Algorithm Theoretical Basis Document

Level 1B

AIRS and CrIS SNPP Calibration Data Subset

Version 2.0

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1. Introduction

The AIRS and CrIS calibrated radiance spectra (Level-1B and Level-1C) are available from the archive at the GFSC DISC as 240 files, 250 MB/file, each representing 6 minutes of data. Reading these daily for the analysis of a multi-annual time period is impractical. The AIRS and CrIS Calibration Subsets (CalSub) extract subsets of key information from the daily Level-1 record. The CalSub products contain the information necessary to evaluate the stability and accuracy of the radiometric and spectral calibration. This reduces the volume of the data by approximately a factor of 100.

AIRS CalSub contains data since 2002/09 until present. While the initial objective of these products was the evaluation of trends in the absolute calibration of AIRS under clear ocean conditions, the task has expanded to include cloudy and extreme hot and cold conditions to facilitate the evaluation data quality under extreme conditions.

SNPP CrIS NSR CalSub data started in 2012/05. It is based on the experience with the AIRS CalSub, and facilitate the comparison of AIRS. The variable names and overall design used by SNPP CrIS CalSub closely parallels the design and definitions of AIRS CalSub equivalent daily files. This release only supports SNPP CrIS NSR because a long time basis is critical to most uses of these products and SNPP FSR and JPSS-1 products would span a shorter period.

The purpose of the Algorithm Theoretical Basis Document (ATBD) is to describe the algorithms used to select the subsets of spectra used to generate calibration subsets. The daily output files are in netCDF format. Details of all parameters saved and some examples in Matlab are in the CalSub Users' Guide. In the following only the parameters needed to create the subsets are defined.

2. Design Overview

Each spectrum is tested to see if it is of potential interest: Clear, extremely cloudy, near a special location, extremely cold, or extremely hot, or some other unusual characteristics. Separately, a globally-representative random sample is selected.

In building the daily CalSub product files, two separate approaches are used, supporting different applications. The CalSub full-spectrum files save the random sample of ~1% of all whole spectra (typically 42000 spectra each day), while the CalSub Summary product saves >~10% of spectra but only about <~10% of the channels in each spectrum for typically 300,000 spectra each day.

In each case, the daily files contain supporting information in addition to the radiance/BT data. The fields "***reason***" (Table 1) and "***site_id***" together tell which criteria each spectrum meets. The files also include geolocation information, surface temperature, spectral characterization, and a variety of per-granule statistics. For AIRS there is also spectral shift information, microwave data from the AMSU-A instrument, and AIRS Visible/Near-IR data. See the Users' Guide for more information.

In the summary files, the selected channels are stored as Brightness Temperatures (BTs) in (channel, obs) arrays to facilitate cross-channel comparisons. In the full-spectrum files they are in radiance units. For AIRS, Level-1B V5 ATBD (Aumann 2006) is used in the summary file, but Level-1C (Aumann et al. 2020) is used in the gap-filled full-spectrum (2645 channels) product.

In this document, symbols in bold italic represent the names of variables that can be read directly from the CalSub product files, like "***reason"*** and "***sst1231r5"***. Variable names with plain formatting, like "q3" and "d1294" can be derived from the data as explained below.

3. Design Details

The input Level-1 data are stored in 6-minute files called granules. Each AIRS granule contains 135 scan lines, with 90 footprints per scan line, grouped as a 90x135x2378 array. CrIS NSR has the same number of observations, but grouped as 9 x 30 x 45 x 1305 array. The design details are explained in terms of one AIRS data granule, granule #215 from 2018/10/31. Figure 1. shows the location of the granule in the S. Indian Ocean between 30S and 50S, centered at 53E, from a night-time overpass.

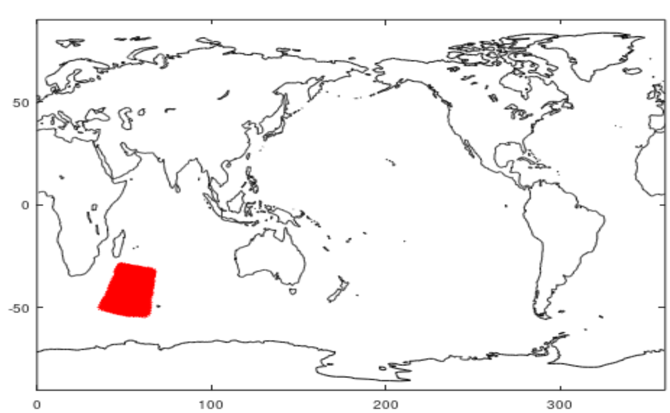

Figure 1. Location of granule 20171931.215.

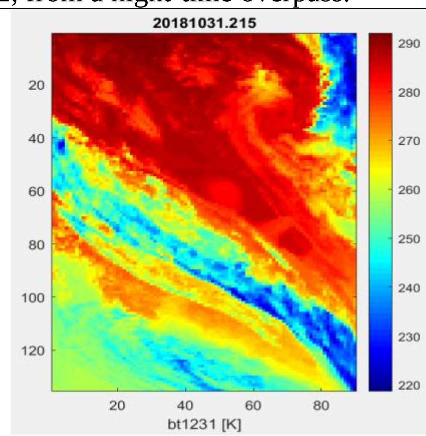

Figure 2. Granule 20181031.215 as observed with the AIRS bt1231 channel

In the following we refer to the BT of individual channels using their nominal spectral response function centroid, e.g. define bt1231 as the brightness temperature of the channel identified as AIRS Level-1B #1291 at 1231.3 cm^{-1}. Figure 2 shows the false color image of bt1231 from AIRS. The warmest (darkest red) areas are relatively clear. Anything from light red to dark blue is increasingly cloudy. Since AIRS and CrIS are in polar orbits with the same 1:30 PM nominal ascending node, the alignment of the two instruments for large area statistical analysis is excellent. However, the orbit altitudes and inclinations are sufficiently different that alignment of individual AIRS and CrIS footprints within 0.1 km of the nominal 12x12 km footprint virtually never happens.

Each footprint saved includes an identification of cloudiness based on parameters derived from Level-1B data: ***stemp_cmc, stemp_clim, sst1231r5/sst1232h5,*** d1231***, cx2616/ce2508, cx1231/ce1232, cx900/ce900,*** and d2194/d2395. There are small naming differences between AIRS and CrIS due to channel availability, e.g. the 1231.3 cm-1 window channel on AIRS is best matched by the 1232.5 cm-1 window channel from CrIS, but the concept is identical.

stemp_cmc. The ***stemp_cmc*** is derived from daily day/night mean SST generated by the Canadian Meteorological Centre (CMC 2012) on a 0.2-degree global daily grid. Over open (non-frozen, warmer than 273K) ocean the ***stemp_cmc*** is closely tied to floating buoys. Over land and all frozen surfaces, the ***stemp_cmc*** uses a fill value. The ***stemp_cmc*** is the temperature at the grid point nearest to the location of each AIRS/CrIS footprint. Figure 3 shows the ***stemp_cmc***.

stemp_clim*.** The ***stemp_clim is based on a monthly mean surface temperature from ECMWF between 2004 and 2008 on a one-degree global grid, separately for the 1:30 AM and 1:30 PM overpasses. The ***stemp_clim*** uses the temperature of the grid-point nearest to the location of each AIRS footprint. Over open ocean it is almost identical to ***stemp_cmc*** with a bias of less than 1K and Standard Deviation (SD) of about 1 K. Unlike the ***stemp_cmc***, the ***stemp_clim*** is meaningful over land and frozen surfaces, but it is not the skin temperatures, but the temperature about 5 cm below the surface. For daytime desert, it may underestimate the true surface skin temperature by 20 K. Figure 4 shows the ***stemp_clim***.

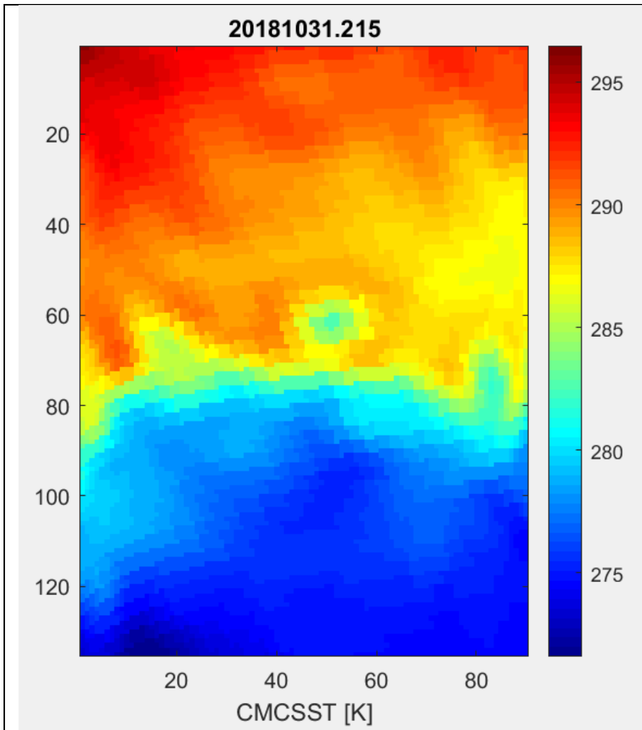

Figure 3. ***stemp_cmc***

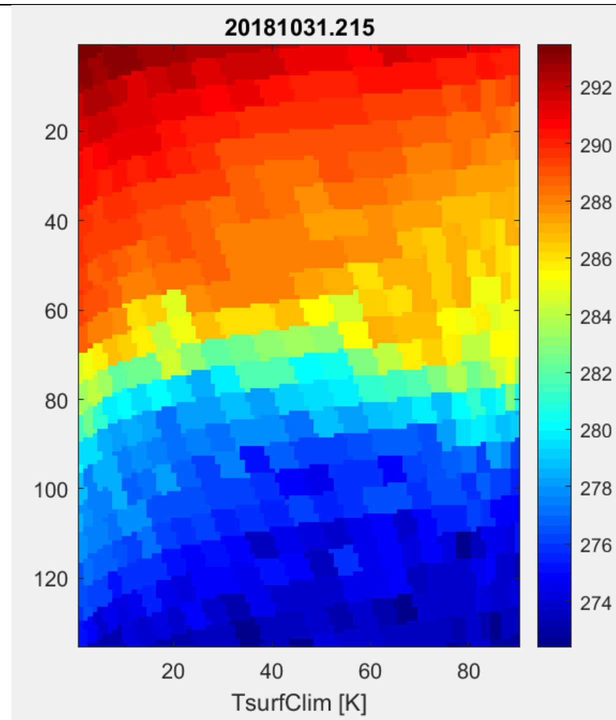

Figure 4. ***stemp_clim***

d2194 is the difference between two lower tropospheric temperature sounding channel at 2194.2 and 2205.3 cm^{-1}, bt2194 and bt2205, corrected for the slant path effect using ***sat_zen***, the satellite zenith angle.

d2194=(bt2194p2-bt2205p3).*cos(***sat_zen***/57.3).^0.3.

The d2194 parameter provides information about the cloud contamination of a footprint. As the cloud height raises above the peak of the weighting function of bt2194, d2194 starts to decrease. It approaches zero when the peak of bt2502 reaches the cloud top. Figure 5 shows an image of d2194. Note the visual correlation between a high d2194 and bt1231 in Figure 2. Figure 6 shows that d2194 is highly correlated with the surface temperature. The line d2194clear=2+(tref-230)*0.112, where tref =***stemp_cmc*** for ocean, tref=***stemp_clim*** for land or frozen surfaces, defines a cloud boundary. A (d2194-d2194clear)>0 defines a cloud threshold.

Conceptually CrIS uses a similar approach. The lower tropospheric lapse rate is given by d2395=bt2395_0h-bt2387_50h, where the "h" stands for the Hanning apodization. The line defined by d2395clear=0.35*(tref-220) separate the likely clear from the likely cloud contaminated footprints.

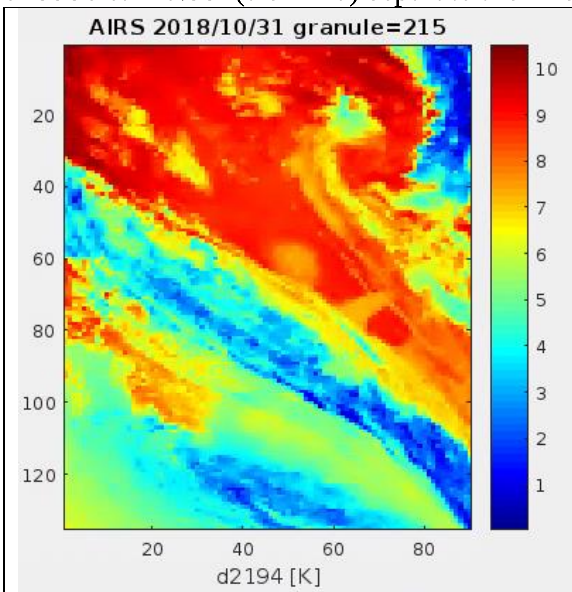

Figure 5. d2194

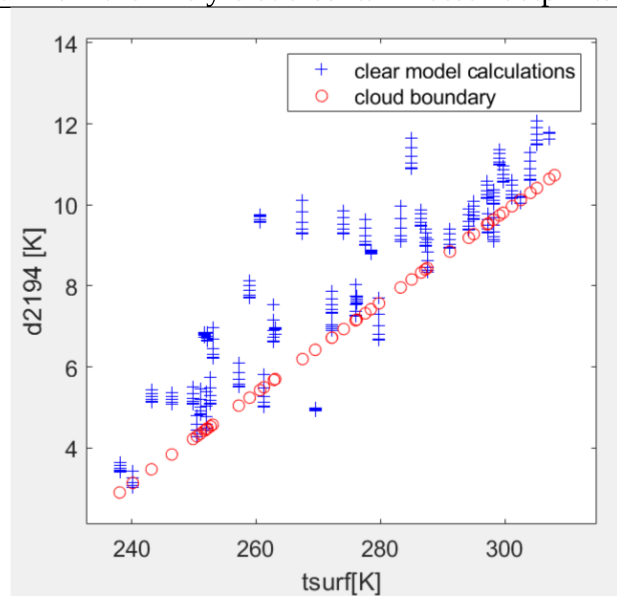

Figure 6. The correlation between surface temperature and d2194

sst1231r5. The ***sst1231r5*** (Aumann et al. 2003 and 2006) is the sea surface temperature deduced from bt1231, assuming that there are no clouds, it can also be interpreted as the surface skin temperature for a surface with emissivity 0.98. The calculation uses of the atmospheric window channel at 1231.3 cm^{-1}, with brightness temperature bt1231, and q3, the difference between bt1231 and the 1227.7 cm^{-1} channel, bt1227. Figure 7 shows the surface skin temperature minus bt1231 as function of q3 based on calculation with LBLRTM_ck25 for 3363 ocean profiles from ECMWF under cloud-free conditions.

The surface skin temperature, ***sst1231r5***, can be stated as

sst1231r5=bt1231+0.2806+1.2008.*q3+0.2962.*q3.^2+1.0489./cos(***sat_zen***/57.3).

For the 3363-profile training set the ***sst1231r5*** agrees with the ECMWF surface temperature with a standard deviation SD=0.45K (by definition zero bias).

d1231. We define d1231=***sst1231r5***-tref+dc. The tref is the ***stemp_cmc*** for open ocean, ***stemp_clim*** for land and frozen surfaces. The dc is the first order correction to the ***stemp_cmc*** for diurnal effects and wind effects. The ***stemp_cmc*** is 0.2K warmer than the true SST during the day, 0.2K colder during the night overpasses. Due to wind-related surface cooling the surface is actually 0.2K colder than the buoy. This means that for the day overpass the ***sst1231r5*** should equal the ***stemp_cmc***, while the ***sst1231r5*** will be 0.4K colder for the night overpasses, i.e. for the 1:30 AM overpasses dc=-0.4K, for the 1:30 PM overpasses dc=0. Figure 8 shows a scatter diagram of d1231 as function of d2194- d2194clear for all 12150 points in the granule. Points with d2194-d2194clear<0 and abs(d1231)>4K are cloudy. (The red points are explained below).

We define open ocean spectra which pass an abs(d1231)<2K test as forecast clear. This definition is consistent with the QC applied by the major NWC to eliminate cloudy data. With this definition 2745 of the 12150 spectra in the granule (22%) are forecast clear. ***i_found_forecast_clear_ocean*** counts the number of forecast clear cases in each granule.

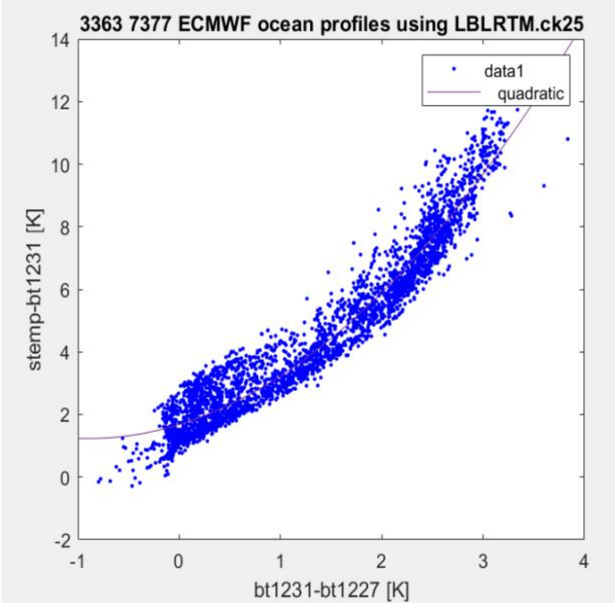

Figure 7. ***sst1231r5*** training using ECMWF

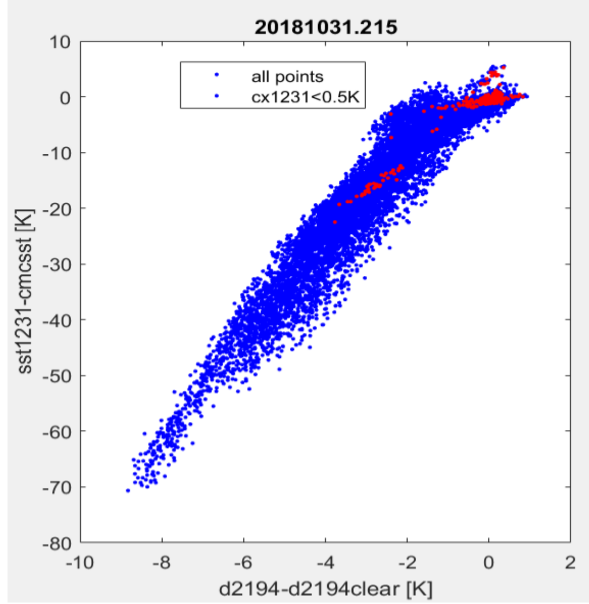

Figure 8. The pseudo lapse rate (PLR) can be used to identify cloud contamination.

The CrIS ***sst1232h5*** uses conceptually the same approach, with q3h=bt1232_50h-bt1227_50h and

sst1232h5=bt1232_50h-0.3240+0.0352*q3h+0.3192*q3h.^2+1.8341./ cos(***sat_zen***/57.3).

cxnnn. For AIRS the spatial coherence of each footprint is represented by ***cx2616***, ***cx1231***, and ***cx900***, defined as max(btxxx)-min(btxxx) in the four nearest neighbors of the spectrum at btxxx.
The CrIS ***ce2508***, ***ce1232*** and ***ce900*** spatial coherence parameters are conceptually similar to AIRS, once the 9x30x45 array is remapped to a 90x135 image, but the four neighboring fields of view are measured by four different detectors. The Matlab code for this transformation given in Appendix 1.

4. Data Selection:

The reason for selecting a particular spectrum for the Calibration Subset is encoded in two parameters: ***reason*** (Table 1) and ***site_id*** (Table 2, same as Table 2.3.3-1 in the CalSub Users' Guide). The ***reason*** parameter has to be tested on a bit level, not its numerical values, *e.g.* a spectrum may be deemed clear (***reason*** bit 1 set), but may use a less stringent definition of clear defined in ***site_id***.

1	clear (***site_id*** defines details)
2	special site (***site_id*** 1..30)
3	cold clouds
4	random near nadir
5	hottest scene in a granule
6	spare
7	uniform cloud (***site_id***=96)
8	random full-swath
9	land fires (***site_id***=79)
10	bt1231 or bt901>335K (***site_id***=78)

Table 1. Bit-level ***reason*** definitions

-2	frozen surfaces clear spectra
-1	clear non-frozen land spectra
0	SCT clear non-frozen ocean spectra
1	Egypt-1 test site at E26.10 N27.12
2	Simpson Desert at E137.0 S24.5
3	Dome Concordia at E123.37 -75.12
4	Mitu Colombia/Brazil Tropical Forest at E290.5 N1.5
5	Boumba S.E. Cameroon Tropical Forest at E14.5 N3.5
6	Sonora Desert at E245.35 N32.25
7	ARM SGP at N36.62 E262.50
8	TWP Manus S2.006 E147.425
9	TWP Naru at S0.521 E166.916 within 50 km
10	N.Pole
11	S.Pole
12	Siberian tundra (Surgut) at E73.37 N61.15
13	Hunnan Rainforest at E100.5 N23.9
14	ARM Barrow Alaska at N71.32 E203.34
15	ARM Atqusuk at N70.32 E203.33
16	TWP Darwin at S12.425 E130.891
17	Lake Qinhai at N36.75.E100.33 3196 meter elevation
18	Dunhuang Gobi Desert at E94.33 N40.17
19	Lake Titicata at E290.67 S15.88 3800 meter elevation
20	Lake Taho California at E240.0 N39.1
21	Toolik Alaska at E210.40 N68.6
22	Park Falls, WI Tower N45.94 E269.7
23	Brenham, TX N30.16 W96.40
24	Crosbyton, TX N33.66 W101.25
25	Beltsville, MD N39.0 E283.13
26	Pacific Missile Range W. Kawai N22.02 E200.21
27	N38.50 E244.33
28	N34.88 E242.12
29	N32.97 E242.02
30	N39.10 E332.0
31..77	spare
78	bt1231>335K
79	land night fire
80..87	reserved
88	random spectra
89..95	reserved
96	ocean low stratus
97	hottest spectrum in each granule
98	Pseudo Lapse Rate (PLR) clear non-frozen ocean
99	cold cloud spectra (bt900<225K)

Table 2. Definition of ***site_id***

4.1. Clear spectra

4.1.1. Spatial Coherence Test (SCT) clear spectra

The use of a SCT for identifying clear footprints predates AIRS by several decades. Details are described in Aumann et al. 2003, 2006, and 2021, which also extend the use of this technique to CrIS. Define the SCT test as (***cx1231***<0.5K or ***cx900***<0.5K for AIRS, ***ce1232***<0.5K or ***ce900***<0.5K for CrIS). The "or" ensures that the spatial coherence test does not fail if there is a data dropout on one or the other channel.

Figure 8 shows d1231 parameter as function of d2194-d2194clear. The blue dots are all points. The red dots pass the ***cx1231***<0.5K test. A ***cx1231***<0.5K test alone is insufficient to identify clear spectra. The reason for this is that spatially uniform cloud covers also pass, but for them d1231 is typically much colder than expected. Spectra which pass ***cx1231***<0.5K and satisfy abs(***sst1231r5-stemp_clim***)<4K over non-frozen ocean are defined as SCT clear and identified by ***site_id***=0, ***reason*** bit 1 set. In the granule used as example, 240 SCT clear cases are identified. In order to minimize a statistical distortion, only up to 1000 randomly selected SCT clear cases from each granule are saved. The actual count is saved in ***i_found_SCT_clear_ocean***.

The left panel of Figure 9 shows the time series of the mean(d1231) for day and night SCT clear tropical oceans between 2012 and 2016. The mean for the day overpasses is -0.18K, for the night overpasses it is -0.25K. The absolute calibration of AIRS is claimed to be 0.1K. It is likely that even with tight SCT filtering, a fraction of the cold bias is due to cloud contamination. The time series of the daily yield is shown in the right panel of Figure 9. The daily mean count of footprints identified as clear was 7800 for the day, 4400 for the night overpasses.

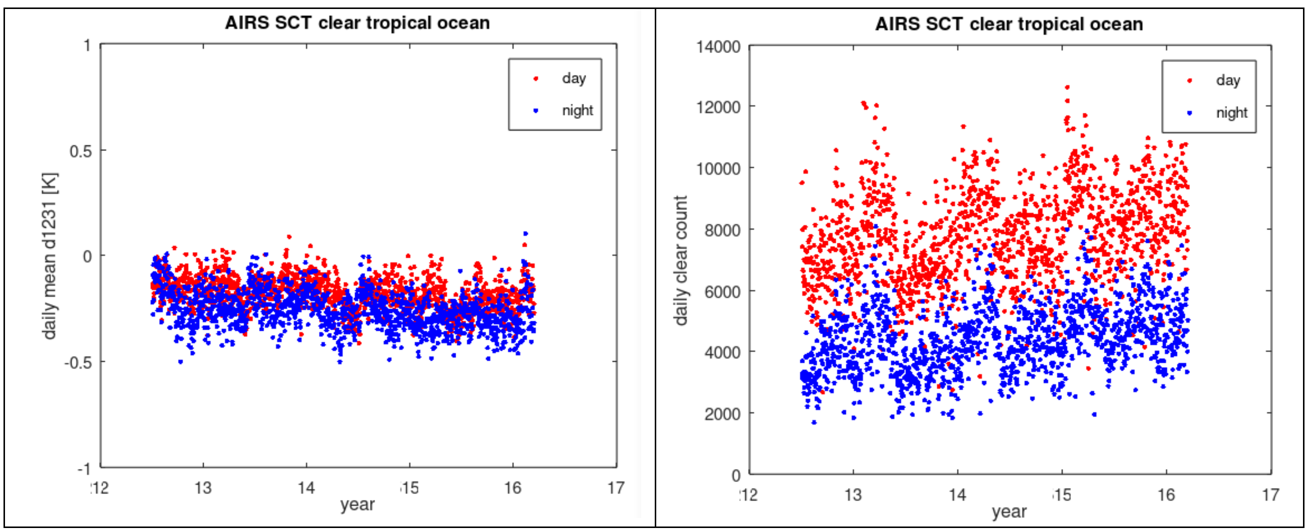

Figure 9 AIRS time series of SCT clear tropical ocean since September 2002 relative to the ***stemp_cmc***. Left: mean. Right: daily count.

The red points in Figure 8, which pass the ***cx1231***<0.5K test but fail the abs(d1231)<4 condition, are spatially extremely uniform ocean stratus clouds.

Figure 10 shows similar data from CrIS. The left panel of Figure 10 shows the time series mean(d1232) for day and night SCT clear tropical oceans between 2012 and 2016. The mean for the day overpasses is +0.01, for the night overpasses it is -0.12K. The absolute calibration of CrIS SNPP is claimed to be

0.1K. The time series of the daily yield is shown in the right panel of Figure 10. The daily mean count of footprints identified as clear was 5700 for the day, 3700 for the night overpasses.

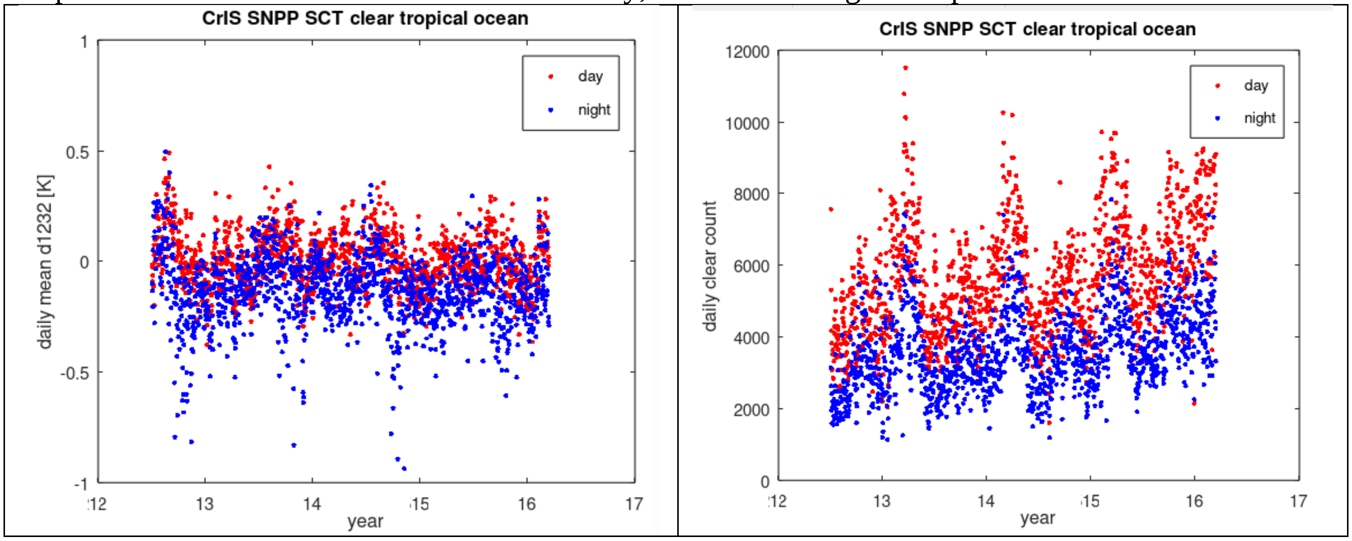

Figure 10. CrIS SNPP time series of SCT clear tropical ocean relative to the ***stemp_cmc***. Left: mean. Right: daily count.

The small differences in results from AIRS and CrIS may be dominated two effects:

1. AIRS OBC was used as calibrated pre-launch, while the CrIS SNPP OBC calibration was refined on-orbit, likely with the use of the SST.
2. The SCT from AIRS is based on a single detector, measuring the radiance from the surrounding fields.

For CrIS the SCT is based on the detectors surrounding the field of view, which is scan angle dependent.

4.1.2. Pseudo Lapse Rate (PLR) clear spectra

a) Ocean:
Spectra which fall below the red line in Figure 6 are likely cloudy. In Figure 8 these cases are associated with d2194-d2194clear<0. In the 20201031.215 ocean granule 972 of 12150 (8%) footprints satisfy the d2194-d2194clear>0 condition. A spectrum which satisfies d2194-d2194clear>0 and d1231<4K and cx1231<5K is defined as PLR clear over ocean (***reason*** bit 1 set, ***site_id***=98). In this granule, 827 of 12150 footprints are PLR clear, with a bias of 0.03 K and SD=0.8 K relative to the ***stemp_cmc***.
The parameter ***i_found_plr_clear_ocean*** saves the PLR clear ocean cases identified from the ocean pixels in each granule, but only up to 1000 randomly selected cases from each granule are saved. For this granule 956 ocean cases are PLR.

At first glance the PLR clear ocean would appear to be preferable to SCT clear ocean since their yield is three time higher. An unanticipated problem with PLR clear is the warming of the mid-troposphere. The left panel of Figure 11 shows the time series of PLR clear bias in d1231. For the PLR clear tropical ocean, we find that the d1231 day bias of -0.35K, the night bias is -0.31K, both have a trend of -20 mK/yr, *i.e.* more cloud contamination. The standard deviation has also increased to 0.53K. The right panel of Figure 11 shows that the yield has increased. The reason for this is not that the co2 mixing ratio has increased, for a US standard atmosphere d2194 increases only 0.38 mK/ppmv, but that d2194 is sensitive to a change in the mid-tropospheric lapse rate.

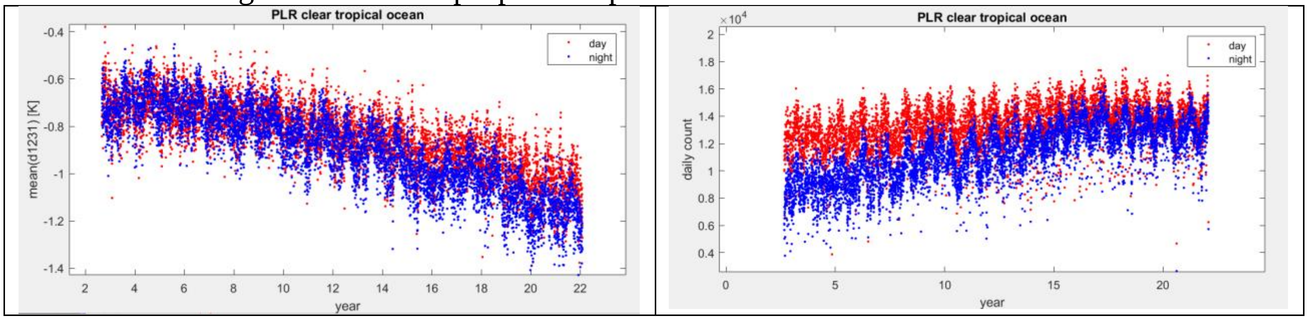

Figure 11. Time series of AIRS SCT clear tropical ocean since September 2002 relative to the ***stemp_cmc***. Left: mean. Right: daily count.

As the surface temperature increases, the mid-tropospheric lapse rate has to increase, and under clear conditions d2194 is proportional to the mid-tropospheric lapse rate. The d2194clear threshold is based on climatology and is fixed. A steeper lapse rate with a fixed threshold causes spectra increasingly being mis-identified as PLR clear. The number of spectra identified as PLR clear has increased by about 1%/year over the past 20 years, but the PLR clear cases are also increasingly cloud contaminated, which causes the bias to change at the rate of -20 mK/yr. The conceptually similar PLR test for CrIS has the same problem. This effect was not anticipated in the design of the CalSub, but it may be corrected in a future release.

b) Land
The main use of PLR clear is for land, where the SCT test is overpowered by surface non-homogeneity. Non-frozen land is identified by ***stemp_clim***>274K. If in addition d2194-d2194clear>0 and abs(***sst1231r5-stemp_clim***)<20K, the spectrum is defined as PLR clear. The parameter i_found_plr_clear_land saves the PLR clear land cases, but only up to 1000 randomly selected cases from each granule are saved. These cases are identified as ***reason*** bit 1 set, ***site_id***=-1. The yield of PLR clear in the tropical zone is typically 13,000 for the day overpasses, 11,000 for the night overpasses. Due to steepening of the lapse rate the yield for the days is increasing at the rate 0.7+/-0.03%/year, for the nights the increase is 2+/-0.05%/year. A similar effect is seen in CrIS.

c) Frozen Surfaces
Frozen surfaces are identified by ***stemp_clim***<274K. If d2194-d2194clear>0 and abs(d1231)<20K, the spectrum is defined as PLR clear. The parameter ***i_found_plr_clear_frozen*** saves the PLR clear frozen surfaces in each granule, but only up to 1000 randomly selected cases from each granule are saved. These cases are identified as ***reason*** bit 1 set, ***site_id***=-2. It is likely that the PLR clear for frozen surfaces show a similar sensitivity to the mid-tropospheric lapse rate, but this is still to be analyzed.

4.2. Cloudy spectra

4.2.1. Random Nadir Spectra (RNS)

To uses of cloud-free spectra for the analysis of global warming introduces a potential data selection bias. The random nadir spectra selection supports climate applications of AIRS and CrIS data. In both cases the high latitudes are oversampled by the polar orbit. The RNS represent globally uniformly sampled near-nadir data.

Define vx as the pointer to the 135 x 6=810 footprints within 3.3 degrees of nadir, then randomly select 135*cos(***lat***) footprints from the 810 footprints. At low latitudes 135 footprints will be save for each granule. With increasing latitude fewer and fewer footprints are saved. The resulting thinning of the data corrects for the over-coverage of high latitudes by the polar orbit.

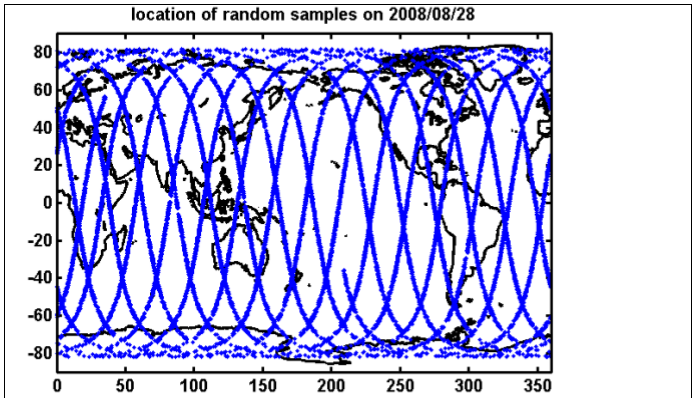

Figure 12. Spatial coverage of RNS from one day.

Figure 12 shows the location of the sample from 2008/08/28. The night (descending) orbits go from north to south. The thinning of the samples at high latitudes is evident. Since the orbit coverage repeats every 16 days, 16 days of data represent a uniformly covered globe.
On average 22000 spectra each day are defined as RNS. They are identified by (***reason*** bit 4 set). These spectra are identified as ***site_id***=88, ***reason*** bit 4 set. The ***site_id*** may be overwritten if these spectra are also identified as SCT or PLR clear.

Figure 13 shows a time series of RNS from AIRS and CrIS from the tropical oceans. AIRS day/night 284.21K/283.48K. CrIS day/night 284.32/283.50. The differences are consistent with a 100 mK absolute calibration accuracy of AIRS and CrIS under warm scene conditions.

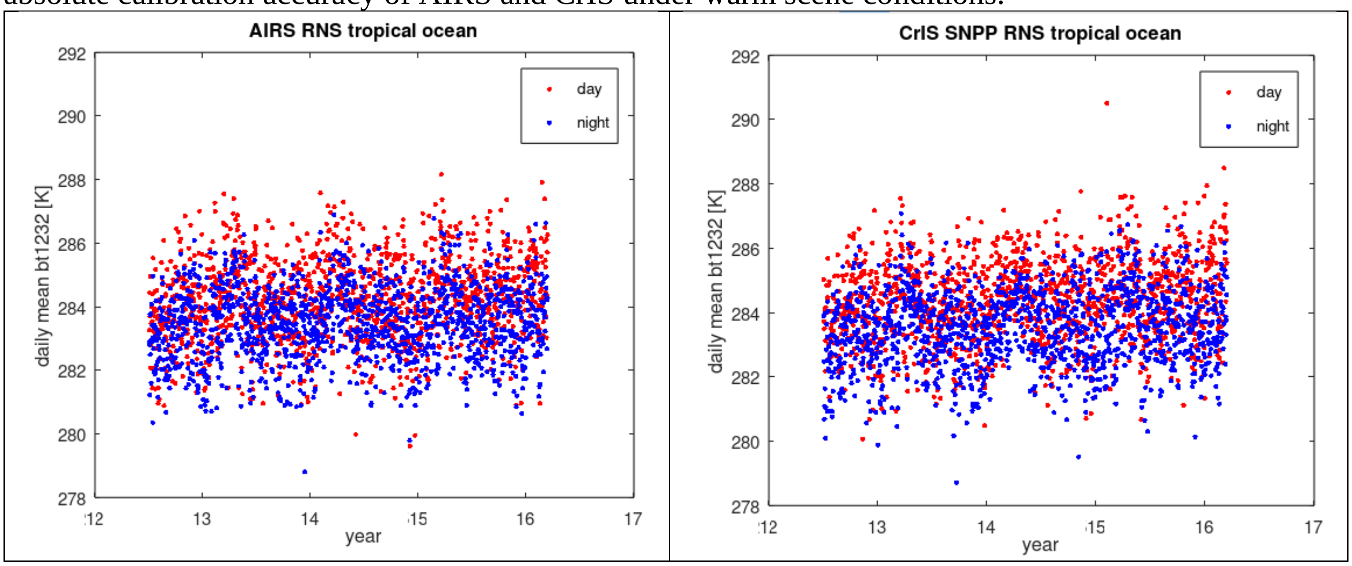

Figure 13 shows a time series of RNS from AIRS and CrIS from the tropical oceans.

4.2.2. Random Full-swath Spectra (RFS)

As in the case of the RNS, the RFS are thinned at high latitudes. Define vx as the pointer to the 12150 footprints in an AIRS or CrIS granule. Randomly select 270*cos(***lat***) footprints from the 12500 footprints. This procedure selects typically 44,000 spectra per day, which form the basis for the full-spectrum CalSub products. These spectra are identified as ***site_id***=88, ***reason*** bit 8 set.
The RFS data are useful for the evaluation of the left/right symmetry of the data and diurnal cycle effects. A shift in the diurnal cycle is a predicted side effect of global warming. On the ascending (day) orbit, the data from the left side of the scan correspond to a local time of about 1PM, while the right side of the scan correspond to about 2 PM. Due to the diurnal cycle at 1:30PM, the tropical land the left side of bt1231 is 0.5K warmer than the right side, but has no significant trend. On the descending (night) orbits, the data from the left side of the scan correspond a local time of 2AM, while the right side is at 1AM. The left-right difference for bt1231 is -0.08K i.e. the night is younger and the surface is still warmer at 1AM. The effect is much weaker than on the day orbits.

4.2.3. Uniform Clouds

The red points in Figure 8, which pass the SCT test, but have d1231<-4K condition are identified by ***site_id***=96, ***reason*** bit 7 set. Most, but not all of the extremely uniform cloud tops clouds on a 45 km scale are stratus cloud between 1 to 2 km above the surface, i.e. 6-12K colder than the surface. The parameter ***i_found_sct_low_stratus_ocean*** saves the count of these cases from each granule. Some cloud tops colder than 225K do satisfy the ***cx1231***<0.5K test.

Figure 14 shows the time series of the count of stratus clouds from AIRS and CrIS. While the seasonal and day/night patterns are similar, on average, AIRS identifies 2000 day, 5000 night stratus clouds, CrIS identifies 700 day, 2000 night stratus clouds. The reason for this difference is under evaluation.

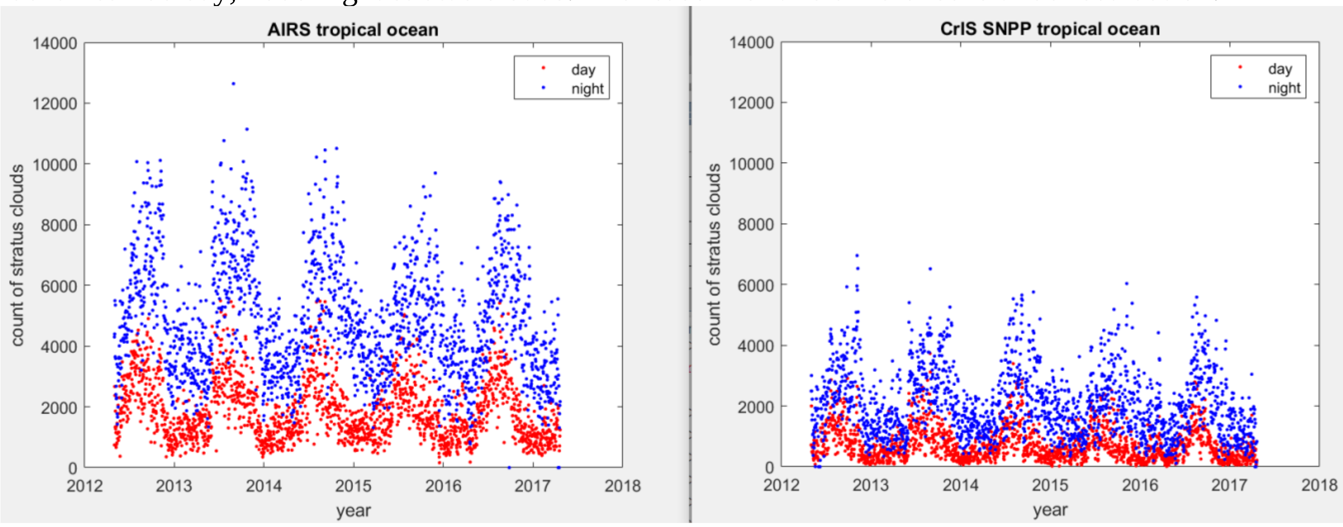

Figure 14. Time series of the count of stratus clouds from AIRS and CrIS.

4.2.4. Cold clouds

Cases where bt1231<225K and abs(***lat***)<50 degree are saved ***reason*** bit 3 set and ***site_id***=99. Further filtering can be used to separate Deep Convective Clouds (DCCs) and tropopause overshooting DCC. For details see Aumann et al 2011.

4.3. Special sites

There are 30 special sites (Table 2) which can provide routine ground truth measurements. All footprints within 50 km of special calibration sites are saved with ***reason*** bit 2 set. The parameter ***site_id***, with values between 1 and 30, identifies the special site by name and location. Due the polar orbit, only sites above 30N or below 30S are seen twice each day (at 1:30AM and 1:30PM). Some high-latitude sites, like Dome Concordia in Antarctica, are seen on 8 overpasses each day. The primary use of the Dome C site is to compare different sounders in polar orbit under cold scene conditions. Figure 15 shows the daily mean bt1232,5 of Dome C overpasses for AIRS and CrIS between 2012 and 2018, when the CrIS midwave band failed. Until then AIRS and CrIS agreed within 50 mK. The Antarctic winter measurement on Dome C also represent the coldest temperature extremes.

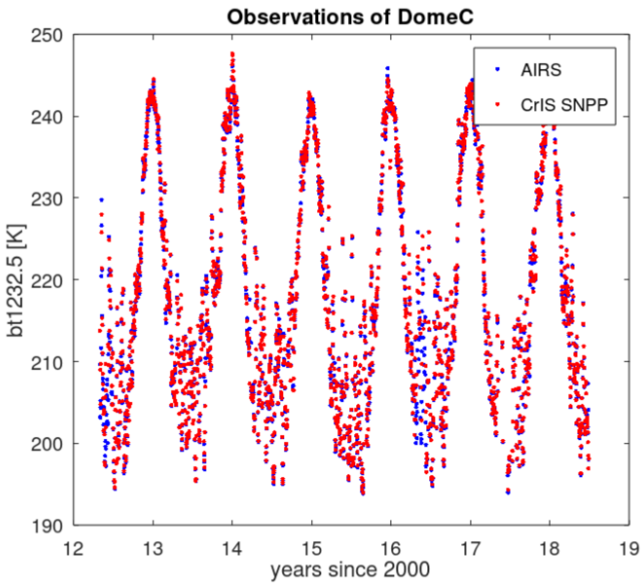

Figure 15. overlay of AIRS and CrIS observation of Dome C.

4.4. The hottest spectrum in a granule

In support of potentially climate applications of AIRS data the location of the coordinates and bt1231 of the hot spot in each granule is saved in ***i_max_bt1231_lat*** and ***i_max_bt1231_lon*** for each granule. These cases are identified as ***site_id***=97, ***reason*** bit 5 set.

For CrIS the hottest spectrum is selected based on bt900_0h. This inconsistency with AIRS may be corrected in a future release.

4.5. Fires

This is an experimental test for night land fires when bt1231>280K and bt2508-bt1231>5. These cases are identified by ***site_id***=79, ***reason*** bit 9 set. Figure 16 is the time series of the AIRS daily fire count between 2002 and 2022.

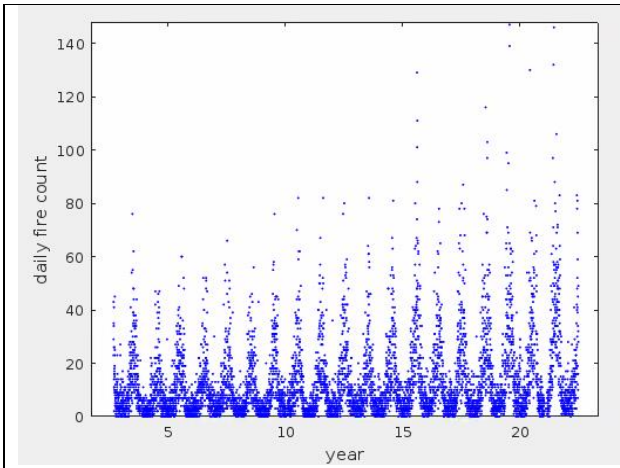	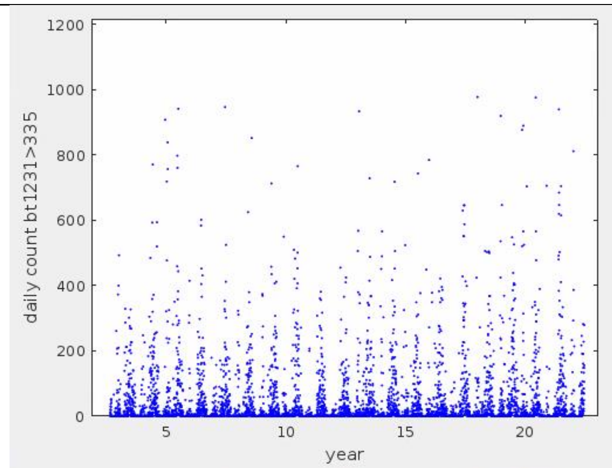
Figure 16. Time series of the fire count with AIRS.	Figure 17. Time series of the count of bt1231>335K cases.

The number of cases identified is saved in ***i_count_land_fire***. Conceptually, this algorithm works with CrIS, but as of July 2022 the CrIS SNPP fire count is not available.

Only very large night land fires are detected with the AIRS and CrIS 15 km footprint. The identification facilitates the examination of trends and the examination of the spectra for minor gases and aromatics. This fire detection algorithm is not to be confused with MODIS or VIIRS type fire detection products.

4.6. Extremely hot cases

Cases where bt1231 or bt901 for AIRS (bt1232_5h or bt900_0h for CrIS) exceed 335 K are identified by ***reason*** bit 10 set and ***site_id***=78. As of July 2022 the time series for this parameter has not been evaluated. Under RNS tropical land conditions, the mean day/night AIRS 99 percentiles are 327.4/298.1K, compared to CrIS day/night 327.6K/298.2K, in agreement within 0.1K. The day values are well below 335K.

5. Quality Control

The AIRS and CrIS quality control parameters are different:

AIRS:

The AIRS L1b data quality is characterized by the CalFlag (2378x135) parameter for each channel and each of the 135 scan lines in each data granule. The mCalFlag is the median over the 2378 channels replicated for all 90 cross-track footprints, i.e. it is dimensioned 90x135.

QFlag1=(bt1231<100)|(***lon***<-200); QFlag=QFlag1 | mCalFlag>0;

AIRS BT from individual channels and complete spectra are saved only if QFlag==0.

CrIS SNPP:

QFlag=(rad900_0==0)|(rad1232_50==0)|(rad2507_50==0)|(***lon***<-200);
QFlag1=QFlag | max1i>1.5 | bt900_0h<150 | bt900_0h>360;
QFlag2=QFlag | max2i>0.5 | bt1232_50h<150 | bt1232_50h>360;
QFlag3=QFlag | max3i>0.05 | bt2507_50h<150 | bt2507_50h>360;

where max1i, max2i, and max3i are the maximum of the imaginary radiance component of each three CrIS bands.

The CrIS BTs are saved only if QF=0 for the appropriate band. Complete spectra are saved only if all three bands pass the QC test.

For the gaussian mean and stdev statistical analysis, the results are insensitive to QC, since more than 99.9% of the data pass the AIRS and CrIS QC. A more interesting question would be: Is there a scene temperature sensitivity of the number of cases which fail the QC. A scene sensitivity could create a data selection effect, which would create a statistical bias. As of July 2022 this question has not been answered.

6. References

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Dictionary of Abbreviations

AIRS	Atmospheric Infrared Sounder
AMSU	Advanced Microwave Sounding Unit
ATBD	Algorithm Theoretical Basis Document
CrIS	Cross-track Infrared Sounder
ECMWF	European Center for Medium Range Forecasting
FOV	Field of View (projected on the ground pertaining to one dwell time)
GES DISC	Goddard Earth Sciences Data and Information Services Center
GSFC	Goddard Space Flight Center
LBLRTM	Line-By-Line Radiative Transfer Model
NEdT	Noise Equivalent Delta Temperature
NEN	Noise Equivalent Radiance
NWS	National Weather Service
QA	(Data) Quality Assessment
SST	Surface Skin Temperature or Sea Surface Temperature
V/NIR	Visible/Near IR wavelength channels (AIRS only)

Appendix 1: Matlab code to convert CrIS horizontal geometry to AIRS equivalent.

```
function [cxbt, bte]=cx_filter_cris(bt,cmode);
% input btemp bt 9 x 30 x m
% output
% bte is a 90x135 image (if m=45)
% cxbt = spatial coherence  9x30xm
If nargin<2;cmode=1;

m=size(bt);
% clean up nan
v=find(~isnan(bt));mbt=mean(bt(v));v=find(isnan(bt)); bt(v)=mbt;

% covert bt into an image bte
bte=zeros(3*m(2),3*m(3)); % bte      90x180
fov=[1,2,3;4,5,6;7,8,9];
for n=1:3;  for k=1:3;  r=squeeze(bt(fov(n,k),:,:));  i3=(k:3:90);  j3=(n:3:3*m(3));  bte(i3,j3)=r(1:m(2),1:m(3));  end;end;

If cmode==0;
% create 5 pixel spatial coherence image
% same as AIRS cxbt=cx_filter(bte)
 xd=diff(bte);  x1=xd(1,:); xdr1=[xd' x1']'; xdl1=[x1' xd']';       xd=diff(bte'); x1=xd(1,:);
 xdr2=[xd' x1']; xdl2=[x1' xd']; cxbt=abs(xdr1)+abs(xdl1)+abs(xdr2)+abs(xdl2);

% convert cxbt back to the original bt format
cxbt=zeros(size(bt));% cx       9x30x60
for n=1:m(2);  for k=1:m(3);  for i3=1:3; for j3=1:3; cxbt(fov(j3,i3),n,k)=cxbt(3*(n-1)+i3,3*(k-1)+j3);  end;  end;  end;end;

else
   % cmode>0. This is for CRIS,where the 3x3 rotates.
   cxbt=zeros(size(bt));
   for n=1:m(2);  for k=1:m(3); cxbt(1:m(1),n,k)=max(bt(:,n,k))-min(bt(:,n,k));  end;    end;end;
```