An Evaluation of Satellite-Derived Atmospheric Motion Vector (AMV) Characteristics Using TCI HDSS Dropsondes

Brian McNoldy[1], Chris Velden[2], Sharan Majumdar[1]

[1] University of Miami

[2] University of Wisconsin - Madison

TCI Science Team Meeting - 18-19 October 2016 - Boulder, CO

TCI AMV/Dropsonde Comparisons

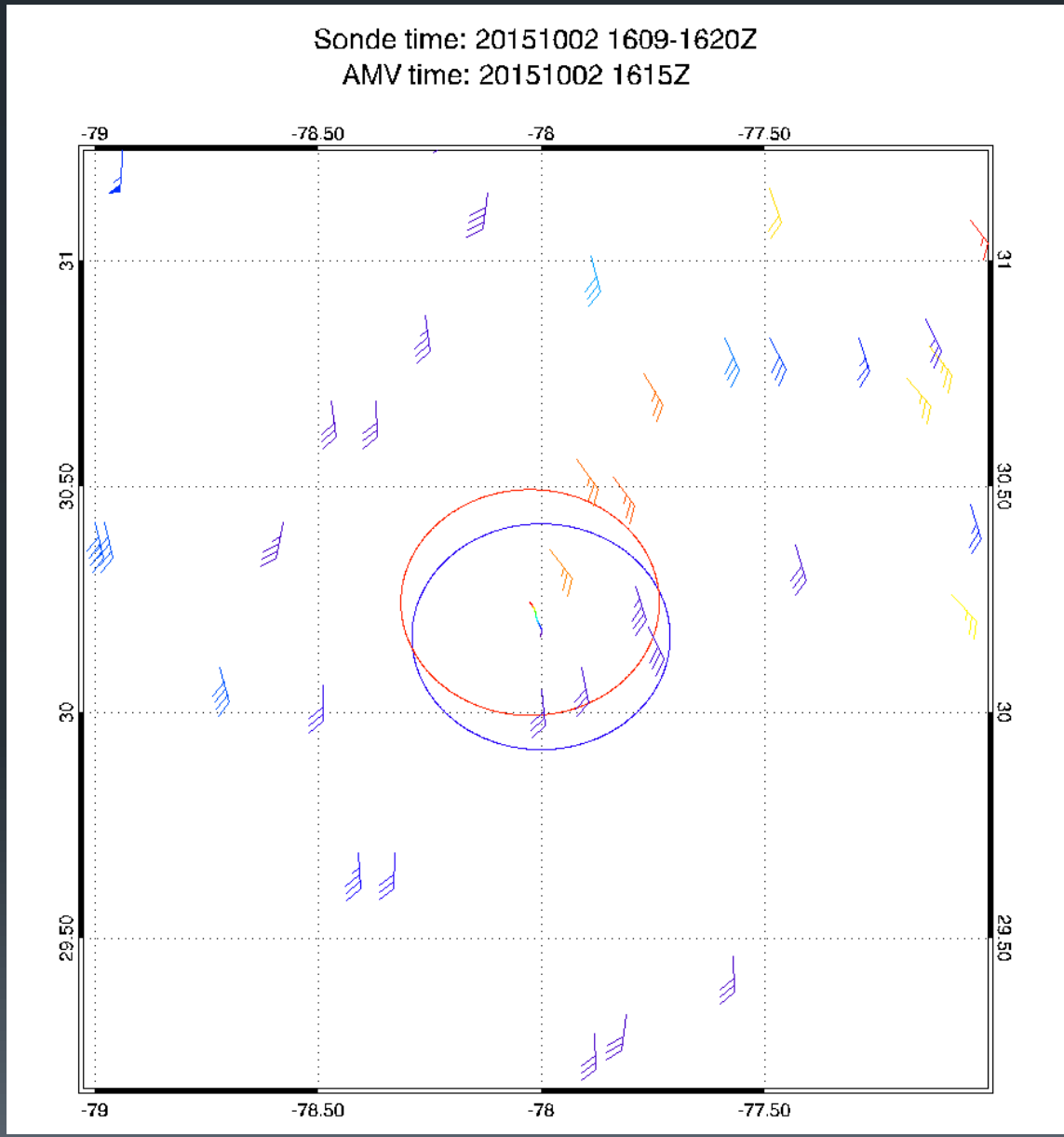
- Project motivation: How good are AMVs in defining TC outflow, and can a mix of high-resolution dropsondes with the AMVs better define the 4-D structure evolution?
- First step: Characterize the AMVs by comparing to co-located (space and time) HDSS dropsonde wind profiles
  - Evaluate the accuracies and height assignments
- Utilize 8 TCI flights over Hurricanes Joaquin & Patricia in Oct 2015 and hourly AMV datasets produced by UW-CIMSS from GOES-East
- AMV selection:
  - Within 30 minutes of dropsonde
  - Within ¼° of dropsonde (accounting for drift)
  - Quality Indicator (QI) ≥ 0.8
- For uniformity with AMV heights, dropsonde data are averaged into 12.5-hPa vertical bins, from 50 hPa to 1000 hPa

Example of Verifying AMV Selection

Upper-level AMVs in cool colors

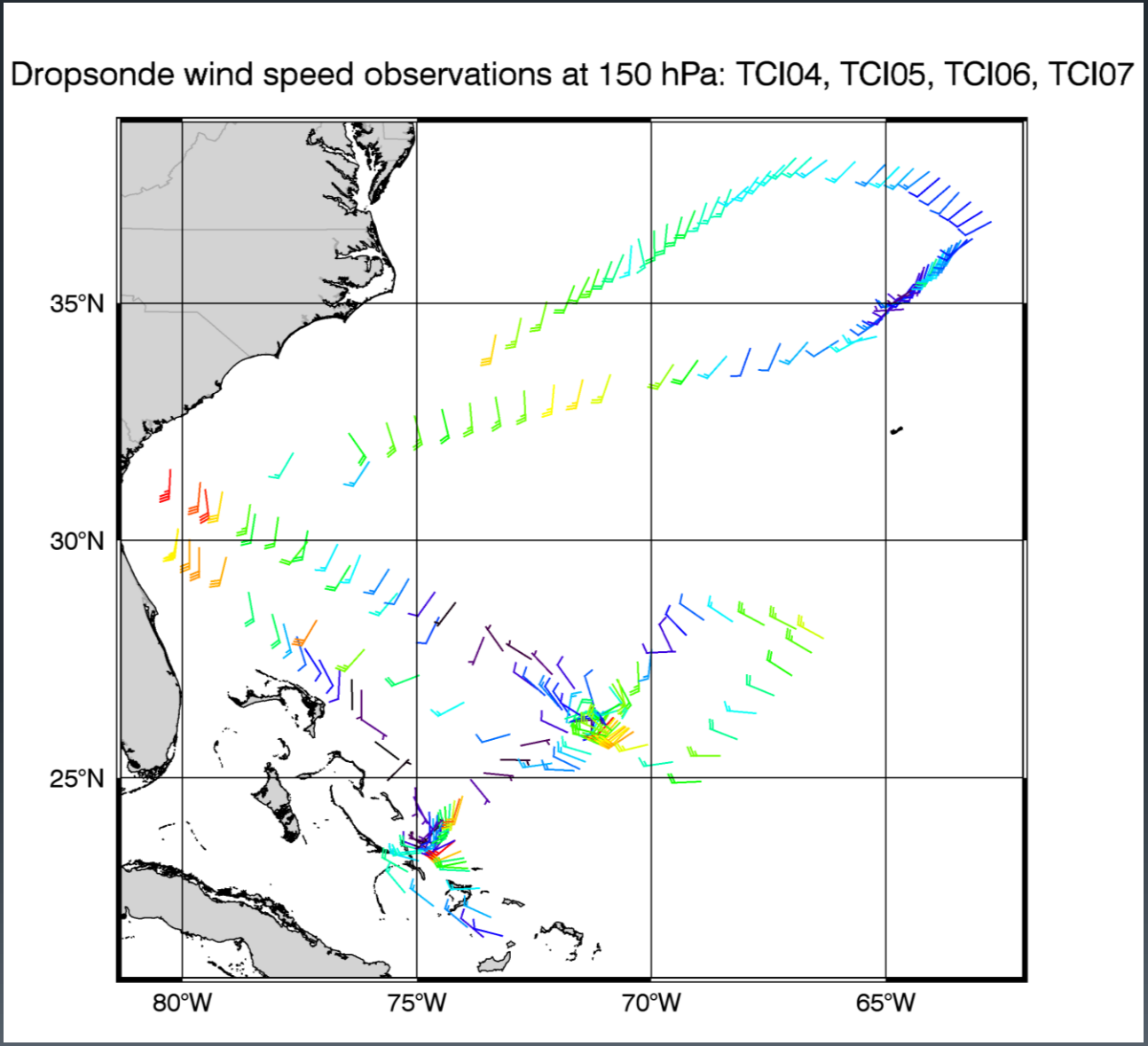
Lower-level AMVs in warm colors

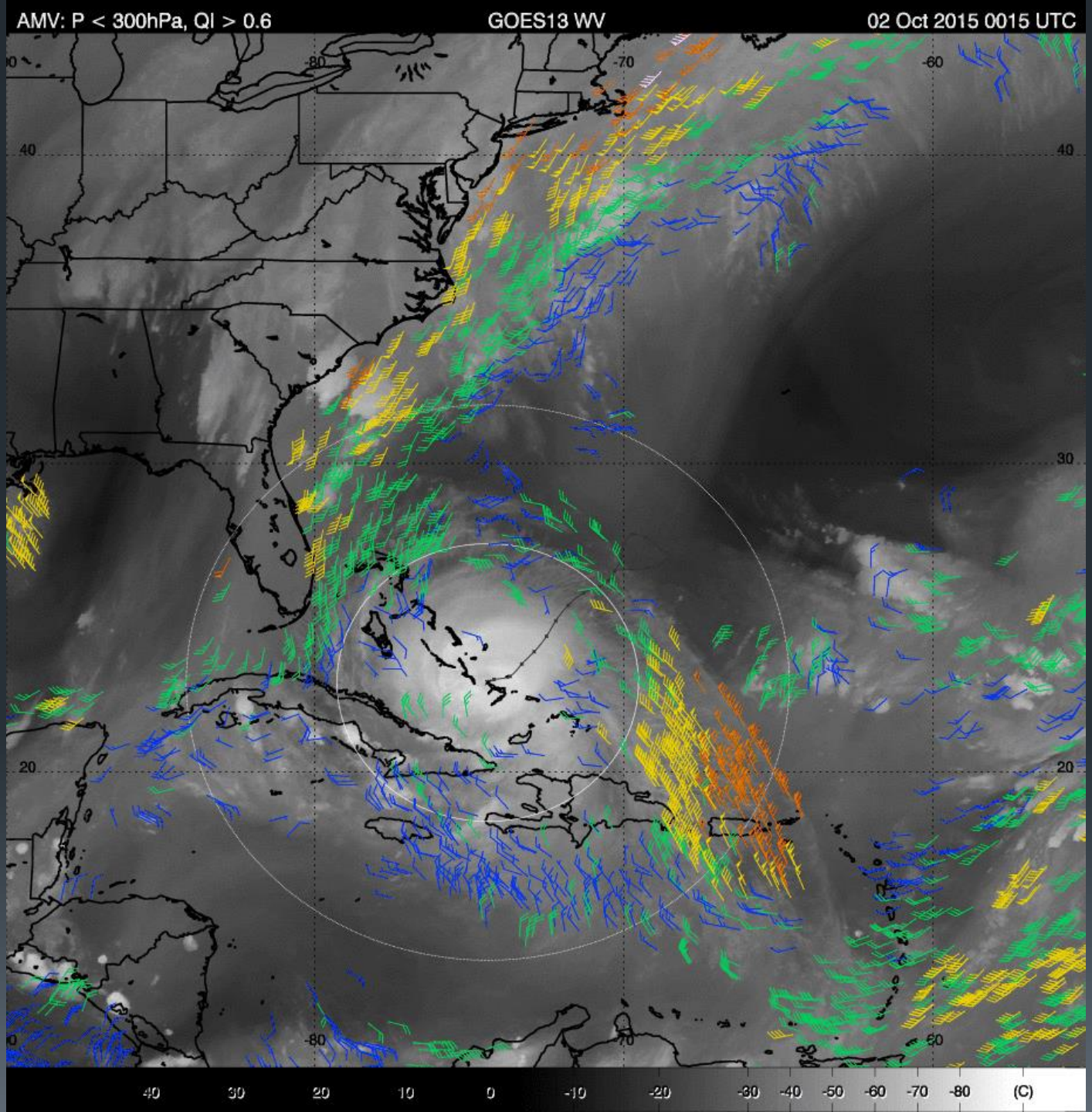
Qualifying radius around dropsonde circled
(blue: top, red: bottom)



Joaquin

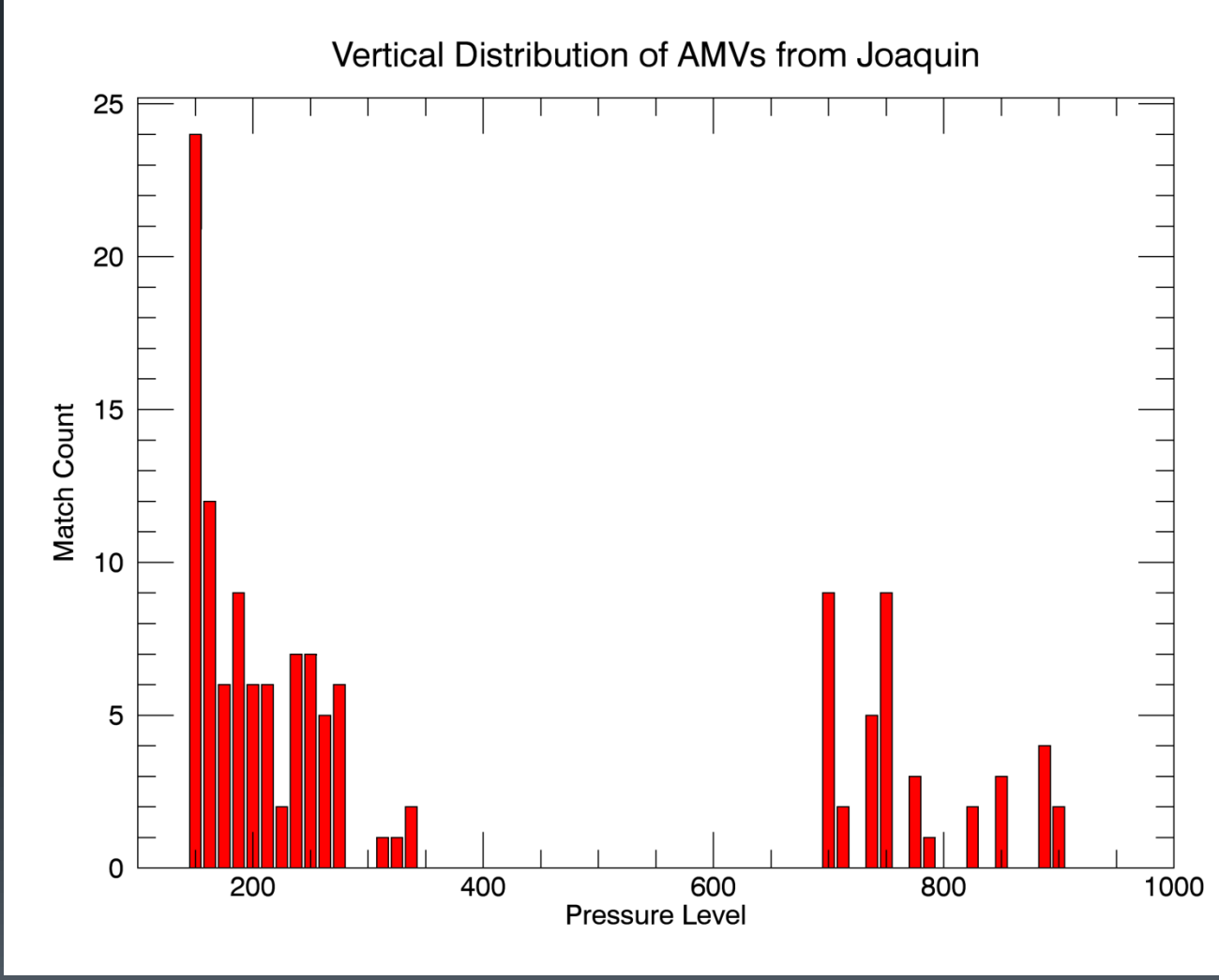
- 4 flights spanning 2 Oct - 5 Oct, 2015
- 329 total dropsondes
- 134 total verifying AMVs




AMV: P < 300hPa, QI > 0.6
GOES13 WV
02 Oct 2015 0015 UTC
40
30
20
-80
-70
-60
40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 (C)

Joaquin: Vertical Distribution of AMVs

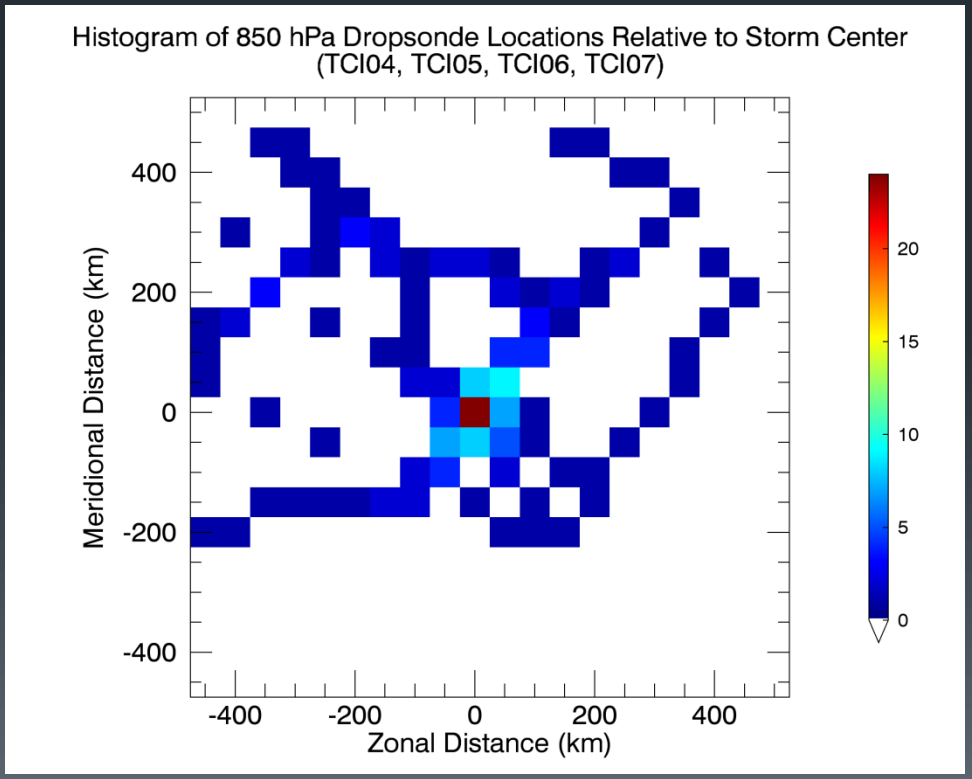
- After applying search criteria, 134 total verifying AMVs remain
- Primarily in 150-350 hPa levels, but some in 700-900 hPa levels
- AMV processing has an upper bound on height assignments at 150 hPa and a lower bound at 950 hPa
- Mid-level AMVs (400-700 hPa) are QC'd out based on Sears & Velden (2012)

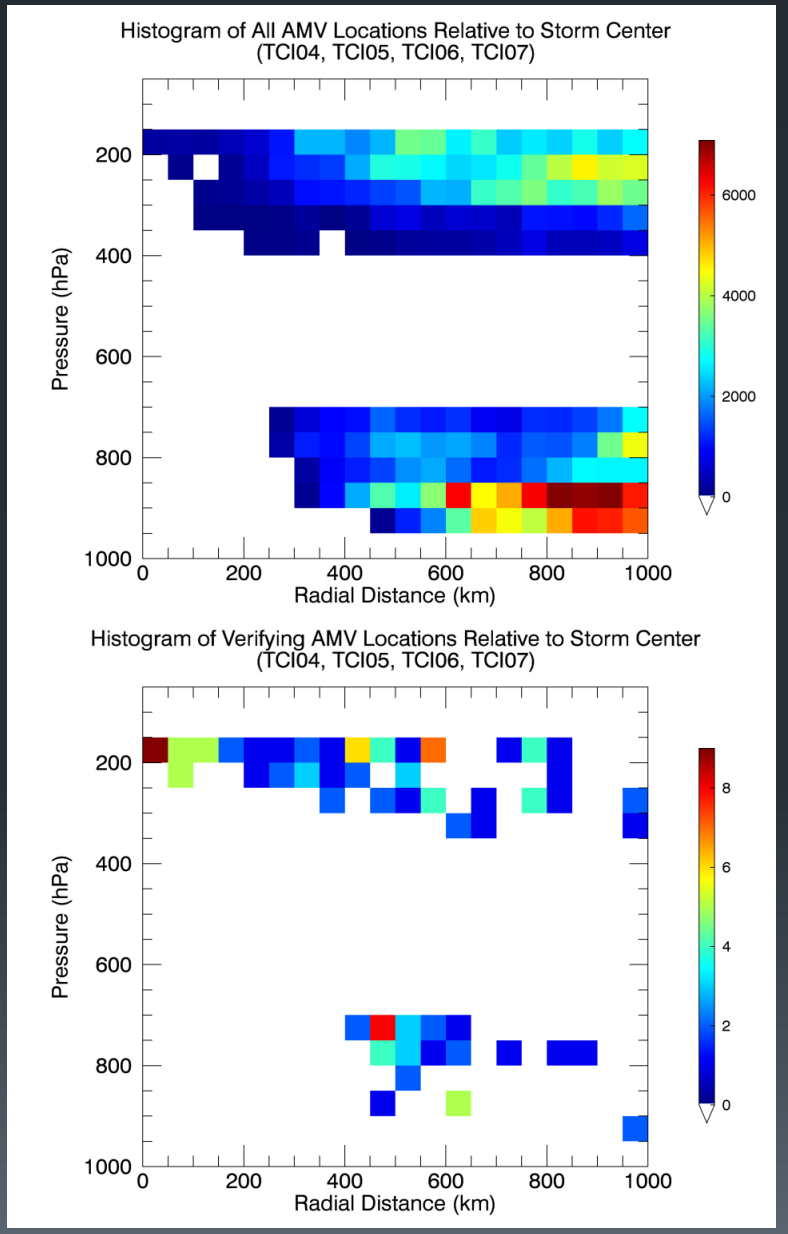


Joaquin: Horiz/Vert Coverage of Observations

Vertical cross-section of AMV Locations relative to storm center (top: all AMVs, bottom: verifying AMVs)

Plan view of dropsonde locations relative to storm center

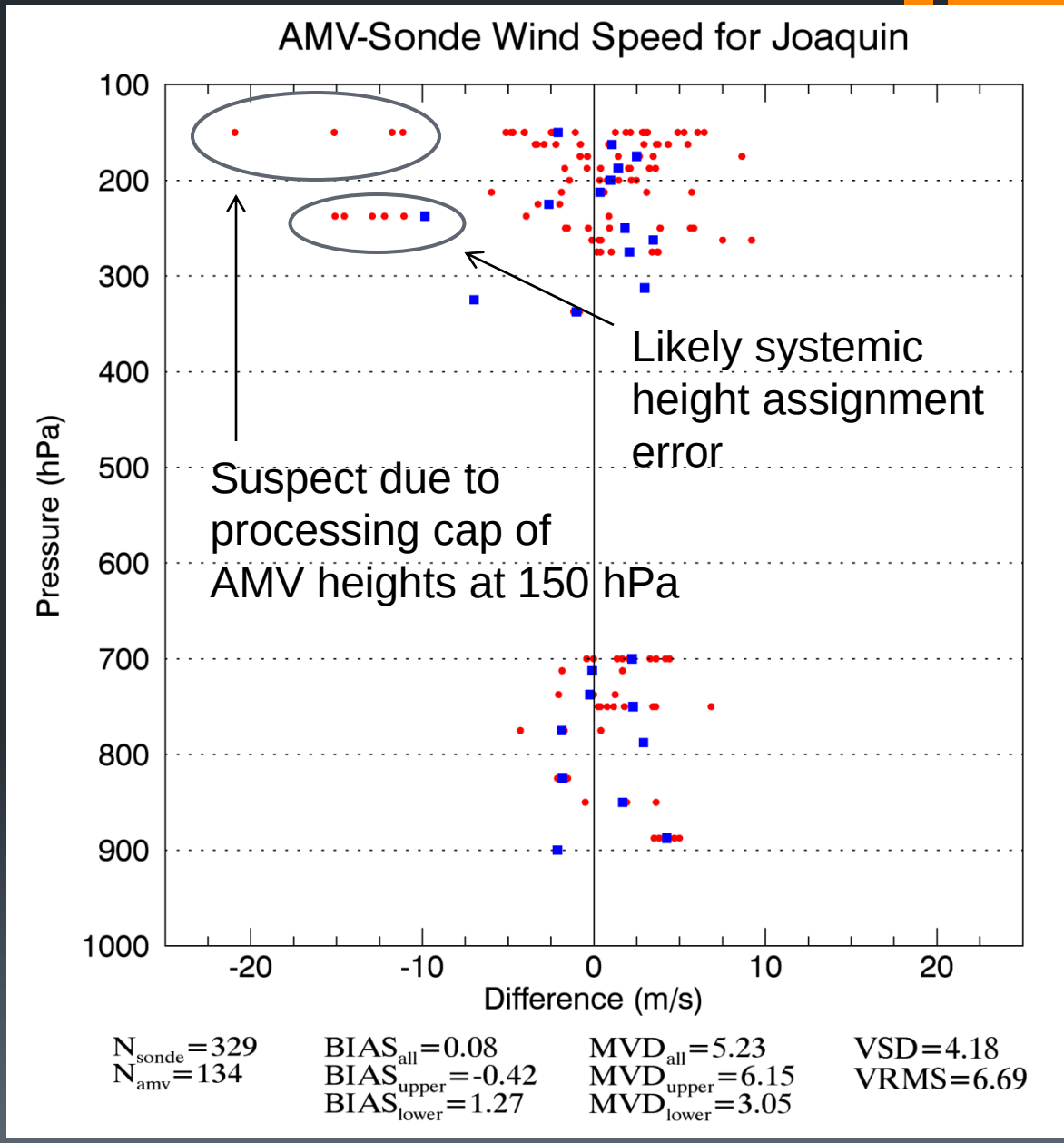




Joaquin: Wind Speed Comparisons

Wind speed differences (AMV minus dropsonde) for all 134 verifying AMVs
[Individual differences in red dots, layer average difference in blue dots]

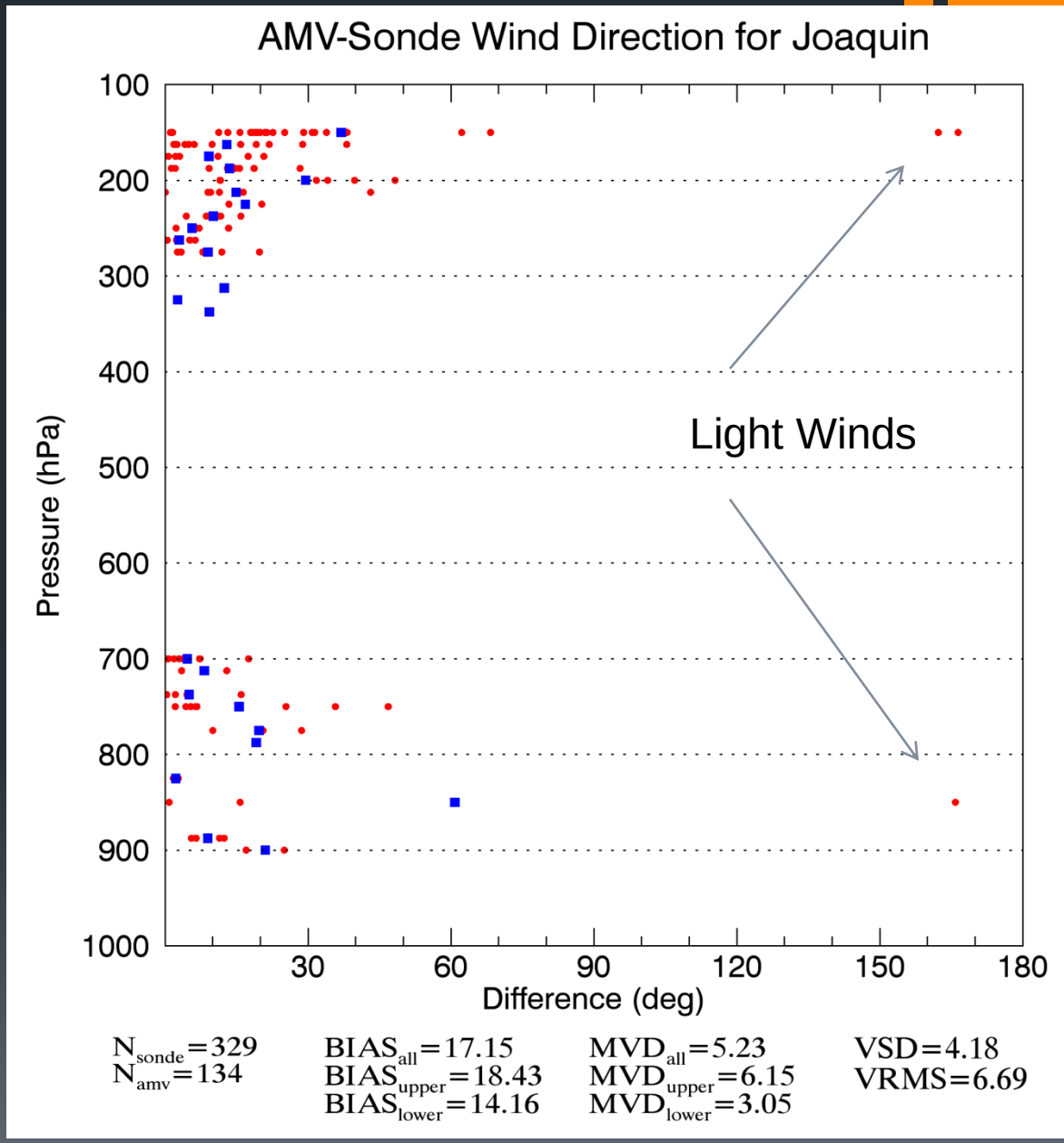
- *Speed bias*
  0.1 m/s
    <500hPa: -0.4 m/s
    >500hPa: 1.3 m/s
- *Mean vector difference*
  5.2 m/s
    <500hPa: 6.2 m/s
    >500hPa: 3.0 m/s
- *Standard deviation*
  4.2 m/s
- *Vector root-mean-square error*
  6.7 m/s



Joaquin: Wind Direction Comparisons

Wind direction differences (AMV minus dropsonde) for all 134 verifying AMVs
[Individual differences in red dots, layer average difference in blue dots]

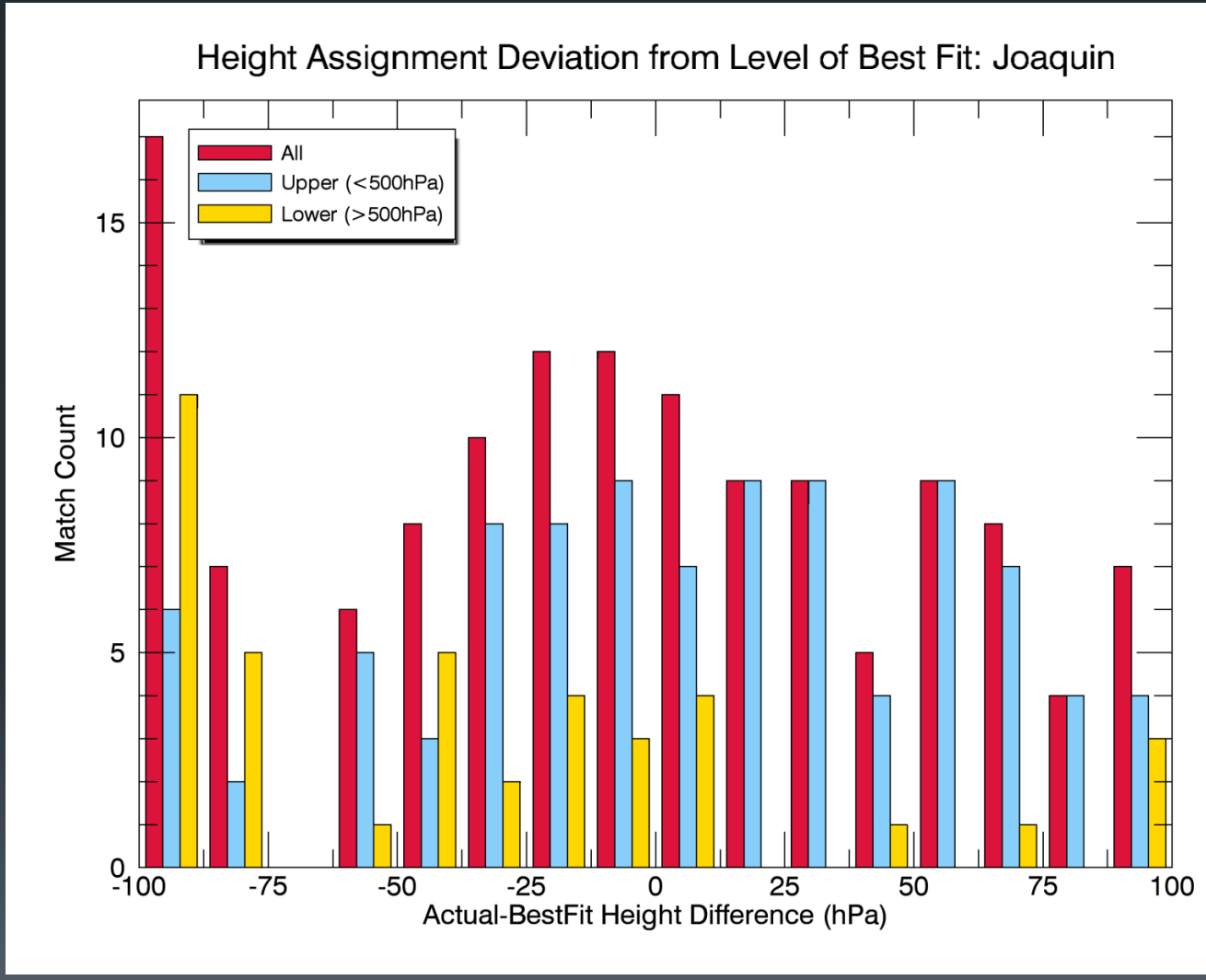
- *Direction bias (incl 3 outliers)*
  17.2 º
    <500hPa: 18.4 º
    >500hPa: 14.2 º



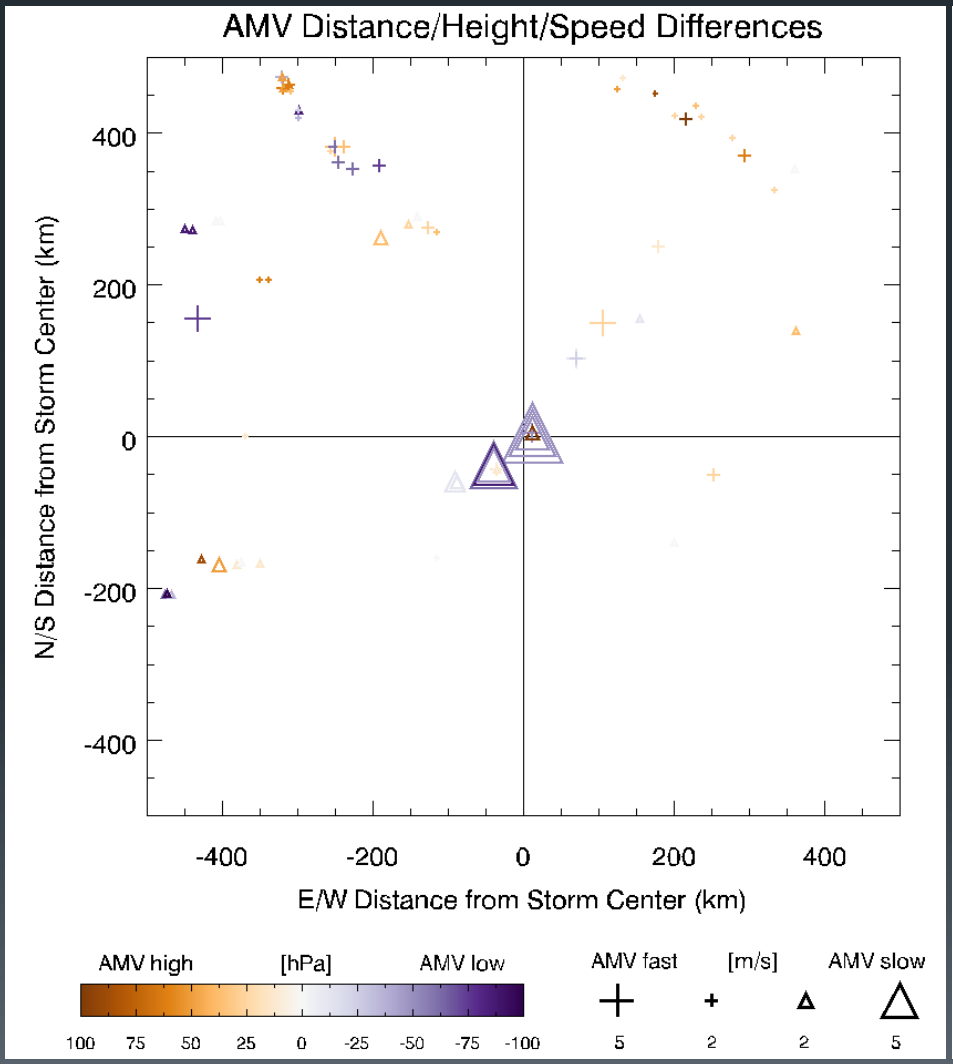
Joaquin: AMV Level of Best Fit (LBF)

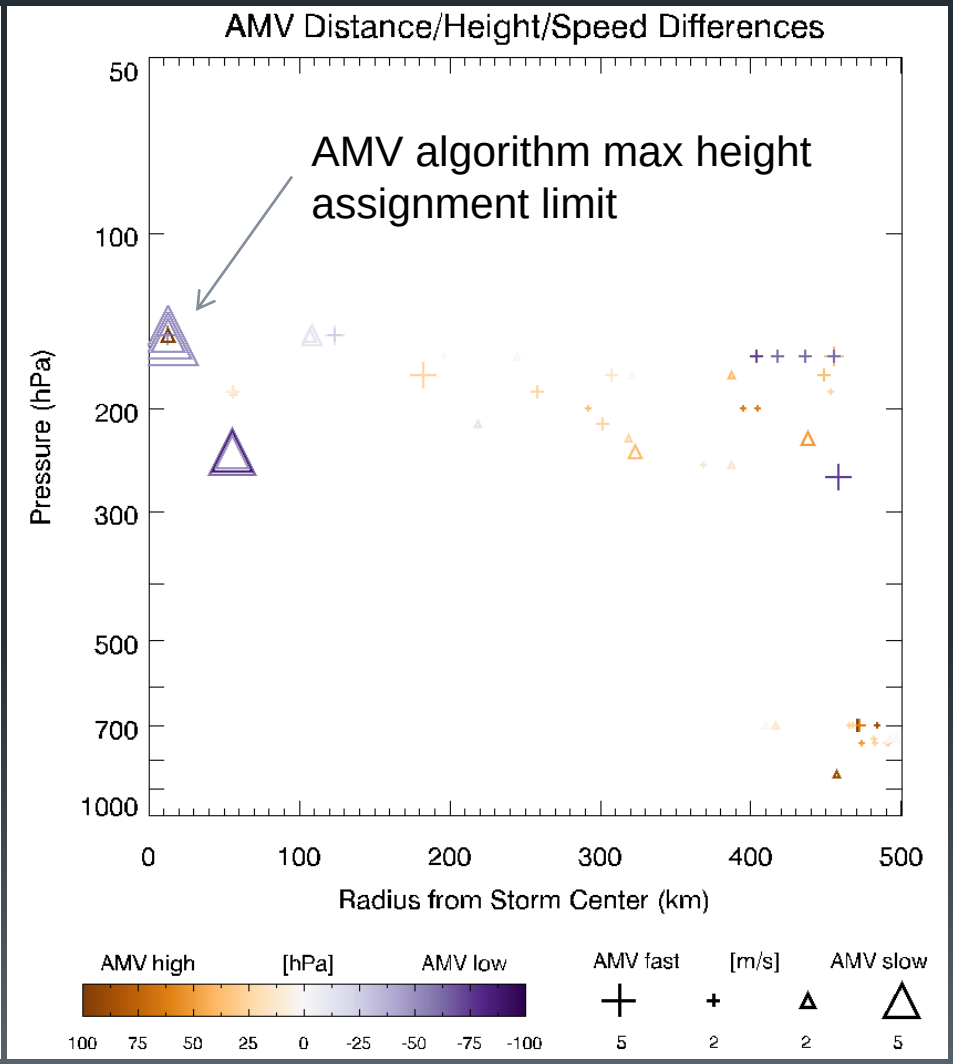
For each verifying AMV, search the matching sonde wind profile for the level that minimizes the AMV-Sonde vector difference, within 100 hPa of original AMV height assignment (i.e., the height assignment an AMV could be given to most closely match the dropsonde).

Negative values: AMVs assigned too high in atmosphere, Positive values: AMVs assigned too low in atmosphere



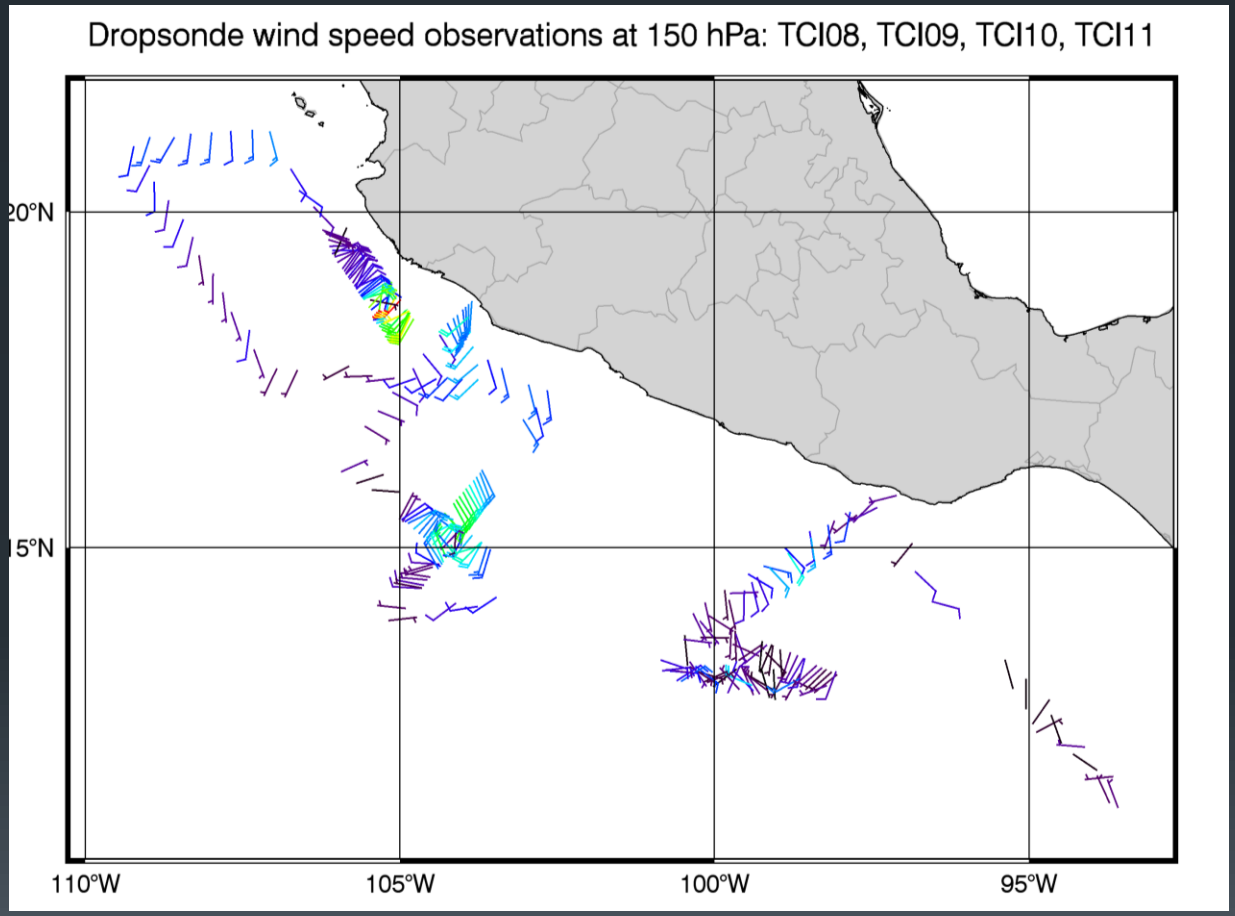
Joaquin: Spatial LBF and Speed Comparisons

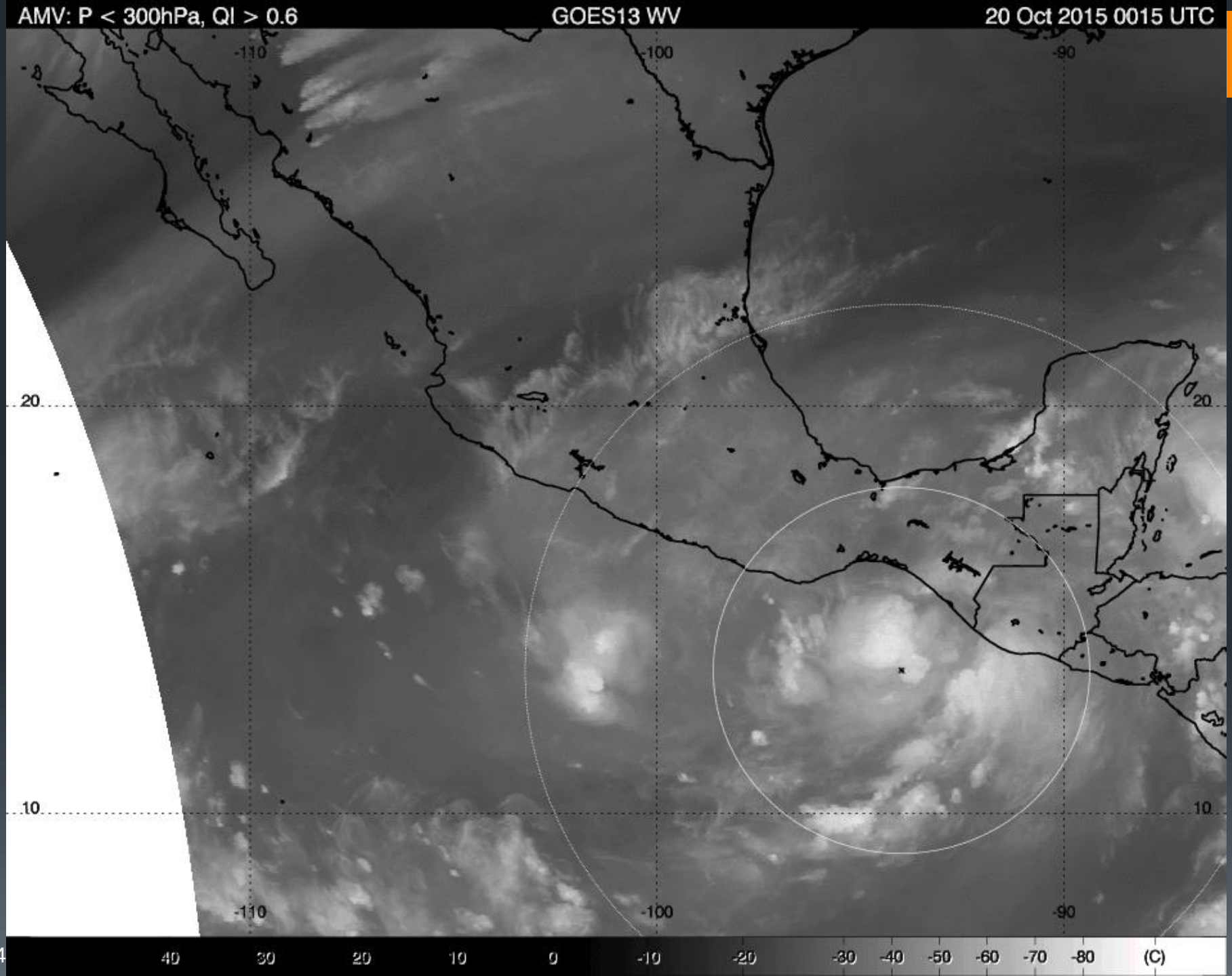




Patricia

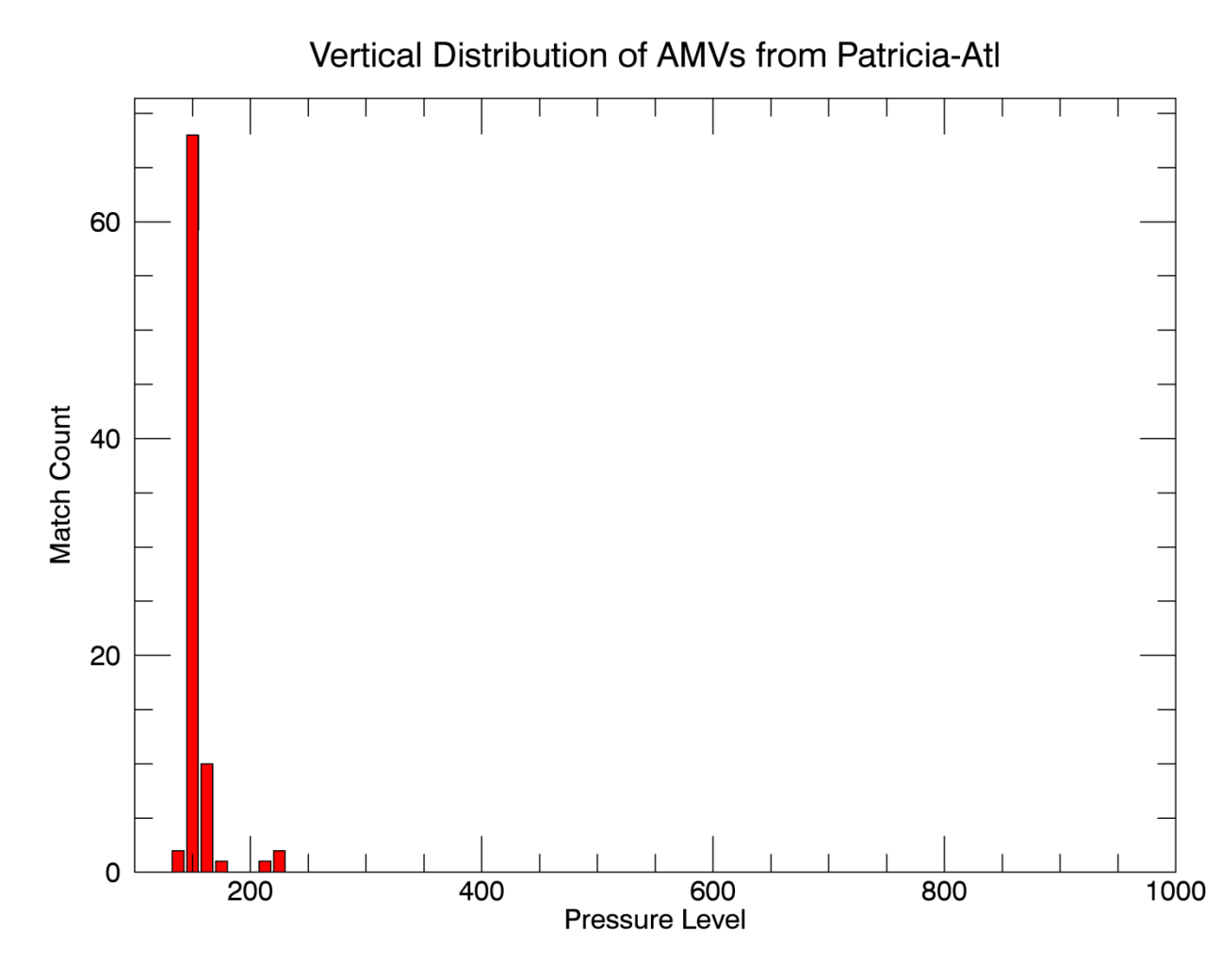
- 4 flights spanning 20 Oct - 23 Oct, 2015
- 257 total dropsondes
- 84 total verifying AMVs




AMV: P < 300hPa, QI > 0.6
GOES13 WV
20 Oct 2015 0015 UTC
-110
-100
-90
20
10
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
(C)

Patricia: Vertical Distribution of AMVs

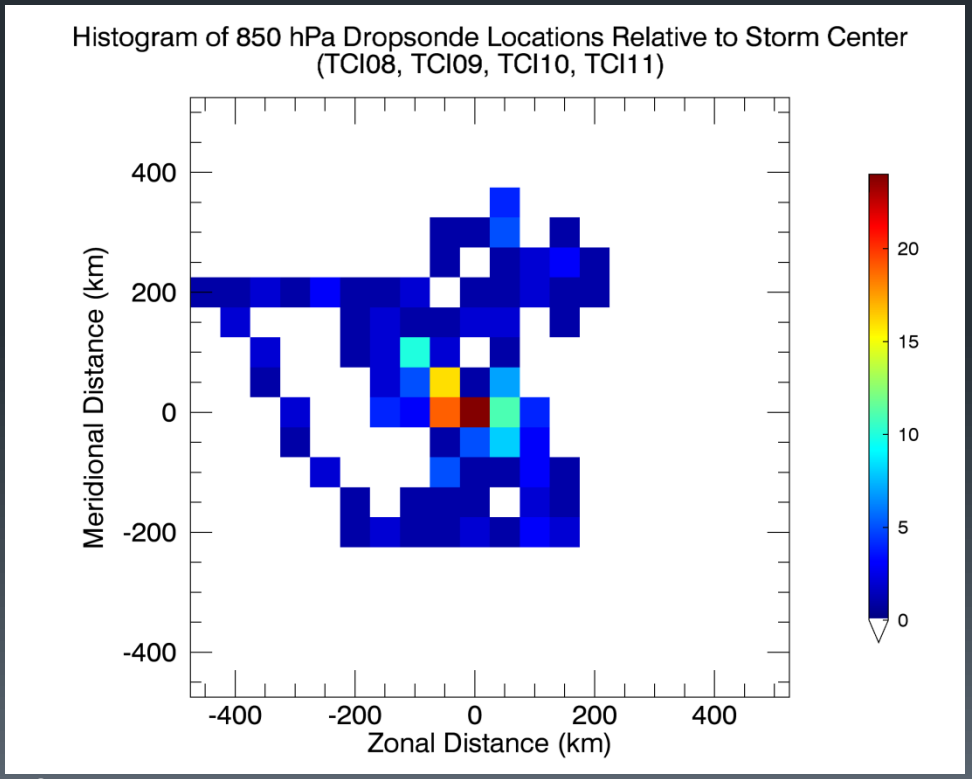
- After applying search criteria, 84 total verifying AMVs remain
- Entirely in upper levels, none in mid-low levels (TCI flight legs were over storm's cirrus canopy)
- AMV processing has an upper bound for height assignments at 150 hPa and a lower bound at 950 hPa
- Mid-level AMVs (400-700 hPa) are QC'd out based on Sears & Velden (2012)

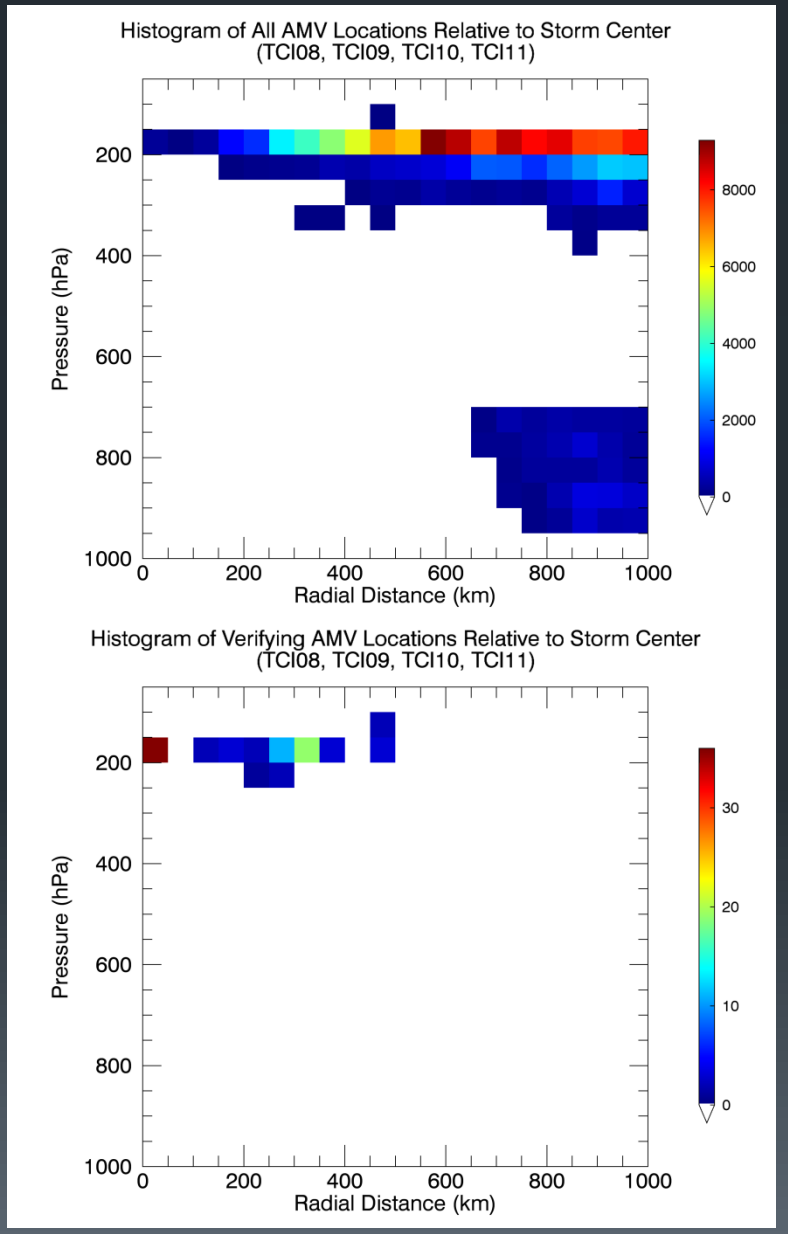


Patricia: Horiz/Vert Coverage of Observations

Vertical cross-section of AMV Locations relative to storm center (top: all AMVs, bottom: verifying AMVs)

Plan view of dropsonde locations relative to storm center

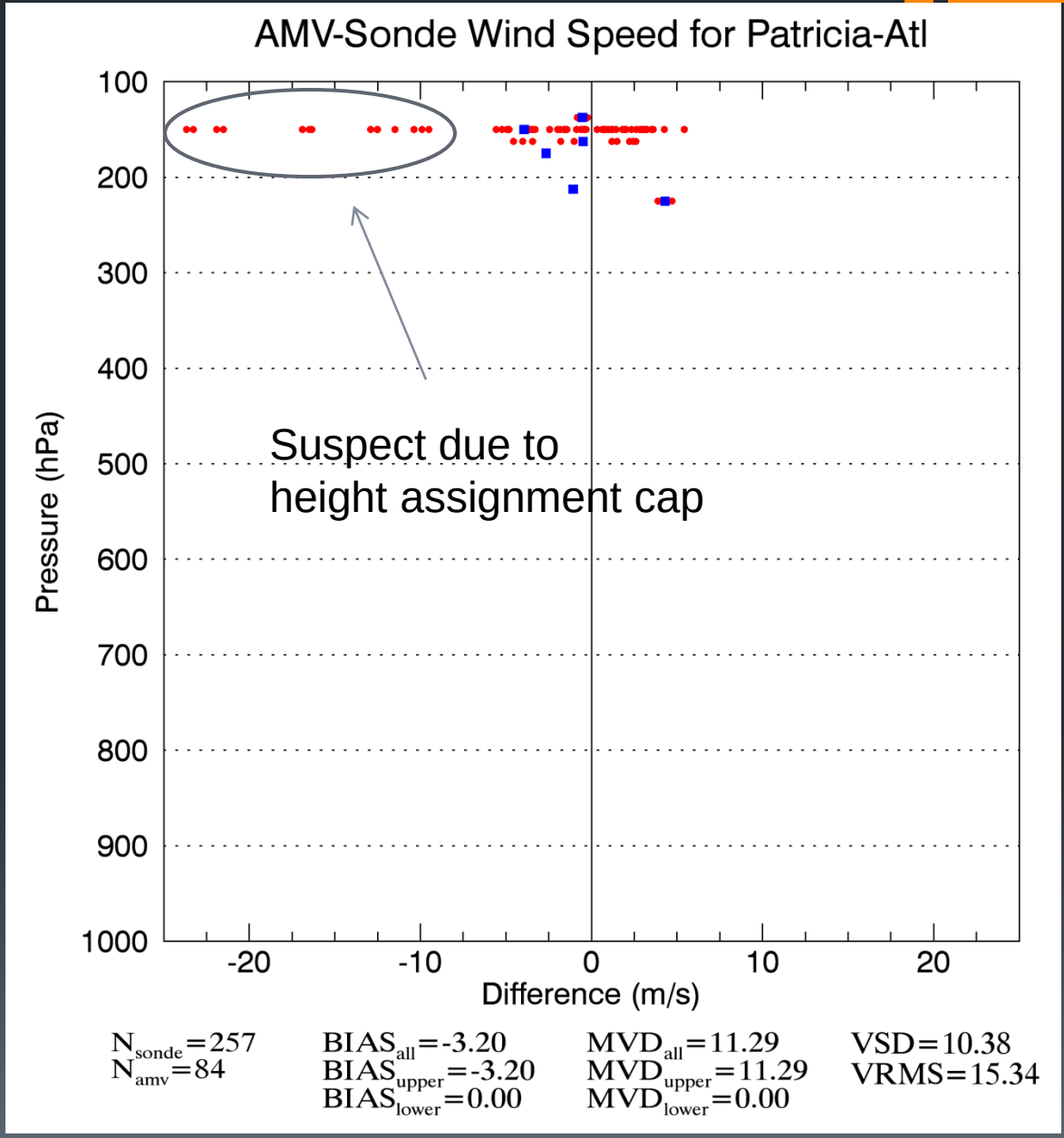




Patricia: Wind Speed Comparisons

Wind speed differences (AMV minus dropsonde) for all 84 verifying AMVs
[Individual differences in red dots, layer average difference in blue dots]

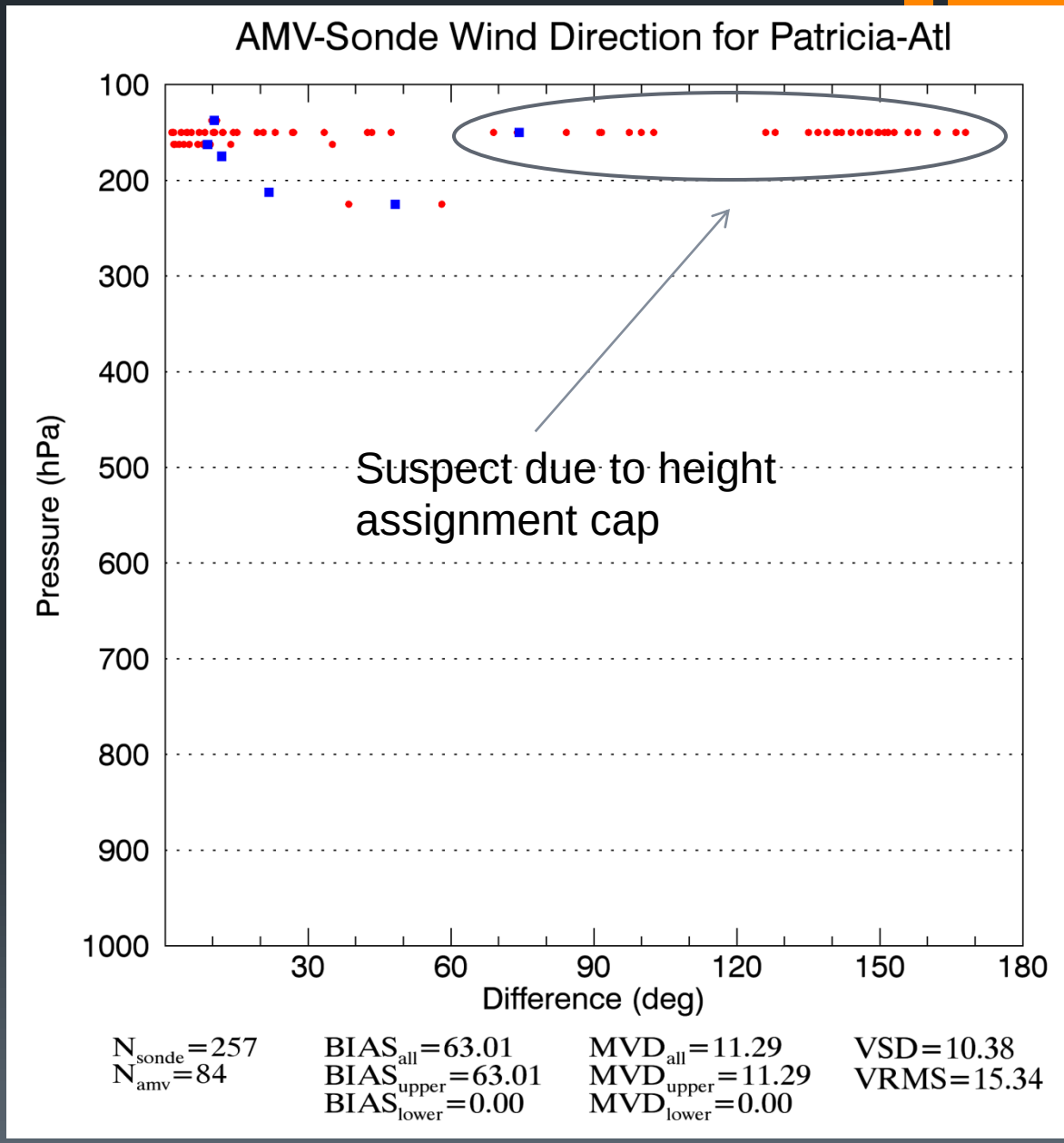
- *Speed bias*
  - *-3.2 m/s*
    - *<500hPa: -3.0 m/s*
    - *>500hPa: N/A*
- *Mean vector difference*
  - 11.3 m/s
    - <500hPa: 11.3 m/s
    - >500hPa: N/A
- *Standard deviation*
  - 10.4 m/s
- *Vector root-mean-square error*
  - *15.3 m/s*



Patricia: Wind Direction Comparisons

Wind direction differences (AMV minus dropsonde) for all 84 verifying AMVs
[Individual differences in red dots, layer average difference in blue dots]

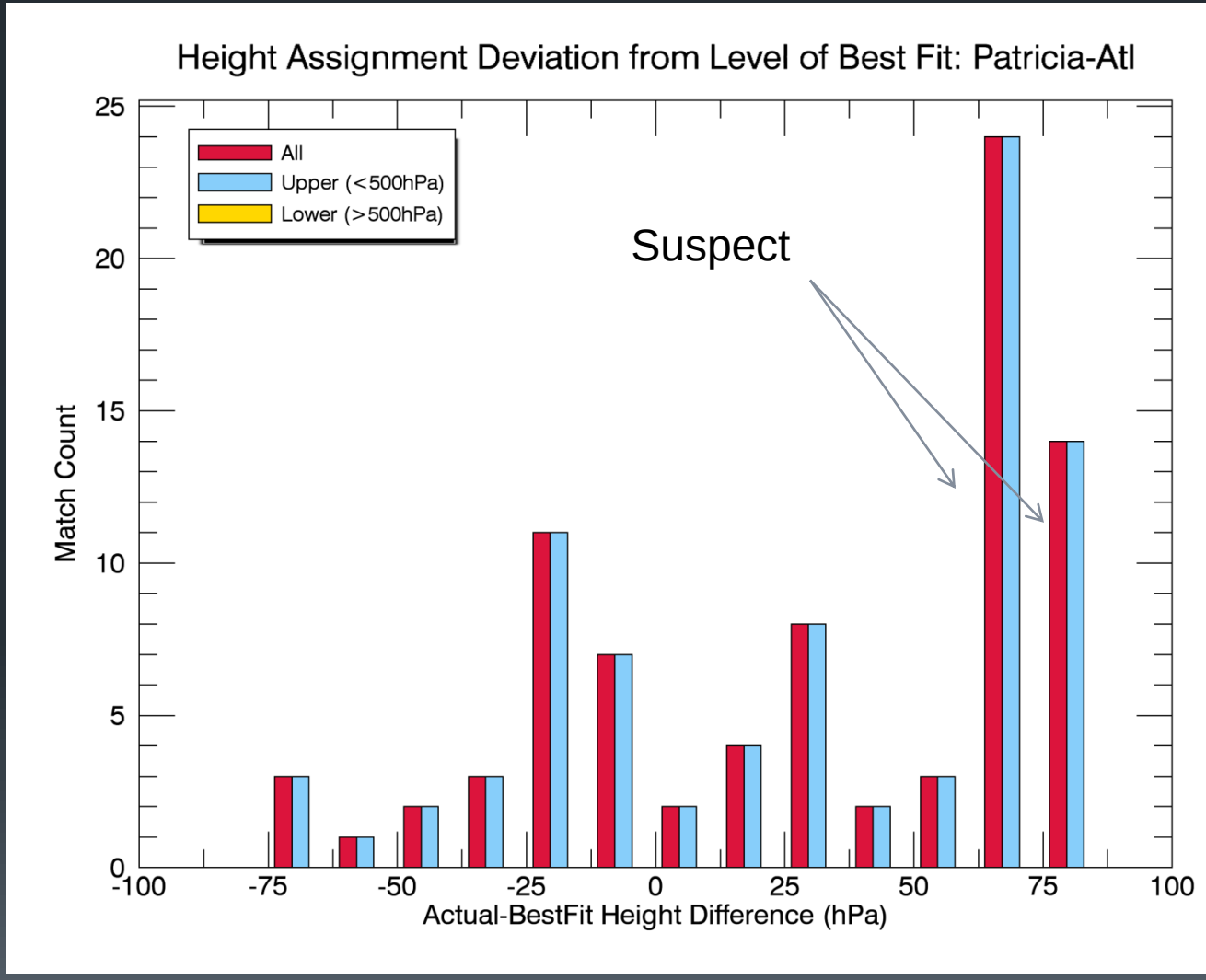
- *Direction bias*
  - *63.0 º*
    - *<500hPa: 63.0 º*
    - *>500hPa: N/A*



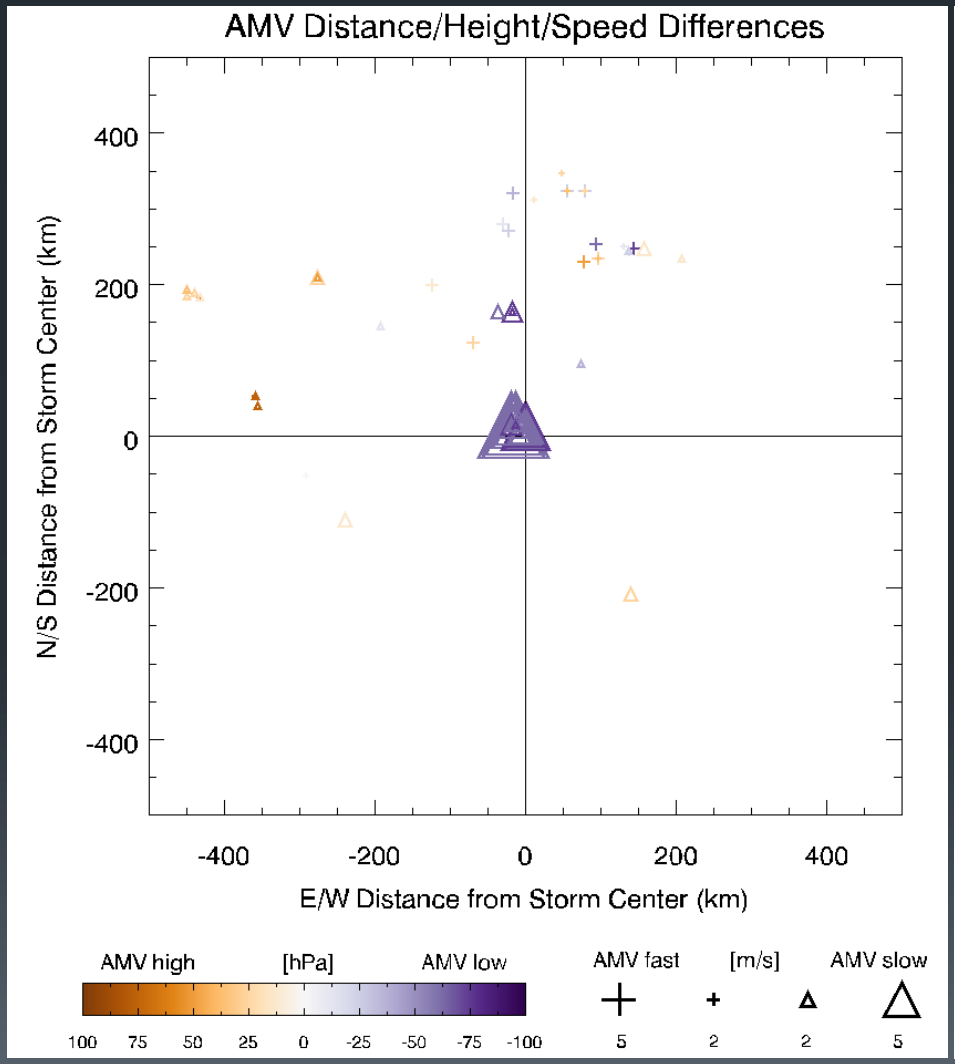
Patricia: Level of Best Fit (LBF)

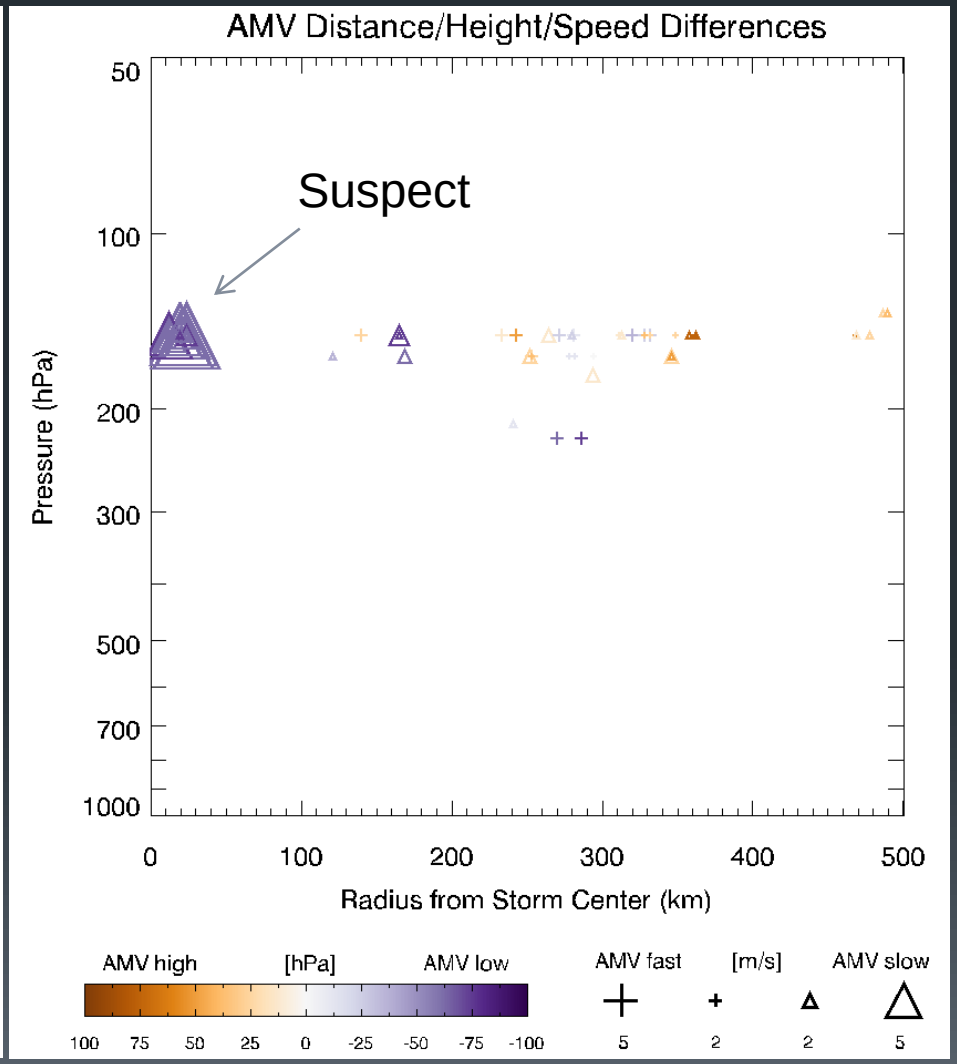
For each verifying AMV, search the matching sonde wind profile for the level that minimizes the AMV-Sonde vector difference, within 100 hPa of original AMV height assignment (i.e., the height assignment an AMV could be given to most closely match the dropsonde).

Negative values: AMVs assigned too high in atmosphere, Positive values: AMVs assigned too low in atmosphere



Patricia: Spatial LBF and Speed Comparisons





Summary

- Project motivation: How good are AMVs in defining TC outflow, and can a mix of high-resolution dropsondes with the AMVs better define the 4-D structure evolution?
- First step: Characterize the AMVs by comparing to co-located (space and time) HDSS dropsonde wind profiles
  - Evaluate the accuracies and height assignments

Preliminary Findings

- Complements the work of Sears and Velden (2012), but with TCI's unique dataset of high-altitude dropsondes over tropical cyclones

- The large number/density of HDSS dropsondes allows for strict matching criteria to be applied to the AMV comparisons
  - Within 30 min, ¼°, and QI ≥ 0.8

- Generally, matching statistics show good agreement between AMVs and collocated dropsonde winds, with some exceptions:
  1) Tropopause bulge over strong TCs such as with Joaquin and Patricia's inner core CDO results in many AMVs being height assigned too low (150 hPa AMVs were best fit at ~80 hPa). The AMV processing cap at 150 hPa for height assignments is too restrictive in TCs
  2) Low-level AMVs in the TC outer circulation/near-environment are sometimes height assigned too high (consequence of sloping TC MBL?)

Future Work

- AMVs appear to be more representative of the wind over a tropospheric layer rather than a specific level (Velden and Bedka, 2005). Does this apply in TC environments such as the outflow layer as well? Investigate layer-wind binning methods
- Explore 4D visualization of the AMV field with the dropsondes to better view the characteristics of the combined datasets