle (was 25-30)
  - 3-4 hrs for initialization (unchanged)
  - ~45 minutes for 12hr run
  - ~9.25 hours for 126 hour run (need longer Vapor wallclock limit)

Hi-Res: Further Speedup Needed for Operational Runs

- Not usable operationally in current form.
- One machine: ~35-50% is waiting on MPI communication
  - Should be nearly 0% since there is no network involved.
  - Conclusion: Either RSL or IBM MPI (or both) have serious problems
- Five machines: ~60-70% is waiting on MPI comm.
- Need to reduce MPI communication
  - Feedback, forcing only needs edge of intermediate domain.
  - Try using OpenMP (shared memory multiprocessing).

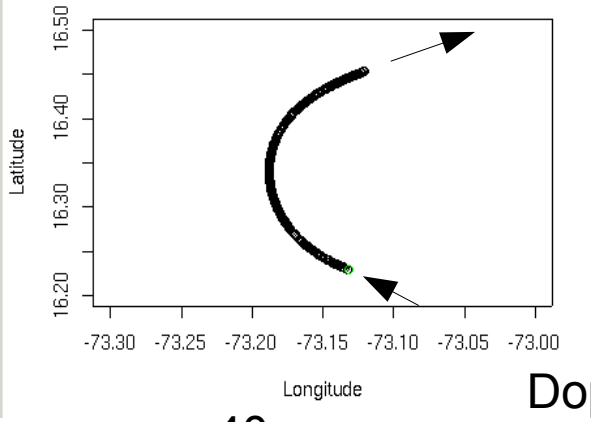
Summary

- HWR4 forecast, track terrible
  - ~20 knot positive intensity bias
- Vapor issues, GWD at high res, low-res POM
- Nest movement: discarding non-hydro. state.
  - Maybe reason for 18s timestep
- Need better MPI efficiency for operational HWR4.

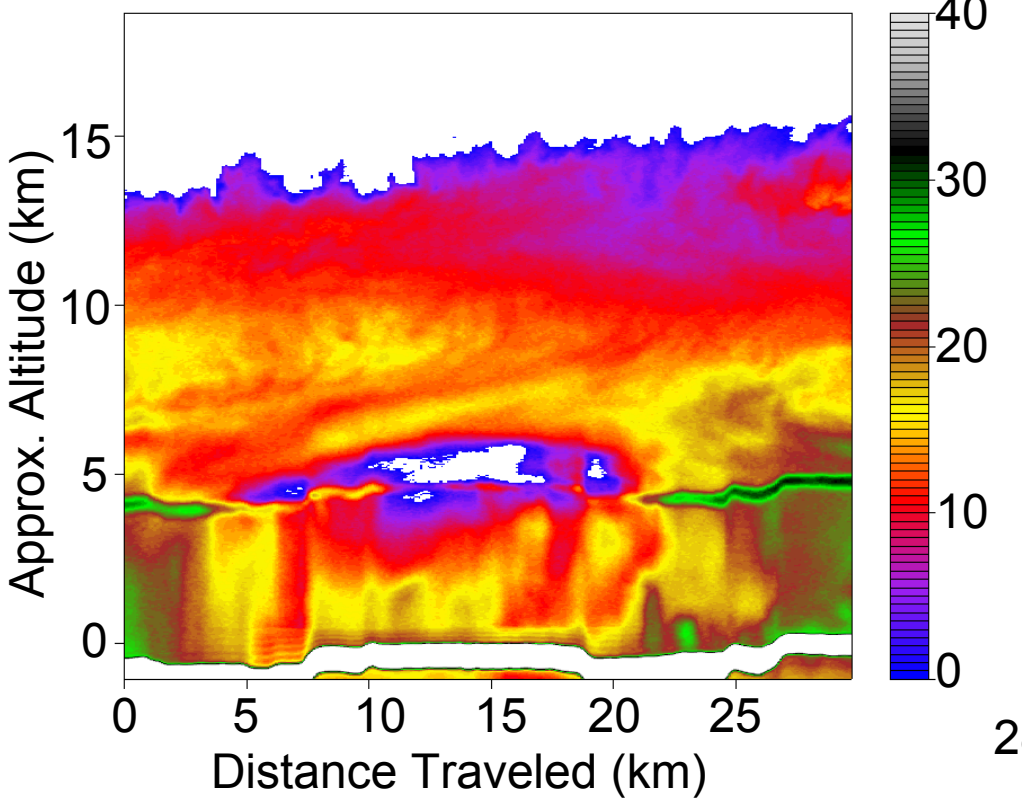
Questions?

Observational Data

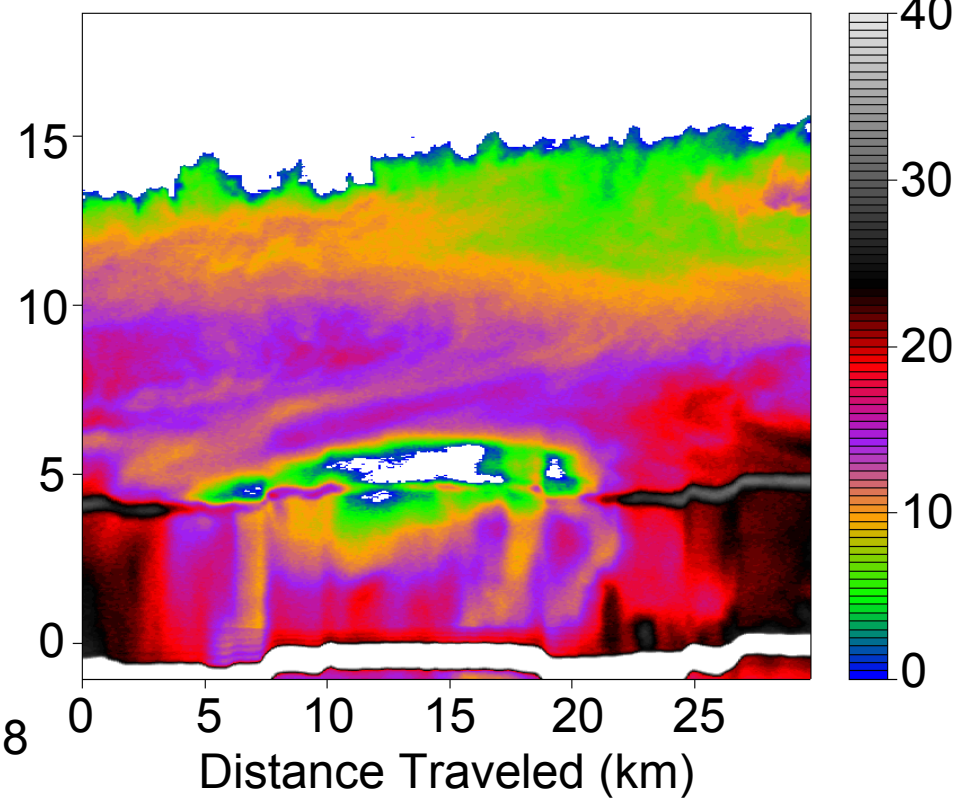
EDOP Data Sample: Dennis (2005)



Reflectivity (dbZ)

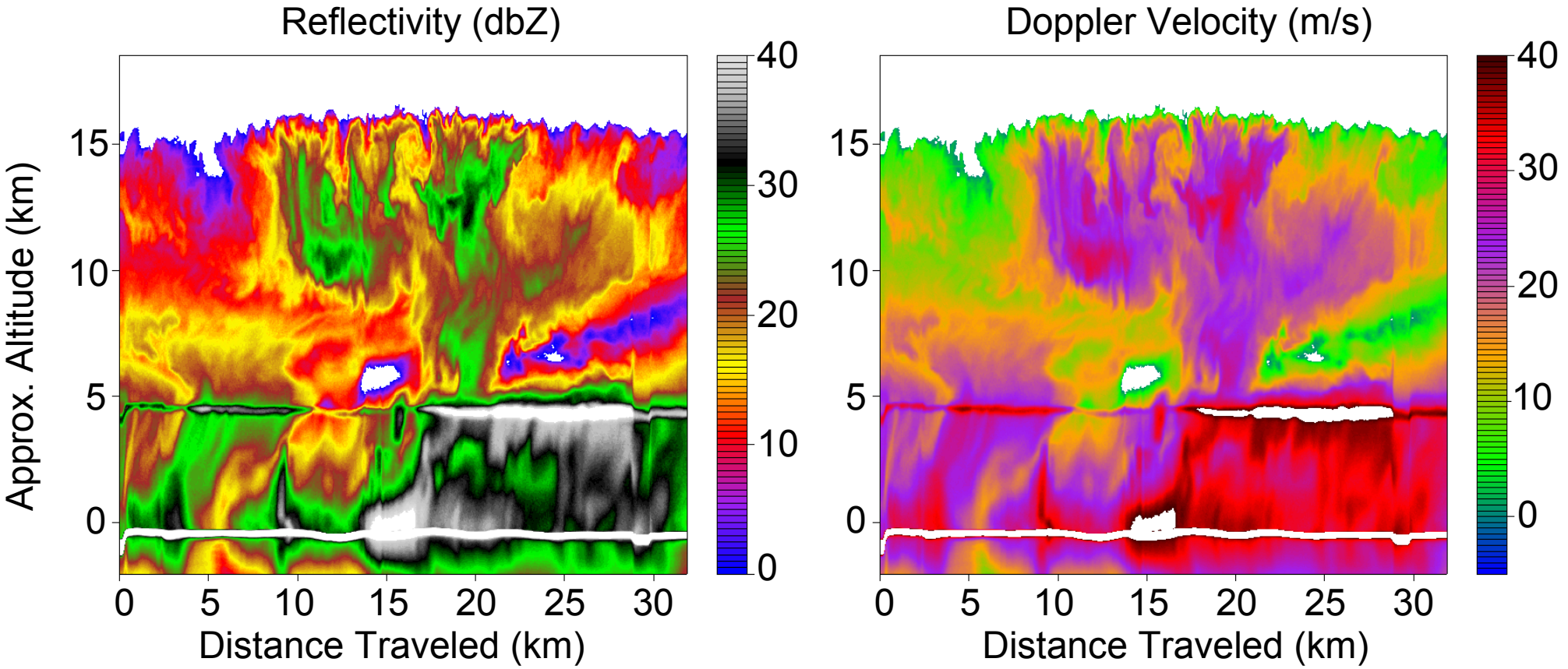


Doppler Velocity (m/s)



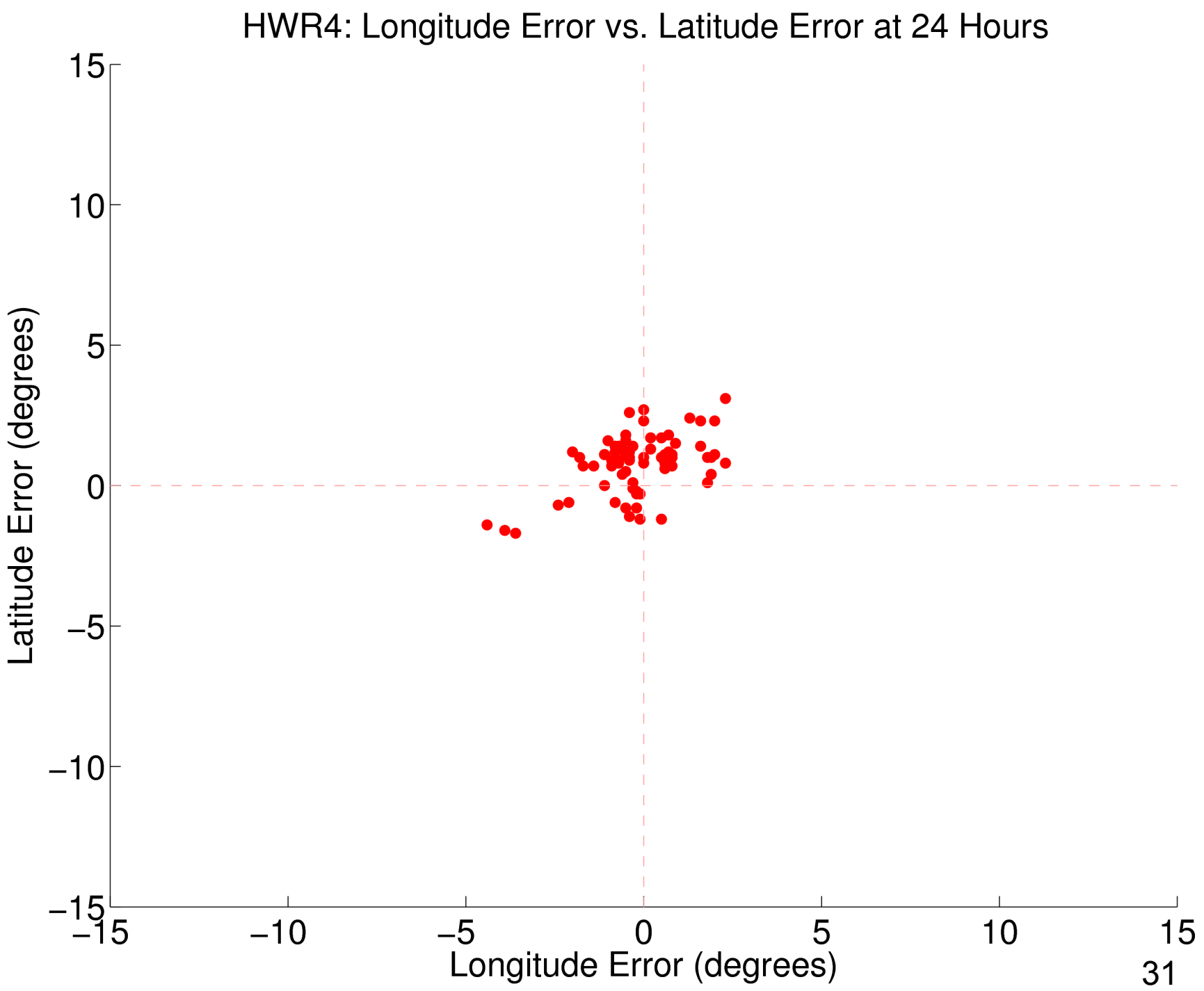
Observational Data

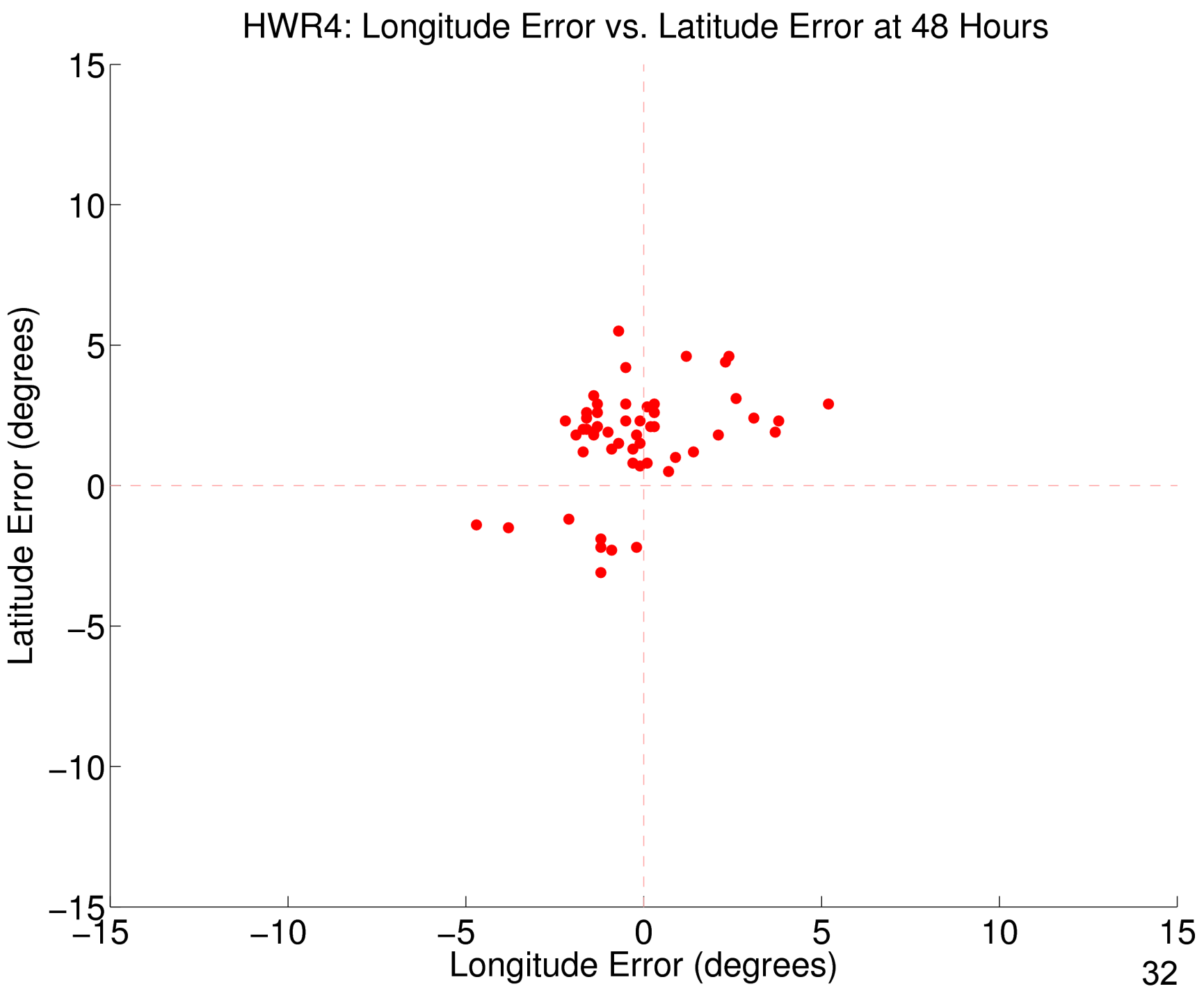
EDOP Data Sample: Dennis (2005)

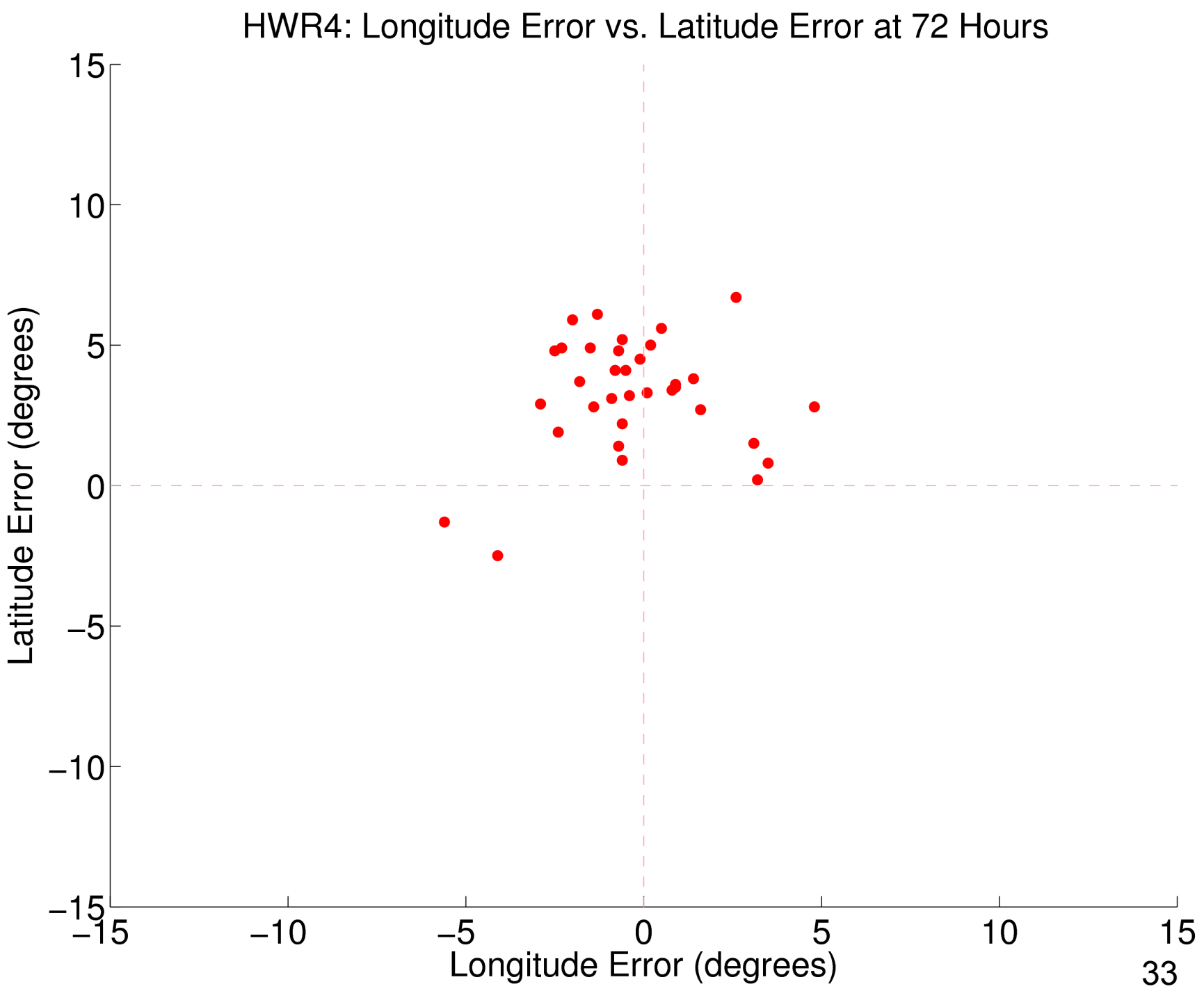


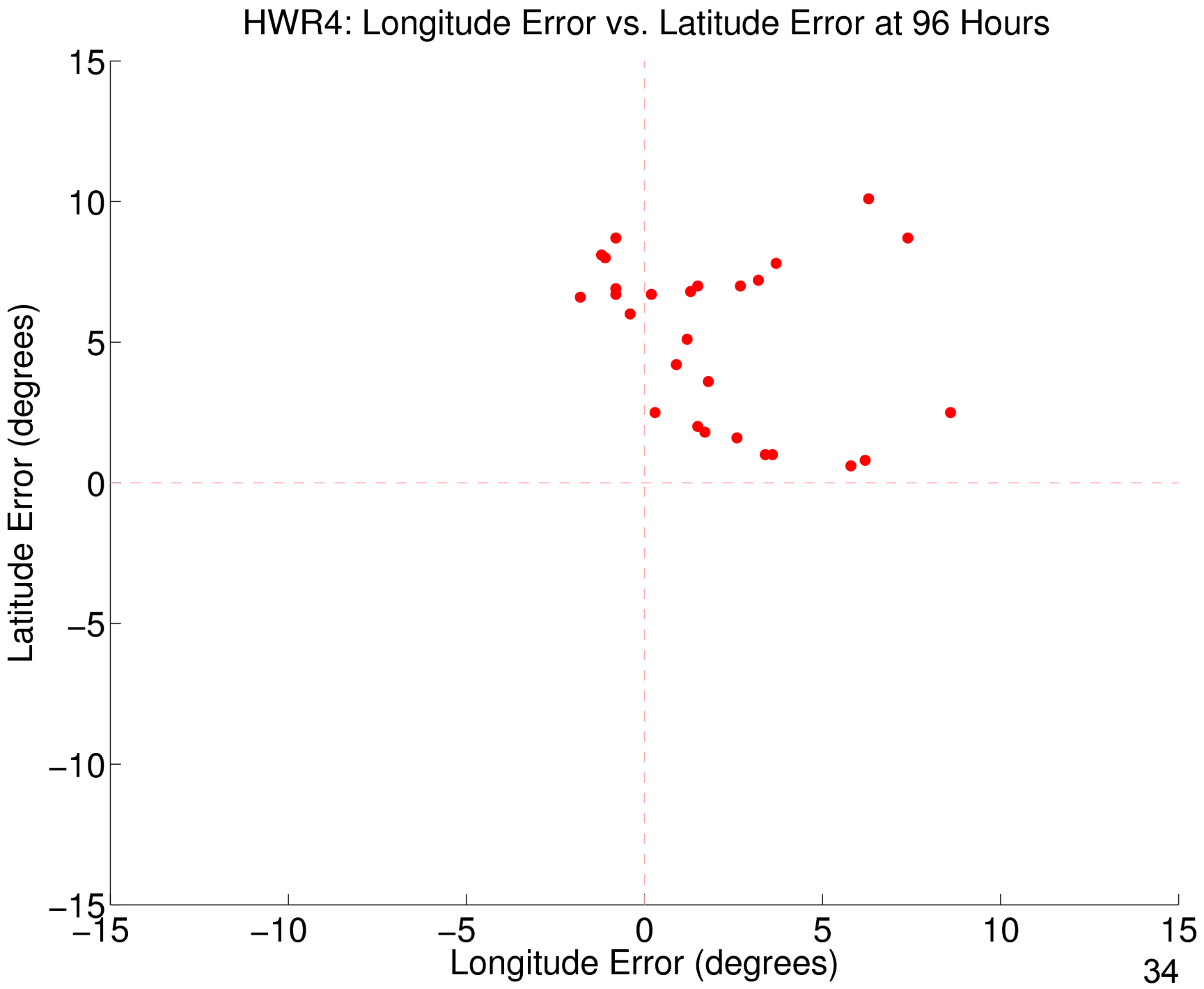
Analysis of Errors

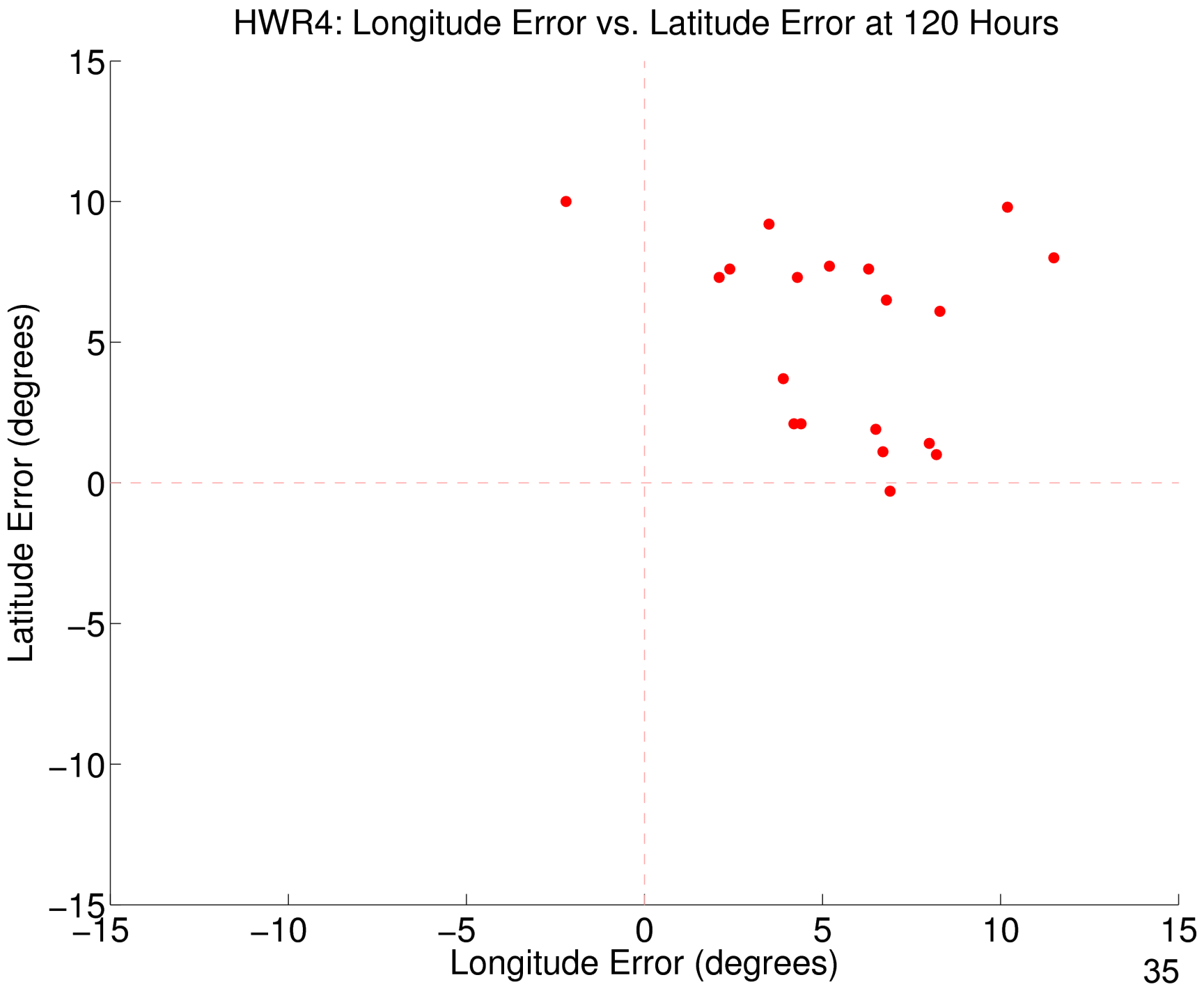
- HWR4 only -- Includes Invest cases, so error is slightly worse than prior three graphs
- ”Best track” is actually Vapor tcvitals
- Error ellipses placed at 1.5 standard deviations

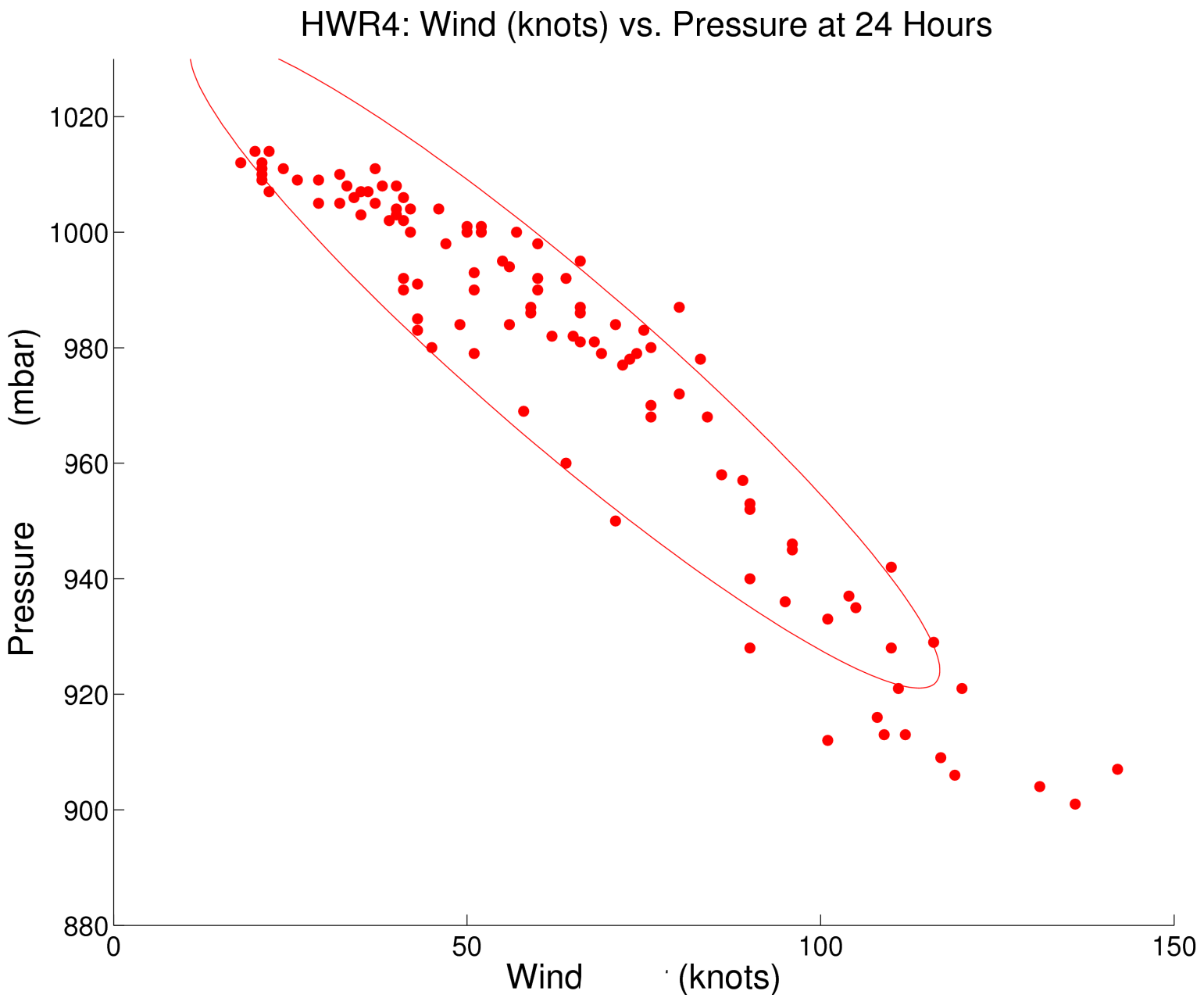

HWR4: Longitude Error vs. Latitude Error at 24 Hours
Latitude Error (degrees)
Longitude Error (degrees)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15

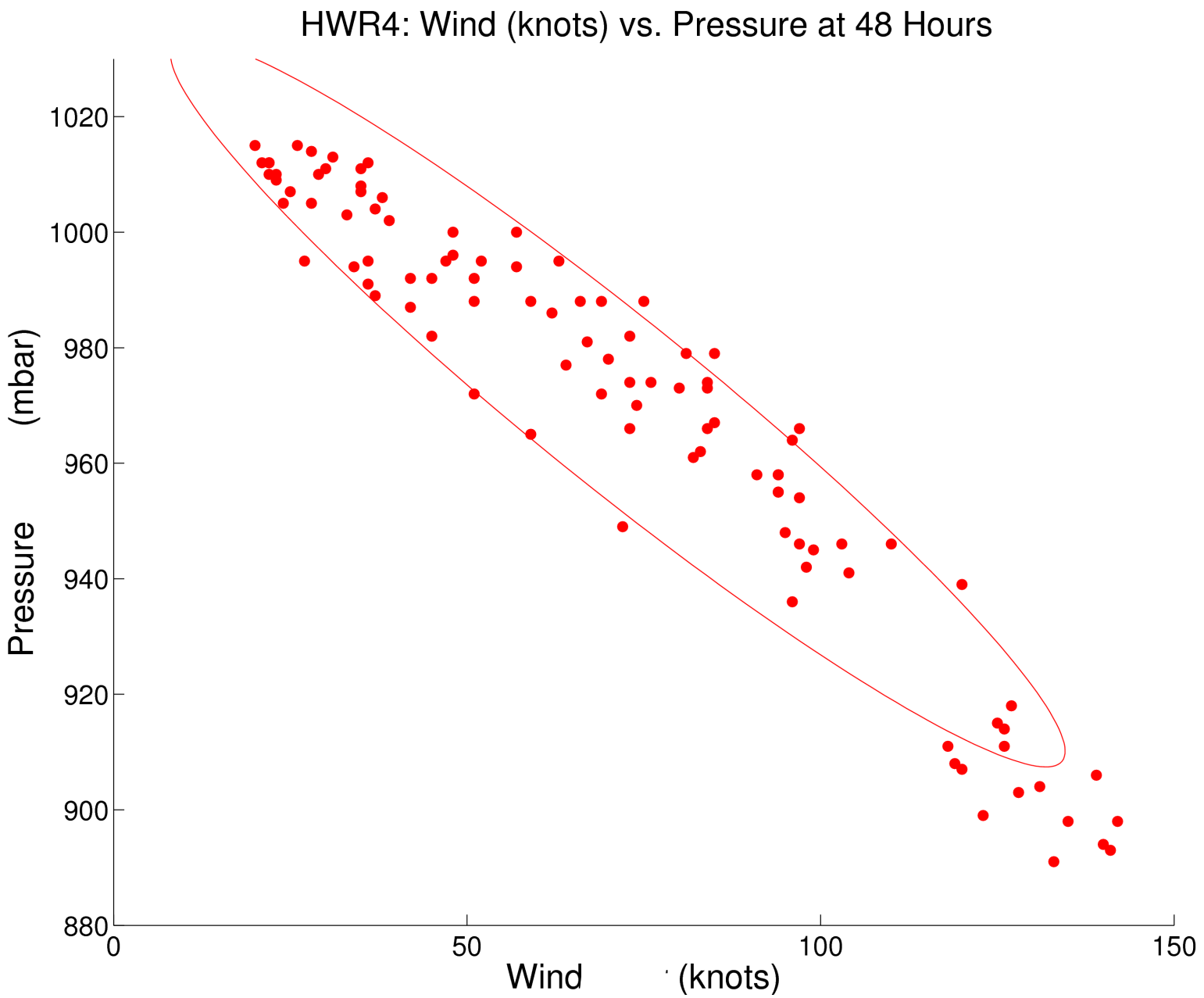

HWR4: Longitude Error vs. Latitude Error at 48 Hours
Latitude Error (degrees)
Longitude Error (degrees)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15

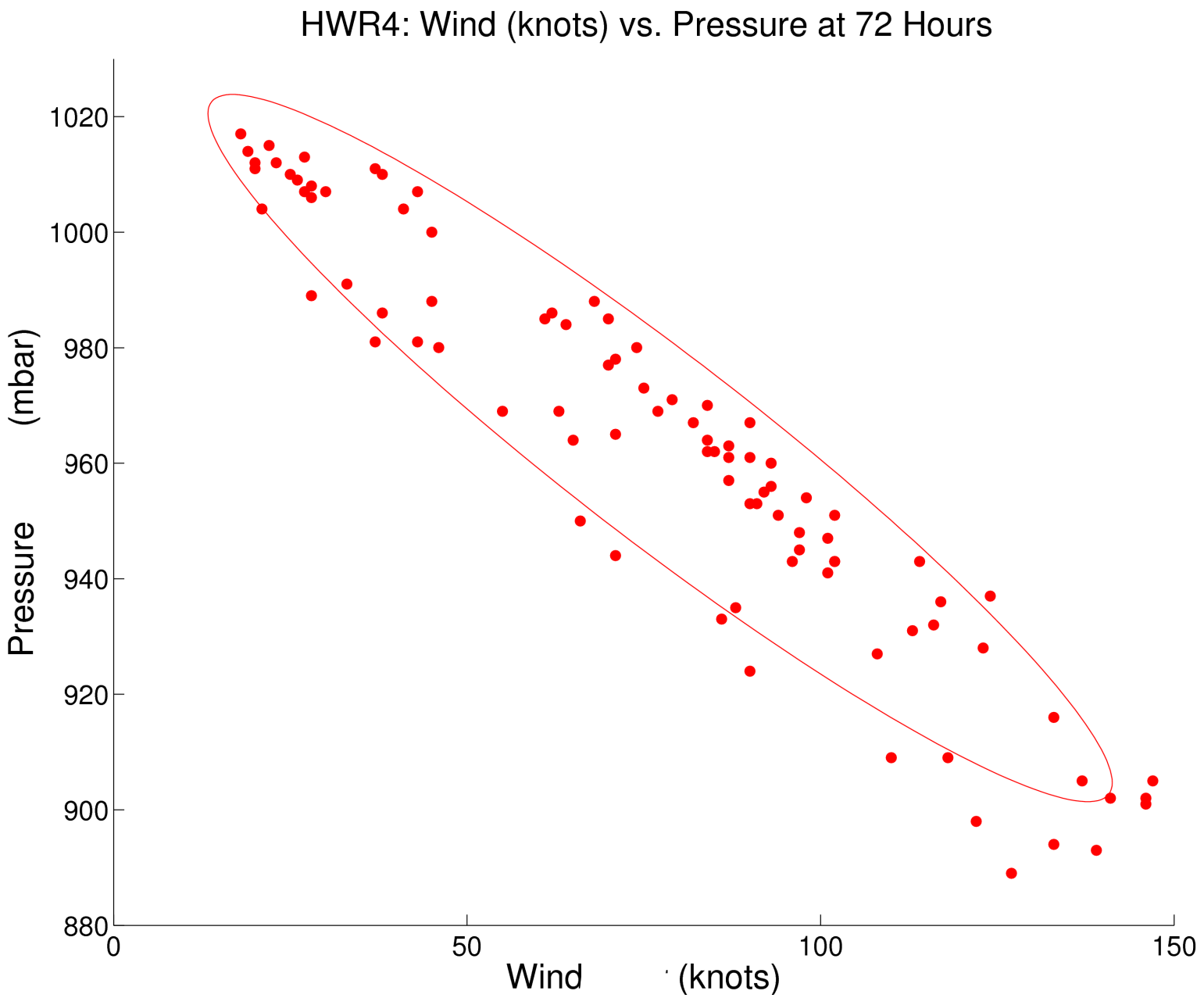

HWR4: Longitude Error vs. Latitude Error at 72 Hours
Latitude Error (degrees)
Longitude Error (degrees)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15
33

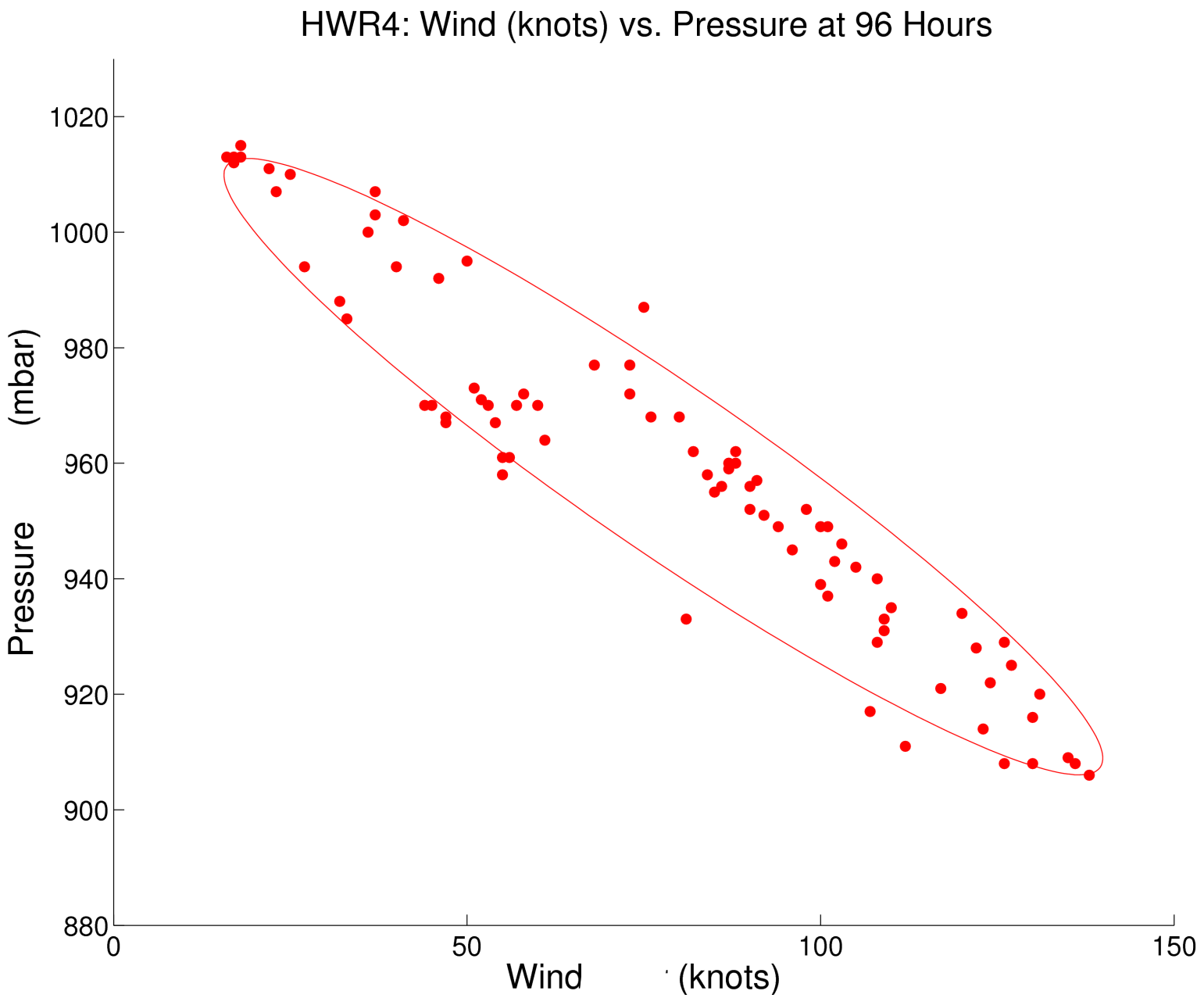

HWR4: Longitude Error vs. Latitude Error at 96 Hours
Latitude Error (degrees)
Longitude Error (degrees)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15
34

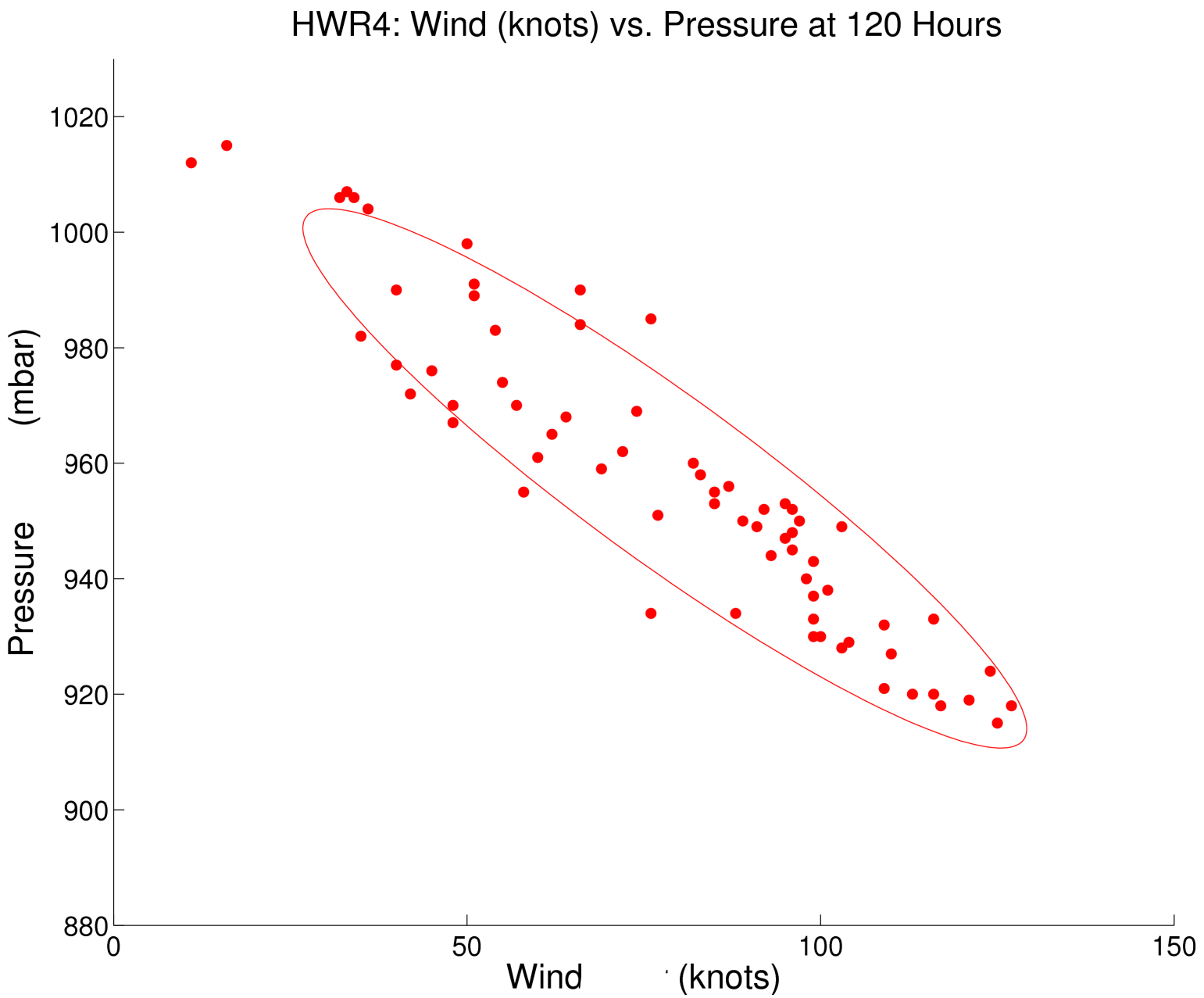

HWR4: Longitude Error vs. Latitude Error at 120 Hours
Latitude Error (degrees)
Longitude Error (degrees)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15

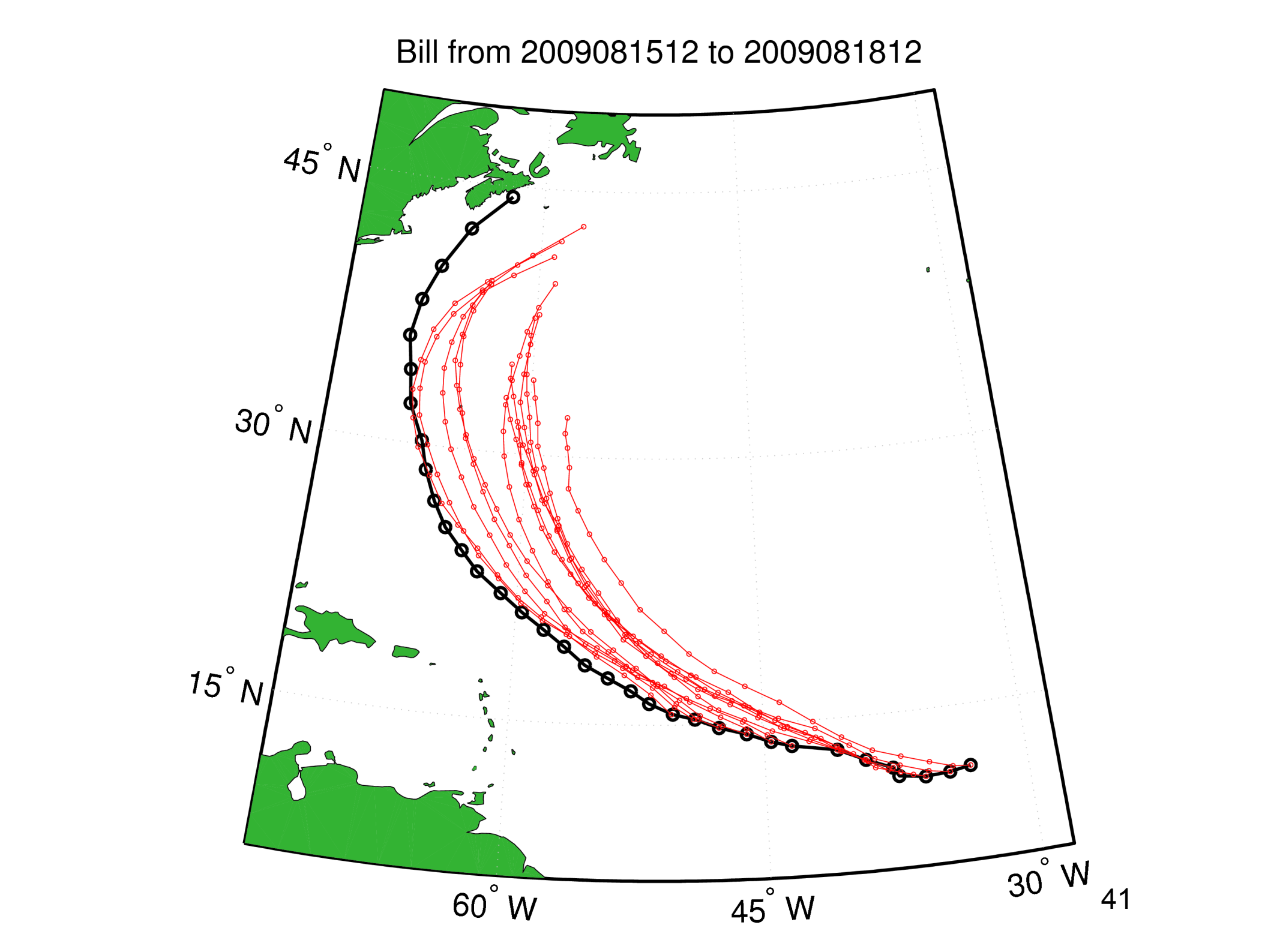

HWR4: Wind (knots) vs. Pressure at 24 Hours
Pressure (mbar)
1020
1000
980
960
940
920
900
880
0
50
100
150
Wind (knots)

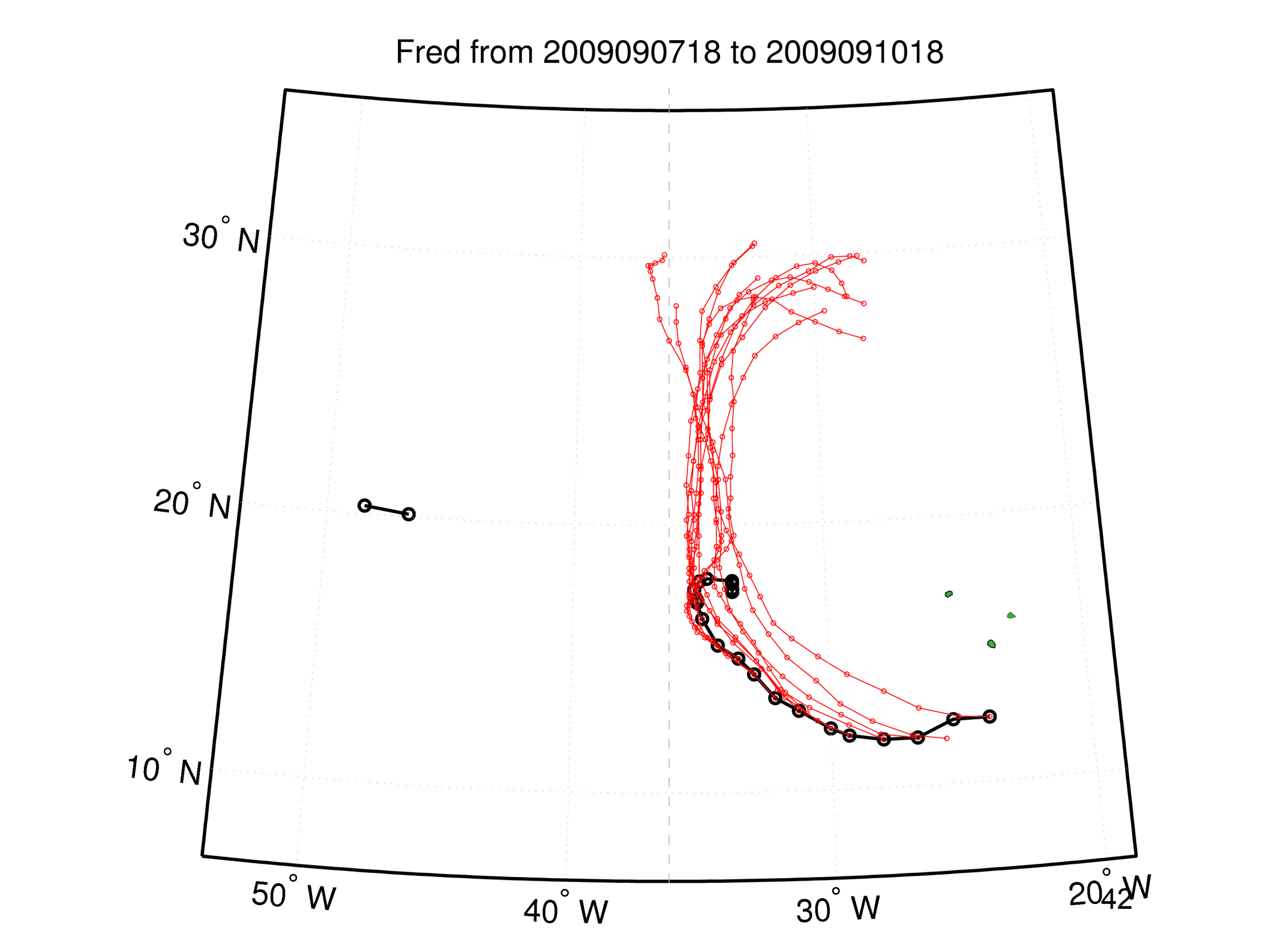

HWR4: Wind (knots) vs. Pressure at 48 Hours
Pressure (mbar)
1020
1000
980
960
940
920
900
880
0
50
100
150
Wind (knots)


HWR4: Wind (knots) vs. Pressure at 72 Hours
Pressure (mbar)
1020
1000
980
960
940
920
900
880
0
50
100
150
Wind (knots)


HWR4: Wind (knots) vs. Pressure at 96 Hours
Pressure (mbar)
1020
1000
980
960
940
920
900
880
0
50
100
150
Wind (knots)

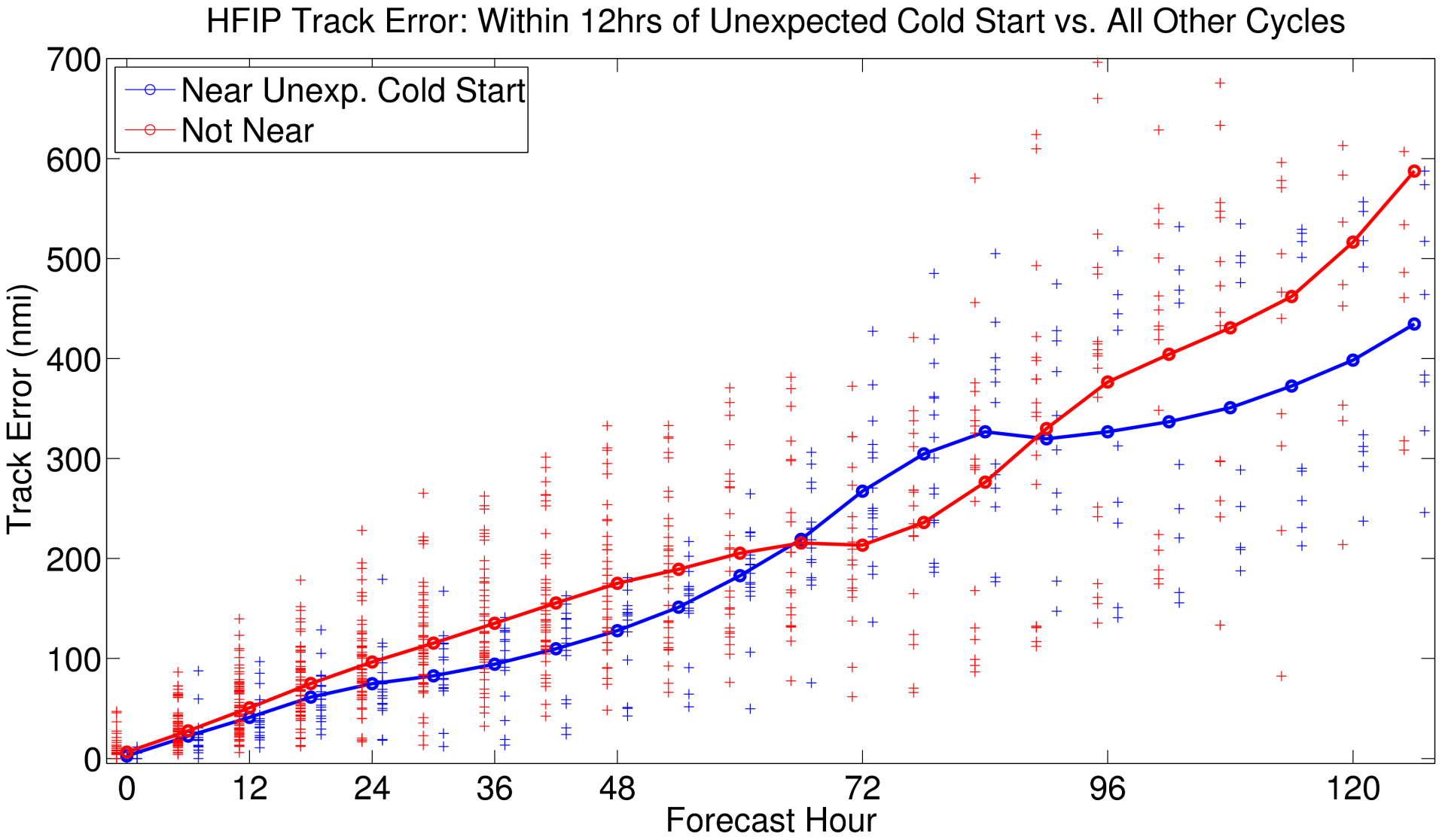

HWR4: Wind (knots) vs. Pressure at 120 Hours
Pressure (mbar)
1020
1000
980
960
940
920
900
880
0
50
100
150
Wind (knots)

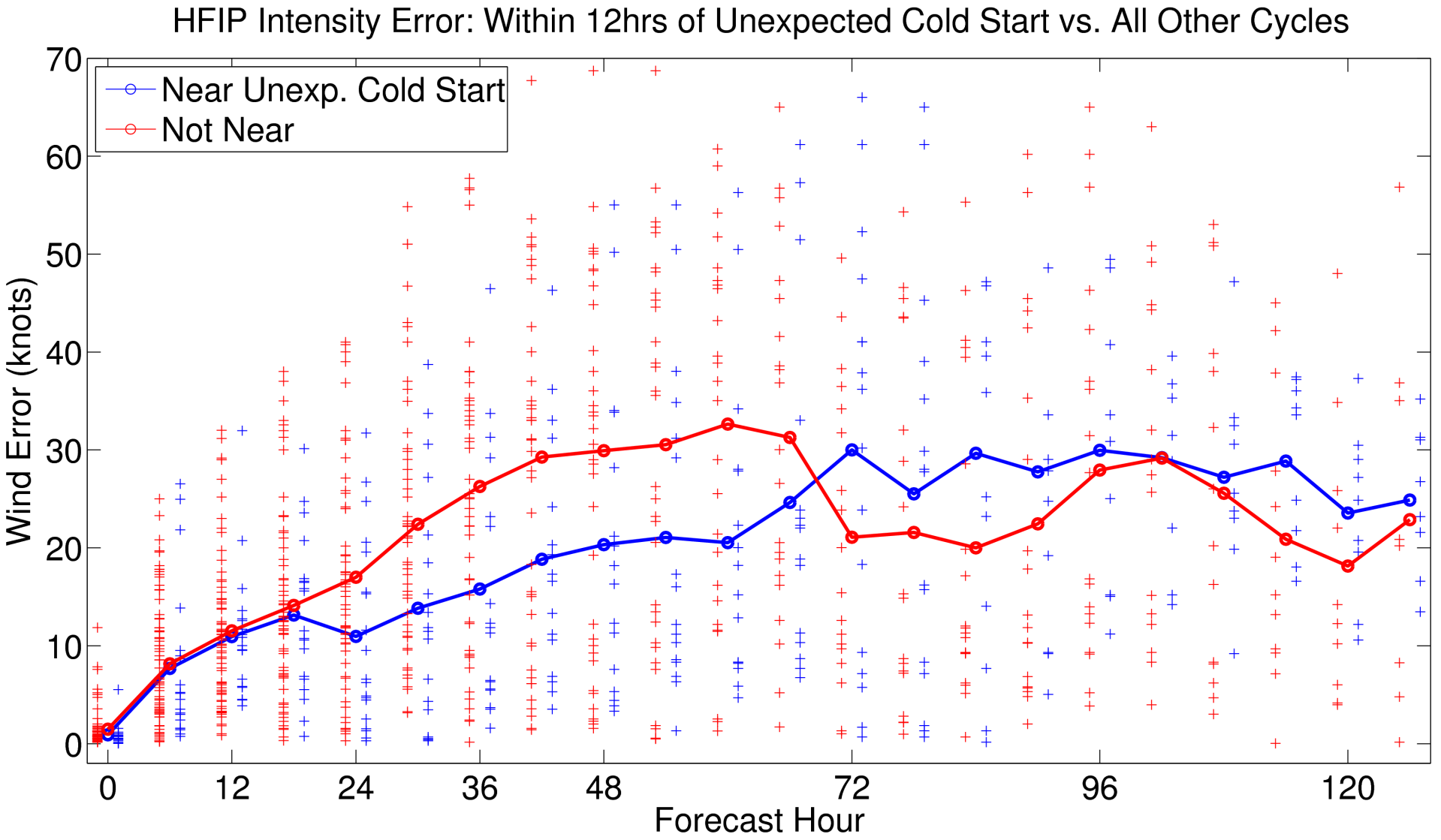

Bill from 2009081512 to 2009081812
45° N
30° N
15° N
60° W
45° W
30° W
41


Fred from 2009090718 to 2009091018
30° N
20° N
10° N
50° W
40° W
30° W
20° W

Conditional Statistics

- Includes INVEST cases (mostly 98L)
- Does not include Danny 05L (run by Vijay) since I don't have the HPSS archive for that, and hence cannot determine which populations each cycle belongs to.
- Populations:
  - Unexpected cold starts
  - FORECAST vs HISTORY
  - SS cat >2, weaker hurricanes, non-hurr.
  - Invest vs non-invest
- Limitiations: most FORECAST cases are Fred, nearly all cases run with ocean are Fred


HFIP Track Error: Within 12hrs of Unexpected Cold Start vs. All Other Cycles
Near Unexp. Cold Start
Not Near
Track Error (nmi)
Forecast Hour
0
100
200
300
400
500
600
700
0
12
24
36
48
72
96
120


HFIP Intensity Error: Within 12hrs of Unexpected Cold Start vs. All Other Cycles
Near Unexp. Cold Start
Not Near
Wind Error (knots)
Forecast Hour
0
10
20
30
40
50
60
70
0
12
24
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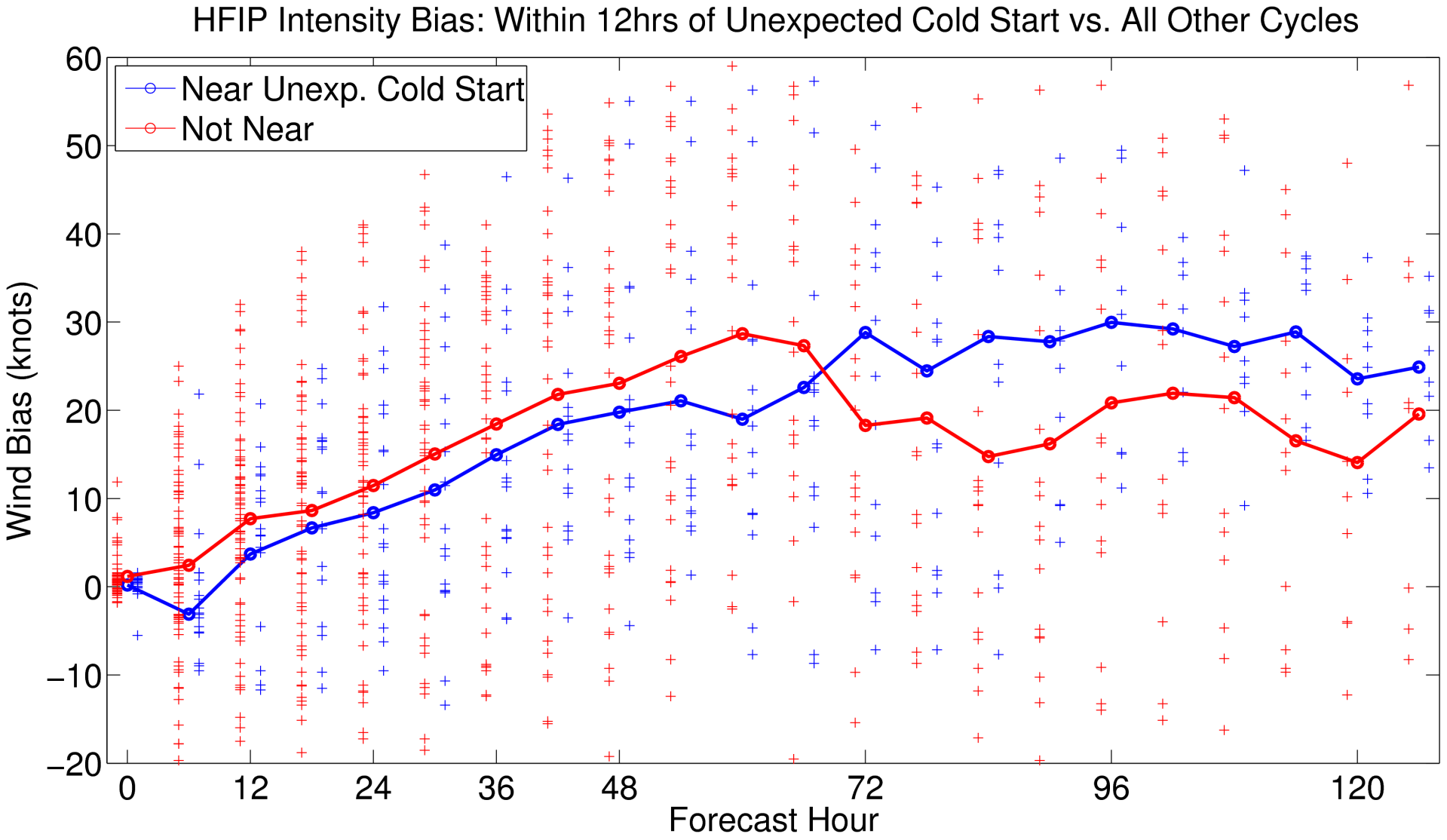
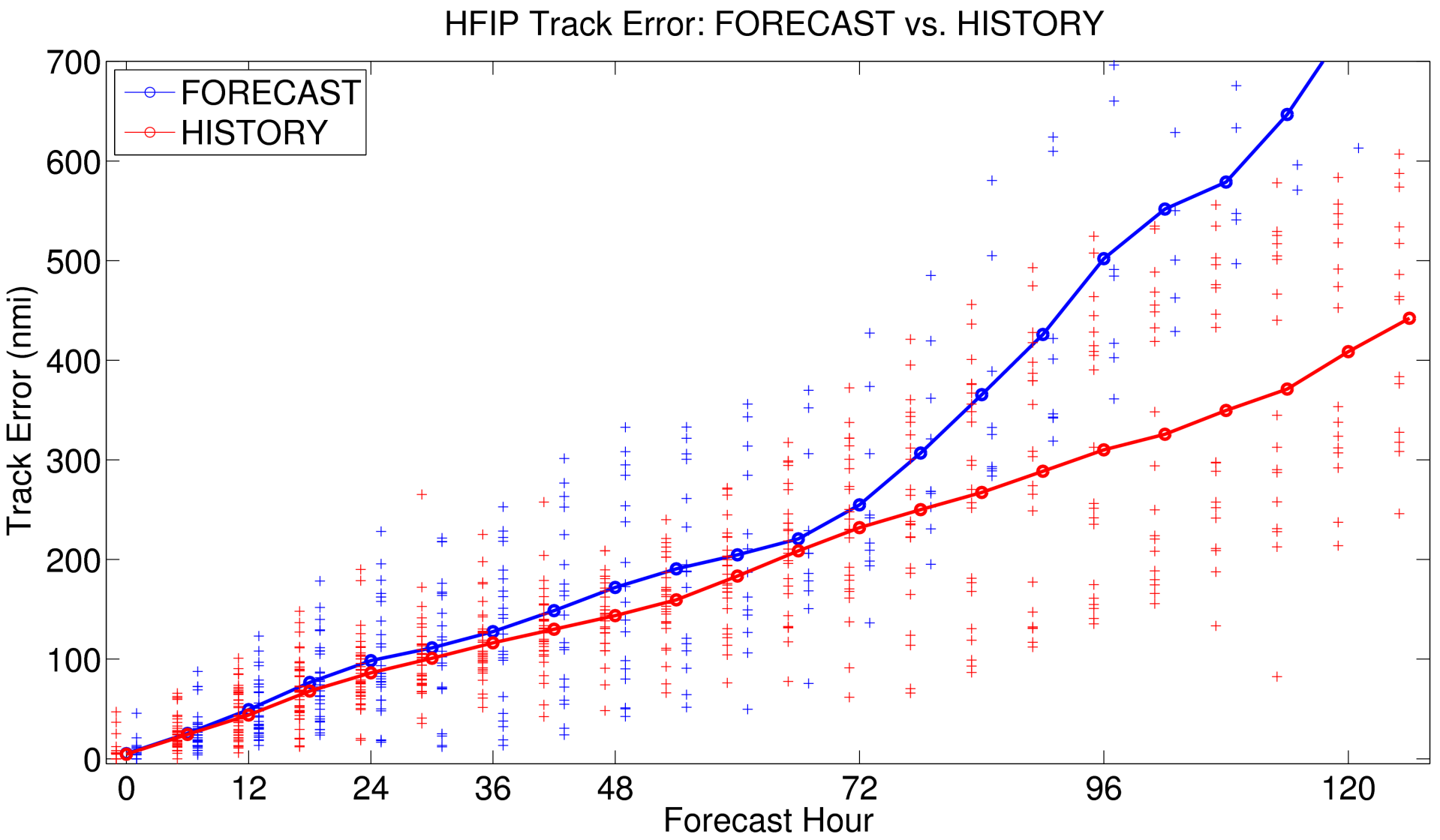
48
72
96
120


HFIP Intensity Bias: Within 12hrs of Unexpected Cold Start vs. All Other Cycles
Near Unexp. Cold Start
Not Near
Wind Bias (knots)
60
50
40
30
20
10
0
−10
−20
0
12
24
36
48
72
96
120
Forecast Hour


HFIP Track Error: FORECAST vs. HISTORY
FORECAST
HISTORY
Track Error (nmi)
Forecast Hour
0
100
200
300
400
500
600
700
0
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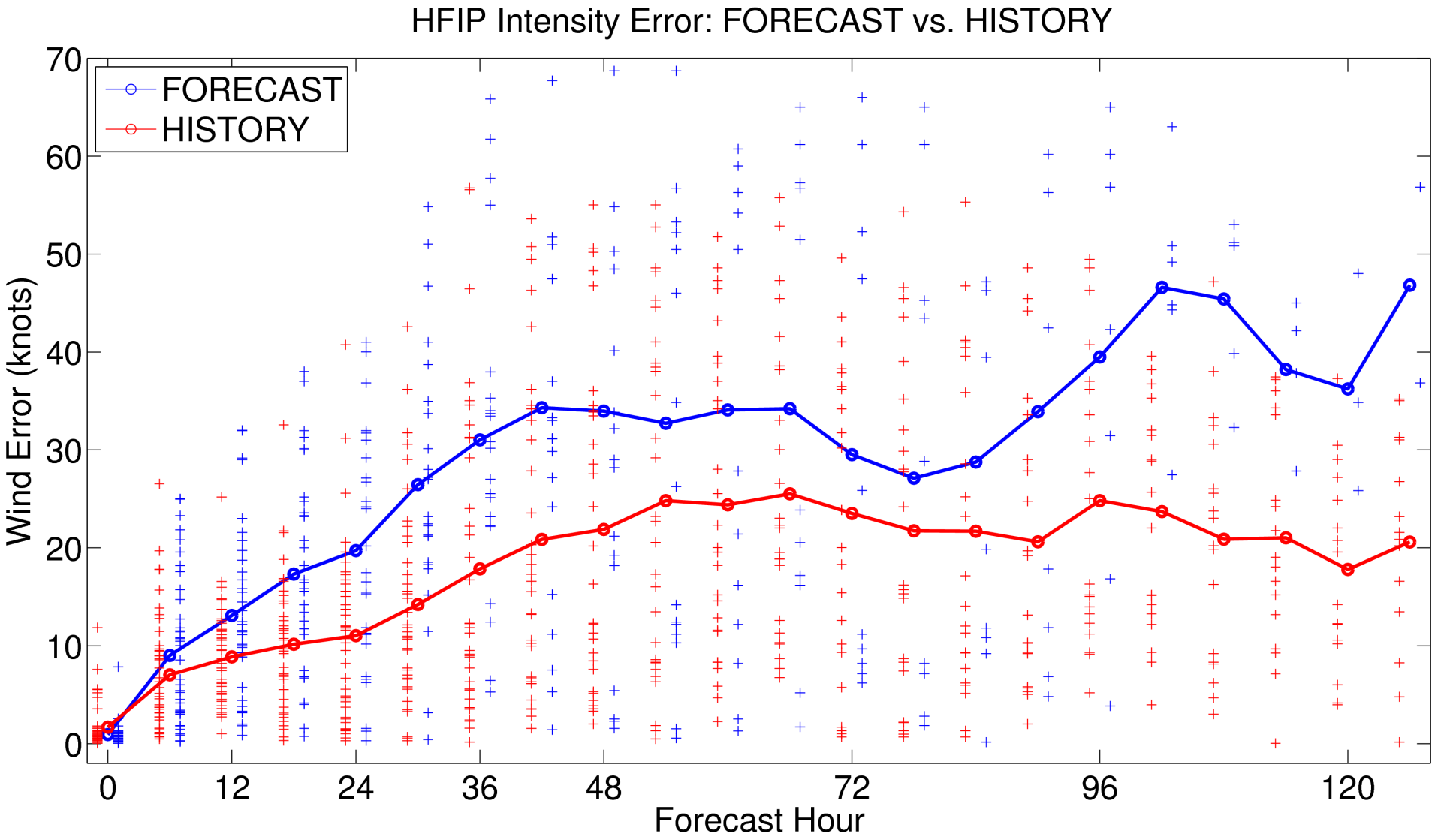
36
48
72
96
120


HFIP Intensity Error: FORECAST vs. HISTORY
FORECAST
HISTORY
Wind Error (knots)
Forecast Hour
0
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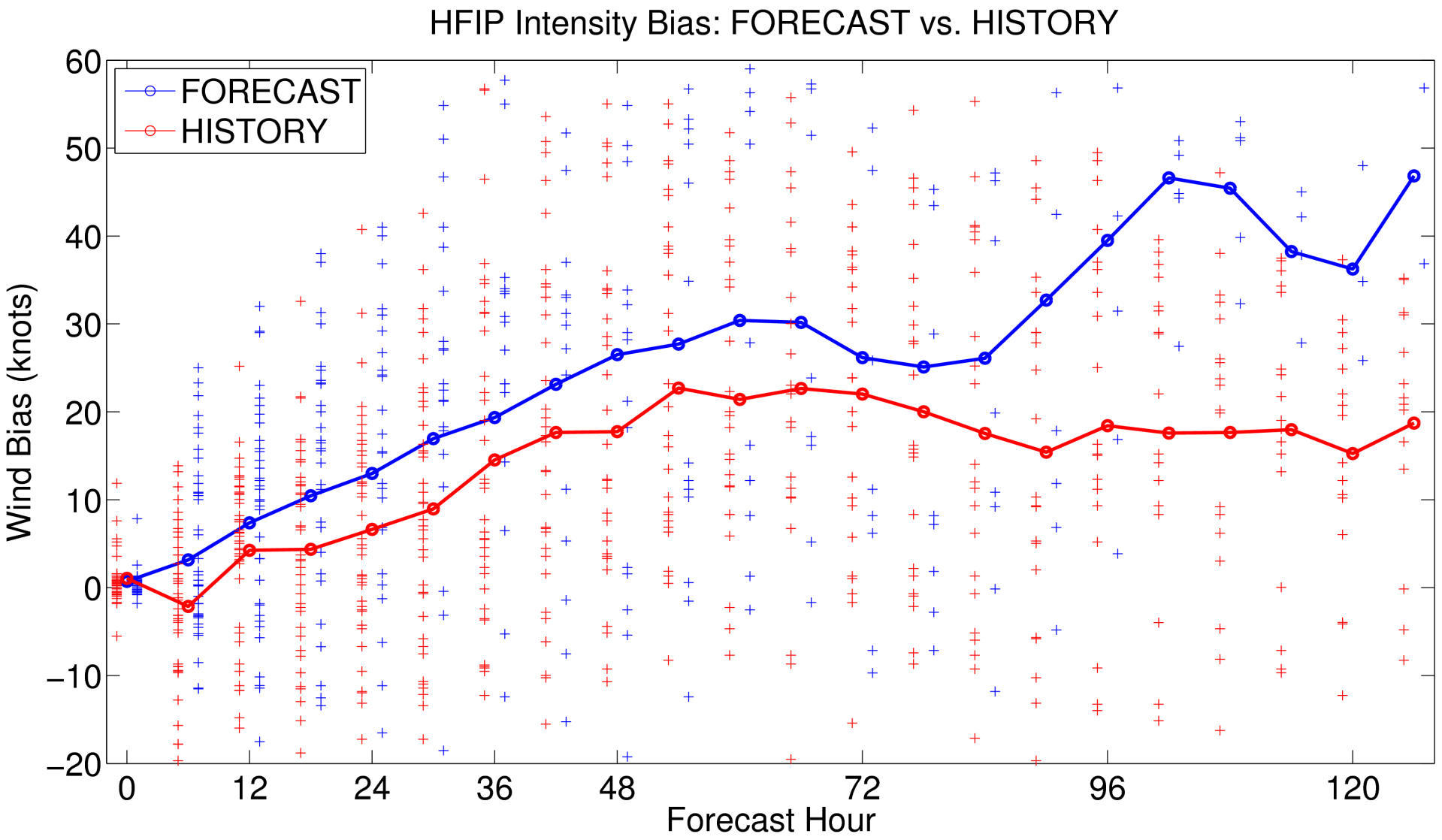
72
96
120


HFIP Intensity Bias: FORECAST vs. HISTORY
FORECAST
HISTORY
Wind Bias (knots)
60
50
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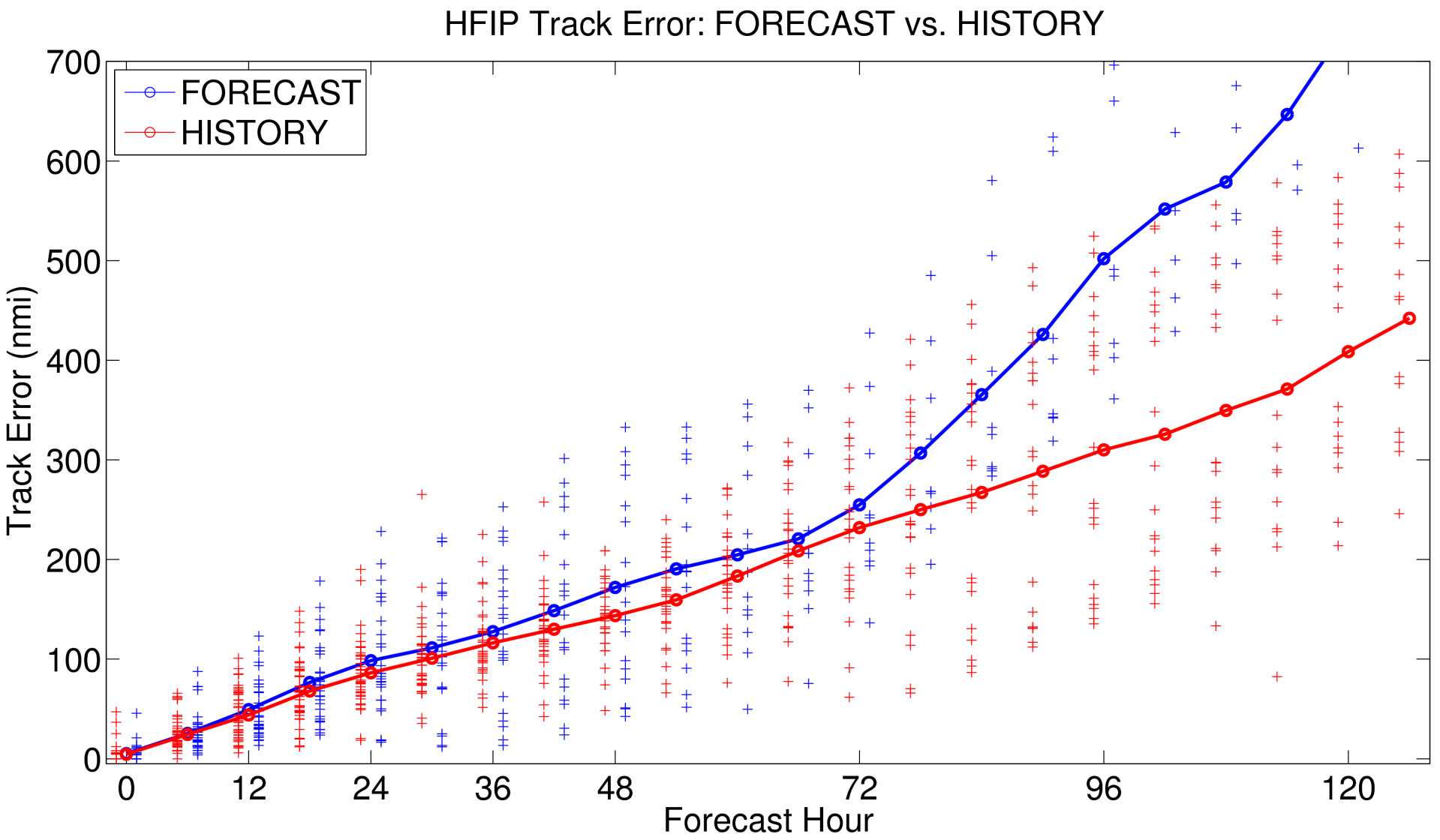
72
96
120
Forecast Hour


HFIP Track Error: FORECAST vs. HISTORY
FORECAST
HISTORY
Track Error (nmi)
Forecast Hour
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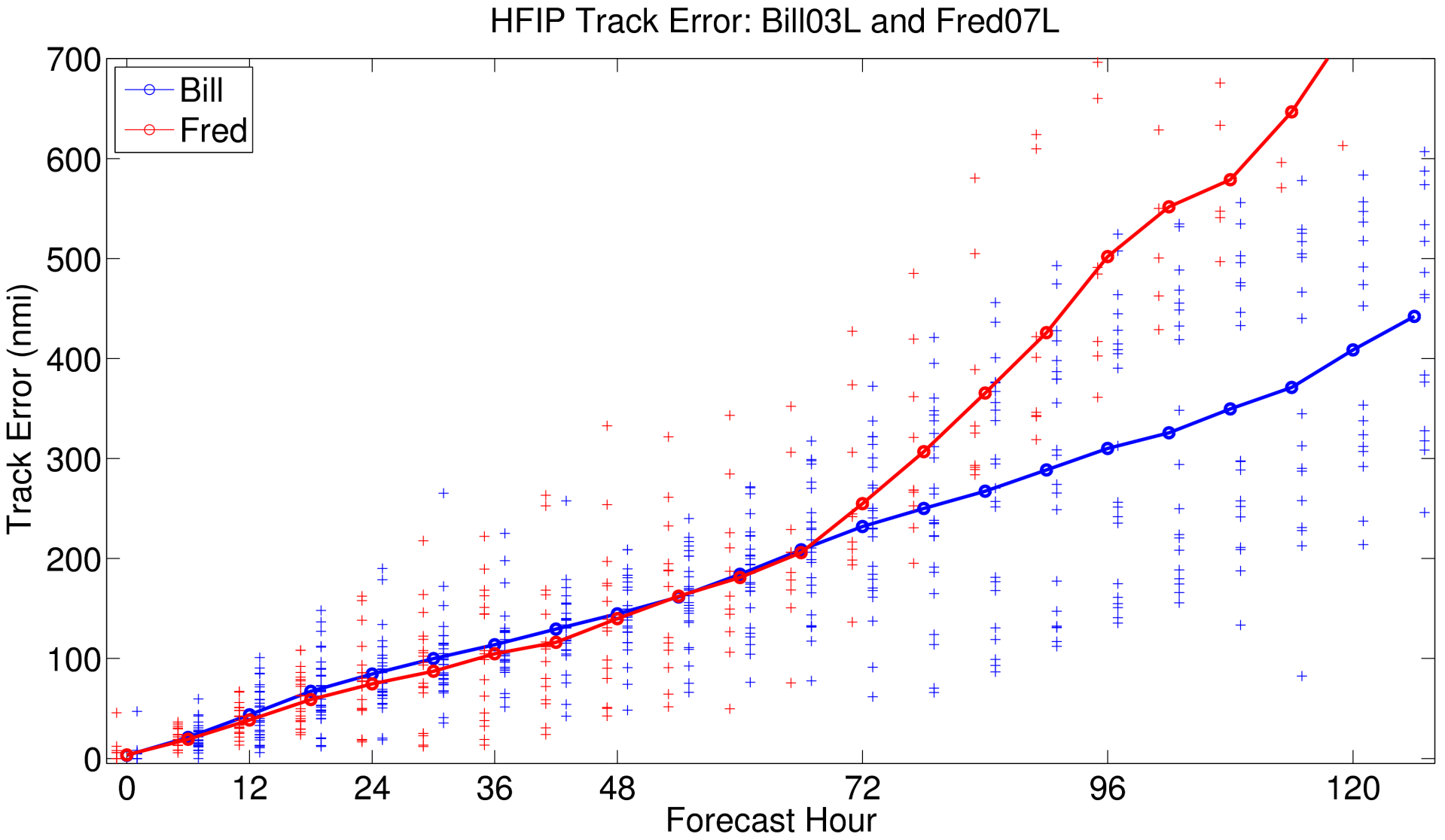
HFIP Track Error: Bill03L and Fred07L
Bill
Fred
Track Error (nmi)
Forecast Hour
0
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200
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400
500
600
700
0
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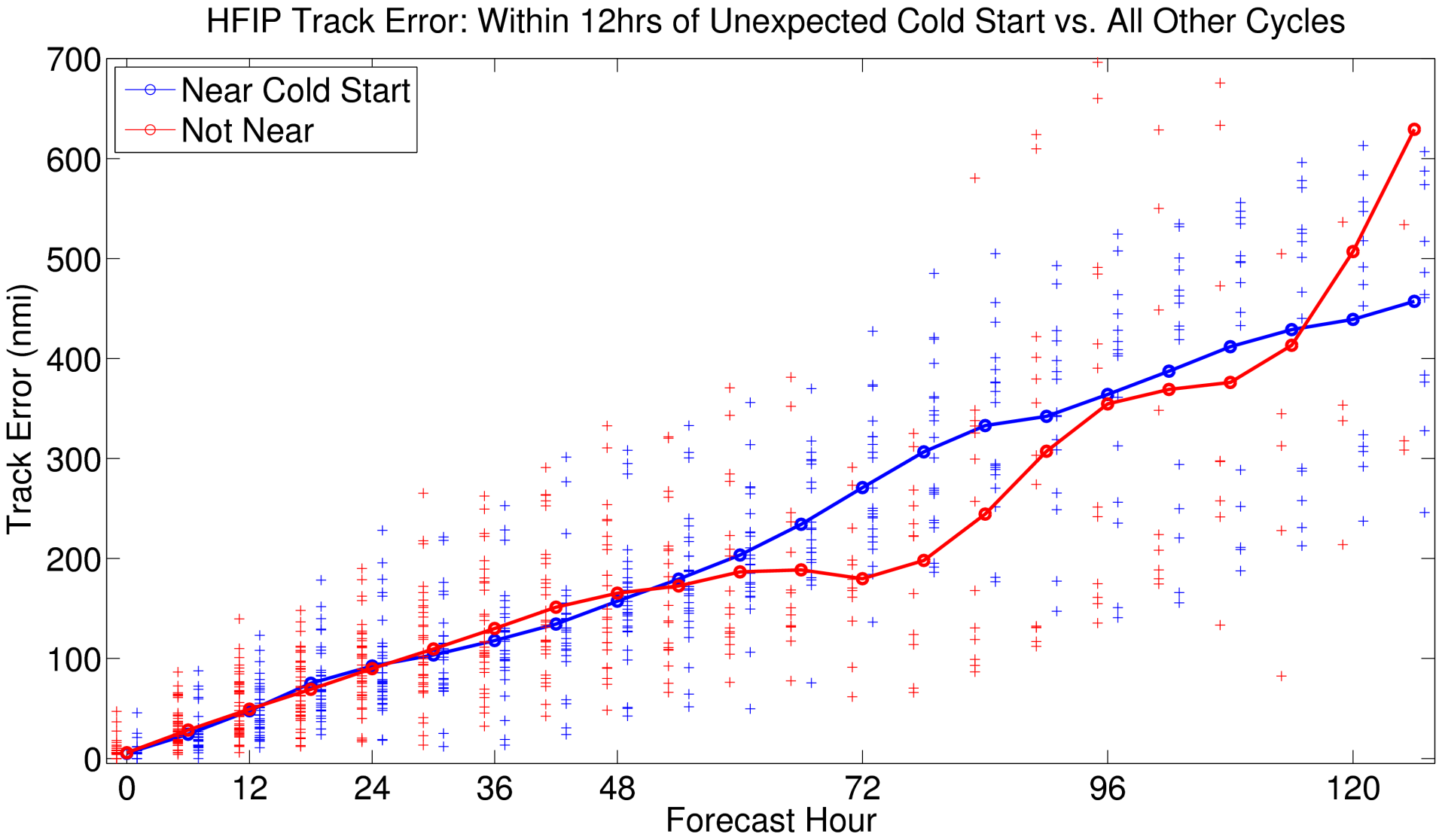
72
96
120


HFIP Track Error: Within 12hrs of Unexpected Cold Start vs. All Other Cycles
Near Cold Start
Not Near
Track Error (nmi)
Forecast Hour
0
100
200
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400
500
600
700
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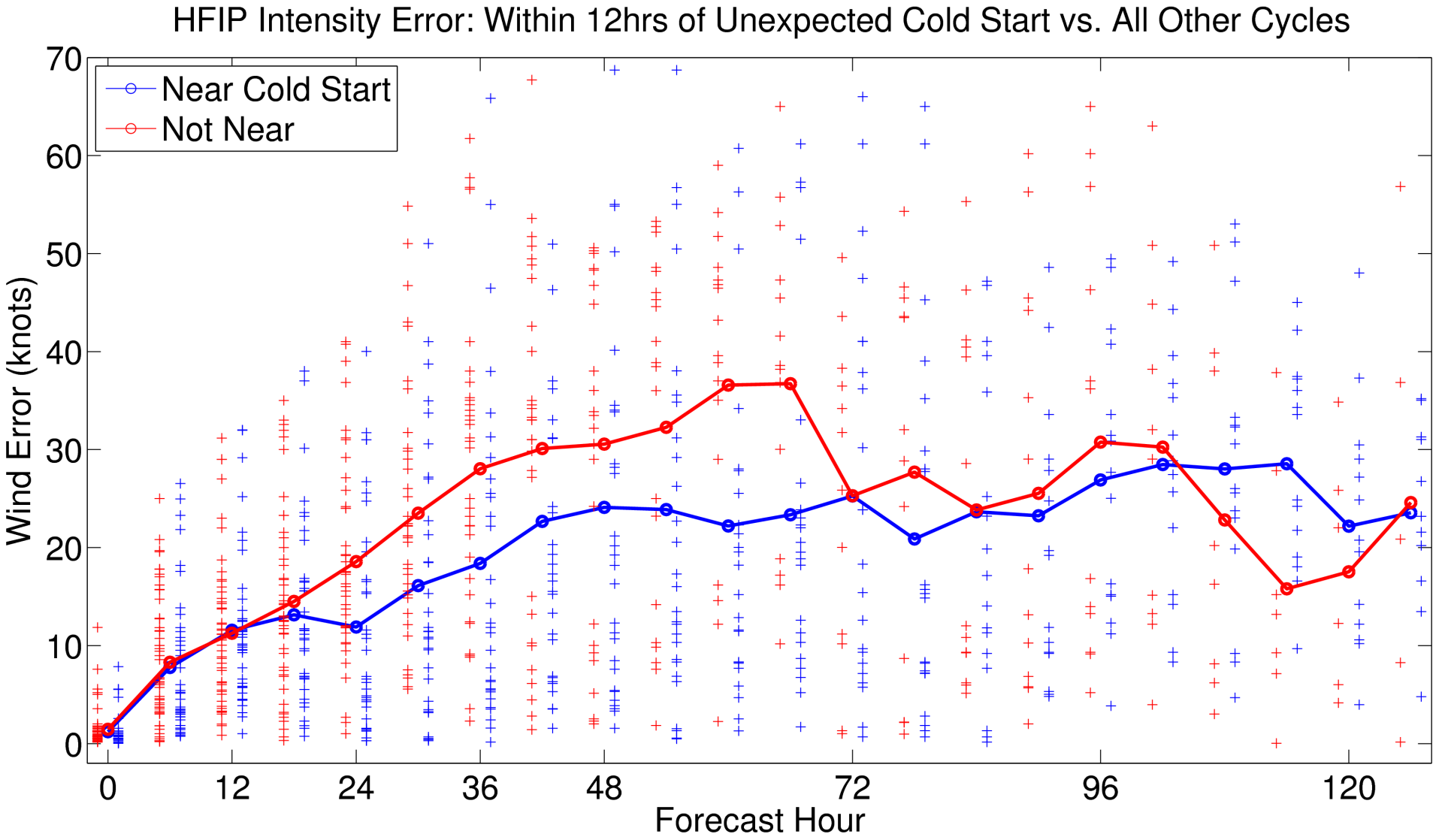
HFIP Intensity Error: Within 12hrs of Unexpected Cold Start vs. All Other Cycles
Near Cold Start
Not Near
Wind Error (knots)
Forecast Hour
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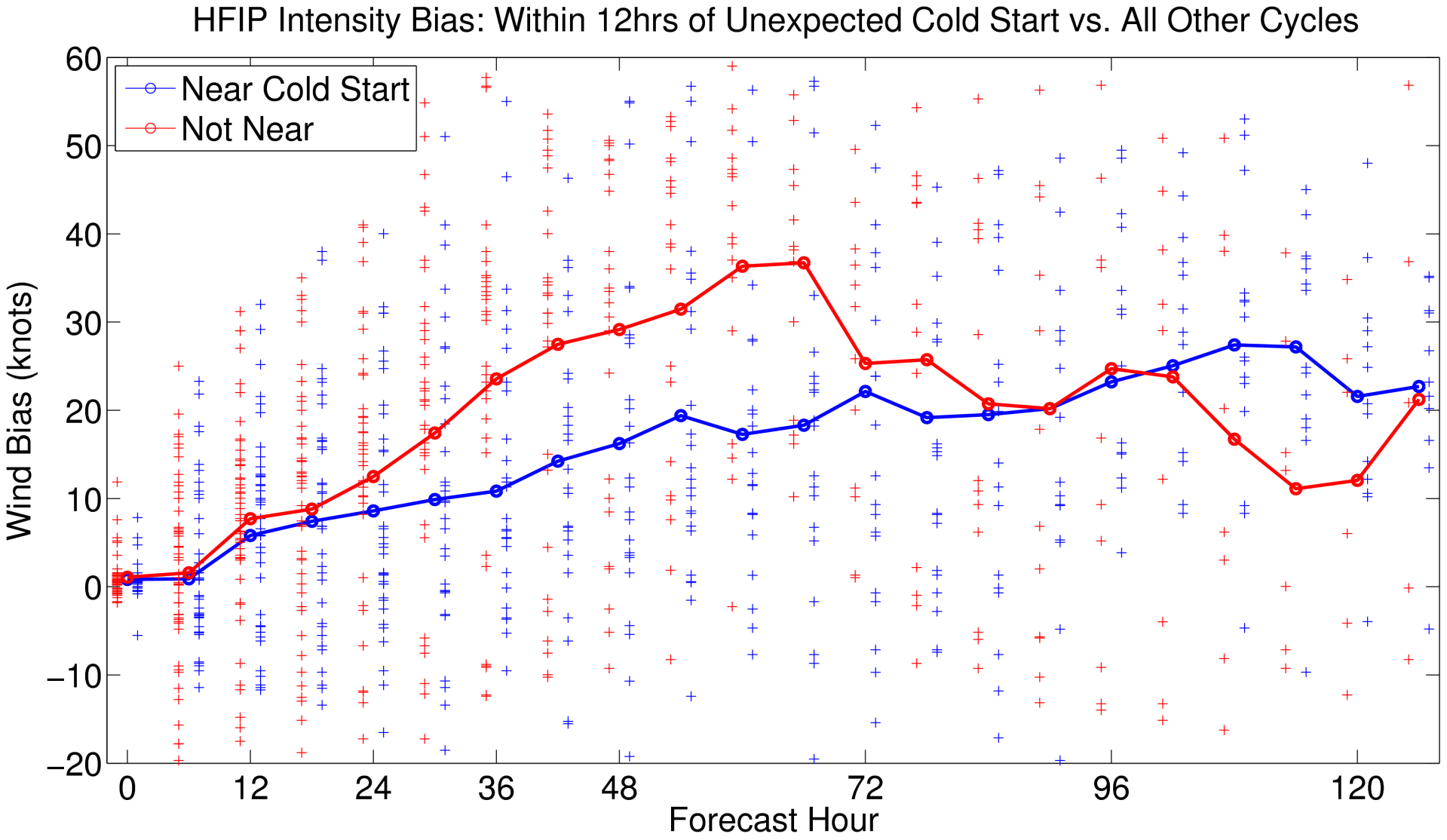
HFIP Intensity Bias: Within 12hrs of Unexpected Cold Start vs. All Other Cycles
Near Cold Start
Not Near
Wind Bias (knots)
60
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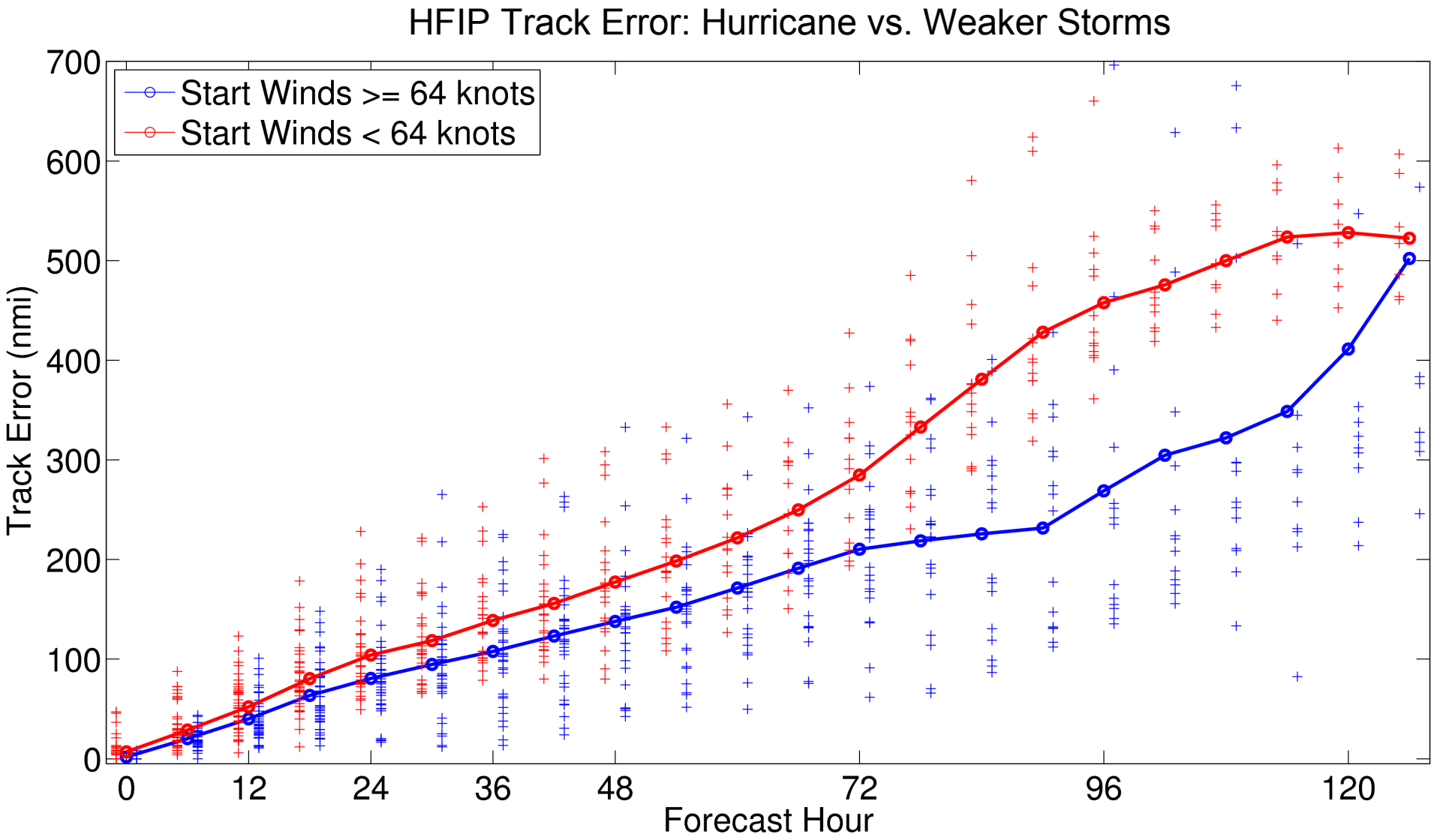
72
96
120
Forecast Hour


HFIP Track Error: Hurricane vs. Weaker Storms
Start Winds >= 64 knots
Start Winds < 64 knots
Track Error (nmi)
Forecast Hour
0
100
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700
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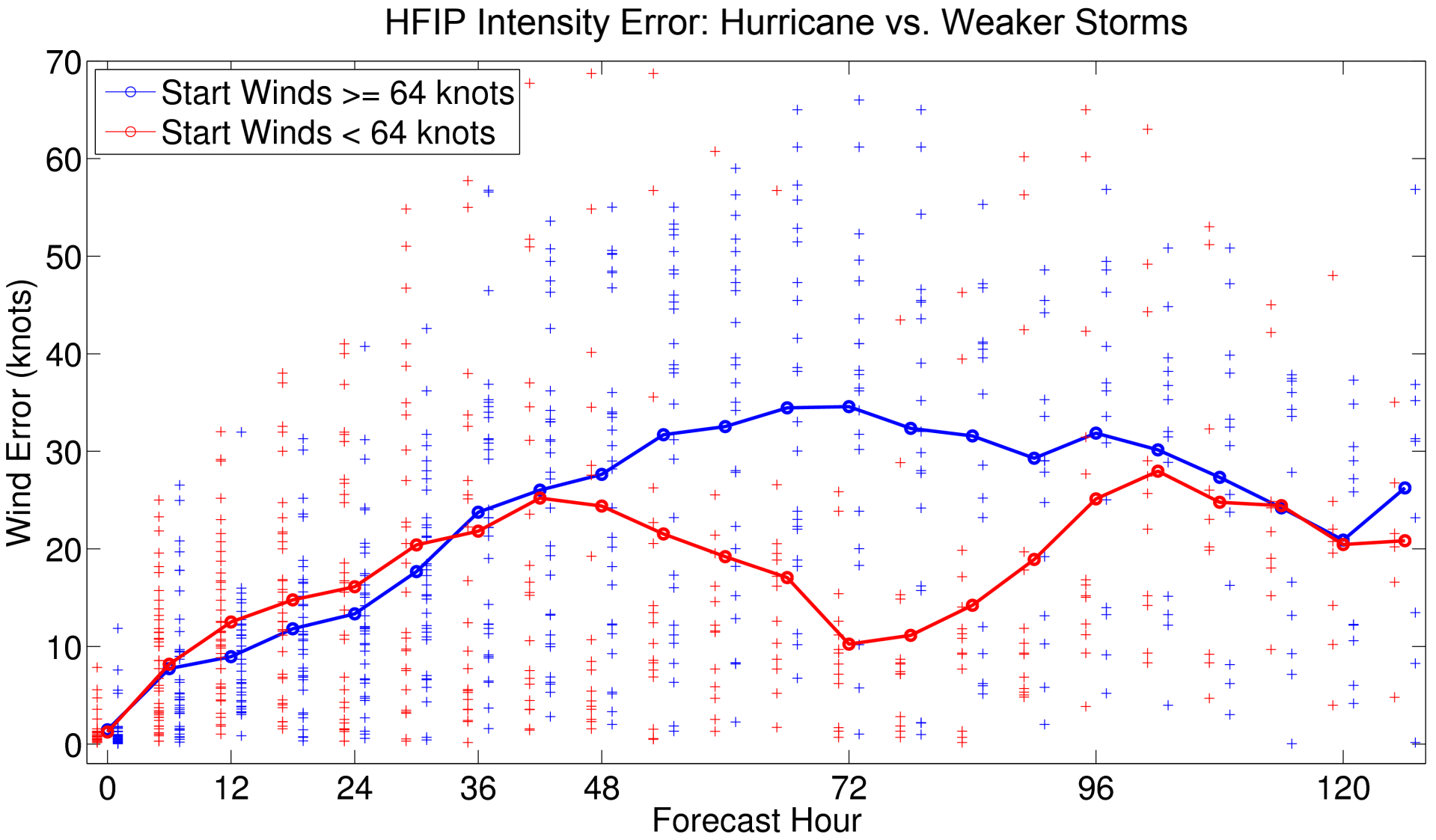
120


HFIP Intensity Error: Hurricane vs. Weaker Storms
Start Winds >= 64 knots
Start Winds < 64 knots
Wind Error (knots)
Forecast Hour
0
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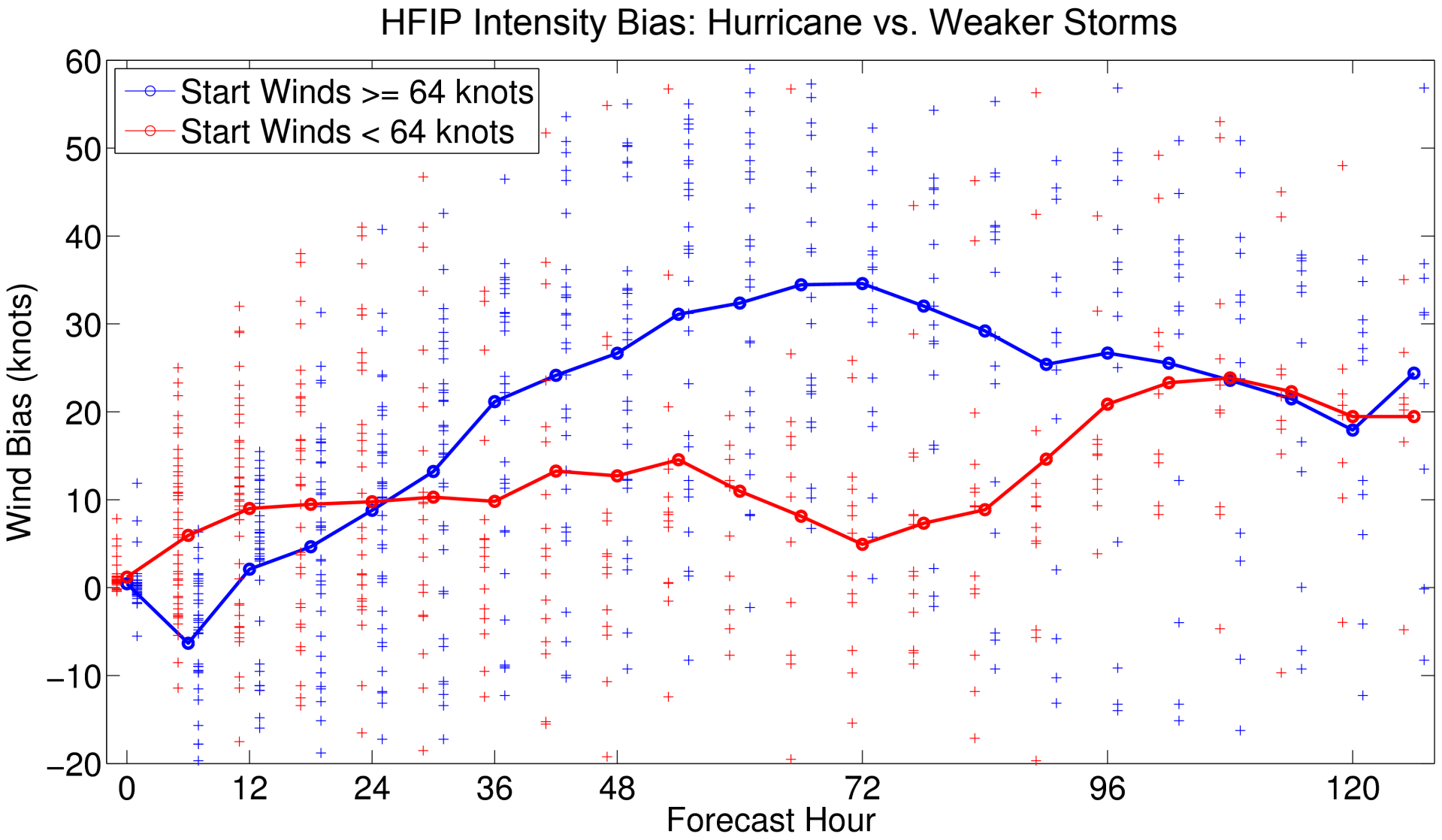
HFIP Intensity Bias: Hurricane vs. Weaker Storms
Start Winds >= 64 knots
Start Winds < 64 knots
Wind Bias (knots)
60
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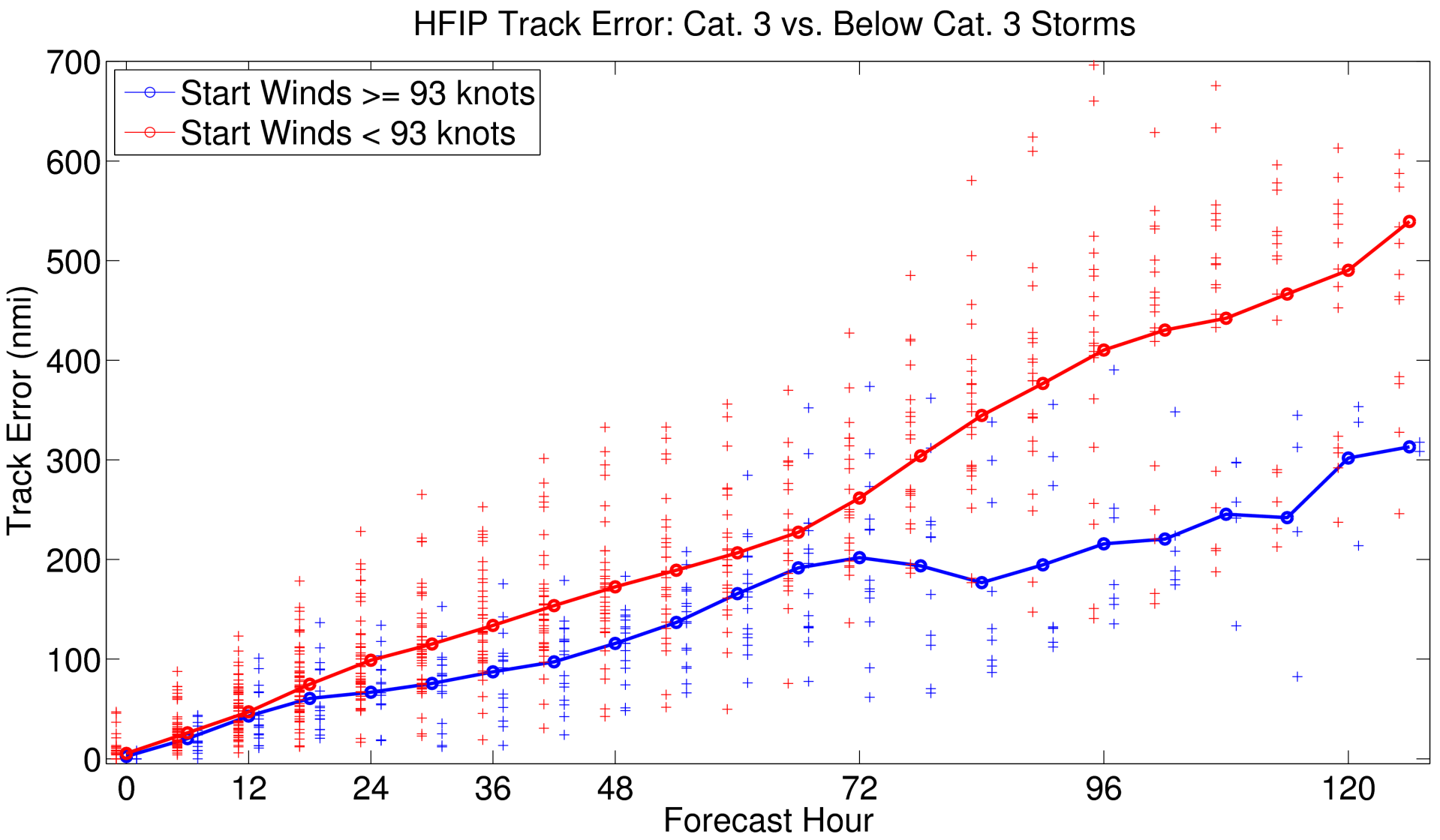
Forecast Hour


HFIP Track Error: Cat. 3 vs. Below Cat. 3 Storms
Start Winds >= 93 knots
Start Winds < 93 knots
Track Error (nmi)
Forecast Hour
0
100
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500
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700
0
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72
96
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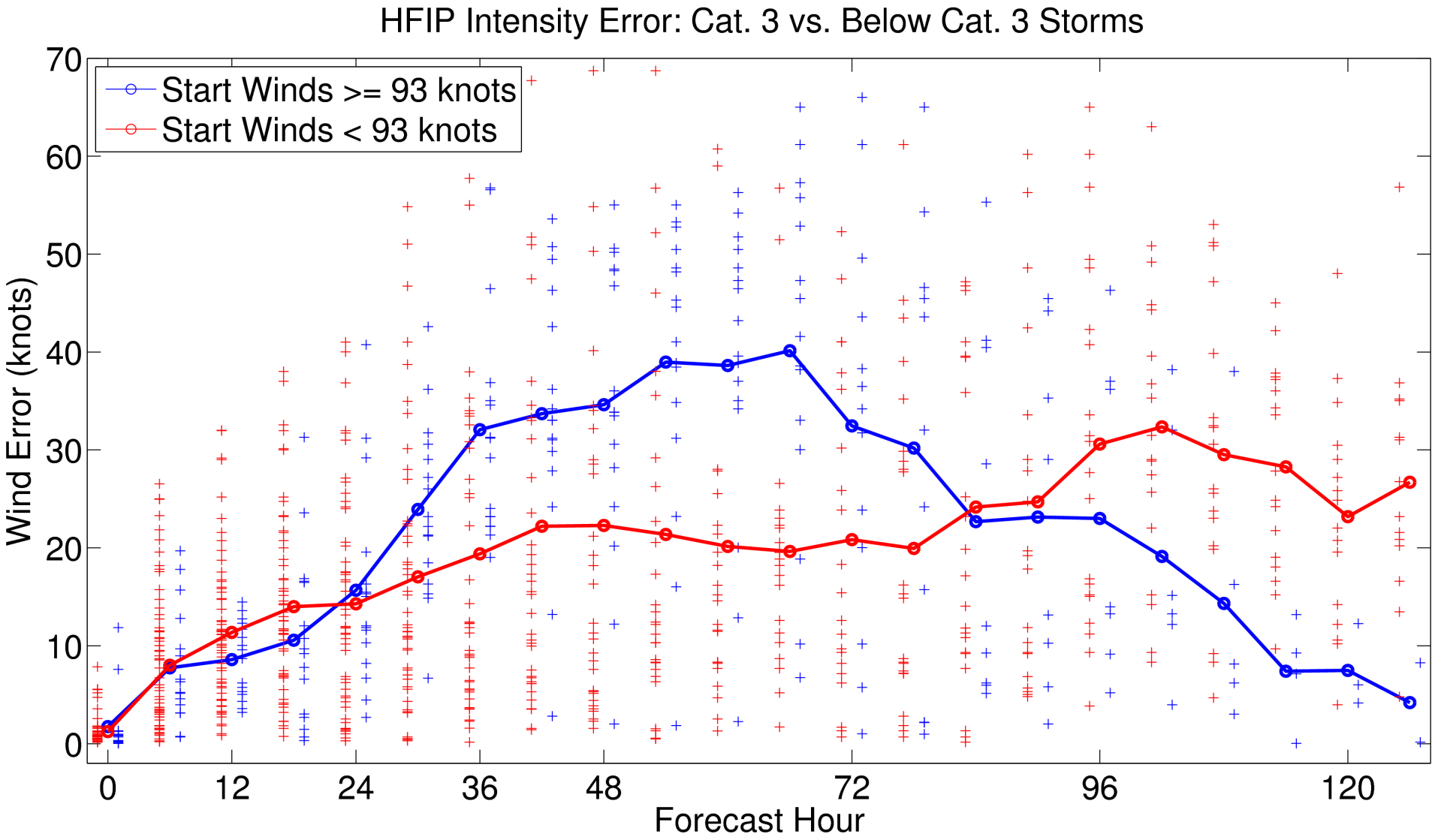
HFIP Intensity Error: Cat. 3 vs. Below Cat. 3 Storms
Start Winds >= 93 knots
Start Winds < 93 knots
Wind Error (knots)
Forecast Hour
0
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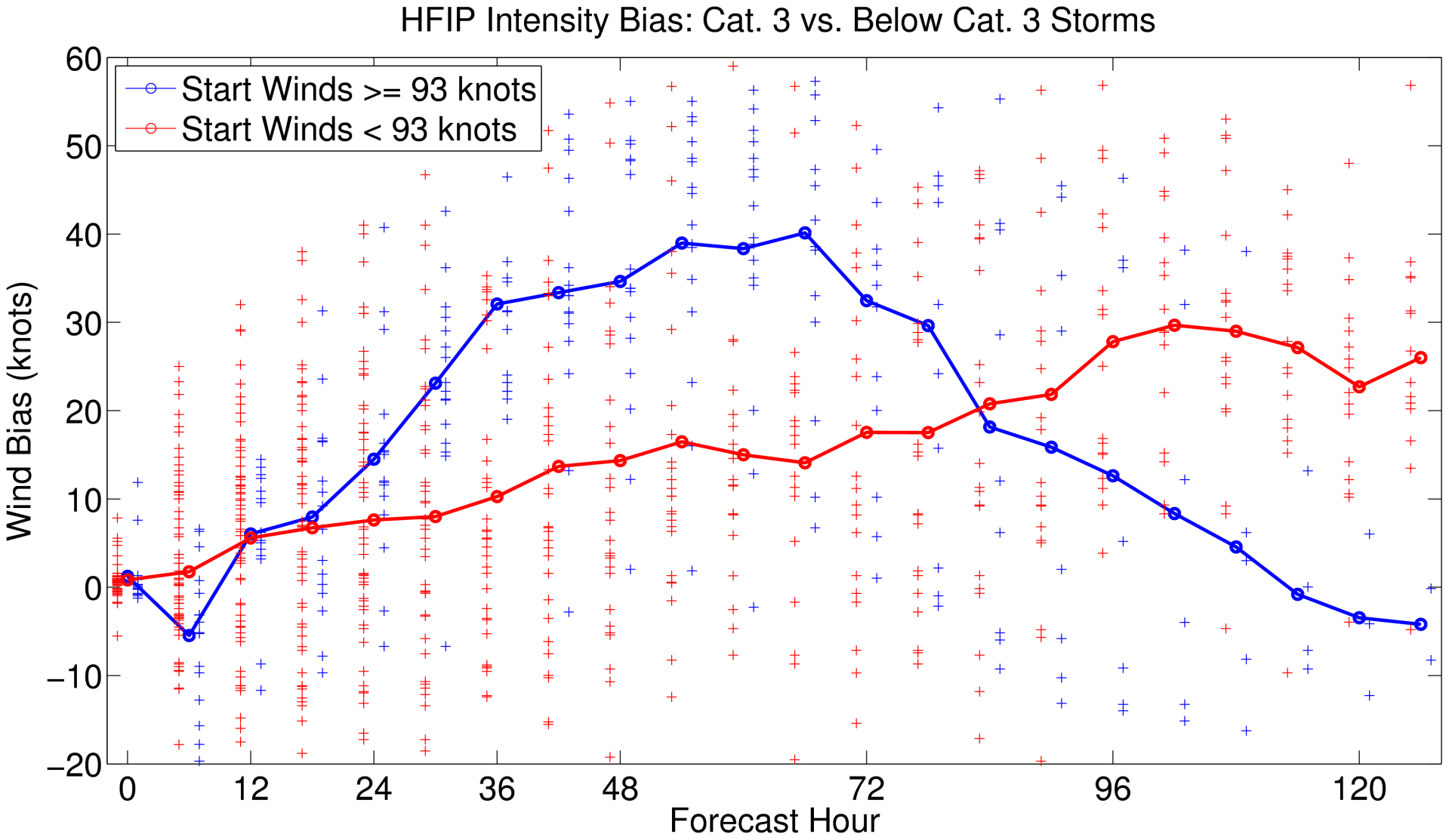
HFIP Intensity Bias: Cat. 3 vs. Below Cat. 3 Storms
Start Winds >= 93 knots
Start Winds < 93 knots
Wind Bias (knots)
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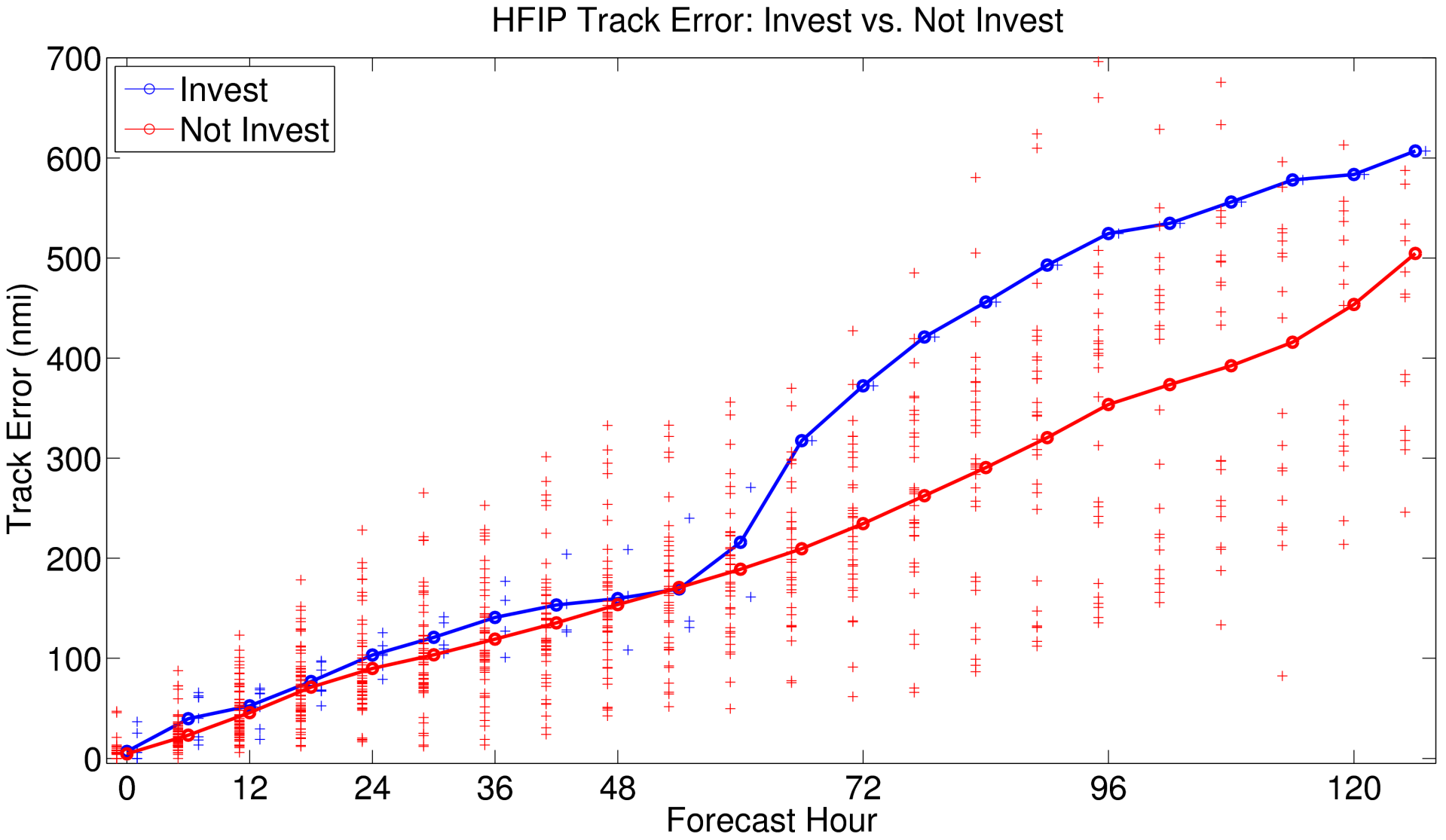
120
Forecast Hour


HFIP Track Error: Invest vs. Not Invest
Invest
Not Invest
Track Error (nmi)
Forecast Hour
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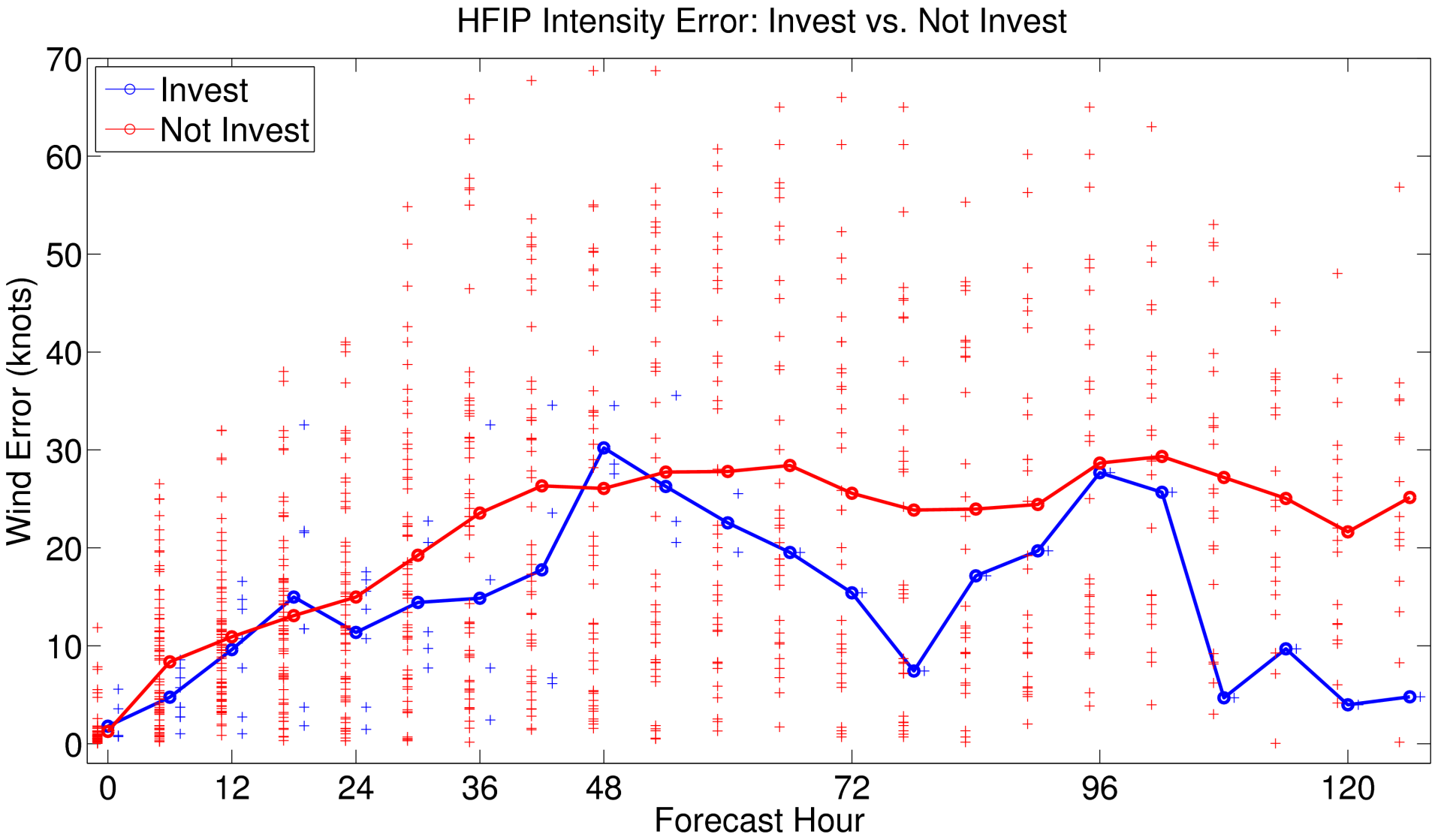
HFIP Intensity Error: Invest vs. Not Invest
Invest
Not Invest
Wind Error (knots)
Forecast Hour
0
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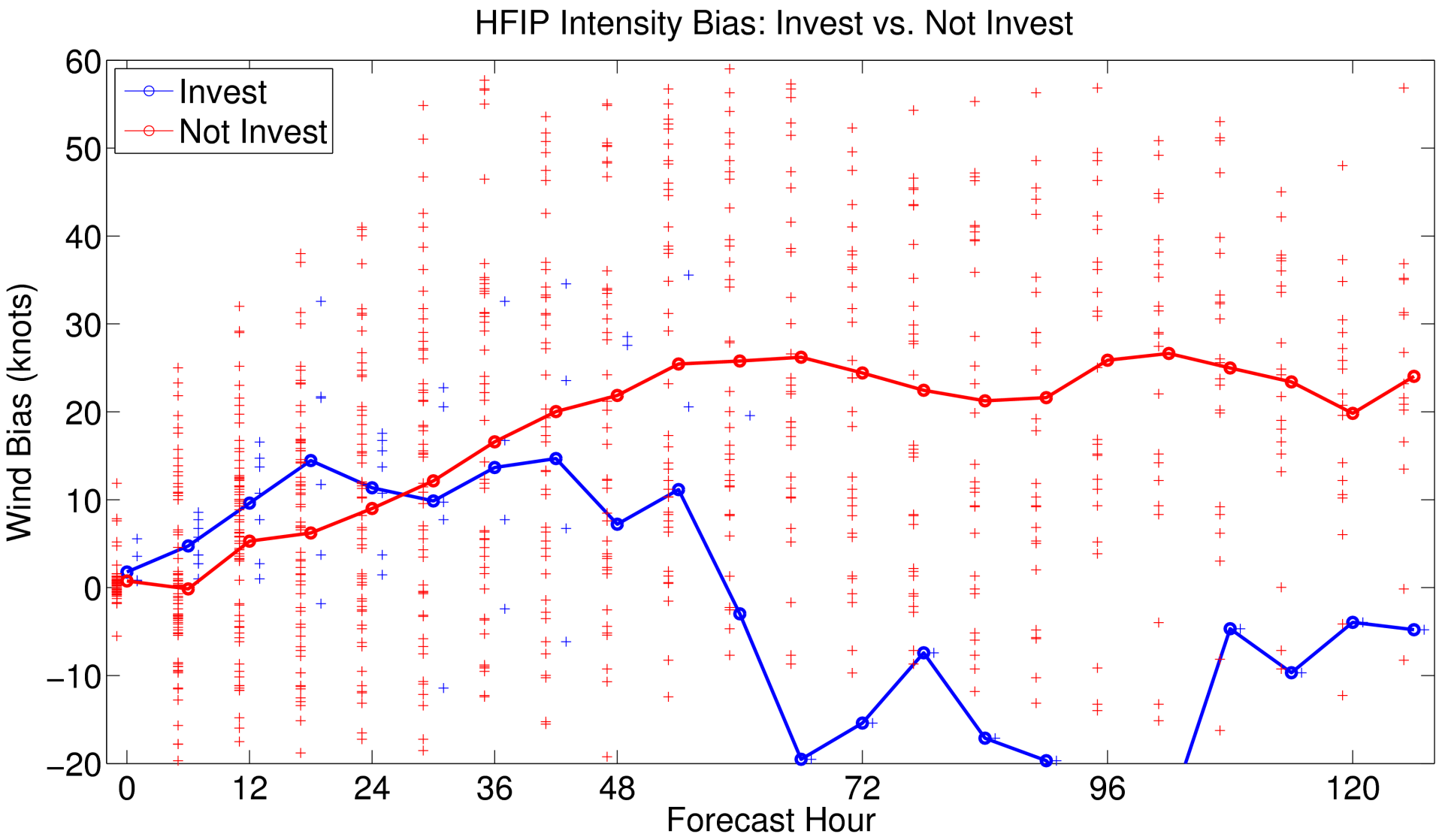
HFIP Intensity Bias: Invest vs. Not Invest
Invest
Not Invest
Wind Bias (knots)
60
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0
12
24
36
48
72
96
120
Forecast Hour