CHIRP User Guide

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Contents

1 Introduction

Spectra of the earth's thermal emission as measured by the AIRS [1], CrIS [2, 7], and IASI [3] hyper-spectral sounders are a significant part of the long term climate record. These instruments have broadly similar spatial sampling, spectral resolution, and band spans. But the spectral response functions differ in detail, leading to significant differences in observed spectra. The Climate Hyperspectral Infrared Radiance Product (CHIRP) provides a single, combined

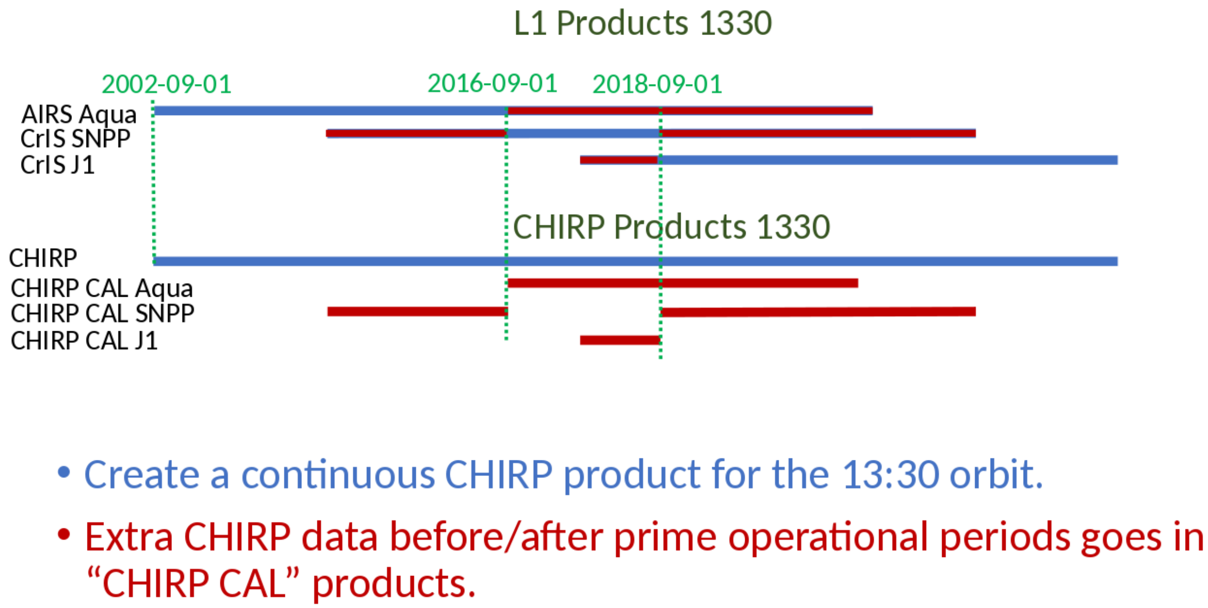

Figure 1: Timeline for CHIRP and component products.

record of these data, by taking advantage of the similar spatial sampling, translating AIRS and CrIS radiances to a common spectral response function, and removing inter-satellite biases. CHIRP provides a stable climate-quality radiance time series spanning AIRS, CrIS, and potentially in the future, IASI radiance data. Other benefits include facilitating instrument comparisons and allowing level 2 retrievals to use a common channel set and radiative transfer algorithm.

The translation from CrIS to CHIRP is done by resampling or double Fourier interpolation. Translation from AIRS to CHIRP is more involved. AIRS is a grating spectrometer with a distinct response function for each channel, while CrIS is a Michelson interferometer with a sinc response function. We use our knowledge of the AIRS spectral response functions to deconvolve AIRS channel radiances to a resolution enhanced intermediate representation, which is then reconvolved to the CHIRP user grid. The CrIS instrument on NASA's SNPP satellite is used as the calibration standard, while a bias adjustment is applied to the other translations [6].

The CHIRP record starts with AIRS data from Fall 2002, and will cross over to CrIS SNPP and then CrIS J1 (aka NOAA-20) as shown in figure 1. This is planned to continue in the future with NOAA-21, 22, etc., with sounder crossover dates to be determined. These sounders share an ascending 1:30 PM (13:30) equatorial crossing time and are combined as shown in 1 to make the CHIRP-1330 product. Although the primary product is a single continuous record, support products in the form of translations for other NOAA sounders and times are also provided as CHIRP-CAL products. These support product allow users to create radiance time series that cross over from one instrument to the next at different times than the CHIRP-1330 product, as long as the CHIRP-CAL product exists for the desired times. For example, a valid time series could use AIRS parent radiances until AIRS ceases operation, and then switch directly to CrIS J1 (NOAA-20).

Section 3 is a short introduction to using the CHIRP data. This is followed by sections with more detail on radiances, sampling, quality control, and NEdN estimates, and an appendix with tables of all variables and attributes. For more detail on the AIRS to CHIRP translation, see reference [4], and for more on bias adjustments and questions of long-term stability, see reference [6].

2 Further Information on CHIRP

Further information and help on using CHIRP, beyond what is discussed below, can be found at https://infraredclimate.org, or send email to chirp@infraredclimate.org. This web site will also contain information on the Level 1b products produced at GES-DIS for the series of CrIS instruments, starting with SNPP-CrIS and continued with the JPSS series of CrIS instruments.

3 Quick Start

CHIRP data is saved as a sequence of granule files, in time order, in netCDF format. A CHIRP observation, or "obs" for short, is a 1679-channel radiance vector with associated values for time, geolocation, latitude, longitude, quality control, and various other support data. The key idea is that each such obs can stand alone as a largely self-sufficient unit of information. CHIRP data is then simply a list of such obs, in time order. The CHIRP radiance data is organized as a 1679×12150 array, channels by obs, while most of the supporting data is organized as 12150-vectors. The choice of 12150 obs per granule is discussed in section 5.

For example, suppose an application needs radiance, channel frequency, quality control, obs time, latitude, and longitude. The CHIRP netCDF fields, data types, and physical units are as follows:

- The CHIRP radiance field is `rad`, a 1679 by 12150 element single precision array, in units of mW sr^{-1} m^{-2}. Channel frequency is `wnum`, a 1679 element double precision vector, in units of wavenumber.

- Quality control fields are `chan_qc` and `rad_qc`. `chan_qc` is a 1679 element int8 array, one flag per channel, with 0=OK, 1=Warn, and 2=Bad. `rad_qc` is a 12150 element int8 array, one flag per obs, where again 0=OK, 1=Warn, and 2=Bad.

- The time field is `obs_time_tai93`, a 12150 element double precision vector, seconds since 1 Jan 1993.

- The geolocation fields are are `lat` and `lon`, 12150 element single precision vectors, with units degrees north and degrees east.

The organization of other support variables is generally similar, and all CHIRP fields and attributes are defined in appendix C. The AIRS-parent CHIRP channels are a subset of the CrIS-parent channels. The `wnum` grid is used for both, with missing AIRS-parent channels flagged as bad. This is discussed in more detail in section 6. The parent AIRS and CrIS radiance data are organized as a sequence of granule files, ordered by scan geometry and observation time. See section 5 for details. CHIRP granules correspond with their parent AIRS or CrIS granules, and inherit most of the parent granule's attributes and supporting data. The stand-alone nature of the CHIRP obs requires some duplication of information—for example the CrIS-parent data includes the FOV number for every obs—but the overhead for this is small in comparison with the space required for the radiance data.

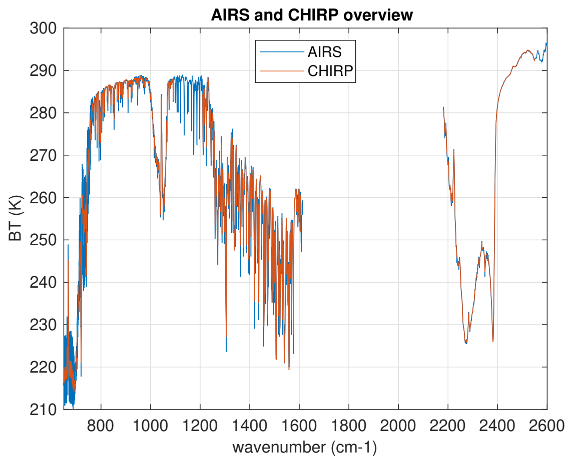

Figure 2: Sample AIRS and AIRS-parent CHIRP spectra, granule means for 19 Aug 2018 granule 25. The CHIRP bands are the intersection of the AIRS and CrIS bands.

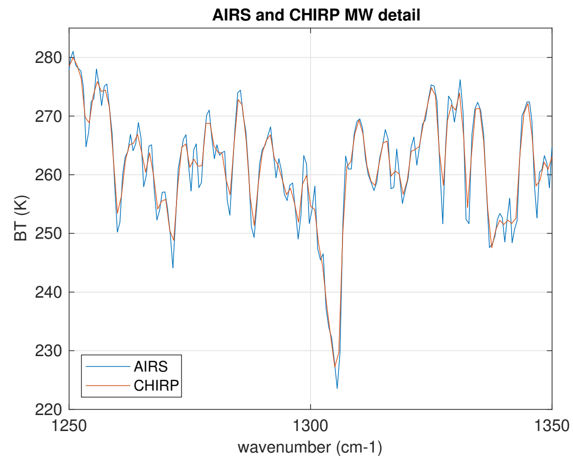

Figure 3: MW detail from the same granule. Note that the data are on two different grids, and what we mainly see is the effect of the CHIRP apodization.

4 Radiances

For a long-term record we need radiance data in a single format—a single frequency grid with a common ILS, and to the extent possible, similar NEdN. CHIRP radiances are for a nominal 3-band interferometer with an OPD of 0.8 cm in the long-wave (LW), 0.6 cm in the medium-wave (MW), and 0.4 cm in the short-wave (SW) bands, with Hamming apodization applied to each band. The MW and SW resolutions are lower than the CrIS-parent FSR OPD of 0.8 cm, and were chosen to to give an approximate match to the AIRS resolution for those bands. Figure 2 shows typical AIRS and AIRS-parent CHIRP BT spectra, the granule means for 19 Aug 2018 granule 25. The CHIRP bands are the intersection of the AIRS and CrIS bands. Figure 3 is a MW detail from Figure 2. Note that the AIRS and CHIRP data are on two different grids, and what we mainly see is the effect of the CHIRP apodization.

For CrIS-parent CHIRP, we interpolate the CrIS Full Spectral Resolution (FSR) product, with an 0.8 cm OPD for all three bands, to the CHIRP grid, and then apply Hamming apodization. The CrIS-parent CHIRP ILS is then a Hamming-apodized sinc for a 0.8 cm OPD in the LW, 0.6 cm in the MW, and 0.4 cm in the SW. Figure 4 shows this ILS for a typical CHIRP MW channel.

We want to match this ILS for the AIRS-parent data. But AIRS is a grating spectrometer with a distinct response function for each channel, while CrIS is a Michelson interferometer with a sinc response function after calibration and corrections. We use our detailed knowledge of the AIRS spectral response functions to deconvolve AIRS channel radiances to a resolution enhanced intermediate representation. This is done by taking a Moore-Penrose pseudo-inverse of the tabulated AIRS SRFs and applying this to the AIRS radiances, giving us deconvolved data at a 0.1 cm^{-1} grid. This is then reconvolved to the CHIRP user grid via resampling or double Fourier interpolation. The resulting translation can be shown to be more accurate than more conventional interpolation or regression [4]. Figure 4 includes the AIRS channel weights and corresponding AIRS SRFs, normalized to the weight values, for AIRS-parent data for this channel. The weights are from a row of a linearized approximation of the AIRS to CHIRP translation.

Hamming apodization (as mentioned above) and an optional bias correction are applied to

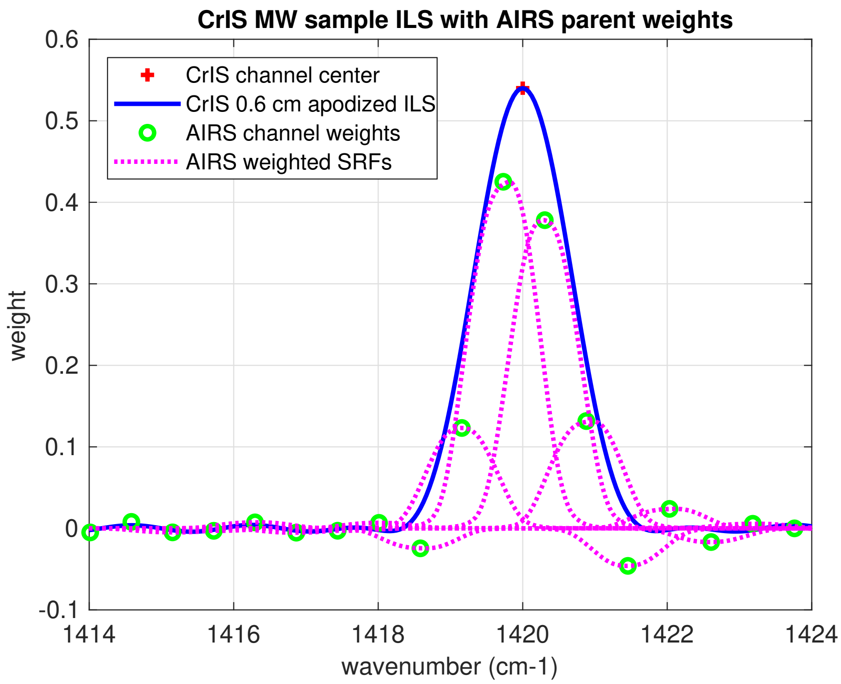

Figure 4: The MW CHIRP apodized ILS, together with weights for the AIRS channels, for the CHIRP channel shown. The AIRS weights are paired with the corresponding AIRS SRFs, normalized to the weight values.

both translations. Currently AIRS and CrIS J1 parent are adjusted to match CrIS SNPP [6]. After translation from CrIS, the three bands have 713, 649, and 317 channels, respectively. These are concatenated for the CHIRP product, for a total of 1679 channels. The CHIRP user grid does not have a constant step size, the frequency steps are $1/(2\,\mathrm{OPD})$. The CHIRP field `wnum` is a 1679-vector which gives channel frequencies, and `rad` is a 1679 by 12150 array of radiance data. AIRS-parent CHIRP uses the same channel set. However the AIRS-to-CHIRP translation gives only 1483 channels, due to slightly different band spans. These are embedded in the 1679 channel set, with missing channels flagged as described in section 6.

5 Sampling

AIRS and CrIS spatial sampling are similar, but not identical. AIRS and CrIS are both in sun-synchronous polar orbits. The CrIS orbital period is 101.5 minutes, giving 227 orbits every 16 days. The AIRS orbital period 98.8 minutes, giving 233 orbits every 16 days. Note that 227 and 233 are both prime; there are no common factors and so no repeating subpatterns. Figure 5 shows global values for satellite subpoint for one day of AIRS and CrIS data, and figure 6 for 16 days, the full period before any repeated positions, for the Caribbean. AIRS and CrIS are cross-track scanners, and in addition to subpoint tracks we want to compare the scan geometry. Figure 7 shows the secant of zenith angles for AIRS and CrIS. The upper plot is for the full scan widths, while the lower is a near-nadir detail. The general agreement is quite good, and the main difference we see is due to the CrIS FOV grouping.

The AIRS L1c scan geometry is organized as 90 cross-track by 135 along-track observations, giving $90 \times 135 = 12150$ obs per granule. The CrIS L1b scan geometry is organized as 9 FOVs

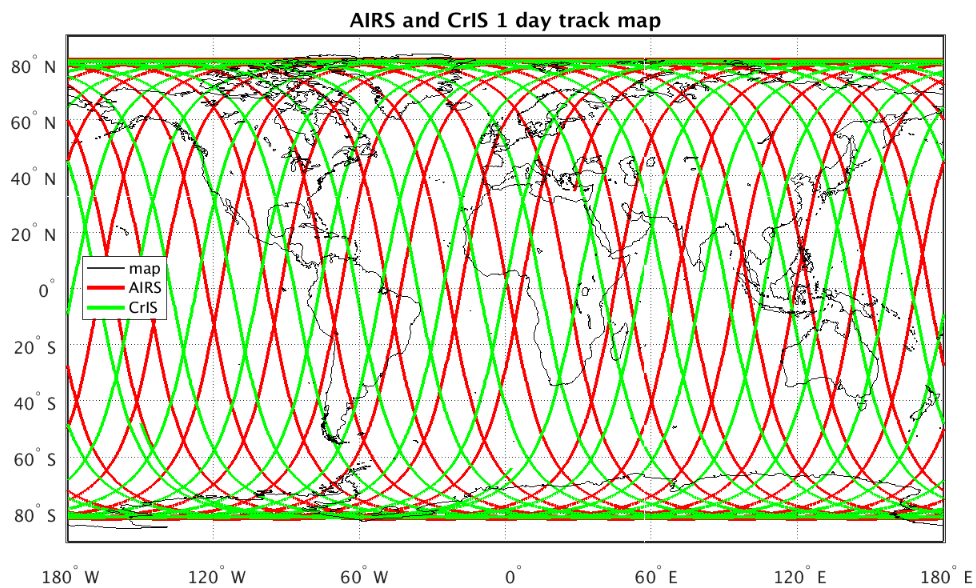

Figure 5: Global one-day subpoint track map.

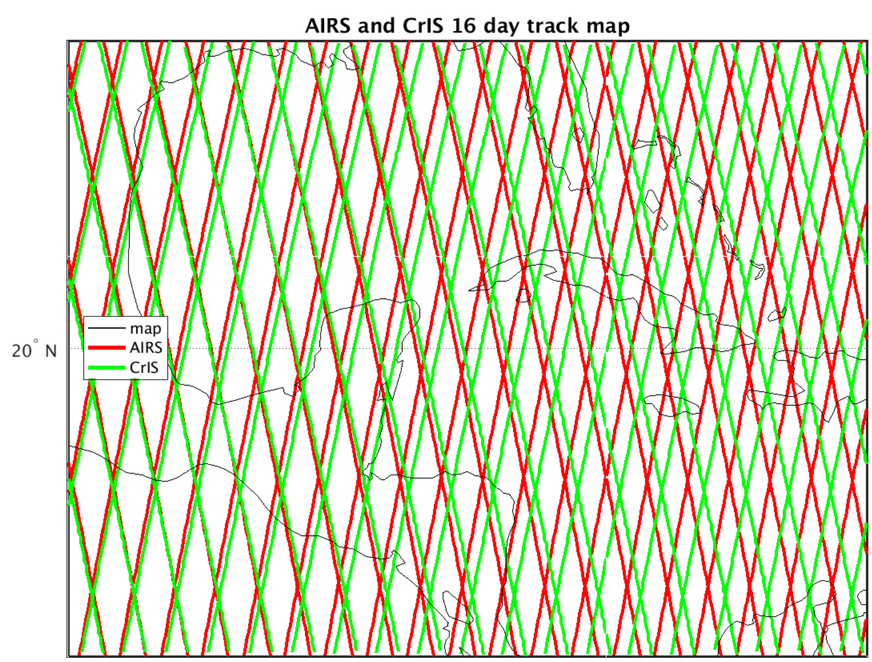

Figure 6: Sixteen day subpoint track map for the Caribbean.

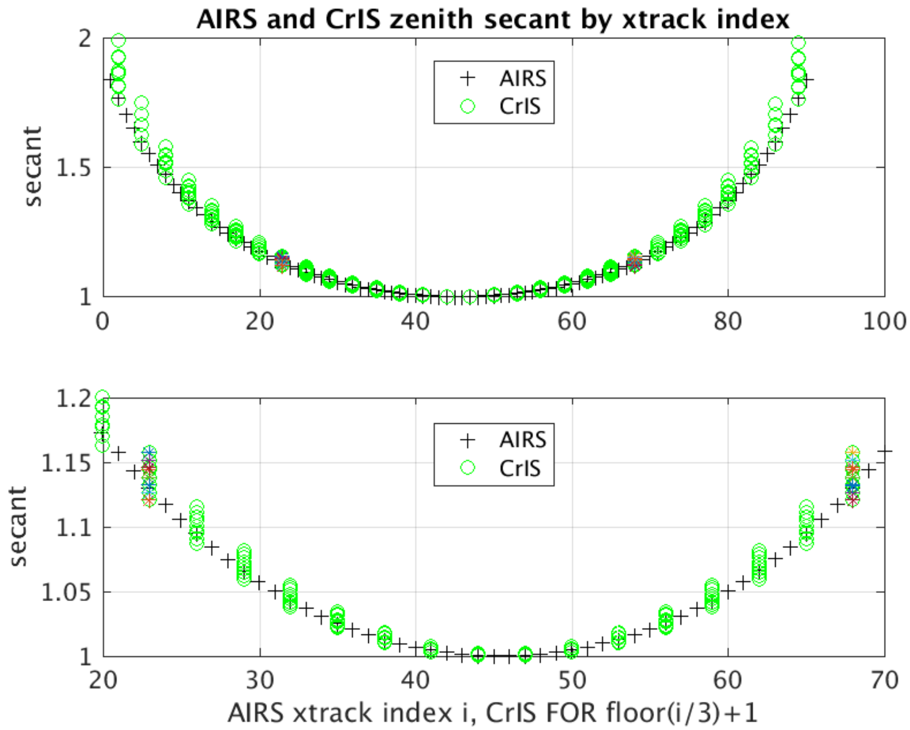

Figure 7: AIRS and CrIS secant of zenith angles

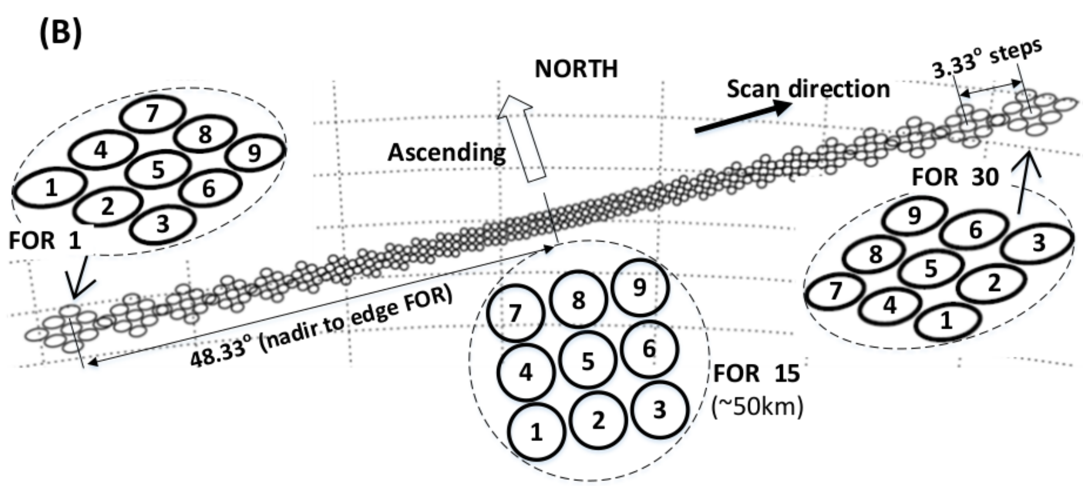

Figure 8: CrIS scan geometry, from the NOAA User's Guide [5]

arranged in a 3×3 field of regard (FOR), giving 9 simultaneous observations. There are 30 cross-track FOR looks and 45 along-track FOR steps. So again we have $9 \times 30 \times 45 = 12150$ obs per granule. Figure 8 shows the relationship of the CrIS FOVs and FOR as the scan moves from nadir to limb. Note that the FOVs rotate withing the FOR as we move toward the limbs. CHIRP provides both AIRS- and CrIS-style indexing, the AIRS-style indexing in the fields `airs_xtrack` and `airs_atrack`, and CrIS-style indexing, where xtrack and atrack are FOR rather than FOV indices, in the fields `xtrack`, `atrack` and `fov_num`. However due to the FOR rotation, we can't treat the CrIS-parent data as a simple cross-track by along-track grid, as with the AIRS-parent, for example for imaging.

6 Quality Control and NEdN Estimates

CHIRP Quality Control (QC) is straightforward. There are two QC fields per granule, `rad_qc`, a 12150-vector with one flag per obs, and `chan_qc`, a 1679-vector with one flag per channel. For both vectors, 0 = OK, 1 = warn, and 2 = bad. For CrIS-parent CHIRP these fields are a summary of the parent product state. For AIRS-parent CHIRP the situation is more complex, due to a significant and variable number of AIRS synthetic channels, and because the set of 1483 channels from the AIRS translation are a subset of the 1679 channels from the CrIS translation.

6.1 AIRS-parent CHIRP QC

For AIRS-parent CHIRP the 1679-element vector `chan_qc` is set to 2 (bad) for those channels that are not part of the 1483 channel set, as translated from AIRS. This is a compromise that give us a single frequency grid for CHIRP, regardless of the parent sounder. If we begin by choosing a set of channels to work with AIRS-parent data, we can continue using that set with the change to CrIS-parent, with no changes in our indexing. In addition to flagging missing channels, `chan_qc` is set to 1 (warn) for the six channels at the translation band edges, and when the synthetic component exceeds a threshold, as described below.

The 12150-element vector `rad_qc` has a flag for each obs. These are set to 0 (OK) if the L1c field `instrument_state` is OK and radiance and geo values pass some basic sanity checks. `rad_qc` is always 0 or 2 for AIRS-parent CHIRP, because AIRS L1c doesn't have a warn flag.

6.2 AIRS Synthetic Channels

As an alternative to a warn flag, and to fill band gaps, AIRS L1c provides synthetic values for some observations and channels. That is, for a particular observation—a radiance vector with an associated time, geolocation, and support data—some of the channels may be synthetic. Some of these channels are synthetic only occasionally, others more frequently, and some are always synthetic. These synthetic channels are flagged in the L1c file, for every observation and channel. In addition, the granule file has a per-granule summary, L1cNumSynth, for each L1c channel. This is the number of times the channel was filled with a synthetic value. L1cNumSynth can range from zero, for no synthetic values, to 12150, for all synthetic. Figure 9 shows the sum of all synthetic values by channel, for 5036 consecutive AIRS granules, approximately 21 days of data. Counts are shown on a log scale. Figure 10 shows the same data as synthetic values per channel, sorted by number of synthetic values. This shows the

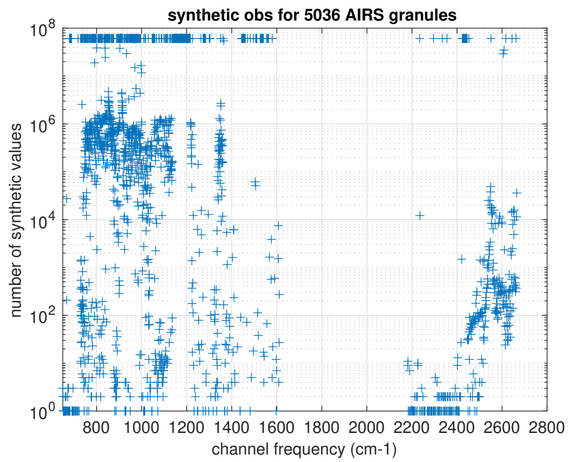

Figure 9: The sum of synthetic values by channel for 5036 AIRS granules. Counts are on a log scale.

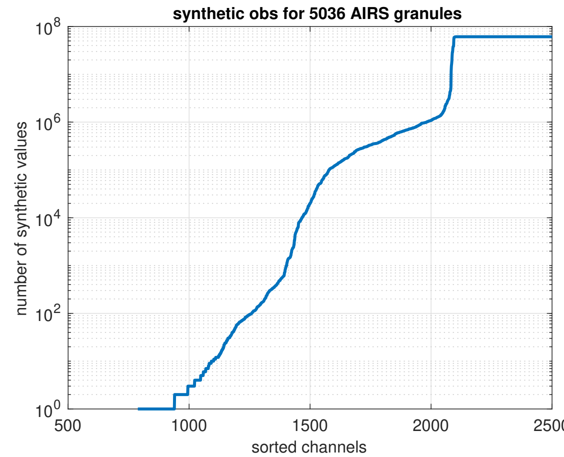

Figure 10: Synthetic values per channel, sorted by number of synthetic values. This shows the range of these values.

wide range of values, from few or no synthetic values for some channels, to entirely synthetic values for others.

For some applications we may not want a significant synthetic component. The CHIRP field `synth_frac` provides the AIRS synthetic component for each CHIRP channel. This can range from zero, for no synthetic component, to one, for entirely synthetic. To get this value we linearize the AIRS to CrIS translation and apply it to the AIRS L1cNumSynth, to get a corresponding NumSynth value for CHIRP. This is normalized as a fraction and becomes the CHIRP field `synth_frac`. Figure 11 shows the AIRS-parent CHIRP synthetic fraction for a single representative granule. This can be used to select channels with a relatively small synthetic component. Figure 12 show the AIRS-parent CHIRP synthetic fraction, sorted by synthetic fraction magnitude. This shows the variability of `synth_frac`. If `synth_frac` > 0.25, we set `chan_qc` to warn.

6.3 AIRS-parent CHIRP NEdN

To find NEdN for AIRS-parent CHIRP, we start with an AIRS L1c NEdN estimate. Unfortunately the synthetic obs do not include values for NEdN. As a compromise we take the mean of valid NEdN values over an AIRS granule and interpolate over the gaps for the synthetic channels. Given the AIRS estimate, we add Gaussian noise at the AIRS NEdN to a black-body spectra at 280K, do the translation, and measure the resulting noise. This is done repeatedly and the mean of the measurement is reported. Details are described in [4]. The correlated fraction of AIRS noise varies from module to module, and is significant for some modules. The translation will preserve this correlation. NEdN estimates for this case are a matter for future work.

Figure 13 shows typical values for AIRS and CrIS NEdN for 2018 doy 231 granules 25 and 21, respectively; two relatively warm granules. Figure 14 shows the corresponding CHIRP NEdN for AIRS and CrIS parent data, for the same granules. The noise is significantly less for the translation. This to be expected since both apodization and down-interpolation reduce noise.

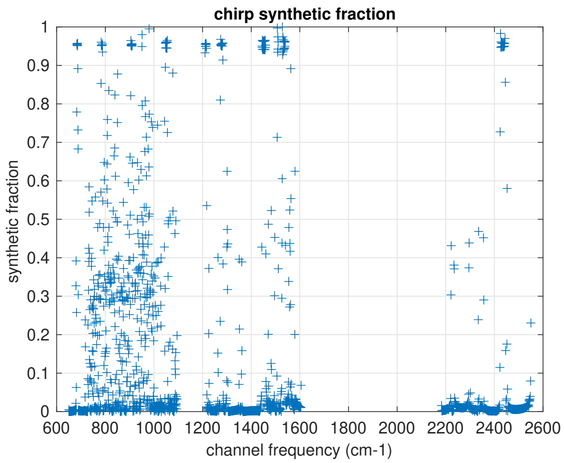

Figure 11: AIRS-parent CHIRP synthetic fraction for a single representative granule. This can be used to select channels with a relatively small synthetic component.

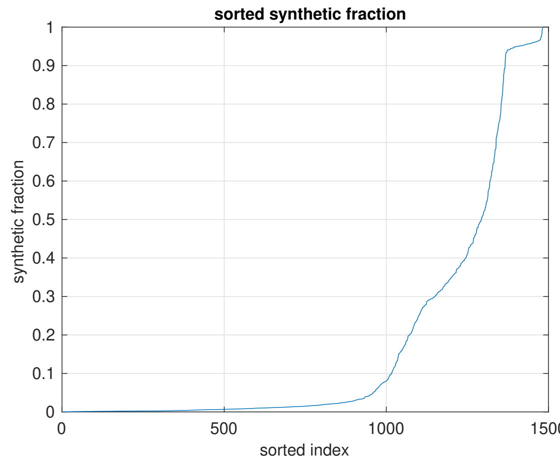

Figure 12: AIRS-parent CHIRP synthetic fraction, sorted by synthetic fraction magnitude. This shows the variability of synth_frac.

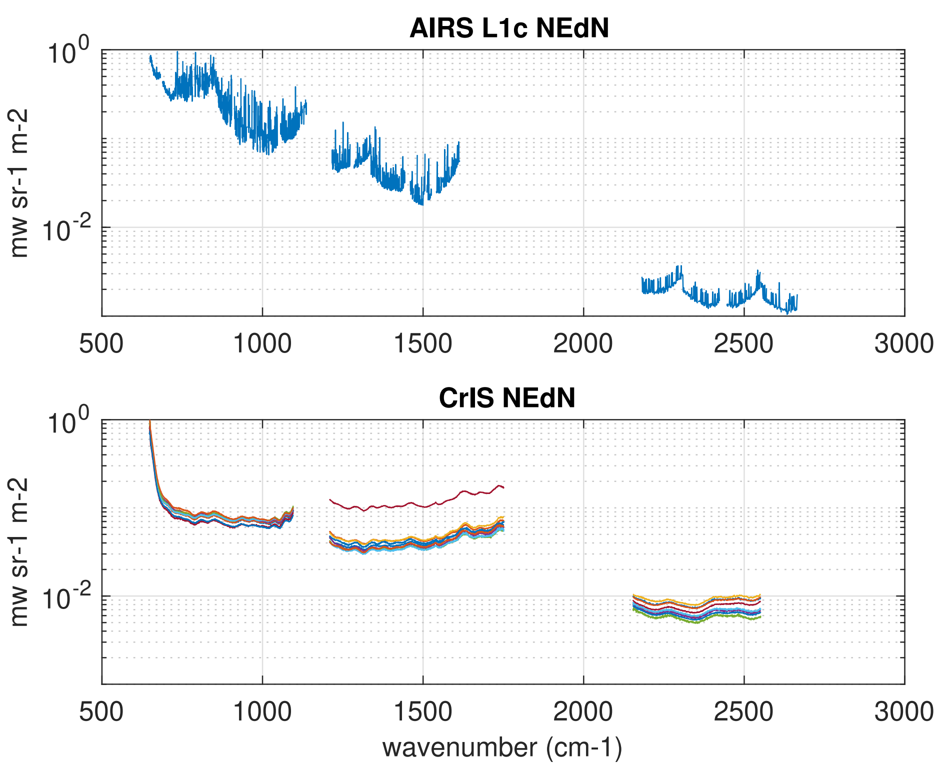

Figure 13: Sample AIRS and CrIS NEdN for 2018 doy 231 granules 25 and 21, two relatively warm granules.

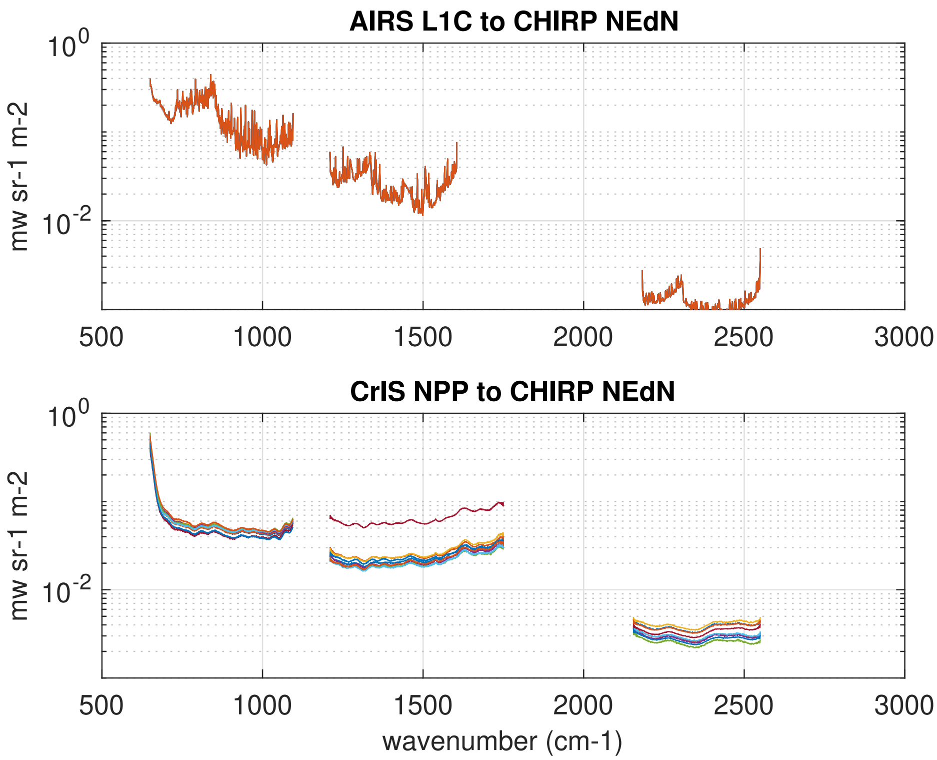

Figure 14: Sample CHIRP NEdN for AIRS and CrIS parent data, for the granules shown in figure 13. The noise is significantly less for the translations.

6.4 CrIS-parent CHIRP QC and NEdN

In contrast with AIRS, CrIS-parent CHIRP QC and NEdN are relatively simple. CrIS-parent CHIRP QC is determined from the CrIS parent, by combining the fields for the individual CrIS bands. `chan_qc` is set to 0 (OK) for CrIS-parent CHIRP. Possibly we should set `chan_qc` to warn at the band edges, as we do for AIRS parent, but we are not doing this now. CrIS-parent CHIRP NEdN is derived from the high res CrIS NEdN with scale factors to take into account the interpolation and apodization. These are

- LW, 0.6325, for Hamming apodization only
- MW, 0.5455, for interpolation and Hamming apodization
- SW, 0.4446, for interpolation and Hamming apodization

References

[1] H. H. Aumann, M. T. Chahine, C. Gautier, M. D. Goldberg, E. Kalnay, L. M. McMillin, H. Revercomb, P. W. Rosenkranz, W. L. Smith, D. H. Staelin, L. L. Strow, and J. Susskind. AIRS/AMSU/HSB on the aqua mission: design, science objectives, data products, and processing systems. *IEEE Transactions on Geoscience and Remote Sensing*, 41:253–264, Feb. 2003.

[2] Y. Han, H. Revercomb, M. Cromp, D. Gu, D. Johnson, D. Mooney, D. Scott, L. Strow, G. Bingham, L. Borg, Y. Chen, D. DeSlover, M. Esplin, D. Hagan, X. Jin, R. Knuteson, H. Motteler, J. Predina, L. Suwinski, J. Taylor, D. Tobin, D. Tremblay, C. Wang, L. Wang, L. Wang, and V. Zavyalov. Suomi NPP CrIS measurements, sensor data record algorithm, calibration and validation activities, and record data quality. *Journal of Geophysical Research (Atmospheres)*, 118(D17):12734, Nov. 2013.

[3] F. Hilton, R. Armante, T. August, C. Barnet, A. Bouchard, C. Camy-Peyret, V. Capelle, L. Clarisse, C. Clerbaux, P.-F. Coheur, A. Collard, C. Crevoisier, G. Dufour, D. Edwards, F. Faijan, N. Fourrié, A. Gambacorta, M. Goldberg, V. Guidard, D. Hurtmans, S. Illingworth, N. Jacquinet-Husson, T. Kerzenmacher, D. Klaes, L. Lavanant, G. Masiello, M. Matricardi, A. McNally, S. Newman, E. Pavelin, S. Payan, E. Péquignot, S. Peyridieu, T. Phulpin, J. Remedios, P. Schlüssel, C. Serio, L. Strow, C. Stubenrauch, J. Taylor, D. Tobin, W. Wolf, and D. Zhou. Hyperspectral Earth Observation from IASI: Five Years of Accomplishments. *Bulletin of the American Meteorological Society*, 93:347–370, Mar. 2012.

[4] H. E. Motteler and L. L. Strow. Airs deconvolution and the translation of airs-to-cris radiances with applications for the ir climate record. *IEEE Transactions on Geoscience and Remote Sensing*, 57(3):1793–1803, 2018.

[5] NOAA. Cross track infrared sounder (cris) sensor data record (sdr) user's guide. Technical report, 2013.

[6] L. L. Strow, C. Hepplewhite, H. E. Motteler, S. Buczkowski, and S. DeSouza-Machado. A climate hyperspectral infrared radiance product (chirp) combining the airs and cris satellite sounding record. *Remote Sensing*, 13(3), 2021.

[7] L. L. Strow, H. Motteler, D. Tobin, H. Revercomb, S. Hannon, H. Buijs, J. Predina, L. Suwinski, and R. Glumb. Spectral calibration and validation of the Cross-track Infrared Sounder on the Suomi NPP satellite. *Journal of Geophysical Research (Atmospheres)*, 118(D17):12486, Nov. 2013.

A Acronyms

AIRS	Atmospheric Infrared Sounder
CHIRP	Combined Hyperspectral Infrared Radiance Product
CrIS	Cross-track Infrared Sounder
DISC	Data and Information Services Center
FOV	Field of View
FOR	Field of Regard
FSR	Full Spectral Resolution
GSFC	Goddard Spaceflight Center
ILS	Instrument Line Shape
IASI	Infrared Atmospheric Sounding Interferometer
JPSS	Joint Polar Satellite System
LW	Long-Wave
MW	Mid-Wave
SW	Short-Wave
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NEdN	Noise Equivalent Differential Radiance
QC	Quality Control
SIPS	Science Investigator-led Processing System
SNPP	Suomi-National Polar-Orbiting Preparatory Project
SRF	Spectral Response Function
STAR	Center for Satellite Applications and Research

B Filename Conventions

CHIRP granule filenames are divided into fields separated by a dot character. This is best illustrated by example. The following are typical granule file names for AIRS AQUA, CrIS SNPP, and CrIS J1 (aka NOAA-20).

```
SNDR.SS1330.CHIRP.20180901T1835.m06.g186.L1_AQ.std.v02_20.U.201219110001.nc
SNDR.SS1330.CHIRP.20180821T0129.m06.g016.L1_SN.std.v02_20.U.200917211403.nc
SNDR.SS1330.CHIRP.20180913T2217.m06.g224.L1_J1.std.v02_20.U.201215180423.nc
   1      2     3         4           5    6    7     8    9   10      11        12
```

The 12 fields correspond to CHIRP attributes, and are defined in the table below. Field 7, the `product_name_type_id`, is of particular interest. The sub-fields AQ, SN, and J1 are two letter codes for AIRS AQUA, CrIS Sunomi NPP, and CrIS J1 (aka NOAA-20), respectively. This is the parent sounder for the granule. A suffix "CAL", for example L1_AQ_CAL, L1_NP_CAL, or L1_J1_CAL, indicates a support product, while no suffix (as in the examples above) indicates the primary CHIRP product.

Field	Attribute Name	Comment
1	product_name_project	Always “SNDR”, for Sounder SIPS
2	product_name_platform	Always “SS1330”, a virtual platform in a 13:30 Sun-Synchronous polar orbit
3	product_name_instr	Always “CHIRP”
4	gran_id	Granule start time
5	product_name_duration	Always “m06” meaning 6 minutes
6	product_name_granule_number	Granule number from g001 – g240
7	product_name_type_id	“L1_” + PL [+ “_CAL”], where PL platform code can be “AQ”, “SN”, or “J1”. The optional tag “_CAL” marks redundant calibration data, not considered part of the main CHIRP product.
8	product_name_variant	Always “std”
9	product_name_version	For example “V02_48” for version 02.48
10	product_name_producer	“G” for data produced by NASA GSFC
11	product_name_timestamp	Processing timestamp
12	product_name_extension	Always “.nc”

C Field Definitions

C.1 Dimensions

Name	Size	Description
fov	9	Field-of-view dimension
obs	12,150	number of spectra in 6-minute L1 CHIRP for the 13:30 orbit. 135*90 or 45*30*9
wnum	1,679	IR channel number
fov_poly	8	lat_bnds, lon_bnds points defining the polygon bounding an FOV (anticlockwise as viewed from above)
utc_tuple	8	parts of UTC time: year, month, day, hour, minute, second, millisec, microsec

C.2 Variables

Name	Type	Dim	Description	Units	Ancillary
obs_id	string	obs	unique earth view observation identifier.		
obs_time_tai93	double	obs	earth view observation midtime for each FOV	seconds since 1993-01-01 00:00	bnds
obs_time_utc	uint16	obs, utc_tuple	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, millisec, microsec		
lat	float	obs	latitude of FOV center	degrees_north	bnds
lon	float	obs	longitude of FOV center	degrees_east	bnds
land_frac	float	obs	land fraction over the FOV	unitless	
surf_alt	float	obs	mean surface altitude wrt earth model over the FOV	m	
surf_alt_sdev	float	obs	standard deviation of surface altitude within the FOV	m	
sun_glint_lat	float	obs	sun glint spot latitude at scan_mid_time. Fill for night observations.	degrees_north	
sun_glint_lon	float	obs	sun glint spot longitude at scan_mid_time. Fill for night observations.	degrees_east	
sol_zen	float	obs	solar zenith angle at the center of the FOV	degree	

sol_azi	float	obs	solar azimuth angle at the center of the FOV (clockwise from North)	degree	
sun_glint_dist	float	obs	Distance from the center of the calculated sun glint spot to the center of the spot. Note that there may not be a glint for cloudy or land cases and in ocean cases the glint can move based on wind conditions. Fill for night observations.	m	
view_ang	float	obs	off nadir pointing angle	degree	
sat_zen	float	obs	satellite zenith angle at the center of the FOV	degree	
sat_azi	float	obs	satellite azimuth angle at the center of the FOV (clockwise from North)	degree	
sat_range	float	obs	line of sight distance between satellite and FOV center	m	
asc_flag	ubyte	obs	ascending orbit flag: 1 if ascending, 0 descending		
subsat_lat	float	obs	sub-satellite latitude at scan_mid_time	degrees_north	
subsat_lon	float	obs	sub-satellite longitude at scan_mid_time	degrees_east	
scan_mid_time	double	obs	TAI93 at middle of earth scene scans	seconds since 1993-01-01 00:00	
sat_alt	float	obs	satellite altitude with respect to earth model at scan_mid_time	m	
local_solar_time	float	obs	local apparent solar time in hours from midnight	hours	
utc_tuple_lbl	string	utc_tuple	names of the elements of UTC when it is expressed as an array of integers year, month, day, hour, minute, second, millisecond, microsecond		
rad	float32	obs, wnum	spectral radiance	mW/(m2 sr cm-1)	err, qc
synth_frac	float32	wnum	File mean fraction of signal that is attributed to synthesized AIRS Level-1C values	unitless	
nedn	float32	fov, wnum	noise equivalent differential radiance	mW/(m2 sr cm-1)	
atrack	ubyte	obs	Along-track index of Field Of Regard	unitless	
xtrack	ubyte	obs	Cross-track index of Field Of Regard	unitless	bnds
fov_num	ubyte	obs	Field Of View number in FOR	unitless	
airs_atrack	ubyte	obs	AIRS-like along-track index of Field Of View	unitless	
airs_xtrack	ubyte	obs	AIRS-like cross-track index of Field Of View	unitless	
wnum	float64	wnum	wavenumber	cm-1	bnds

C.3 Attributes

Name	Type	Size	Value	Description
keywords	string	1	EARTH SCIENCE, SPECTRAL ENGINEERING, INFRARED WAVELENGTHS, INFRARED RADIANCE	A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute).
Conventions	string	1	CF-1.6, ACDD-1.3	A comma-separated list of the conventions that are followed by the dataset.

history	string	1		Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance.
source	string	1	AIRS and CrIS instrument telemetry	The method of production of the original data. If it was model-generated, source should name the model and its version. If it is observational, source should characterize it. This attribute is defined in the CF Conventions. Examples: 'temperature from CTD #1234'; 'world model v.0.1'.
processing_level	string	1	1	A textual description of the processing (or quality control) level of the data.
product_name_type_id	string	1	L1	Product name as it appears in product_name (L1A, L1B, L2, SNO_AIRS_CrIS)
comment	string	1		Miscellaneous information about the data or methods used to produce it. Can be empty.
acknowledgment	string	1	Support for this research was provided by NASA.	A place to acknowledge various types of support for the project that produced this data.
license	string	1	Limited to Sounder SIPS affiliates	Provide the URL to a standard or specific license, enter "Freely Distributed" or "None", or describe any restrictions to data access and distribution in free text.
standard_name_vocabulary	string	1	CF Standard Name Table v28	The name and version of the controlled vocabulary from which variable standard names are taken. (Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.) Example: 'CF Standard Name Table v27'.
date_created	string	1	Unassigned	The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended, as described in the Attribute Content Guidance section.
creator_name	string	1	Unassigned	The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.

creator_email	string	1	Unassigned	The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_url	string	1	Unassigned	The URL of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
institution	string	1	Unassigned	Processing facility that produced this file
project	string	1	Sounder SIPS	The name of the project(s) principally responsible for originating this data. Multiple projects can be separated by commas, as described under Attribute Content Guidelines. Examples: 'PATMOS-X', 'Extended Continental Shelf Project'.
product_name_project	string	1	SNDR	The name of the project as it appears in the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
publisher_name	string	1	Unassigned	The name of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_email	string	1	Unassigned	The email address of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_url	string	1	Unassigned	The URL of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
geospatial_bounds	string	1		Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are longitude (decimal degrees_east) and latitude (decimal degrees_north), in that order. Longitude values in the default case are limited to the [-180, 180) range. Example: 'POLYGON ((-111.29 40.26, -111.29 41.26, -110.29 41.26, -110.29 40.26, -111.29 40.26))'.

geospatial_bounds_crs	string	1	EPSG:4326	The coordinate reference system (CRS) of the point coordinates in the geospatial_bounds attribute. This CRS may be 2-dimensional or 3-dimensional, but together with geospatial_bounds_vertical_crs, if that attribute is supplied, must match the dimensionality, order, and meaning of point coordinate values in the geospatial_bounds attribute. If geospatial_bounds_vertical_crs is also present then this attribute must only specify a 2D CRS. EPSG CRSs are strongly recommended. If this attribute is not specified, the CRS is assumed to be EPSG:4326. Examples: 'EPSG:4979' (the 3D WGS84 CRS), 'EPSG:4047'.
geospatial_lat_min	float	1	9.9692099683868690e+36f	Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_min specifies the southernmost latitude covered by the dataset.
geospatial_lat_max	float	1	9.9692099683868690e+36f	Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_max specifies the northernmost latitude covered by the dataset.
geospatial_lon_min	float	1	9.9692099683868690e+36f	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max.
geospatial_lon_max	float	1	9.9692099683868690e+36f	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_max specifies the easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max, through the longitude range discontinuity meridian (either the antimeridian for -180:180 values, or Prime Meridian for 0:360 values), to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175).
time_coverage_start	string	1		Nominal start time. Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_first_valid_obs	string	1		Describes the time of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.

time_coverage_mid	string	1		Describes the midpoint between the nominal start and end times. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_coverage_end	string	1		Nominal end time. Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_last_valid_obs	string	1		Describes the time of the last valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_duration	string	1	P0000-00-00T00:06:00	Describes the duration of the data set. Use ISO 8601:2004 duration format, preferably the extended format as recommended in the Attribute Content Guidance section.
product_name_duration	string	1	m06	Product duration as it appears in product_name (m06 means six minutes)
creator_type	string	1	institution	Specifies type of creator with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the creator is assumed to be a person.
creator_institution	string	1	Jet Propulsion Laboratory -- California Institute of Technology	The institution of the creator; should uniquely identify the creator's institution. This attribute's value should be specified even if it matches the value of publisher_institution, or if creator_type is institution.
product_version	string	1	vxx.xx.xx	Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version.
keywords_vocabulary	string	1	GCMD:GCMD Keywords	If you are using a controlled vocabulary for the words/phrases in your "keywords" attribute, this is the unique name or identifier of the vocabulary from which keywords are taken. If more than one keyword vocabulary is used, each may be presented with a prefix and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key. Example: 'GCMD:GCMD Keywords, CF:NetCDF COARDS Climate and Forecast Standard Names'.
platform	string	1	JPSS-1, Joint Polar Satellite System, SUOMI-NPP, Suomi National Polar-orbiting Partnership, AQUA, Earth Observing System	Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary.
platform_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "platform" attribute.
product_name_platform	string	1	SS1330	Platform name as it appears in product_name

instrument	string	1	AIRS, Atmospheric Infrared Sounder, CrIS, Cross-track Infrared Sounder	Name of the contributing instrument(s) or sensor(s) used to create this data set or product. Indicate controlled vocabulary used in instrument_vocabulary.
instrument_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "instrument" attribute.
product_name_instr	string	1	CHIRP	Instrument name as it appears in product_name
product_name	string	1		Canonical fully qualified product name (official file name)
product_name_variant	string	1	std	Processing variant identifier as it appears in product_name. 'std' (shorthand for 'standard') is to be the default and should be what is seen in all public products.
product_name_version	string	1	vxx_xx_xx	Version number as it appears in product_name (v01_00_00)
product_name_producer	string	1	T	Production facility as it appears in product_name (single character) 'T' is the default, for unofficial local test products
product_name_timestamp	string	1	yymmddhhmmss	Processing timestamp as it appears in product_name (yymmddhhmmss)
product_name_extension	string	1	nc	File extension as it appears in product_name (typically nc)
granule_number	ushort	1		granule number of day (1-240)
product_name_granule_number	string	1	g000	zero-padded string for granule number of day (g001-g240)
gran_id	string	1	yyyymmddThhmm	Unique granule identifier yyyymmddThhmm of granule start, including year, month, day, hour, and minute of granule start time
geospatial_lat_mid	float	1	9.9692099683868690e+36f	granule center latitude
geospatial_lon_mid	float	1	9.9692099683868690e+36f	granule center longitude
featureType	string	1	trajectory	structure of data in file
data_structure	string	1	trajectory	a character string indicating the internal organization of the data with currently allowed values of 'grid', 'station', 'trajectory', or 'swath'. The 'structure' here generally describes the horizontal structure and in all cases data may also be functions, for example, of a vertical coordinate and/or time. (If using CMOR pass this in a call to cmor_set_cur_dataset_attribute.)
cdm_data_type	string	1	Trajectory	The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.)
id	string	1	Unassigned	An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters.

naming_authority	string	1	Unassigned	The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: 'edu.ucar.unidata'.
identifier_product_doi	string	1	Unassigned	digital signature
identifier_product_doi_authority	string	1	Unassigned	digital signature source
algorithm_version	string	1		The version of the algorithm in whatever format is selected by the developers. After the main algorithm name and version, versions from multiple sub-algorithms may be concatenated with semicolon separators. (ex: 'CCAST 4.2; BB emis from MIT 2016-04-01') Must be updated with every delivery that changes numerical results.
production_host	string	1		Identifying information about the host computer for this run. (Output of linux "uname -a" command.)
format_version	string	1	v02.02.07	Format version.
input_file_names	string	1		Semicolon-separated list of names or unique identifiers of files that were used to make this product. There will always be one space after each semicolon. There is no final semicolon.
input_file_types	string	1		Semicolon-separated list of tags giving the role of each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
input_file_dates	string	1		Semicolon-separated list of creation dates for each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
orbitDirection	string	1		Orbit is ascending and/or descending. Values are "Ascending" or "Descending" if the entire granule fits that description. "NorthPole" and "SouthPole" are used for polar-crossing granules. "NA" is used when a determination cannot be made.
day_night_flag	string	1		Data is day or night. "Day" means subsatellite point for all valid scans has solar zenith angle less than 90 degrees. "Night" means subsatellite point for all valid scans has solar zenith angle greater than 90 degrees. "Both" means the dataset contains valid observations with solar zenith angle above and below 90 degrees. "NA" means a value could not be determined.
AutomaticQualityFlag	string	1	Missing	"Passed": all spectra are present and calibrated with no quality issues; "Suspect": at least one spectrum is missing or calibrated with quality issues; "Failed": no calibrated spectra; "Missing": no downlinked data.

AutomaticQualityFlagExplanation	string	1	'Passed': all spectra are present and calibrated with no quality issues; 'Suspect': at least one spectrum is missing or calibrated with quality issues; 'Failed': no calibrated spectra; 'Missing': no downlinked data.	A text explanation of the criteria used to set AutomaticQualityFlag; including thresholds or other criteria.
qa_pct_data_missing	float	1		Percentage of expected observations that are missing.
qa_pct_data_geo	float	1		Percentage of expected observations that are successfully geolocated.
qa_pct_data_sci_mode	float	1		Percentage of expected observations that were taken while the instrument was in science mode and are successfully geolocated.
qa_no_data	string	1	TRUE	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".
title	string	1	13:30 orbit L1 CHIRP	a succinct description of what is in the dataset. (= ECS long name)
summary	string	1	The CHIRP Level 1 product for the 13:30 sun-synchronous orbit consists of calibrated radiance spectra at a common resolution derived from hyperspectral instruments on EOS-Aqua, S-NPP, and JPSS-1/NOAA-20 platforms adjusted to form a continuous climate-quality record.	A paragraph describing the dataset, analogous to an abstract for a paper.
shortname	string	1	SSYN1330CHIRP1 placeholder	ECS Short Name
product_group	string	1	l1_chirp	The group name to be used for this product when it is collected in a multi-group file type, like SNO or calsub
metadata_link	string	1	http://disc.sci.gsfc.nasa.gov/	A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute.
references	string	1		ATDB and design documents describing processing algorithms. Can be empty.
contributor_name	string	1	UMBC Atmospheric Spectroscopy Laboratory: Larrabee Strow	The names of any individuals or institutions that contributed to the creation of this data.
contributor_role	string	1	CrIS L1B Scientist	The roles of any individuals or institutions that contributed to the creation of this data.
wnum_delta_lw	float	1	0.625f	Difference between adjacent wavenumbers in longwave spectrum, in cm-1
wnum_delta_mw	float	1	0.83333333333f	Difference between adjacent wavenumbers in midwave spectrum, in cm-1
wnum_delta_sw	float	1	1.25f	Difference between adjacent wavenumbers in shortwave spectrum, in cm-1