Assimilation and Evaluation of MISR Cloud Tracked Winds with GEOS-5 Operational Data Assimilation System

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Overview

- Status/review of MISR CMV
- Comparison of MISR CMV heights with collocated GOES and MODIS AMV heights
- Forecast Impact of MISR CMV within GEOS-5
- Assimilation benefit of assigning greater uncertainty to along-track component
- Conclusions

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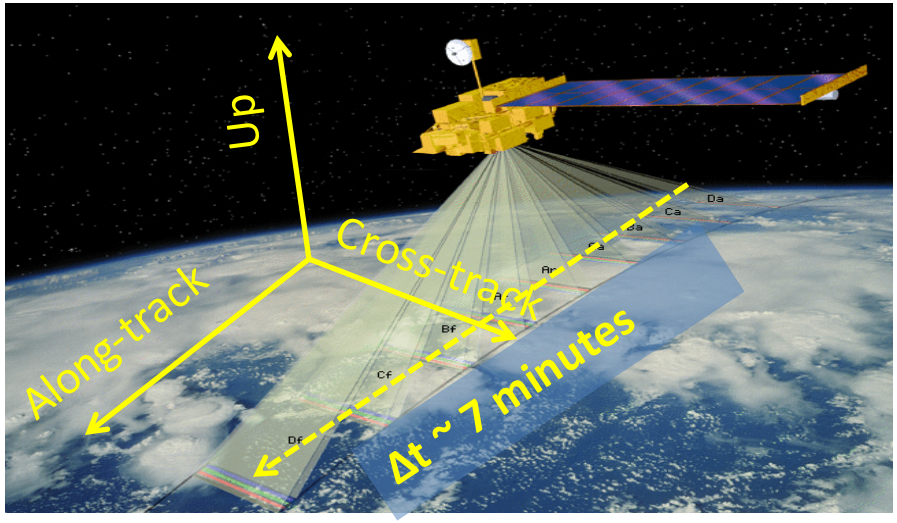
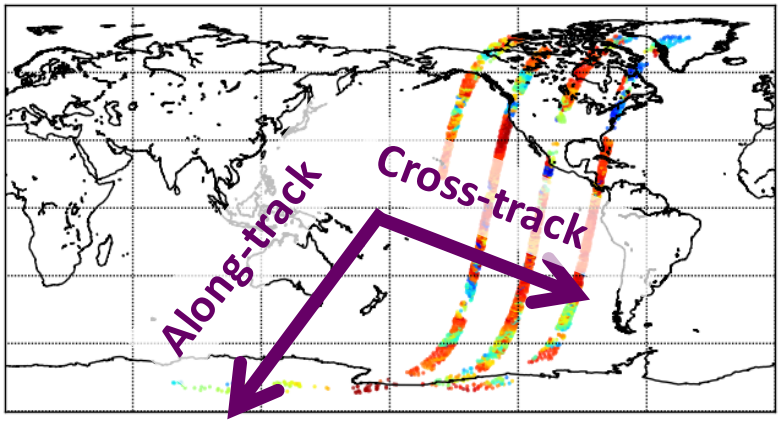
Multi-Angle Imaging SpectroRadiometer (MISR)





MISR wind coverage over 6 hours

MISR instrument

- **On EOS Terra platform. Mission Lifetime: 1999 -> ~2020+**
- **9 view angles, 4 visible channels**
- **275 m resolution, 380 km swath width**

MISR cloud motion vectors

- **Geometric cloud heights**
- **17.6 km resolution of CMV retrieval**
- **100 seconds between consecutive camera views**
- **Global coverage**

Current status/previous NWP results assimilating MISR winds

Center	Thanks to	Status
Naval Research Lab (NRL)	Nancy Baker	NRT MISR winds are being monitored , observation-minus-background (O-B) statistics are reasonable and forecast impact positive
UK Met. Office (UKMO)	Mary Forsythe, Francis Warrick	NRT MISR winds being monitored, O-B statistics are reasonable
German Weather Service (DWD)	Alexander Cress	Offline study shows (2014) shows generally positive forecast impact
Japan Met. Agency (JMA)	Koji Yamashita	Initial investigation (2014) shows mixed forecast impact, suggests utility of further investigation

- Summary of findings:
  - Generally positive forecast impact
  - Concerns about whether current QI is helpful
  - Concerns about georegistration artifacts
  - Concerns about CMV quality over land, especially ice and desert

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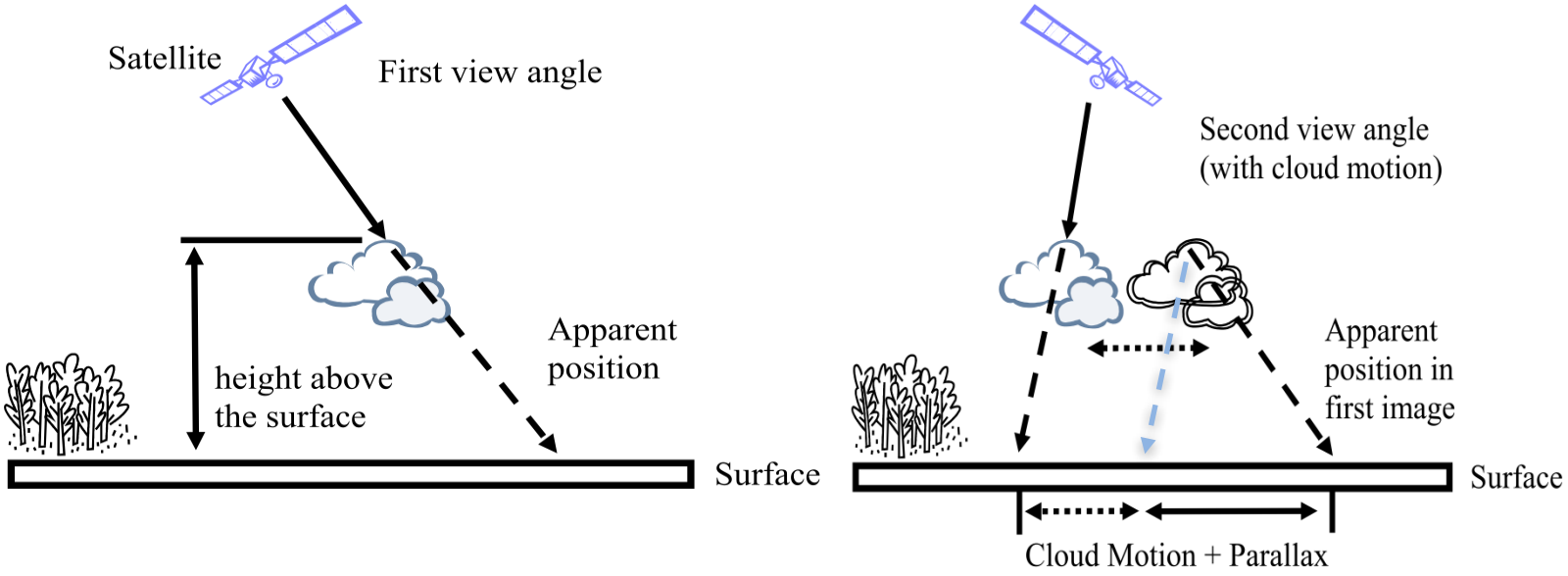
MISR height & along-track error are correlated

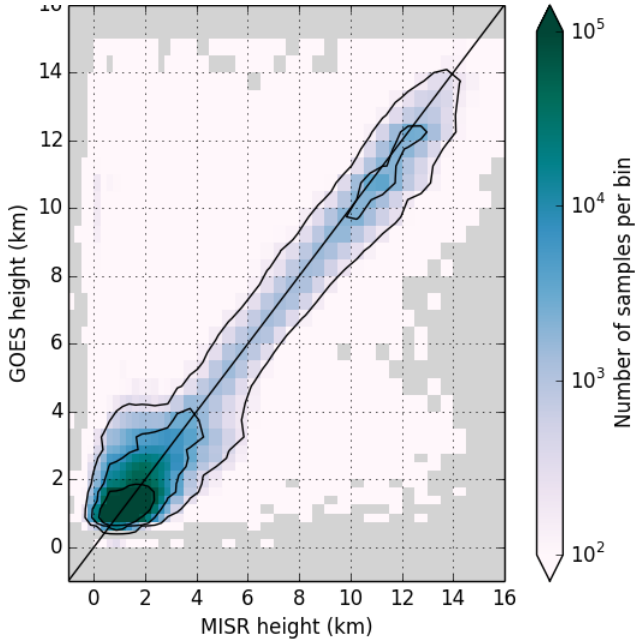
- Time difference between camera views creates ambiguity between along-track motion and parallax
  - Ambiguity causes correlation of height/along-track error
  - Ambiguity greatly enhances MISR CMV sensitivity to camera-pointing, cloud-tracking error



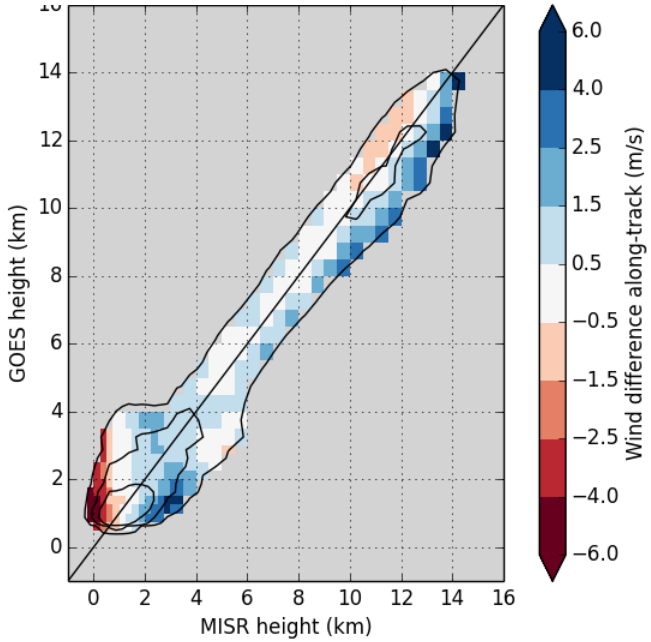
MISR CMV height/along-track bias correlation evident in GOES comparison

- 7 years (2003-2008) of collocations to within 20 km, 30 minutes shown (GOES VIS & IR channels chosen)
- Collocations below constrained to where negligible (<2.5 ms^{-1}) wind shear evident in MERRA reanalysis
- Height binning segregates worst retrievals from rest in visualization
  - Sampling contours represent samples per bin counts of 200, 2000, and 20000
- Errors as large as 5 ms^{-1} found in conjunction with bins 1500 m off the 1:1 line

Samping density

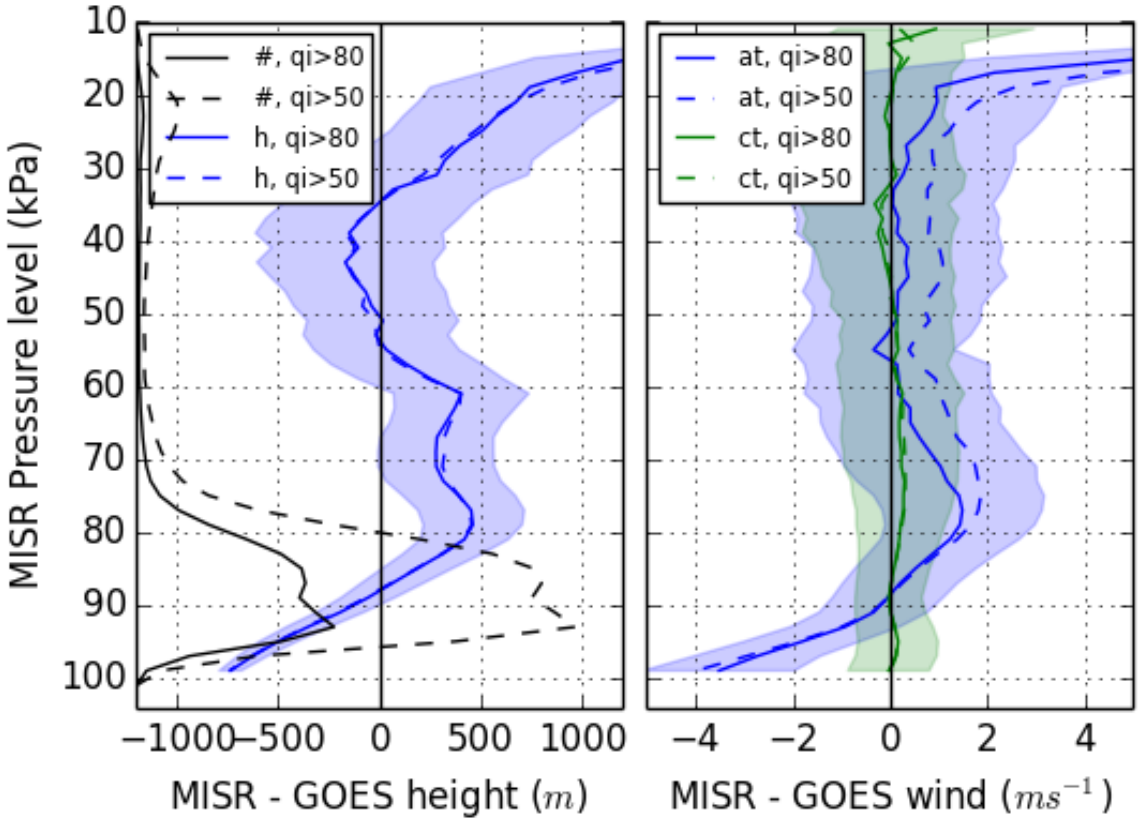


Along-track difference



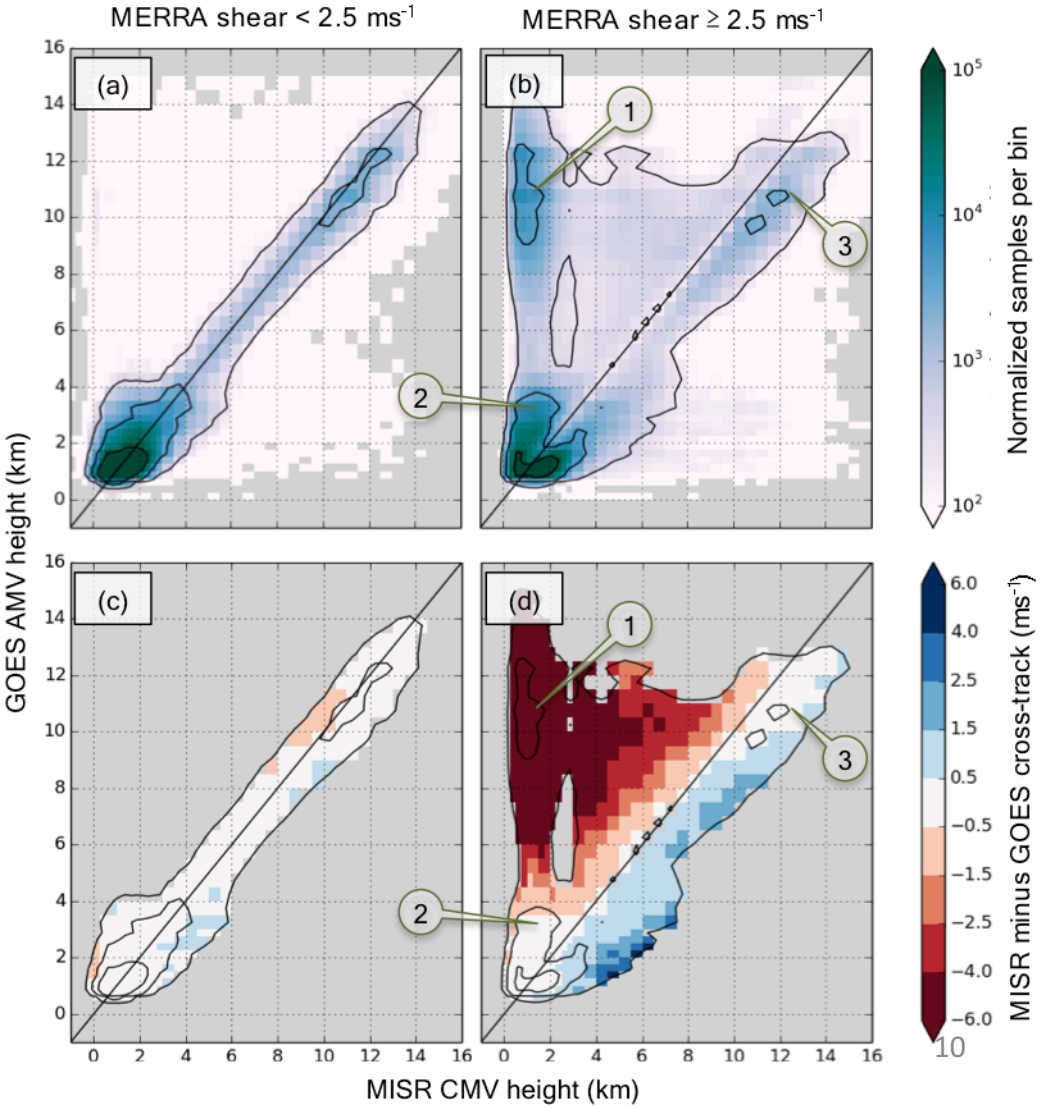
Applying stricter QI threshold diminishes bias, but not evident height/along-track bias correlation

- Profiles below produced from all MISR-GOES collocations with pressure difference < 10 kPa
- Biases along-track (at), cross-track (ct) and in height are shown along with ± ½ std. deviation
- Also shows sampling (#)
- Note absence of bias at peak in sampling (90 kPa)
  - Suggests that some MISR CMV that should be at 90 kPa are too high/low with positive/negative height and along-track bias



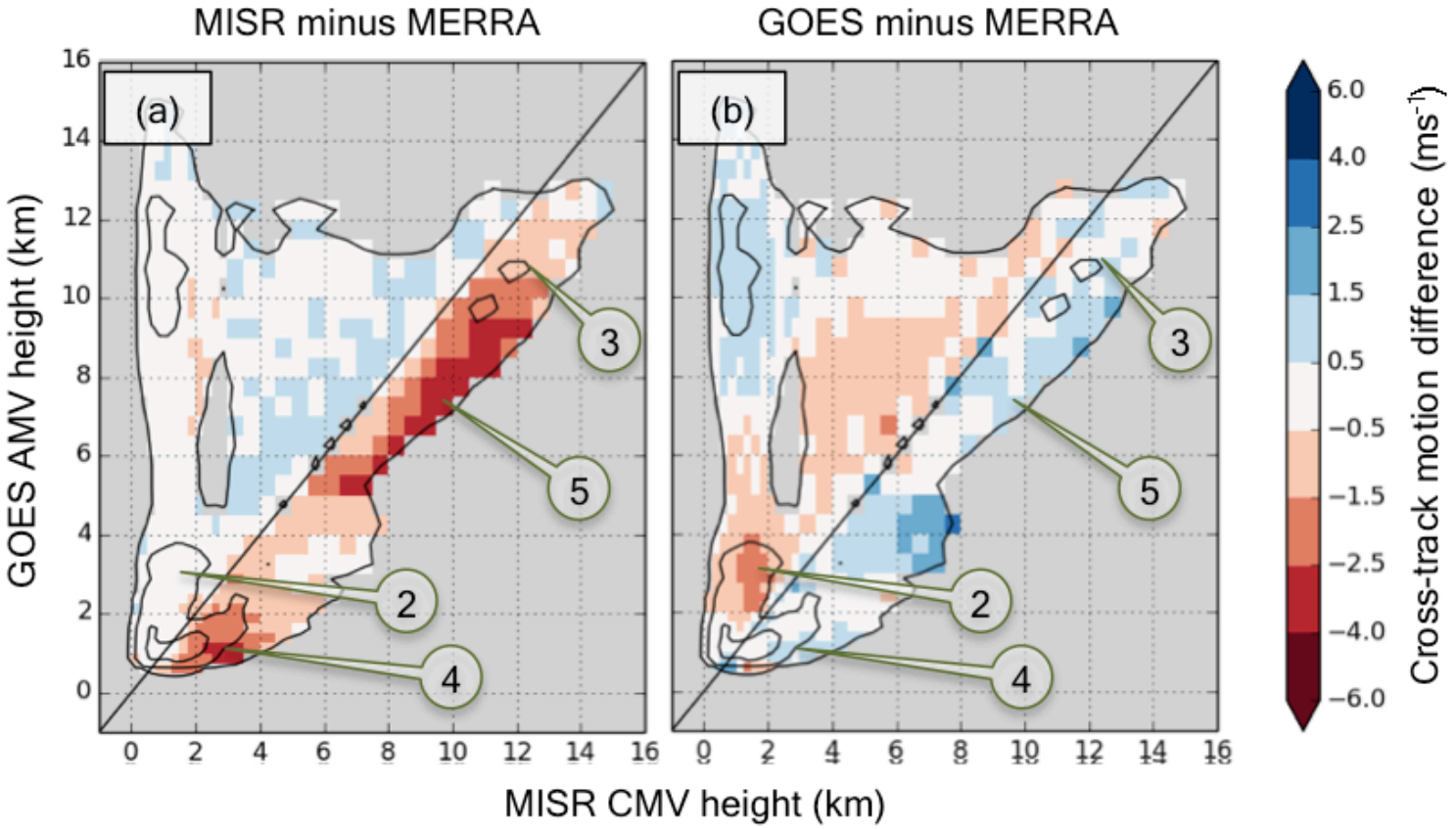
Apparent regimes where MISR and GOES are tracking same cloud, but assigning different heights

- 3 domains of interest
  - 1: MISR and GOES tracking different clouds, with expected difference in wind and height
  - 2 & 3: MISR and GOES produce same wind, but at distinct heights- either MERRA, MISR, or GOES is erroneous



Reanalysis favors MISR wind heights in one case, GOES in another

- Region 2: GOES incorrectly assigned higher height than MISR
- Region 3: MISR incorrectly assigned higher height than GOES
- Regions 3, 4, & 5: Wide pattern of MISR CMV with heights seemingly incorrectly above collocated GOES AMV



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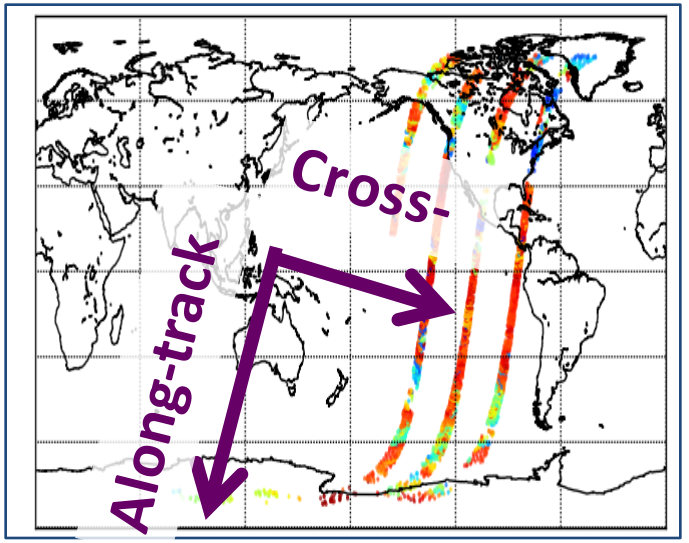
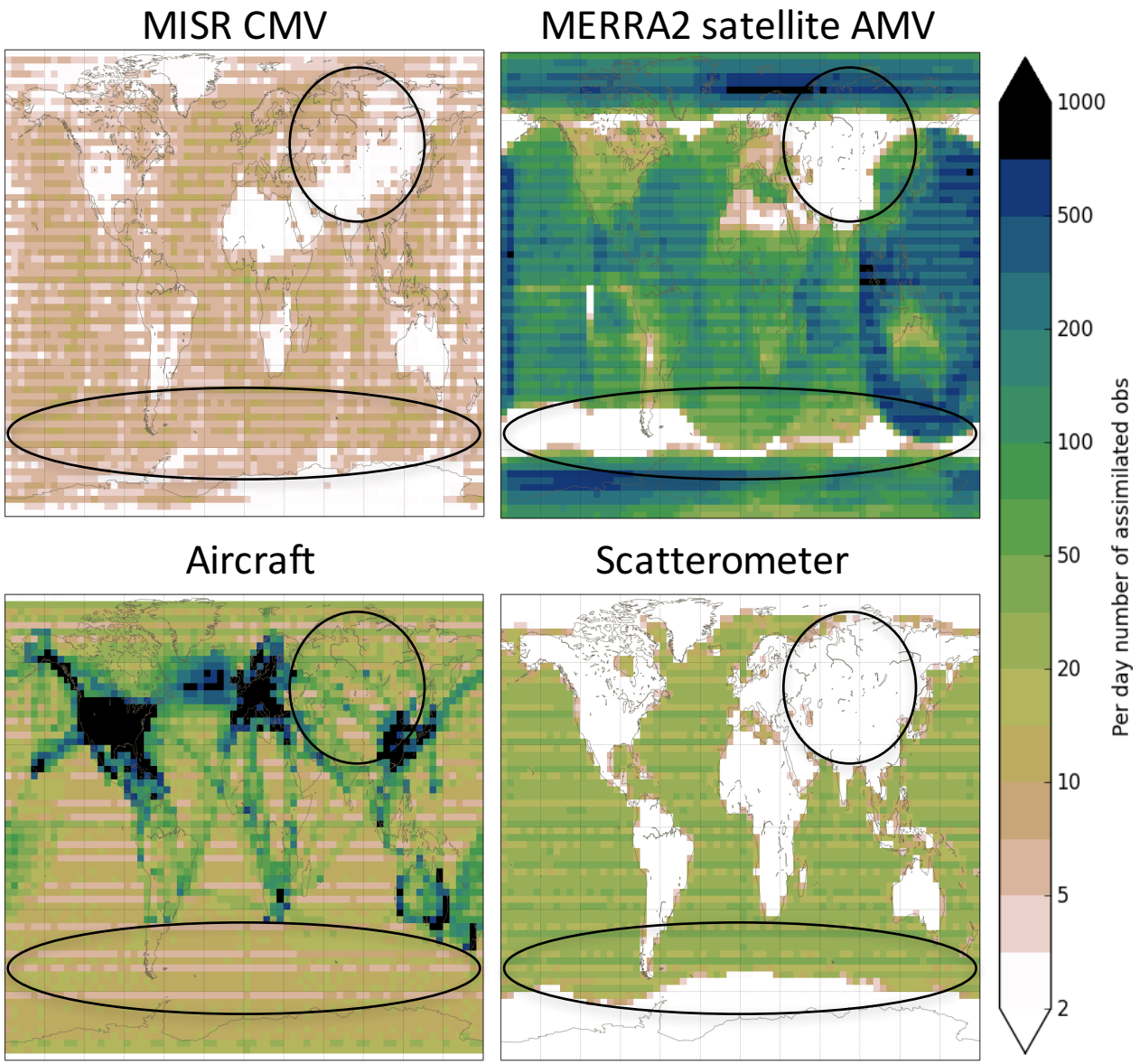
Experimental setup

- GEOS-5 AGCM + GSI analysis (~0.5°, L72)
- Time period: Sep-Nov 2014, Mar-May 2015
- Assimilation strategies
  - Assimilate u and v components
    - Observation error: 3.0 m/s
  - Assimilate along-track and cross track winds
    - 2.0 m/s error for cross track wind
    - 8.0 m/s error for along tack wind

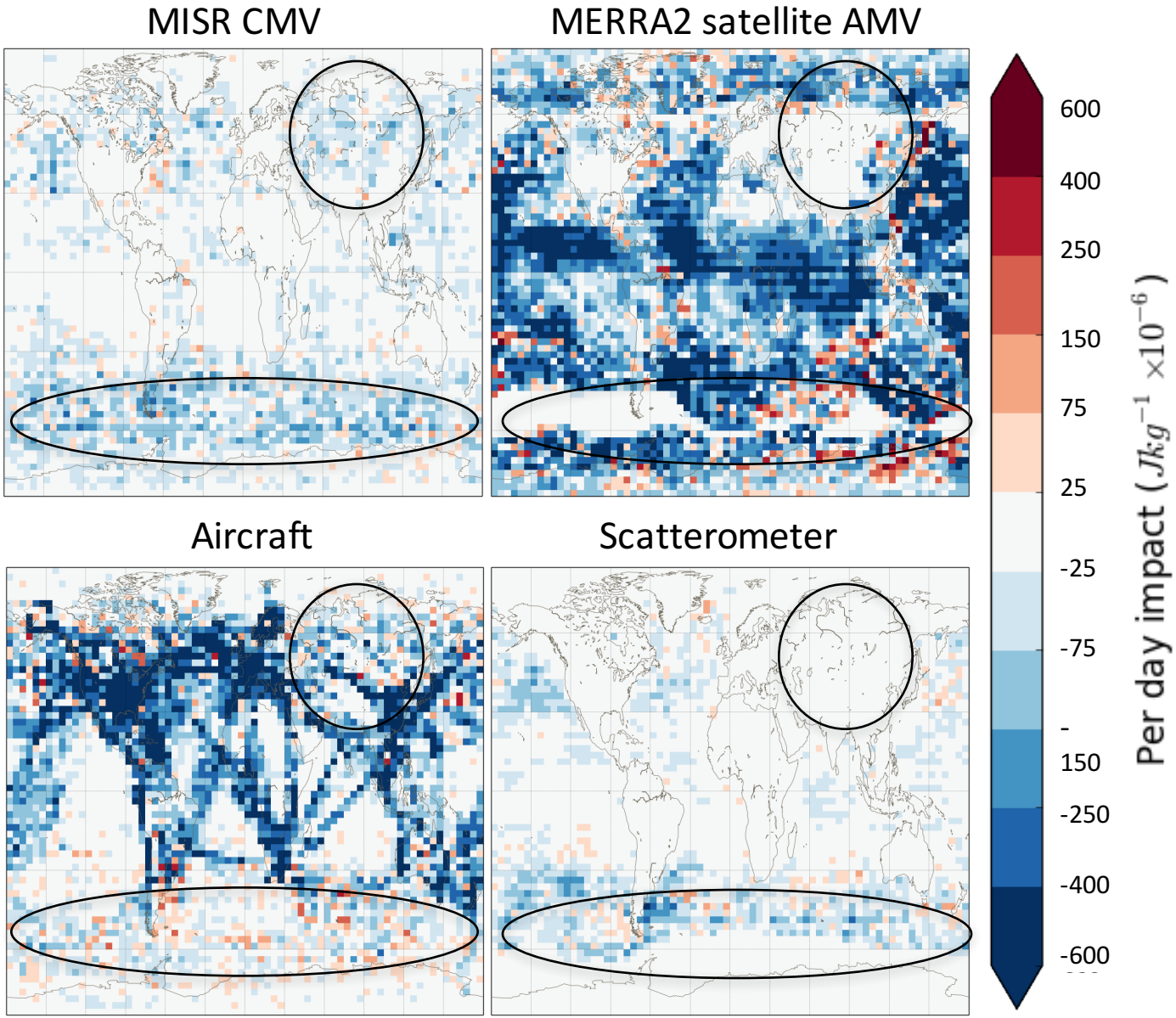


- CMV thinned to 100 km × 100 km × 10 kPa
- Assess the impact of observations with the observation impact on 24-hour forecast error reduction: moist energy norm, calculate every 6 hours

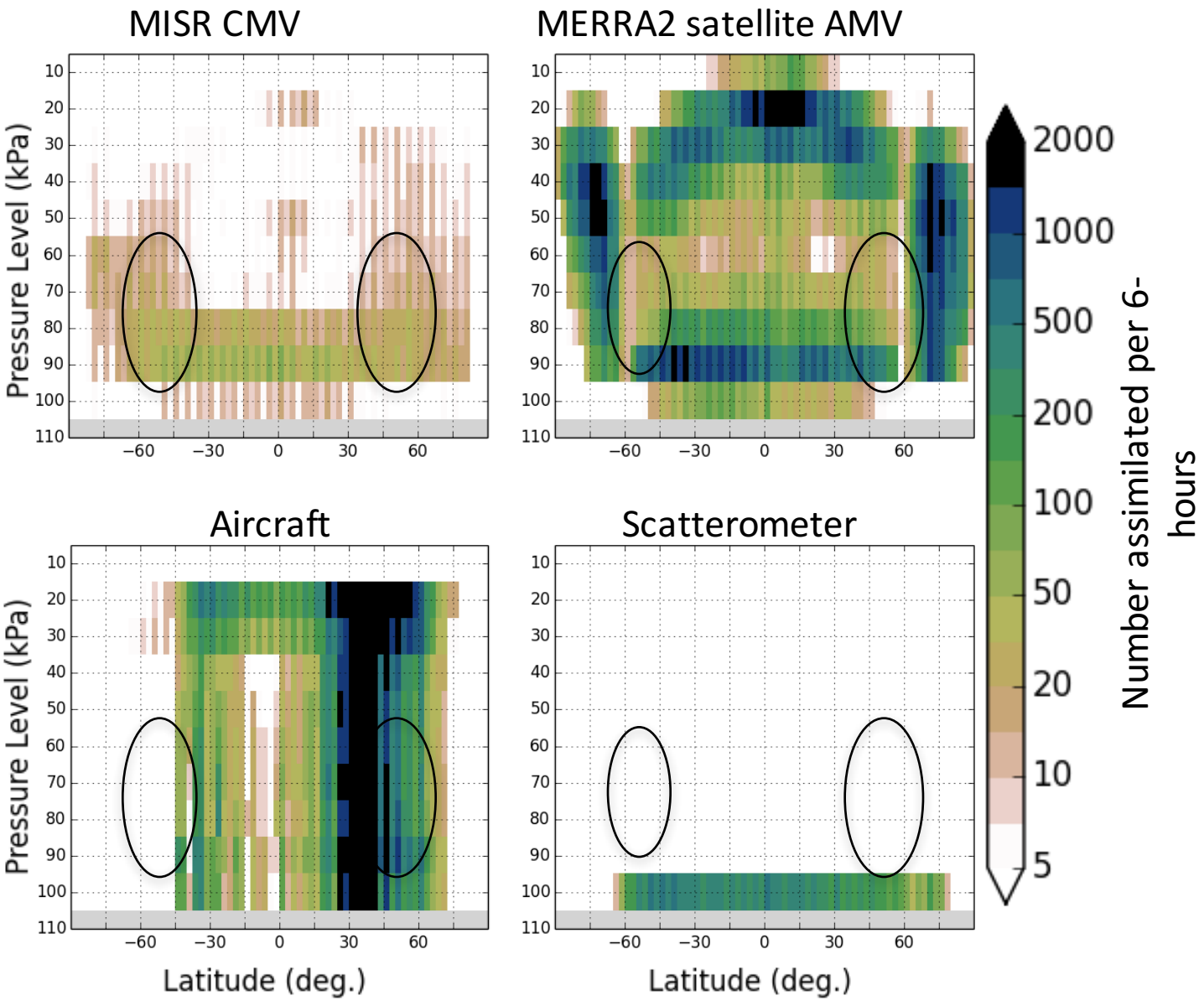
Map of MISR sampling vs. other observations



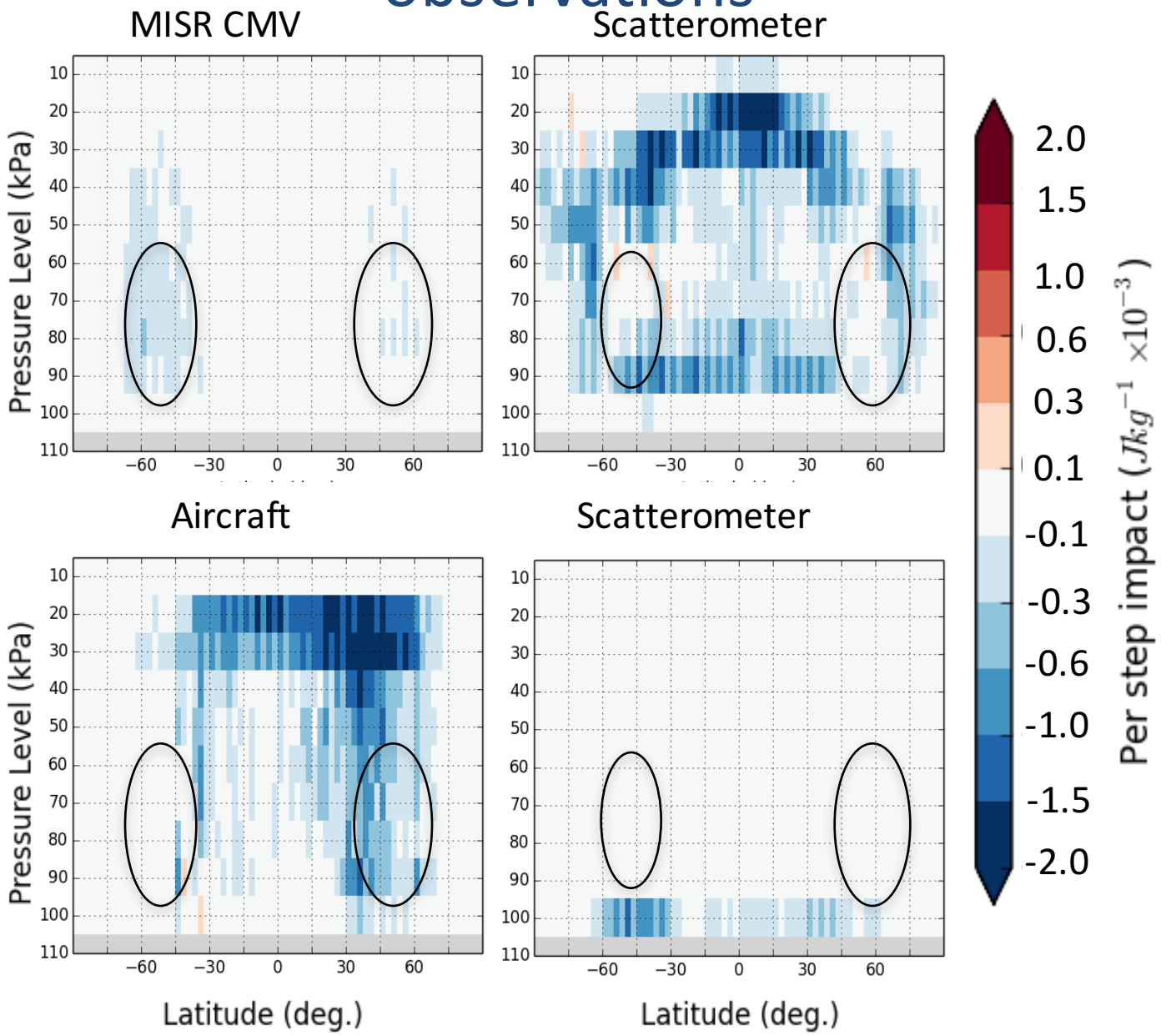
Map of MISR DW run impact vs. other observations



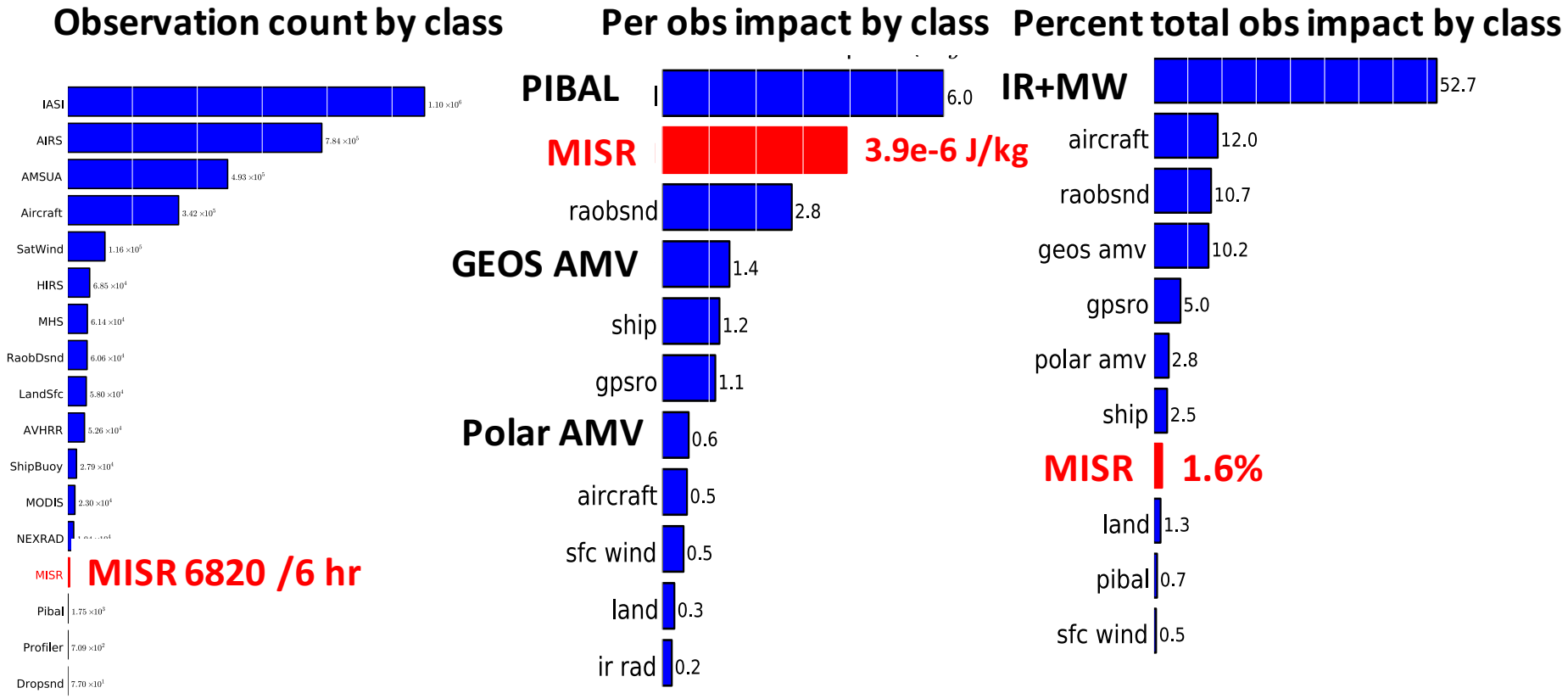
Height distribution of MISR sampling vs. other observations



Height distribution of MISR impact vs. other observations



MISR CMV reduce 24-hour forecast errors in GEOS-5 DAS



- ~6000 MISR observations assimilated in each 6-hour assimilation cycle.
- Per observation impact is the 2nd largest among all observation types.
- The MISR total impact is 1.6 % of the impact from all obs.

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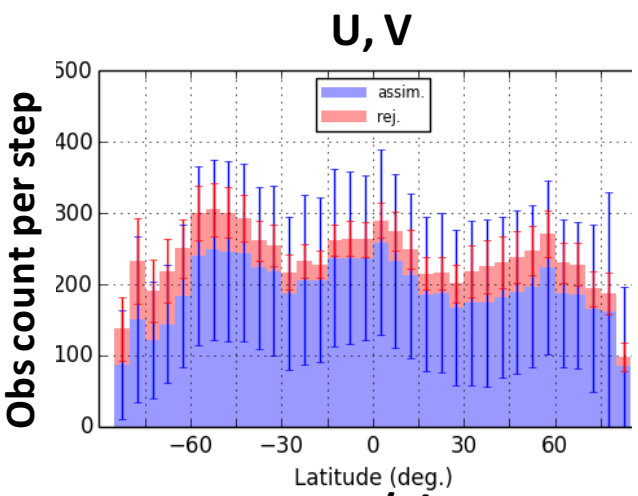
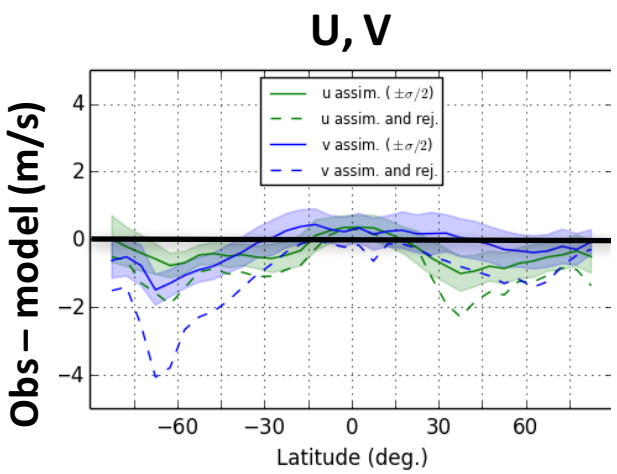
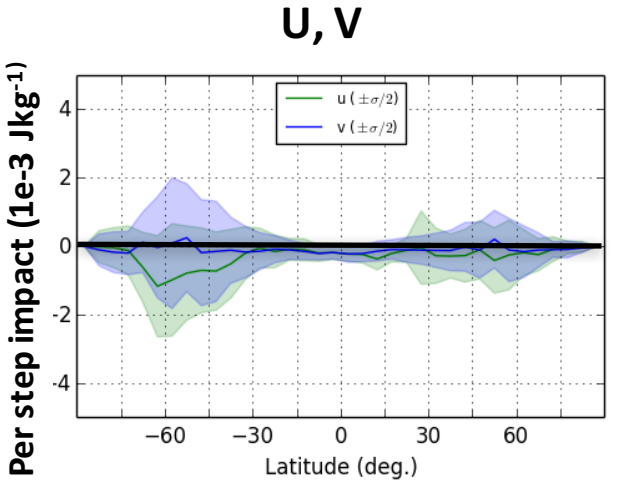
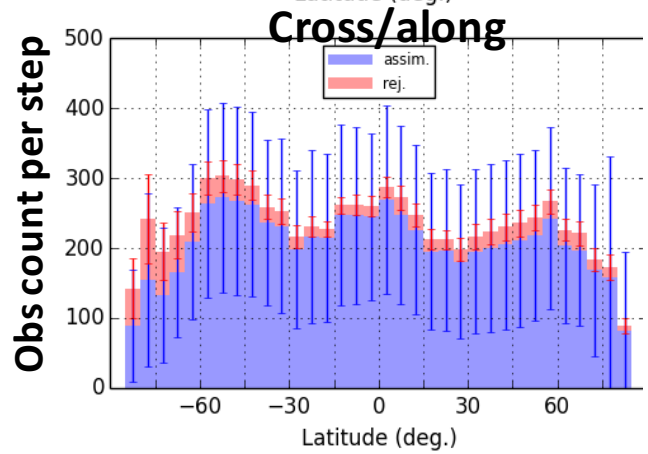
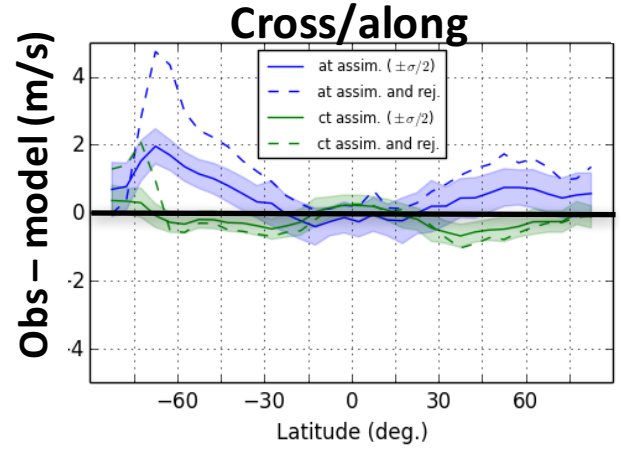
U/V vs. cross/along track wind assimilation as function of latitude

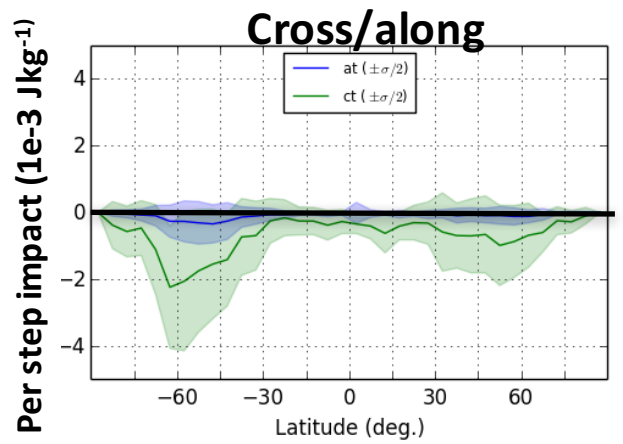








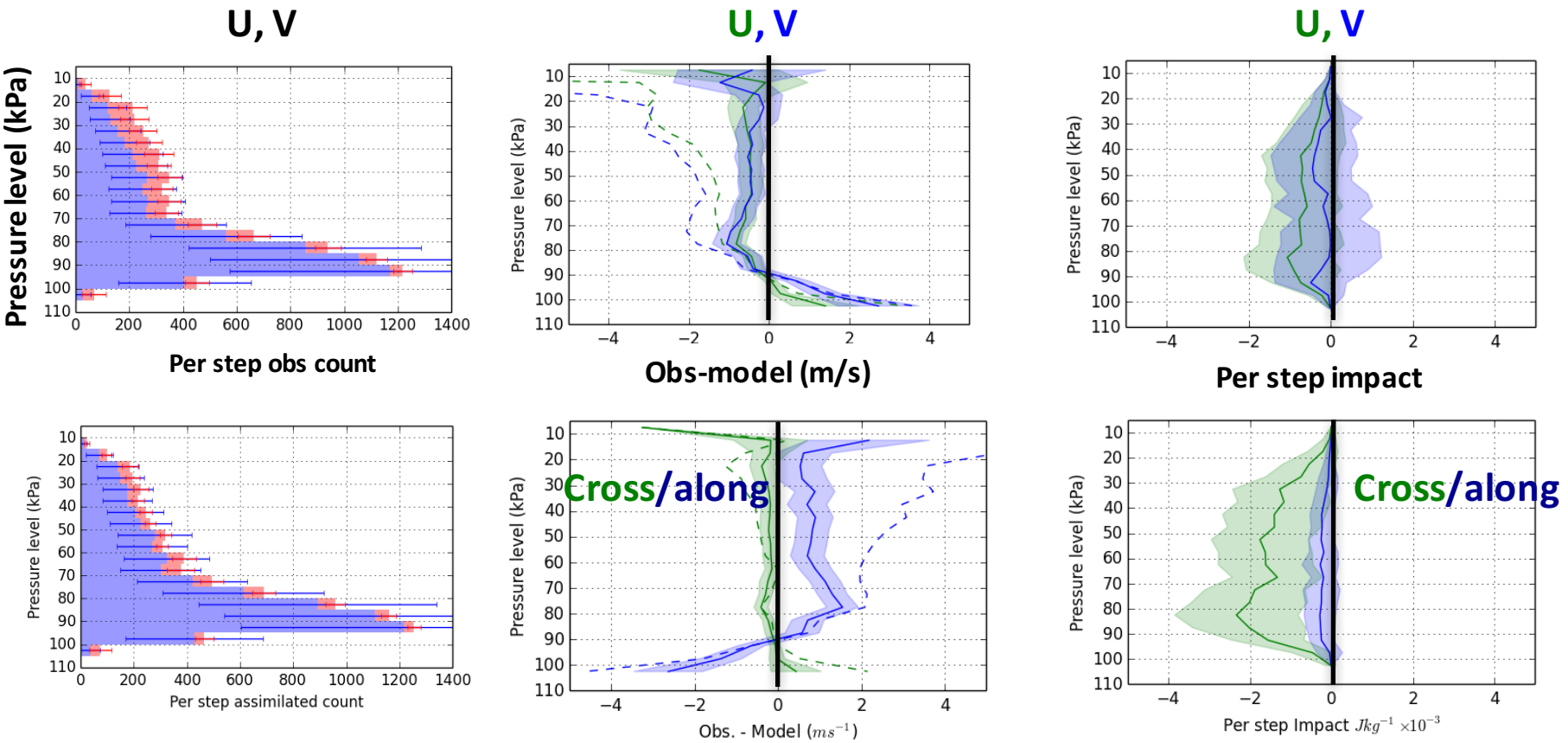




- Assimilate more obs in SH high latitudes with cross/along track than with u/v
- obs – model is smaller with cross-track wind than u component, especially over high lats;
- Per step obs impact from cross-track is about **double** of u component

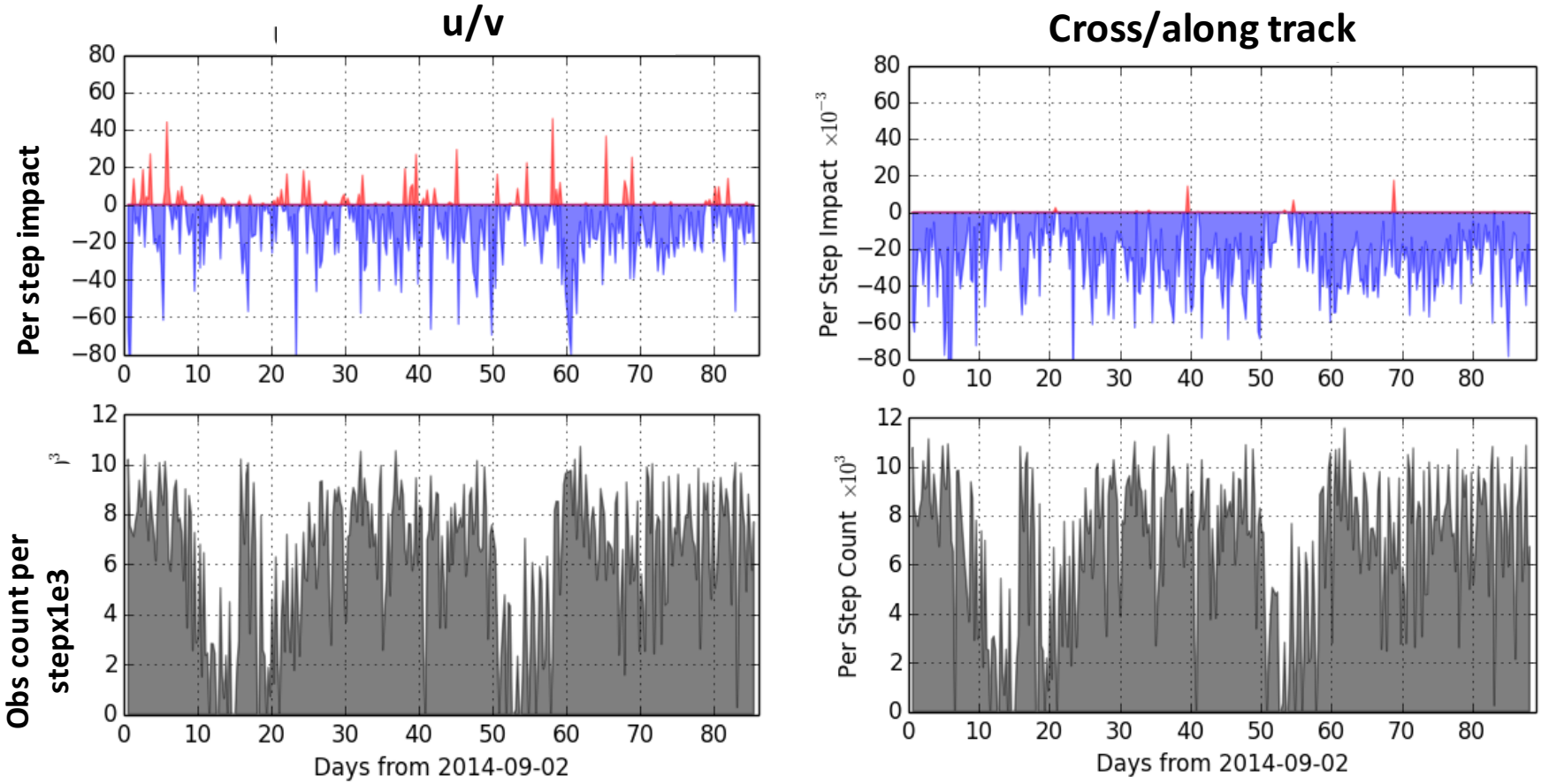
Mueller et al., (in preparation)

U/V vs. cross/along track as a function of height



- Assimilate slightly more observations over high altitude with cross/along track winds
- The cross-track wind is much less noisy than u component when compared to model
- The larger observation error statistics in along track wind reduce the impact of the wind
- The cross-track wind impact is about two times of u component in all levels

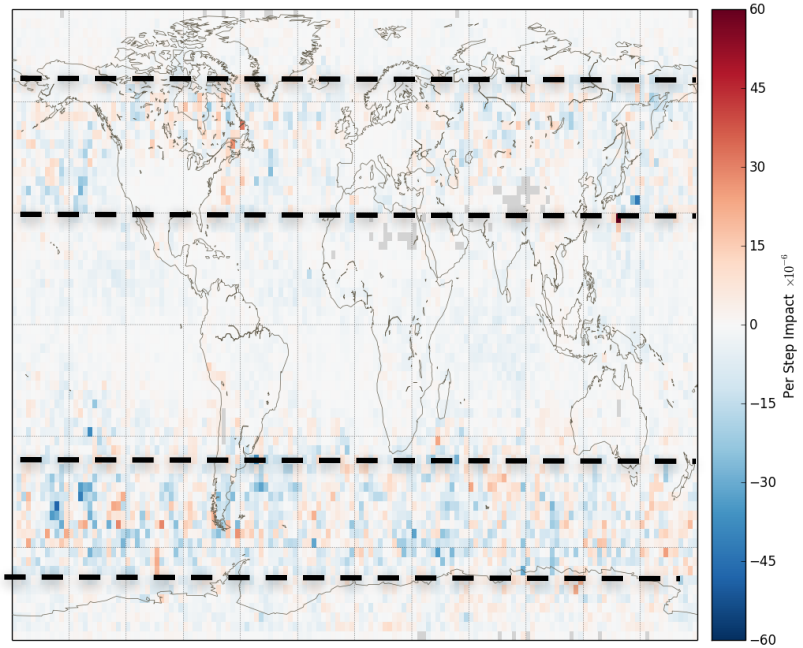
Time series of U/V vs. cross/along track impact



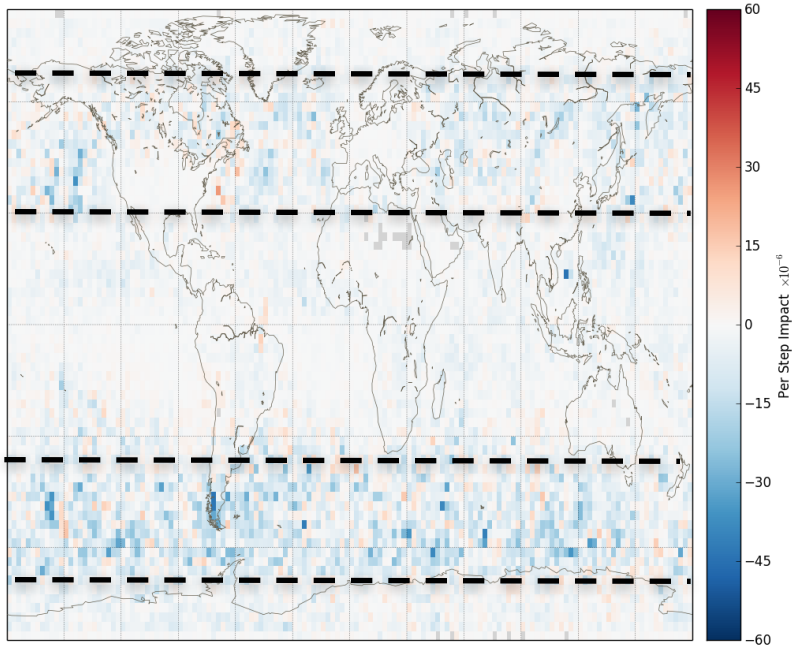
- **Per step aggregate MISR wind impact is strongly correlated with number of obs per step**
- **Cross/along-track wind assimilation consistently performs better than u/v assimilation**

Time mean spatial distribution of the MISR wind obs impact

U/V



Cross/along



- **Cross/along track wind assimilation reduces forecast errors by much larger amount than u/v**
- **Assimilating cross/along track MISR wind better takes advantage of the MISR wind properties.**

Summary

- **MISR CMV status**
  - **Positive O-B statistics in monitoring**
  - **Continuing investigation of forecast impact**
- **MISR CMV vs. GOES AMV height assignment**
  - **Comparison with GOES shows tendency of MISR CMV with jointly biased along-track and height components**
  - **Comparison with GOES also highlights systematic height assignment issues with GOES AMV where MISR CMV heights are more accurate**
- **MISR forecast impact**
  - **Assimilating cross/along track winds doubles the positive impact on forecast error reductions compared to assimilating u/v winds**
  - **The per obs impact of MISR is the 2nd largest among all observation types; The percent total MISR wind impact is 2.2%.**
  - **The NRT MISR winds have similar positive impact on forecast error reduction as retrospective MISR winds.**