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Evaluation of Dual Geostationary Stereo Winds in NAVGEM

Rebecca Stone [1], Patricia Pauley [2], Hui Christophersen [2], and Justin Reeves [3]

1 SAIC, Naval Research Laboratory, Monterey, California, USA
2 Naval Research Laboratory, Monterey, California, USA
3 Fleet Numerical Meteorology and Oceanography Center, Monterey, CA, USA

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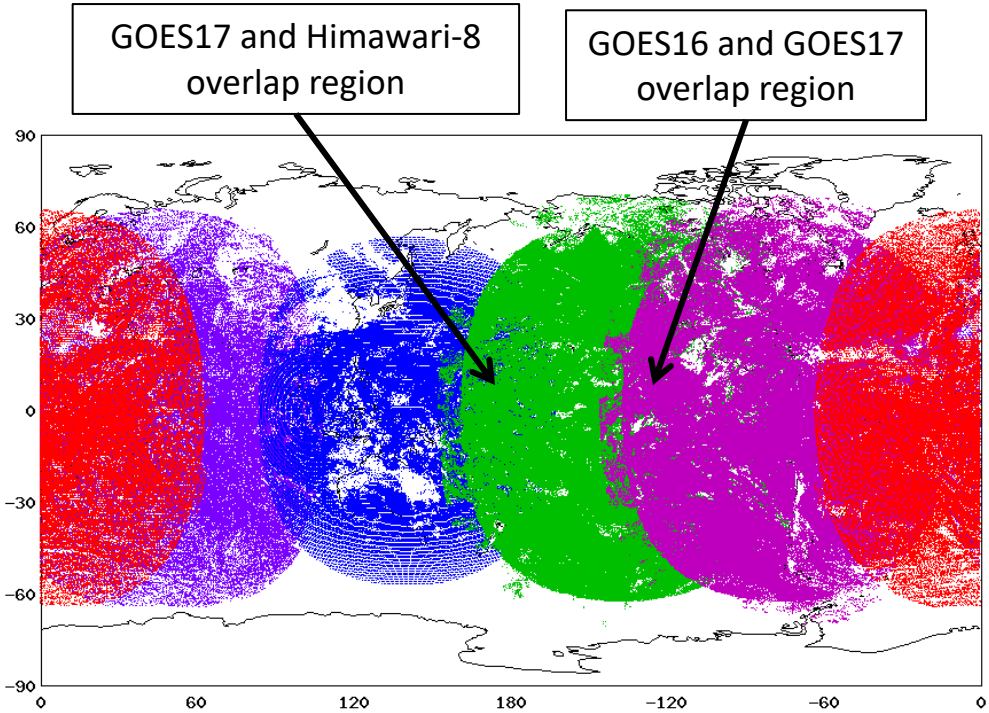
Evaluation of Dual Geostationary Stereo Winds in NAVGEM Overview

- NESDIS and NASA developed and produced dual geostationary winds using the stereo method to jointly retrieve wind vectors with their geometric heights from geostationary satellite pairs (discussed by J. Carr in Monday afternoon presentation).
- We tested in NAVGEM, the U.S. Navy's global numerical weather prediction system for test data 2020040100 - 2020043018.

We present two types of evaluations of these winds:

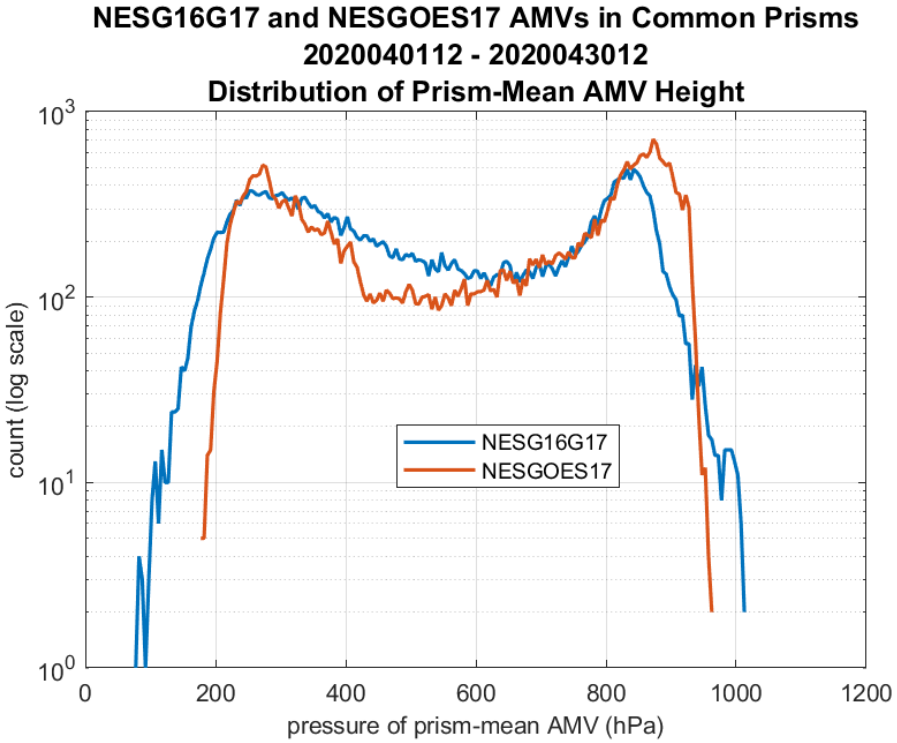
- ➢ Assimilated AMV superobs
  - NAVGEM 2.1 T425L60 with 4DVAR assimilative test run
  - Assimilated both stereo winds and operational winds
- ➢ Collocated pairs of stereo AMVs with constituent satellite IR AMVs
  - Pairs of post-QC, pre-superob individual observations
  - NAVGEM fields used for reference background



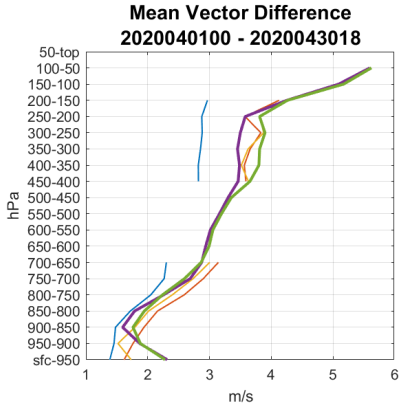
AMV Statistics in Assimilative Test

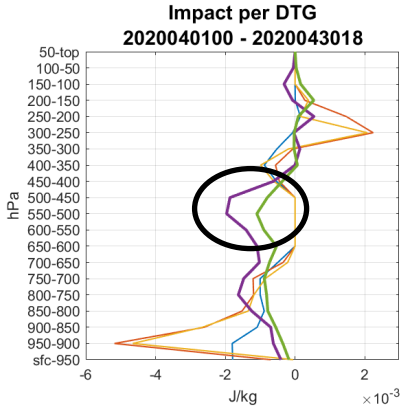
Stereo winds' reported heights were used, with NAVGEM background pressure fields used in height-to-pressure conversion.

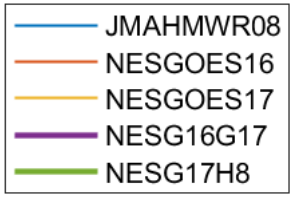
The stereo wind superobs in our test were more widely distributed in height than operational AMVs, especially through the midlevels.

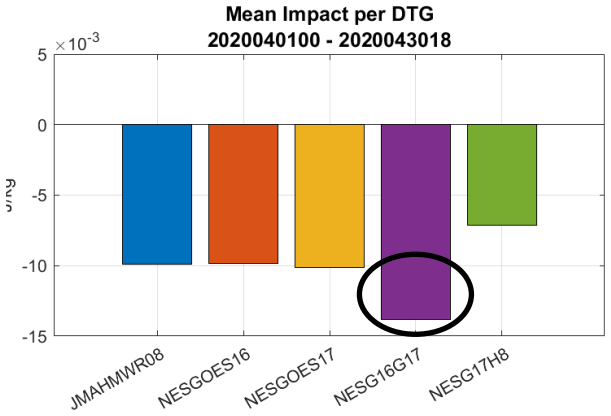


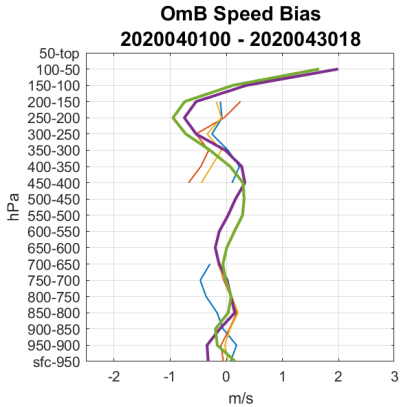
AMV Statistics in Assimilative Test

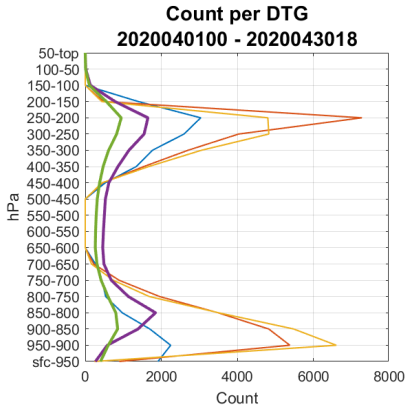












Both sets of stereo winds were strongly beneficial as measured by NAVGEM FSOI.

In particular, NESG16G17 brought beneficial impact to the midlevels, where standard QC measures exclude IR winds (due to their typically nonbeneficial impact there).

Collocated Pairs

of post-QC, pre-superob individual observations

Pairs of one stereo AMV with one collocated constituent satellite AMV

NAVGEM fields used for reference background

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Collocated Pairs

2020040100 – 2020040918
aggregate of 9 days

5 sources

NESGOES16
NESG16G17
NESGOES17
NESG17H8
JMAHMWR08

6 pair types

NESG16G17_NESGOES16
NESG16G17_NESGOES17
NESGOES16_NESGOES17
NESG17H8_NESGOES17
NESG17H8_JMAHMWR08
NESGOES17_JMAHMWR08

Collocation Criteria (initial)

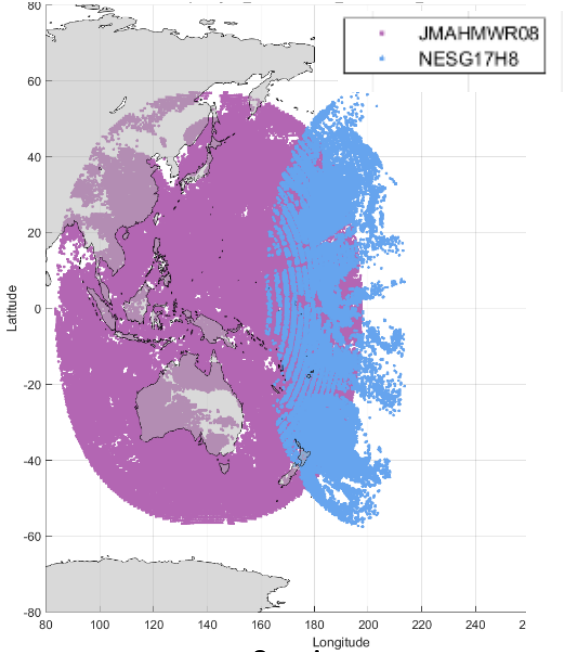
- Distance < 0.01 degree (precision of lat and lon data) ~1.1 km
- Simultaneous (reported time in data file)

No collocation matches with JMAHMWR08

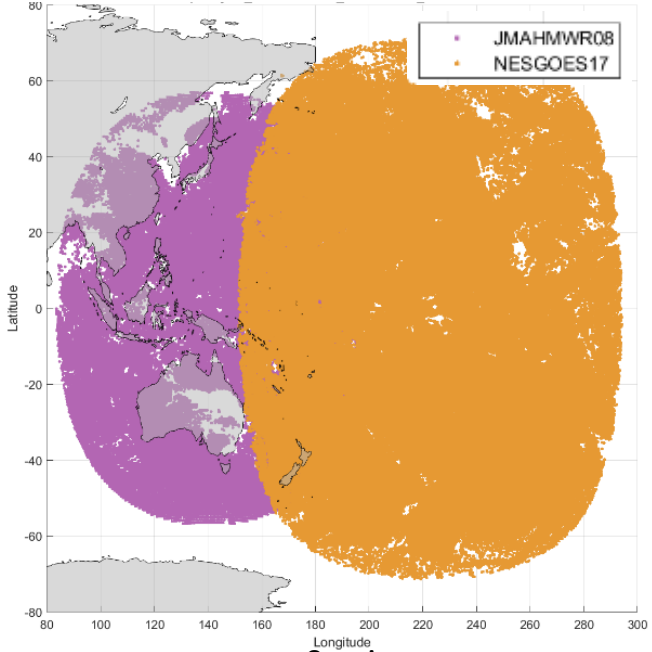
No Collocated Pairs with JMAHMWR08

using distance criteria ~1.1 km

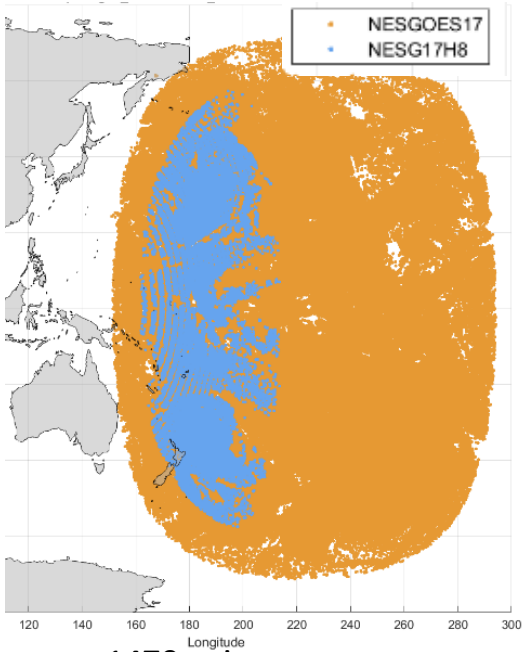
DTG 2020040500 example: plenty of AMVs present, and plenty of “nearby” AMVs.



0 pairs



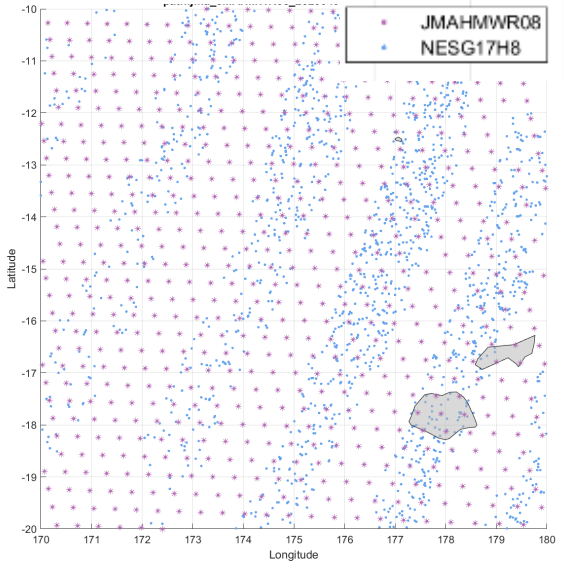
0 pairs

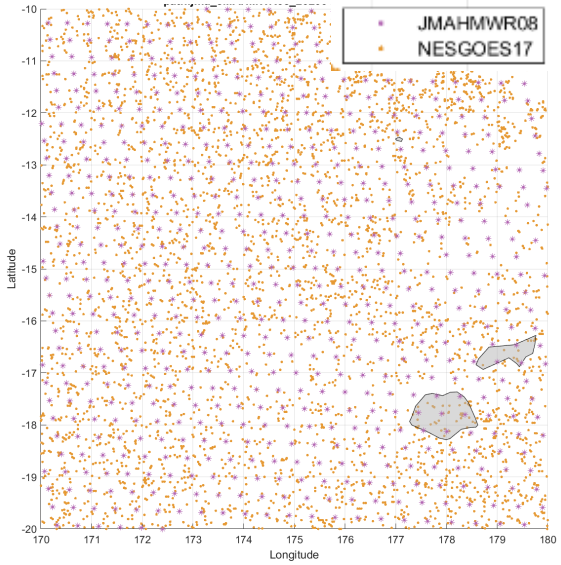


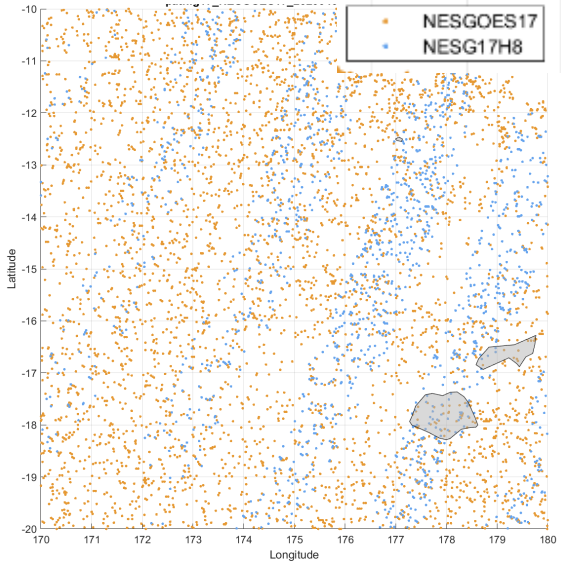
1470 pairs

Why are collocations not found?

zoom in near Fiji



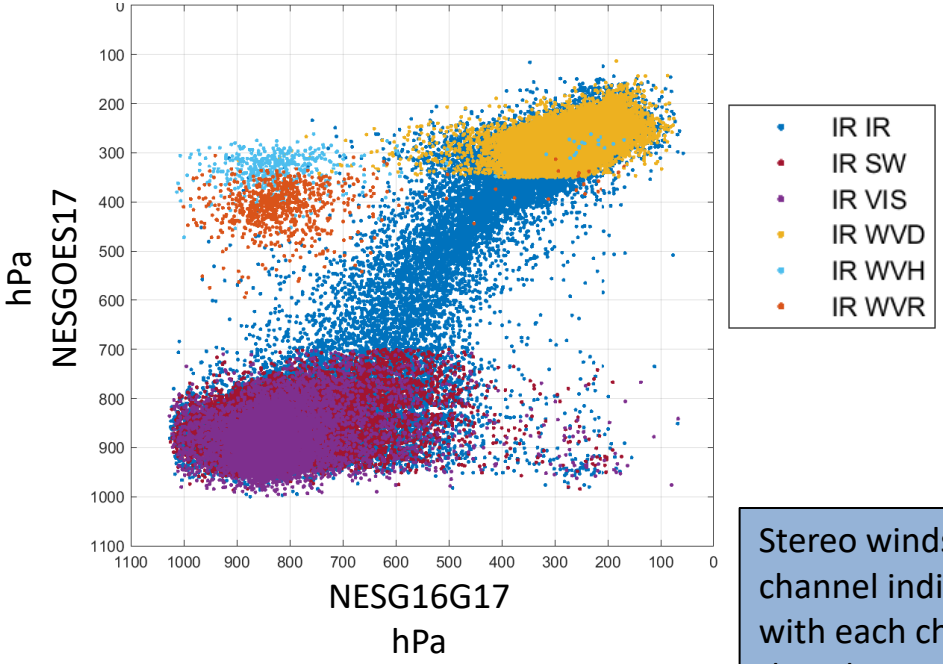




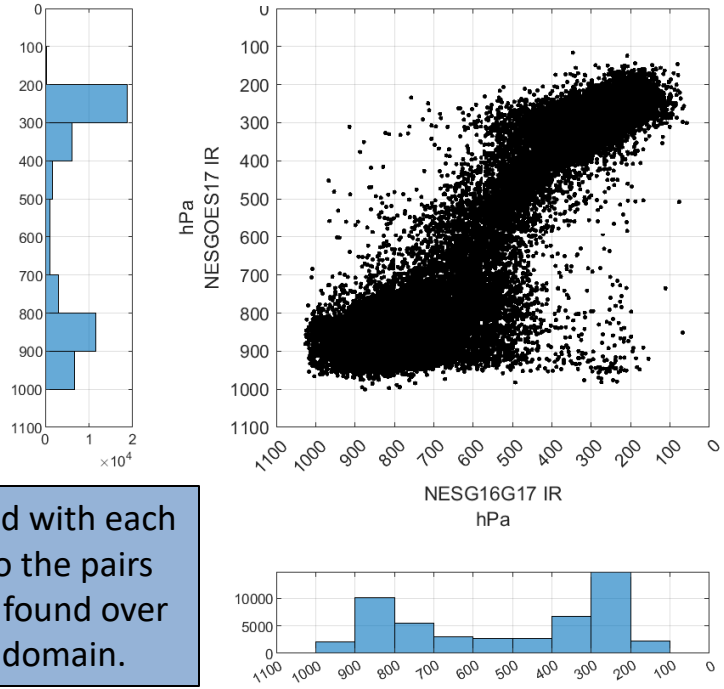
- Himawari-8 winds are provided at regularized locations.
- Distance criteria relaxed to < 0.036 degree (~3.9 km, approximately 10x the area of the 0.01 degree criteria)
- Time match criteria relaxed to a tolerance of <= 601 seconds (because there were no exact timestamp matches)
- These tolerances were chosen such that they would yield about the same number of matched pairs as the other pair groupings.

Where are collocated pairs found?

NESG16G17 NESGOES17 Collocated Pairs
Height Assignment Scatter

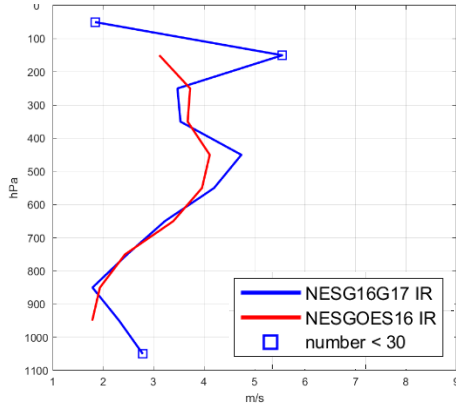


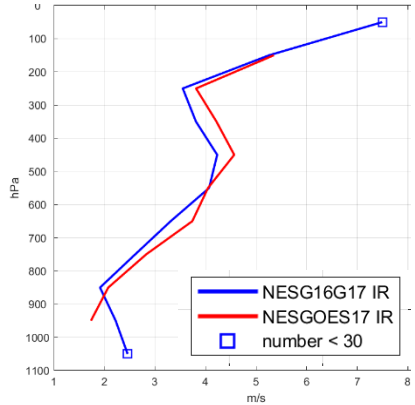
NESG16G17 NESGOES17 Collocated Pairs
Height Assignment Scatter
IR channel matches only

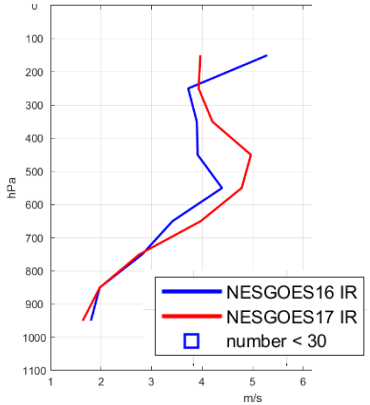


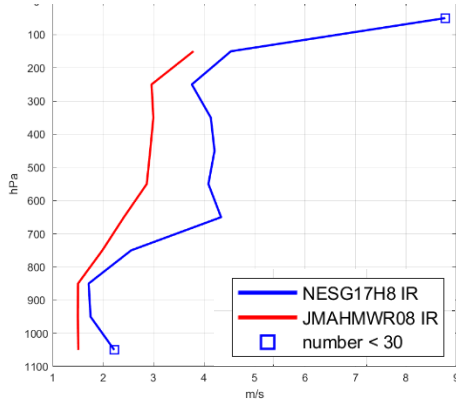
Stereo winds are paired with each channel individually, so the pairs with each channel are found over that channel's vertical domain.

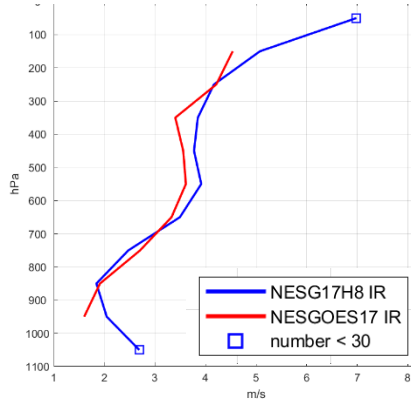
Mean Vector Differences

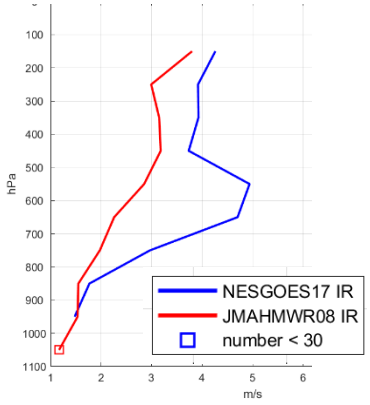










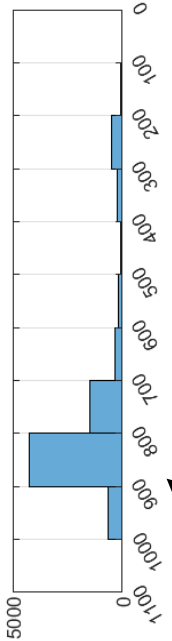


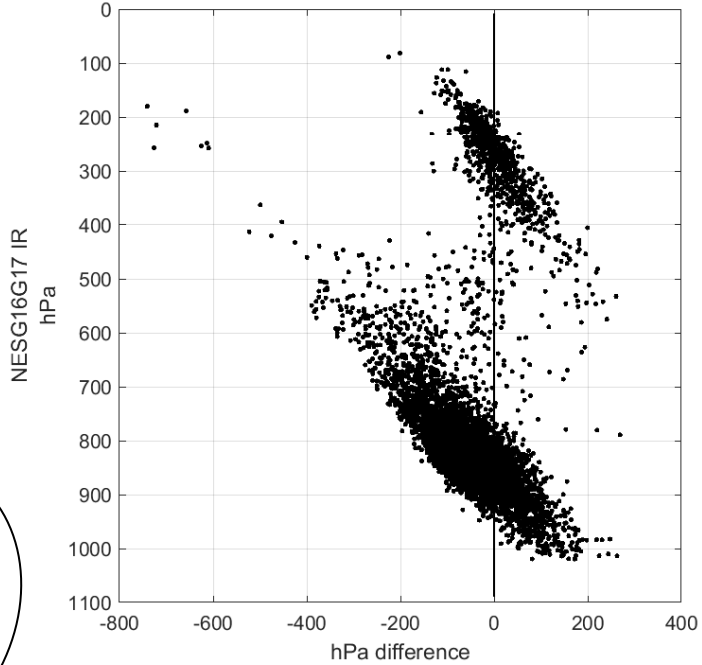
Overall, vector differences of stereo winds are comparable to those of operational winds.

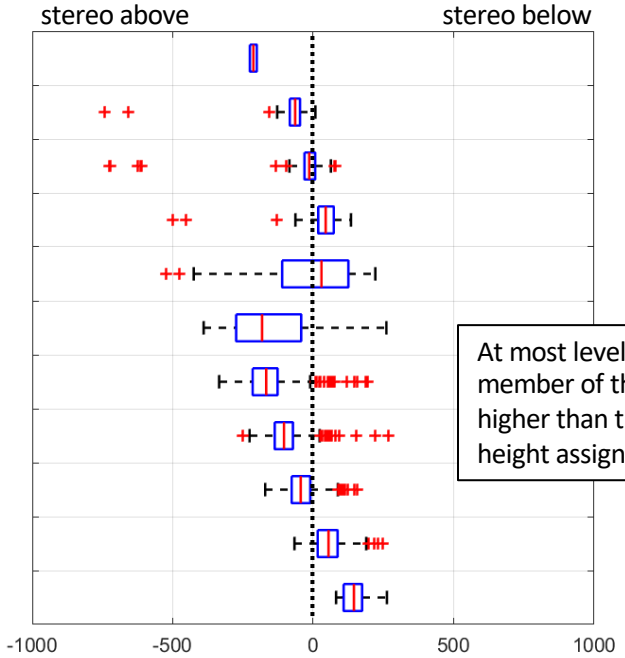
Two curves plotted for same sensor are different because only the collocated pairs are included in the sample plotted.

JMAHMWR08 paired winds have lower MVD, especially in midlevels.

Compare Heights of Paired AMVS NESG16G17 and NESGOES16 IR

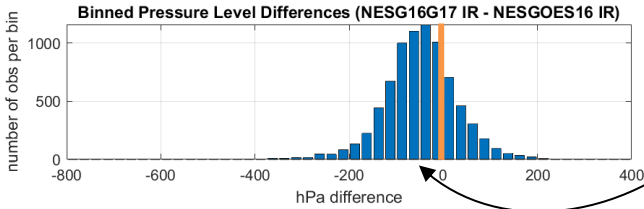






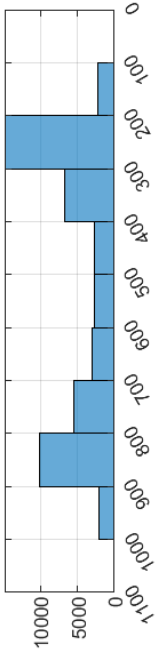
At most levels, the stereo member of the pair is higher than the operational height assignment member.

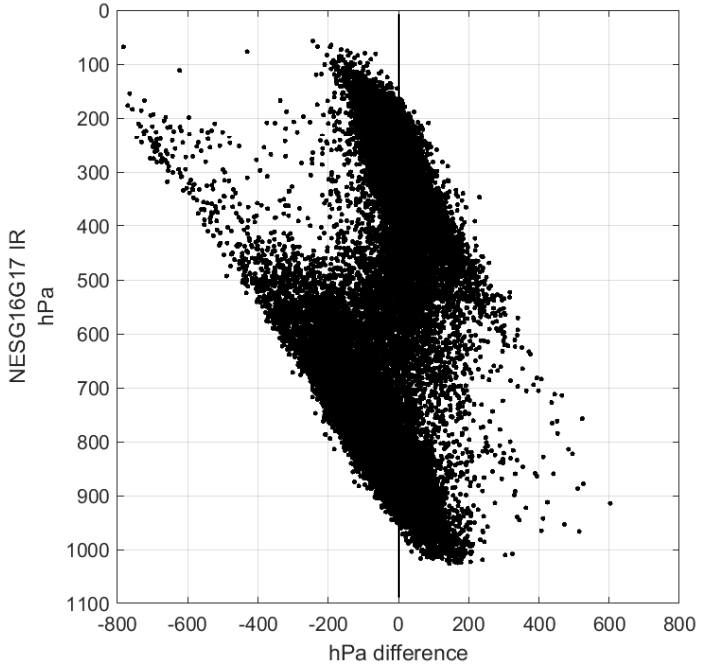
The stereo heights of the pairs are predominantly low level.

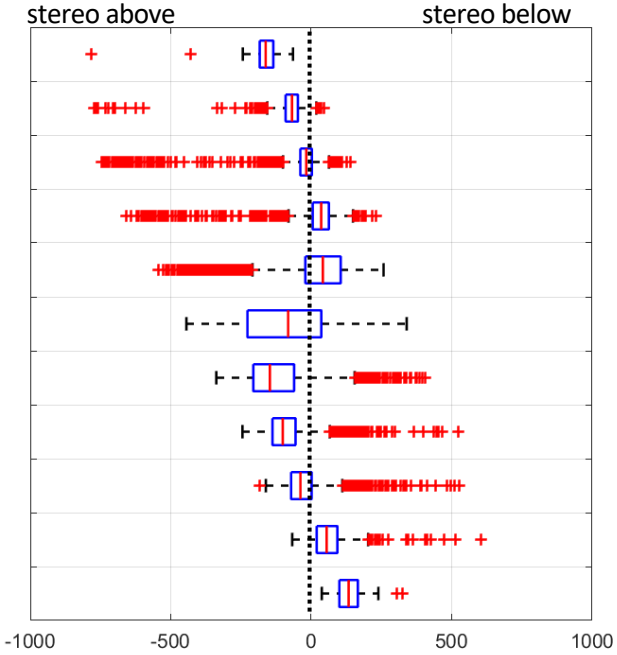


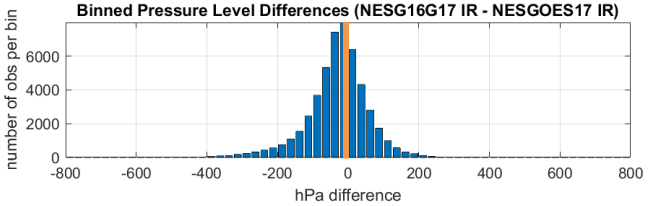
The stereo height members range mostly from 125 hPa above to 25 hPa below the NESGOES16 heights.

Compare Heights of Paired AMVS NESG16G17 and NESGOES17 IR



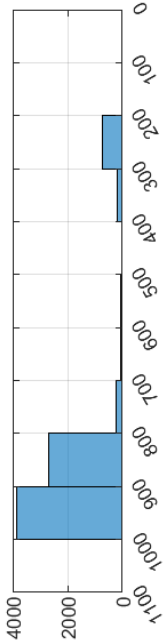


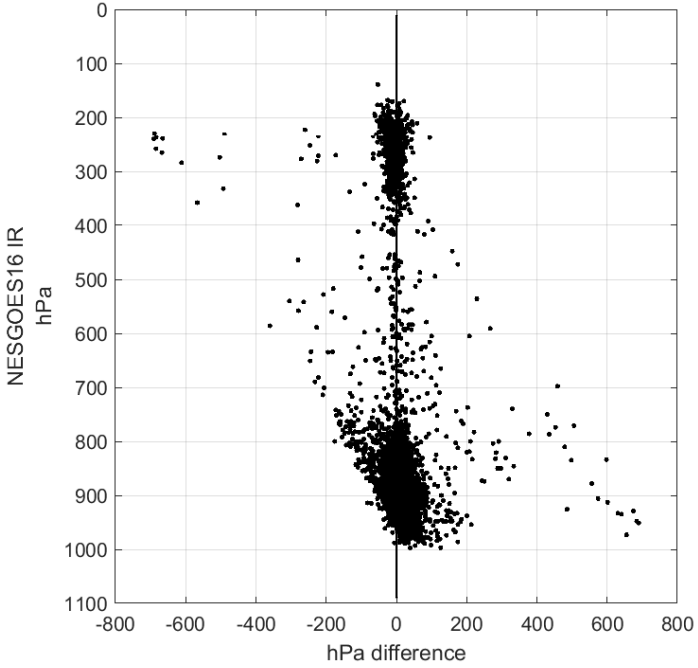


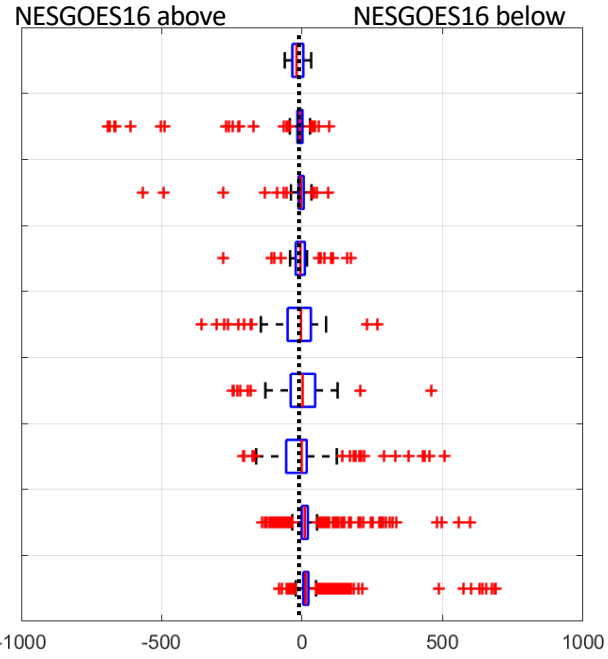


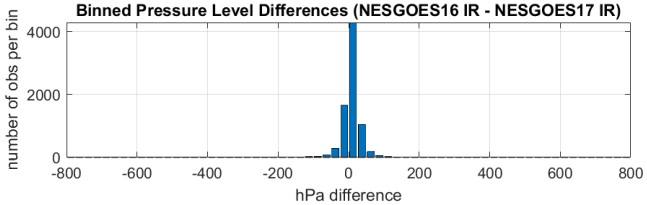
At upper and lower levels, many pairs have two members with heights very close to each other (narrow boxes on boxplot), although there are a fair number of outliers. At midlevels, the stereo member of the pair is usually higher than the operational height assignment member.

Compare Heights of Paired AMVS NESGOES16 IR and NESGOES17 IR









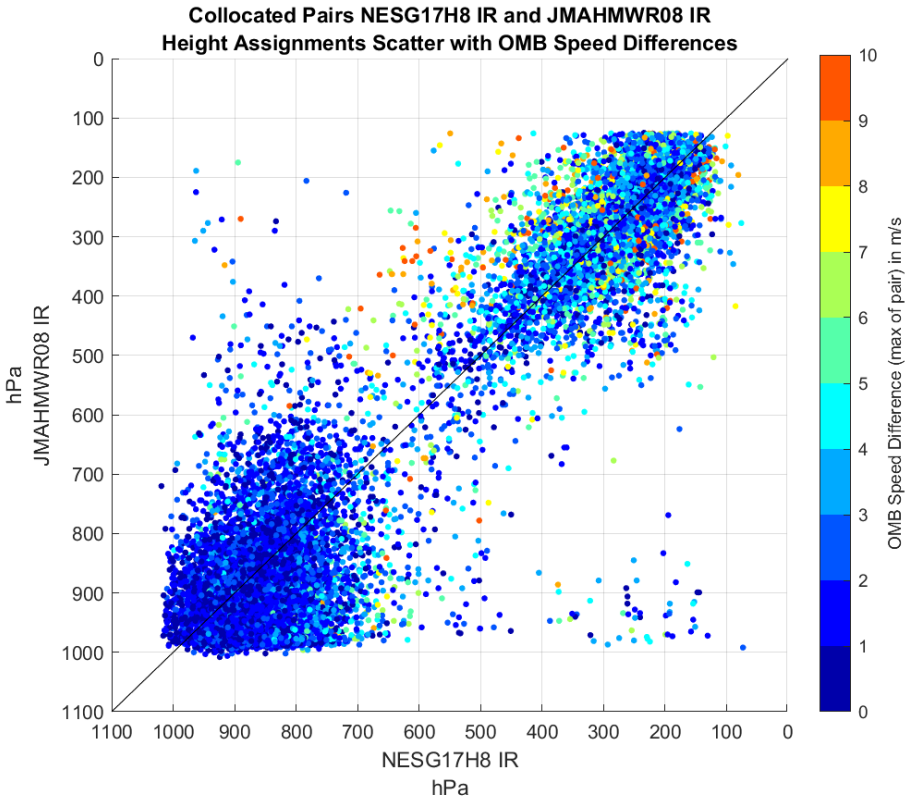
NESGOES16 and NESGOES17 pairs members usually have heights very close to each other. Even at midlevels, the height differences are evenly distributed above and below. At upper levels, the outlier pairs have GOES16 above GOES17; at low levels the outliers have GOES16 below GOES17. (This is natural since GOES16 height is chosen for y-axis.)

OmB and Speed Differences vs. Height Differences

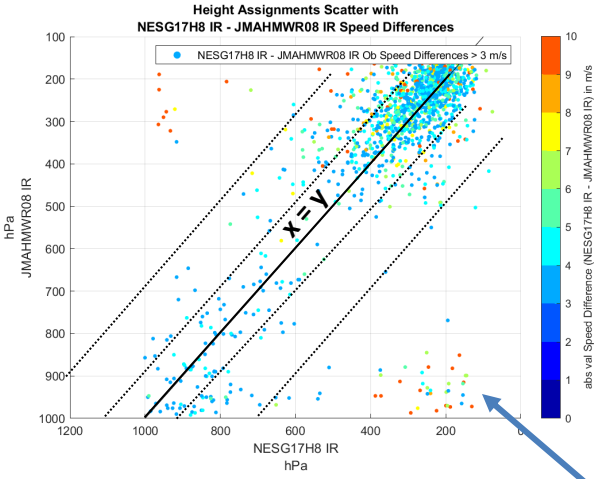
For pairs of obs with large height differences, is one or both of the members likely to have large OmB speed difference?

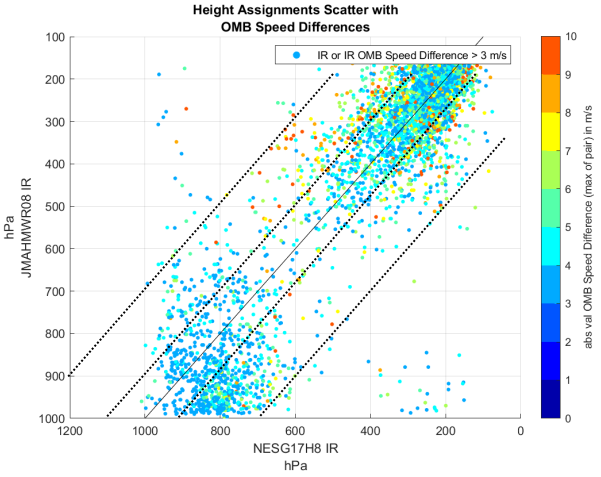
- No strong pattern seen at right
- But low values could obscure higher ones, so remove markers for low OmB speed differences

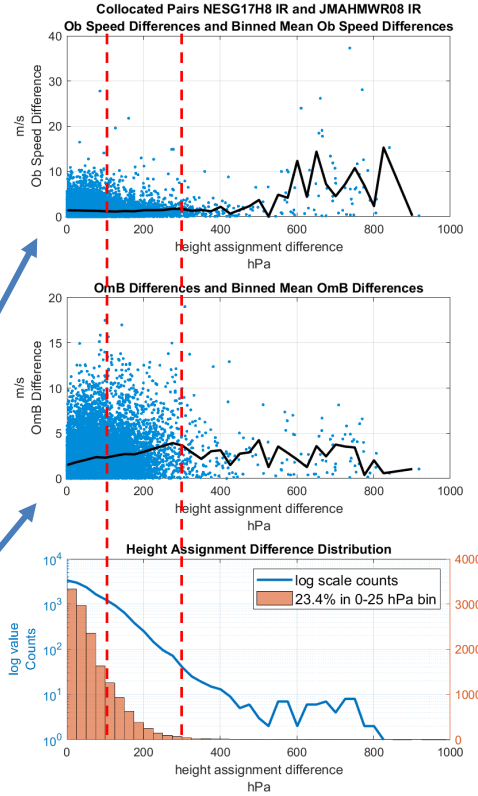
Do the pair members have different observed speeds?



Observed Speeds and OmB Speed Differences for NESG17H8 and JMAHMWR08 IR Pairs





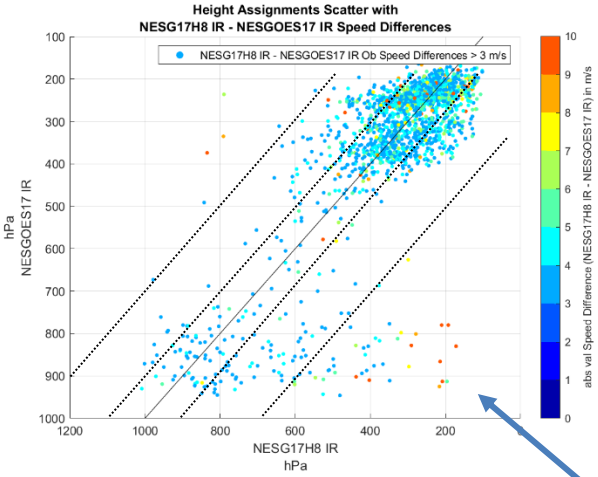


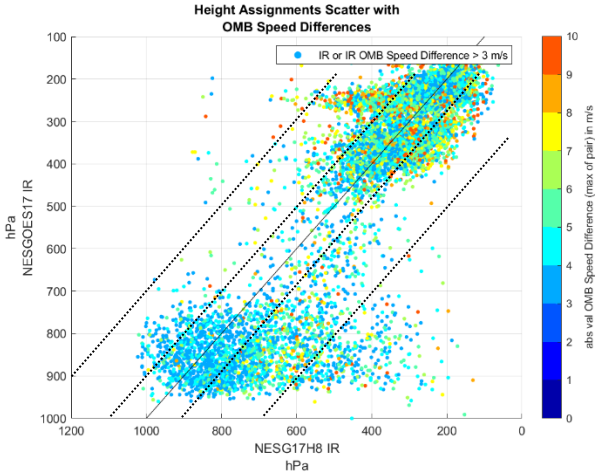
A few pairs of obs with very large height differences tend to have very different observed speed values. But pairs with more moderate height separation do not show a strong trend.

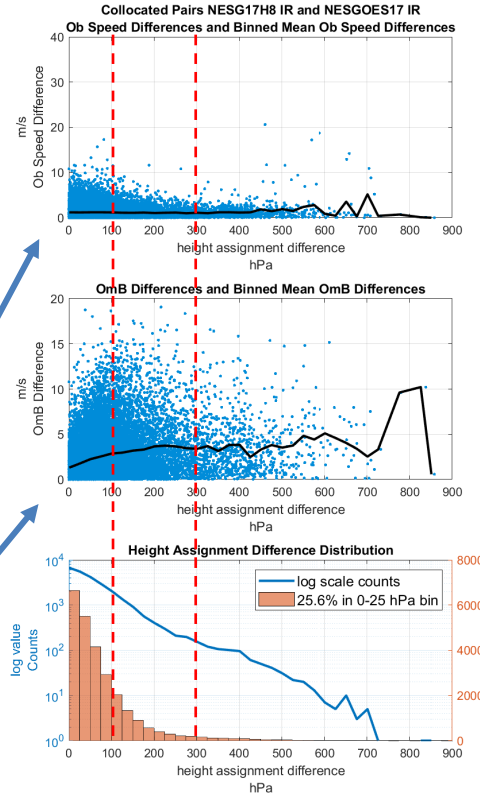
Pairs of obs with larger height differences tend to have slightly larger OmB speed differences.

Pairs of obs with height differences 0-300 hPa are more likely to have increased OmB speed differences than increased ob speed differences.

Observed Speeds and OmB Speed Differences for NESG17H8 and NESGOES17 IR Pairs







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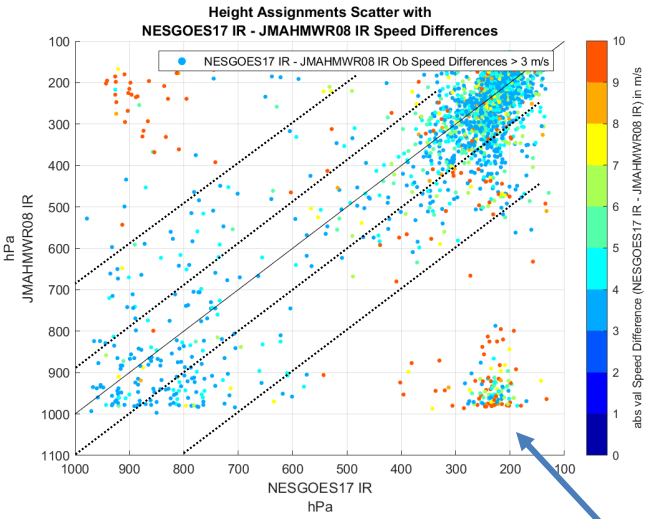
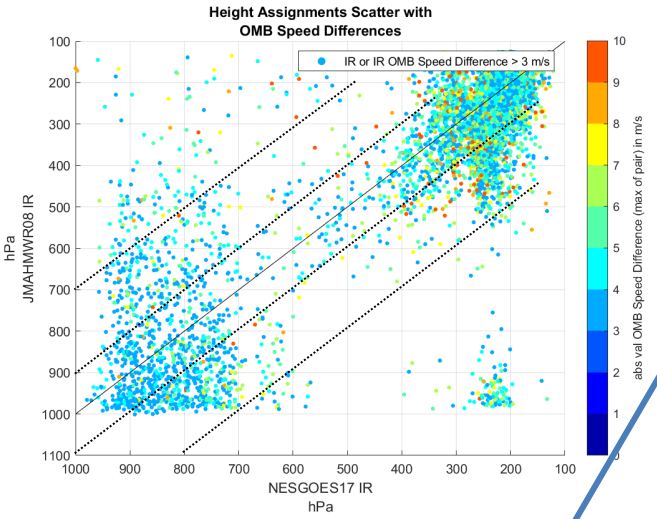
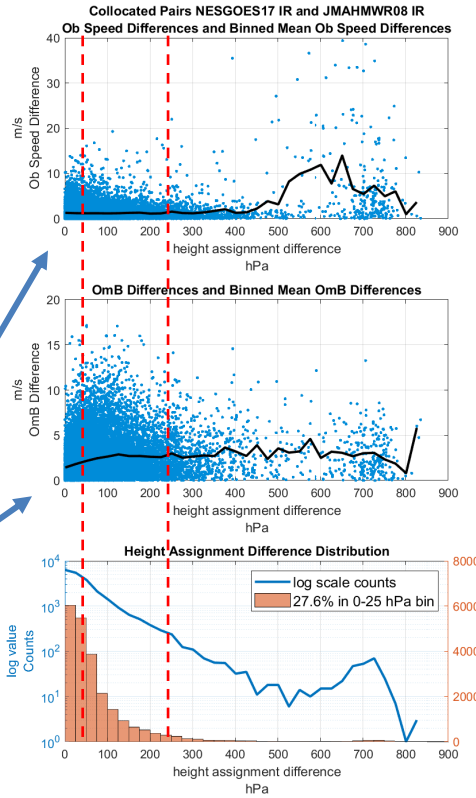
Observed Speeds and OmB Speed Differences for NESGOES17 IR and JMAHMWR08 IR Pairs







A few pairs of obs with very large height differences tend to have very different observed speed values. But pairs with more moderate height separation do not show a strong trend.

There is a weak relationship between height differences and OmB speed differences.

Observed Speed and OmB Speed Difference Take-Aways

Do the partnered winds that are further separated in height have larger differences in observed speed than partnered winds that are close in height?

- Only for the very largest height separations (which are very few). For the preponderance of the pairs, in the previous set of slides, the (top right) bin mean ob speed difference curve tended to be flat, then noisy out to the right where the counts are small.

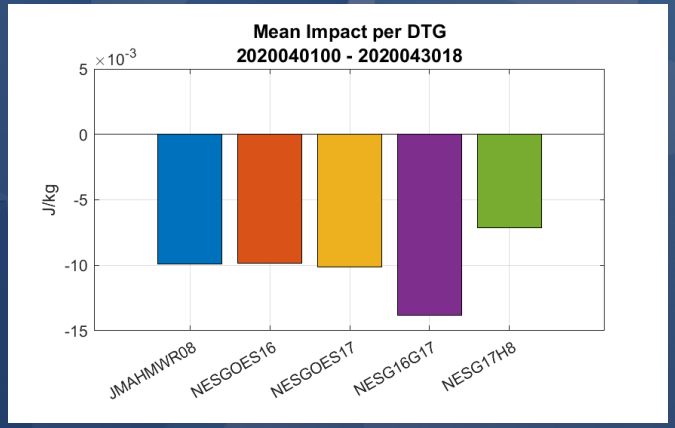
For pairs of obs with large height differences, is one or both of the members likely to have large OmB speed difference?

- For more moderate height differences (up to about 300-400 hPa), there is a trend for OmB speed differences to increase with height separation. Widely separated pairs are too sparse to draw a conclusion.

Therefore, it is likely that a collocated pair with height difference of 400 hPa or less represents a single cloud feature that has an incorrect height assignment for one member and a correct height assignment for the other member. A collocated pair with a very large height difference is likely to represent different features, although there is a relatively small number of these pairs.

Conclusions and Future Work

- The stereo winds were beneficial in the assimilative test.
- The stereo winds were no more duplicative/redundant than overlapping operational geostationary winds.
- Collocated pairs of AMVs, one with stereo height and one operational method height, were more similar in observed speed than in OmB speed; they are likely to be the same feature assigned at different heights.



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- Although the original impetus for development and testing of stereo winds was to help compensate for issues with GOES17, **the quality of the winds/height assignments is at least as good as the operational winds.**
- Further development, including of low earth orbit/geostationary stereo winds is ongoing.
- We look forward to testing more stereo wind data sets in the future.

Backup and Supplemental Slides

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Backup and Supplemental Slides

Collocation Details

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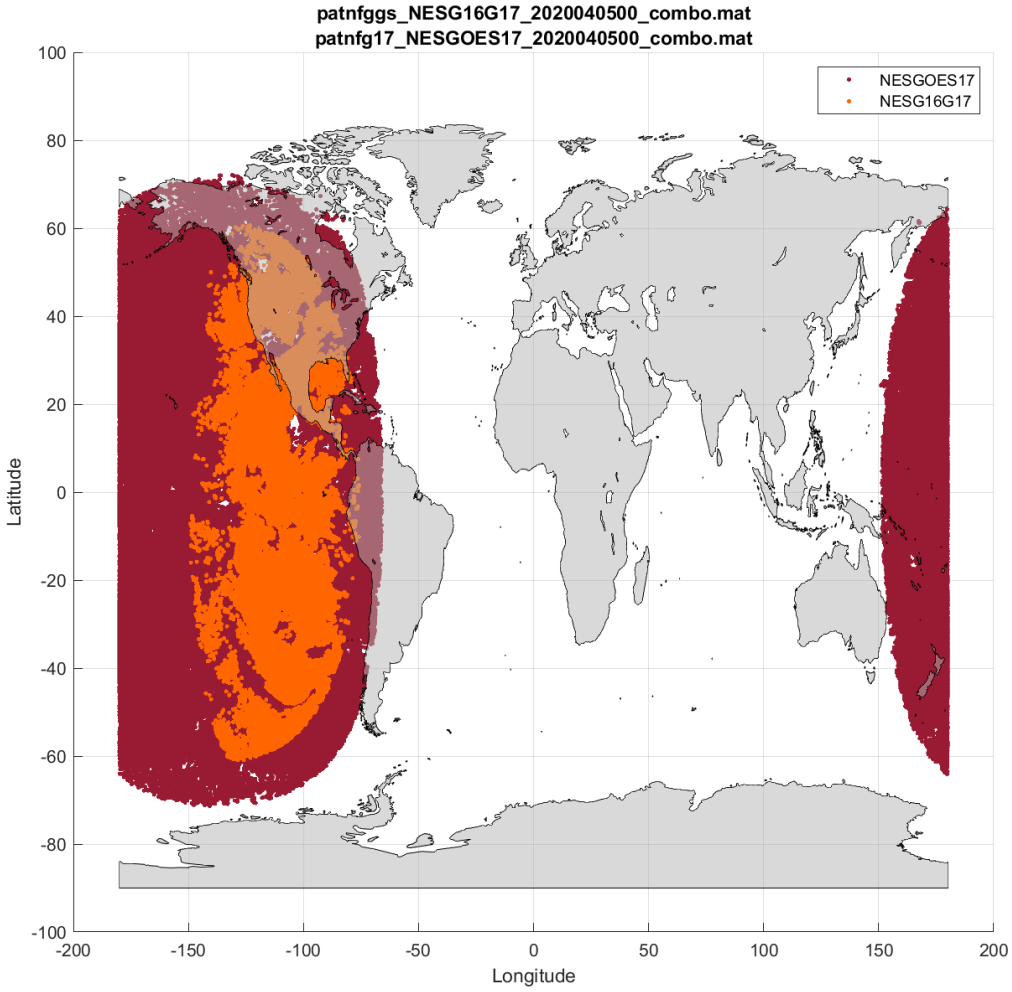
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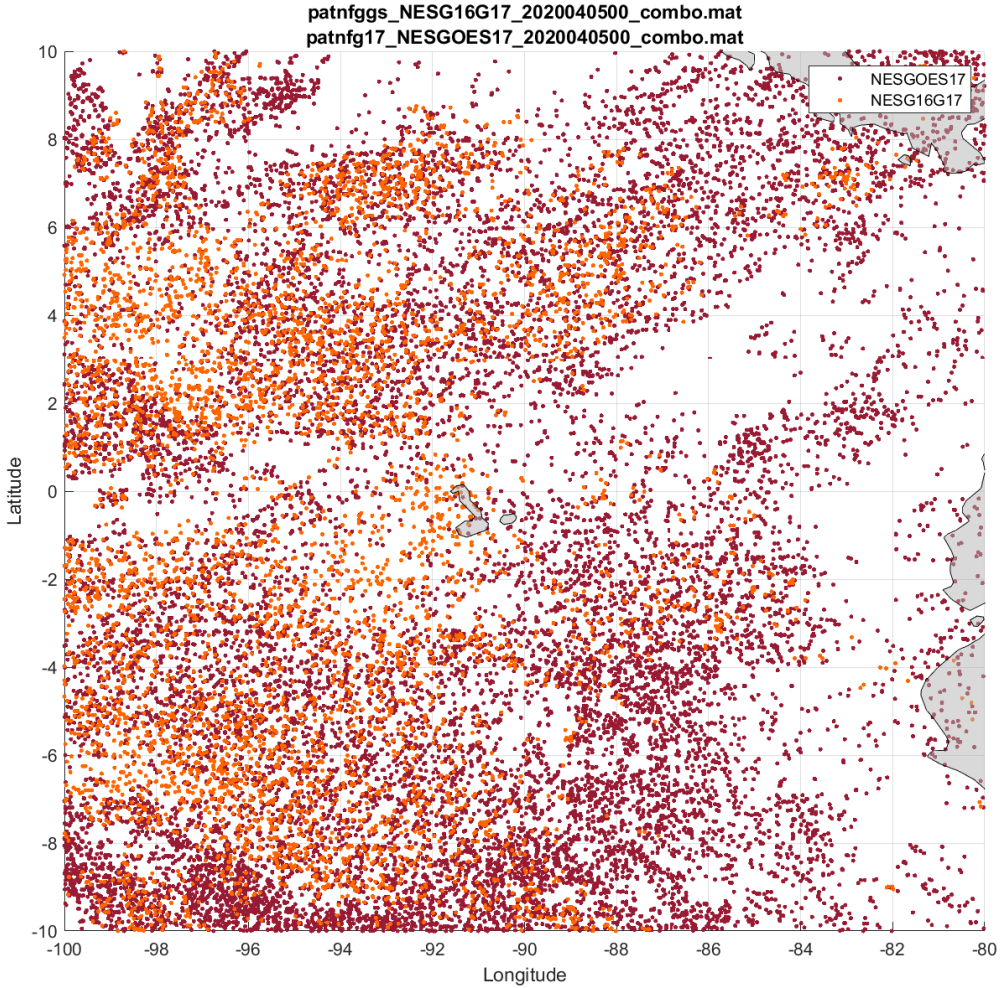
patnfg17_NESGOES17_2020040500_combo.mat
NESGOES17
NESG16G17
Latitude
Longitude
100
80
60
40
20
0
-20
-40
-60
-80
-100
-200
-150
-100
-50
0
50
100
150
200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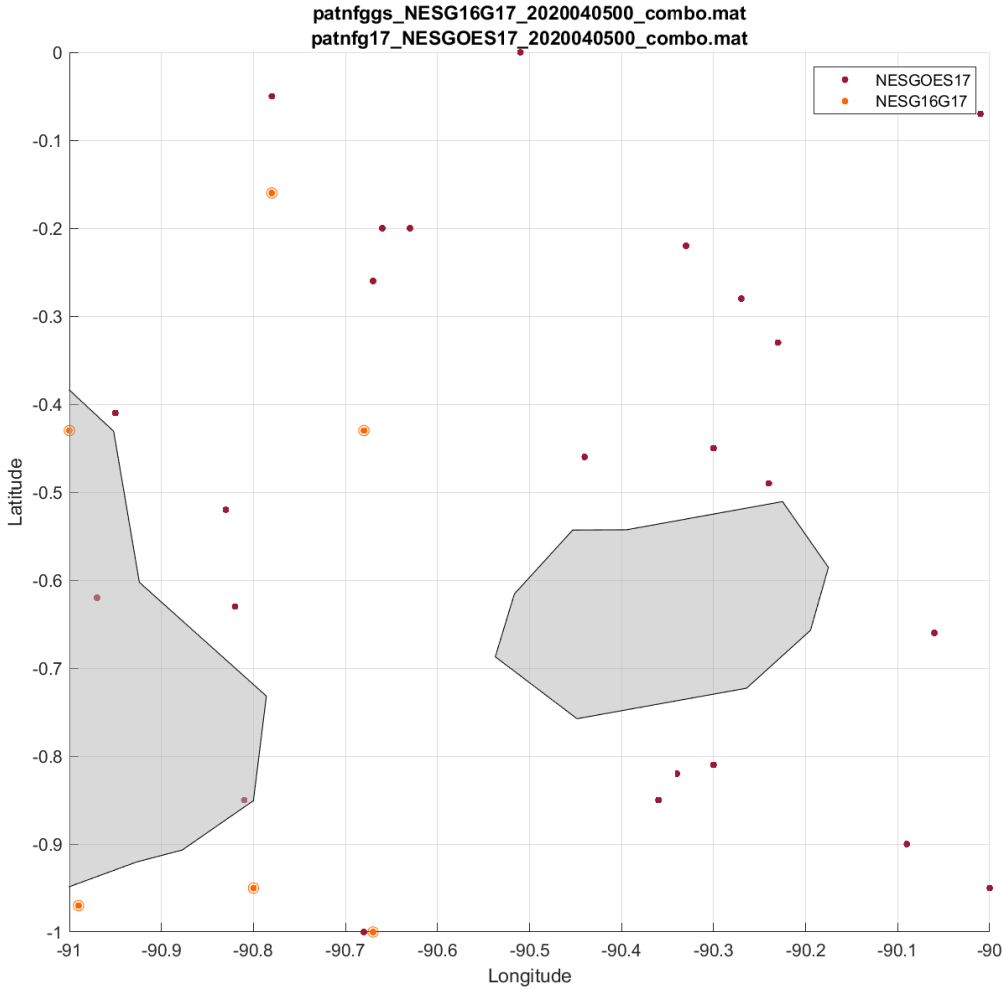
patnfg17_NESGOES17_2020040500_combo.mat
NESGOES17
NESG16G17
Latitude
Longitude
10
8
6
4
2
0
-2
-4
-6
-8
-10
-100
-98
-96
-94
-92
-90
-88
-86
-84
-82
-80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patnfg17_NESGOES17_2020040500_combo.mat
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NESG16G17
Latitude
Longitude
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-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-91
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-90.7
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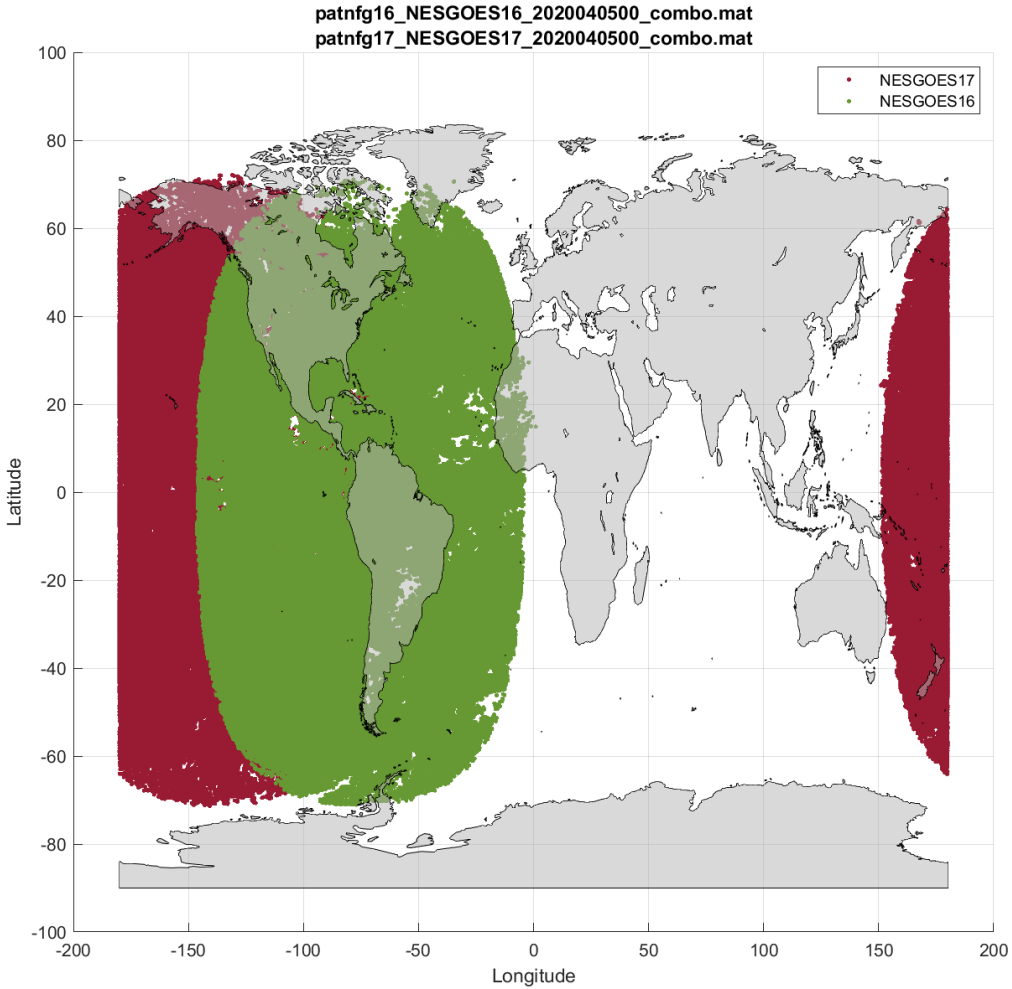
-90.5
-90.4
-90.3
-90.2
-90.1
-90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patnfg17_NESGOES17_2020040500_combo.mat
NESGOES17
NESGOES16
Latitude
Longitude
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80
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-100
-50
0
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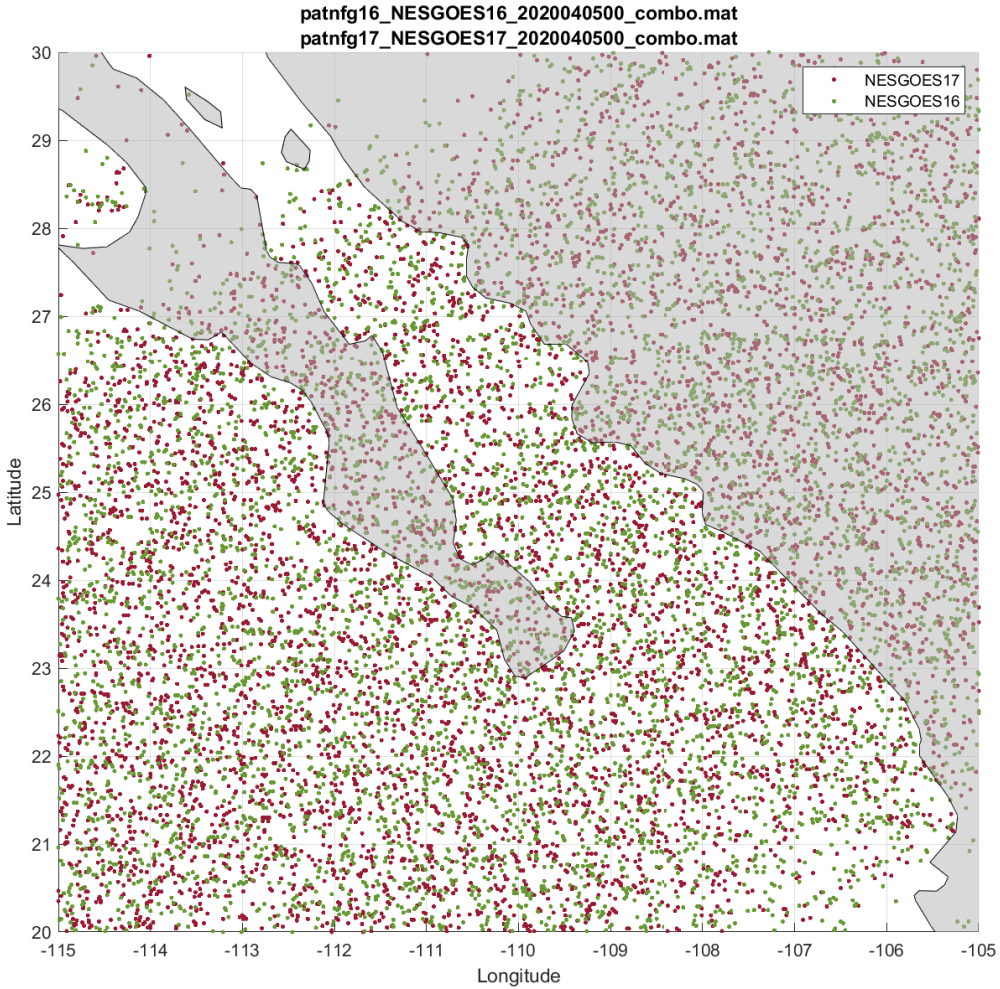
100
150
200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NESGOES17
NESGOES16
Latitude
Longitude
30
29
28
27
26
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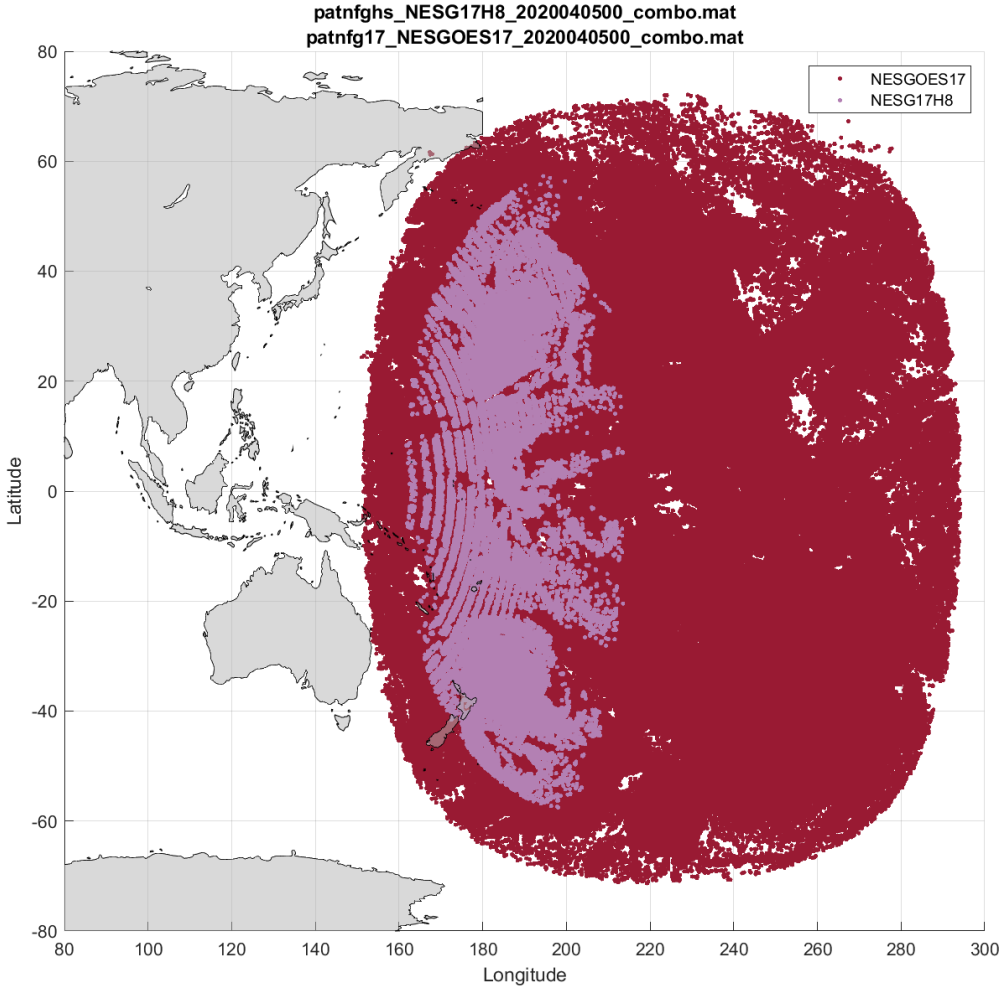
-105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NESGOES17
NESG17H8
Latitude
Longitude
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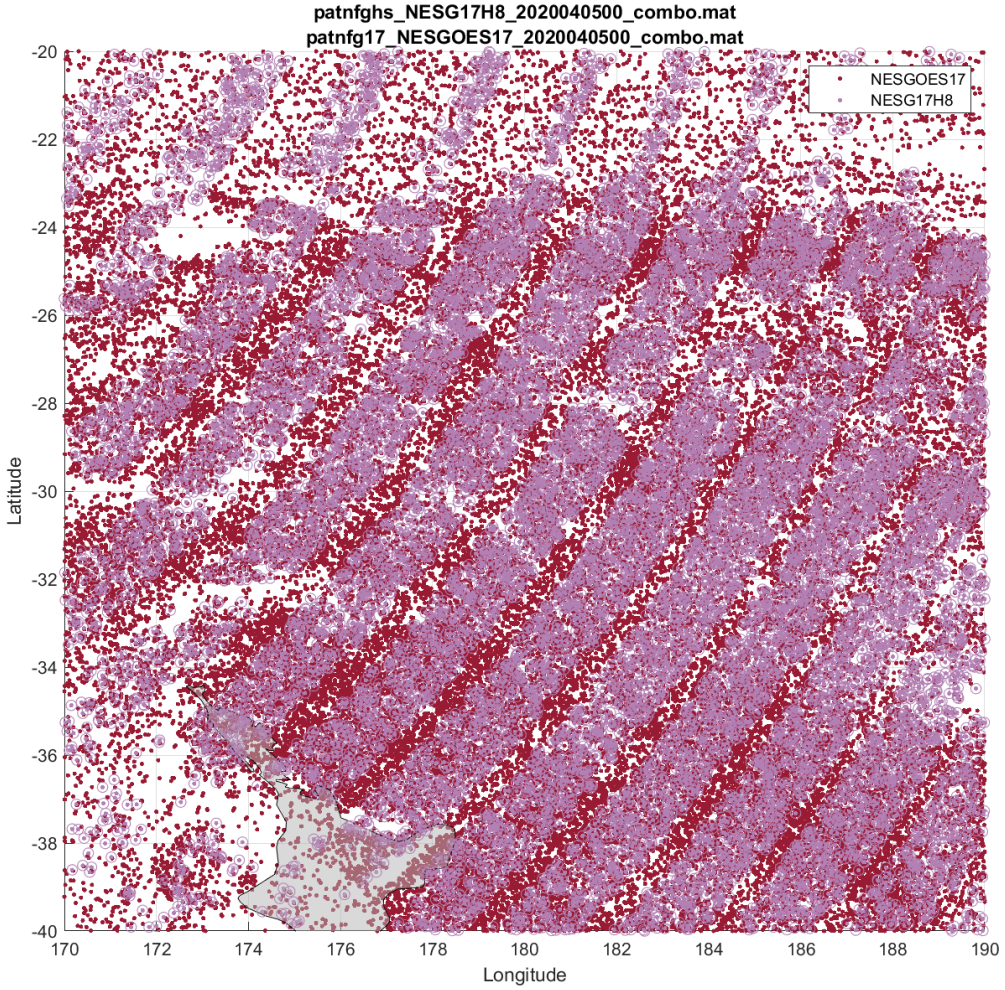
280
300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patnfg17_NESGOES17_2020040500_combo.mat
NESGOES17
NESG17H8
Latitude
Longitude
-20
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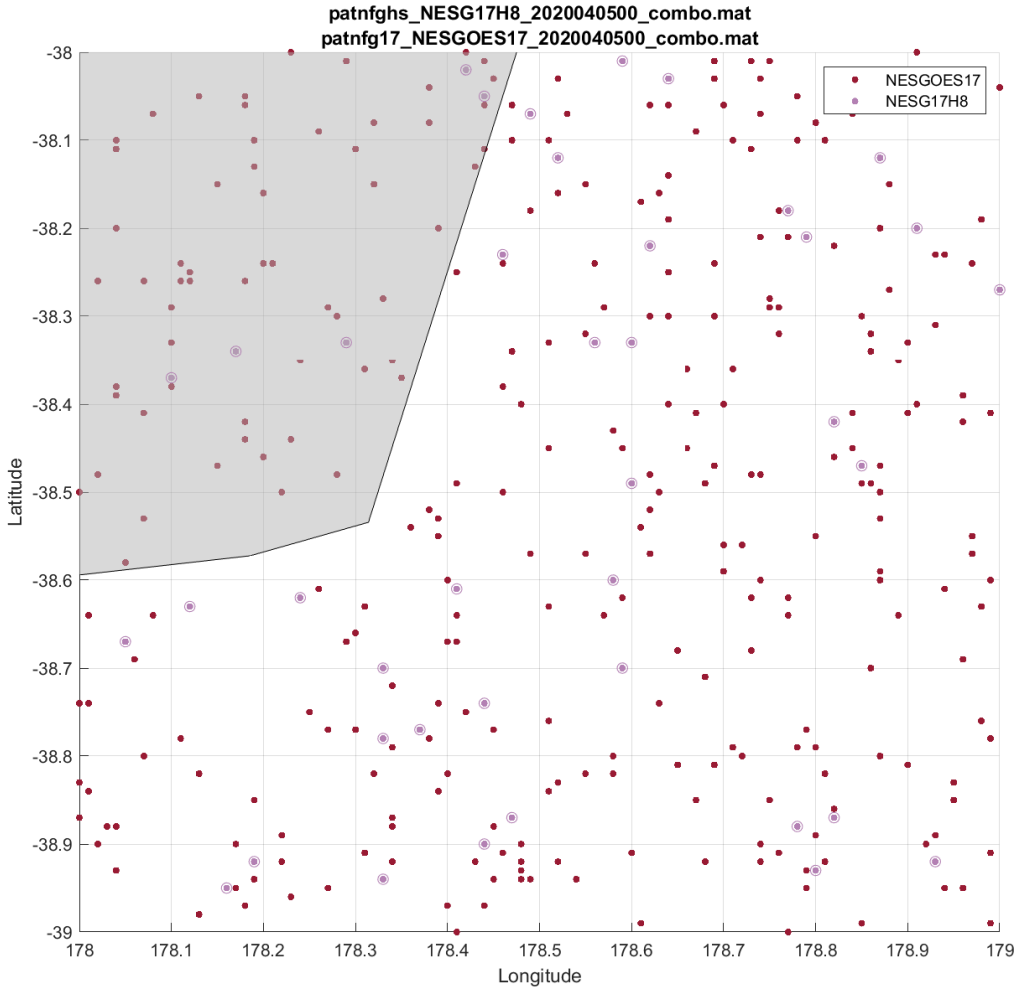
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patnfg17_NESGOES17_2020040500_combo.mat
NESGOES17
NESG17H8
Latitude
Longitude
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-38.3
-38.4
-38.5
-38.6
-38.7
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178.7
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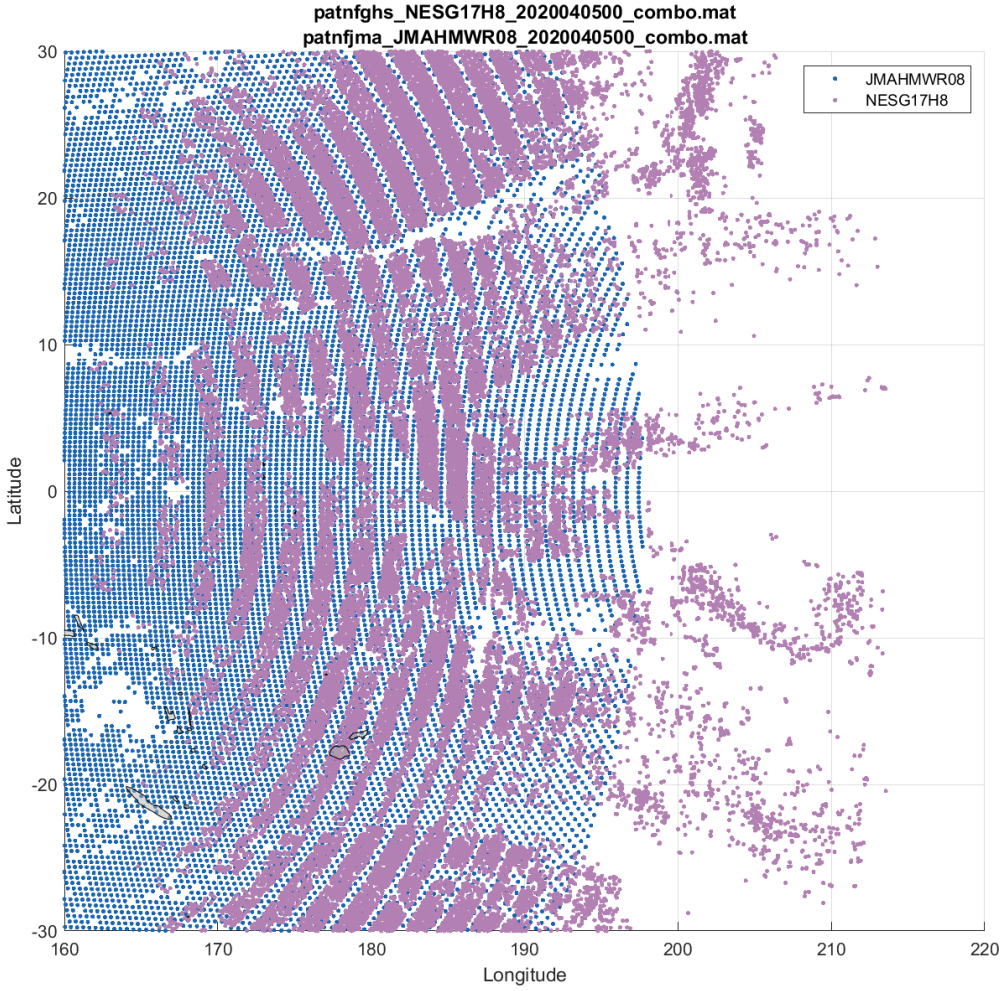
179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patnfjma_JMAHMWR08_2020040500_combo.mat
JMAHMWR08
NESG17H8
Latitude
Longitude
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10
0
-10
-20
-30
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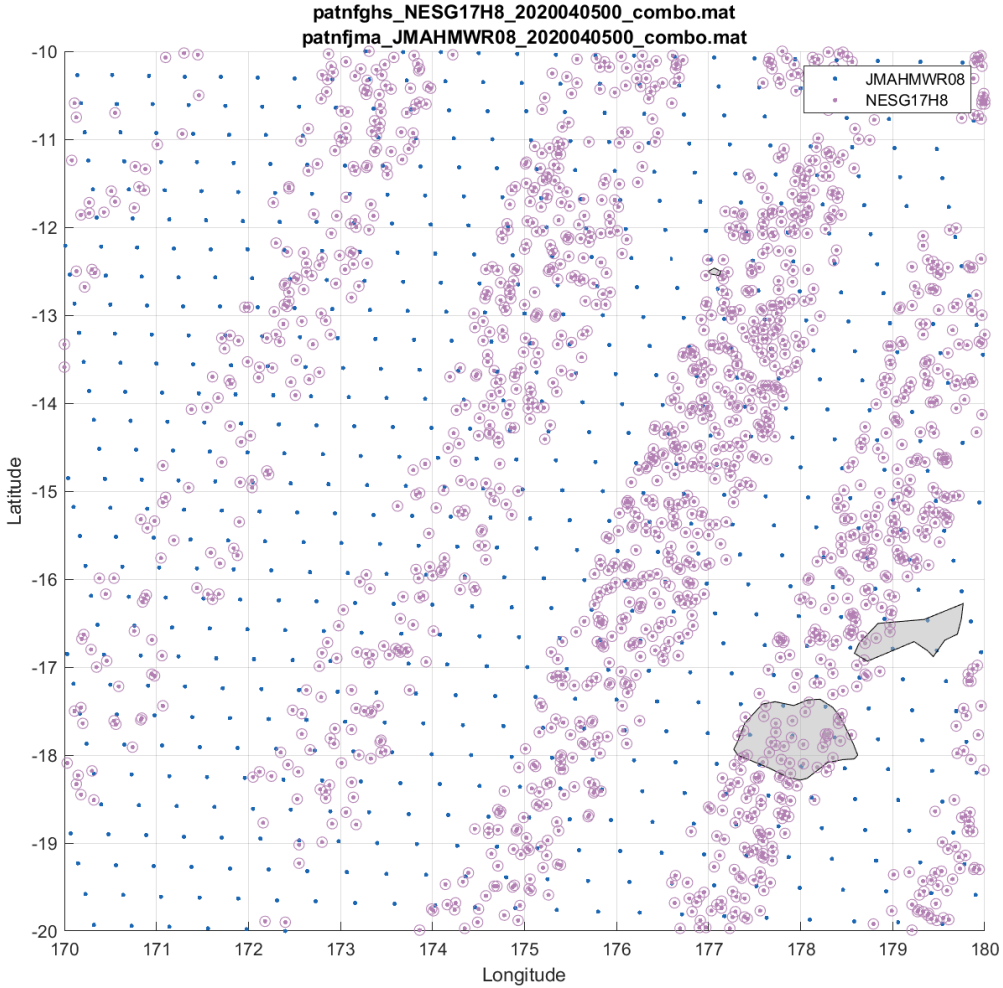
170
180
190
200
210
220


patnfghs_NESG17H8_2020040500_combo.mat
patnfjma_JMAHMWR08_2020040500_combo.mat
JMAHMWR08
NESG17H8
Latitude
Longitude
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
170
171
172
173
174
175
176
177
178
179
180

Why JMAHMWR08 needed different collocation criteria
Example DTG 2020040500

There are:

- 57188 NESG17H8 obs
- 393653 JMAHMWR08 obs

For a NESG17H8 ob located at

0.2200 185.5900

there are 8 JMAHMWR08 obs at a separation of .02 degrees, but these are not identified as “collocated” using the criteria

0.2400 185.5900
0.2400 185.5900
0.2400 185.5900
0.2400 185.5900
0.2400 185.5900
0.2400 185.5900
0.2400 185.5900
0.2400 185.5900

Over the JMA disc, at precision of a hundredth of a degree, there are ~ 101,710,000 possible locations.

393,693 obs are reported

53,258 locations are used

0.05 % of possible locations used

Average of 7.4 obs per location

46,205 are used again at 2020040600 (86.7 %)

Over the GOES17 disc, at precision of a hundredth of a degree, there are ~ 162,100,000 possible locations.

1,643,158 obs are reported

1,571,161 locations are used

1 % of possible locations used

Average of 1 ob per location

47,864 are used again at 2020040600 (3.05 %)

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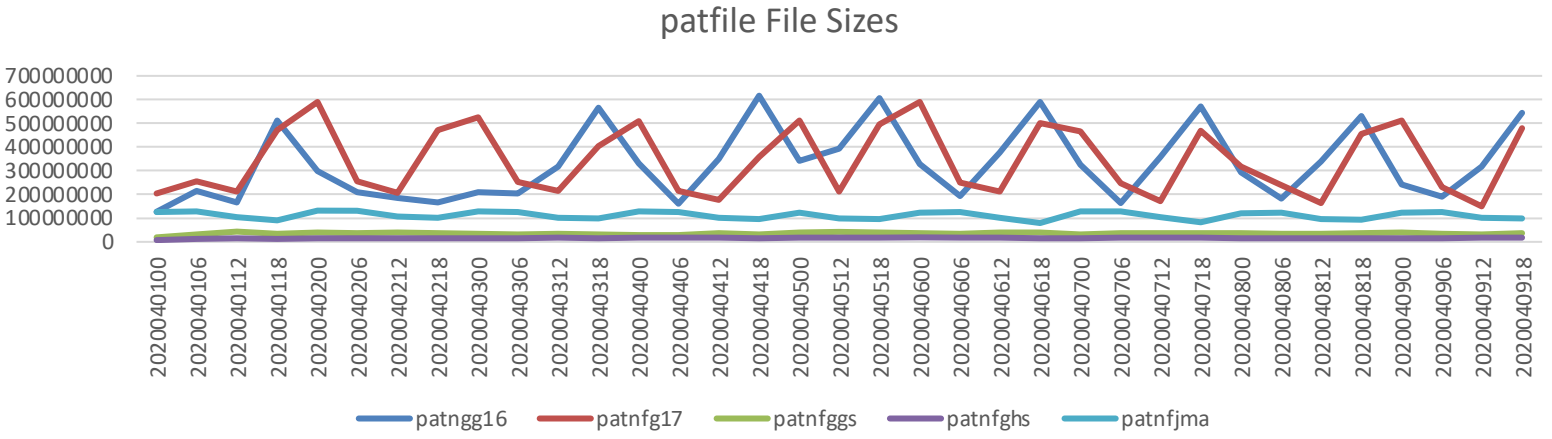
Why JMAHMWR08 needed different collocation criteria

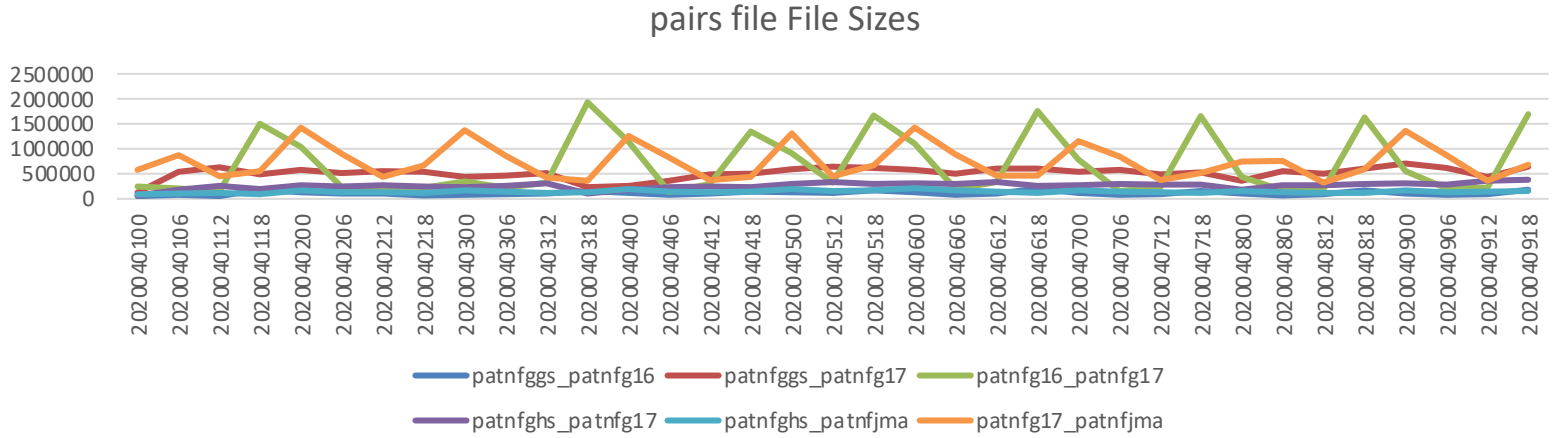
- JMAHMWR08 AMV locations are on some kind of regular grid.
- NESDIS AMV locations are determined by a cloud-finding algorithm.

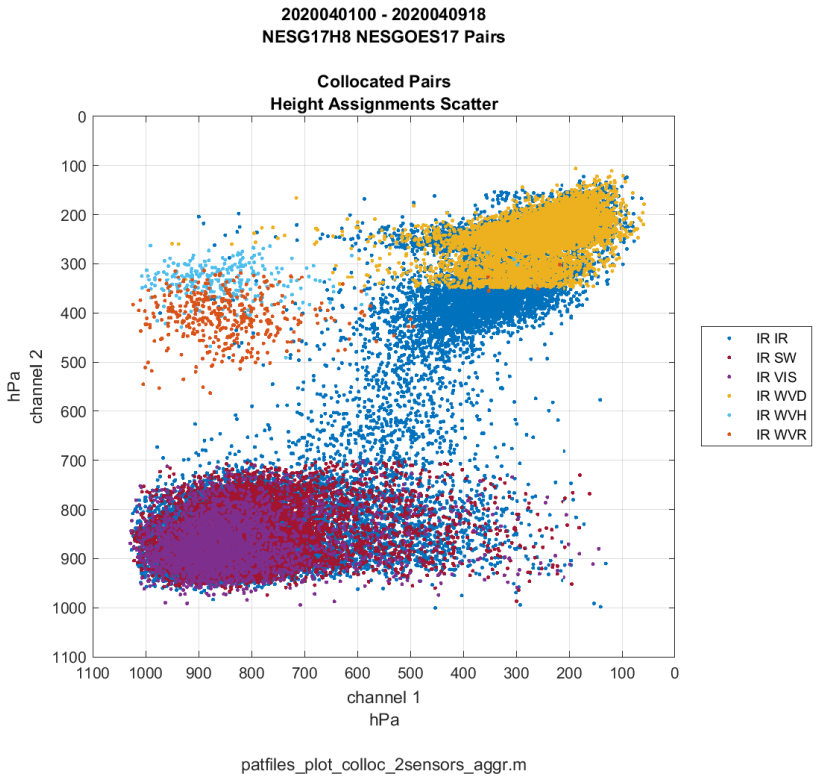
- The collocation criteria of ~1.1 km is the smallest distance resolvable by the precision of the data files; latitude and longitude are reported only to the second decimal place.
- For a given sensor 1 AMV at location ownlat, ownlon, I compute distance (in degrees) to all the AMVs from sensor 2
  - RR = sqrt(sensor_2_ob_lat - ownlat).^2 + (sensor_2_ob_lon - ownlon).^2);
  - Then require RR < .01-.0001 degrees, or 1.1008 km
- Pairs that meet this criteria are at the SAME reported latitude and longitude, to the precision of the data.

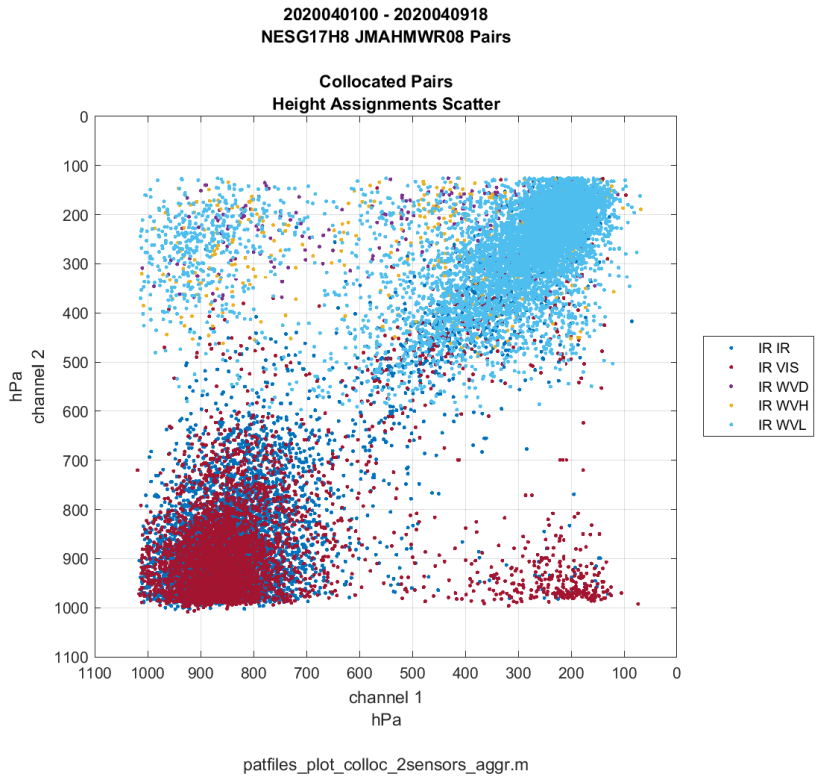
- For the 35 DTGs examined, the JMAHMWR08 files did not have any AMVs at the SAME reported latitude and longitude as AMVs in either the NESG17H8 stereo AMVs or the NESGOES17 operational AMVs.

Size of pair files after changing collocation criteria



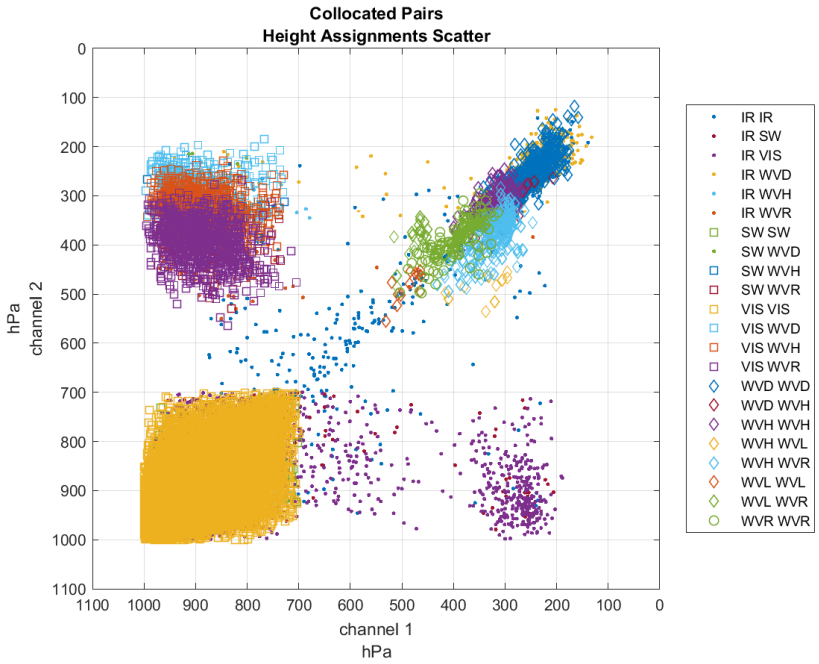






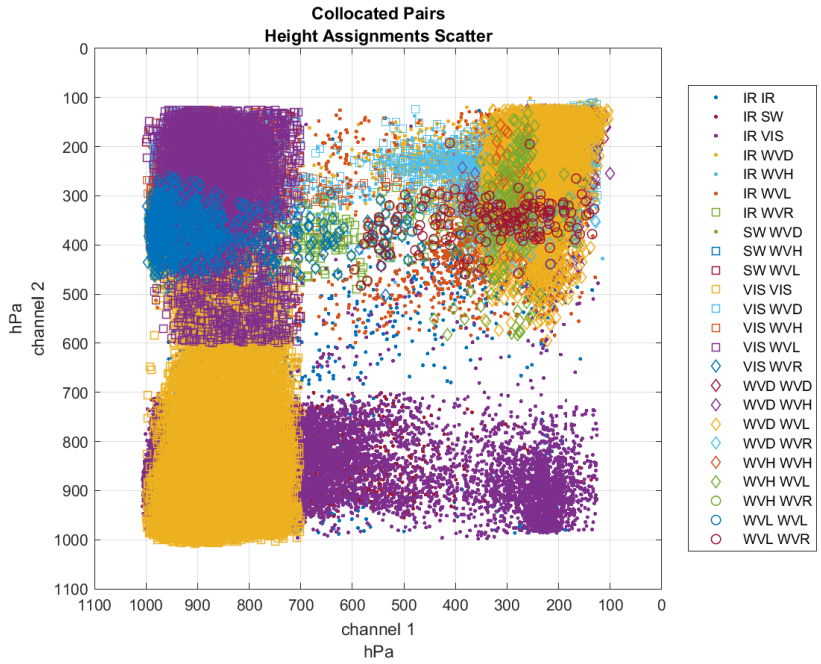
For JMAHMWR08, WVD, WVH, and WVL are all cloud-top winds from different channels. No clear-sky winds.

2020040100 - 2020040918
NESGOES16 NESGOES17 Pairs

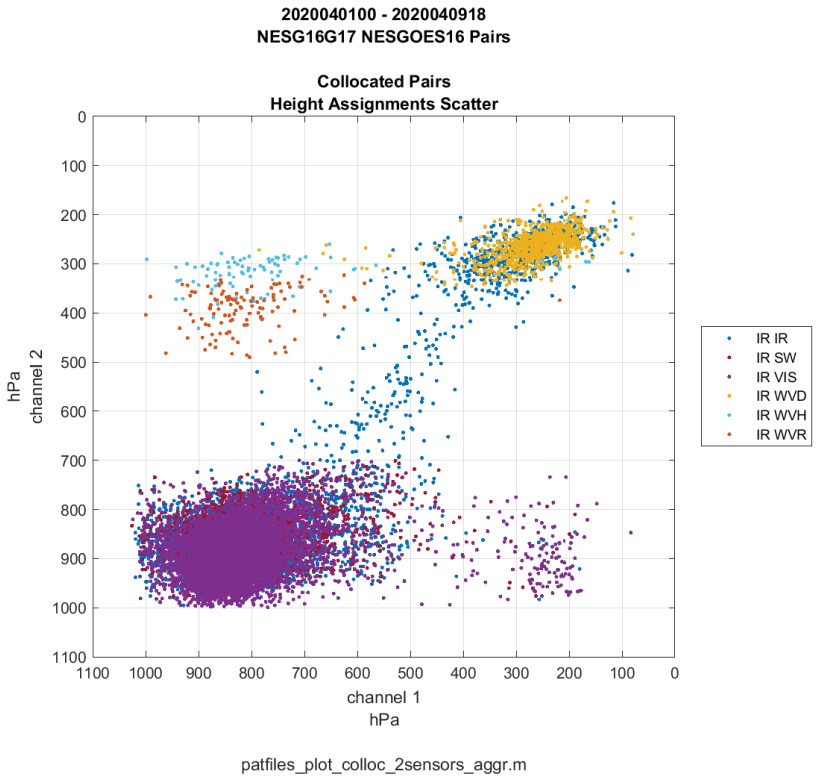


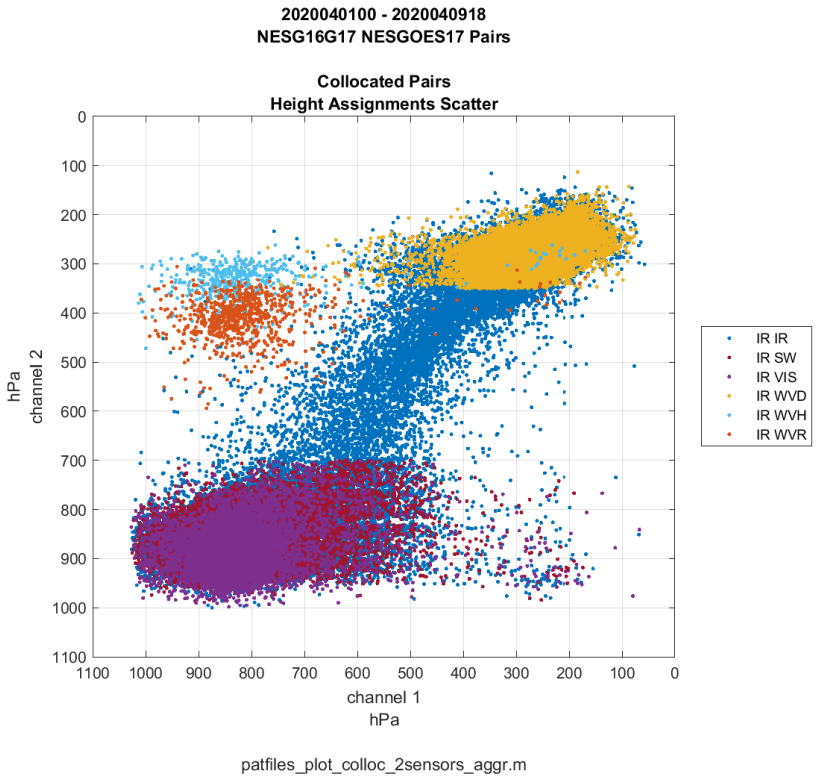
patfiles_plot_colloc_2sensors_aggr.m

2020040100 - 2020040918
NESGOES17 JMAHMWR08 Pairs



patfiles_plot_colloc_2sensors_aggr.m


2020040100 - 2020040918
NESG16G17 NESGOES16 Pairs
Collocated Pairs
Height Assignments Scatter
hPa
channel 2
channel 1
hPa
IR IR
IR SW
IR VIS
IR WVD
IR WVH
IR WVR
patfiles_plot_colloc_2sensors_aggr.m


2020040100 - 2020040918
NESG16G17 NESGOES17 Pairs
Collocated Pairs
Height Assignments Scatter
hPa
channel 2
channel 1
hPa
IR IR
IR SW
IR VIS
IR WVD
IR WVH
IR WVR
patfiles_plot_colloc_2sensors_aggr.m

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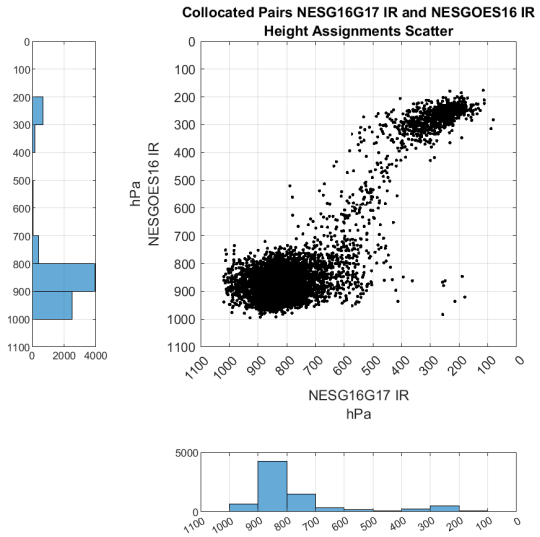
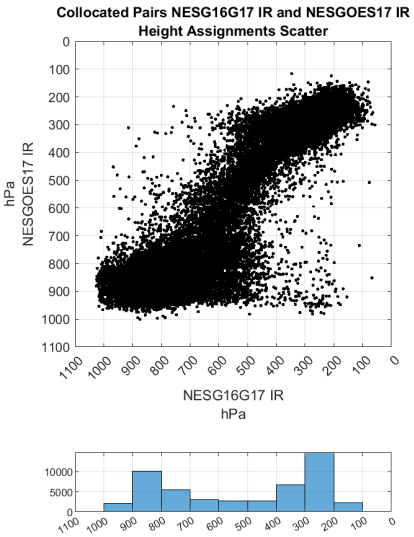
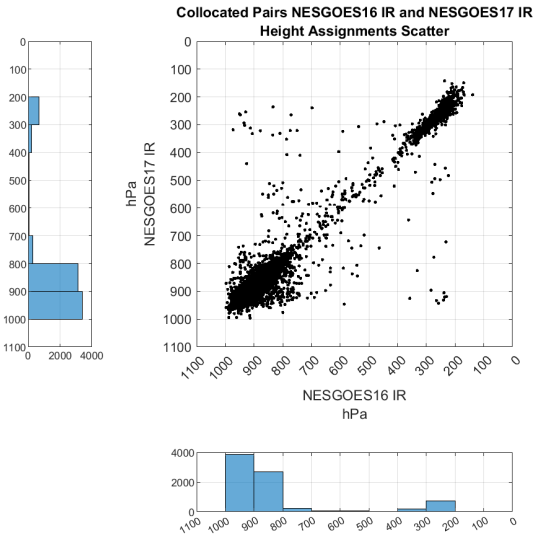
Quantities and Locations of IR/IR Pairs

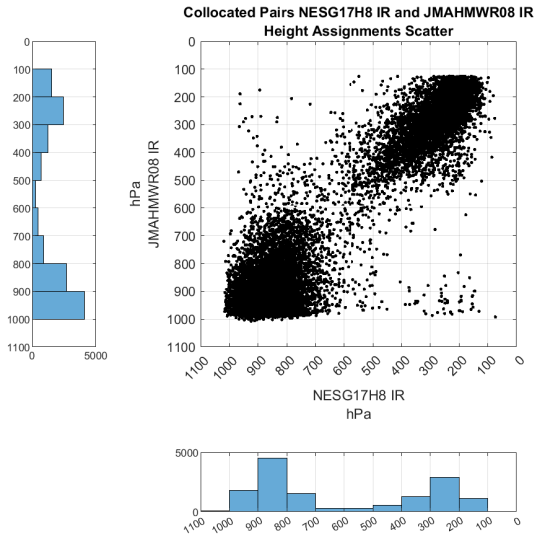


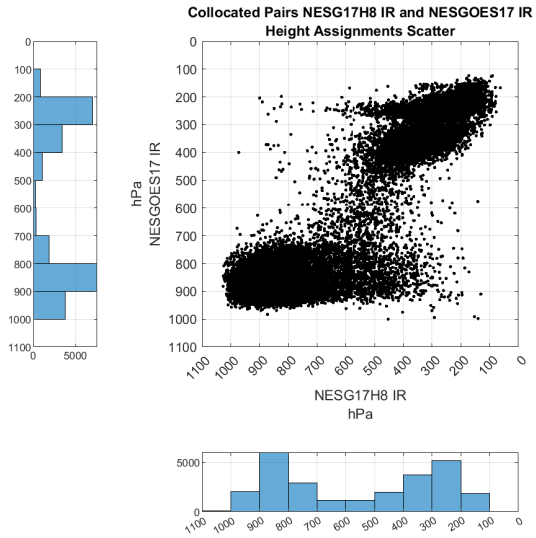


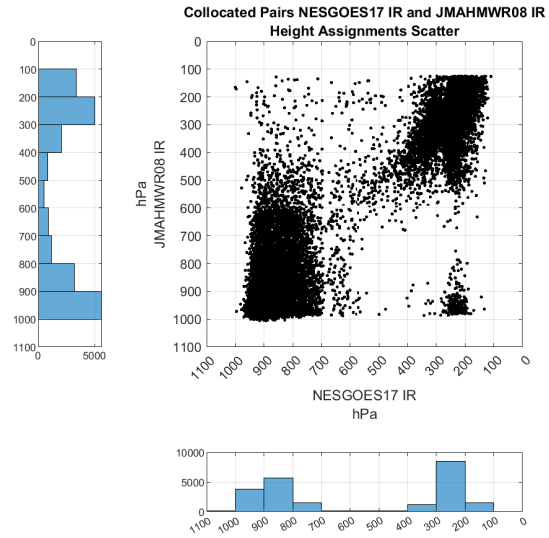


U.S. NAVAL RESEARCH LABORATORY

Quantities and Locations of IR/IR Pairs







Backup and Supplemental Slides

Height to Pressure Calculation Details

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Converting Geometric Height to Pressure Level

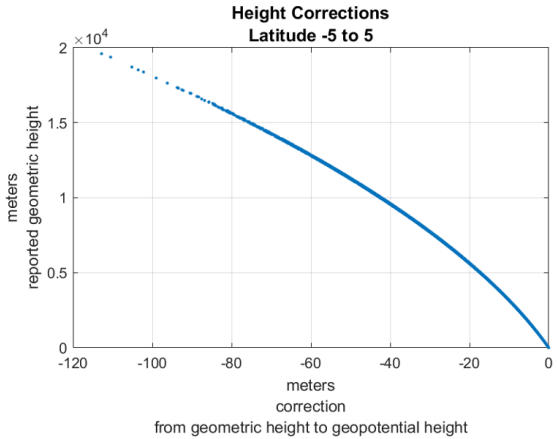
alat_rad = rlat_ob(n) * deg_rad

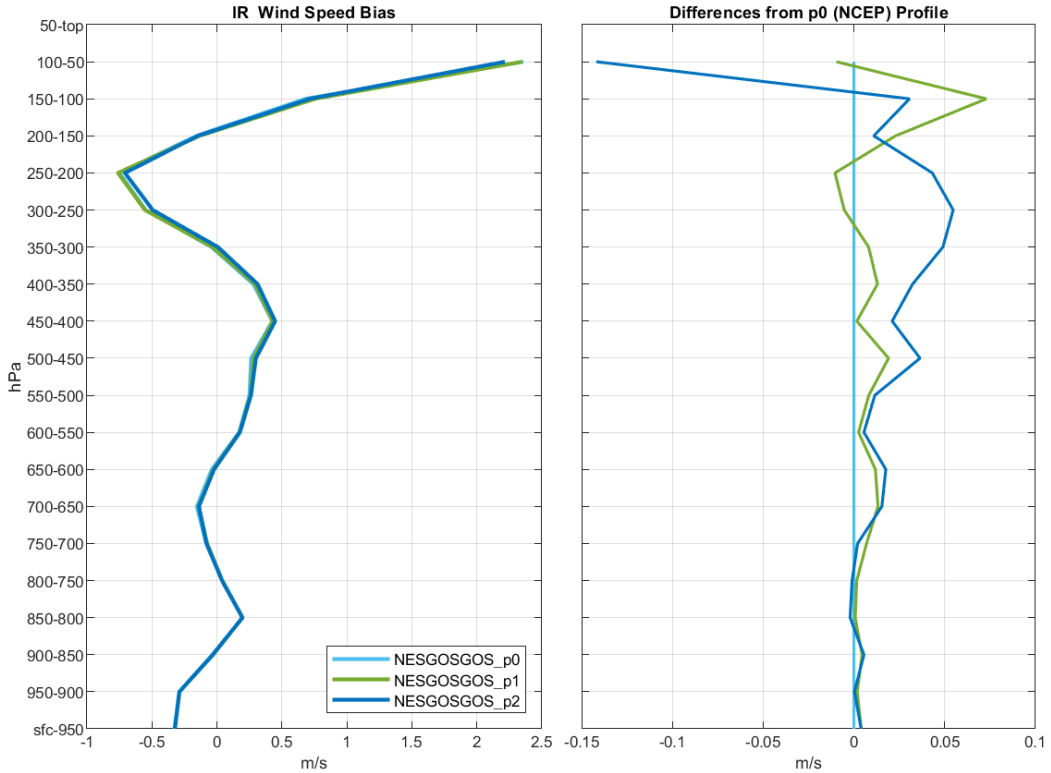
sinsq = sin(alat_rad)**2

earth_radius = 6378137. / (1.006803 - 0.006706*sinsq)

$$\text{gravity} = 9.780325 * \frac{(1+0.00193185*\text{sinsq})}{\text{sqrt}(1.0-0.00669435*\text{sinsq})}$$

$$z\_ob(2,n) = \frac{(\text{gravity}/\text{grav\_45}) * (\text{earth\_radius}*z\_ob(1,n))}{(\text{earth\_radius}+z\_ob(1,n))}$$





U.S. NAVAL RESEARCH LABORATORY

Converting Geometric Height to Pressure Level

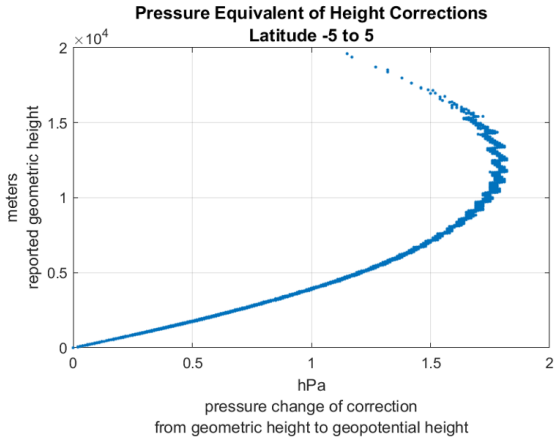
alat_rad = rlat_ob(n) * deg_rad

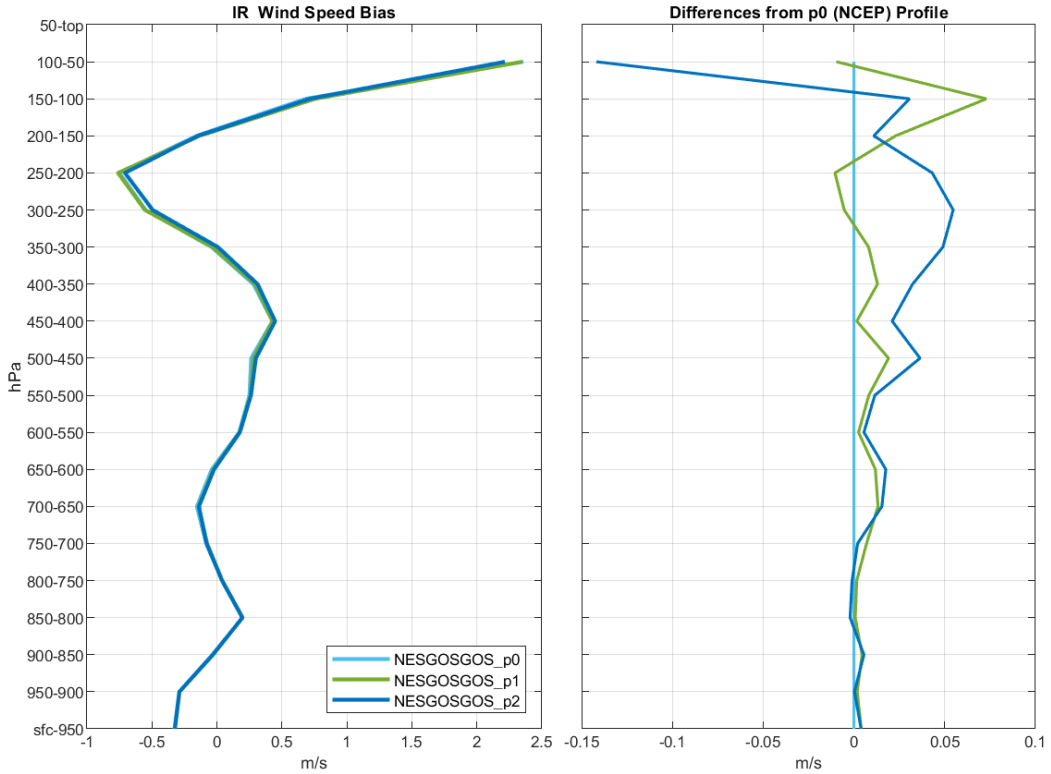
sinsq = sin(alat_rad)**2

earth_radius = 6378137. / (1.006803 - 0.006706*sinsq)

$$\text{gravity} = 9.780325 * \frac{(1+0.00193185*\text{sinsq})}{\text{sqrt}(1.0-0.00669435*\text{sinsq})}$$

$$\text{z\_ob(2,n)} = \frac{(\text{gravity/grav\_45}) * (\text{earth\_radius}*\text{z\_ob(1,n)})}{(\text{earth\_radius}+\text{z\_ob(1,n)})}$$





Backup and Supplemental Slides

Collocated Pairs of Superobs

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For each AMV, identify:

- prism number
- ilvl
- itime
- quadrant

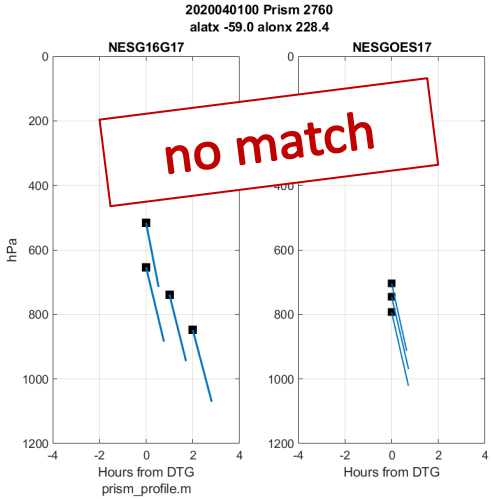
To form AMV collocated pairs:

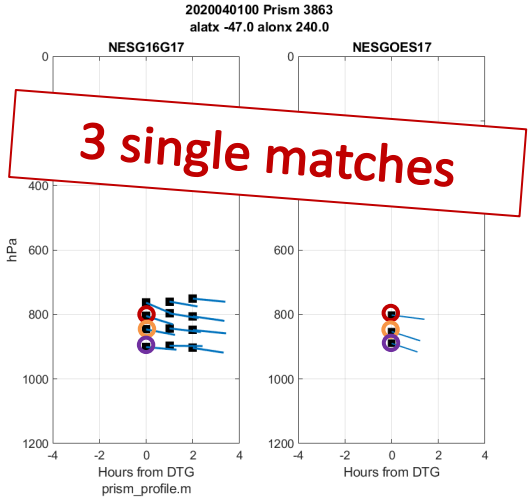
For each sensor_1 AMV, check for matching sensor_2 AMV

- prism number (2 degree box)
- ilvl (50 hPa layer)
- itime (1 hour interval)

If no matches, go to next sensor_1 AMV.
If a single match exists, save it.
If more than one match exists, require quadrant match; save if success; if no match, go to next sensor_1 AMV.

sensor_1	sensor_2
901.2129	889.8000
846.4357	853.2500
804.6996	802.0000





For each AMV, identify:

- prism number
- ilvl
- itime
- quadrant

To form AMV collocated pairs:

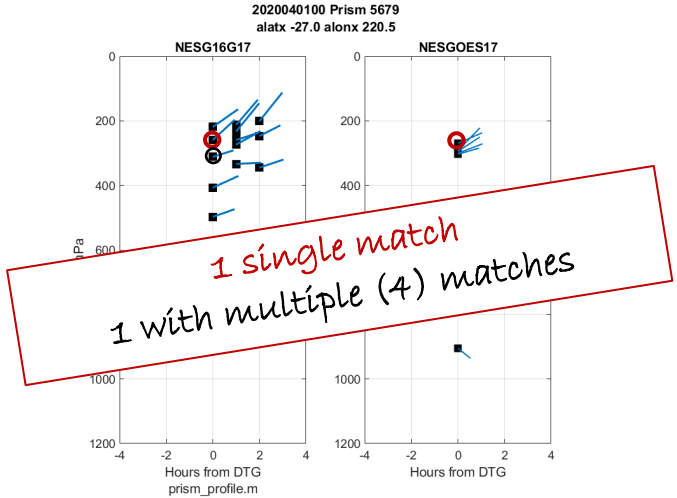
For each sensor_1 AMV, check for matching sensor_2 AMV

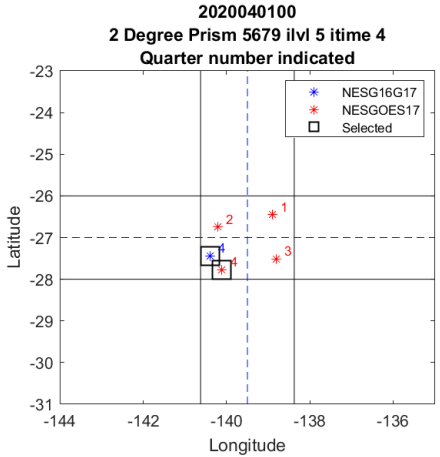
- prism number (2 degree box)
- ilvl (50 hPa layer)
- itime (1 hour interval)

If no matches, go to next sensor_1 AMV.

If a single match exists, save it.

If more than one match exists, require quadrant match; save if success; if no match, go to next sensor_1 AMV.





For each AMV, identify:

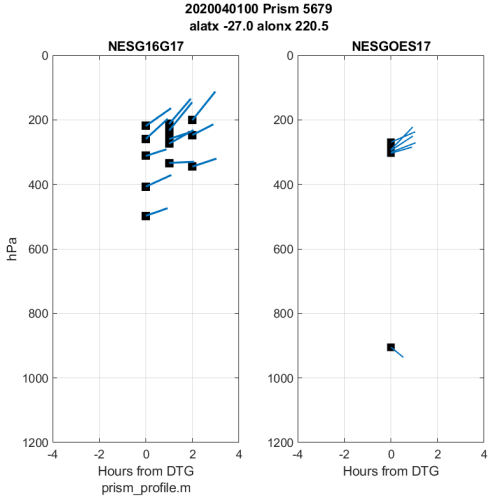
- prism number
- ilvl
- itime
- quadrant

To form AMV collocated pairs:

For each sensor_1 AMV, check for matching sensor_2 AMV

- prism number (2 degree box)
- ilvl (50 hPa layer)
- itime (1 hour interval)

If no matches, go to next sensor_1 AMV.
If a single match exists, save it.
If more than one match exists, require quadrant match; save if success; if no match, go to next sensor_1 AMV.

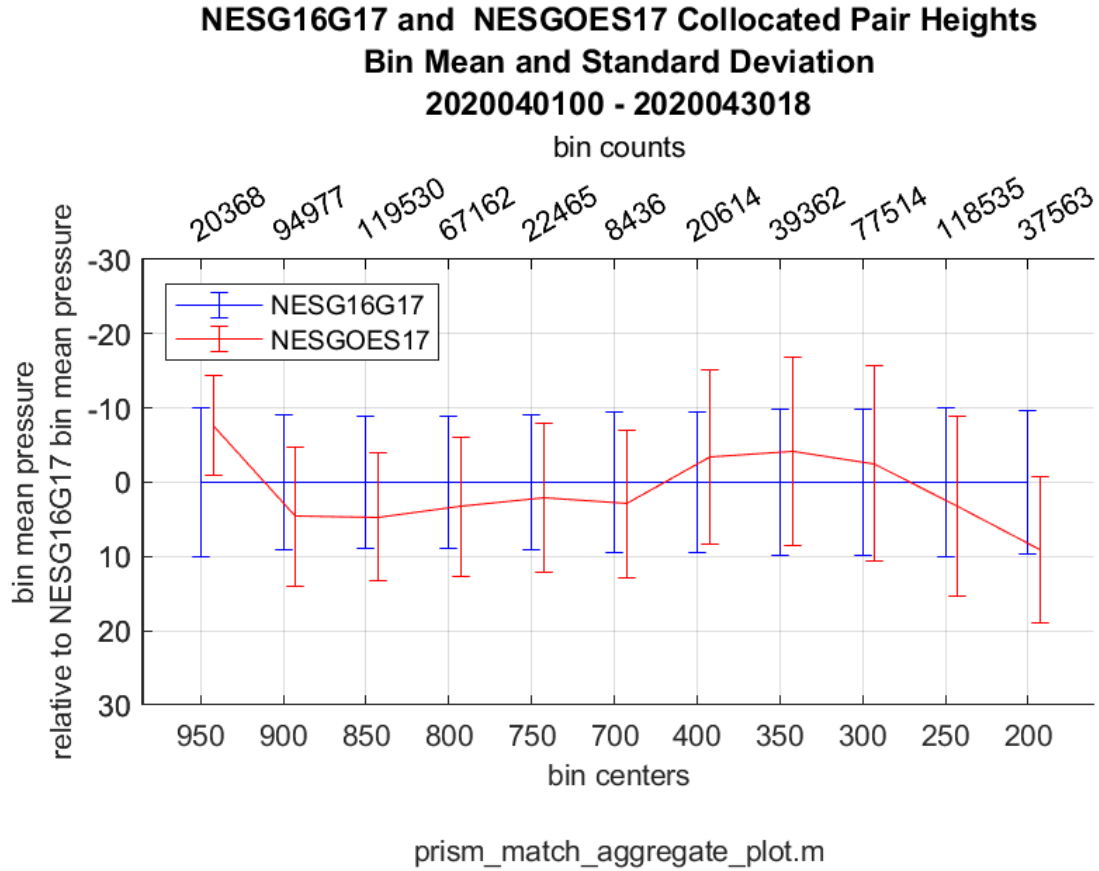


2020040100_table_prism_5679_ilvl_5_itime_4_gt2_1.txt

1124285	-27.44	-27	219.6	220.5	99	32	5679	311.82385	5	0	4	13.293	-2.048	-3.53	3.97	99	-20	NESG16G17IR	29S	naf file	0

2020040100_table_prism_5679_ilvl_5_itime_4_gt2_2.txt

1115322	-27.77	-27	219.89	220.5	99	32	5679	303.60001	5	0	4	13.685	-1.924	-3.14	4.91	99.6	-20	NESGOES17IR	59S	naf file	0
1121825	-27.51	-27	221.19	220.5	99	32	5679	292.375	5	0	4	14.067	-7.029	1.54	1.39	99	-20	NESGOES17IR	89S	naf file	0
1148584	-26.75	-27	219.78	220.5	99	32	5679	300.5	5	0	4	15.879	-2.945	-1.23	2.75	99	-20	NESGOES17IR	29S	naf file	0
1159988	-26.45	-27	221.1	220.5	99	32	5679	294.875	5	0	4	14.135	-4.47	-3.5	2.8	99.38	-20	NESGOES17IR	89S	naf file	0


NESG16G17 and NESGOES17 Collocated Pair Heights
Bin Mean and Standard Deviation
2020040100 - 2020043018
bin counts
20368
94977
119530
67162
22465
8436
20614
39362
77514
118535
37563
NESG16G17
NESGOES17
bin mean pressure
relative to NESG16G17 bin mean pressure
-30
-20
-10
0
10
20
30
950
900
850
800
750
700
400
350
300
250
200
bin centers
prism_match_aggregate_plot.m