Recent and Upcoming Changes in Satellite Wind Usage in U.S. Navy NWP

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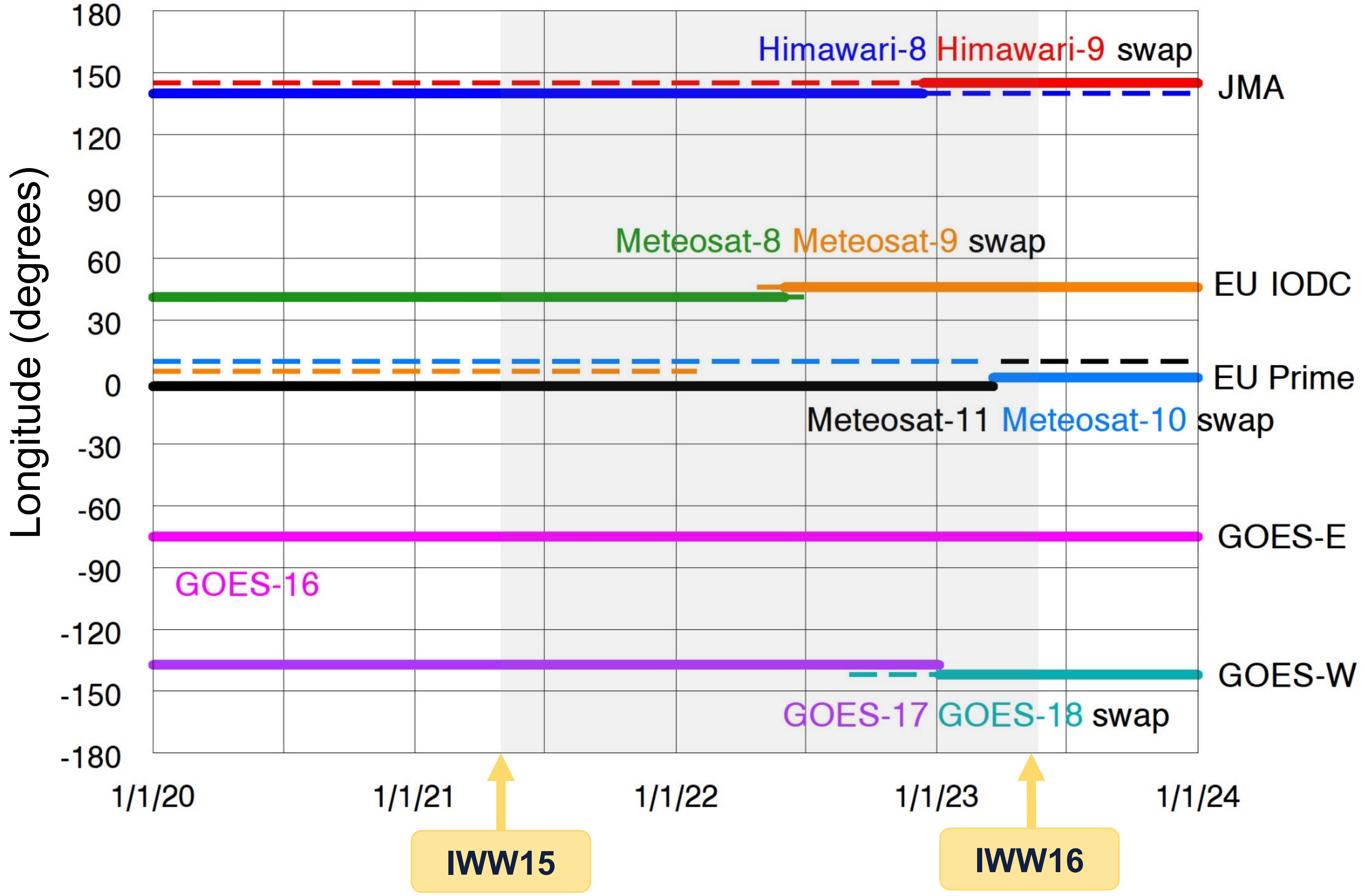
Overview



Significant satellite changes since IWW15!

- GEO satellite swaps (within series)
- KOMPSAT-2A
- Metop-A to Metop-C
- NESDIS switch to NCCF
- New UW VIIRS products
- U.S. Navy changes to satwind DA

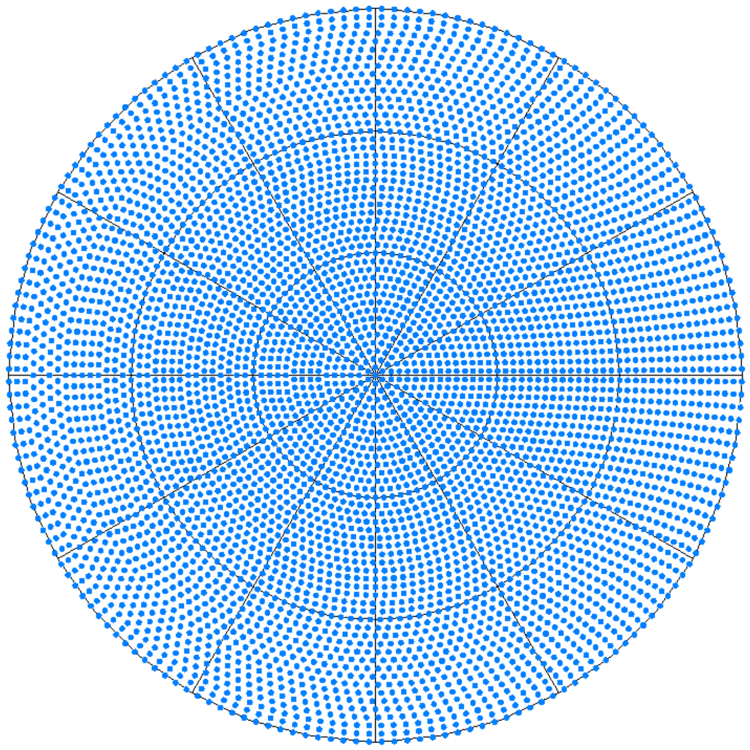
Satwinds in NAVGEM

NAVGEM: Navy Global Environmental Model

- FNMOC OPS: T681L60
- NRL test: T425L60

Satwind processing

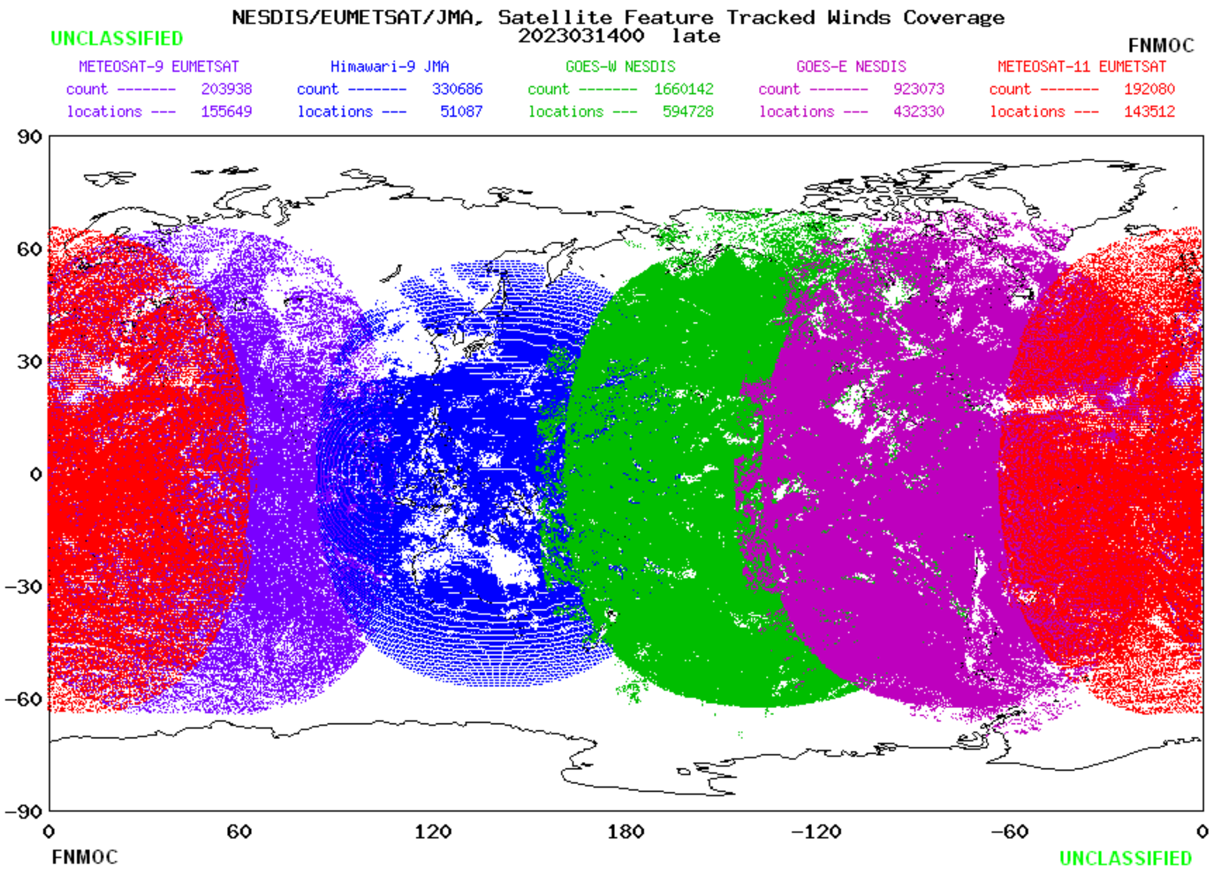
- Superobs computed separately for each satellite, each channel, each data provider
- Obs collected within a prism, one-hour time window, and 50 hPa layer
- Prisms quartered horizontally with superobbing attempted in each quarter when obs too disparate



2° grid "prisms" used for superobs

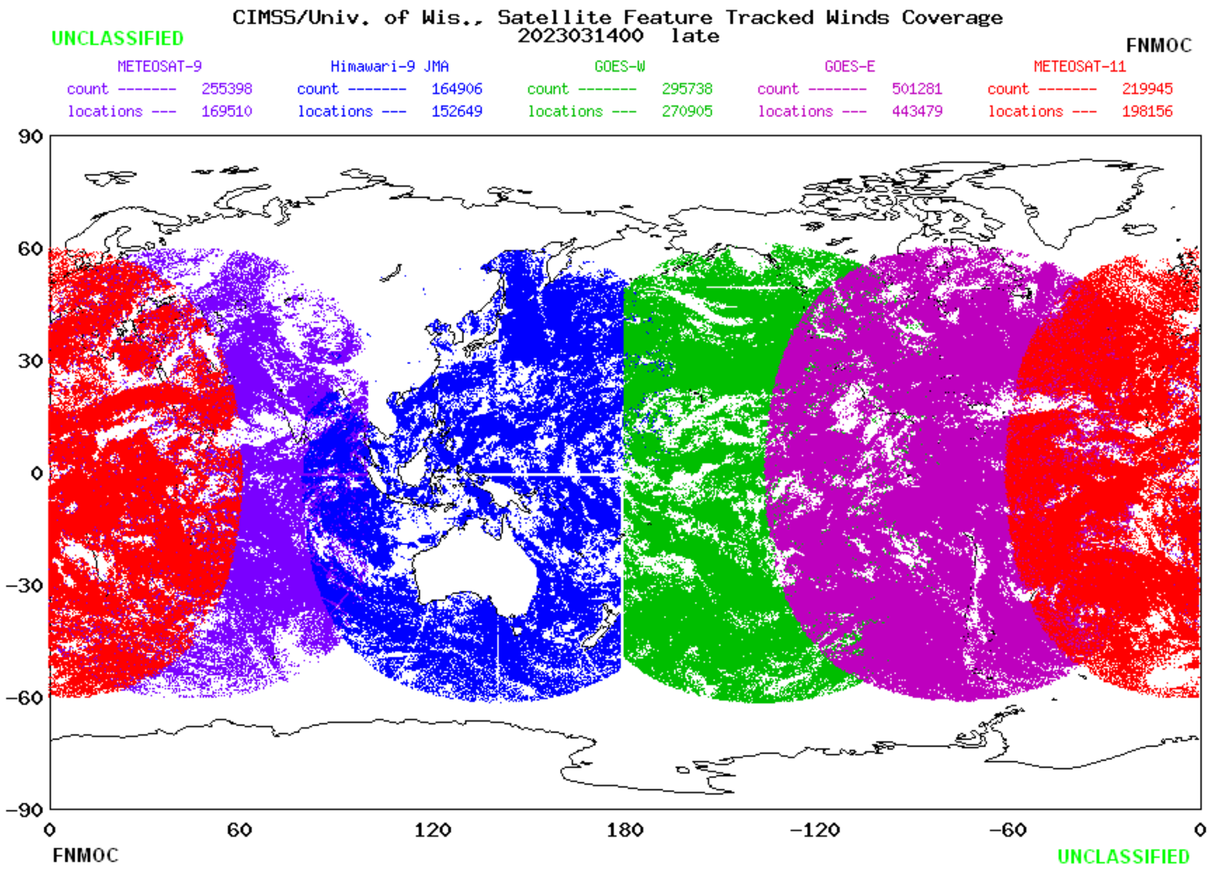
Satwinds in NAVGEM

Geo AMVs from Operational Providers



Processed by NESDIS, EUMETSAT, JMA

Geo AMVs from UW CIMSS



Same satellites as left, but processed by UW CIMSS

Note: Superobs offset horizontally by ½ prism

U.S. NAVAL RESEARCH LABORATORY

Meteosat Swaps

Meteosat-8 ⟶ Meteosat-9 (Jun 2022)

Meteosat-11 ⟶ Meteosat-10 (Mar 2023)

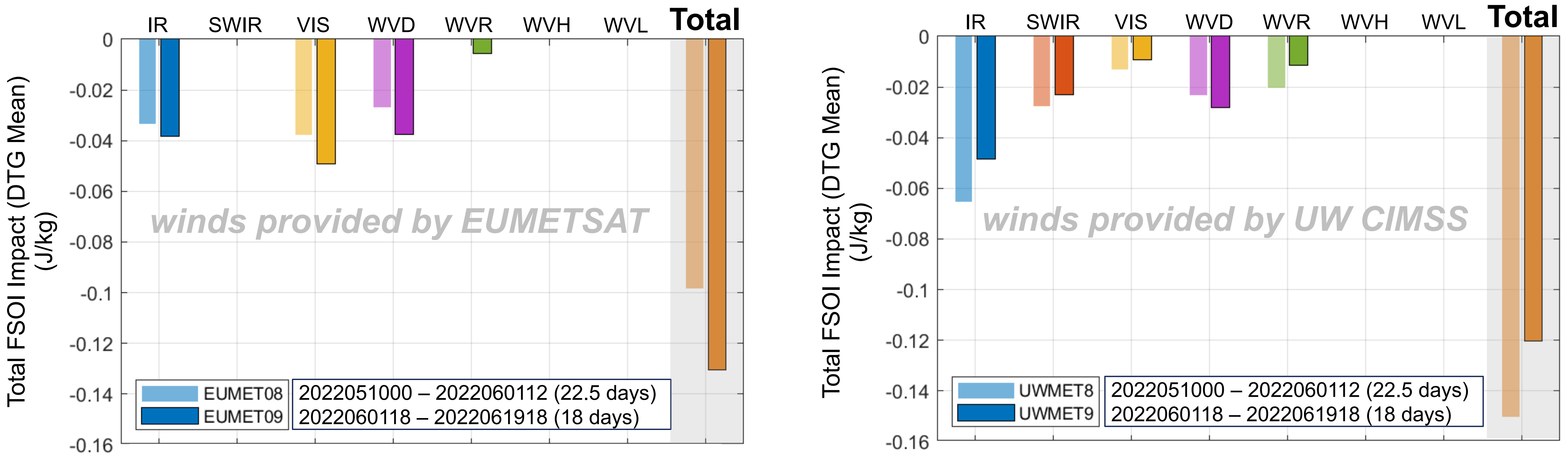
- Replacement with *previously used* satellites within the same series
- No changes in formatting/processing by data providers
- No changes in NRL/FNMOC satwind code required
- Switchovers occurred with minimal problems on 1 June 2022 and 21 March 2023
- Given available resources, full assimilation tests deemed unnecessary

The following plots compare before and after statistics from FNMOC ops.

Differences may be due to comparing different periods.

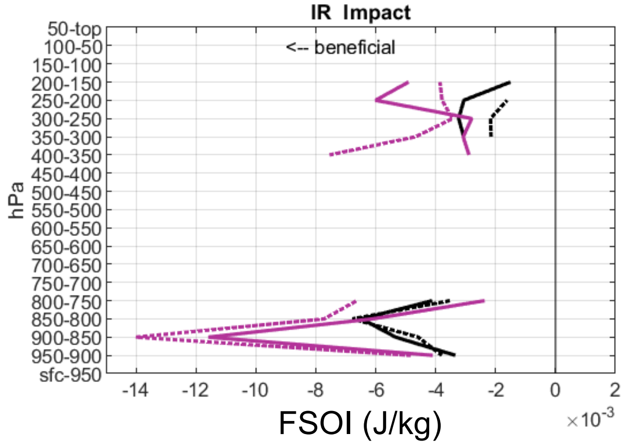
Meteosat-8/9 Swap

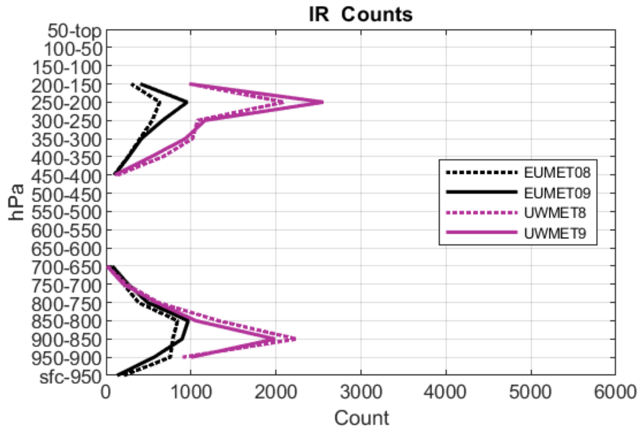
Comparison of FSOI by channel for MET09 vs MET08

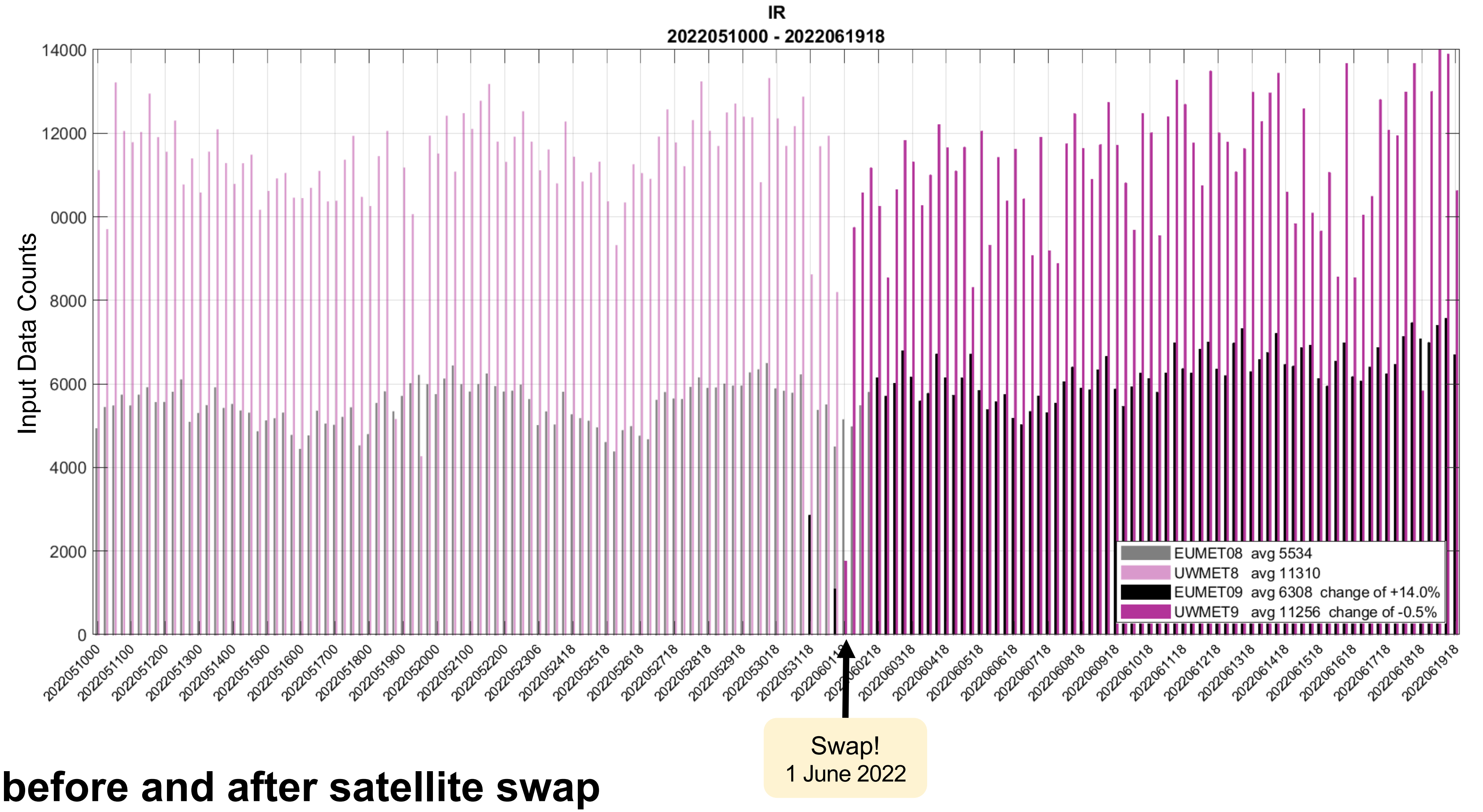


- Negative FSOI indicates beneficial impact (measure of error reduction in 24-hr forecasts due to assimilating obs).
- Increased beneficial impact for EUMETSAT winds from all channels.
- Decreased beneficial impact for UW from most channels, although cloud-top water vapor impact increased.
- Total impact (orange) shows more beneficial for MET09 for EU (left) but less beneficial for UW (right) for MET09.

Meteosat-8/9 Swap







Comparison of IR AMVs before and after satellite swap

- Both EUMETSAT and UW datasets show an *increase in counts aloft for MET09*
- EUMETSAT impact for MET09 is more beneficial, but change in UW impact is mixed

Himawari-8/9 Swap

Himawari-8 → Himawari-9 (Dec 2022)

- Replacement with *previously used* satellite within the same series
- No changes in processing by JMA, but UW CIMSS switched to “Enterprise” software
  - “Enterprise” software: “NOAA Framework Enterprise Wind and Cloud Algorithms”
  - Note that the CIMSS continues to use their “heritage” auto-editor for large-scale wind products

Himawari-8/9 Swap

Himawari-8 → Himawari-9 (Dec 2022)

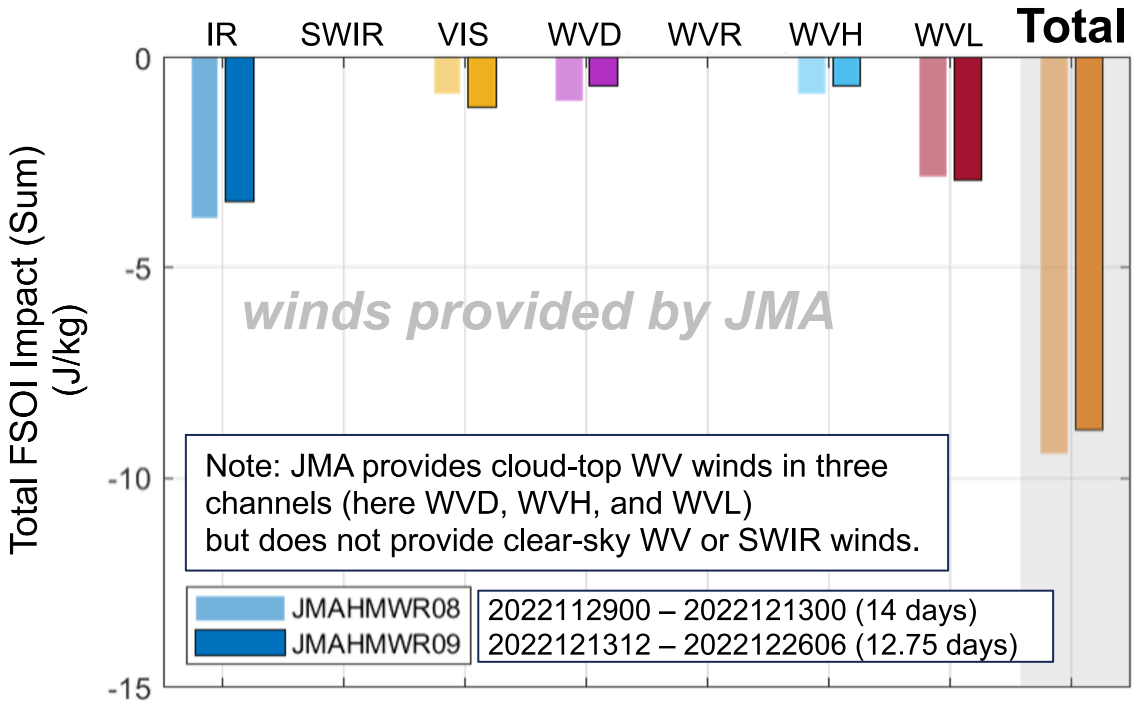
- Replacement with previously used satellite within the same series
- No changes in processing by JMA, but UW CIMSS switched to “Enterprise” software
- No changes in NRL/FNMOC satwind code required
- Switchover occurred with minimal problems on 13 December 2022
- Assimilation tests performed but not shown here
  - Limited experiment substituting HMWR09 for HMWR08 had virtually the same counts, MVD, and speed bias for IR AMVs as the control using HMWR08 for 2022100200-2022100318

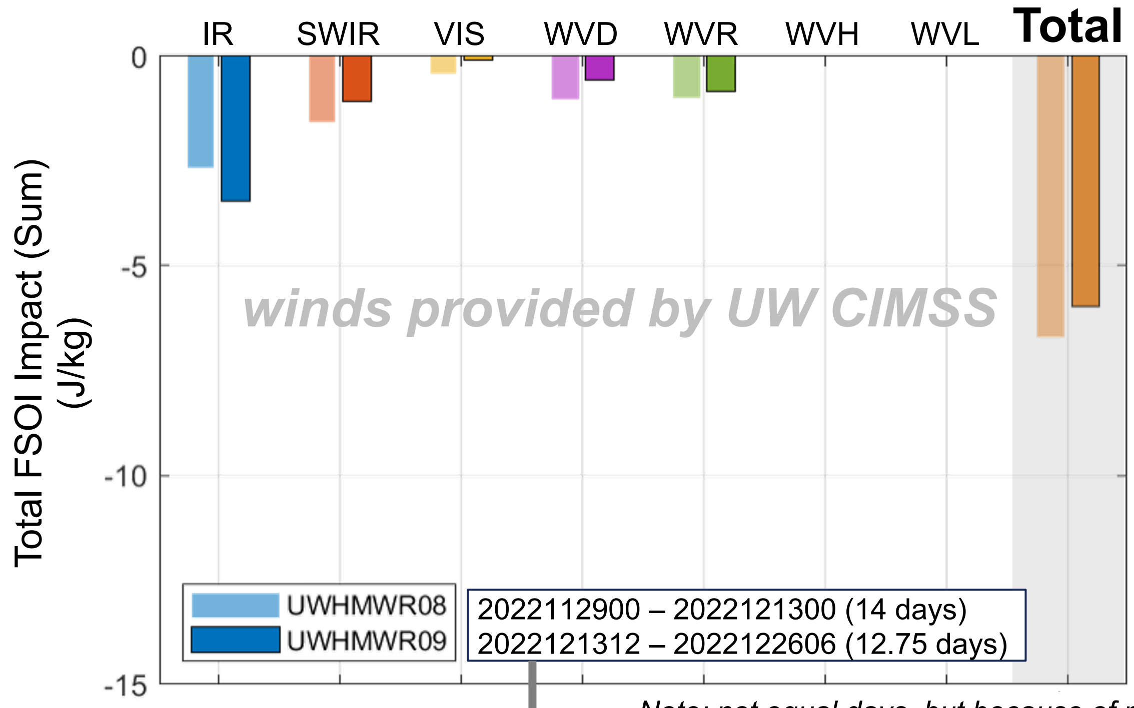
The following plots compare statistics from FNMOC ops.

Reduction in data counts from CIMSS noted, associated with the change in software.

Himawari-8/9 Swap

Comparison of FSOI by channel for Himawari-9 vs Himawari-8

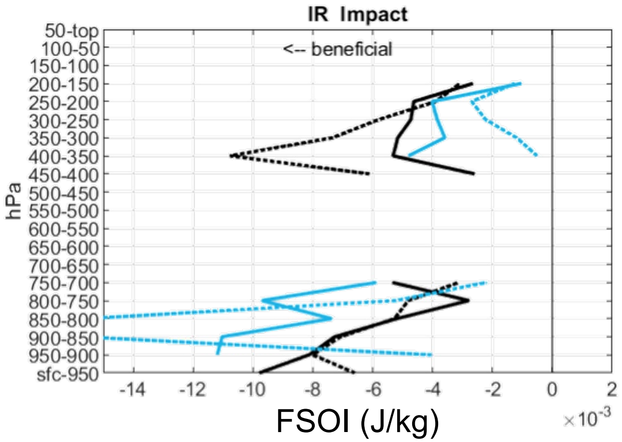


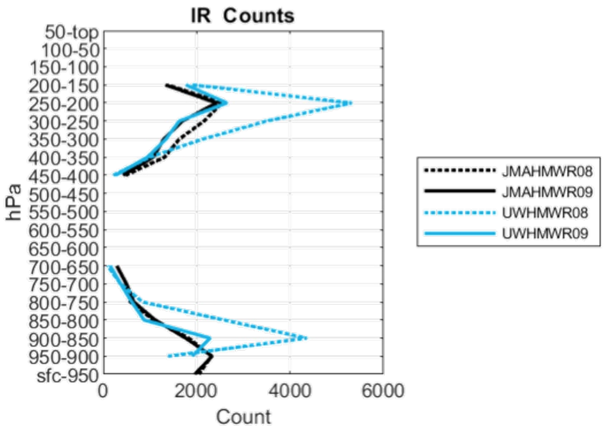


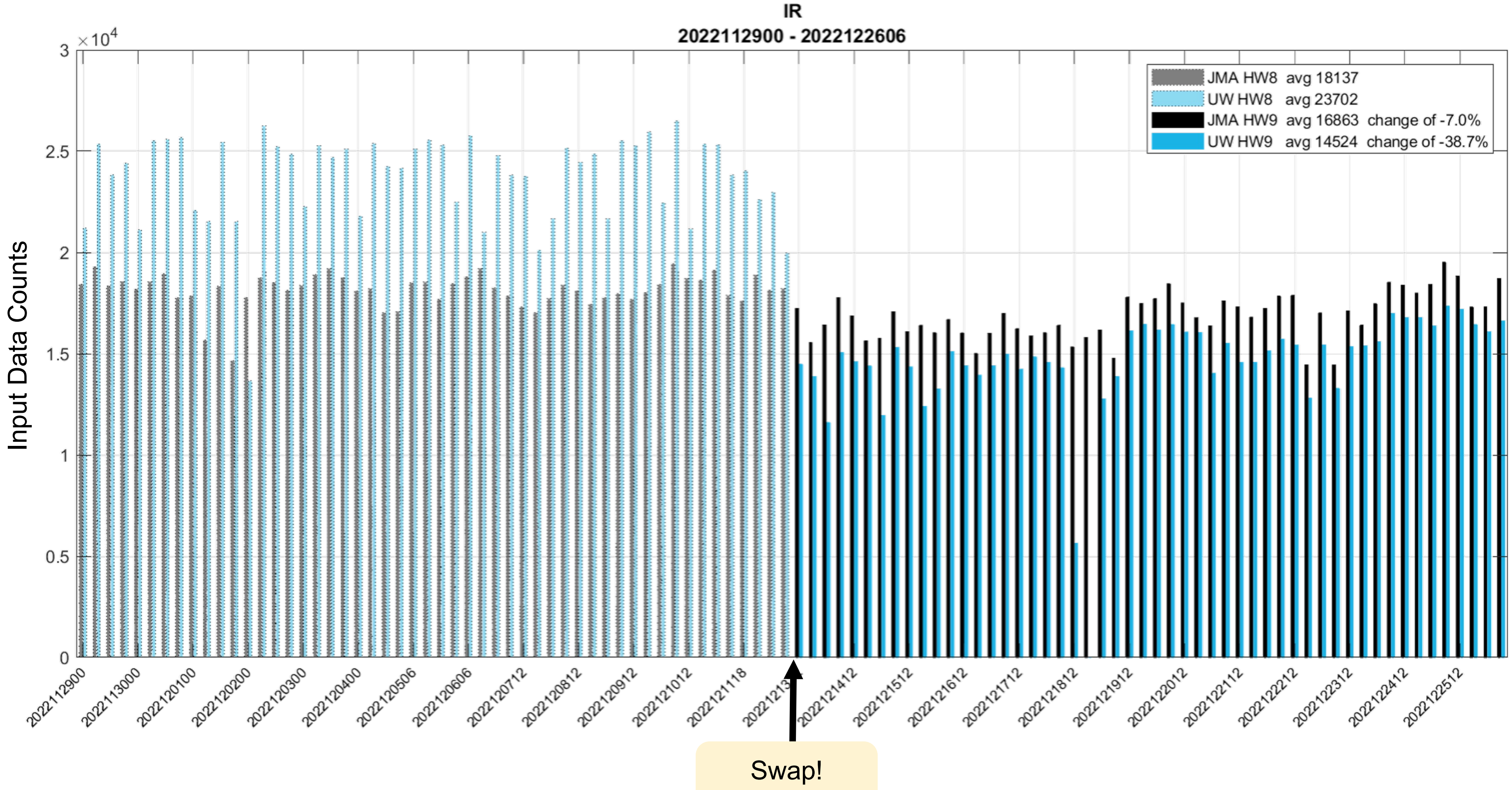
Note: not equal days, but because of missing data these two tests compare the same amount of data in each series.

- Negative FSOI indicates beneficial impact
- Total impact (orange) less beneficial for HMWR09 for both JMA (left) and UW (right)
- Decreased beneficial impact for JMA comes from IR, WVD, despite increased impact from VIS
- Decreased beneficial impact for UW comes from all channels except IR

Himawari-8/9 Swap







Comparison of IR AMVs before and after satellite swap

- Both JMA and UW datasets show a decrease in counts aloft for HMWR09, especially UW
- JMA impact for HMWR09 less beneficial aloft, but UW impact more beneficial despite fewer obs

GOES-17/18 Swap

GOES-17 ⟶ GOES-18 (Dec 2022/Jan 2023)

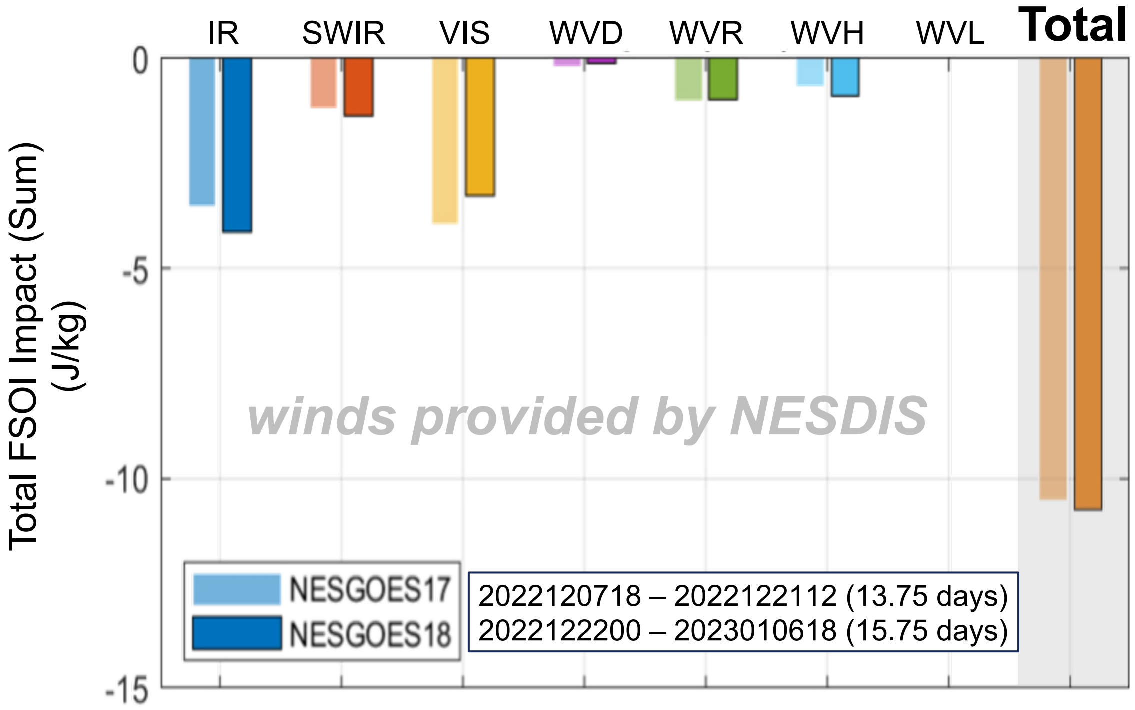
- Replacement with new satellite within the same series
- No changes in processing by NESDIS, but CIMSS switched to “Enterprise” software
- Changes in NRL/FNMOC satwind code required since GOES-18 is a new satellite
- Switchovers occurred on 21 Dec 2022 for NESDIS, 5 Jan 2023 for UW CIMSS
- Assimilation tests presented by Rebecca Stone (see her presentation later today)

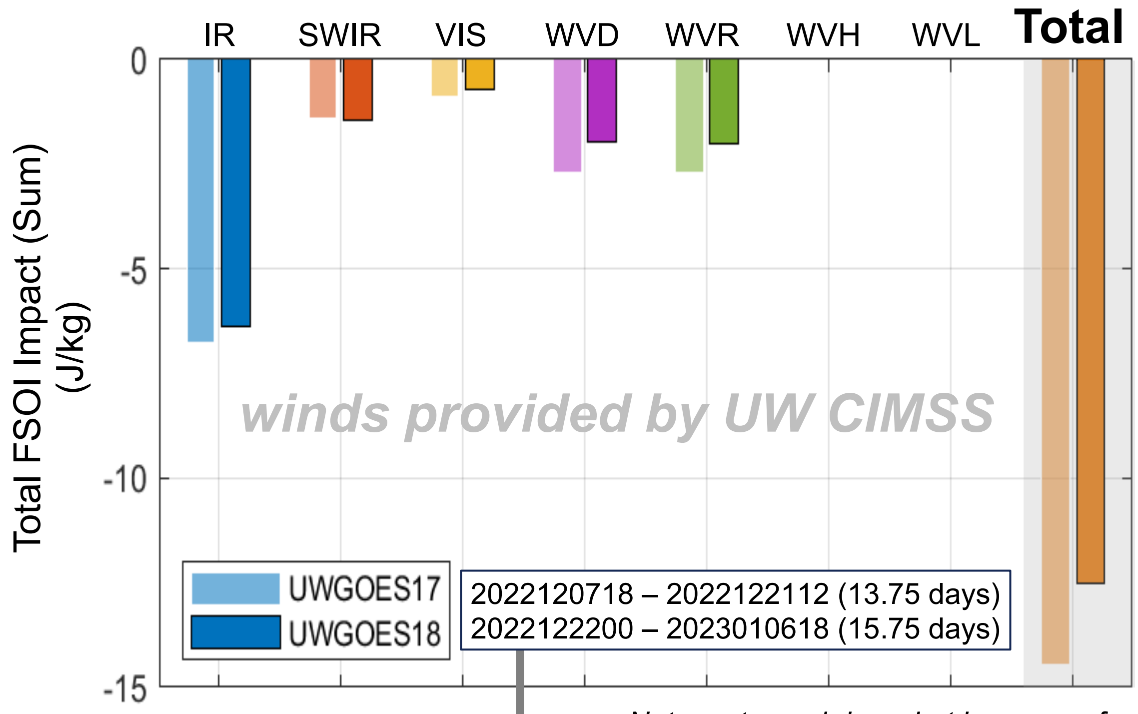
The following plots compare statistics from FNMOC ops.

The plots show data roughly two weeks before and after the switchovers.
Reduction in data counts from CIMSS noted, associated with the change in software

GOES-17/18 Swap

Comparison of FSOI by channel for GOES18 vs GOES17

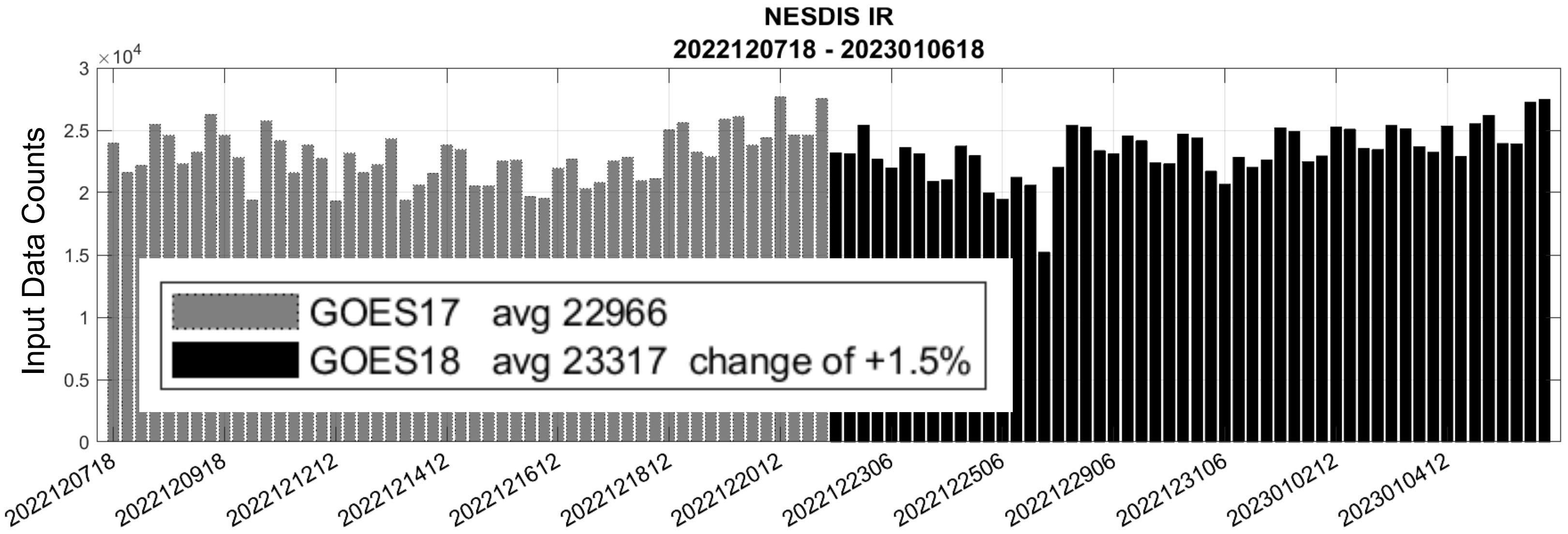


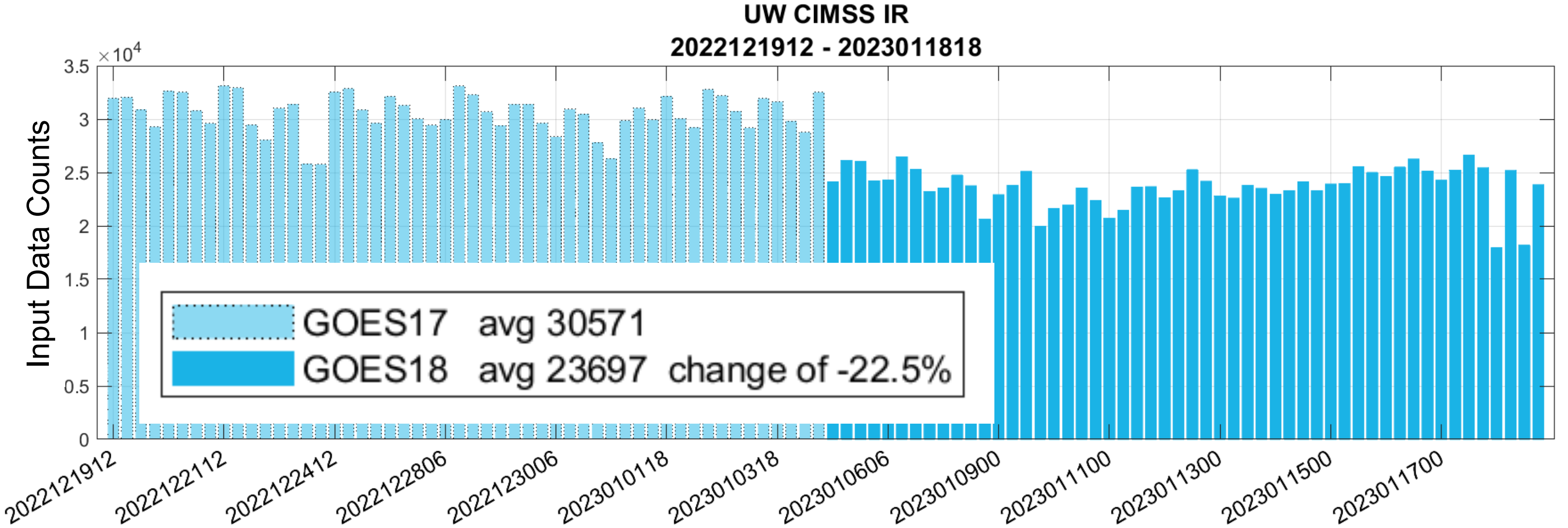


Note: not equal days, but because of missing data these two tests compare the same amount of data in each series.

- Negative FSOI indicates beneficial impact.
- Total impact (***orange***) is more beneficial for GOES18 for NESDIS (left) and less beneficial for UW (right).
- Decreased beneficial impact for NESDIS GOES18 comes from VIS, despite greater impact compared to UW.
- Decreased beneficial impact for UW comes from all channels except IR.

GOES-17/18 Swap





Comparison of IR AMVs before and after satellite swap

- NESDIS counts are similar
- UW counts show a large decrease for GOES18 (change to "Enterprise" software)

GEO-KOMPSAT-2A

GEO-KOMPSAT-2A evaluated as a possible backup for Himawari-8/9

- Satellite subpoint at 128.2°E vs. Himawari-9 at 140.7°E; ***large overlap***
- Changes in NRL/FNMOC satwind code required—KOMPSAT-2A is a new satellite
  - Excluded KOMPSAT-2A AMVs with times on the half hour to only use AMVs with times on the hour for consistency

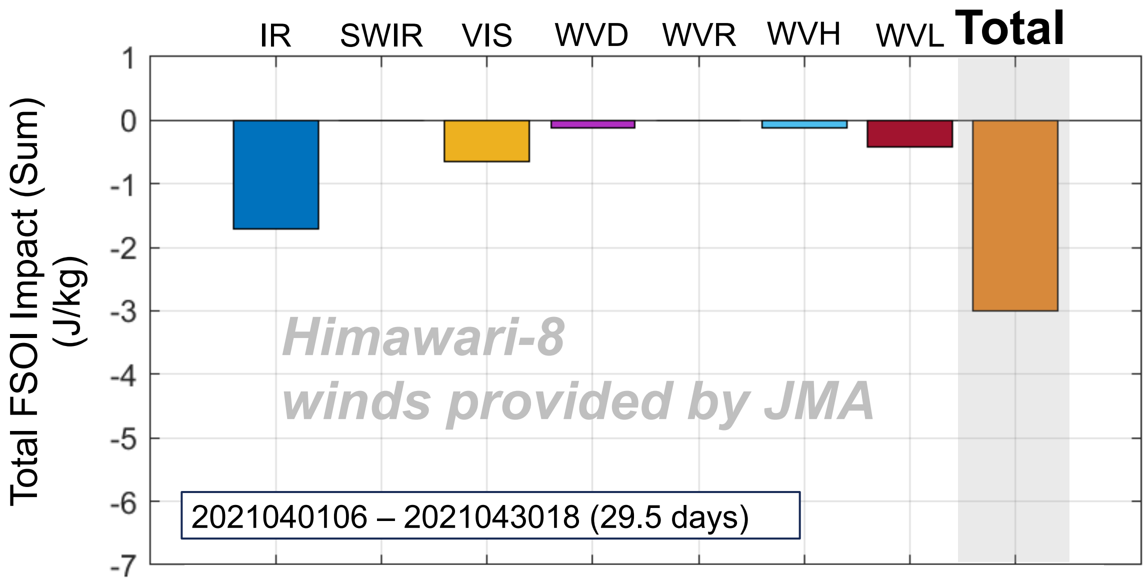
GEO-KOMPSAT-2A

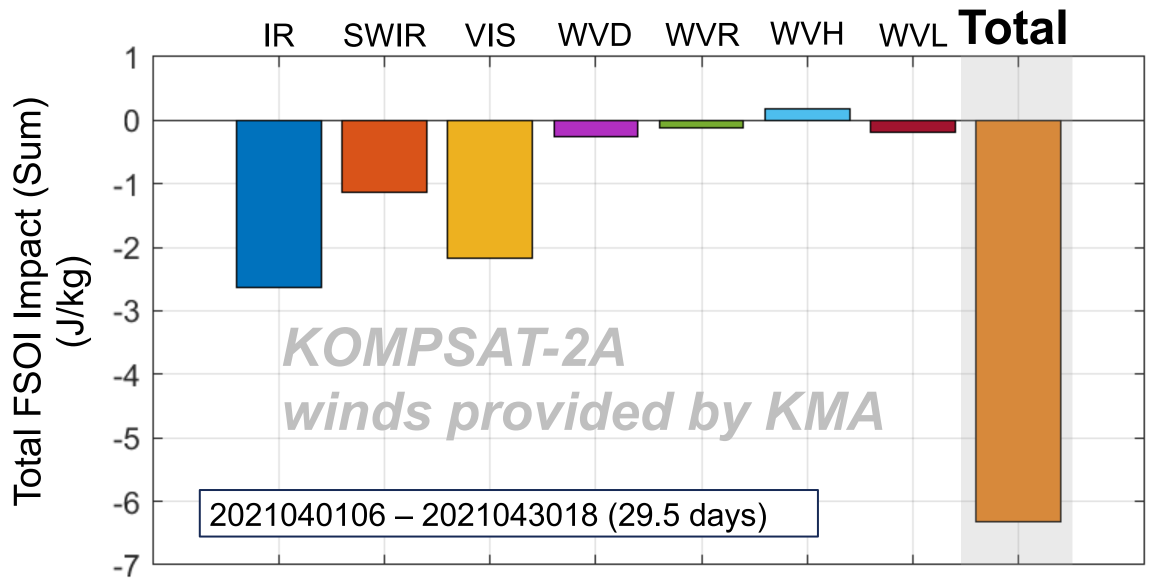
GEO-KOMPSAT-2A evaluated as a possible backup for Himawari-8/9

- Satellite subpoint at 128.2°E vs. Himawari-9 at 140.7°E; ***large overlap***
- Changes in NRL/FNMOC satwind code required—KOMPSAT-2A is a new satellite
- Evaluated as part of a larger test of multiple satwind datasets for April 2021
  - QC relaxed for both test and control (no land masking, no channel exclusions, no pressure level exclusions)
  - ***KOMPSAT-2A—substituted for Himawari-8 in test***
  - INSAT-3DR—substituted for INSAT-3D in test
  - KNMI Metop-C ASCAT winds—added to NESDIS Metop-A/B ASCAT winds for test
  - UW MODIS SWIR—added for test (had been inadvertently turned off at FNMOC)
  - UW VIIRS SWIR—added for test
  - UW Tandem VIIRS triplets—added for test

The following plots are from the April 2021 assimilation test.

Comparison of FSOI by channel for KMA KOMPSAT-2A vs JMA Himawari-8

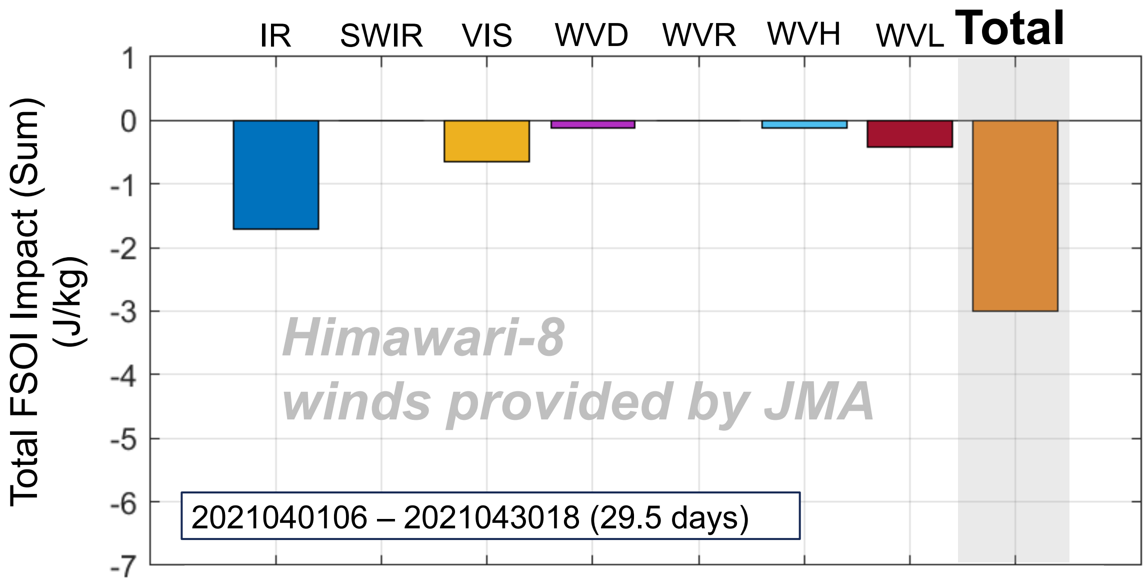


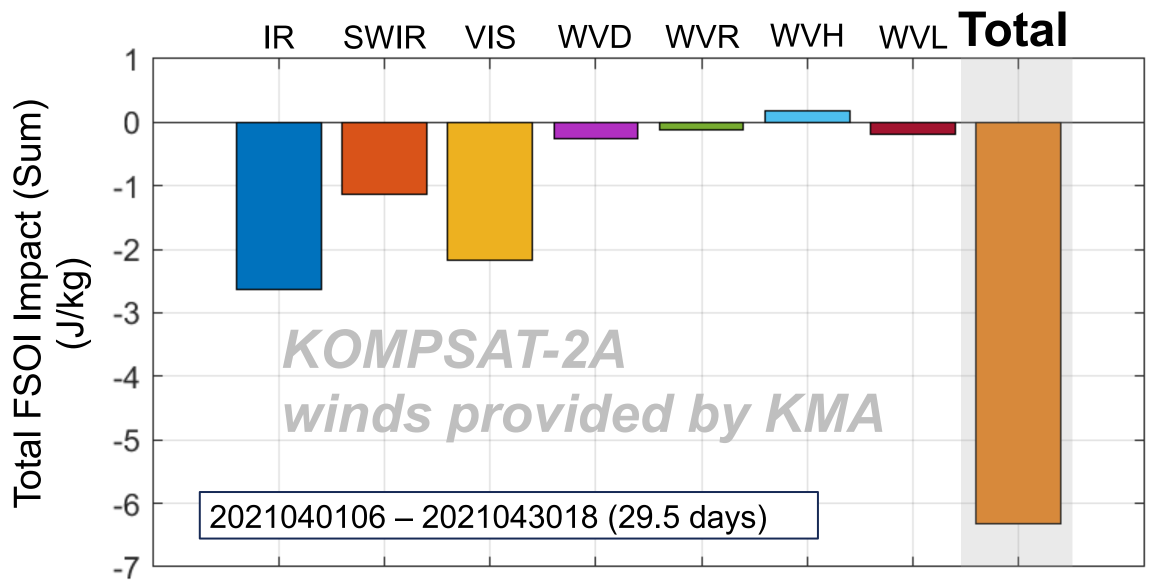


- Negative FSOI indicates beneficial impact.
- Total impact (***orange***) more beneficial for KOMPSAT-2A than JMA.
- Increased beneficial impact for KOMPSAT-2A comes from IR, SWIR, and VIS channels.
- WV channels have small impact for both satellites.

GEO-KOMPSAT-2A

Comparison of FSOI by channel for KMA KOMPSAT-2A vs JMA Himawari-8





Recommendations for operational use of KOMPSAT-2A AMVs scheduled for next NAVGEM update (spring 2023):

- Use SWIR AMVs operationally—no SWIR AMVs provided for Himawari-8/9
- Use VIS AMVs below 400 hPa operationally—greater beneficial impact than Himawari-8/9
- Use IR AMVs as second backup for Himawari-8/9 below 400 hPa
- Omit use of all WV AMVs—counts and impact small

KNMI Metop-C ASCAT

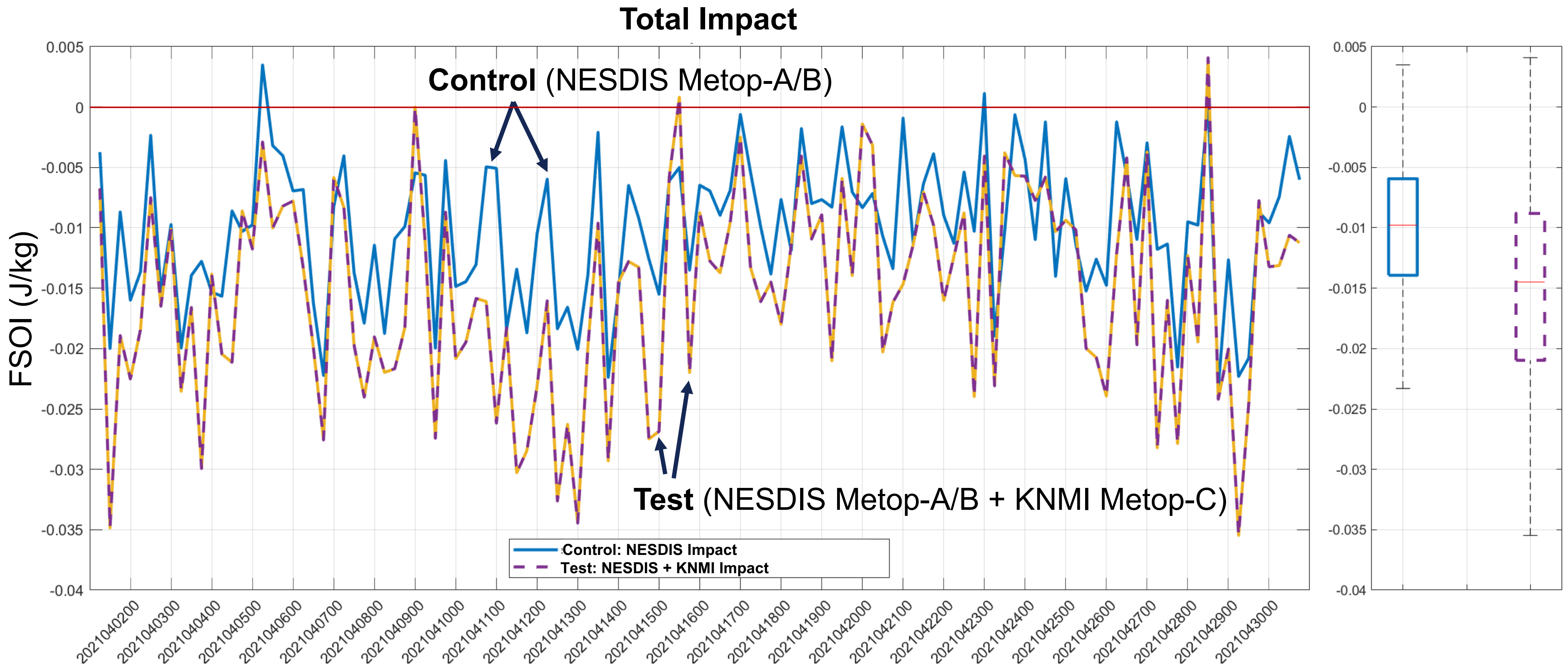
Metop-A ⟶ Metop-C

- Metop-A decommissioned in November 2021
- NESDIS Metop-C ASCAT winds not yet available, so FNMOC obtained KNMI ASCAT
- KNMI Metop-C ASCAT winds used operationally at FNMOC starting in January 2022
- Changes in NRL/FNMOC satwind code required for KNMI ASCAT
  - Previous code included dealiasing for NESDIS ASCAT winds, where the wind closest to the background value was chosen
  - KNMI ASCAT winds already dealiased by KNMI
  - Higher-resolution KNMI ASCAT thinned to roughly the same resolution as NESDIS ASCAT

The following plots are from the April 2021 assimilation test.

Note that KNMI Metop-C ASCAT was used in addition to NESDIS Metop-A and Metop–B ASCAT.
NESDIS Metop-A/B ASCAT were superobbed together rather than separately.

KNMI Metop-C ASCAT



- Scatterometer is data consistently beneficial (negative) day-in day-out.
- The additional scatterometer data in the test run gave greater reduction in the global error norm.
- The additional data did not have significantly more outlier non-beneficial DTGs.

NESDIS Metop-B ASCAT

Metop-B legacy → Metop-B NCCF (NESDIS Common Cloud Framework)

- Both Metop-B and Metop-C ASCAT winds included in change
- Only Metop-B ASCAT was evaluated—use of KNMI Metop-C ASCAT retained
- Change advertised as no change in algorithm or format, but differences present
  - Side-by-side comparison of observations showed some differences in quality flags and NCEP background, but most observations were identical
  - Possible difference in KNMI ASCAT version may have led to differences in quality flags
  - Differences in NCEP background likely associated with differences in access times

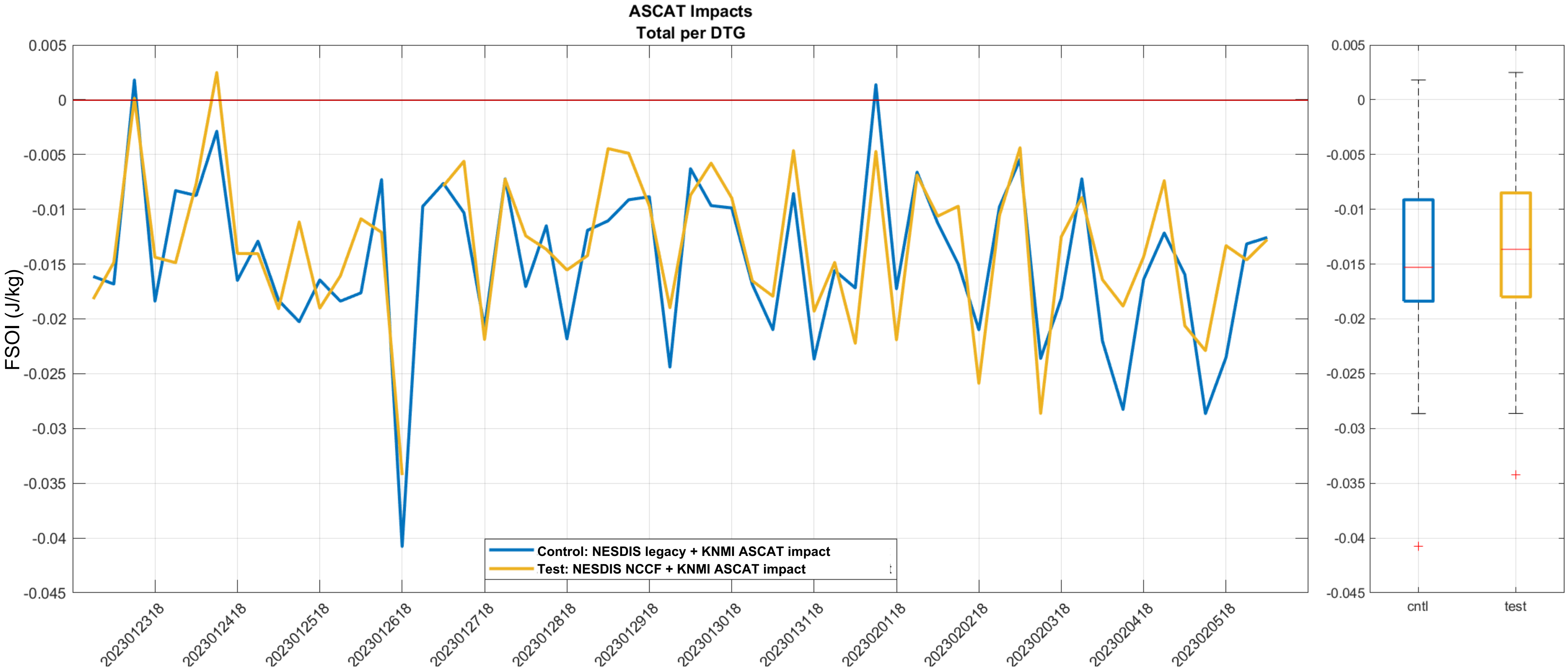
NESDIS Metop-B ASCAT

Metop-B legacy → Metop-B NCCF (NESDIS Common Cloud Framework)

- Both Metop-B and Metop-C ASCAT winds included in change
- Only Metop-B ASCAT was evaluated—use of KNMI Metop-C ASCAT retained
- Change advertised as no change in algorithm or format but differences present
- No changes in NRL/FNMOC satwind code required
- NCCF Metop-B ASCAT used operationally at FNMOC starting in February 2023

The following plots are from a two-week assimilation test.

NESDIS Metop-B ASCAT



- Control (blue) vs test (yellow) impacts are similar and beneficial.

UW Tandem VIIRS Winds

New dual-satellite polar winds

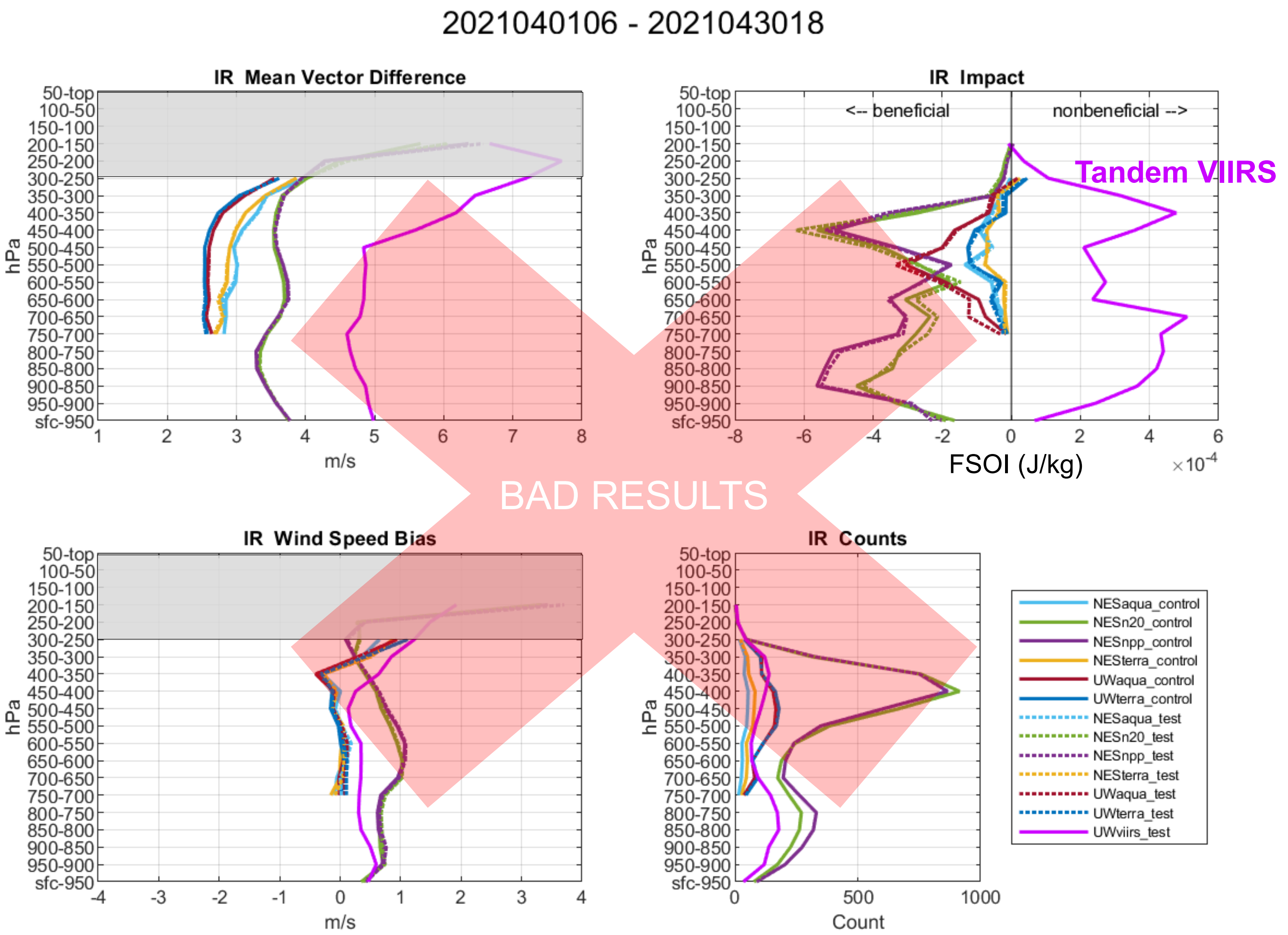
- Triplet winds formed using data from successive swaths from NPP and N20
  - Polar regions only—from pole to 40°
  - 50 min vs 100 min image interval should produce higher quality winds than using a single satellite
  - UW CIMSS Tandem VIIRS winds use the “Enterprise” software
- Tested as part of April 2021 assimilation test
- Changes in NRL/FNMOC satwind code required—new product
- Evaluated as part of a larger test of multiple satwind datasets
- Changes scheduled to go in this spring with the next global model update

The following plots are from the April 2021 assimilation test.

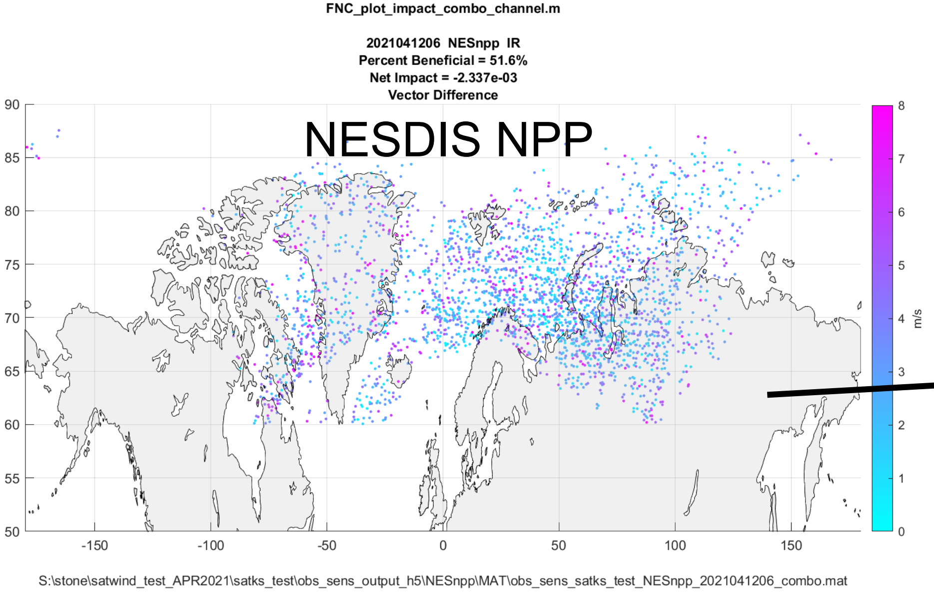
UW Tandem VIIRS Winds

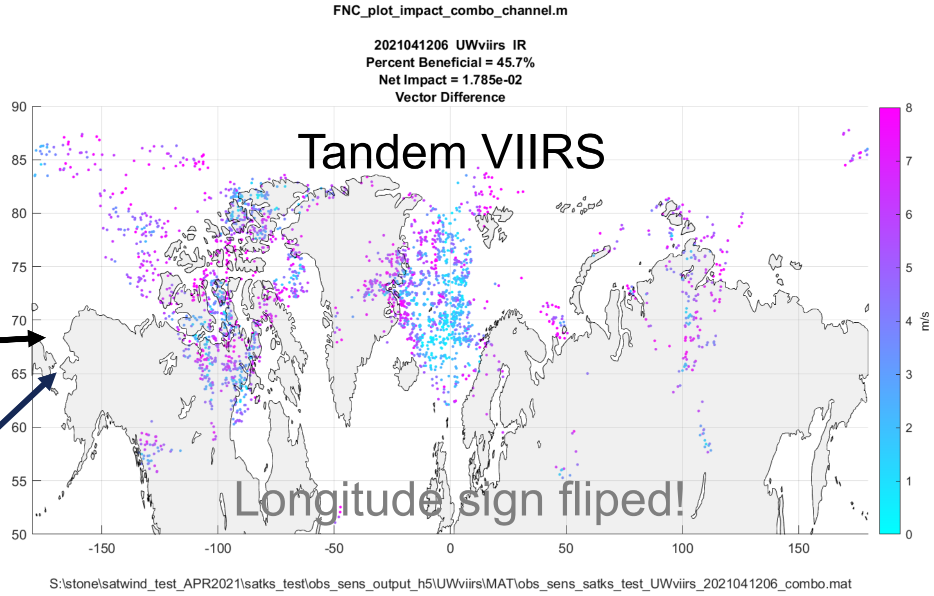
Original test run

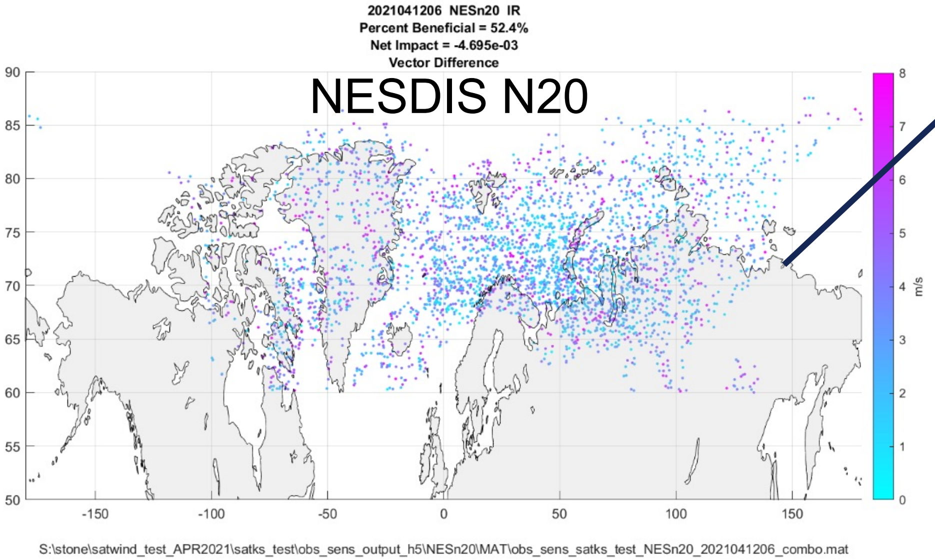
- Tandem VIIRS in magenta compared to other polar winds
- *Large non-beneficial FSOI*
- Mean Vector Difference large



UW Tandem VIIRS Winds







Comparison of coverage shows longitude sign flip

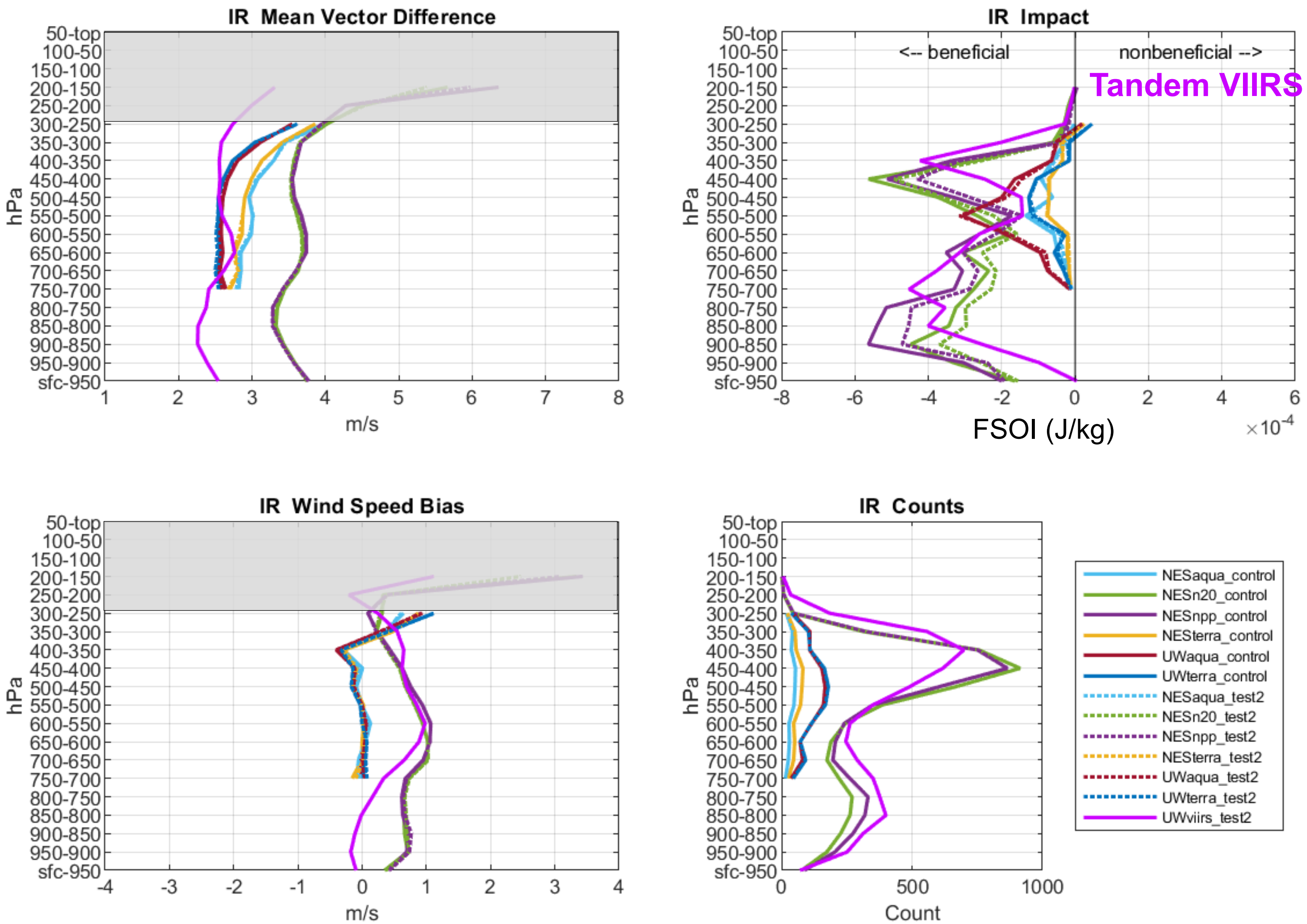
- UW CIMSS “heritage” software assigns positive longitudes to degrees west rather than east => requires sign flip
- *Tandem VIIRS winds use the “Enterprise” software which does not need a sign flip*
- NRL/FNMOC software was modified to remove the sign flip for Tandem VIIRS winds

UW Tandem VIIRS Winds

2021040106 - 2021043018

Corrected test run

- Tandem VIIRS in magenta compared to other polar winds
- Impact now very beneficial
- MVD now similar to MODIS
- Wind speed bias similar to NESDIS NPP and N20



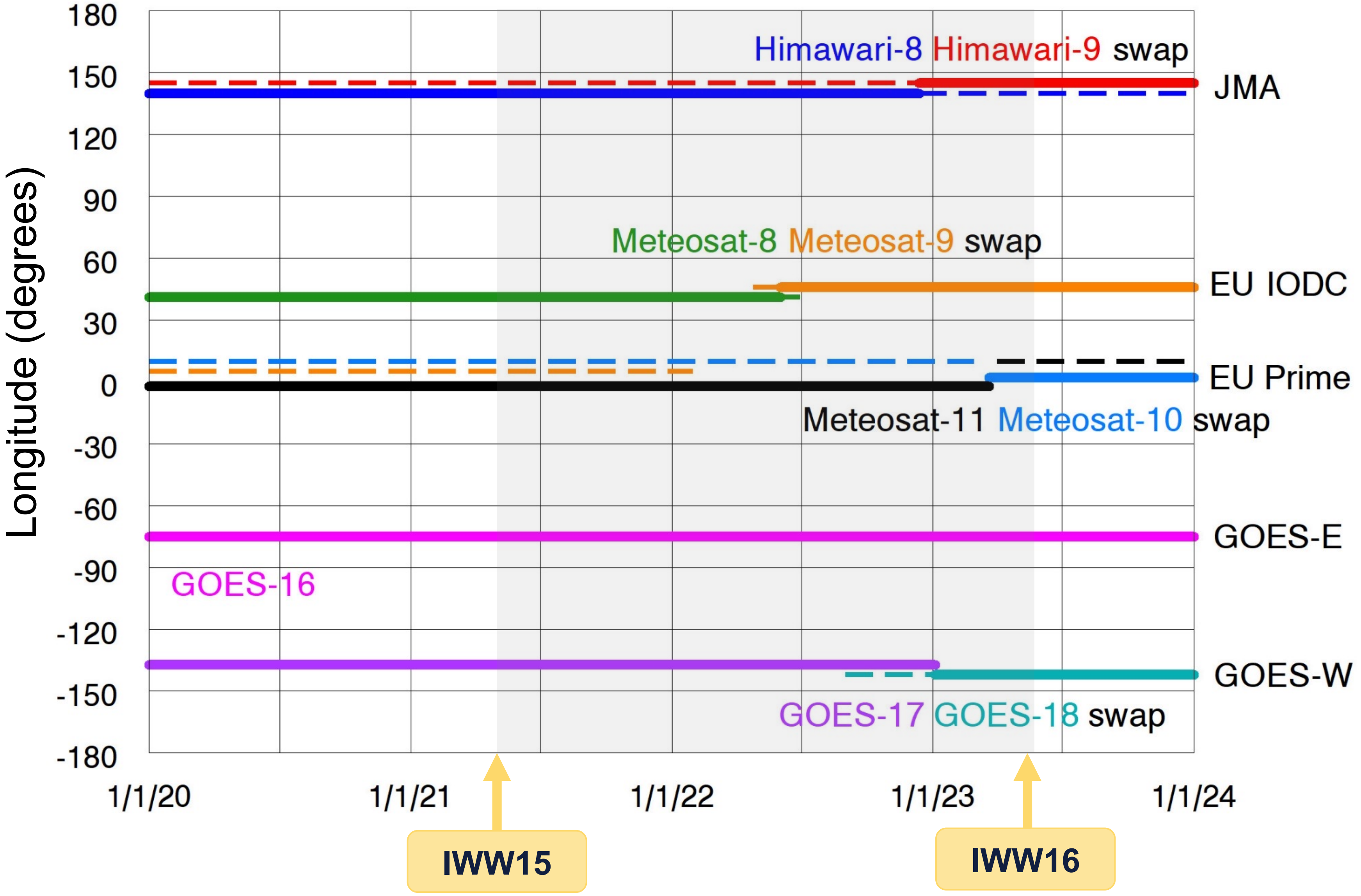
Future Work

- Accommodate upcoming operational satwind changes in current operational code
  - N21 VIIRS winds
  - Meteosat-12 AMVs
  - NESDIS GOES Enterprise winds
  - Others as they come up!

- Test new satwind sources for future use
  - HSIR wind profiles

- Refactor the aging NRL/FNMOC satwind preprocessor

Summary



Significant satellite changes since IWW15!

- GEO satellite swaps (within series)
- KOMPSAT-2A
- Metop-A to Metop-C
- NESDIS switch to NCCF
- New UW VIIRS products
- U.S. Navy changes to satwind DA

Questions

Code Refactoring

Use of satellite parameter files

- Details of satellite characteristics and QC moved to external files
  - Files include parameters for anything in current code that is satellite dependent
    - Satellite name, id number, subpoint longitude, data provider, start and end dates, internal file names
    - Channel names, frequencies, QI thresholds by channel
    - Superob prism size, staggering, whether to use prism quartering
    - Logical flags to activate specific QC checks, vertical pressure limits to apply to data
    - Assigned observation errors by pressure level and eventually by channel

Code Refactoring

Use of satellite parameter files

- Details of satellite characteristics and QC moved to external files
  - Files include parameters for anything in current code that is satellite dependent
  - Separate files for each satellite provider
  - Separate files for each model to accommodate model dependencies in current code
  - Separate files for major changes
    - New satellite or switch of existing satellite from backup to primary
    - Change in format or internal file name
    - Change in location of satellite subpoint longitude

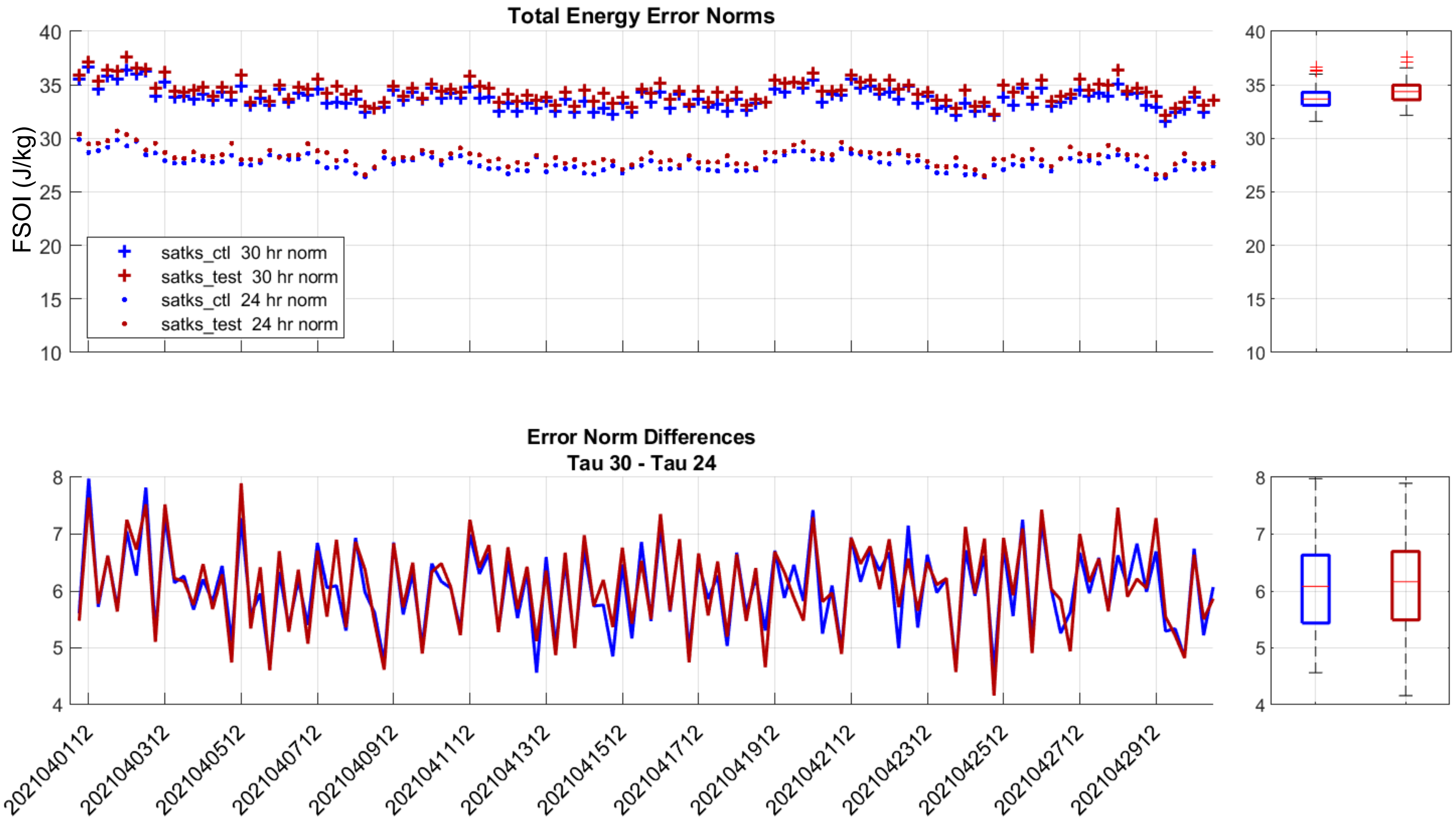
Code Refactoring

Use of satellite parameter files

- Details of satellite characteristics and QC moved to external files
  - Files include parameters for anything in current code that is satellite dependent
  - Separate files for each satellite provider
  - Separate files for each model to accommodate model dependencies in current code
  - Separate files for major changes
- Initial set of satellite parameter files defined back to 2015
  - For both operational providers and UW CIMSS
  - For both NAVGEM and COAMPS
  - For geostationary satellites used operationally

Readers for satellite parameter files and data files completed

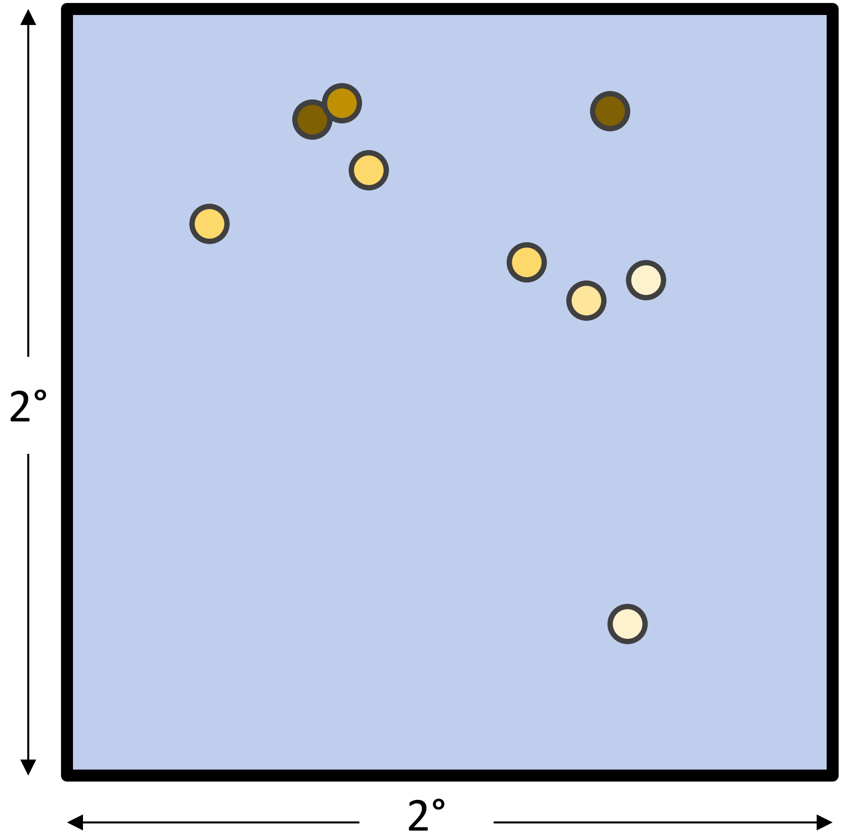
Backup Slides – Error Norms



Superob Quartering Methodology

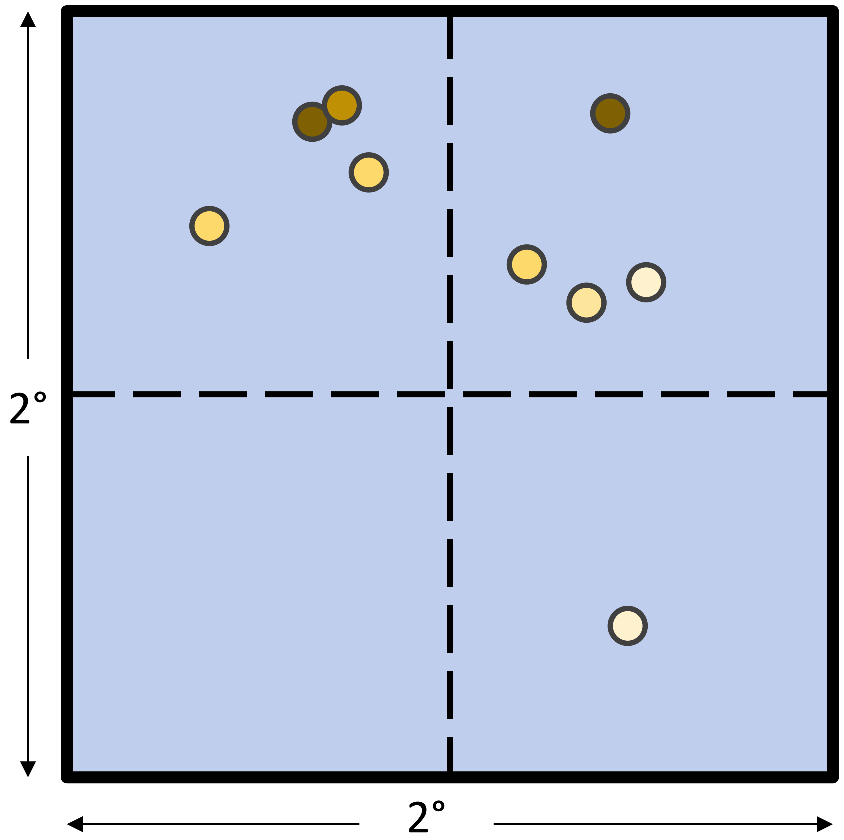
The following slides illustrate how quartering works.

Superob Quartering Methodology



9 AMVs observed in a 2°x2° "prism"

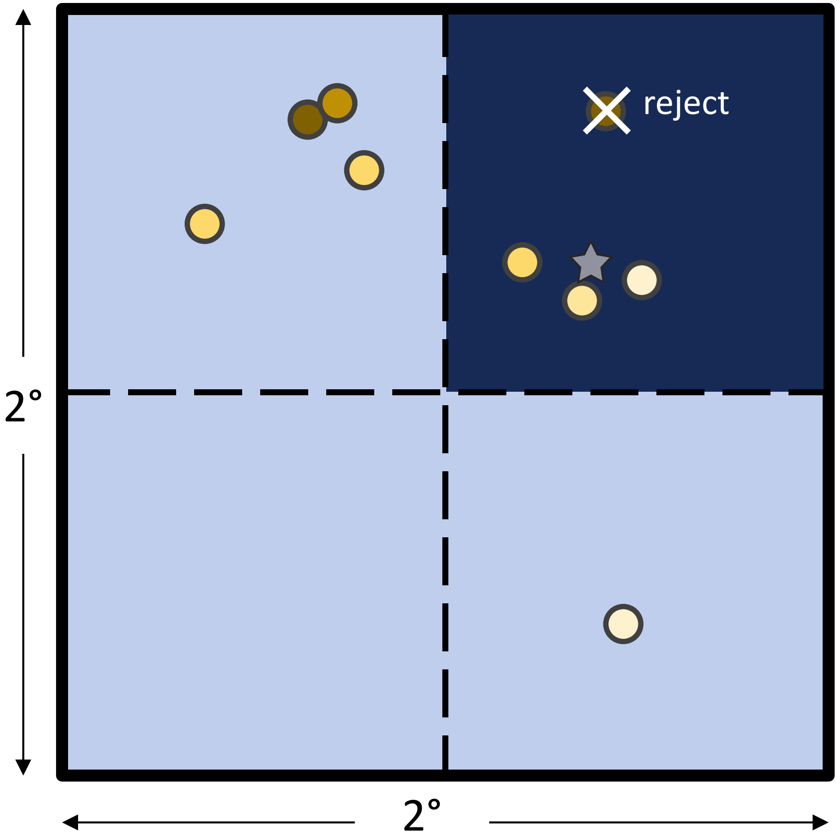
Superob Quartering Methodology



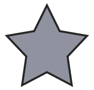
9 AMVs observed in a 2°x2° “prism”

The ranges of speed and direction exceed the predetermined threshold, so the prism is “quartered”

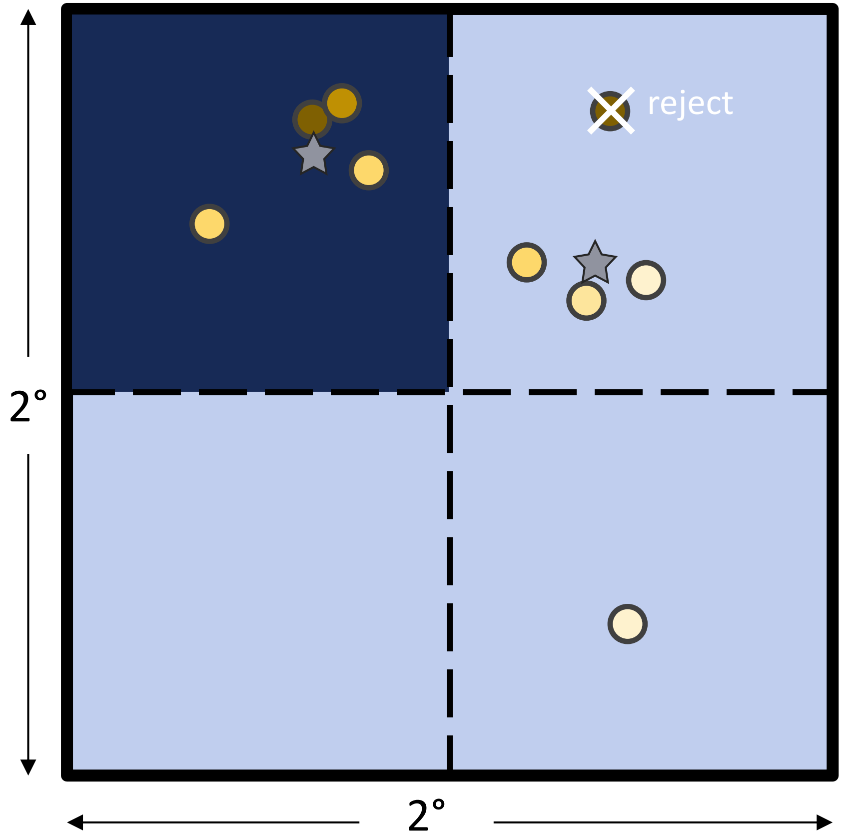
Superob Quartering Methodology



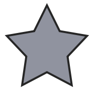
In the first quarter, rejecting one outlier allows a superob to be formed



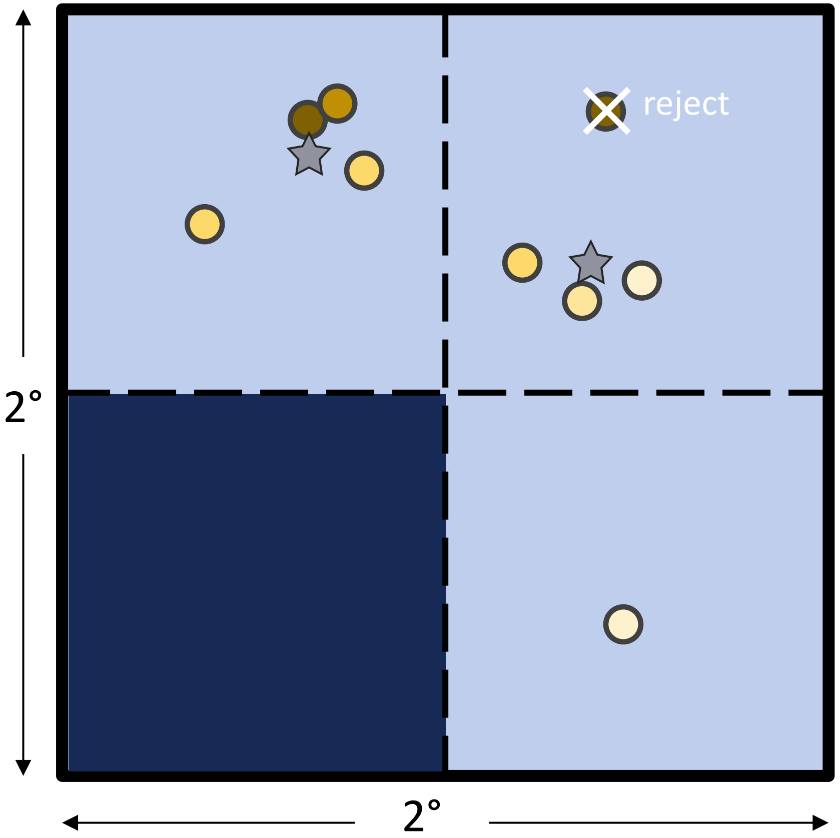
Superob Quartering Methodology



In the second quarter, all observations are within the threshold, so another superob is formed

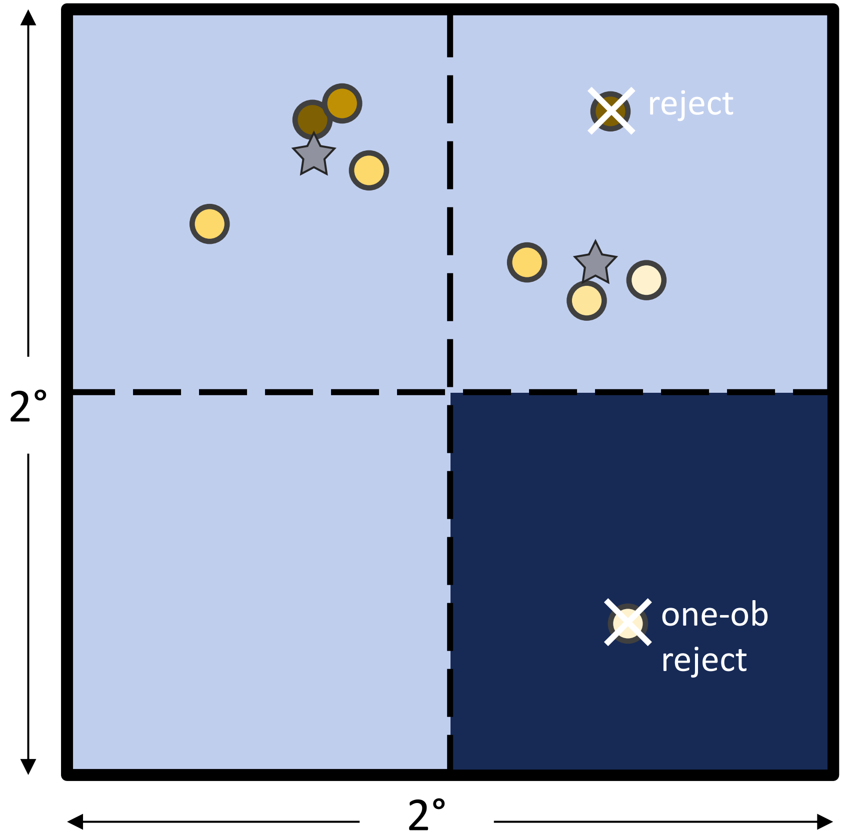


Superob Quartering Methodology



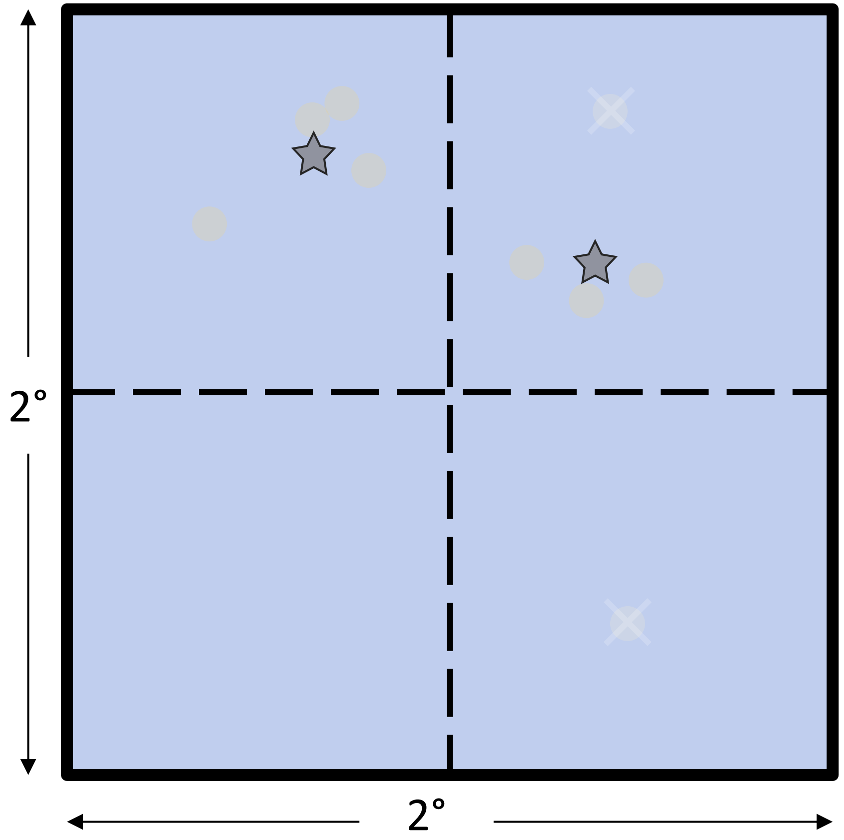
In the third quarter, there are no observations to make a superob.

Superob Quartering Methodology



In the fourth quarter, there are fewer than two observations, so no superob is made.

Superob Quartering Methodology



The 9 AMVs in this prism are turned into 2 superobs.