# AIRS and CrIS sampling comparisons

H. E. Motteler, L. L. Strow

UMBC Atmospheric Spectroscopy Lab
Joint Center for Earth Systems Technology

July 20, 2017

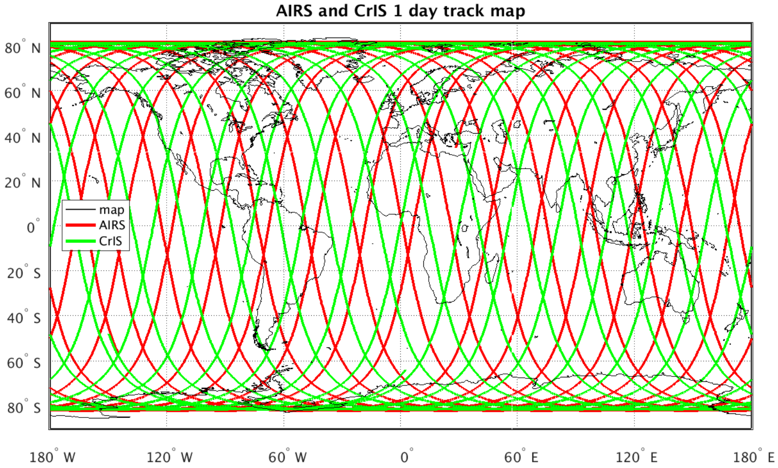
# topics

- orbital parameters and secants of zenith angles
- equal area bands, bins, and latitude weighted subsetting
- detailed AIRS and CrIS sampling comparisons
- 16-day, seasonal, and annual AIRS and CrIS PDFs
- sampling variation for CrIS FOVs 1 and 9.

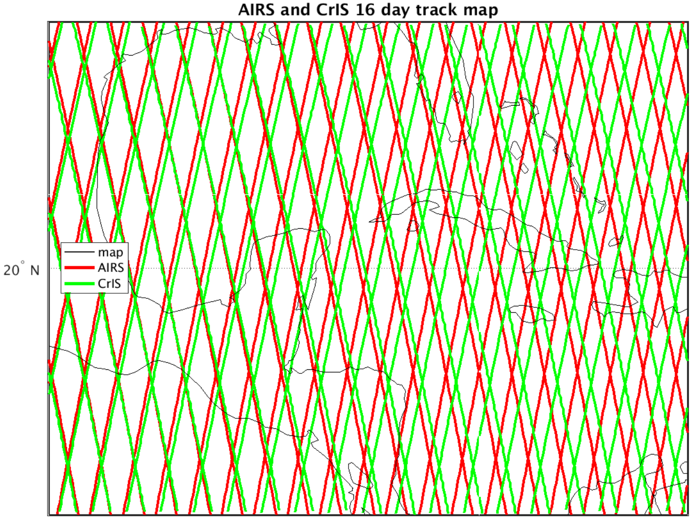
# orbital parameters

- we want to compare AIRS and CrIS obs coverage. Both are in sun-synchronous polar orbits
- the CrIS orbital period is 101.5 minutes $\pm 0.2$ seconds, giving 227 orbits every 16 days
- the AIRS orbital period 98.8 minutes, giving 233 orbits every 16 days
- 227 and 233 are both prime; there are no common factors and so no repeating subpatterns
- the scan patterns and in particular the secant of zenith angles are relatively close, as shown in a subsequent slide

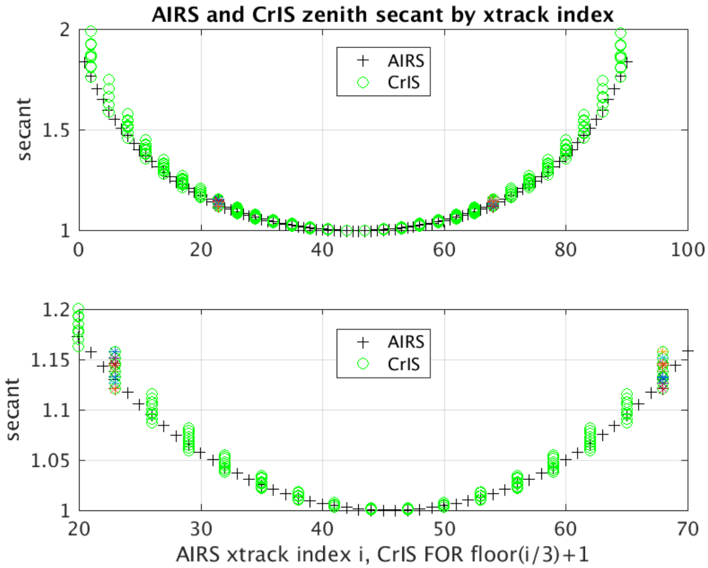
# one-day track map



# 16 day track maps



# AIRS and CrIS secant of zenith angles



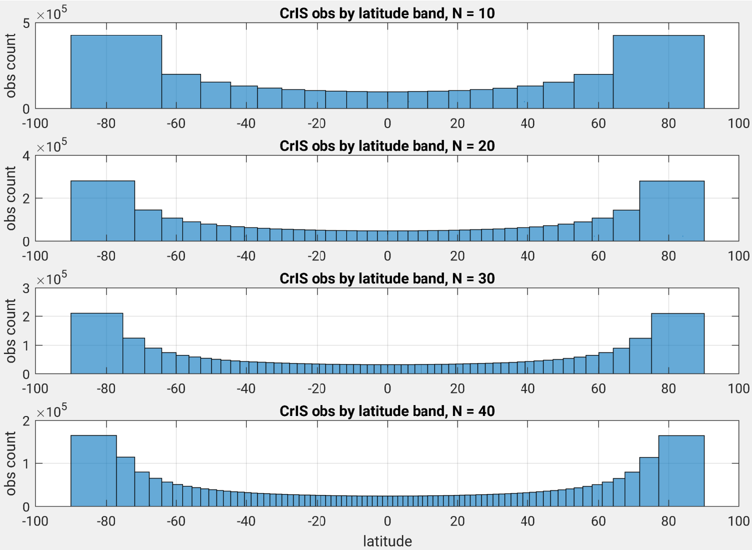
# test data

- most comparison tests of orbital parameters shown here are done with a 16 day data set from 20 Apr to 5 May 2016, chosen for no missing AIRS or CrIS obs
- PDFs are shown for the 16 day set, the 2016 seasons, and all of 2016 broken out by land and ocean
- aside from some of the final CrIS-only FOV comparisons, all tests and PDFs shown here were done with both ascending and descending orbital phase
- tests shown here are with either near-nadir or full scans; near-nadir for AIRS is cross-track indices 43–48, and for CrIS fields of regard 15 and 16

# equal area bands and bins

- we use latitude bands to test our latitude weighted subsetting, and equal area bins to examine obs and mean times per bin to compare AIRS and CrIS sampling
- equal area bins are formed from 24 equal area latitude bands from pole to equator (and so 48 bands total) and longitude steps of 4 degrees
- we have looked at other binning parameters; smaller bins give greater variation. The values chosen may be reasonable for evaulating samping for long span tests
- the equal area subsetting is not actually used in the tabulation of PDFs; the bins there are brightness temperature obs counts

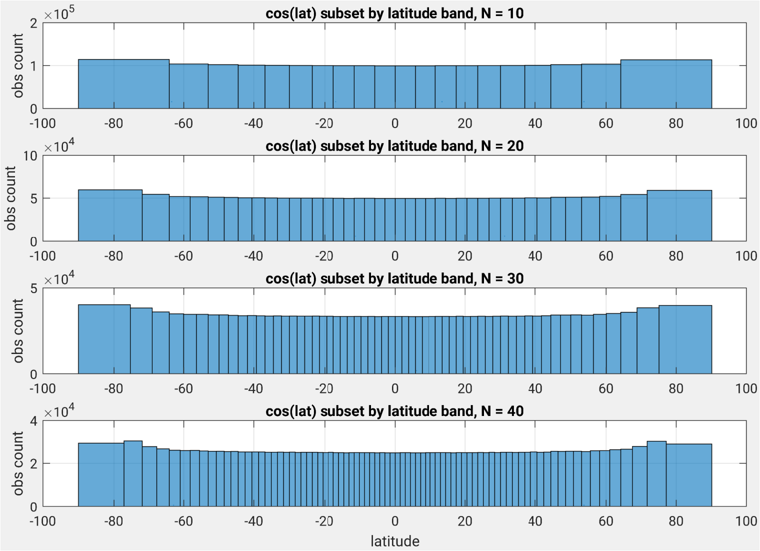
# CrIS 16–day near-nadir obs count by latitude band



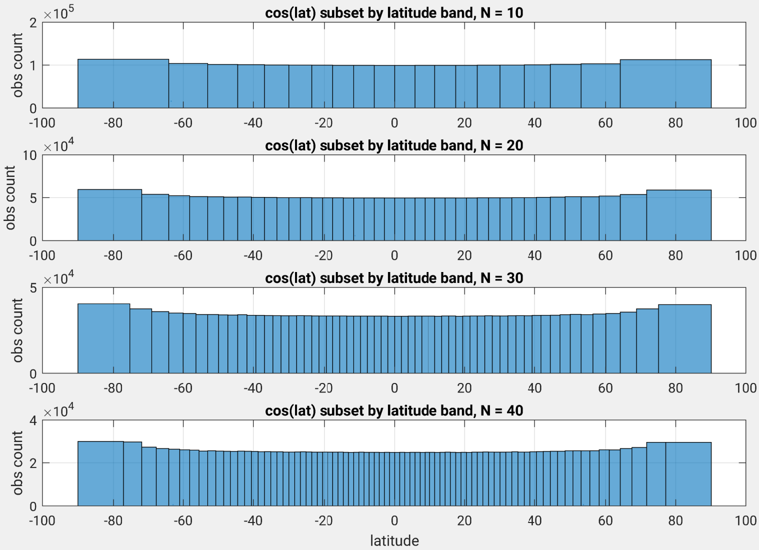
# latitude weighted subsetting

- we want to do global stats with equal area sampling
- AIRS and CrIS oversample significantly towards the poles, so we want to drop some of those obs
- a simple heuristic is to keep all obs such that $X < \text{abs}(\cos(\text{lat}))$, where $X$ is a random variable from the uniform distribution $[0, 1]$
- as shown on subsequent slides, this works fairly well.
  It is not hard to do better; for example $X < \text{abs}(\cos(\text{lat})^{1.1})$ gives more uniform sampling for $N$ up to around 40. But that is a hack.
- all subsequent results here, and in particular all the PDFs, are done with the basic cosine subsetting unless otherwise noted

# CrIS cosine of latitude subset



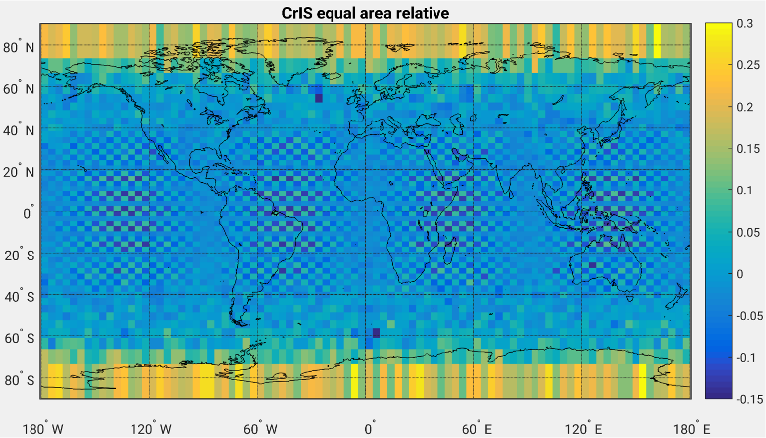
# AIRS cosine of latitude subset



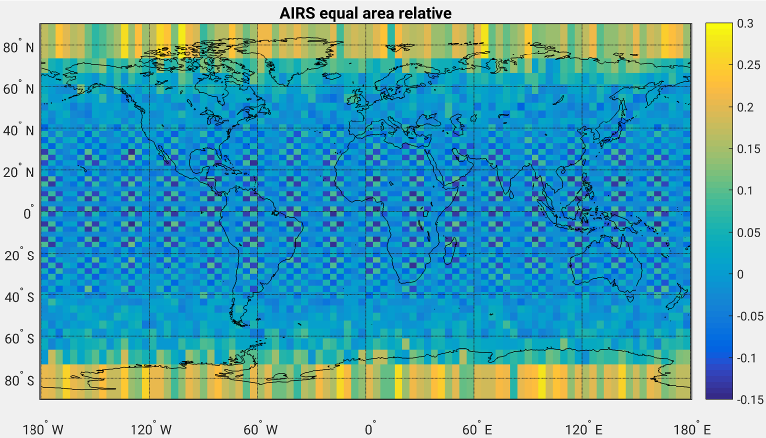
# AIRS and CrIS sampling comparisons

- we compare obs counts and time differences per equal area bin for AIRS and CrIS near-nadir and full scan obs
- Let $c_i$ be the obs count for bin $i$, and $m$ the mean of $c_i$ over all bins for a particular instrument and test. Then $(c_i - m)/m$ is the relative count for bin $i$. This is what we show for the single-instrument maps. We also consider the difference of two such maps
- similarly, let $t_i$ be the mean obs time for bin $i$ and $n$ the mean time over all obs in the test; then $t_i - n$ is the time difference for bin $i$. This is what we show for the single-instrument maps. As with relative obs counts, we also consider the difference of two such maps. In both cases the units for the colormaps are days.

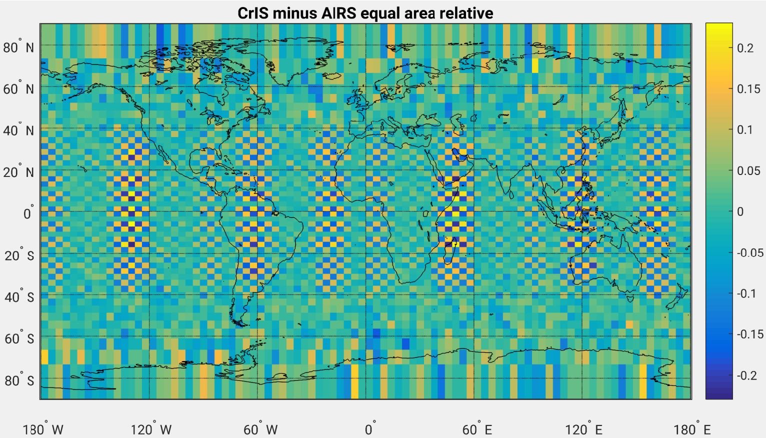
# CrIS near-nadir relative obs count by equal area bin



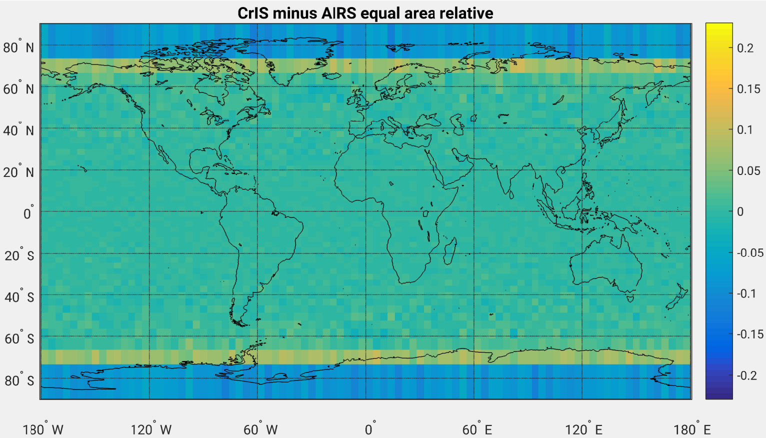
# AIRS near-nadir relative obs count by equal area bin



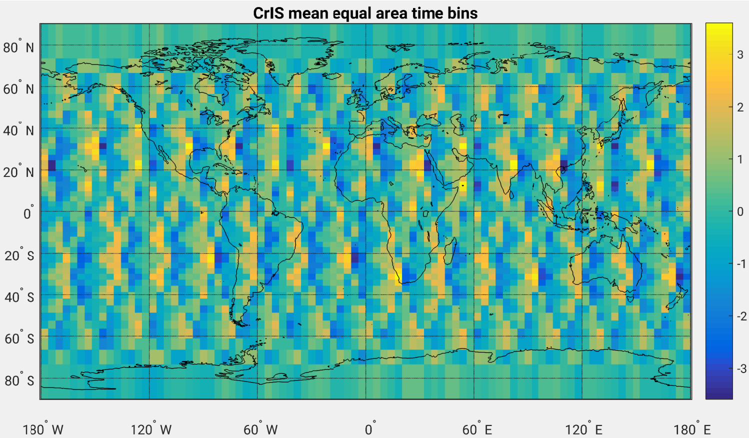
# CrIS minus AIRS near-nadir relative obs difference



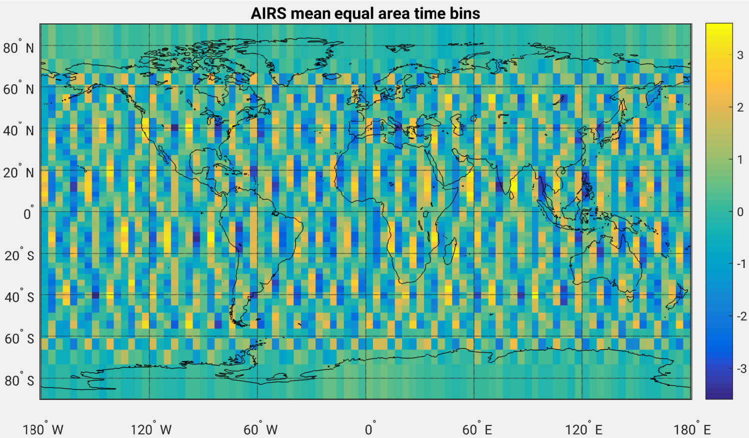
# CrIS minus AIRS full-scan relative obs difference



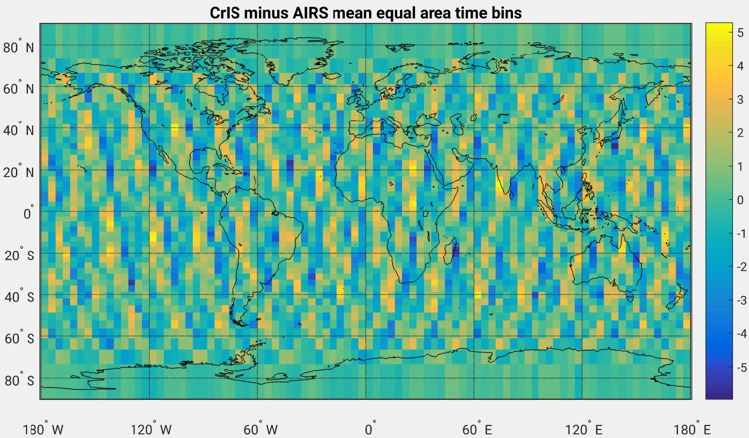
# CrIS near-nadir mean time by equal area bin



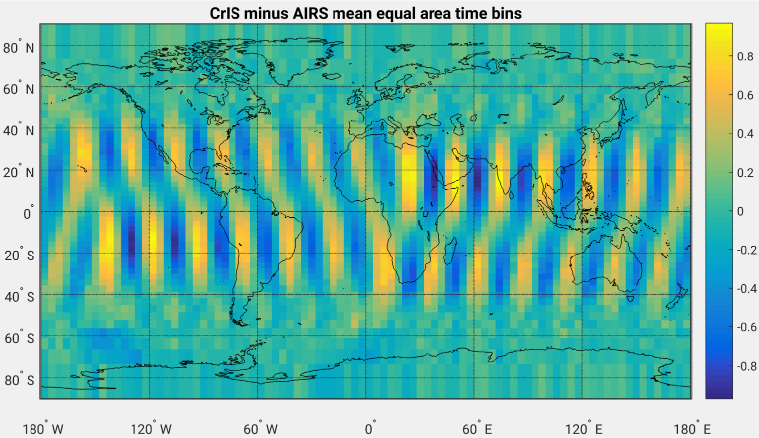
# AIRS near-nadir mean time by equal area bin



# CrIS minus AIRS near-nadir time difference



# CrIS minus AIRS full-scan time difference



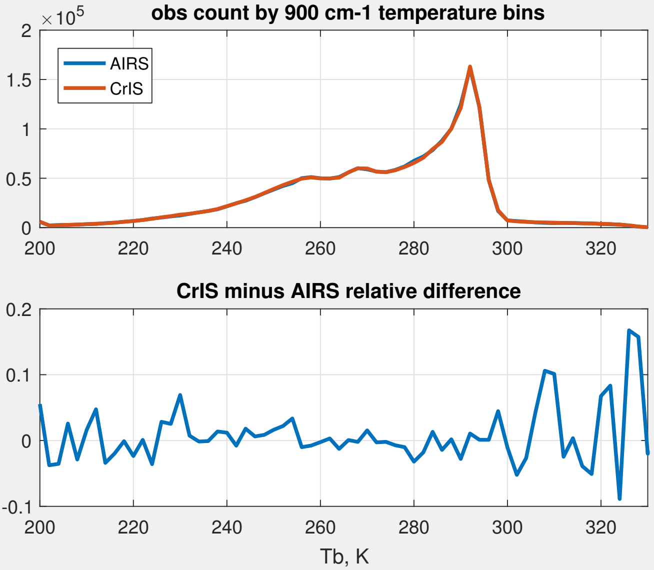
# AIRS and CrIS PDFs

- we create PDFs (or obs per $T_b$ bin tabulations) for AIRS and CrIS as follows

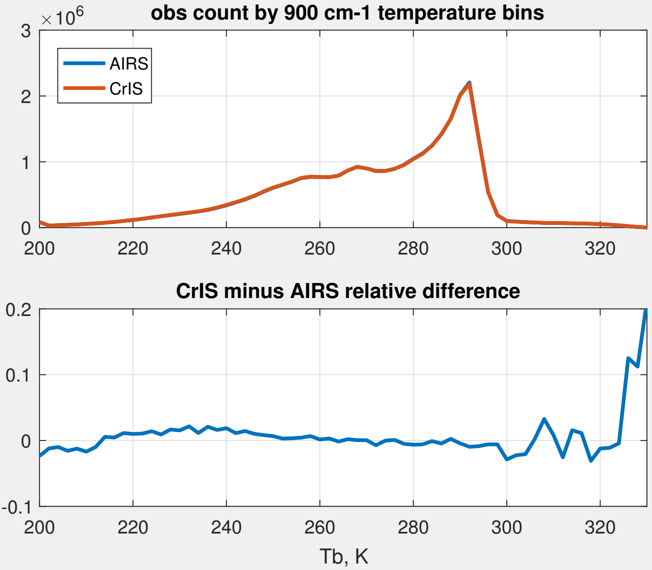
  1. choose a test period and any subsetting options
  2. tabulate obs by $T_b$ bin the test periods, for both AIRS and CrIS. Let $n_a$ be the total number of AIRS and $n_c$ the total number of CrIS obs. Continue only if $n_a$ and $n_c$ are close, typically within about 1 pct
  3. normalize the CrIS counts to AIRS, multiplying by $n_a/n_c$.
  4. examine the relative difference of the normalized counts. If $k_a$ and $k_c$ are AIRS and CrIS counts for $T_b$ bin $K$, this is $(k_c n_a/n_c - k_a)/k_a$.

- to increase the sample space, we would like to work with full scans, if possible

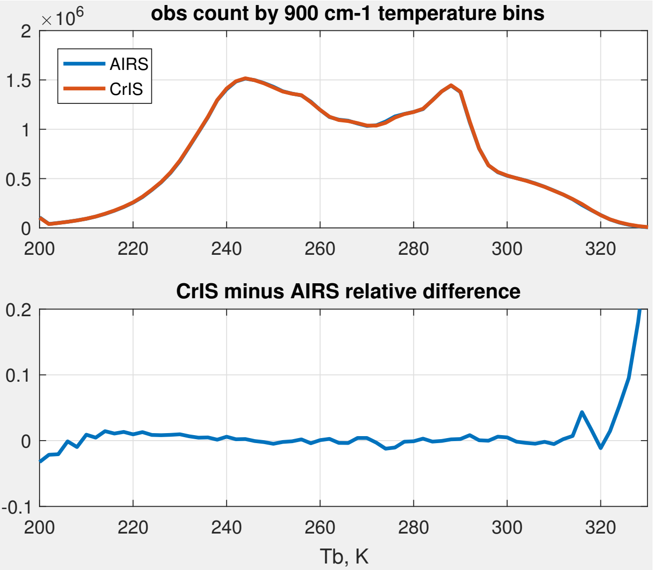
# 16 day near-nadir obs by Tb bin



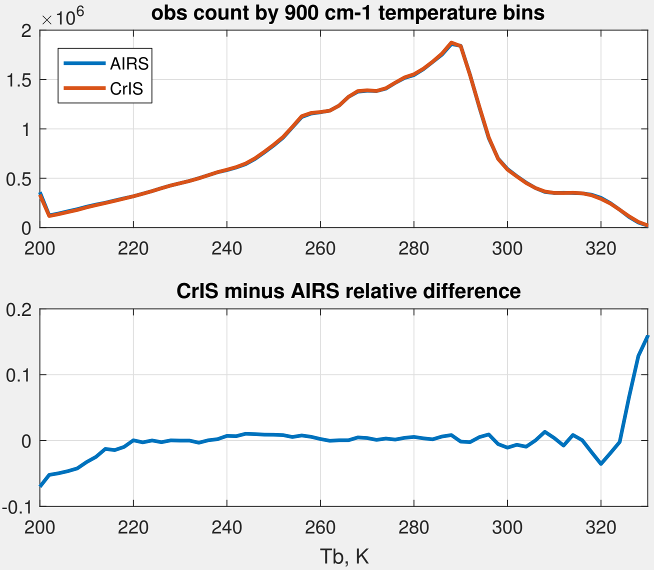
# 16 day full scan obs by Tb bin



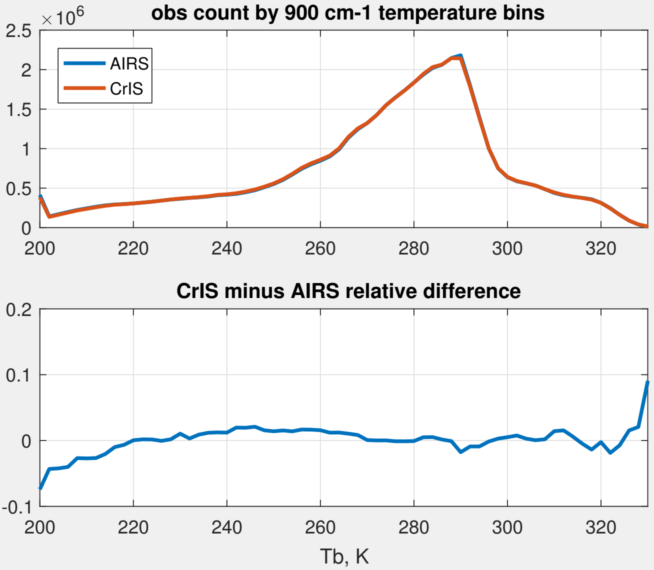
# 2016 winter full-scan land only



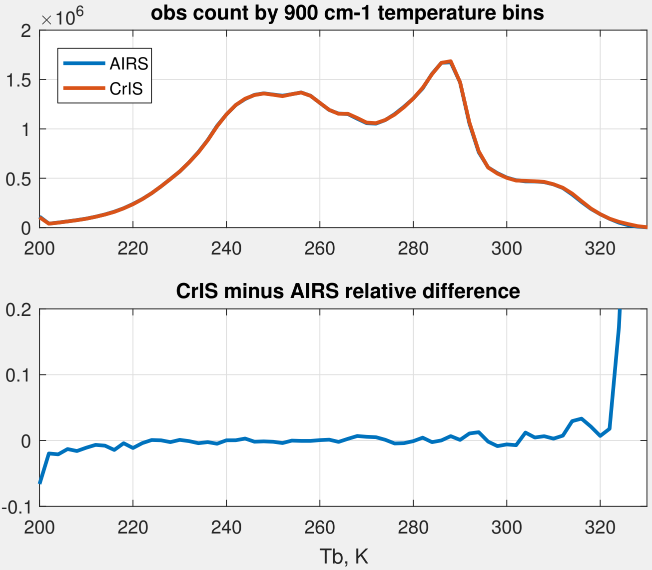
# 2016 spring full scan land only



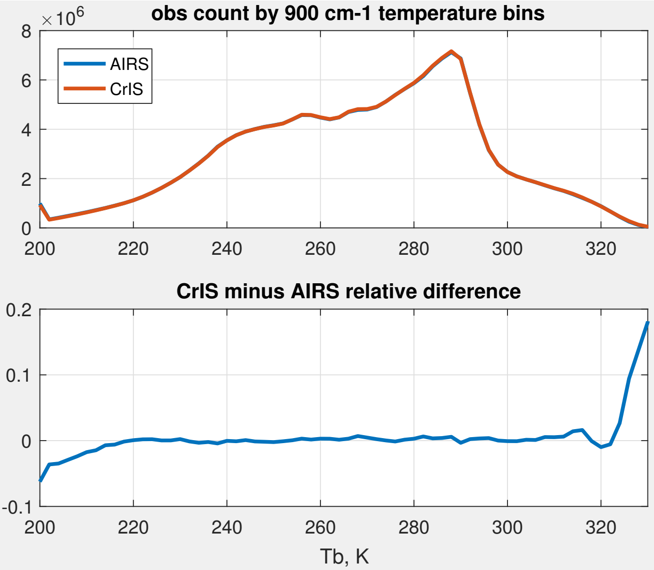
# 2016 summer full scan land



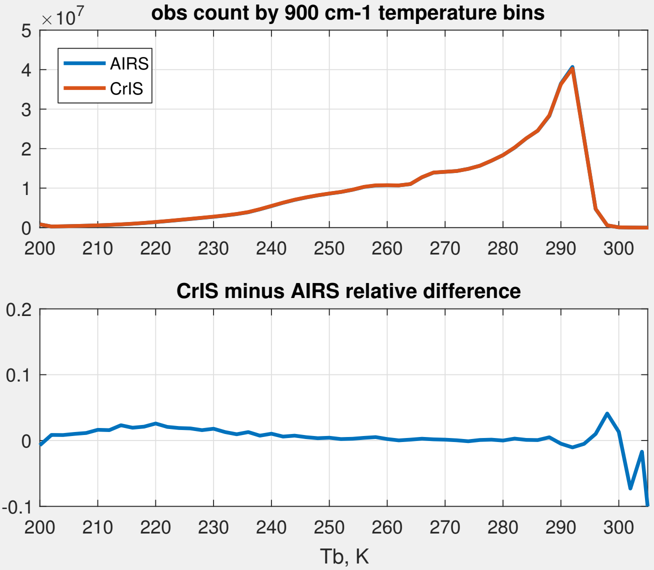
# 2016 fall full scan land



# 2016 full year full scan land



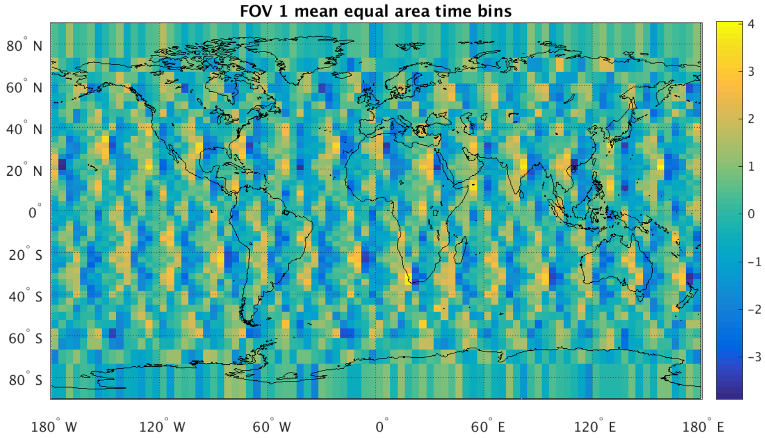
# 2016 full year full scan ocean



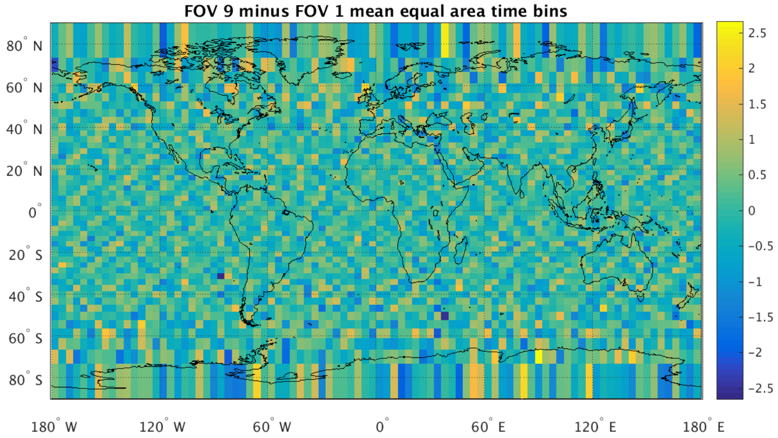
# CrIS FOV comparisons

- in these tests we apply our methods for AIRS and CrIS comparisons to individual CrIS FOVs
- the range of test parameters is expanded; we look at both ascending and descending together and descending alone, and binning at both coarser and finer resolutions
- the next group of tests is from the 20 April 2016 16 day set, near-nadir only (FOR 15 and 16), with latitude weighted subsetting turned on.
- the time differences are calculated as before, but the 72-band obs count stats are for raw obs count, not relative counts

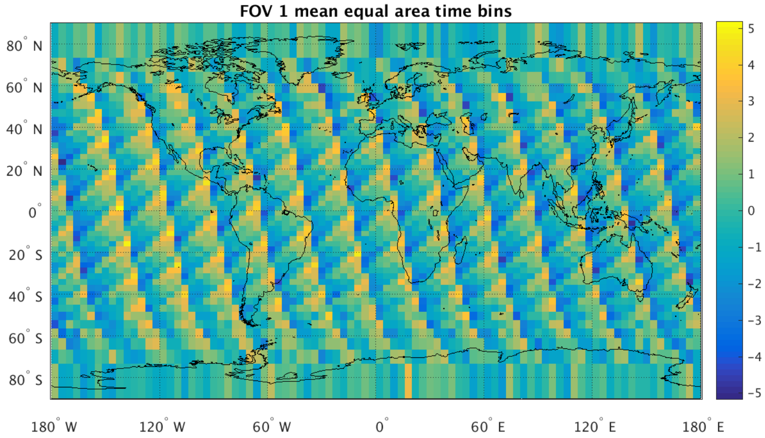
# FOV 1 only ascending and descending



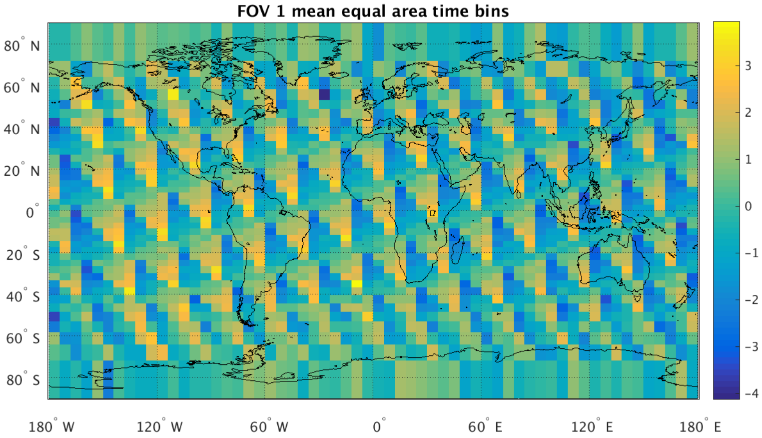
# FOV 9 minus FOV 1 ascending and descending



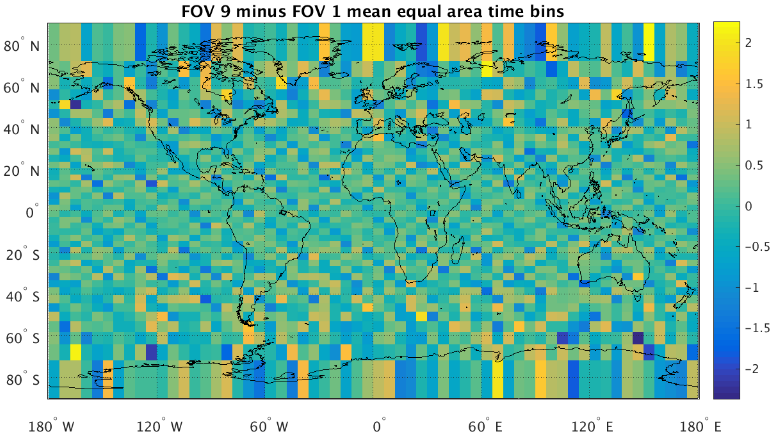
# FOV 1 descending 48 band



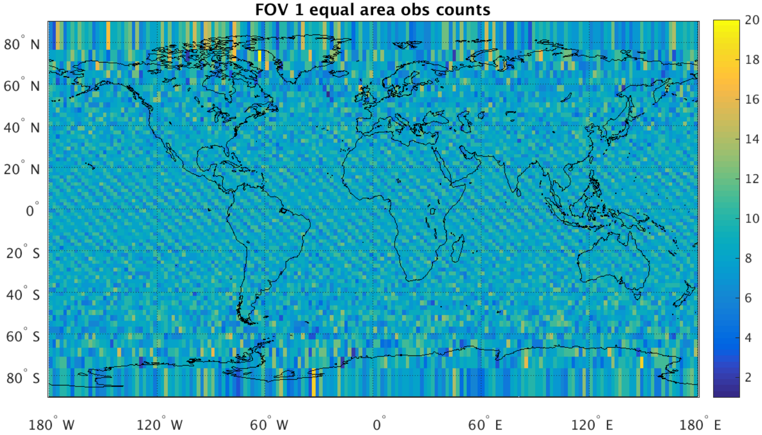
# FOV 1 descending 40 band



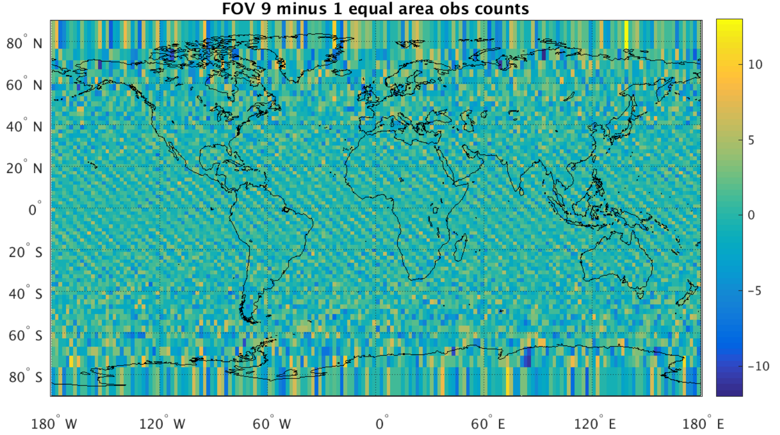
# FOV 9 minus FOV 1 descending 40 band



# FOV 1 72 band raw obs counts, descending



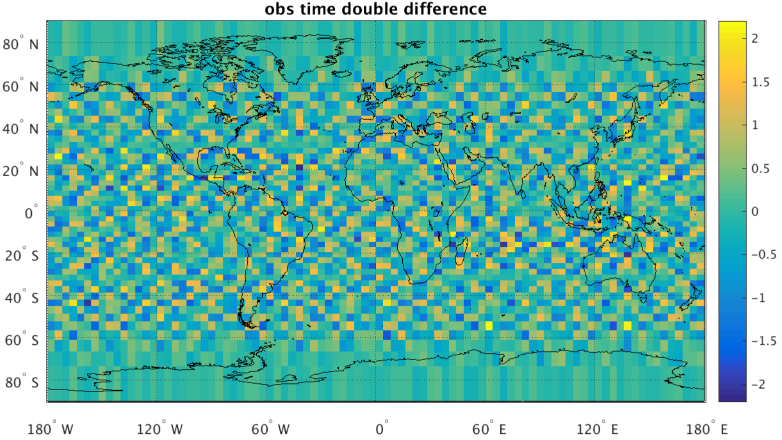
# FOV 9 minus FOV 1 72 band raw obs diff, descending



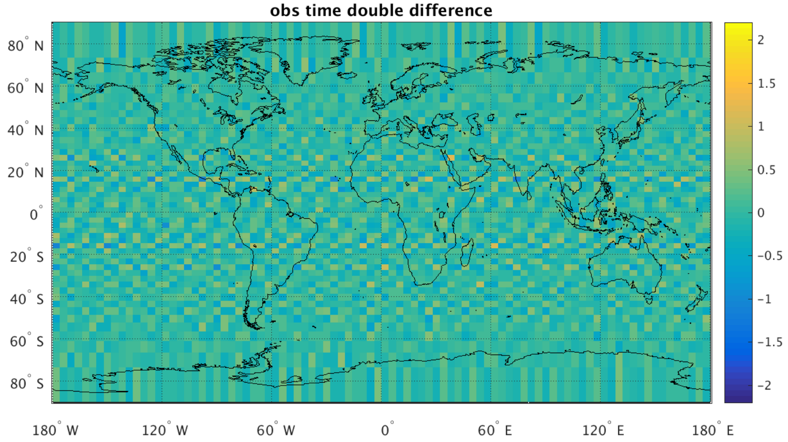
# CrIS FOV comparisons

- in the remaining tests we look at double differences for different time spans. The single differences are FOV 9 minus FOV 1, as above
- the first double difference has the second single difference shifted by 7 days
- the second double difference has the second single difference shifted by 16 days, a complete orbital cycle
- in theory with all subsetting turned off the double difference for the 16 day shift should be zero, because the orbital cycle repeates
- the remaining residual may be due to some mix of varying QC and small actual variation in the obs

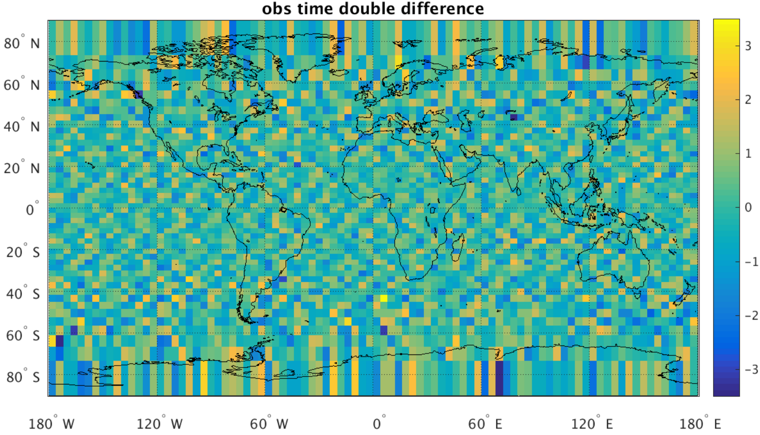
# double difference for a 7 day shift, no subsetting



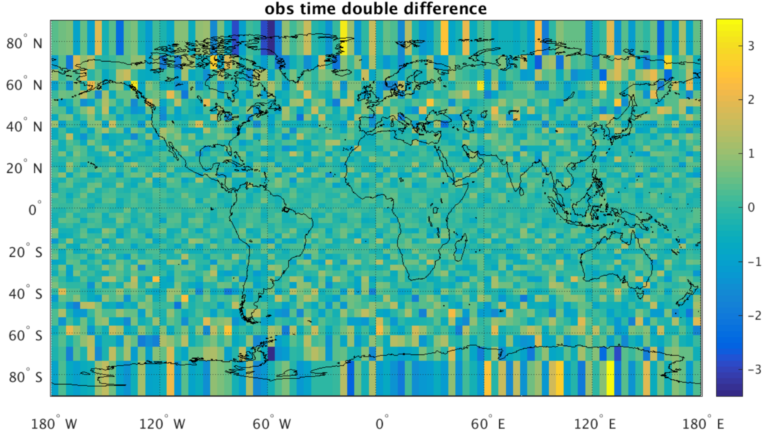
# double difference for a 16 day shift, no subsetting



# double difference for a 7 day shift, latitude subset



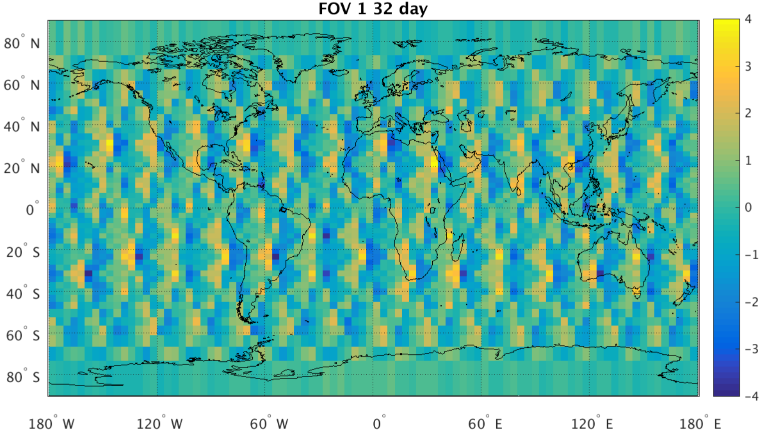
# double difference for a 16 day shift, latitude subset



# CrIS FOV comparisons

- adding the latitude weighted subsetting increases the time variation and obscures the shifts in the 16 day sampling pattern
- the final test is a sort of sanity check on our time sampling; we compare FOV 1 alone with no subsetting for 16 and 32 day periods
- our time measure is mean bin time minus mean test time
- we would expect this measure to be relatively stable over multiples of the 16 day pattern; so for example the means for a 32 day test would be similar to the means for a 16 day test
- as with the double differences this is only partially true

# FOV 1 near-nadir 32 day, no subsetting



# FOV 1 near-nadir 32 day minus 16 day, no subsetting