Testing of GOES-18 Atmospheric Motion Vectors in NAVGEM

NAVGEM 2.1 T425L60 with 4DVAR with NESDIS GOES18 Test Data

- Comparison of GOES18 with GOES17 operational data
- Comparison of GOES18 baseline algorithm AMVs with GOES18 enterprise algorithm AMVs

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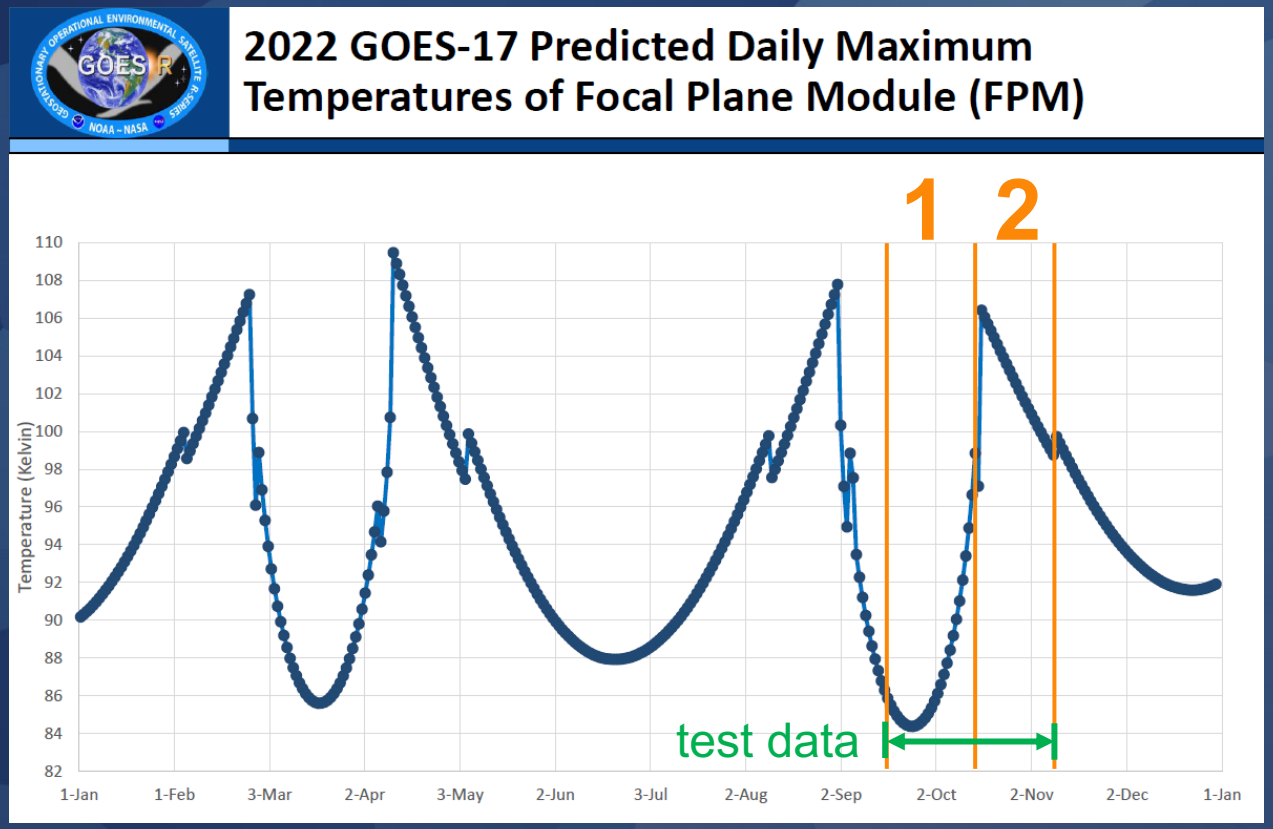
GOES18 Test Data

Comparisons with GOES16 and GOES17 Operational Algorithm



Comparison Period 1: 2022091600–2022101418 pre-warming
Comparison Period 2: 2022101500–2022110618 warming period mitigations
Both Periods Together: 2022091600–2022110618

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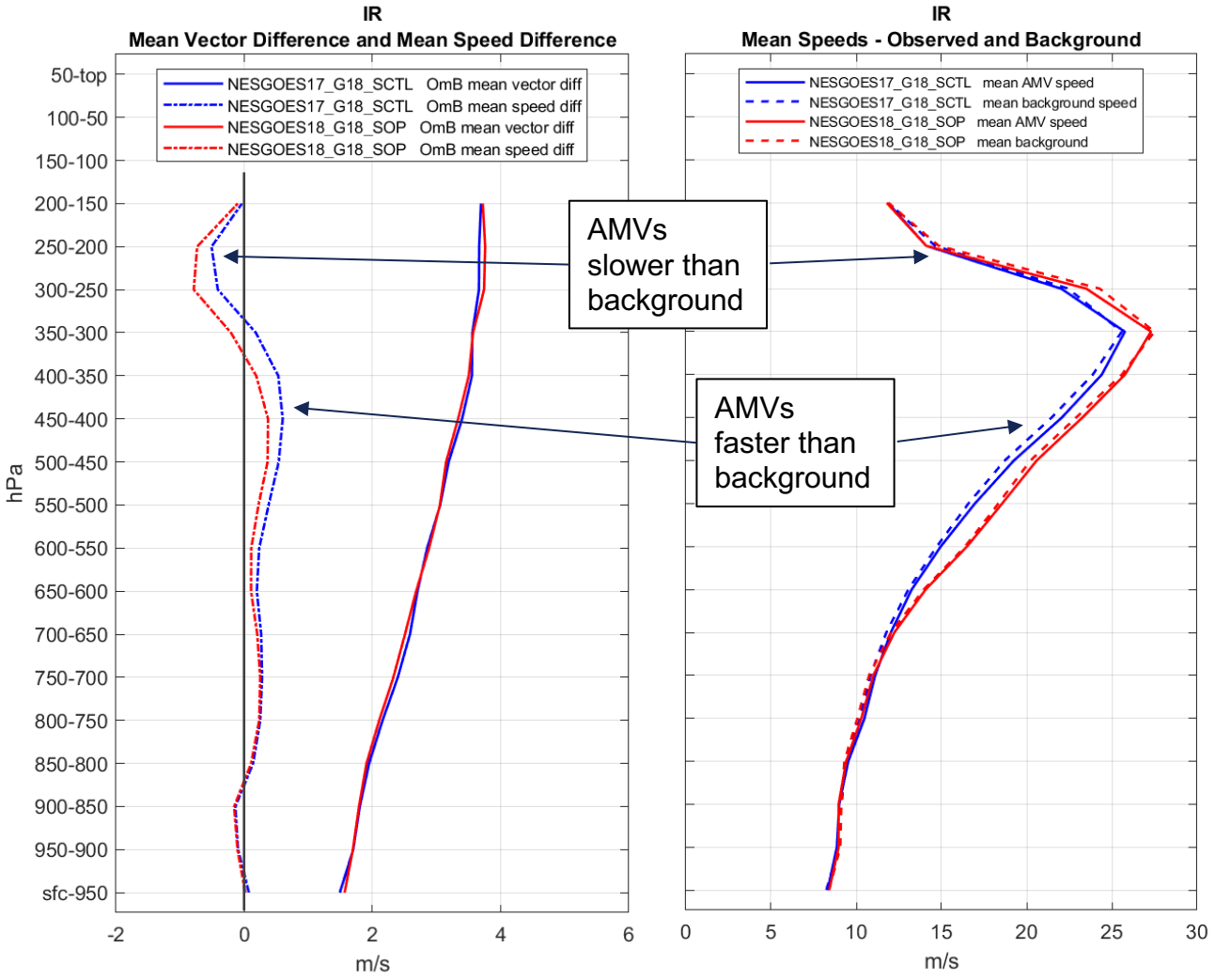
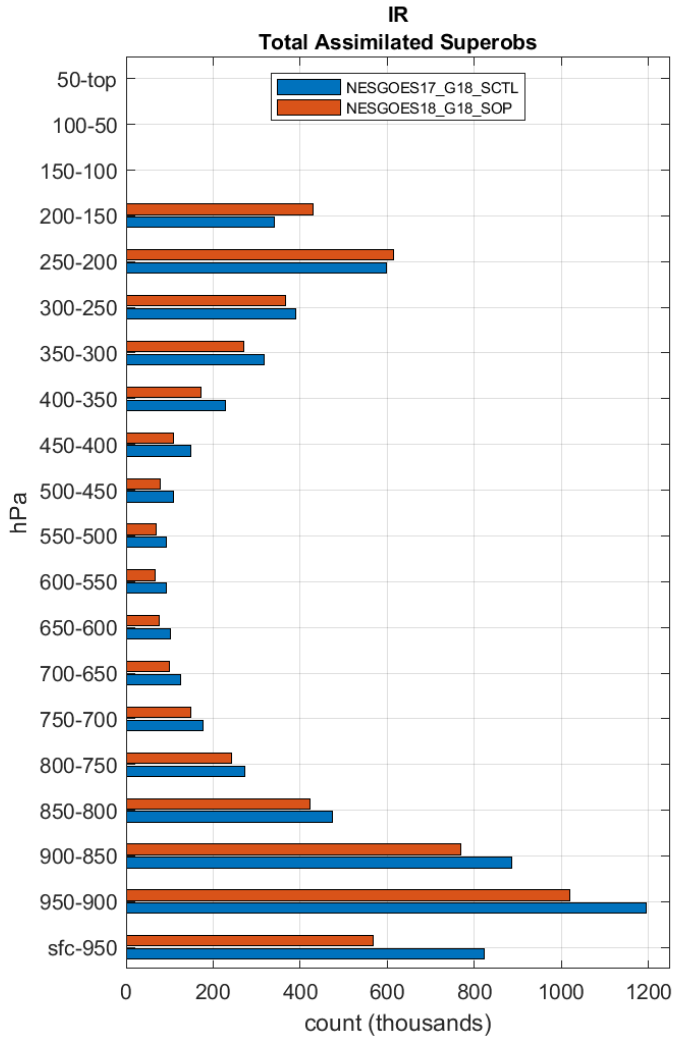
Control run label G18_SCTL
Test run label G18_SOP

Compare GOES17 and GOES18 Wind Speed for Period 1 + Period 2



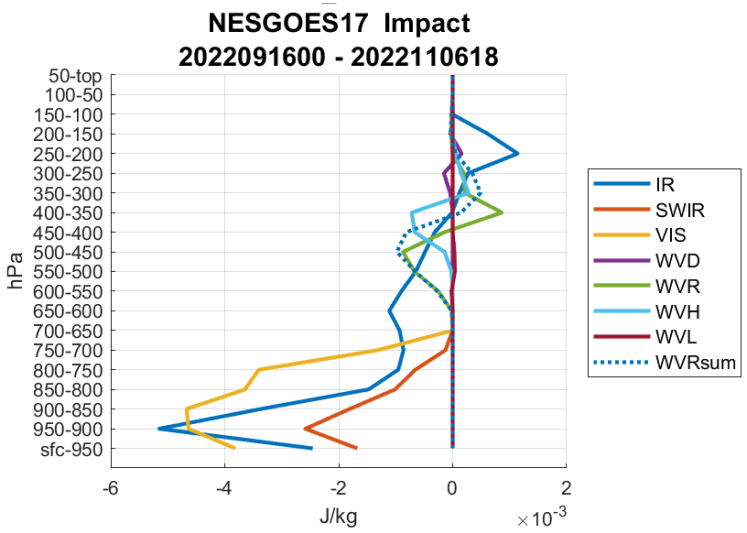


Center panel: GOES18 mean wind speed was very similar to GOES17, except these differences seen in mid-level IR (300-700 hPa).

Left panel: GOES18 mean OmB speed difference is more negative than GOES17 (smaller fast bias 350 hPa and below, larger slow bias above 350 hPa).

Background responds strongly to observations: max difference between GOES17 and GOES18 mean wind speed profile ~ 2 m/s, greater than max OmB bias of either sensor ~ < 1 m/s.

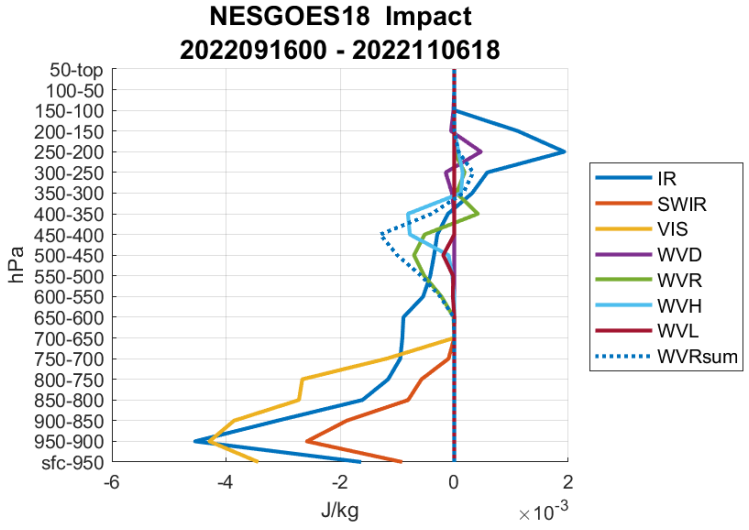
Compare GOES17 and GOES18 Impact Profiles for Period 1 + Period 2

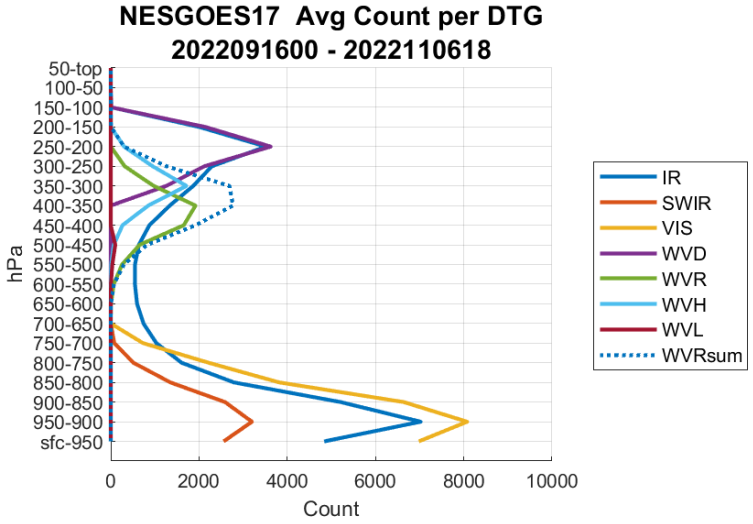


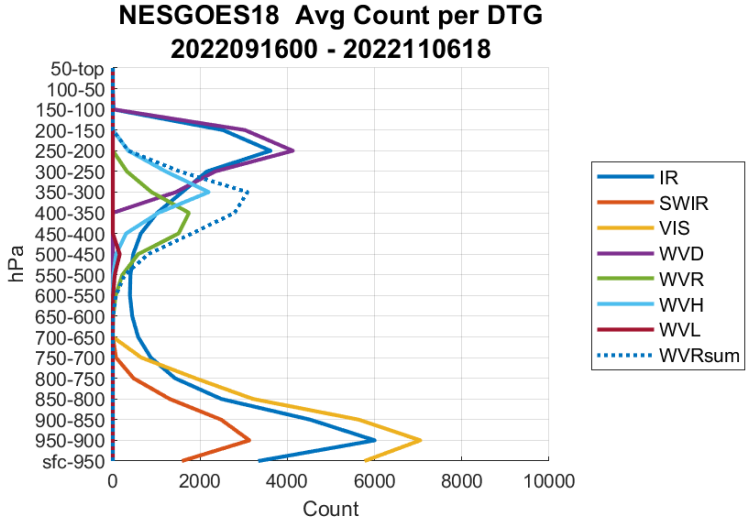
GOES18 impact profiles are similar to GOES17, except GOES18 IR aloft is more nonbeneficial.

GOES18 at lower levels has lower counts than GOES17 (IR, SWIR, and VIS).

WVD = cloud top water vapor ch 8
WVH = clear air water vapor ch 8
WVR = clear air water vapor ch 9
WVL = clear air water vapor ch 10
WVRsum = WVH + WVR + WVL

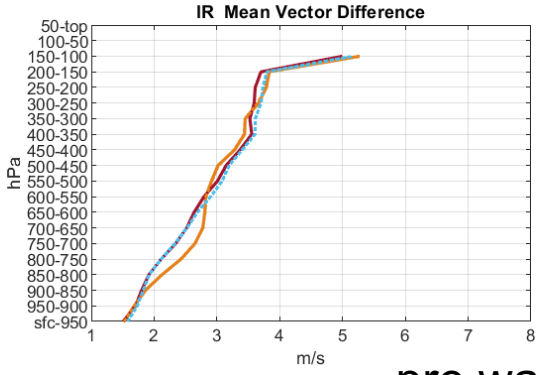


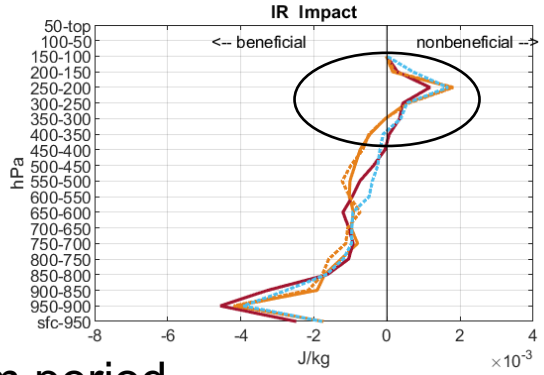




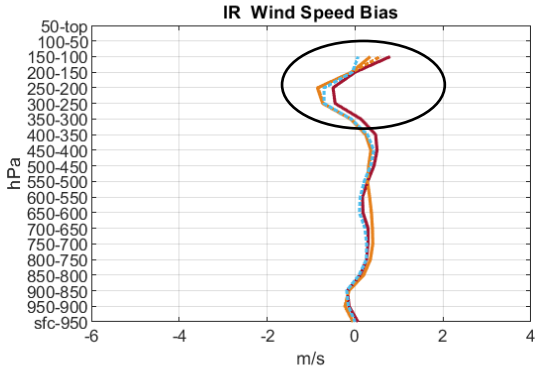
IR Statistics
Compare Periods 1 and 2

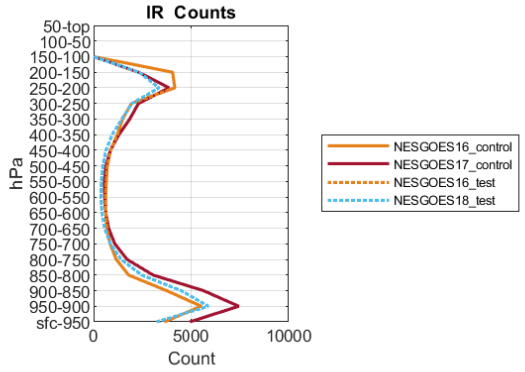
2022091600 - 2022101418



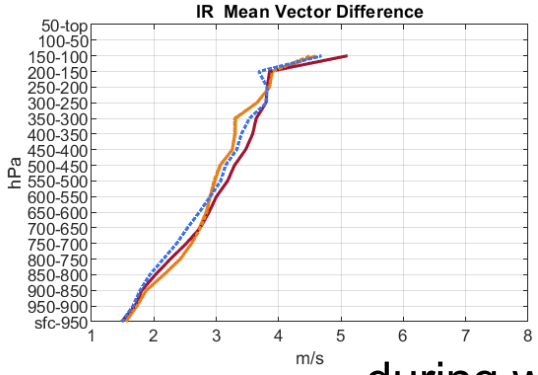


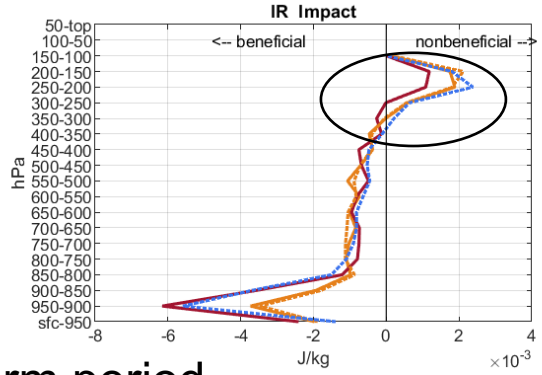
pre warm period



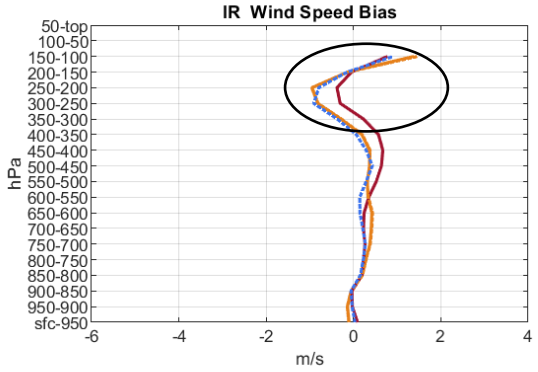


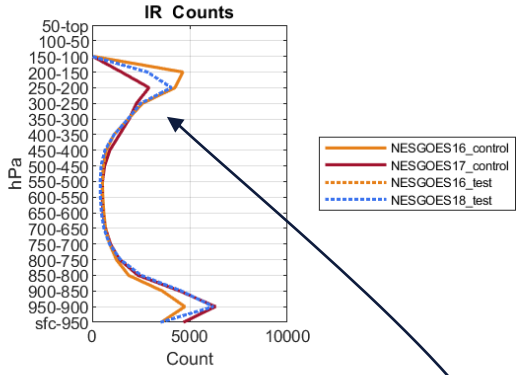
2022101500 - 2022110618





during warm period

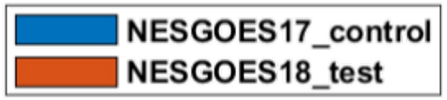


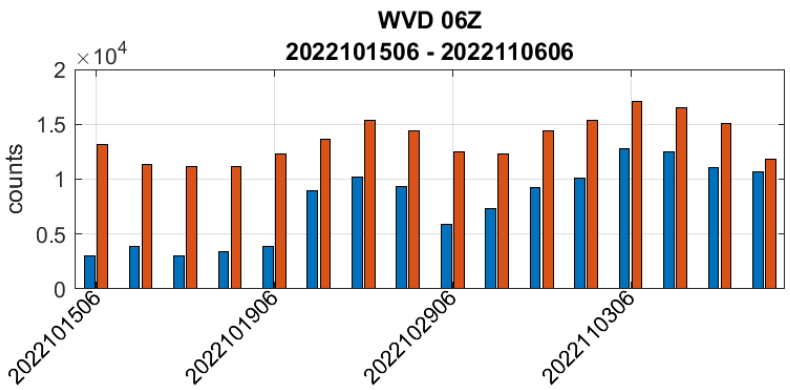


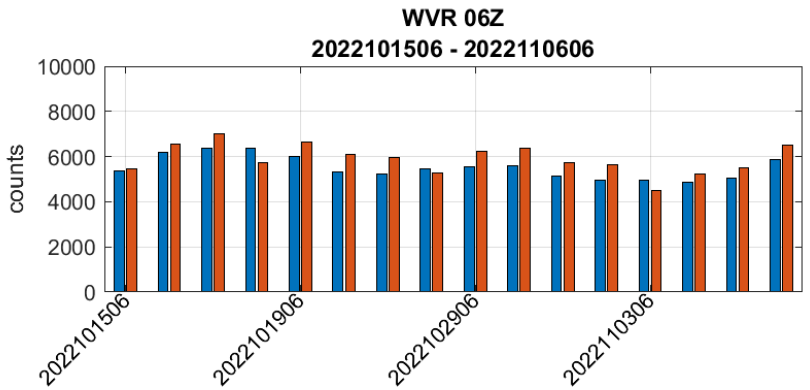
- Overall GOES18 has very similar statistics to GOES16 and GOES17.
- Upper level IR:
  - Wind Speed Bias for GOES18 (blue) more similar to GOES16 (orange) than GOES17 (red) both periods
  - Counts for GOES18 higher than for GOES17 during warm period mitigation
  - Nonbeneficial FSOI still present

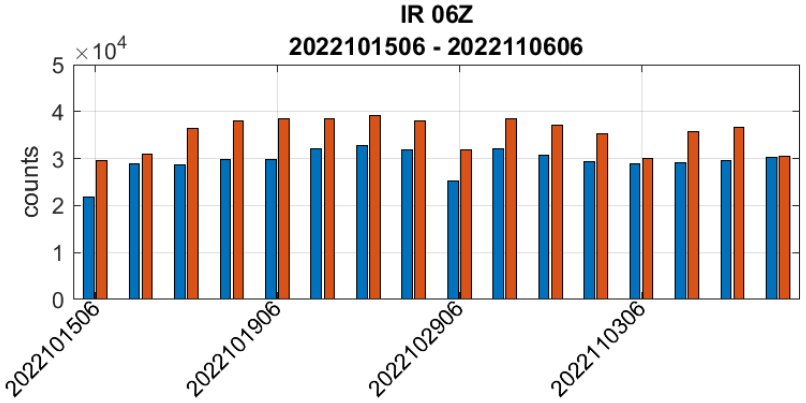
How are counts affected by time of day? Period 2 (warm period)

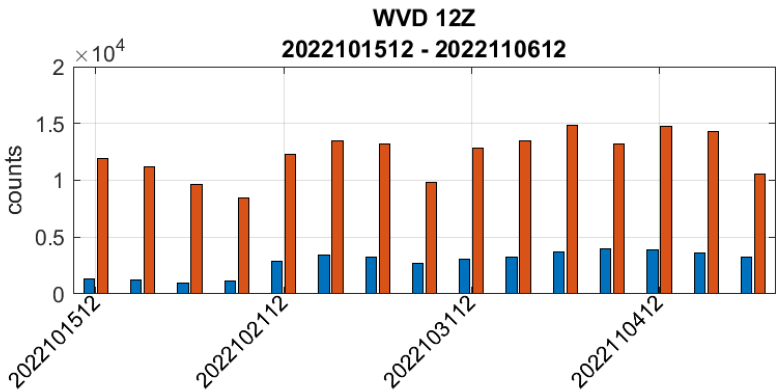
- WVD (and WVH): GOES18 counts are higher than GOES17 generally, but especially in the 12Z window.
- WVR: GOES18 counts are much larger than GOES17 in the 12Z window.
- IR: GOES18 counts do not decrease in the 06Z and 12Z windows (as seen for GOES17).

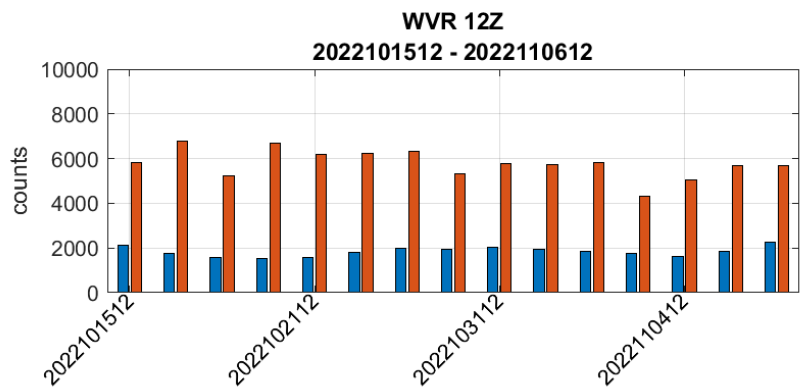


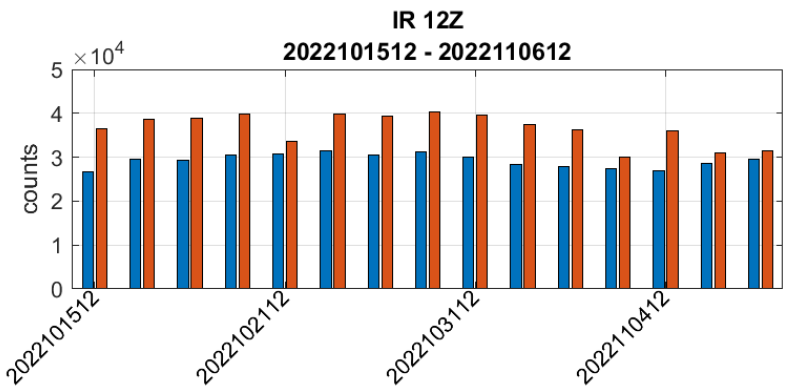




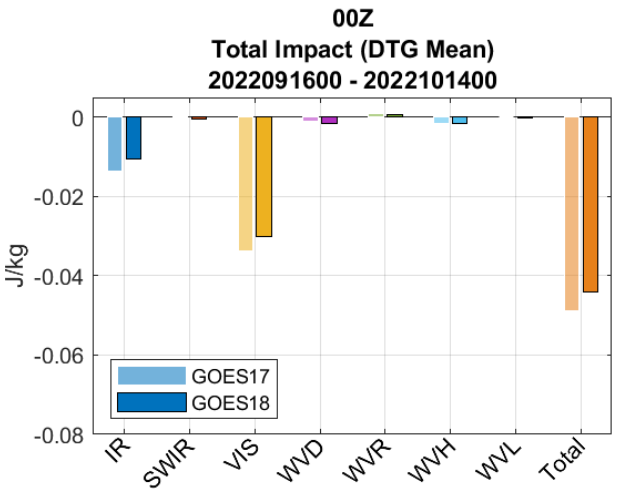




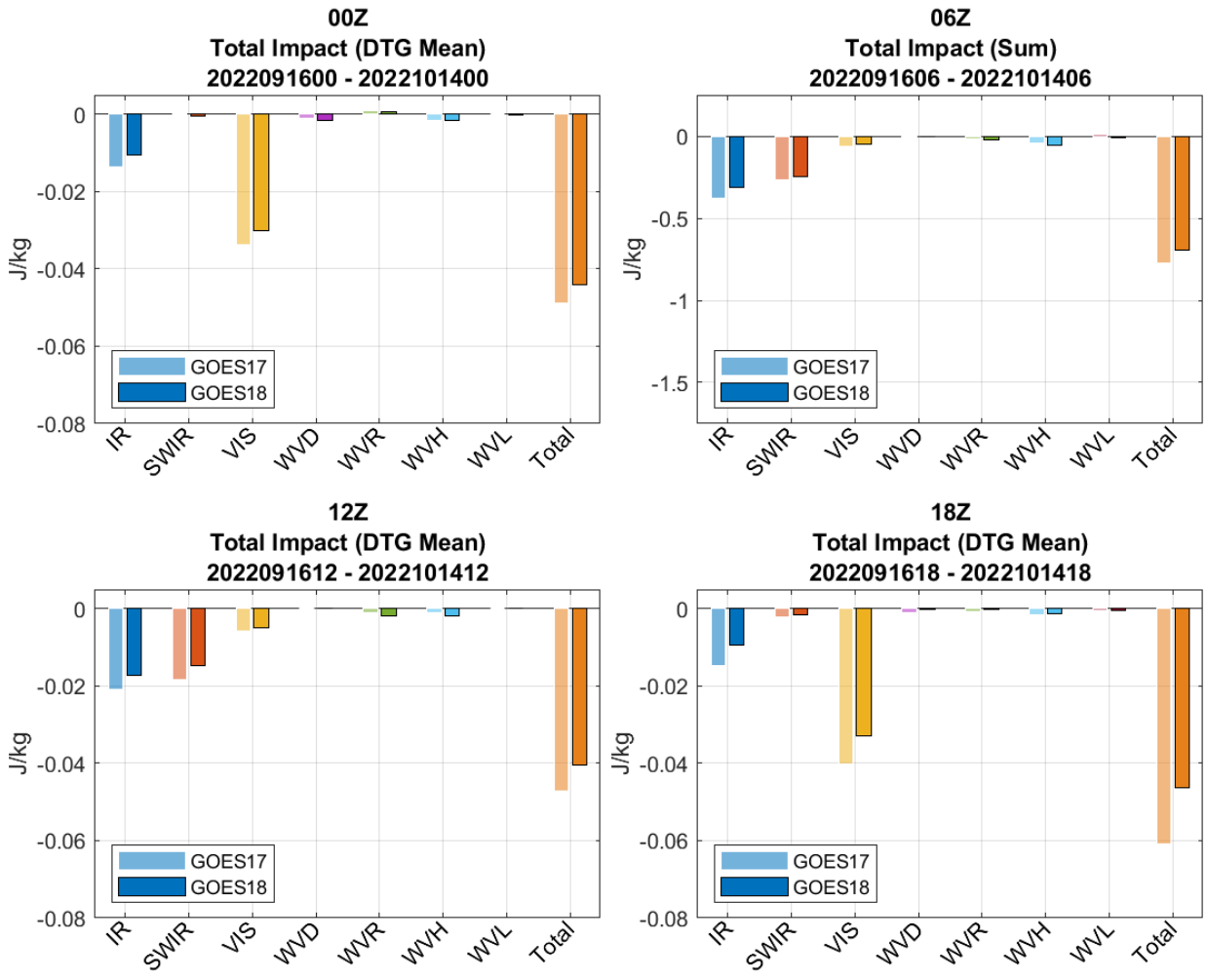




GOES18 beneficial FSOI less than GOES17



GOES18 beneficial FSOI less than GOES17



All analysis times in Period 1

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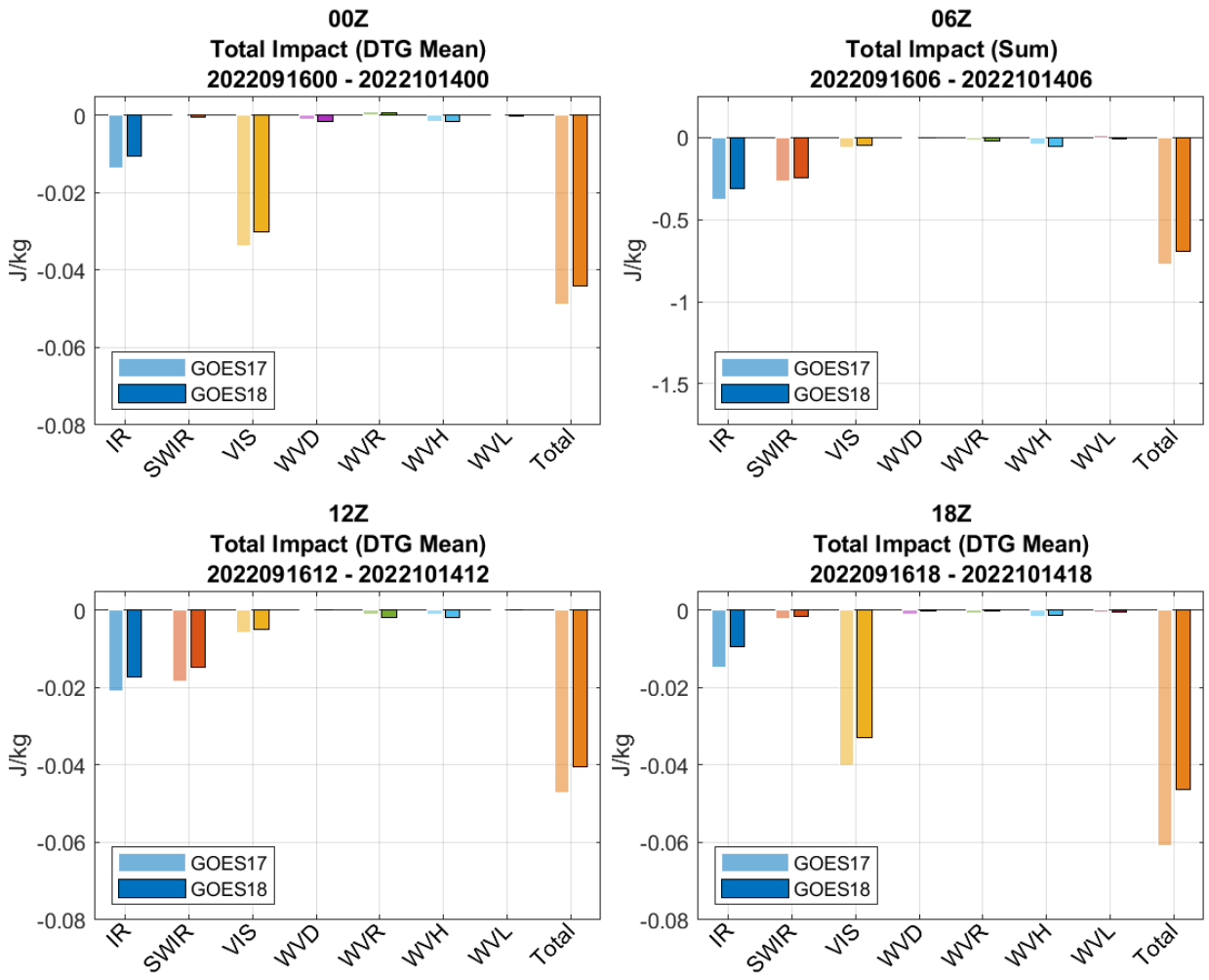
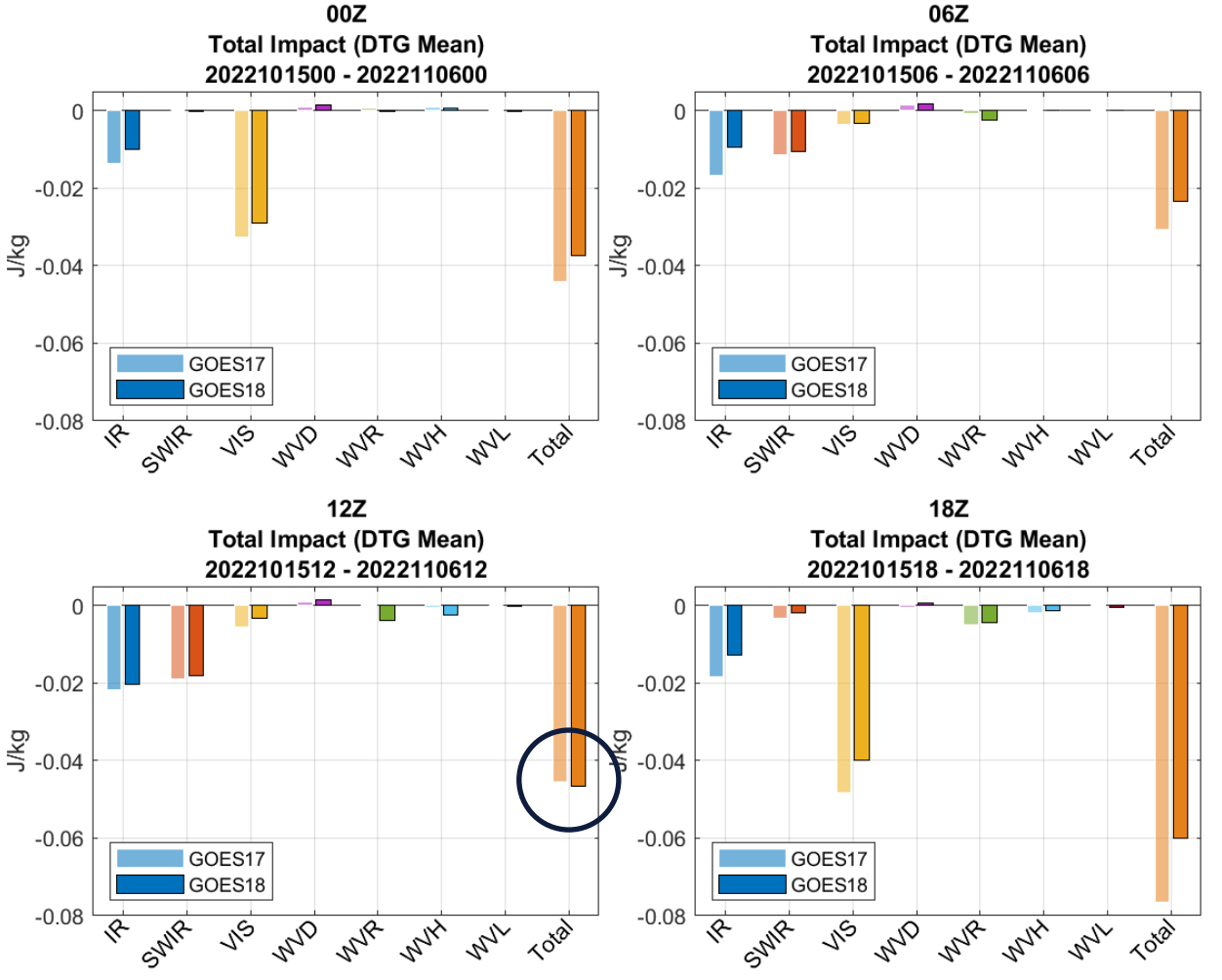
GOES18 beneficial FSOI less than GOES17



All analysis times in Period 1



All analysis times except 12Z in Period 2 (warm period)

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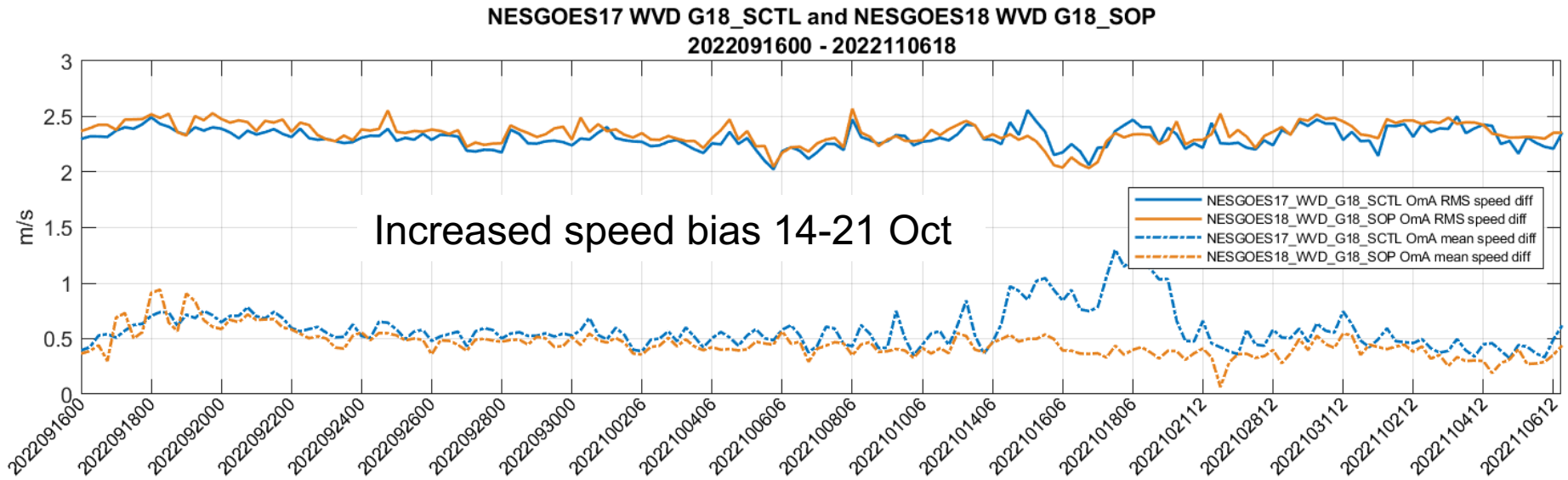
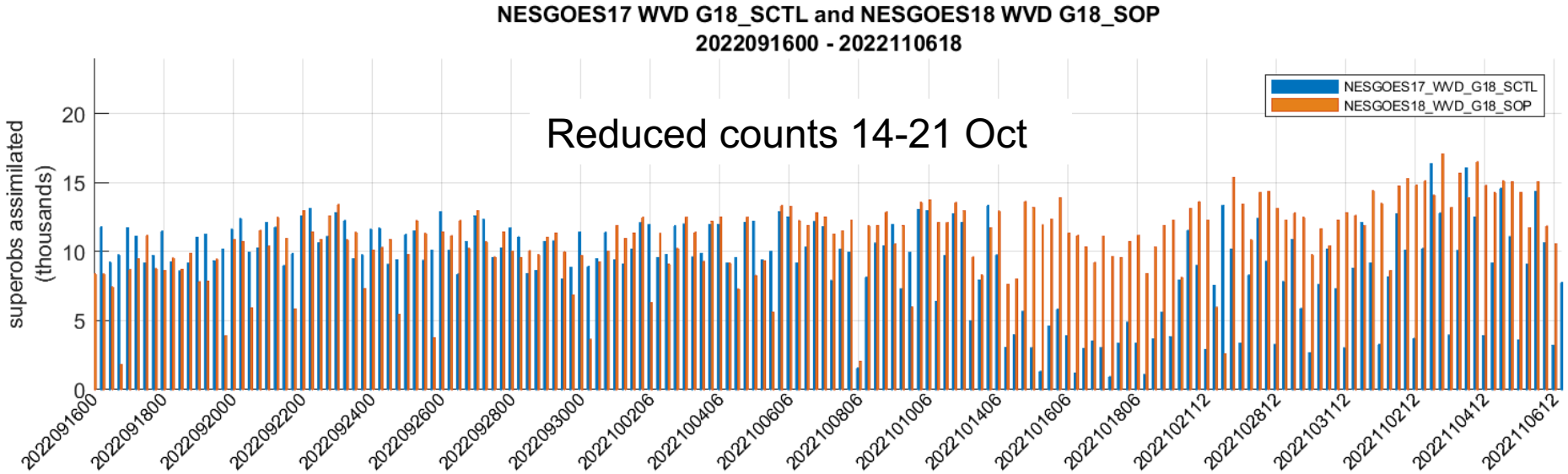
Differences Across Period 1 and Period 2 GOES17 Water Vapor Channels





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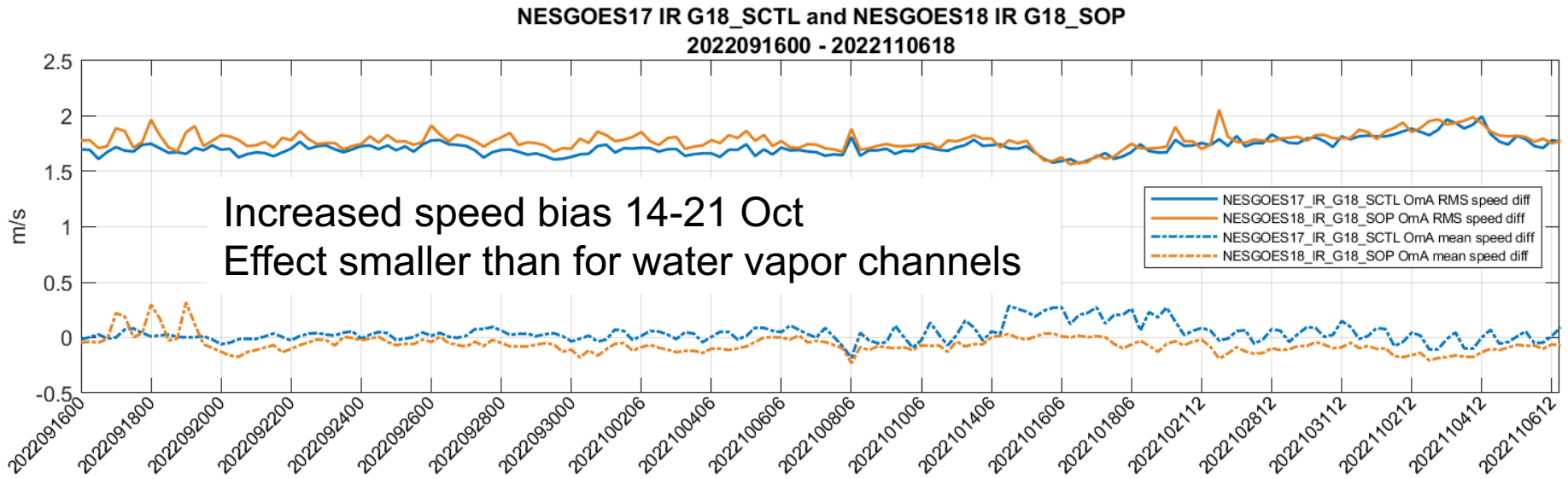
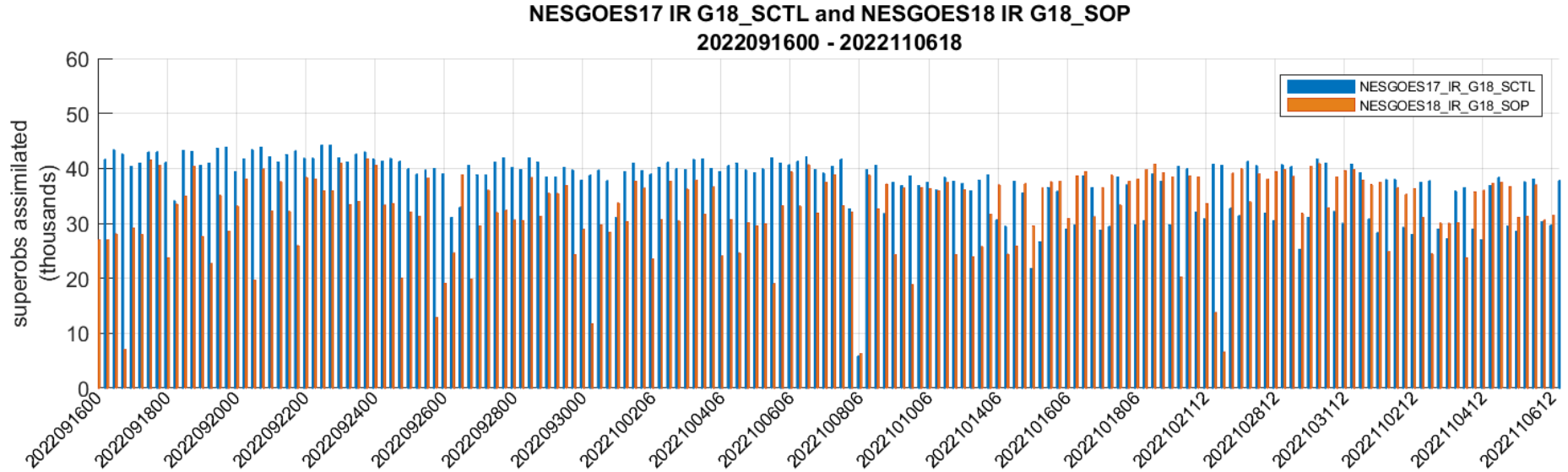
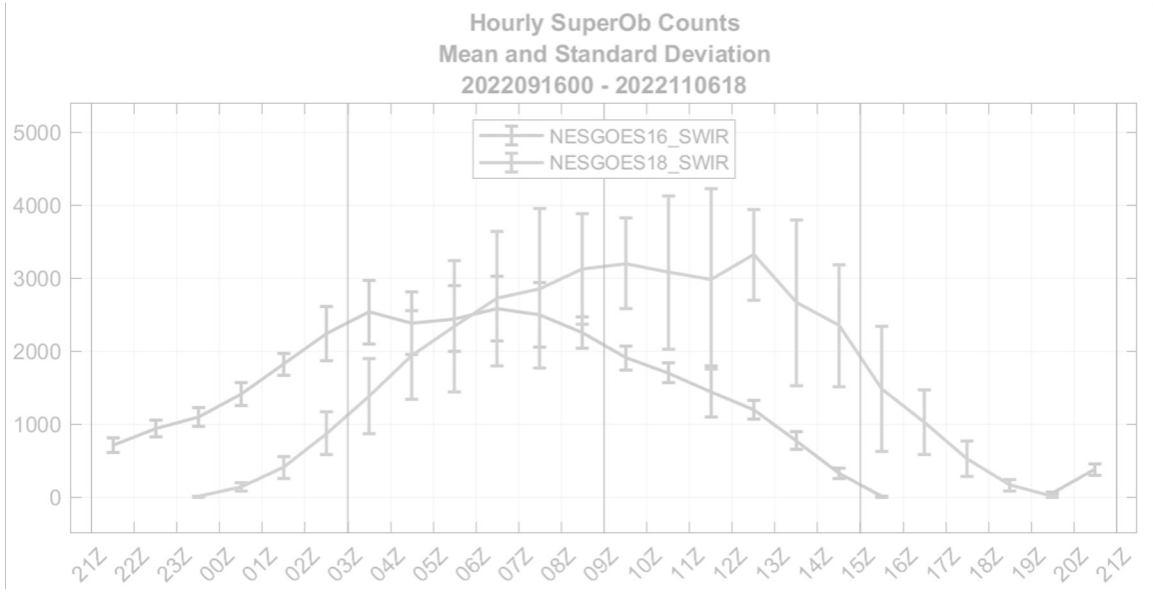
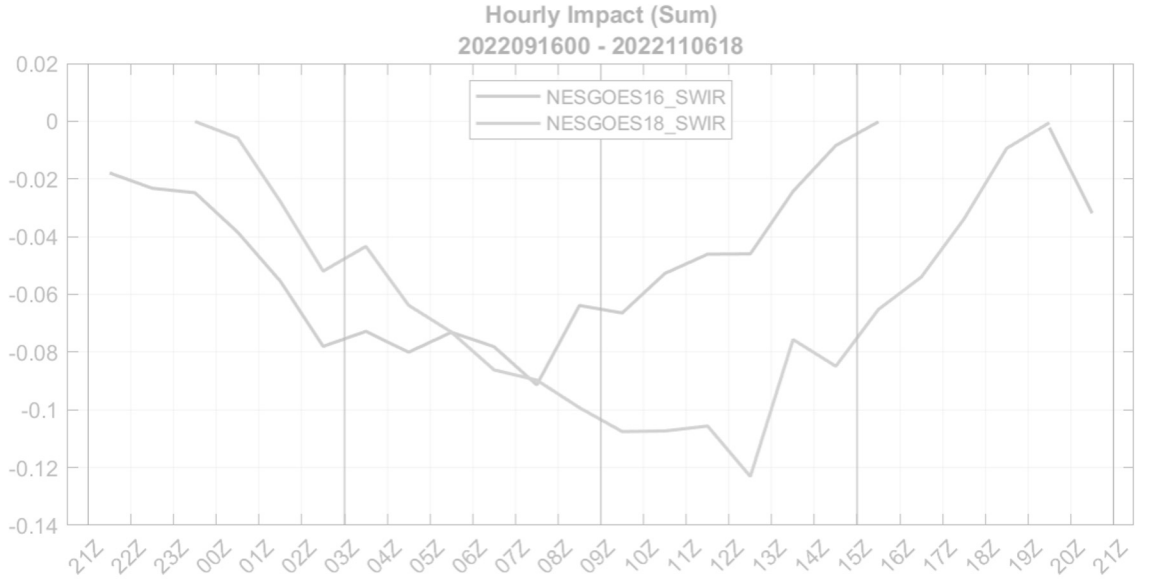
Differences Across Period 1 and Period 2 GOES17 IR





GOES16 and GOES18 SWIR Hourly Counts and Impact



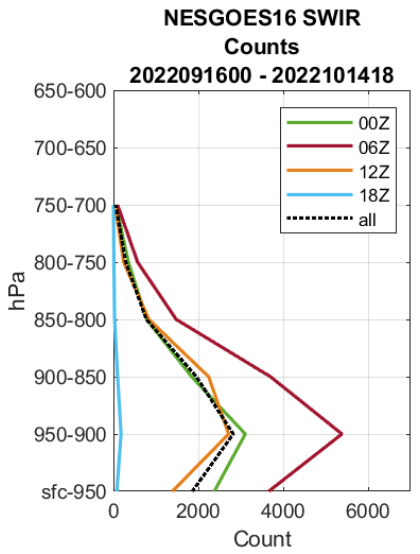


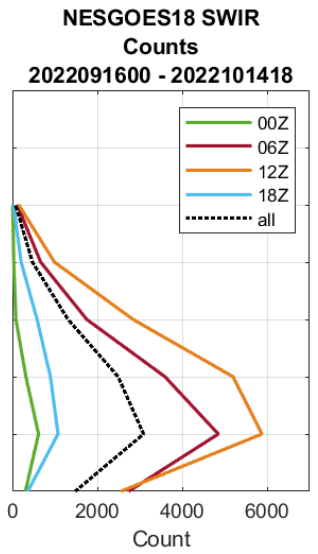
Blue curves at left:
GOES16 SWIR AMVs stop (at dawn) and start (at dusk) both in the 18Z window.

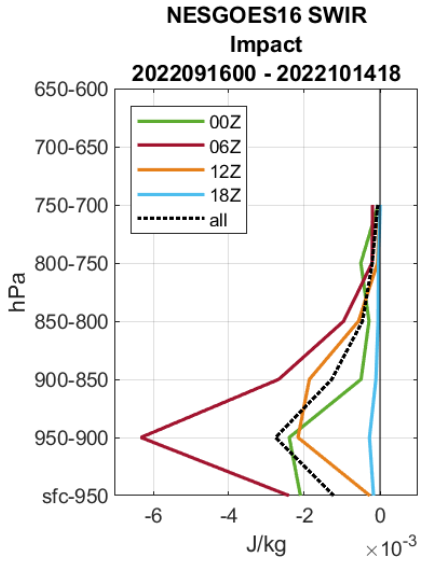
Orange curves at left:
GOES18 SWIR AMVs stop (at dawn) in the 18Z window and start (at dusk) in the 00Z window.

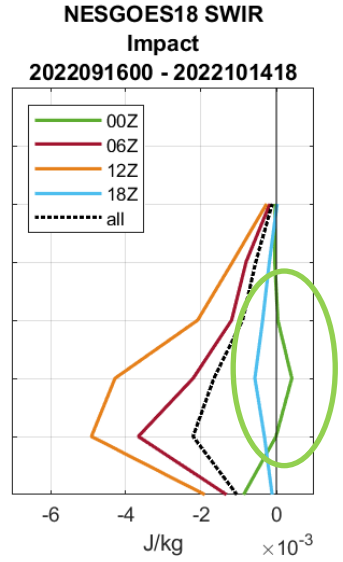
The impacts curves do not rise into nonbeneficial territory here because the whole column total impact is plotted.

Further investigation is needed to recommend appropriate QC changes (if any). Low hourly counts could be used, or perhaps a local dusk check would be better.

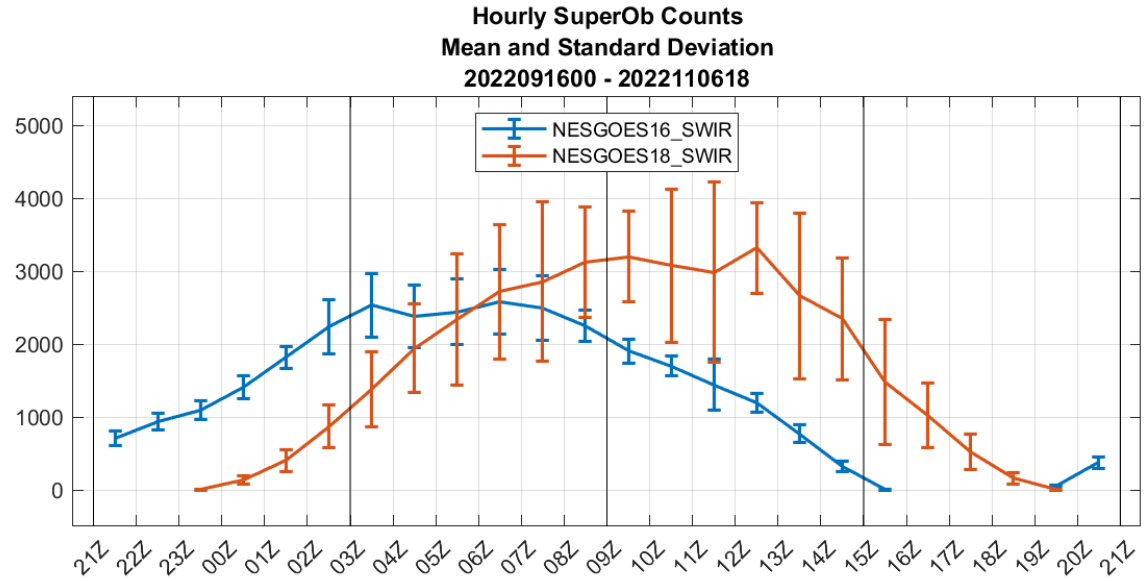






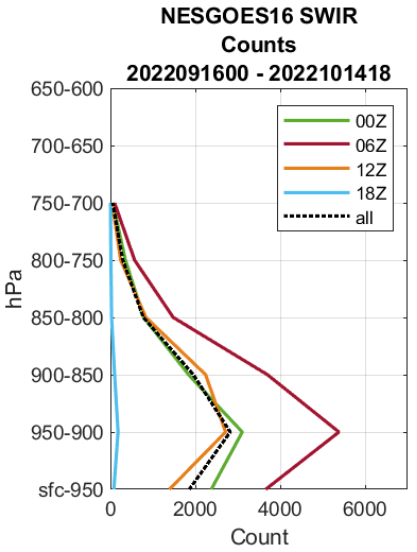


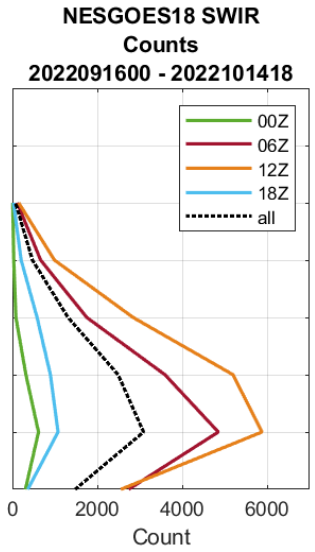
GOES16 and GOES18 SWIR Hourly Counts and Impact

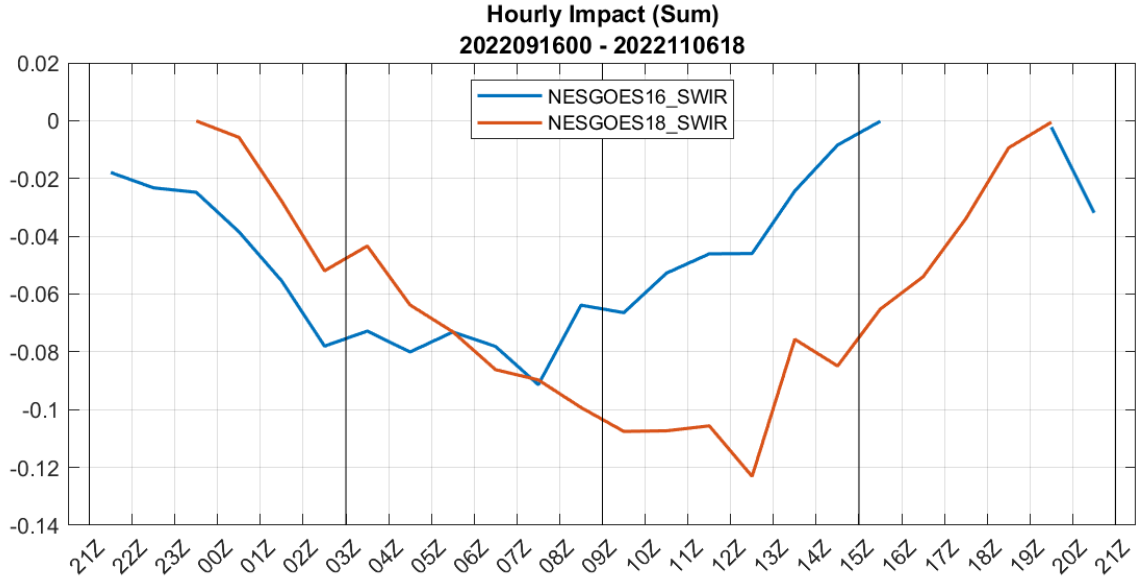


Blue curves at left:
GOES16 SWIR AMVs stop (at dawn) and start (at dusk) both in the 18Z window.

Orange curves at left:
GOES18 SWIR AMVs stop (at dawn) in the 18Z window and start (at dusk) in the 00Z window.

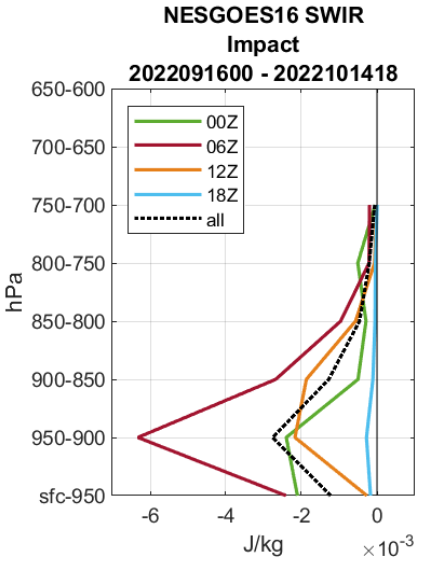


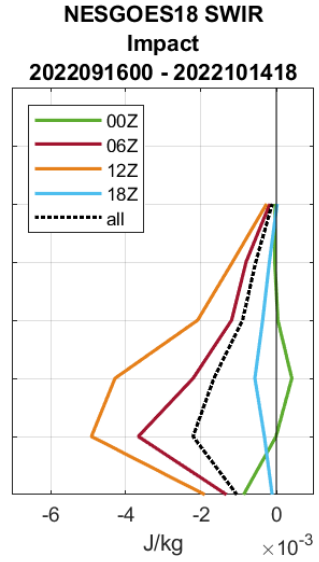




The impacts curves do not rise into nonbeneficial territory here because the whole column total impact is plotted.

QC checks for low hourly counts, or perhaps a local dusk check, could be devised. Further investigation is needed.





Try to Isolate Nonbeneficial SWIR AMVs

Are the nonbeneficial impacts occurring in any particular region?

- Equatorial East Pacific (ITCZ)
- Also seen in GOES16

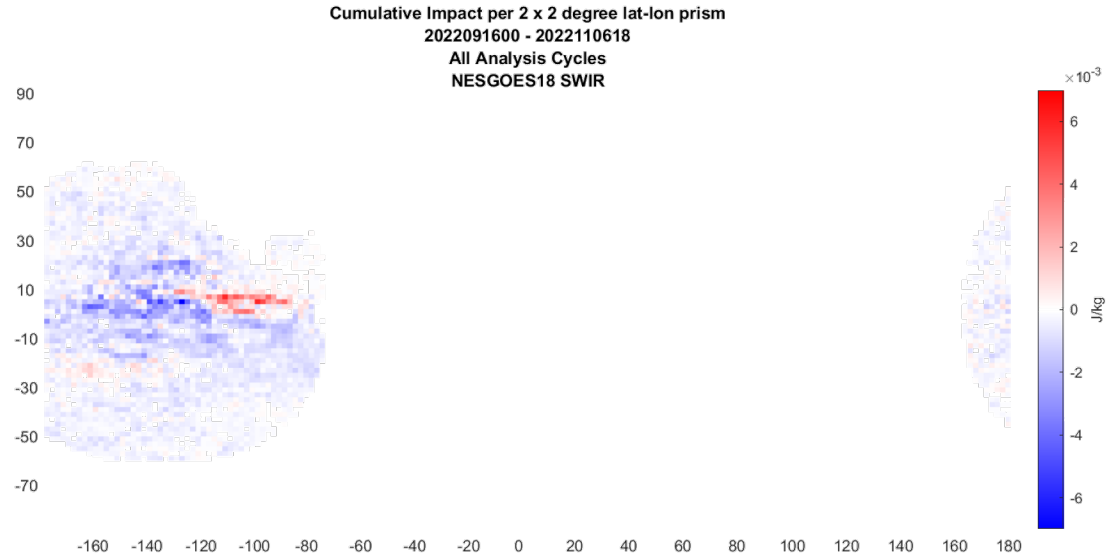
Telltale statistics?

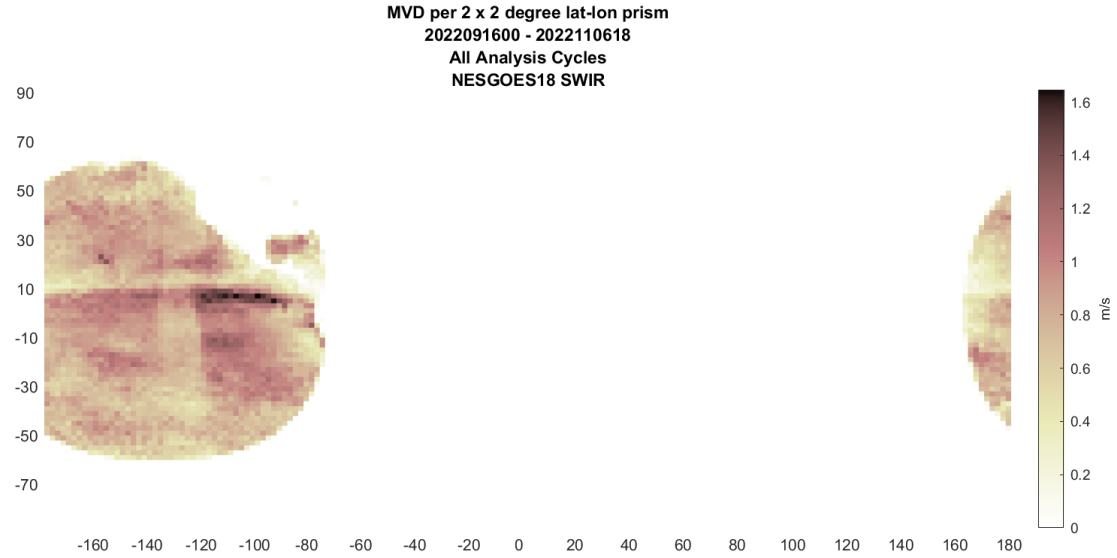
- Coincides with region of larger MVD

Could removal of near-TC AMVs improve statistics?

- Most of the near-TC AMVs are north of the ITCZ
- No significant changes in impacts, vector difference, or wind speed bias in region where counts were changed the most by removal of the near-TC AMVs

Near-TC AMVs are not responsible for harm in region of SWIR nonbeneficial impacts, or in the region north of that, where most of them are located.





Summary (Part 1)
GOES18 comparisons with GOES17 and GOES16

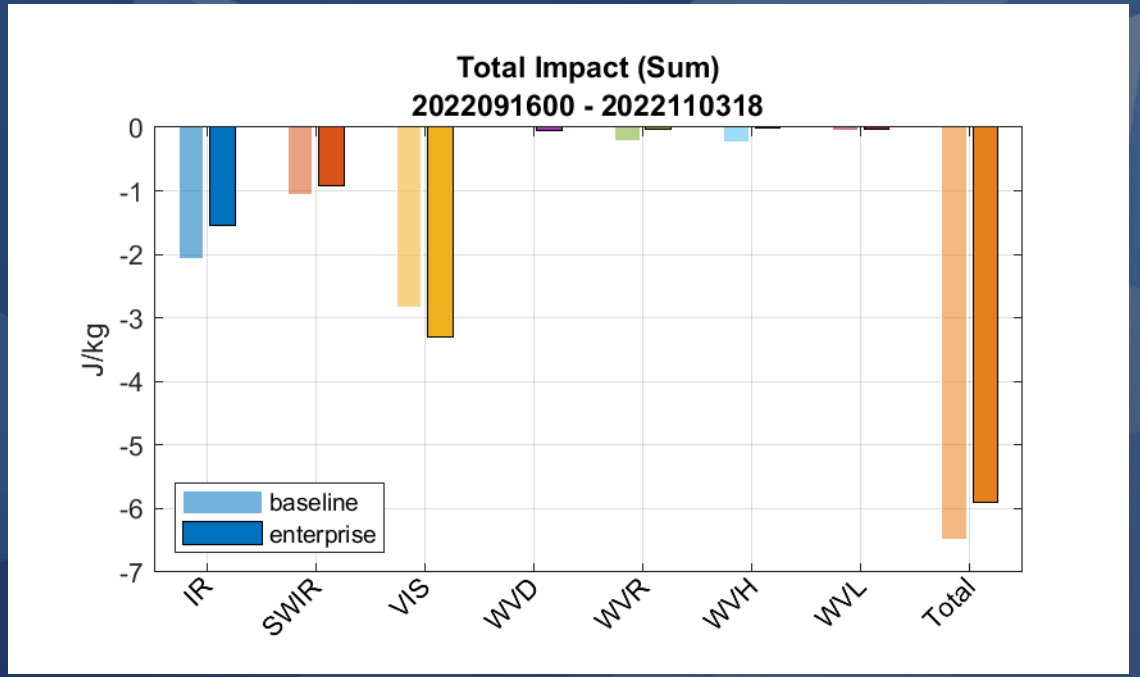
GOES18 compared with GOES17 and GOES16

- Between the control run with GOES17 and the test run with GOES18, there was no significant change in model verification metrics.
- Compared with GOES17, GOES18 IR winds were on average faster, especially 250-600 hPa. The quantity of IR winds was about the same, but GOES18 showed increased nonbeneficial FSOI aloft.
- Compared with GOES16, GOES18 IR statistics were similar: counts were the same or slightly lower than GOES16, and RMS wind speed difference was slightly smaller.
- Water vapor channels' FSOI remained mainly near neutral or nonbeneficial for GOES16, GOES17, and GOES18; but GOES18 clear air water vapor AMVs show some promise.

Warm period compared to pre-warm period

- GOES18 had higher counts than GOES17 during warm period mitigation.
- By analysis cycle:
  - GOES18 water vapor channel counts were higher than GOES17 in all cycles, but especially in the 12Z window.
  - GOES18 IR counts did not decrease in the 06Z and 12Z windows, as they did for GOES17.
  - GOES18 (total of all channels) gave less beneficial FSOI during both periods and during each analysis cycle EXCEPT the 12Z window during the warming period mitigations.
- SWIR showed nonbeneficial impacts for GOES18 (and GOES17) during the 00Z analysis window (local evening); further investigation is needed to recommend appropriate QC changes (if any).

GOES18 Baseline and Enterprise AMV comparison



Test run G18_SOP assimilating all operational data

- except pulling out NESGOES17 and putting in NESGOES18 Baseline Operational Algorithm AMVs

Test run G18_EN2 assimilating all operational data

- except pulling out NESGOES17 and putting in NESGOES18 Enterprise Algorithm AMVs

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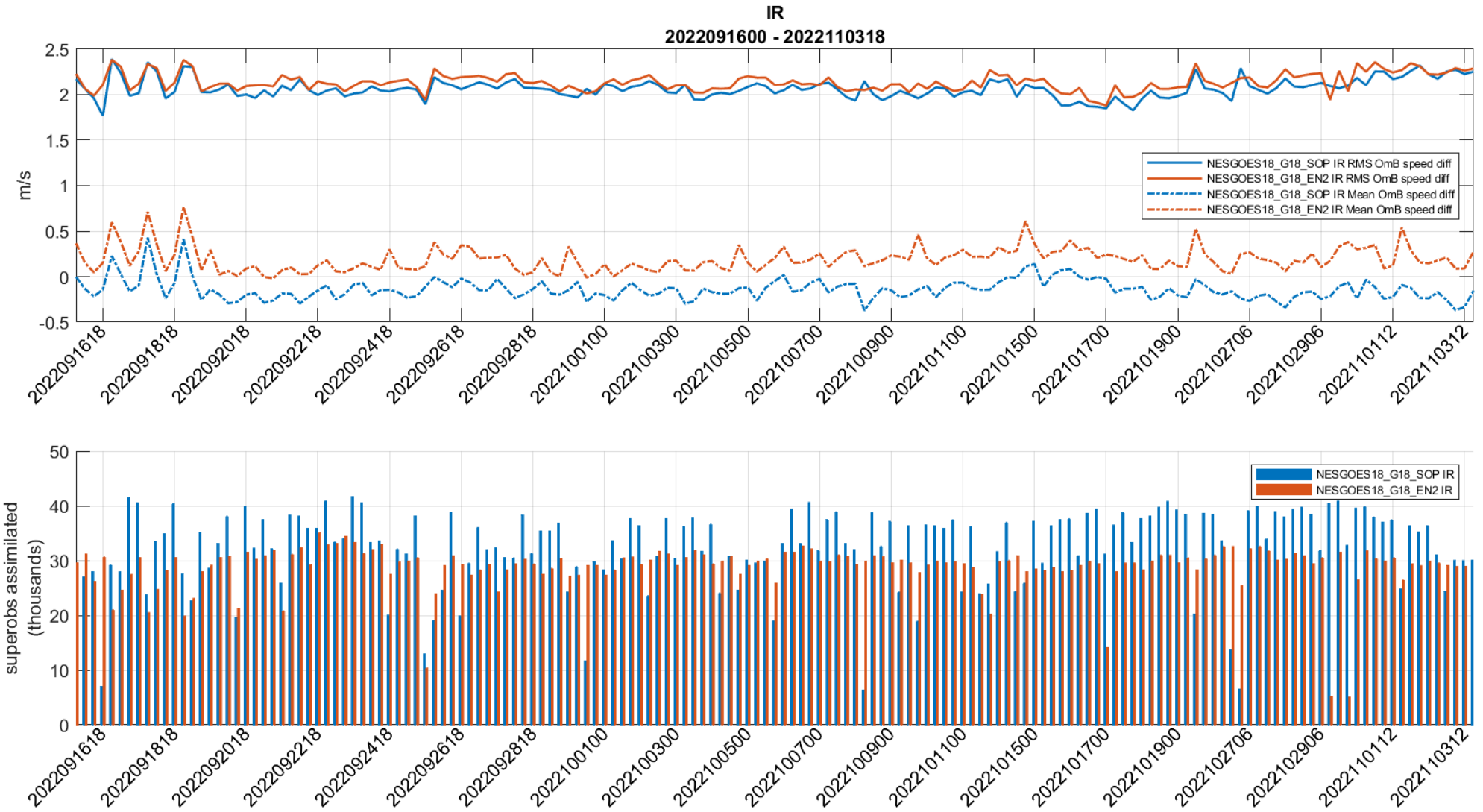
Compare Baseline and Enterprise IR



Baseline winds have slightly lower OmB RMS speed difference in NAVGEM; the mean speed difference goes from negative (baseline winds slower than background) to positive (enterprise winds faster than background).

Baseline winds usually have higher counts.

Compare Baseline and Enterprise IR

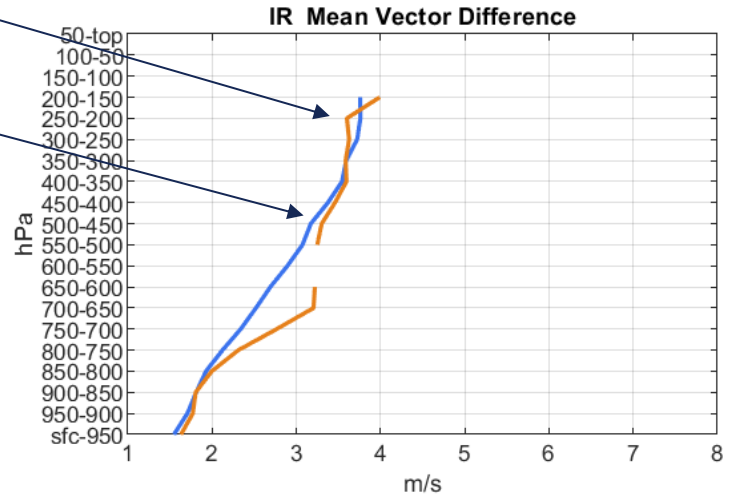
Enterprise winds have lower OmB MVD aloft; baseline winds have lower MVD in NAVGEM below 300 hPa.

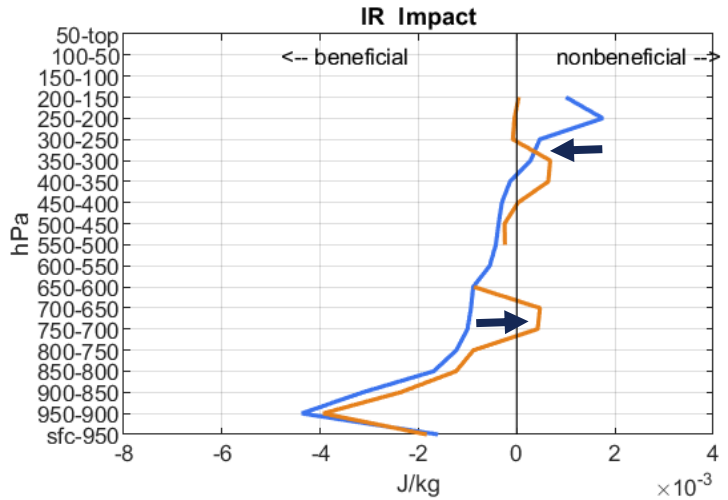
Upper level nonbeneficial FSOI is reduced, but remains nonbeneficial. FSOI in midlevels goes from beneficial to nonbeneficial.

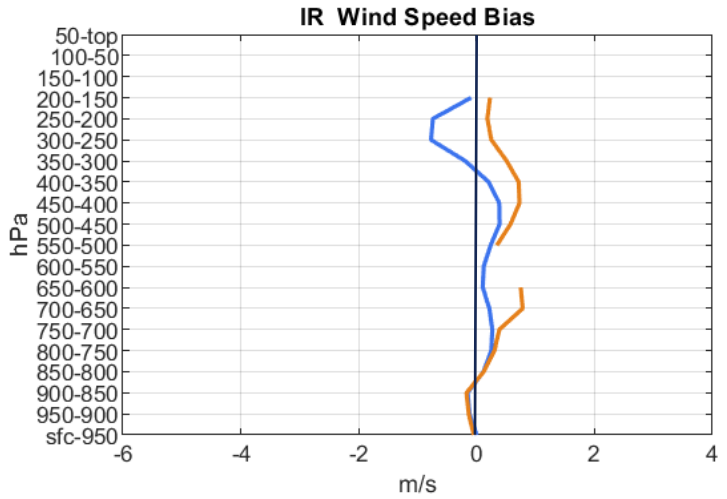
Enterprise wind speed bias profile becomes positive (faster than background) everywhere above 900 hPa.

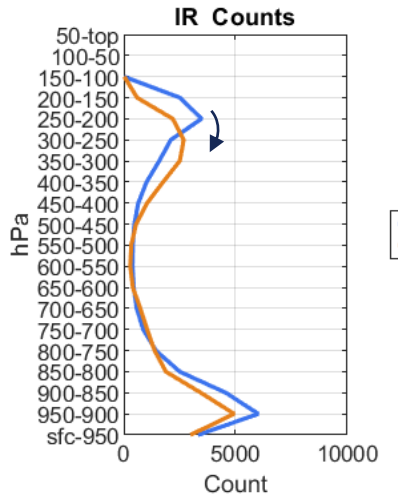
The upper level peak in baseline wind counts near 200 hPa is shifted downward to 300 hPa for the enterprise winds.

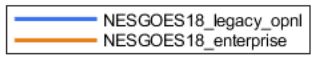
2022091600 - 2022110318



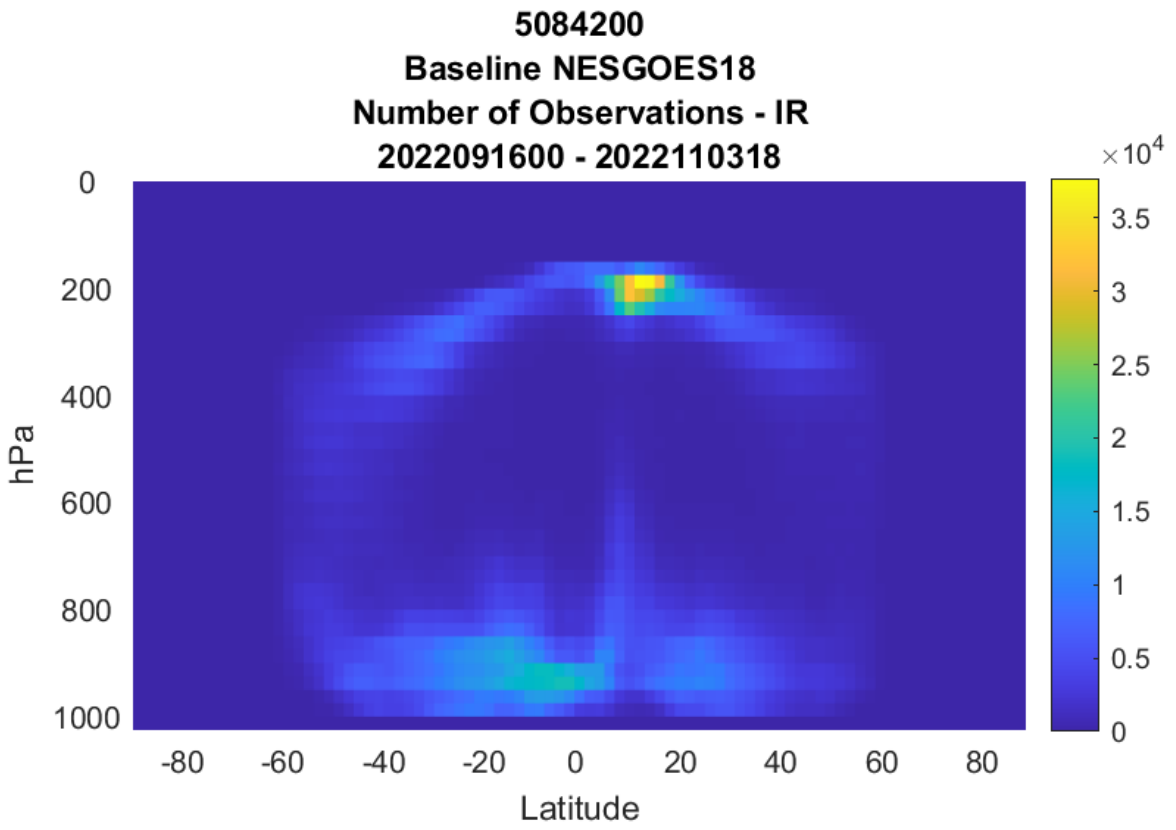


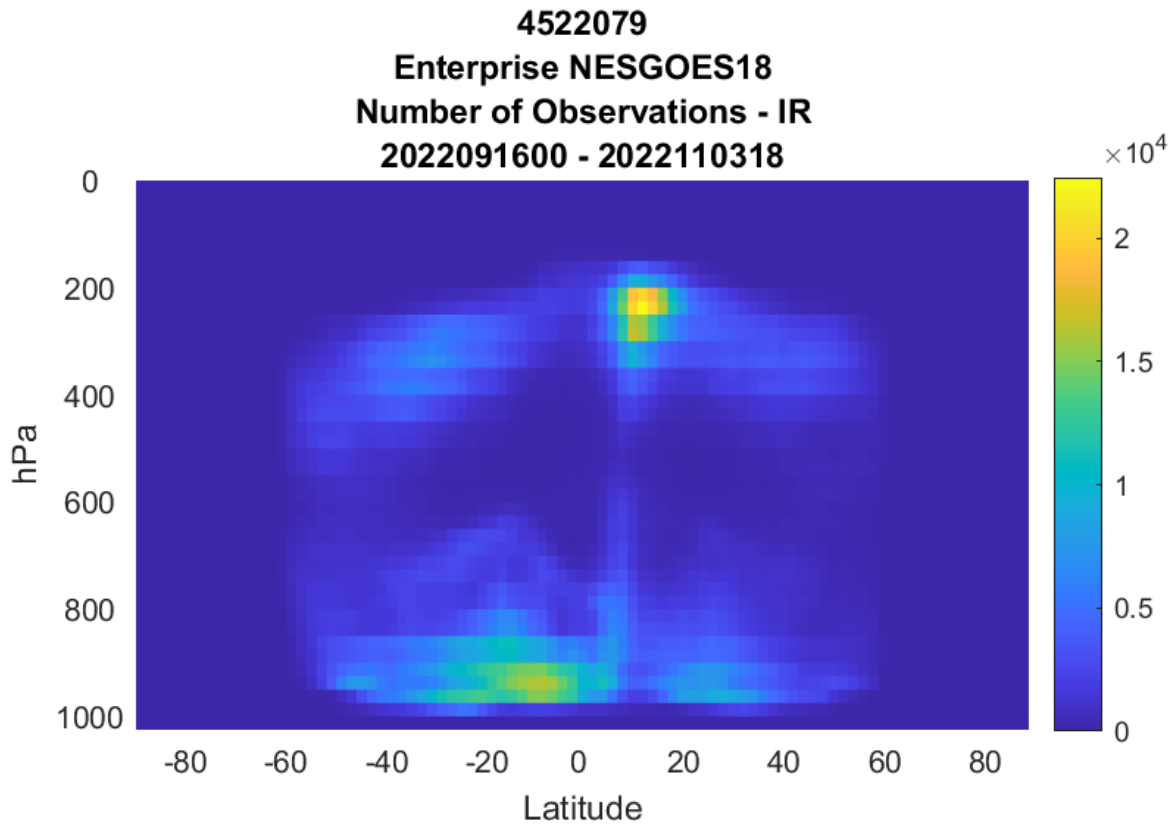






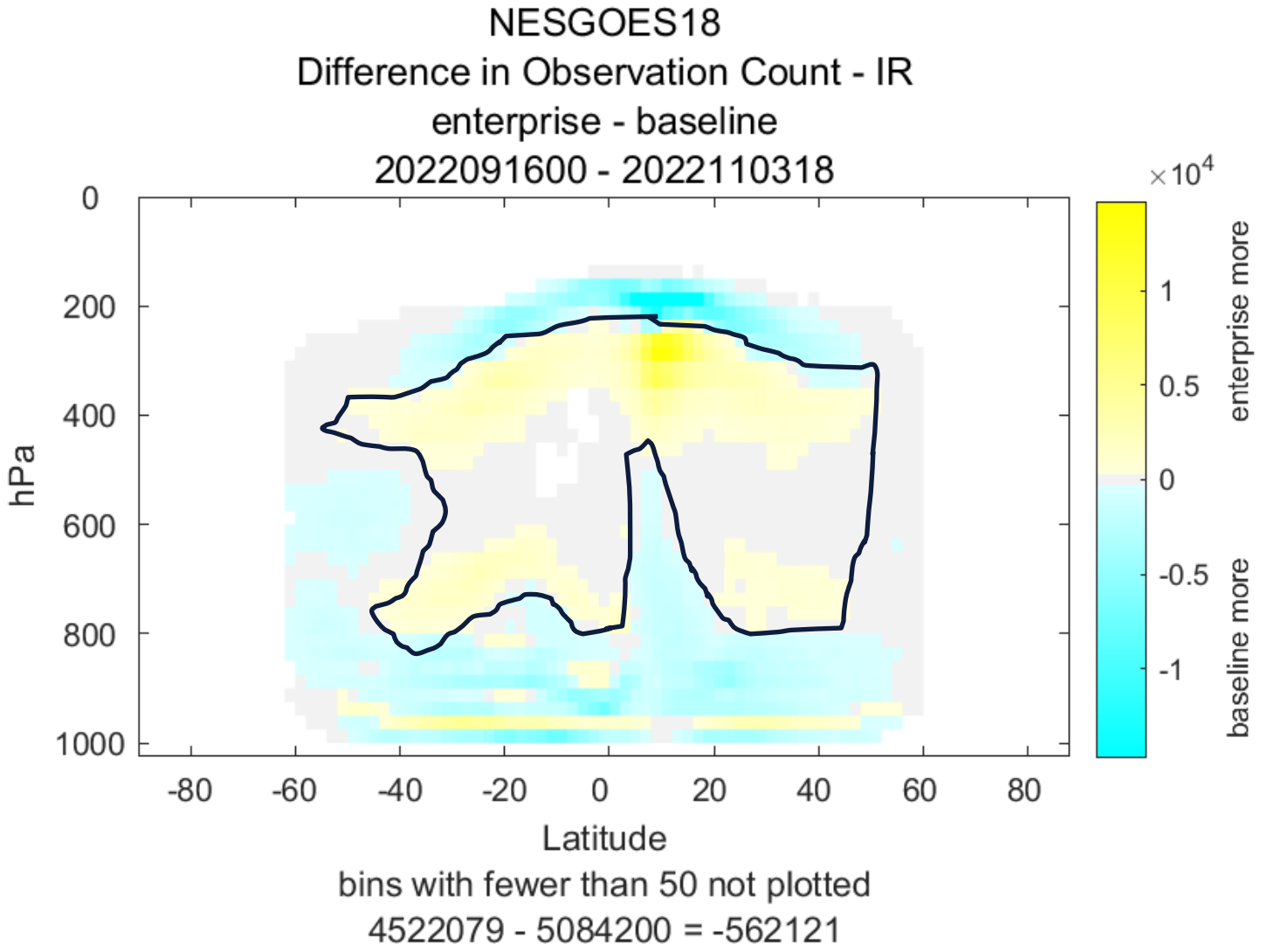
Compare Baseline and Enterprise IR Counts





More baseline winds (blue) at the top and bottom; more enterprise winds (yellow) in the middle of the domain.

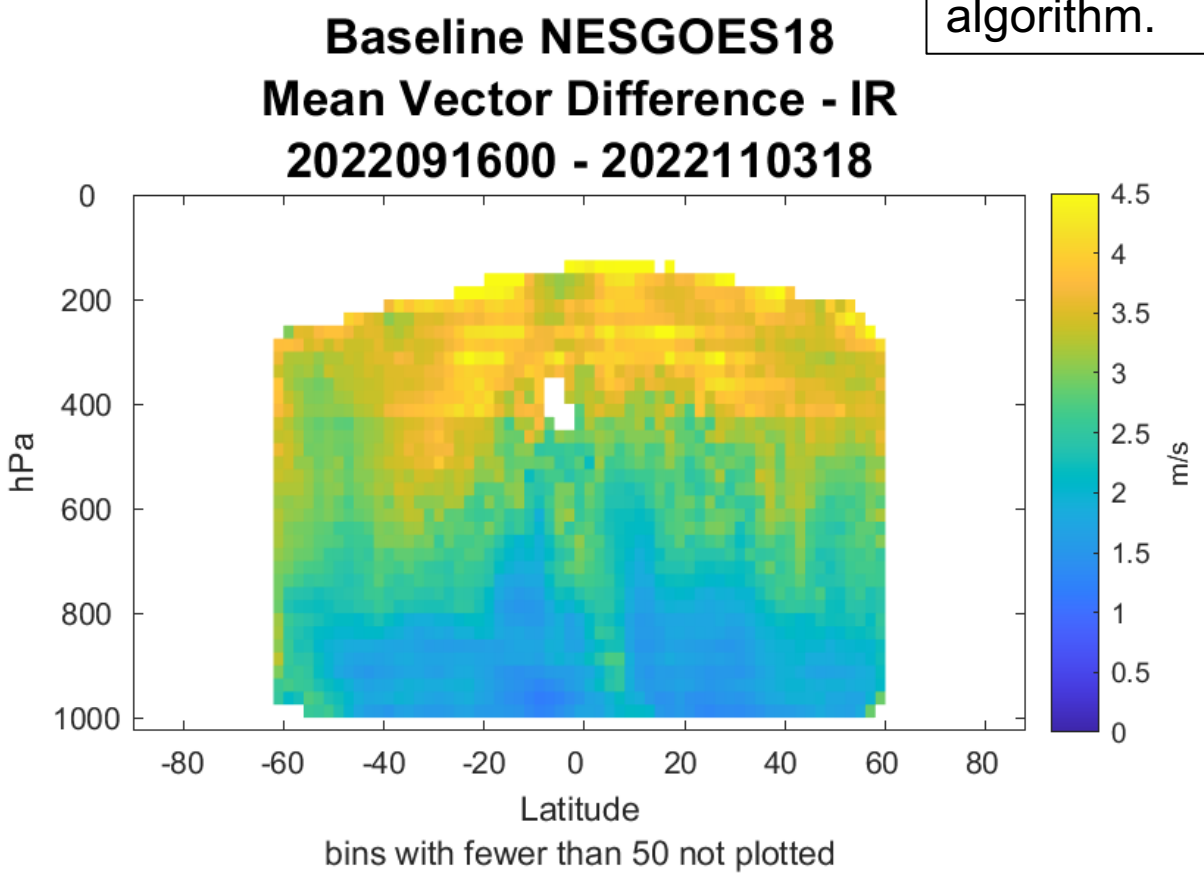
Black outline shows core area where enterprise counts exceed baseline counts.

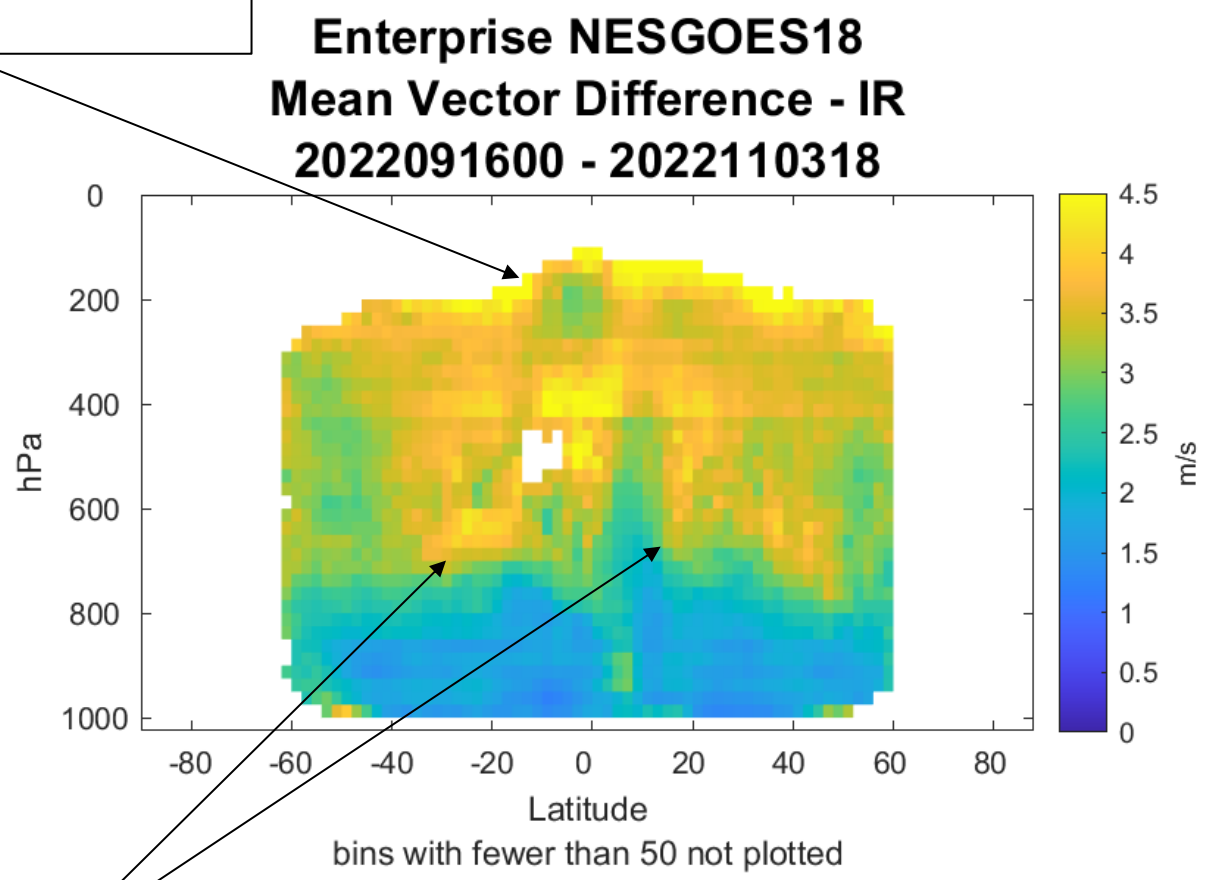


Difference plots have filter applied wherever the bin counts for baseline or enterprise winds are <50, for the ~6 weeks.

MVD

Area of decreased MVD for enterprise winds algorithm.

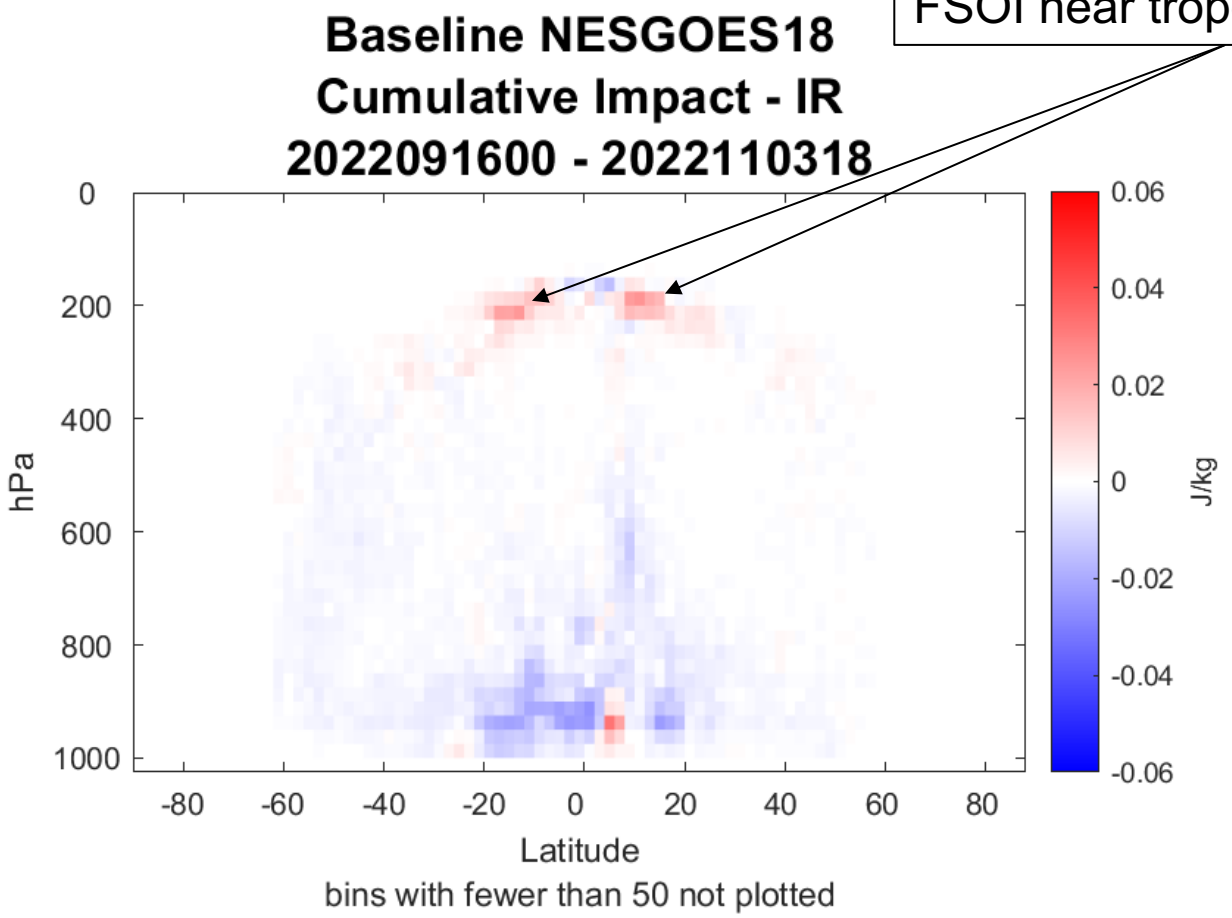


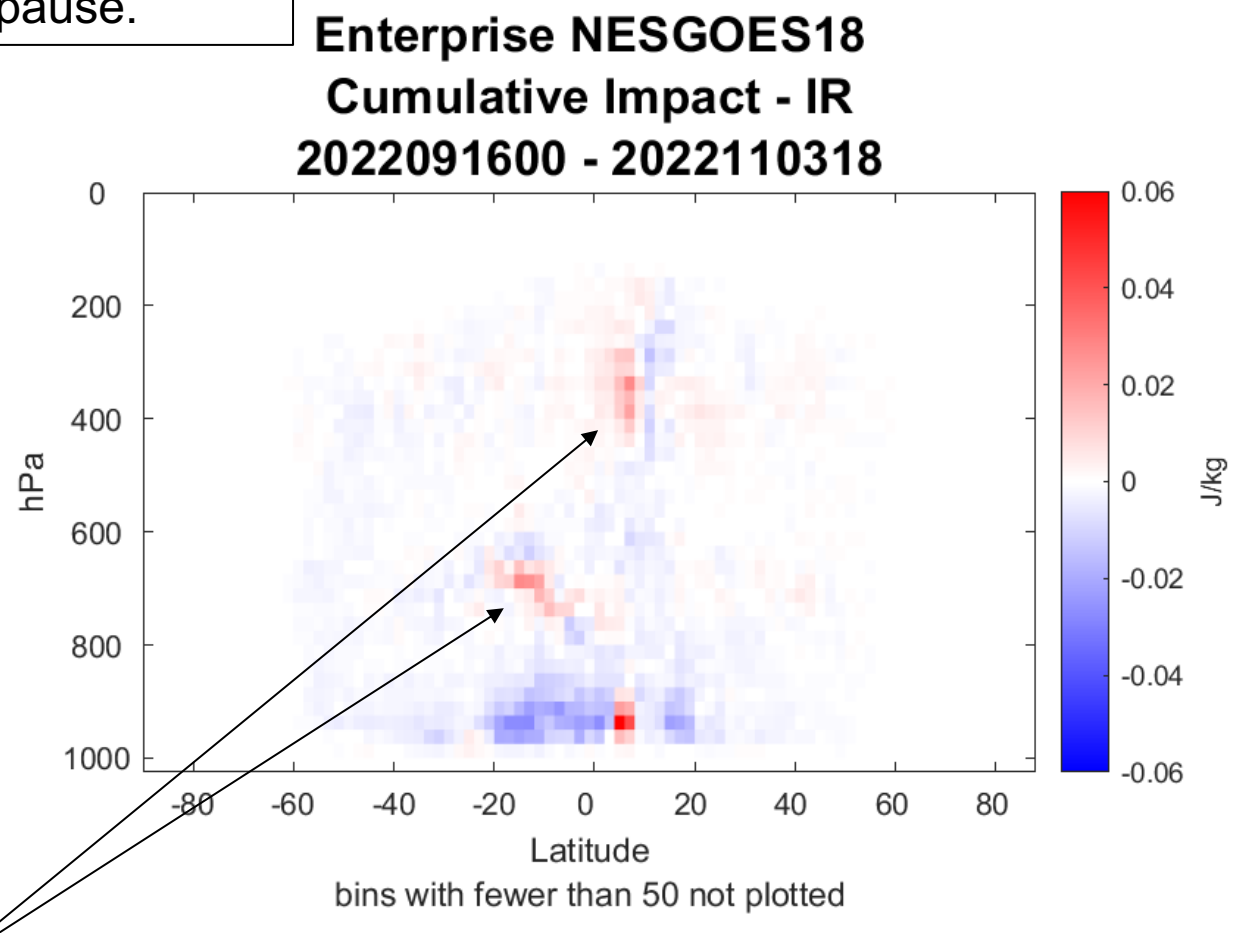


Areas of increased MVD for enterprise winds algorithm.

FSOI

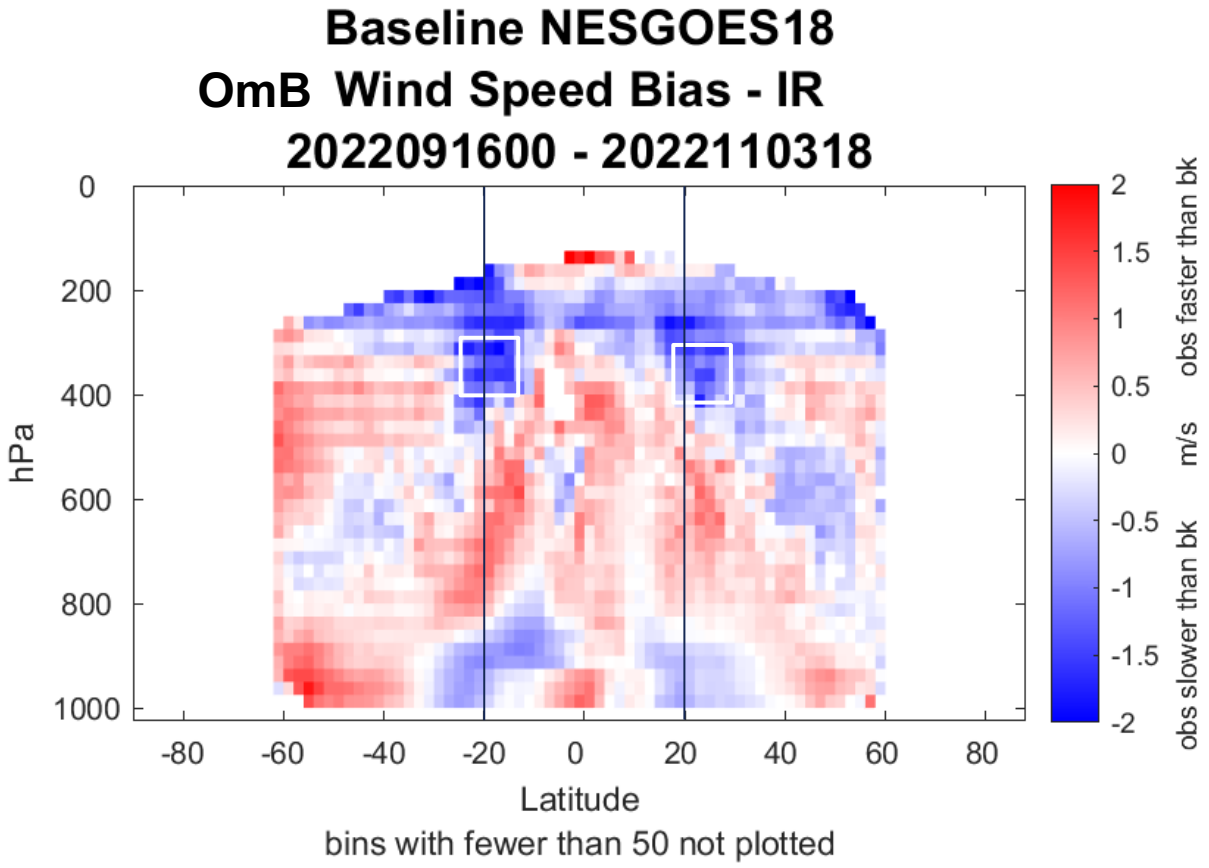
Enterprise winds reduce these areas of nonbeneficial FSOI near tropopause.

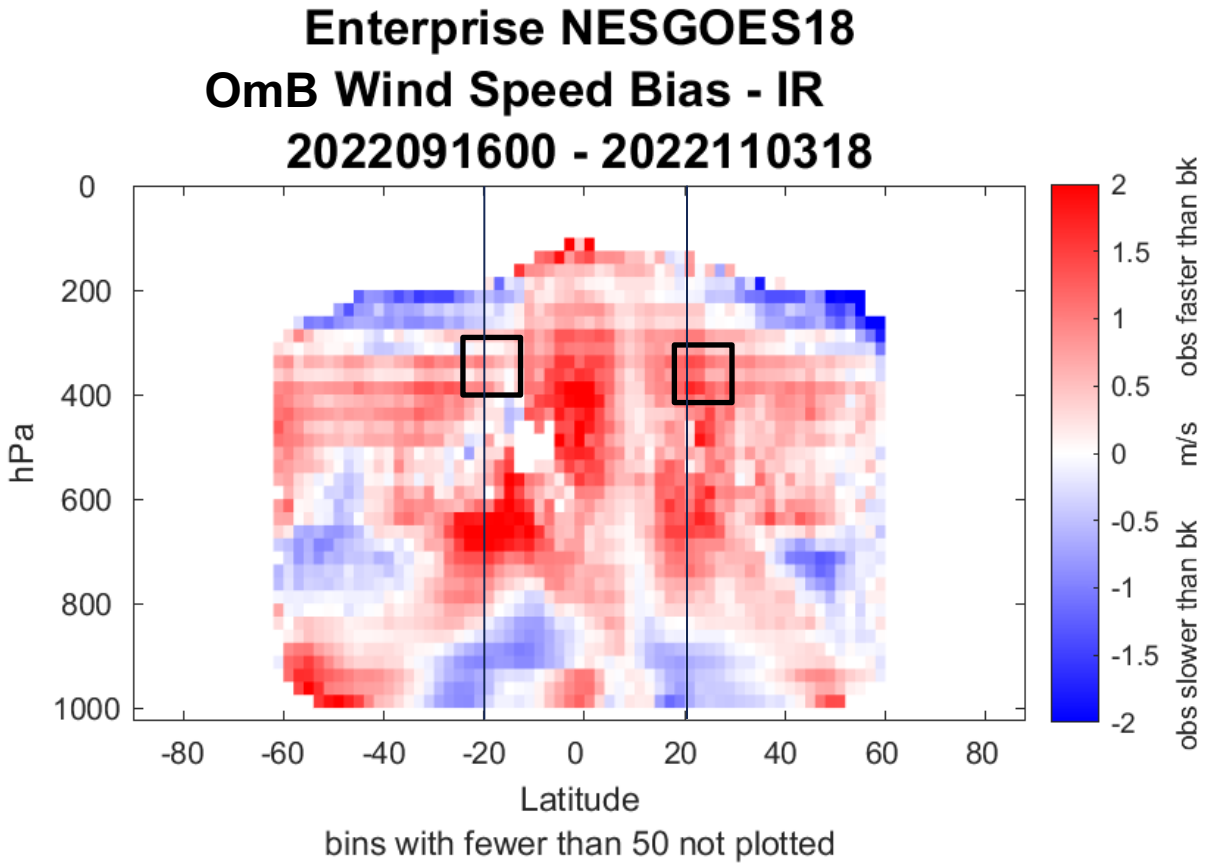




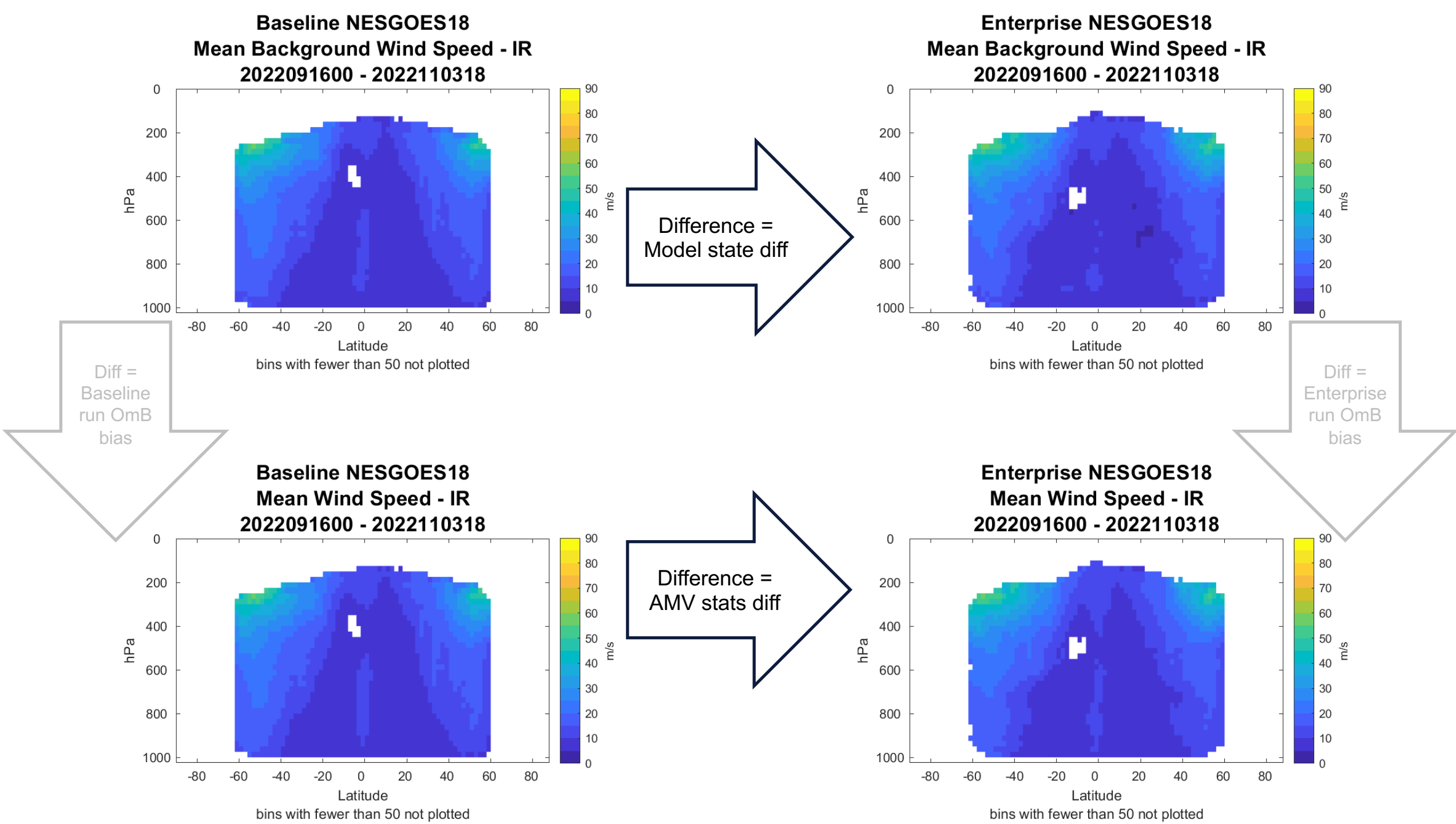
New areas of nonbeneficial FSOI in midlevels.

Mean OmB Wind Speed (Bias)





Baseline winds have the strongest slow bias aloft near 20S and 20N (near the squares marked). Enterprise AMVs show a reversal to faster-than-background wind bias aloft in these regions.


Baseline NESGOES18
Mean Background Wind Speed - IR
2022091600 - 2022110318
hPa
m/s
Latitude
bins with fewer than 50 not plotted
Difference =
Model state diff
Enterprise NESGOES18
Mean Background Wind Speed - IR
2022091600 - 2022110318
Diff =
Baseline
run OmB
bias
Diff =
Enterprise
run OmB
bias
Baseline NESGOES18
Mean Wind Speed - IR
2022091600 - 2022110318
Difference =
AMV stats diff
Enterprise NESGOES18
Mean Wind Speed - IR
2022091600 - 2022110318

Difference in mean model state (at ob locations) closely resembles mean difference in AMVs over most of the region plotted.

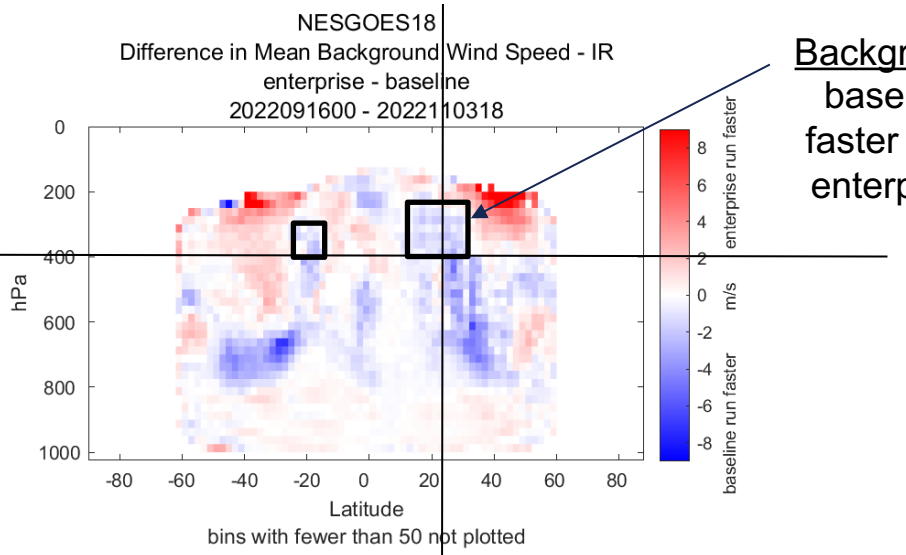
Two areas with small but detectable differences are marked in these images: near 300-400 hPa and 20 degrees north and south latitude.

In both marked regions, the baseline run background state has faster winds speeds than the enterprise test run, despite the enterprise AMVs being faster than baseline AMVs (and more numerous in those regions).

These areas correspond with areas on previous slide where the baseline winds have the strongest slow bias (or possibly model state has strongest fast bias). The enterprise AMVs show a reversal to faster-than-background wind bias in these regions.

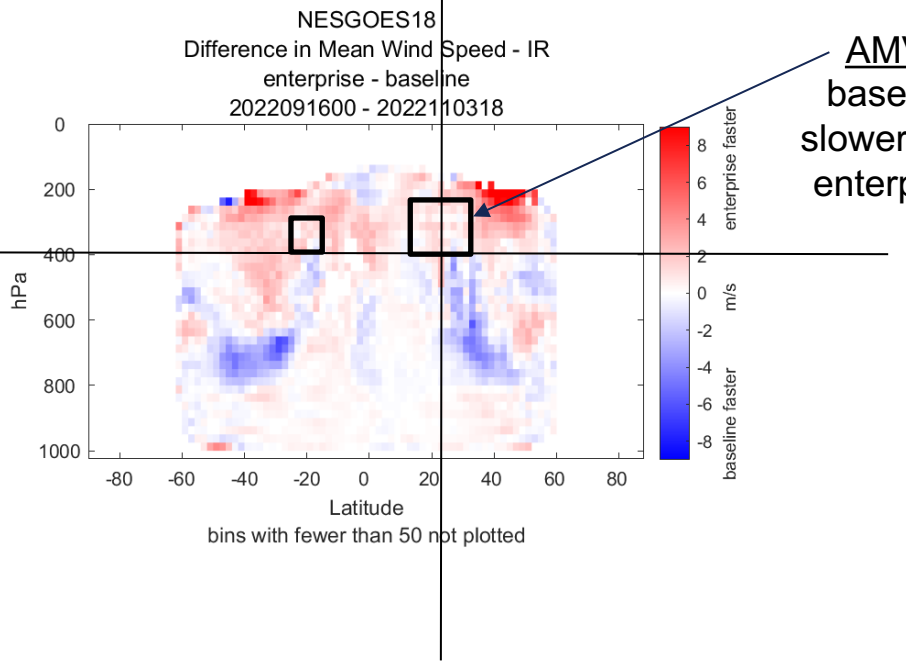
The two test runs each received different GOES18 AMV input, resulting in different (mean) innovations. In this case those mean innovations happen to be different in sign. However, when combined with all the other observations, plus other details of the DA system, the backgrounds are only slightly different.

Mean model state difference



Background
baseline
faster than
enterprise

Mean AMV stats difference



AMVs
baseline
slower than
enterprise

Summary (Part 2)
Comparison of Baseline and Enterprise GOES18 winds

IR Band

- Counts:
  - Baseline winds had higher counts than enterprise winds overall, but enterprise winds were distributed more through the depth of the atmosphere, so that baseline wind counts were higher very high and very low in the atmosphere, while enterprise wind counts were higher in midlevels.
  - The upper level peak in baseline wind counts near 200 hPa was shifted downward to 300 hPa for the enterprise winds. Enterprise winds' faster bias corresponded with their shift downward in the atmosphere. (A feature with the same observed motion, but assigned below jet instead of at jet level would have faster bias relative to the background.)
- Vector Differences: Baseline winds had lower OmB MVD in NAVGEM below 300 hPa; enterprise winds had lower MVD aloft.
- FSOI:
  - Enterprise winds reduced the upper level nonbeneficial FSOI, but not enough—the total remained nonbeneficial.
  - Enterprise winds reversed midlevel FSOI; baseline were beneficial, but enterprise were nonbeneficial.
- RMS Speed Difference: Enterprise winds' OmB RMS speed difference with NAVGEM was slightly higher than baseline.
- Mean Speed Difference:
  - Bias against NAVGEM changed from negative (baseline winds slower than background) to positive (enterprise winds faster than background).
  - Baseline AMVS had slower-than-background bias aloft near 20 S and 20N. Enterprise AMVs showed a reversal to faster-than-background wind bias aloft in these regions.

Comments and Questions?

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Backup and Supplemental slides

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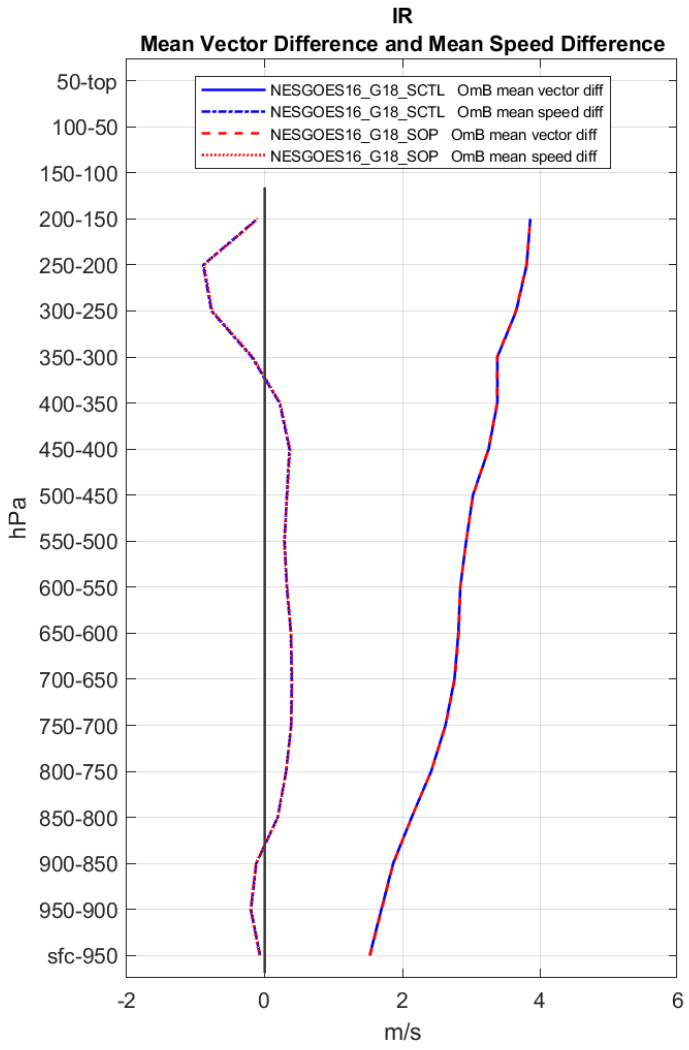
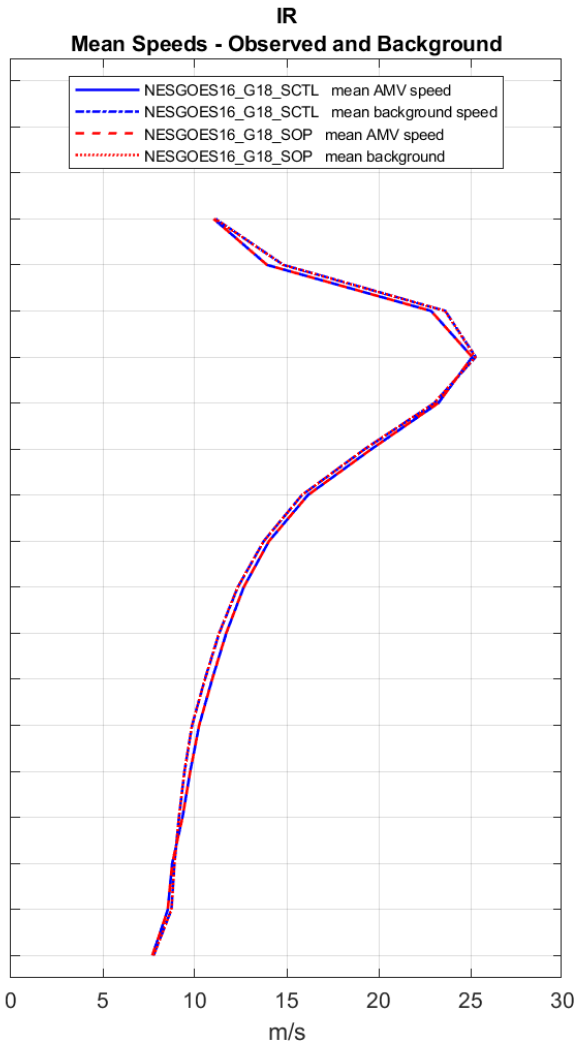
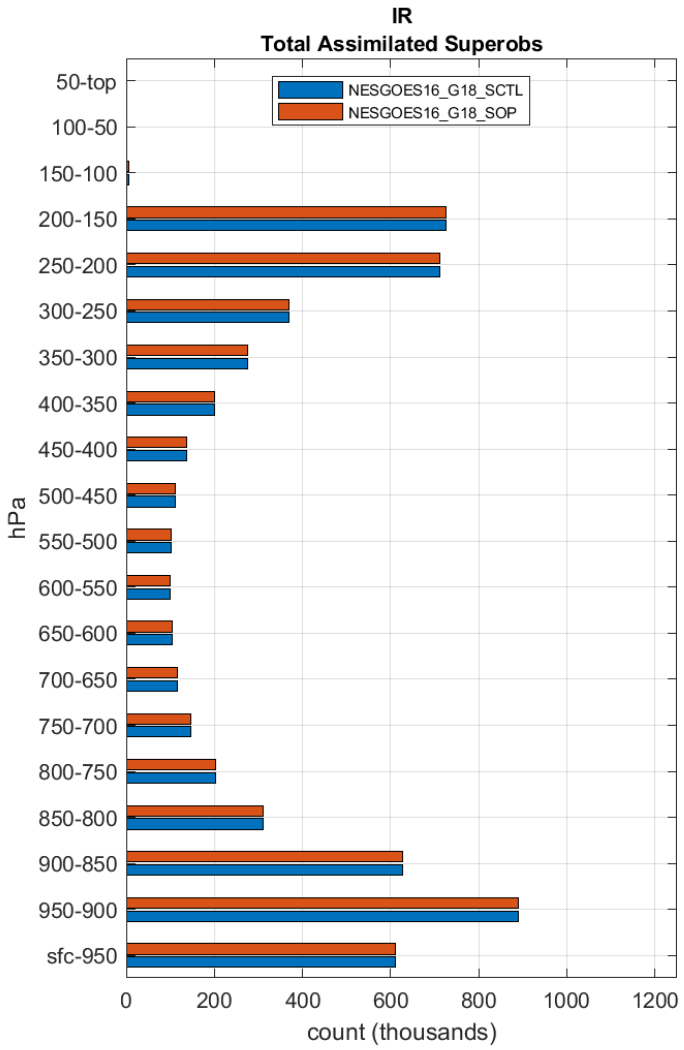
Compare GOES16 in control and test for Period 1 + Period 2







GOES16 MVD and mean speed difference from each run are indistinguishable.

Backup Slides

Comparison Period Details

Comparison Period 1 (GOES17 and 18)
2022091600 - 2022101418

- Before GOES17 warming period threshold shift, with carve-outs for GOES18 interleave period outage
  - Total of 107 DTGs, 26+ days of data
- During GOES18 interleave, stabilize run by substituting in GOES17OP.
  - The primary comparison will be between GOES18OP and GOES17OP (without cooling problems), so do not want to introduce differences in OP/EN algorithm.
- Remove these DTGs from analysis period_1:
  - 2022093006
  - 2022101118
  - 2022101200
  - 2022101206
  - 2022101212
  - 2022101218
  - 2022101300
  - 2022101306
  - 2022101312

Comparison Period 2 (GOES17 and 18)
2022101500 - 2022110618

During GOES17 warming period
- Cooling Timeline Activated 14 Oct – 5 Nov

Missing 5 DTGs due to failure/restart of control and test runs
- 2022101912 - 2022102012

Removed 20 DTGs due to PDA I&T outage
- Operational Algorithm GOES18 AMVs not available
- During PDA I&T outage, run stabilized by substituting GOES18 Enterprise Algorithm
- 2022102200 - 2022102618

Removed 4 DTGs due to FNMOC alpha outage (GOES18 AMVs not available)
- 2022103012 - 2022103106

Total of 63 DTGs, 15+ days of data

Comparison Period 3 (Baseline and Enterprise) 2022091600 - 2022110318

Removed 1 DTG due to missing Operational winds file
- 2022093006

Removed 8 DTGs due to GOES18 interleave period
- 2022101118 - 2022101312
- During GOES18 interleave period, run stabilized run by substituting GOES17 Operational Algorithm

Missing 5 DTGs due to failure/restart of control and test runs
- 2022101912 - 2022102012

Removed 20 DTGs due to PDA I&T outage
- Operational Algorithm GOES18 AMVs not available
- During PDA I&T outage, run stabilized by substituting GOES18 Enterprise Algorithm
- 2022102200 - 2022102618

Removed 5 DTGs due to FNMOC alpha outage (GOES18 AMVs not available)
- 2022103006 - 2022103106

Last Enterprise winds test file was for 2022110318

Backup Slides

How are counts affected by time of day?

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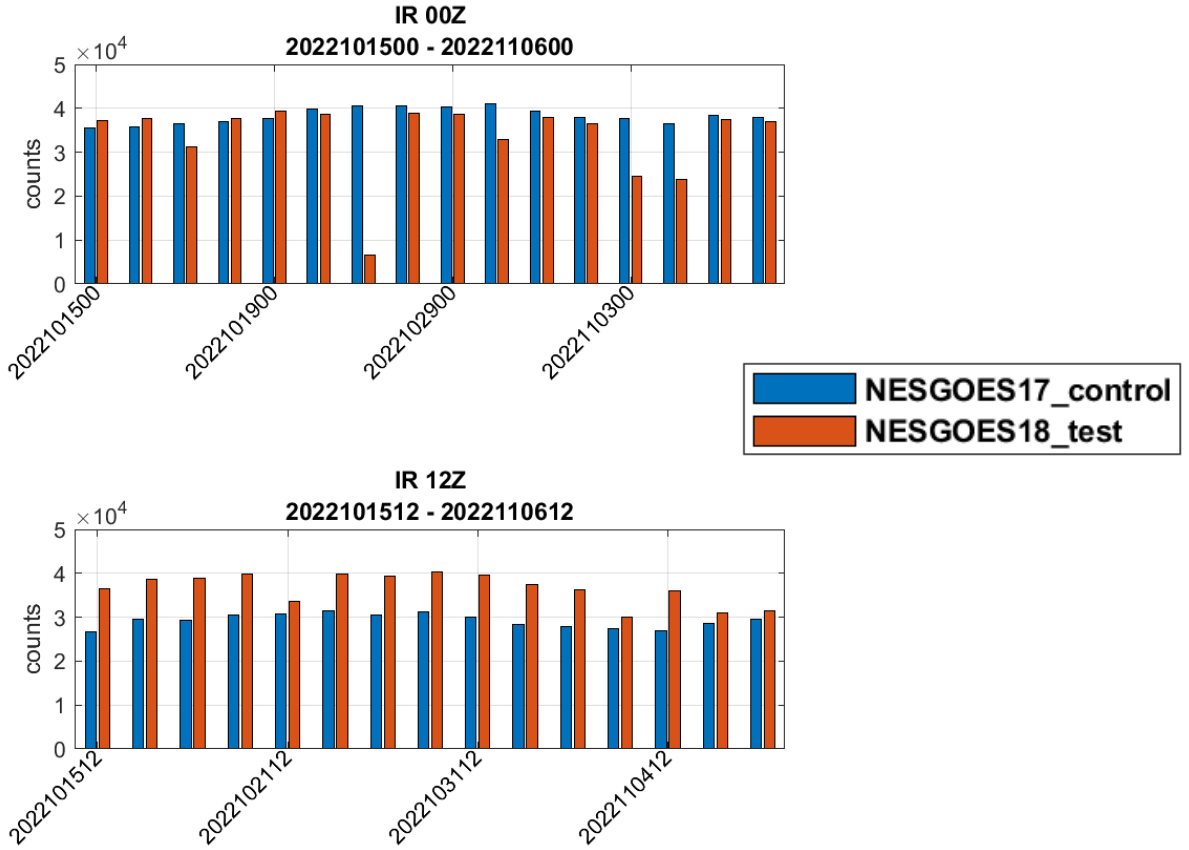
How are counts affected by time of day? Period 2 (warm period)

IR: GOES18 counts do not decrease in the 06Z and 12Z windows (as seen for GOES17).
WVD and WVH: GOES18 counts are higher than GOES17 generally, but especially in the 12Z window.
WVR: GOES18 counts are much larger than GOES17 in the 12Z window.



How are counts affected by time of day? Period 2 (warm period)

IR: GOES18 counts do not decrease in the 06Z and 12Z windows (as seen for GOES17).
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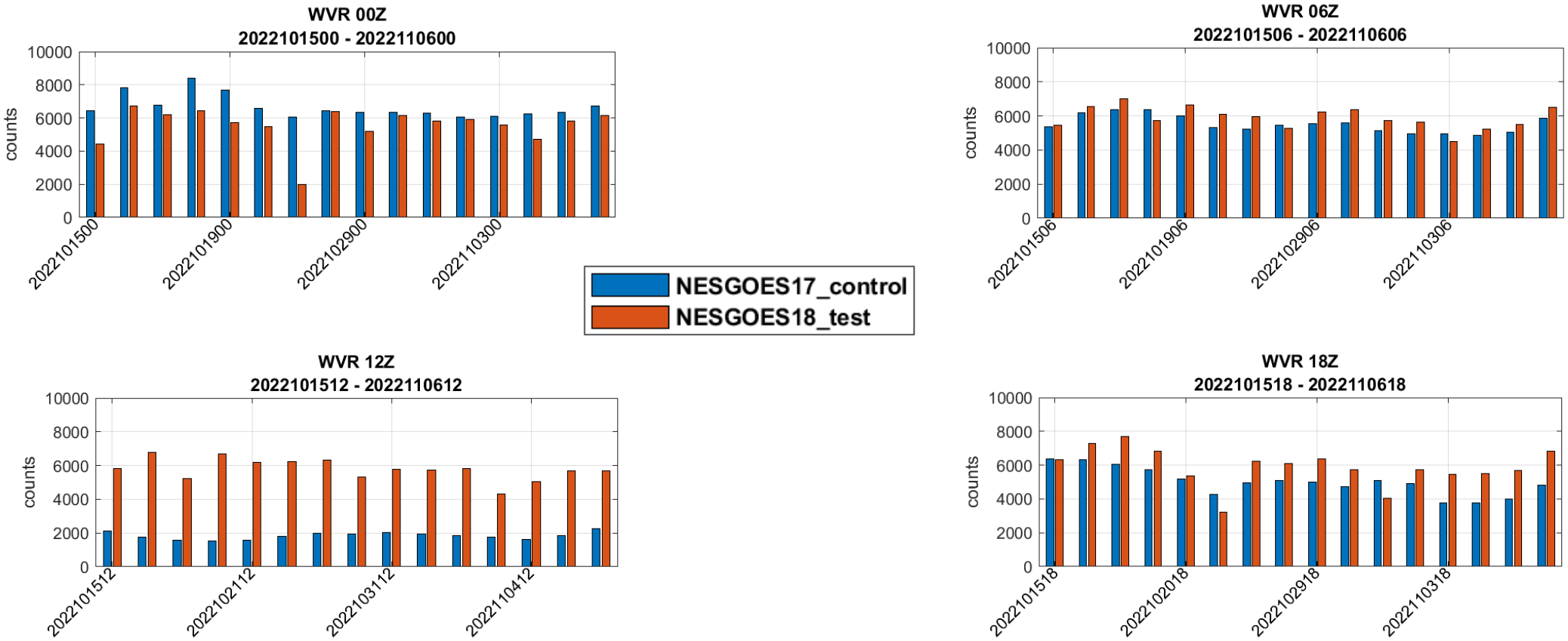

Backup Slides

Efforts to Isolate Nonbeneficial SWIR AMVs

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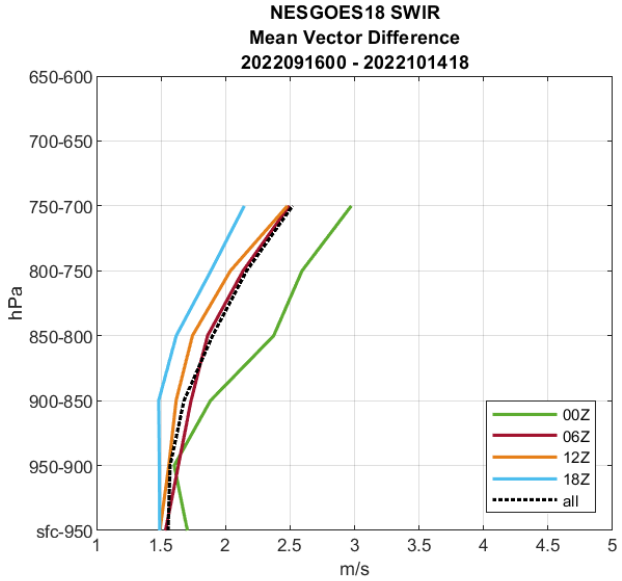
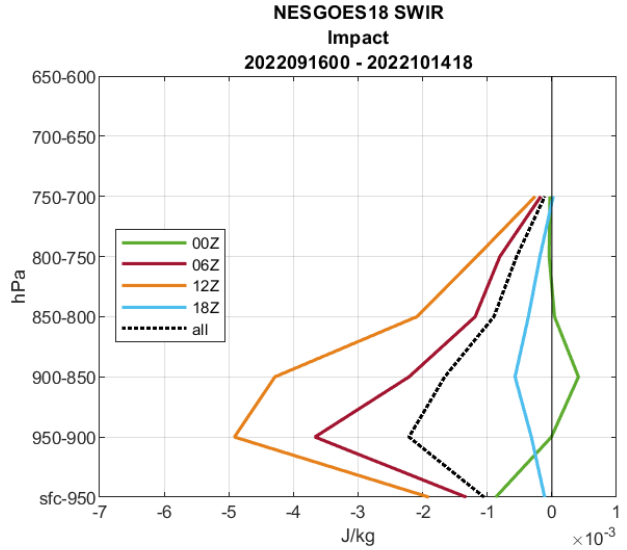
GOES18 SWIR Diurnal Stats

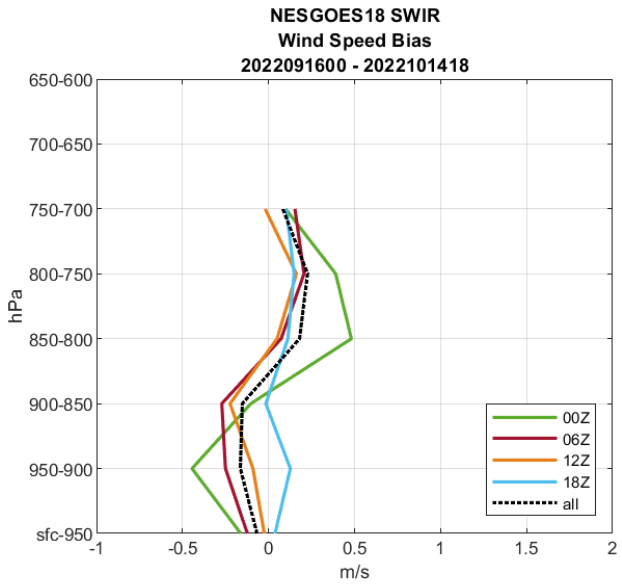
Can we identify and isolate cause of nonbeneficial GOES SWIR AMVs?

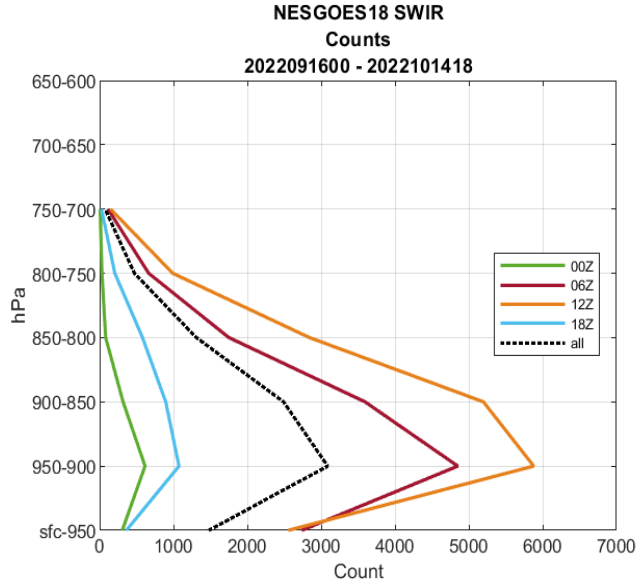
There are some differences in statistics for the AMVs in the 00Z window, but the most striking difference at 850-900 hPa is the counts.

Do GOES16 18Z (evening) stats follow same pattern as GOES18 00Z (evening) stats?





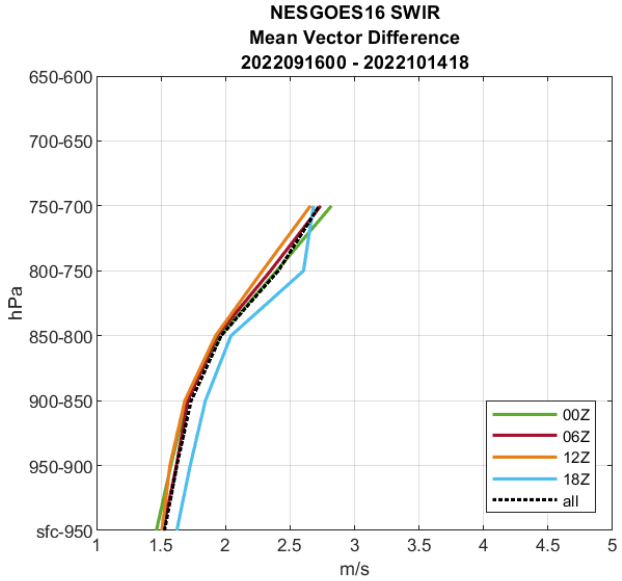


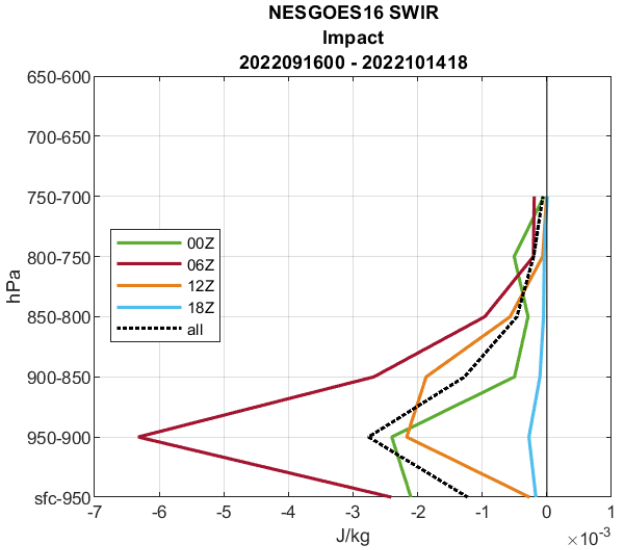


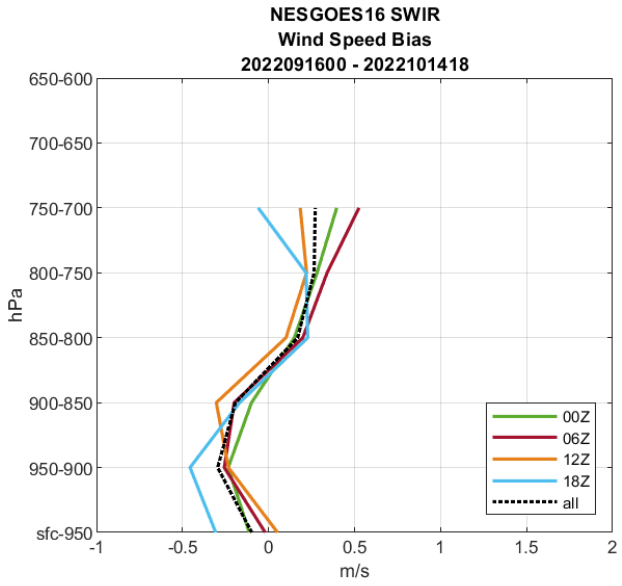
GOES16 SWIR Diurnal Stats

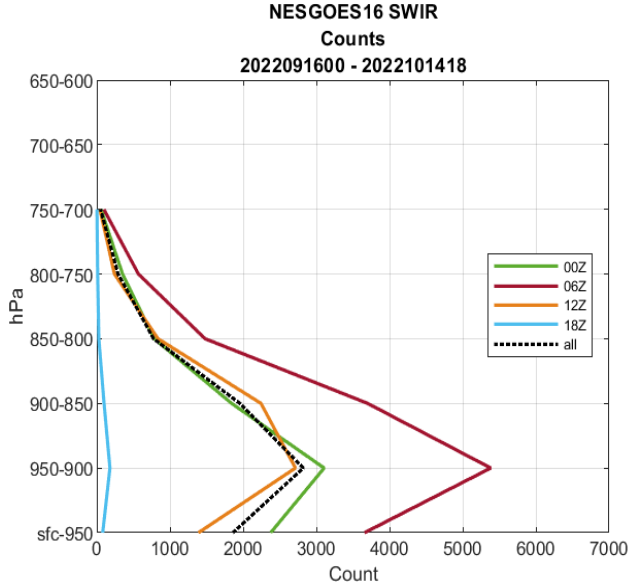
Nonbeneficial impacts are not found in any of the GOES16 analysis windows, although they are near zero in the 18Z window.

The GOES16 18Z (evening) MVD and speed bias profiles do not separate as much as the GOES18 00Z (evening) stats, although counts are very low.









Try to Isolate Nonbeneficial SWIR AMVs

NESGOES16

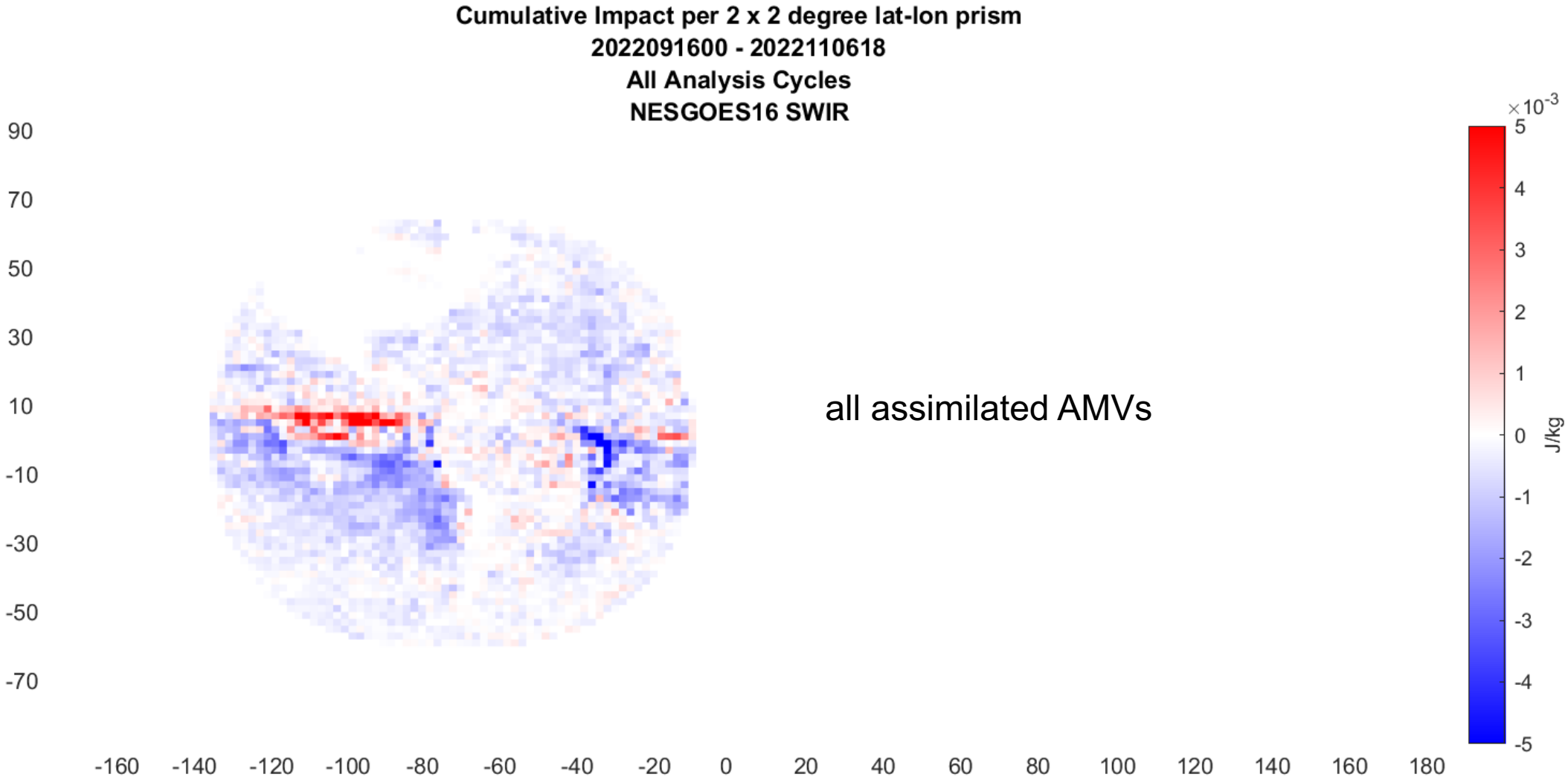
all assimilated AMVs

(first slide)

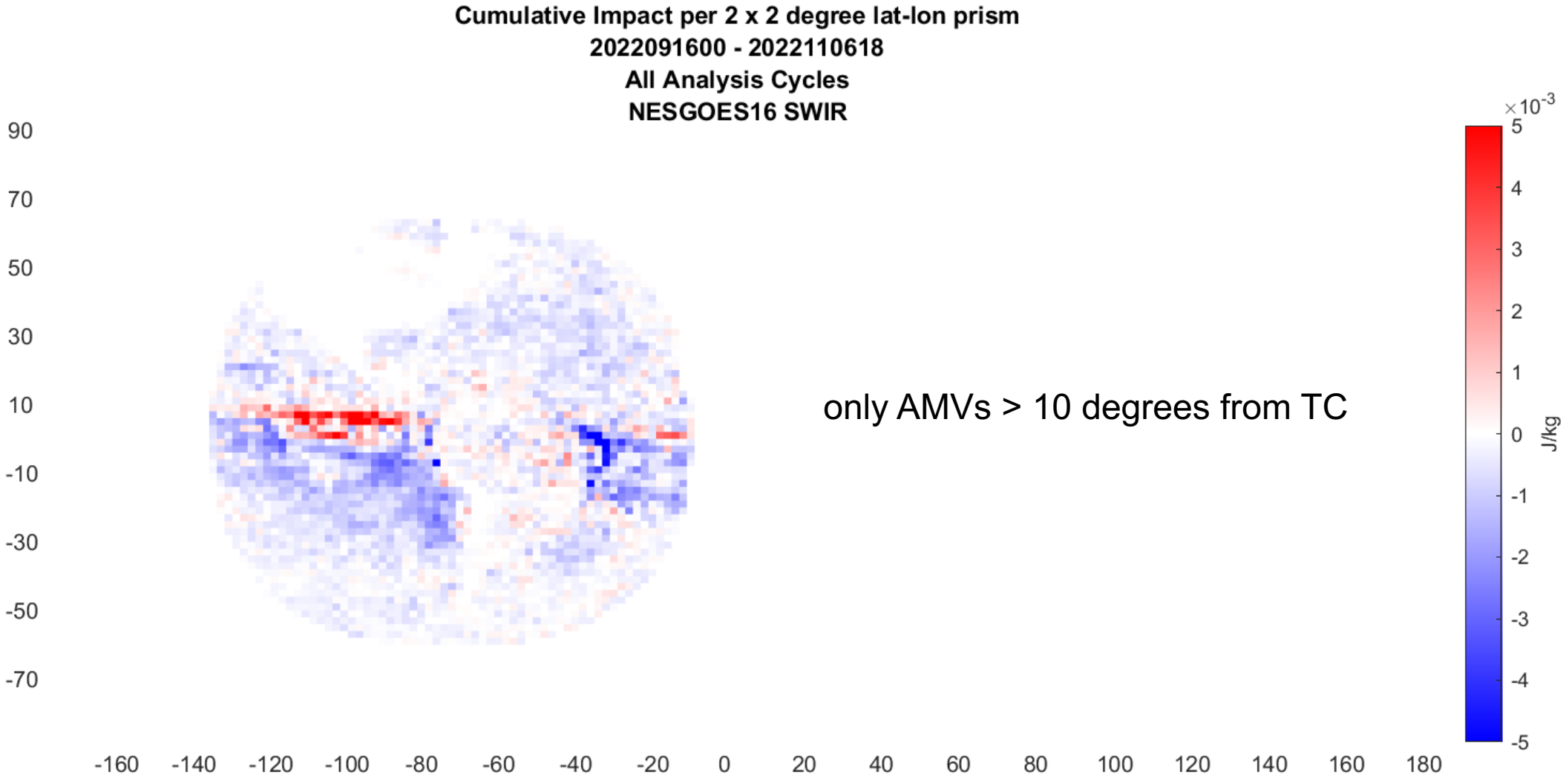
NESGOES16

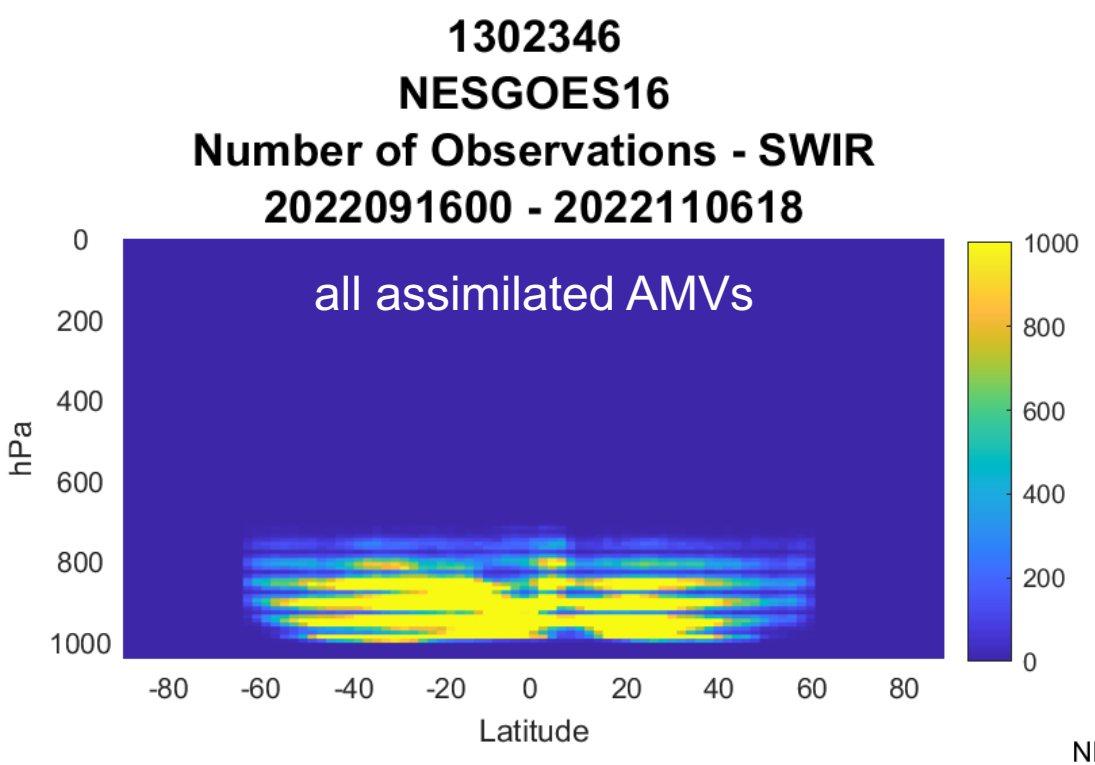
only AMVs > 10 degrees from TC

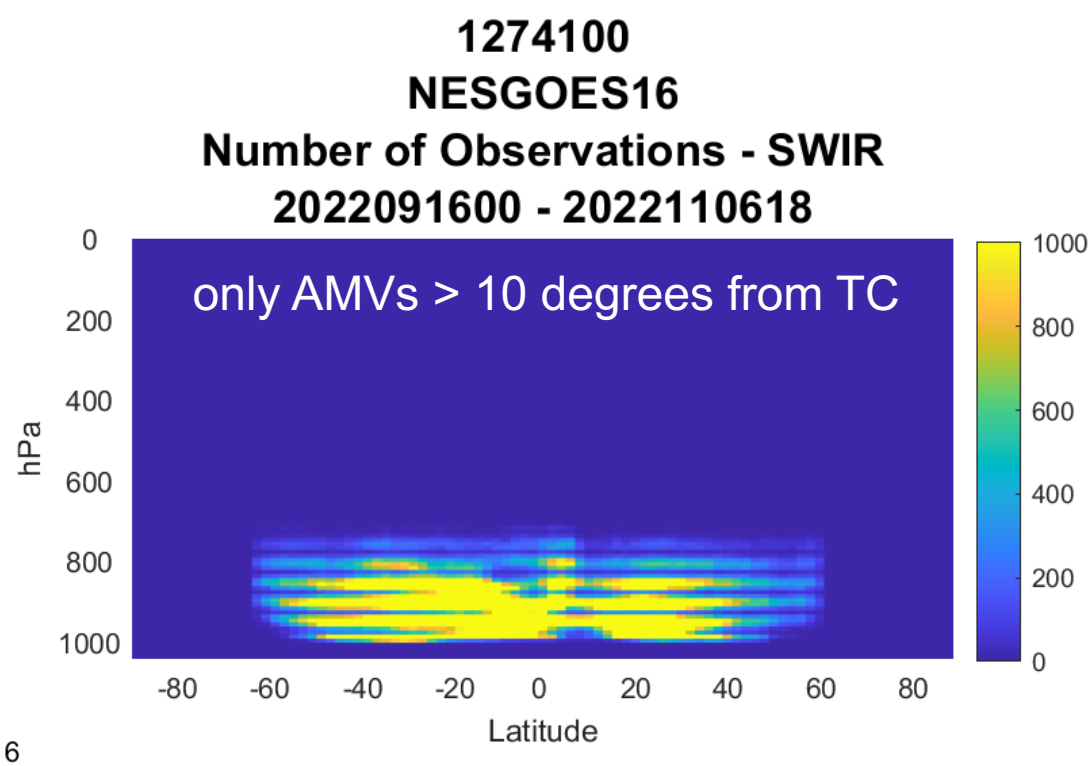
(next slide)



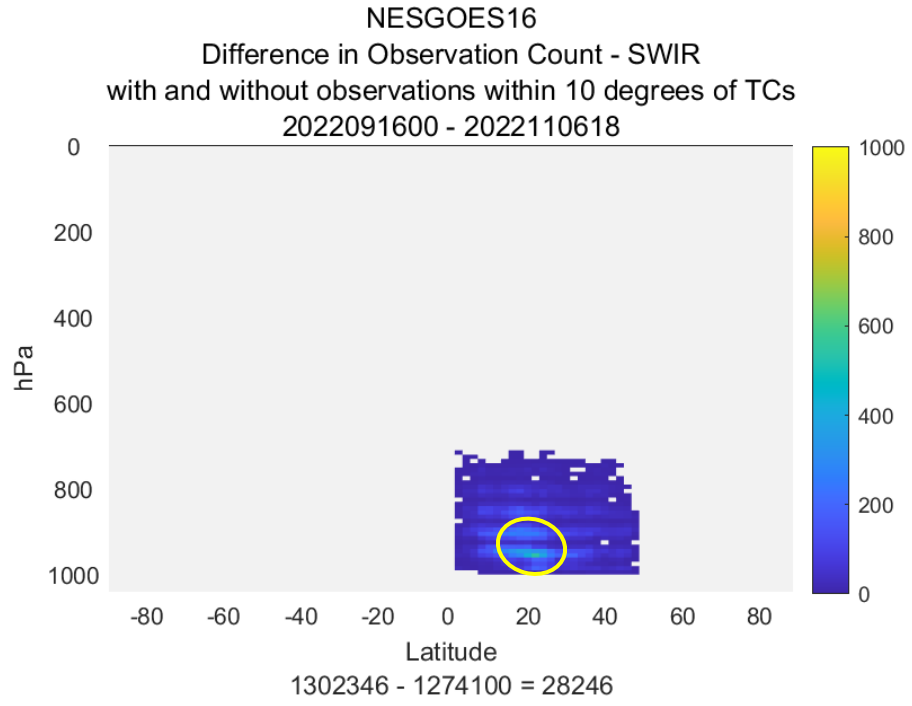
all assimilated AMVs


Cumulative Impact per 2 x 2 degree lat-lon prism
2022091600 - 2022110618
All Analysis Cycles
NESGOES16 SWIR
90
70
50
30
10
-10
-30
-50
-70
-160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180
×10-3
5
4
3
2
1
0
-1
-2
-3
-4
-5
J/kg
only AMVs > 10 degrees from TC

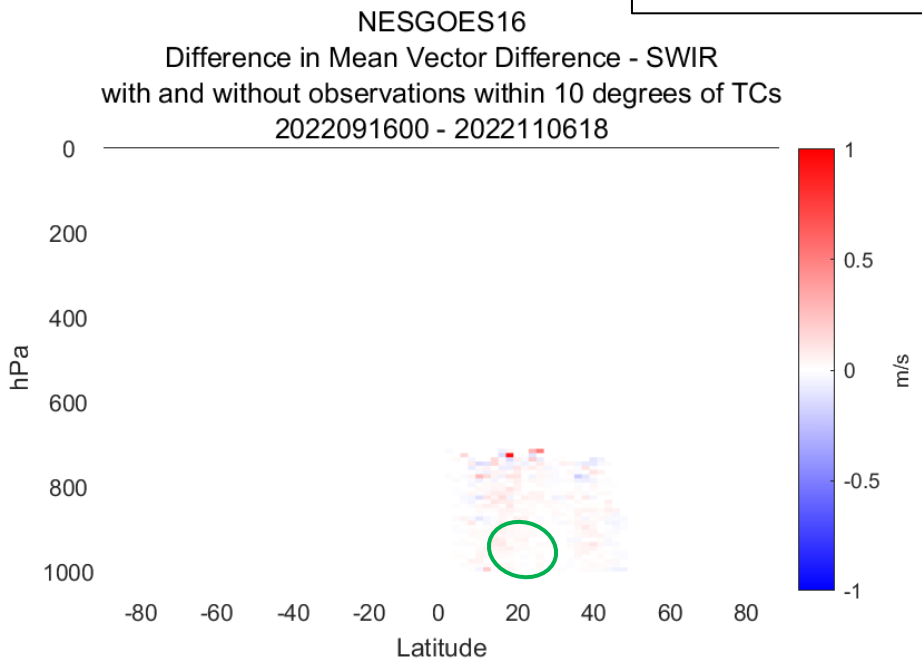


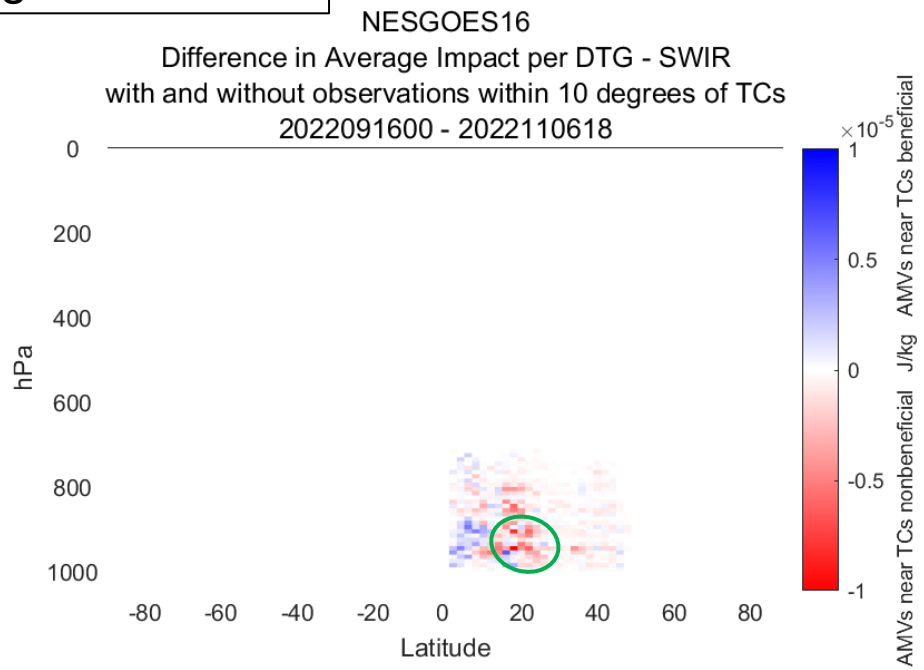


Most of the 28246 removed SWIR AMVs are below 850 hPa, and near 20 N.

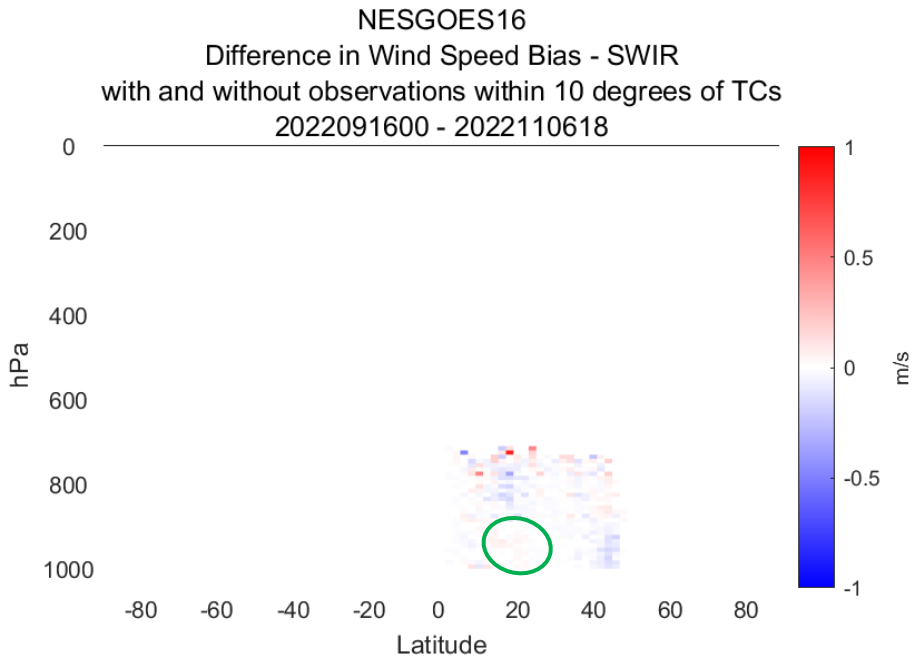


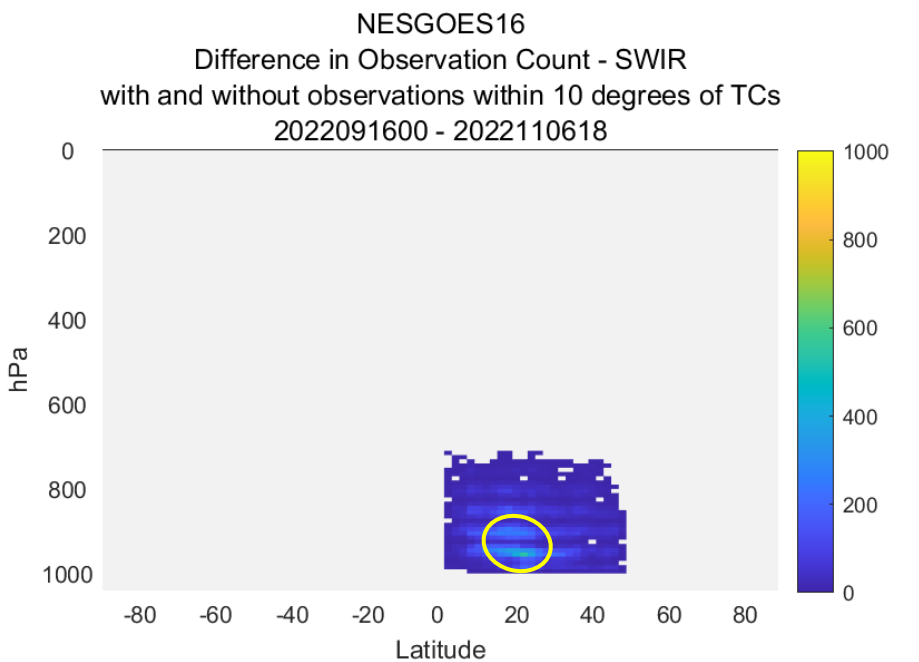
Differences due to AMVs > 10 degrees from TC

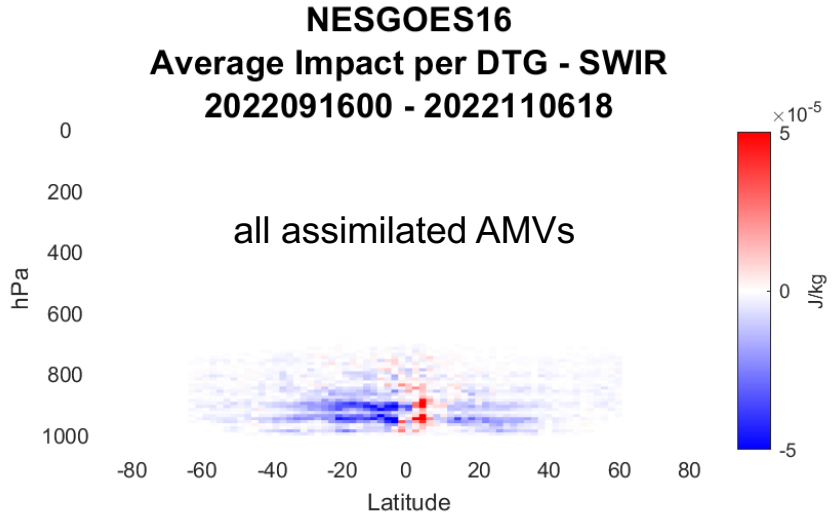


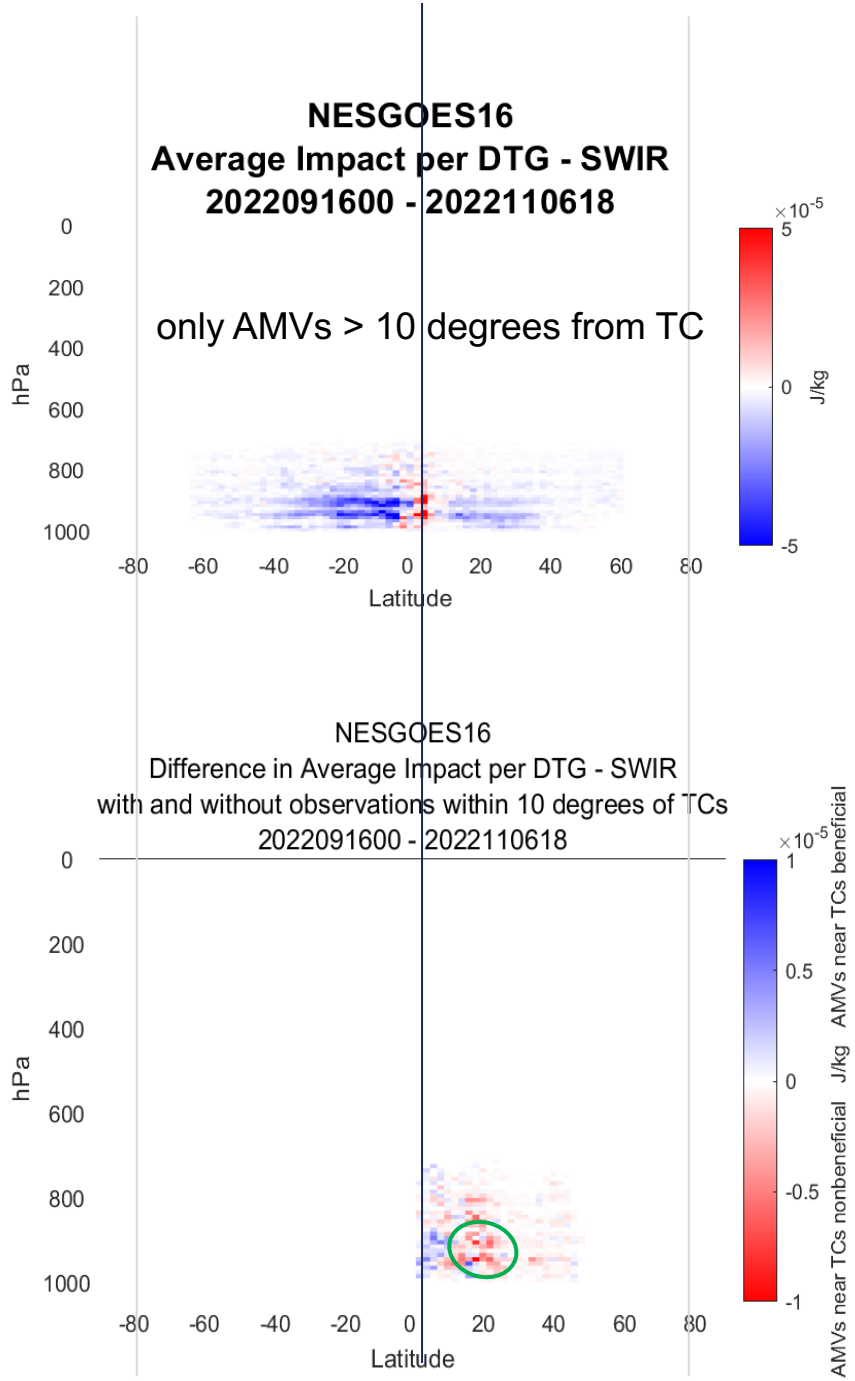


The removed SWIR AMVs are largely nonbeneficial, but they are not distinguished in MVD or wind speed bias.









The removed SWIR AMVs are largely nonbeneficial, but they are not at the location of the strongest cluster of nonbeneficial impacts.

Backup Slides

Compare Baseline and Enterprise Vector Differences

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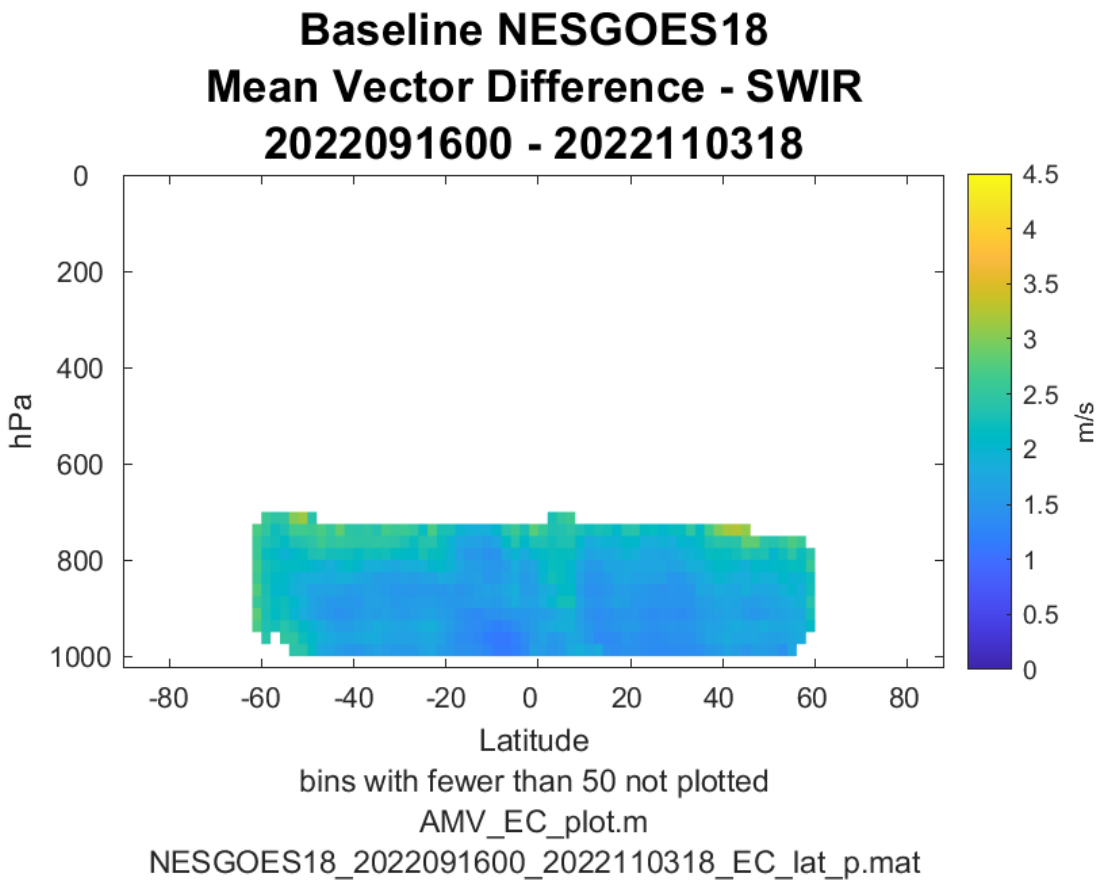
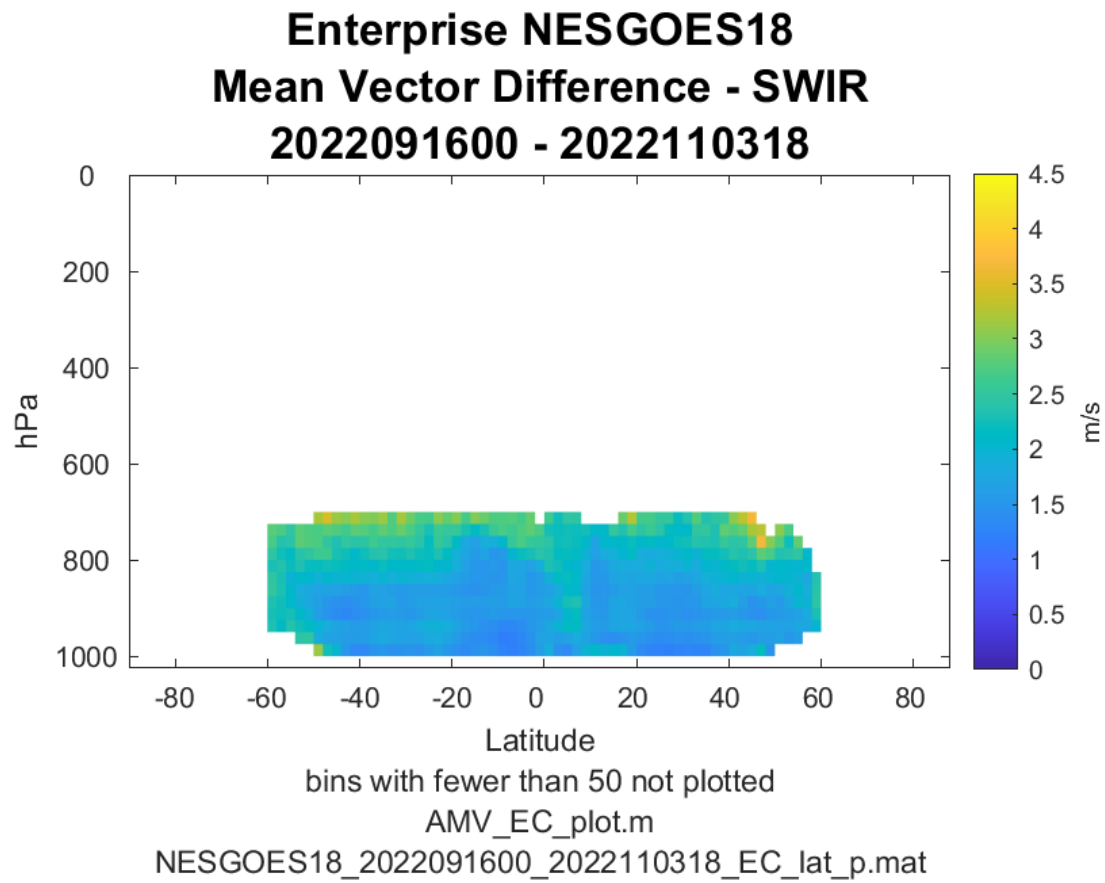
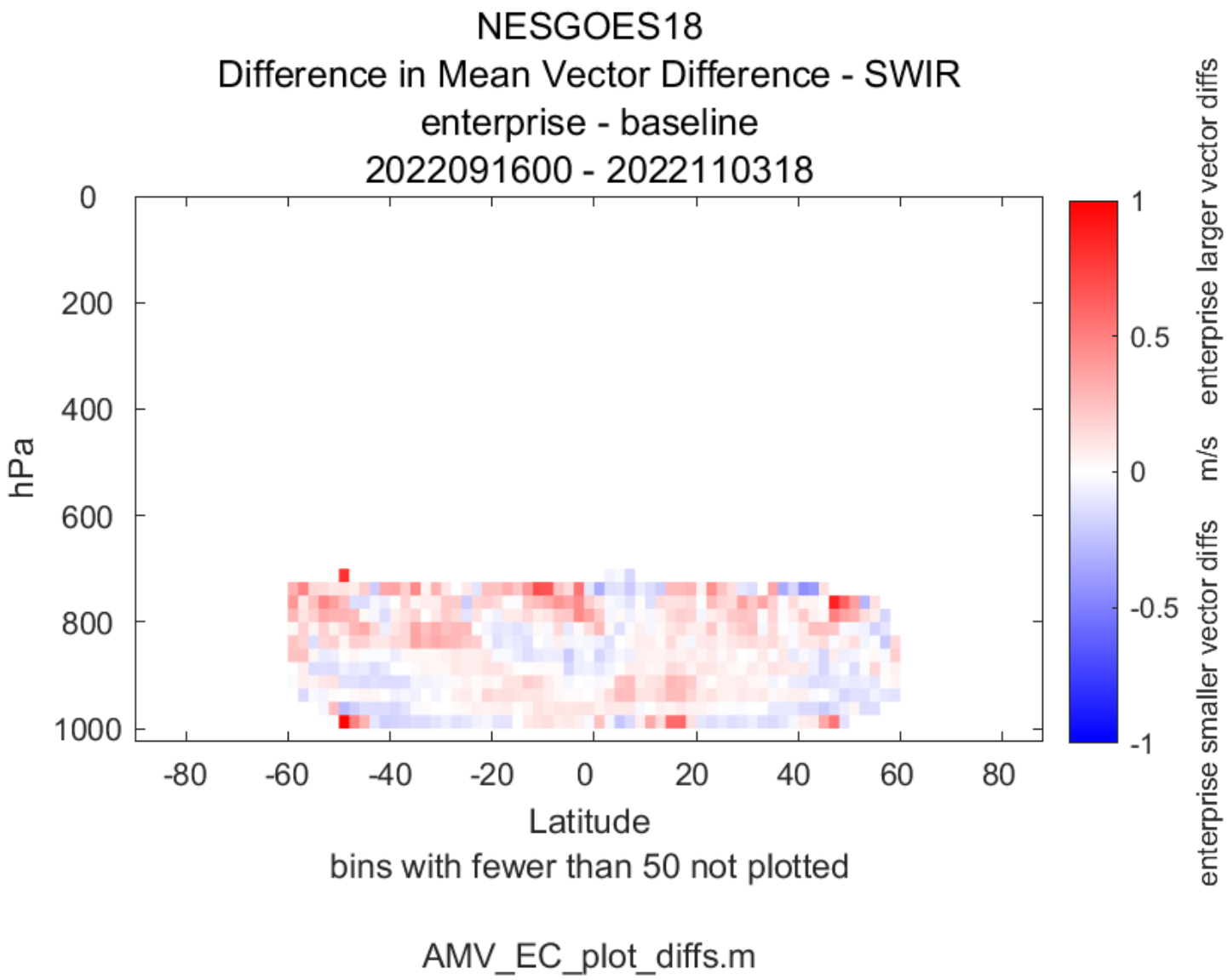
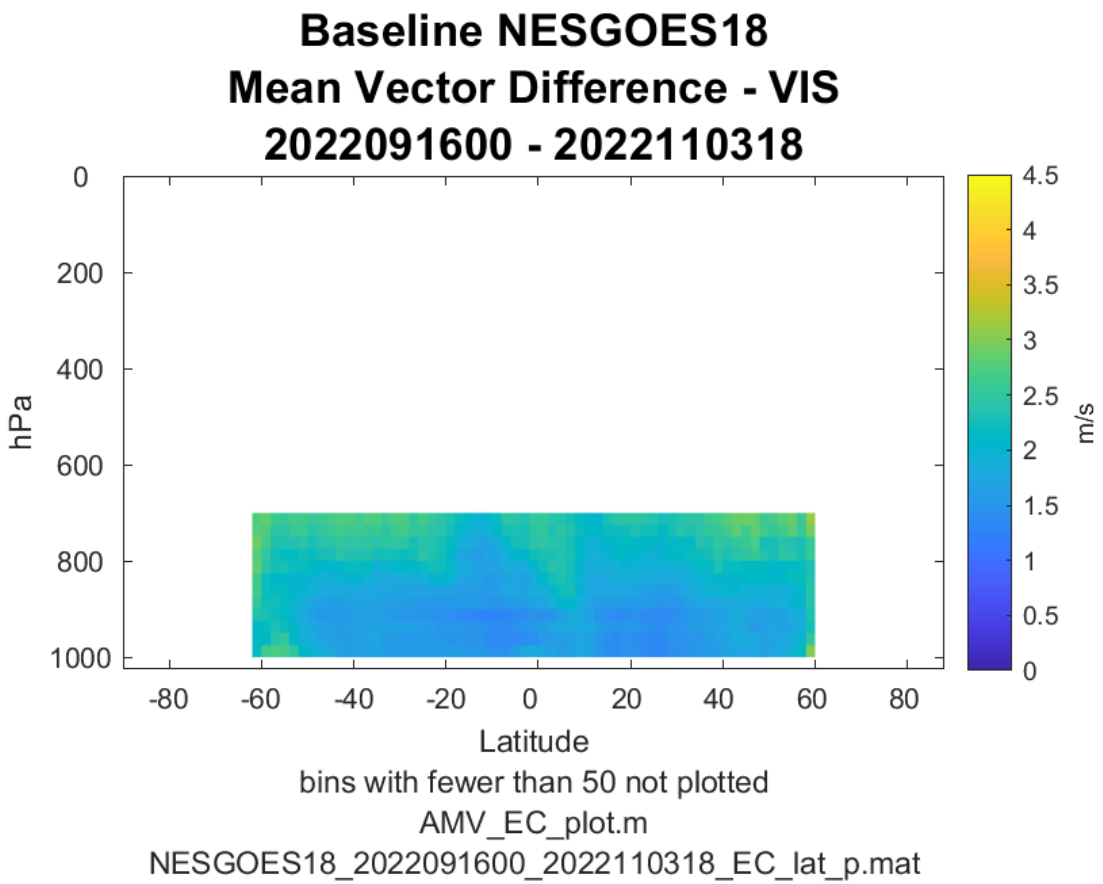
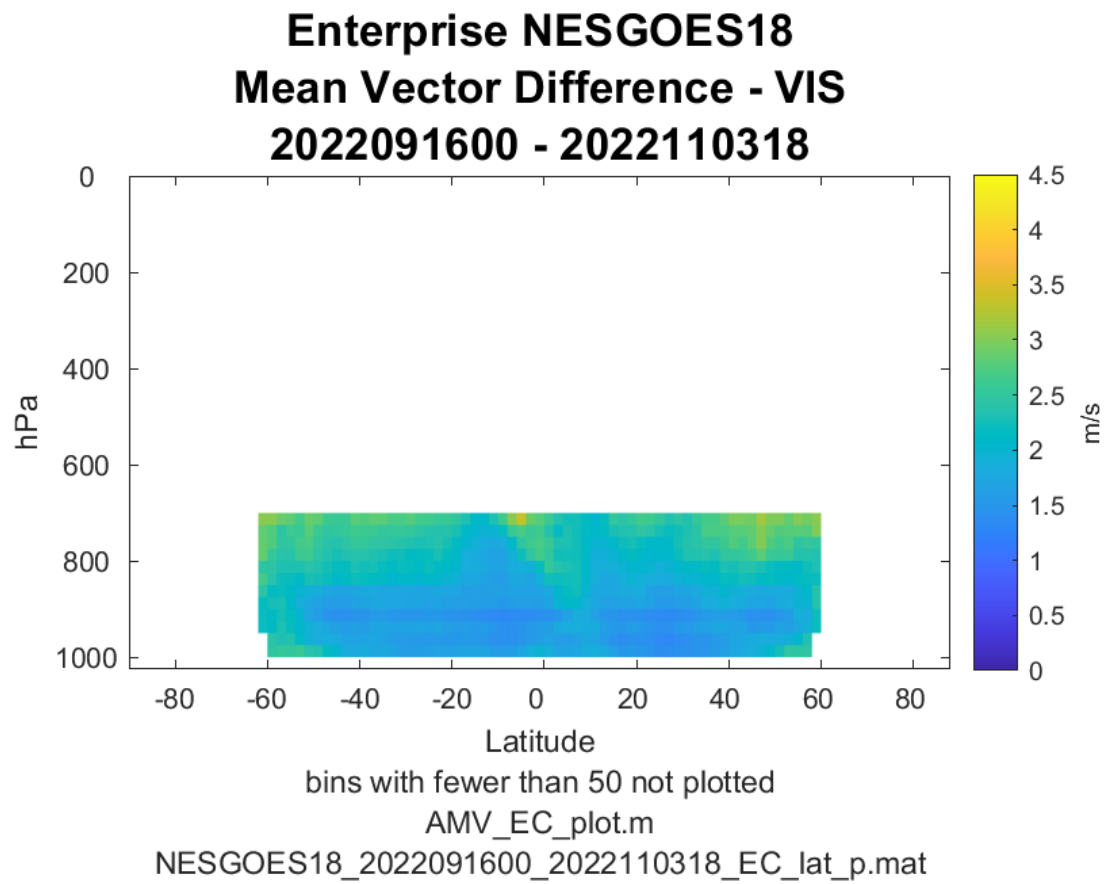

Baseline NESGOES18
Mean Vector Difference - SWIR
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
m/s
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat


Enterprise NESGOES18
Mean Vector Difference - SWIR
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
m/s
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat

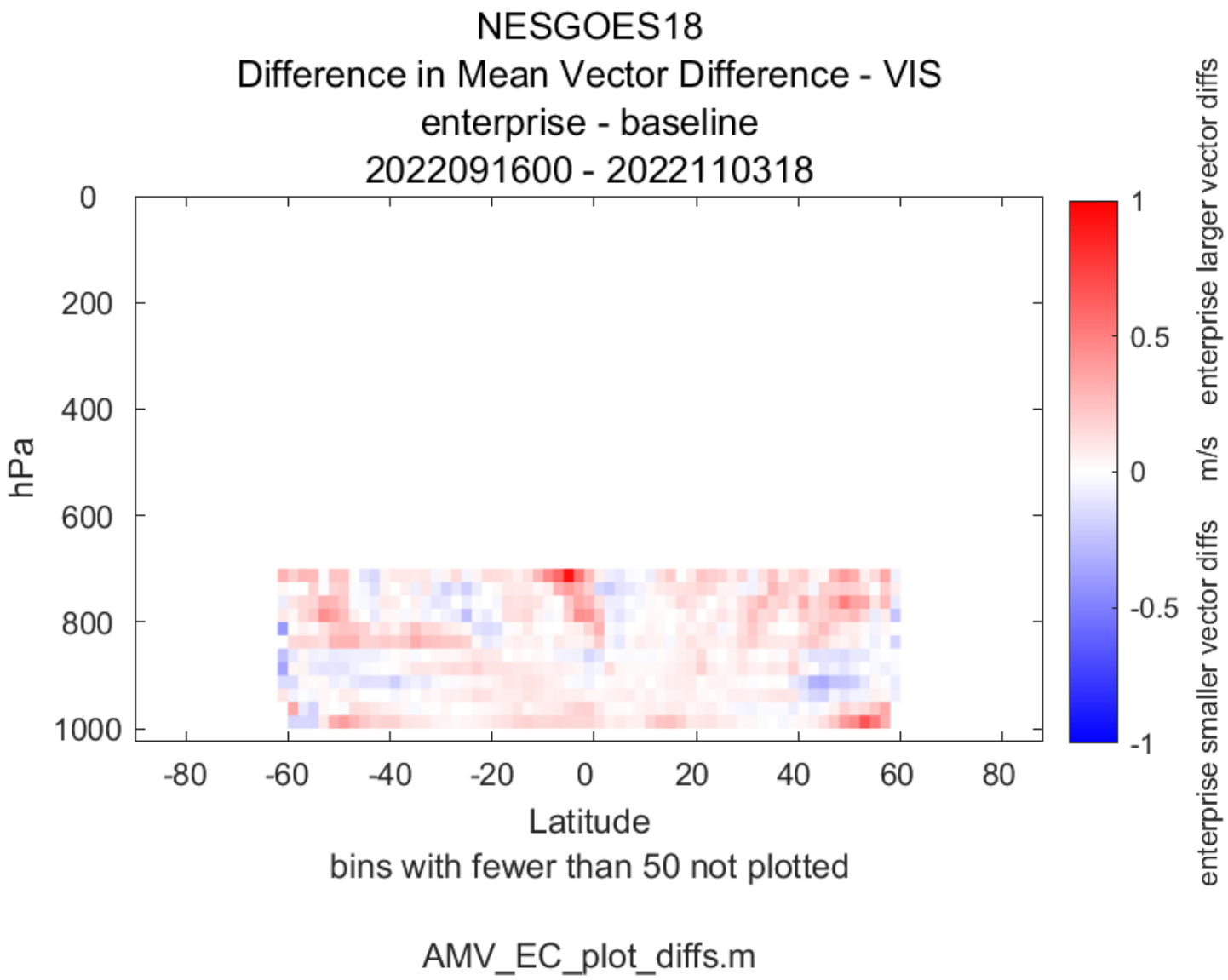
Contrast in OmB vector differences are scattered and fairly small.

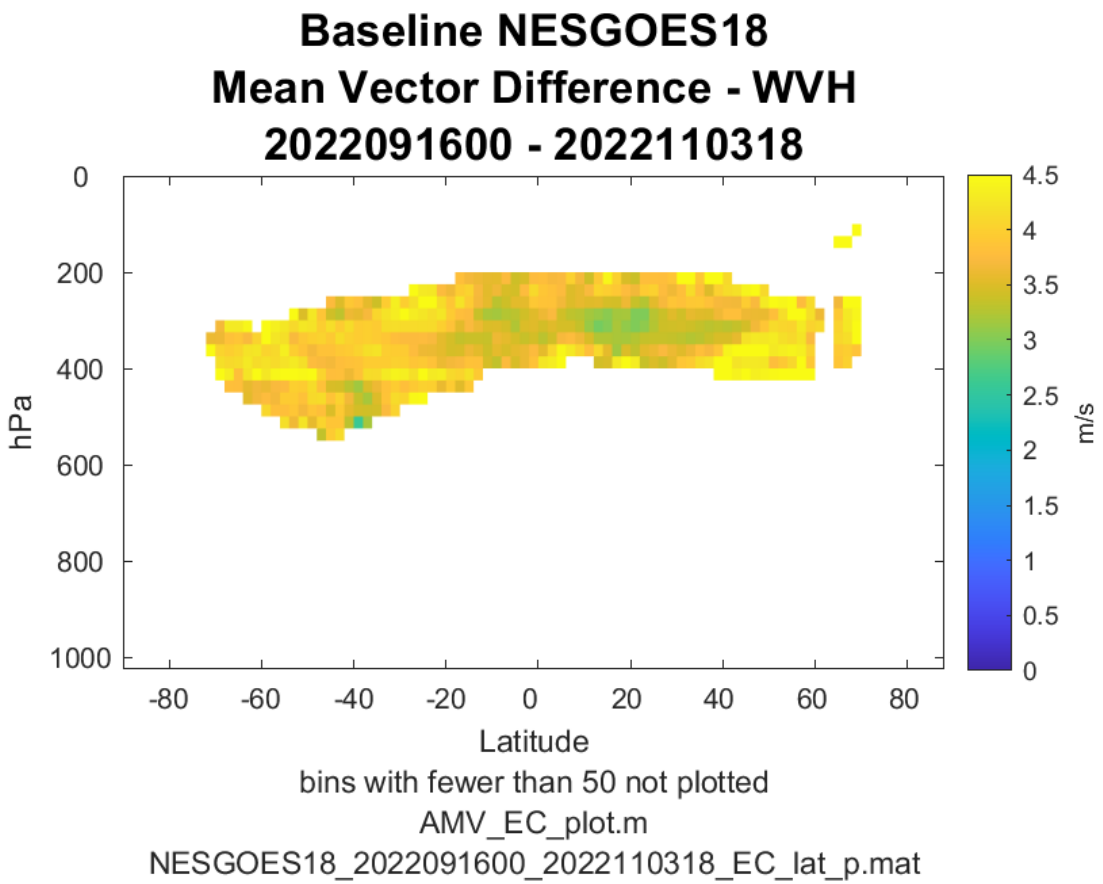


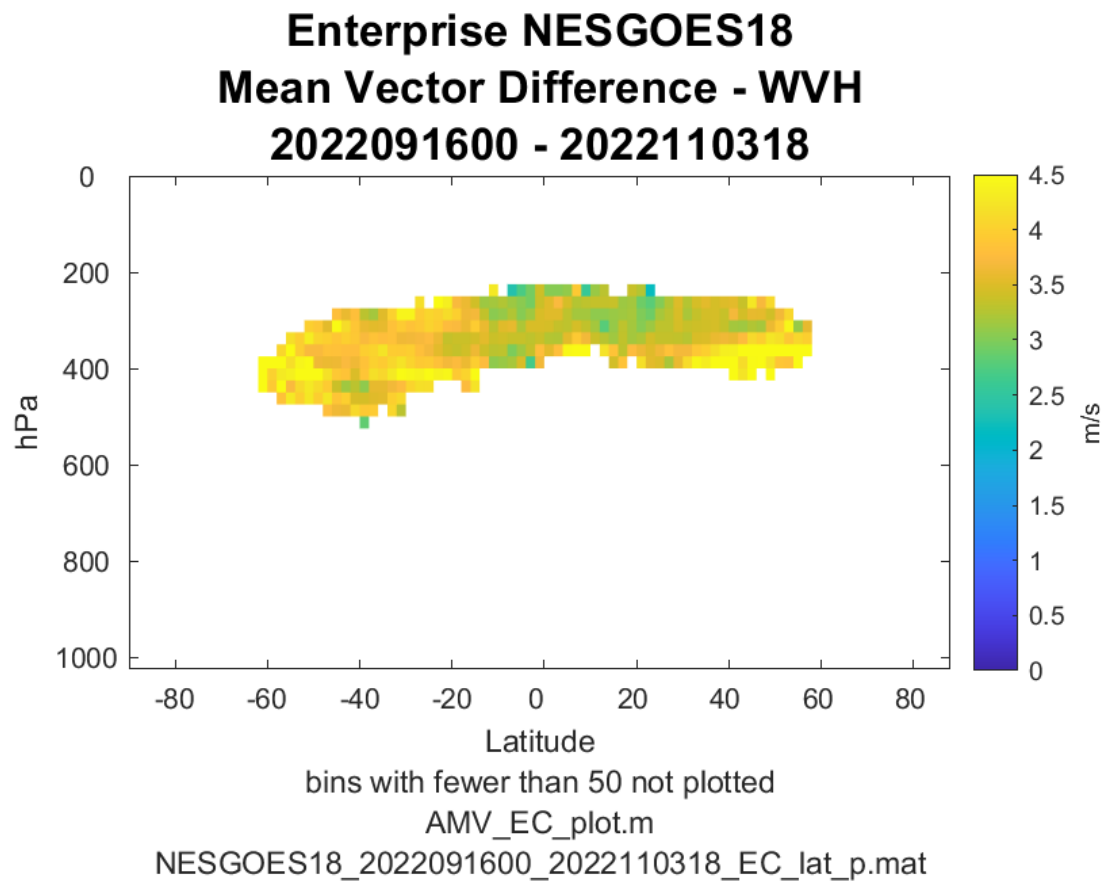

Baseline NESGOES18
Mean Vector Difference - VIS
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
m/s
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat


Enterprise NESGOES18
Mean Vector Difference - VIS
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
m/s
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat

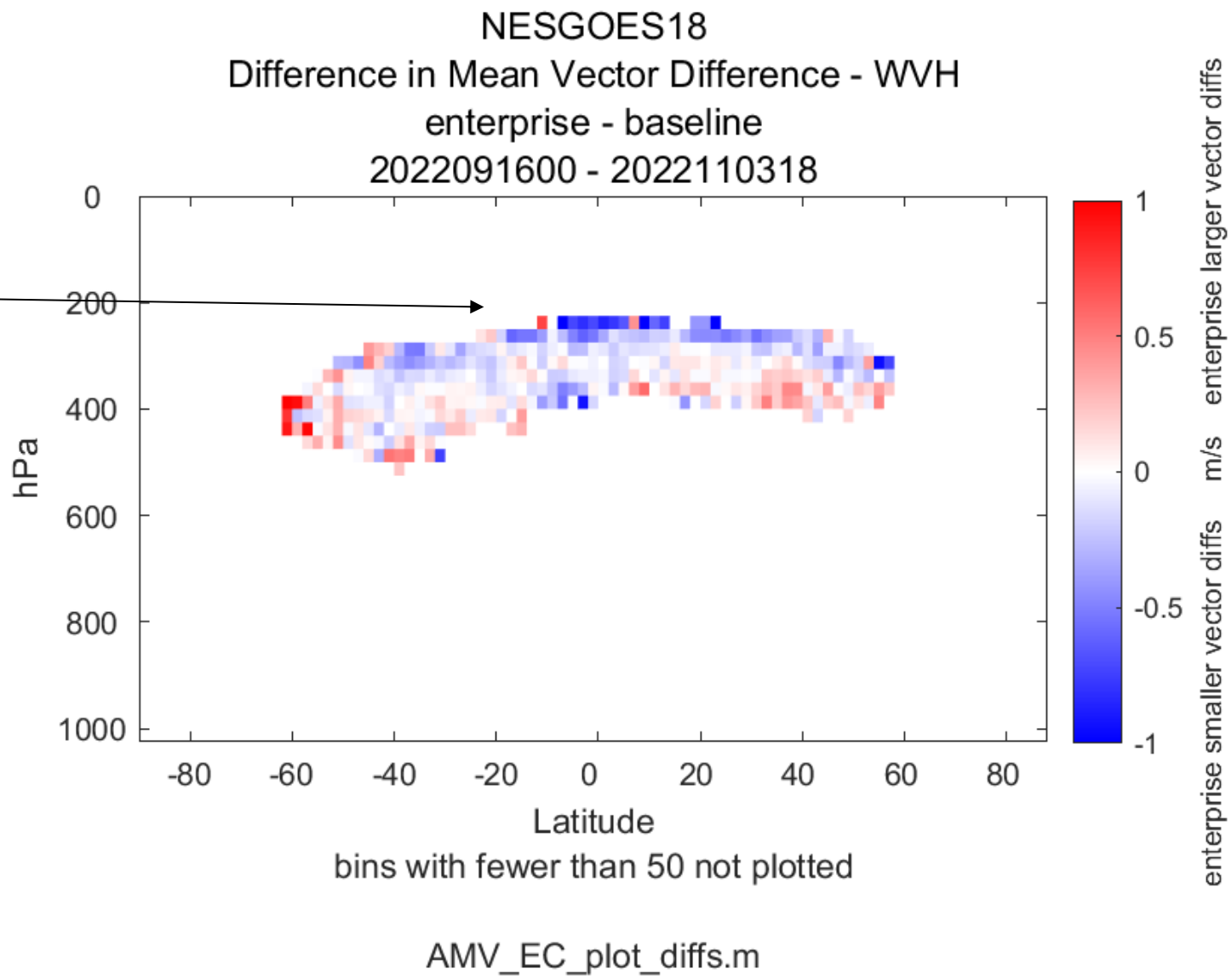
Contrast in OmB vector differences are scattered and fairly small.



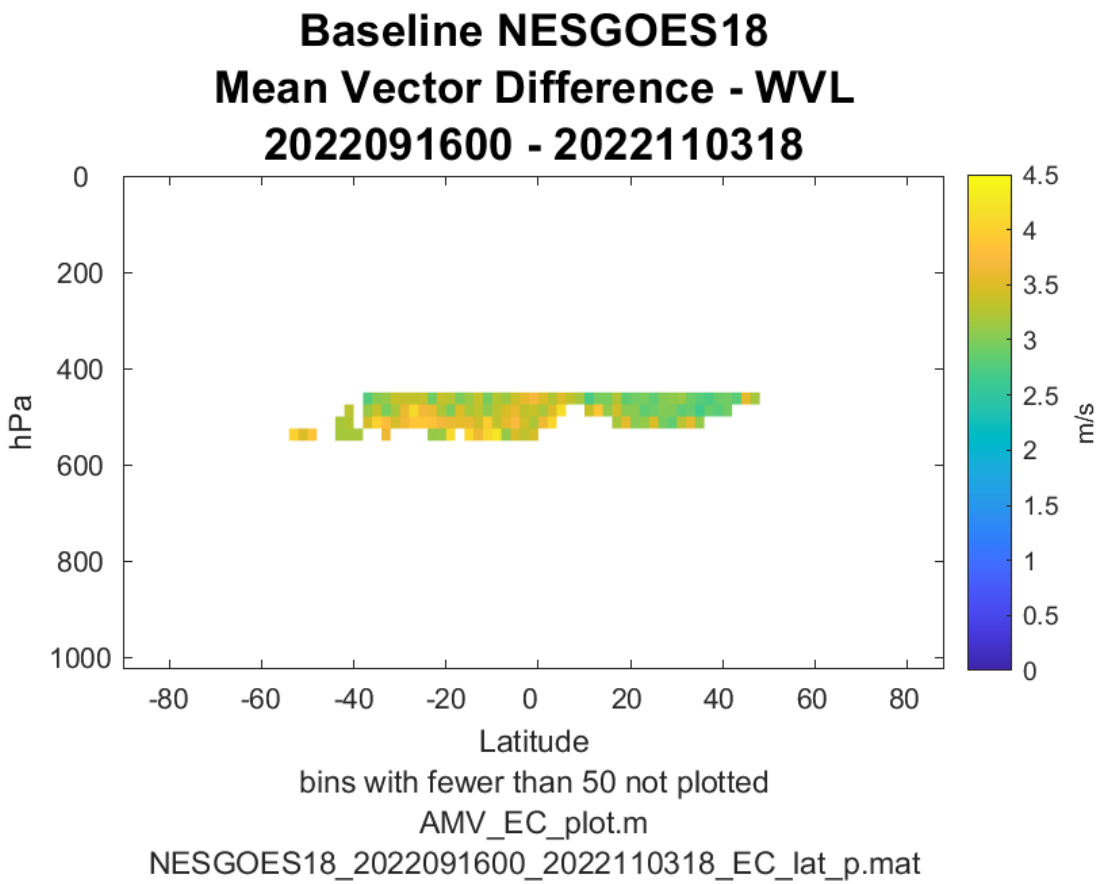

Baseline NESGOES18
Mean Vector Difference - WVH
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
m/s
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat

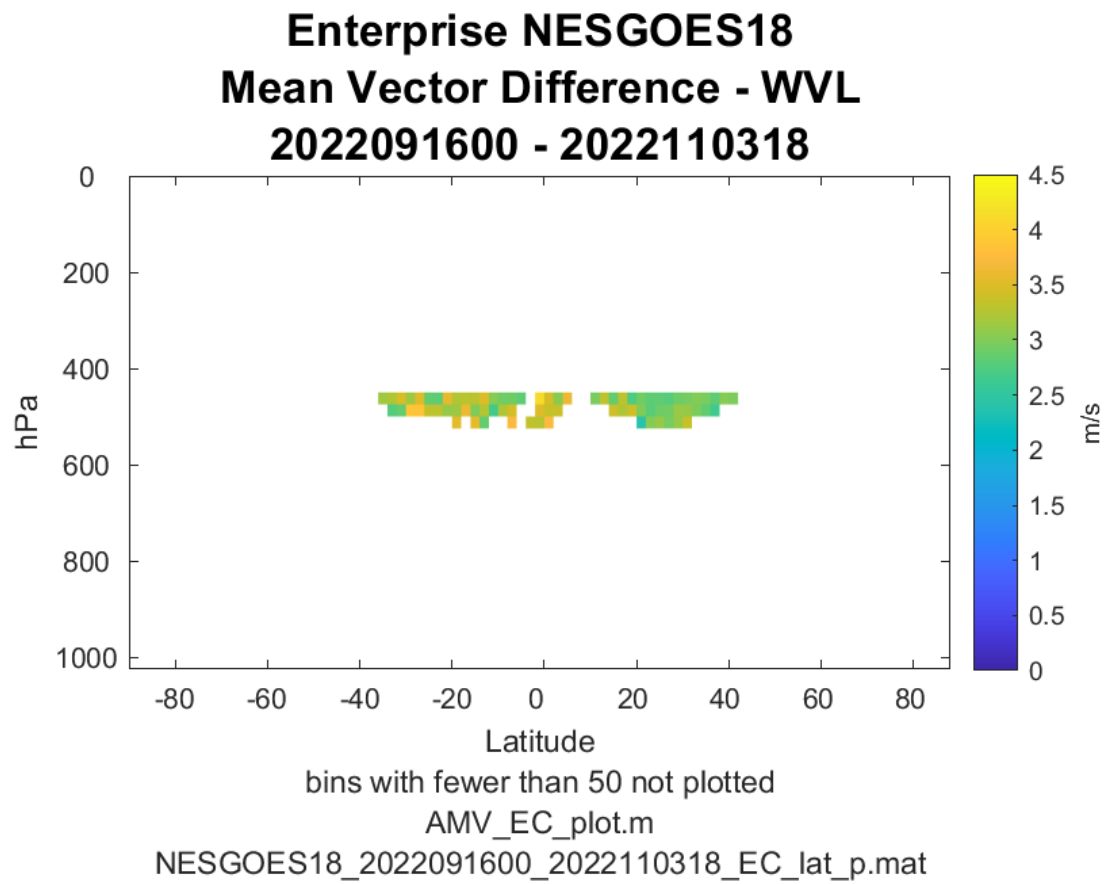

Enterprise NESGOES18
Mean Vector Difference - WVH
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
m/s
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat

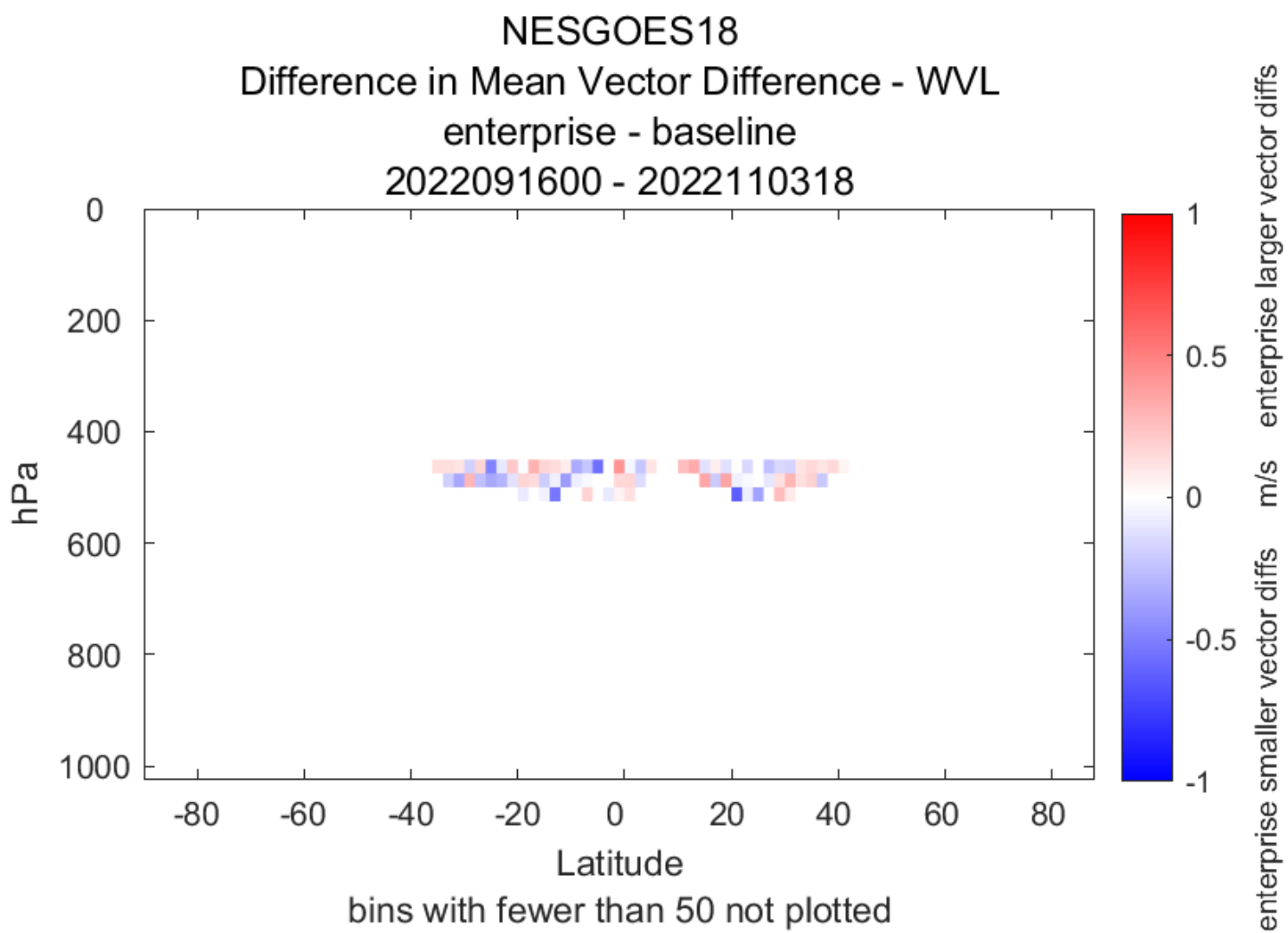
Smaller OmB vector differences (blue) near top of layer.



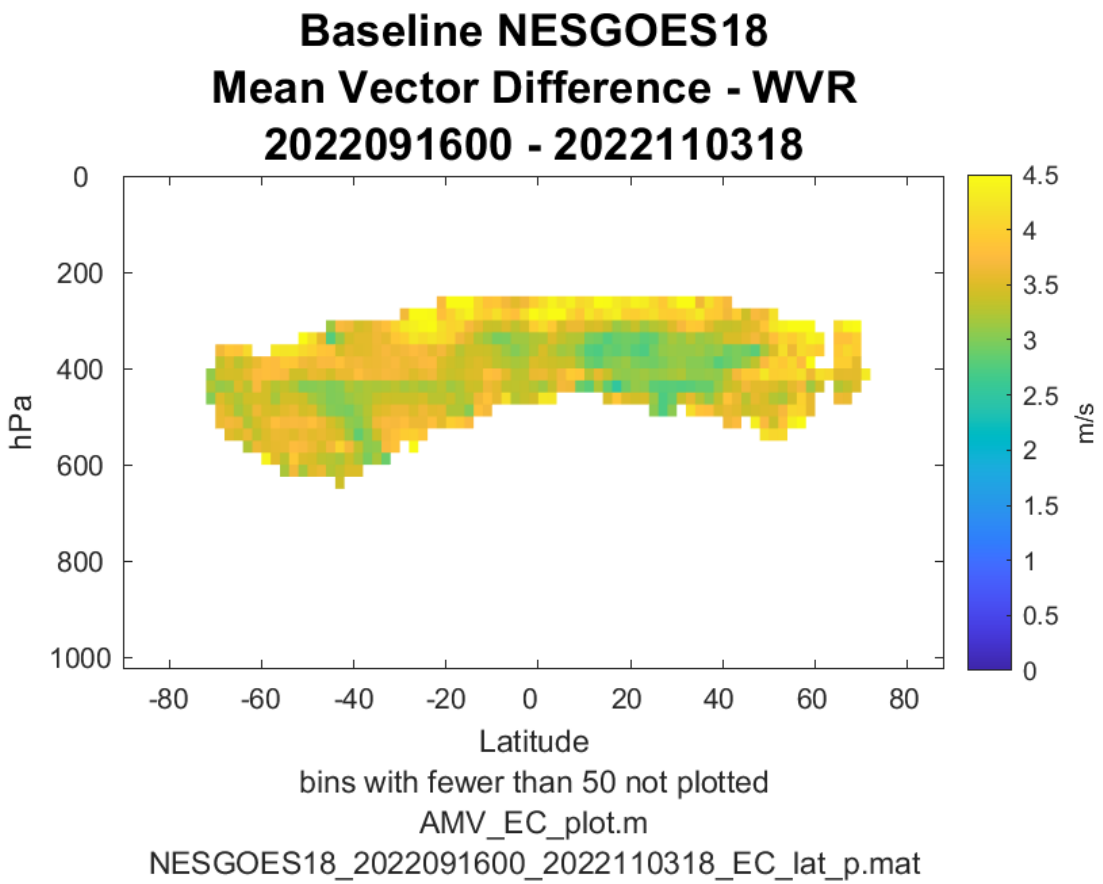
AMV_EC_plot_diffs.m

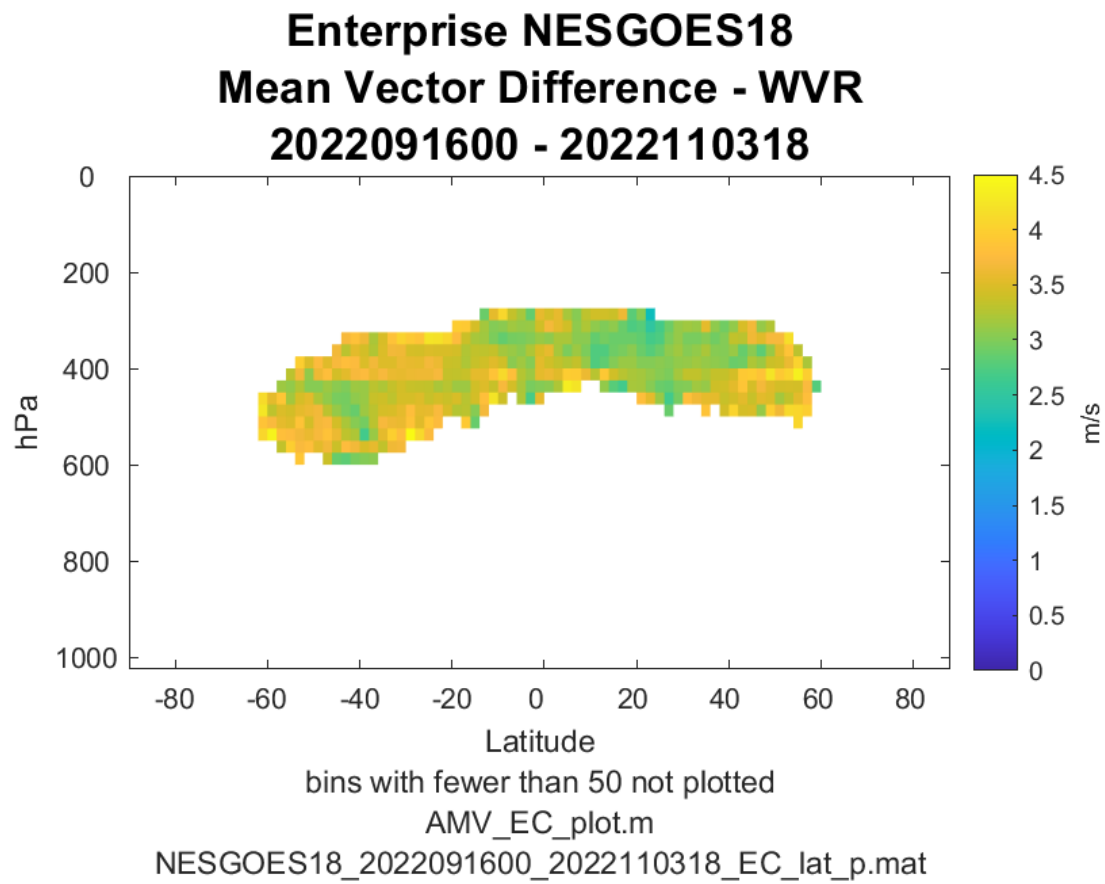

Baseline NESGOES18
Mean Vector Difference - WVL
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
m/s
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat


Enterprise NESGOES18
Mean Vector Difference - WVL
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
m/s
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat

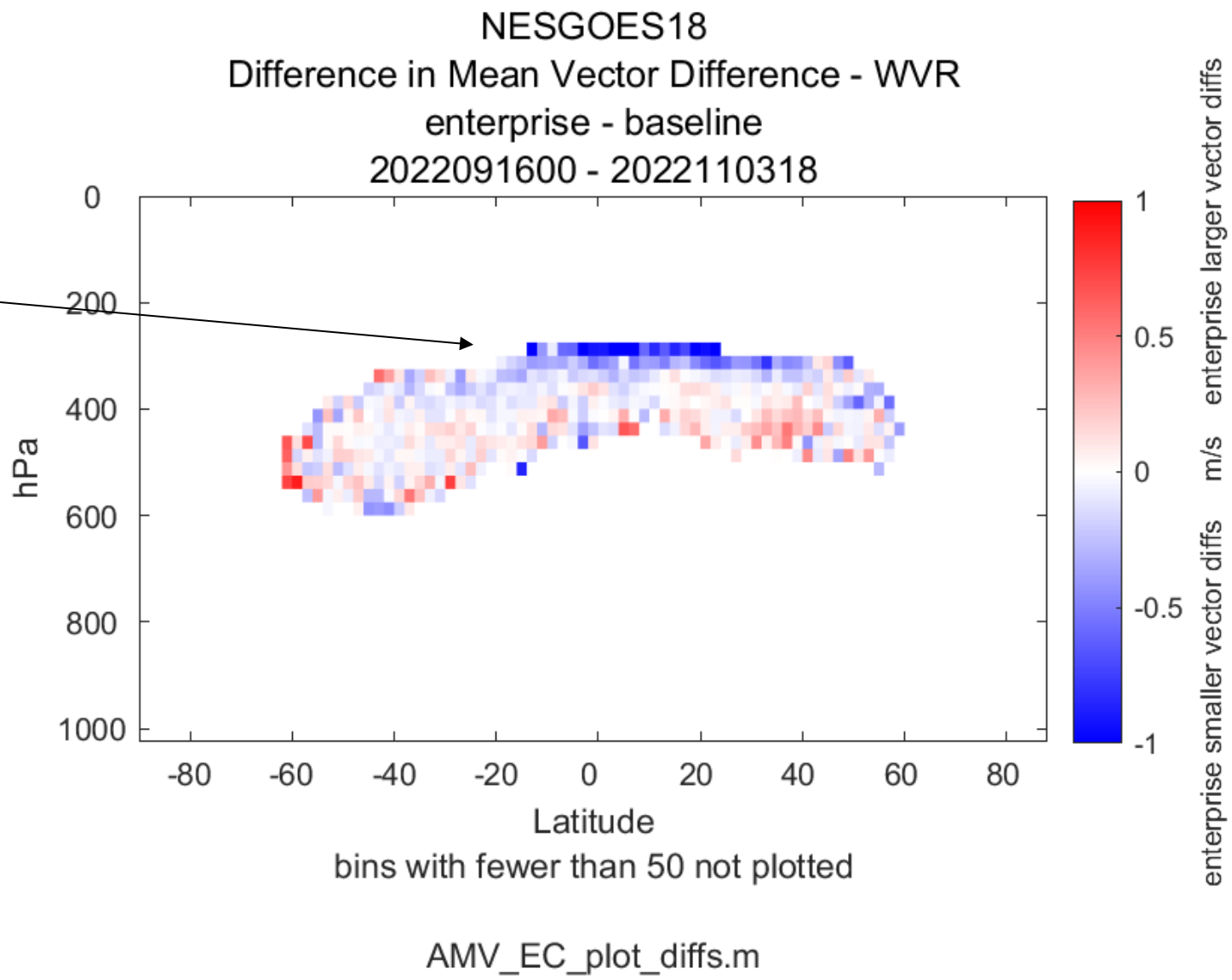


AMV_EC_plot_diffs.m


Baseline NESGOES18
Mean Vector Difference - WVR
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
m/s
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat


Enterprise NESGOES18
Mean Vector Difference - WVR
2022091600 - 2022110318
hPa
0
200
400
600
800
1000
-80
-60
-40
-20
0
20
40
60
80
Latitude
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
m/s
bins with fewer than 50 not plotted
AMV_EC_plot.m
NESGOES18_2022091600_2022110318_EC_lat_p.mat

Smaller OmB vector differences (blue) near top of layer.



AMV_EC_plot_diffs.m