CrIS L1b Project, Part 2

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Outline

- Project overview
- Software
- Documentation
- Product
- Data Access

CrIS L1B Project Overview

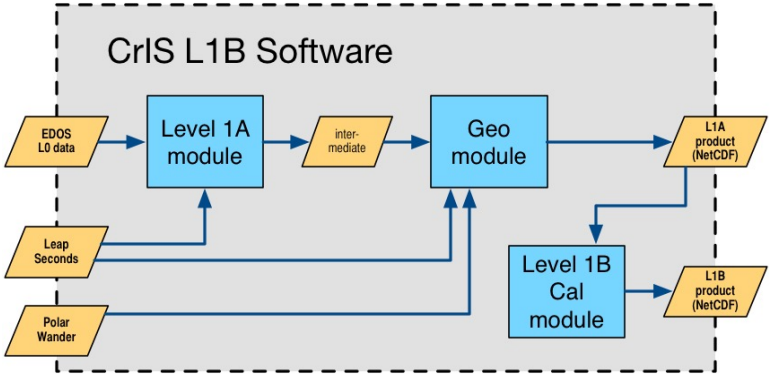
- Funded by NASA to create software to generate a **climate quality** SNPP and NOAA-20 CrIS Level 1B mission data record
- Level 1B = calibrated, navigated radiance spectra
- Stability of the product over the mission is a priority
- Joint effort at Univ. of Wisconsin – Madison (Joe Taylor, PI) and Univ. of Maryland – Baltimore County (Larrabee Strow, PI)
- Completely different implementation from IDPS, though the underlying algorithm theory is mostly the same
- File formats, granulation and other conventions were developed in collaboration with Sounder SIPS and the ATMS team at JPL and are common with the ATMS L1B product

Progress to Date

- Mid 2015: Preliminary SNPP sample data released
- Late 2016: Version 1 software and documentation delivered
  - Supports SNPP NSR product generation
- Late 2017: Version 2 software and documentation delivered
  - Added support for FSR product generation, various improvements included added Geo outputs
- March 2018: Preliminary NOAA-20 sample data released
- September 2018: Version 2.1 software delivered
  - Added support for NOAA-20, minor improvements

CrIS L1B Software

- Three primary software components:
  - Level 1A: unpacks and granulates the raw telemetry stream (instrument, 8-sec science, four-min engineering, spacecraft diary)
  - Geo: geolocation including surface information
  - Level 1B: performs spectral and radiometric calibration



- L1A and Geo were developed from scratch in Python
- L1B Cal was adapted from existing UW/UMBC software (CCAST), written in Matlab
- "Glue" code was developed in Python and Bash
- Command-line scripts are provided to run L1A+Geo, L1B, or entire processing chain
- Inputs are EDOS L0 data, Leap Seconds and Polar Wander files

Software Packaging and Delivery

- Leverage lessons learned from the CSPP project, to create self-contained, portable binary packages that can be run on any RHEL6-compatible Linux system
- The software is delivered to the Sounder SIPS (Ruth Monarrez, lead), in binary and source form, with test data
- Sounder SIPS performs testing and integration, and provides feedback to the CrIS team
- One or more re-deliveries may be done if warranted
- The mission products are generated and distributed by GES DISC.
- Also leverage co-located Atmosphere SIPS (Liam Gumley, lead) to test software and generate preliminary datasets for internal evaluation
- Feedback from Science Team (Chris Barnet, lead) and SIPS is incorporated in design and development
- Note science code is run directly to generate the product, avoiding the expense of re-writing software.

Documentation

- Documentation describing each product release is available for download from GES DISC
  - Algorithm Theoretical Basis Document (ATBD)
  - Product Users' Guide (PUG)
  - Quality Flags Description Document
- Current ATBD is a "delta" format, will become standalone
- A Software Users' Guide is also delivered with each product release

File Format

- The software produces L1A and L1B product files
- NetCDF-4 format
- 6-min granules, UTC-aligned, one granule per file
- File and variable attributes conform to CF, ACDD and ISO standards where possible
  - Additional attributes were included for legacy compatibility
- Sounder SIPS maintains a data dictionary that can be exported to CDL

NSR and FSR

- The spectral resolution of data received from SNPP CrIS has varied over the mission
- To support the two goals of providing the longest possible dataset and the highest resolution dataset, the SNPP CrIS L1B product is available at two resolutions:
  - Normal Spectral Resolution (NSR), starting on April 19, 2012
  - Full Spectral Resolution (FSR), starting on November 2, 2015
- NOAA-20 has supported FSR product for the entire mission
- Current plan is to product the NOAA-20 product only at FSR

SNPP NSR and FSR
L1B product resolution (cm^{-1})

	NSR	FSR
Start date	April 19, 2012 (granule 001)	Nov. 2, 2015 (granule 162)
LWIR resolution	0.625	0.625
MWIR resolution	1.250	0.625
SWIR resolution	2.500	0.625

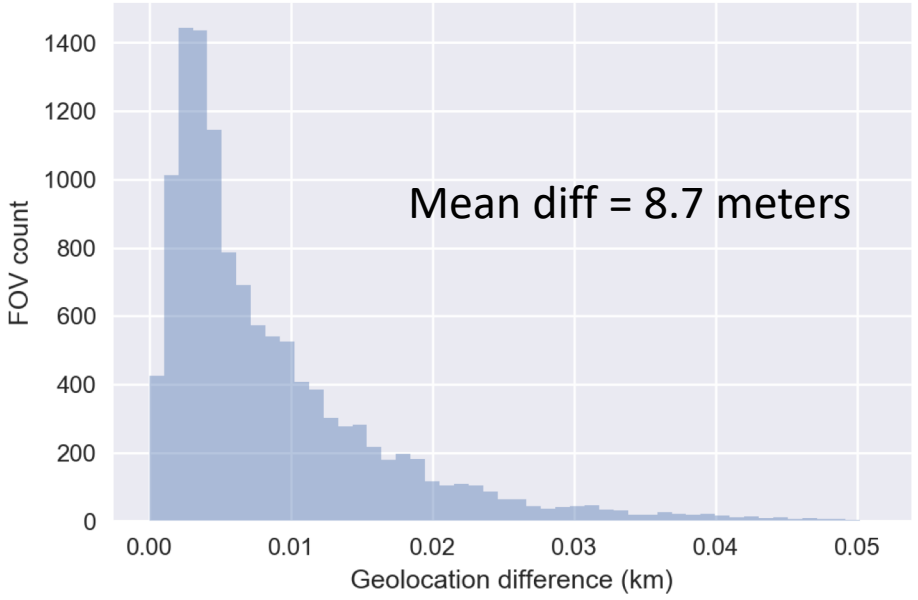
L1A Product

- L1A Product consists of
  - Telemetry values which have been unpacked and granulated
  - Bit-trimmed interferograms
  - Geolocation variables
  - Quality information
- Telemetry values are decoded using parameters from an XML database maintained by the instrument manufacturer
  - New XML database versions will be integrated as they become available
- Currently there are no plans to archive L1A
- Because decoding telemetry values is non-trivial, the CrIS L1B team recommends that the L1A product be archived in the future, or possibly software sufficient to reproduce the L1A product
- A formal definition of the Level 1A product is planned for the next year, considered a pre-requirement for archiving data

Geolocation

- Geolocation variables are in both L1A and L1B files
- Geo variables include
  - terrain-corrected and non-corrected lat/lon
  - surface information
  - solar and satellite geometry and spacecraft vectors
- V2.0 added: local_solar_time, sat_sol_zen, sat_sol_azi, mean_anom_wrt_equat, asc_node_tai93, asc_node_lon, asc_node_local_solar_time, and solar_beta_angle.
- Future refinements will include improved sun glint calculations and improved estimations of orbital information
- Geolocation will be assessed by comparing with VIIRS

V2.1 L1B (non-terrain corrected) vs SDRs
SNPP Granule 20180930T1454



L1B Product Variables

Science

rad_lw
rad_mw
rad_sw
nedn_lw
nedn_mw
nedn_sw
scan_sweep_dir
for_num
fov_num
wnum_lw
wnum_mw
wnum_sw
obs_time_tai93
obs_time_utc
utc_tuple_lbl
instrument_state

Geolocation

lat	sol_azi	subsat_lon
lon	sun_glint_dist	scan_mid_time
lat_bnds	local_solar_time	sat_alt
lon_bnds	sat_sol_zen	sat_pos
land_frac	sat_sol_azi	sat_vel
surf_alt	solar_beta_angle	sat_att
surf_alt_sdev	view_ang	asc_node_lon
lat_geoid	sat_zen	asc_node_tai93
lon_geoid	sat_azi	asc_node_local_solar_time
sun_glint_lat	sat_range	mean_anom_wrt_equat
sun_glint_lon	asc_flag	attitude_lbl
sol_zen	subsat_lat	spatial_lbl

Quality

rad_lw_qc
rad_mw_qc
rad_sw_qc
/aux/geo_qualflag
cal_lw_qualflag
cal_mw_qualflag
cal_sw_qualflag
cal_qualflag

Obs ID

obs_id
fov_obs_id

Aux

geo_qualflag
rad_imag_lw
rad_imag_mw
rad_imag_sw
max_opd_lw
max_opd_mw
max_opd_sw
spectral_fold_point_lw
spectral_fold_point_mw
spectral_fold_point_sw
measured_laser_wlen
smoothed_laser_wlen
smoothed_neon_wlen
neon_wlen

Quality Information

- Quality flag variables are bit-fields in L1A and L1B products, with individual flags indicating problems affecting input or encountered in processing
  - An overall value of 0 indicates no problems
  - Attributes fully describe the meanings of each possible flag value, as prescribed by CF
  - L1B QFs are provided for each observation (i.e. spectrum)
- Version 2.0 reorganized L1B QF bit-fields into new variables
- Version 2.0 added Quality Control variables containing an integer value summarizing the quality of each spectrum
  - Example:

rad_lw	longwave real spectral radiance
rad_lw_qc	rad lw QC

- Data quality tests will be added and refined in future versions, possibly resulting in added QF bits.

Attributes

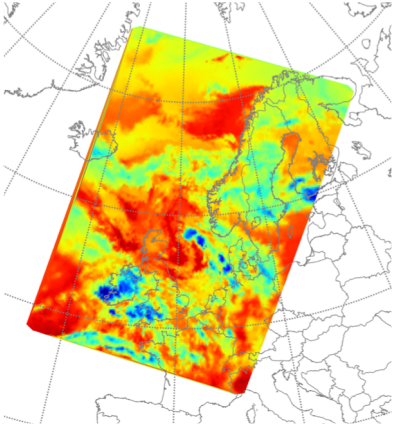
- Global (file-level) attributes contain summary information about the granule. For example:
  - Percent of data that is missing, geolocated and science mode
  - Geolocation bounds
  - Granule start and end times
  - Software and product version numbers
- Variable attributes Example:

```
float rad_lw(atrack=45, xtrack=30, fov=9, wnum_lw=717);
  :units = "mW/(m2 sr cm-1)";
  :ancillary_variables = "rad_lw_qc";
  :long_name = "longwave real spectral radiance";
  :standard_name = "toa_outgoing_radiance_per_unit_wavenumber";
  :coordinates = "lon lat";
  :description = "longwave real spectral radiance";
  :_FillValue = 9.96921E36f; // float
  :coverage_content_type = "physicalMeasurement";
```

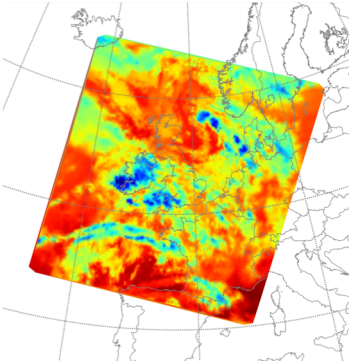
IDPS SDR vs CrIS L1B Products

	IDPS SDR	NASA L1B
Granule size	31.997 sec	6 min
File type	HDF5	NetCDF4
Geolocation	in a separate file	included in the same file
Terrain-corrected Geo?	no	yes (corrected and uncorrected geo available)
Wavenumbers included?	no	yes
Missing data representation	multiple values in -999.x range	single value near data max or min
L1A product?	no	yes

IDPS SDR file (15 granule aggregated)

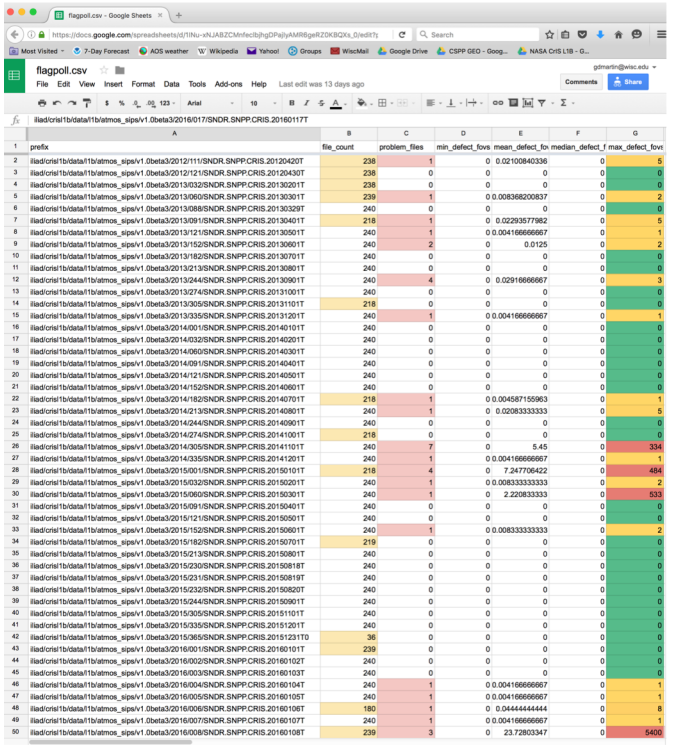


L1B file (1 granule)



Flagpoll

- Scans L1B quality flags for multiple granules, reports on issues found
- Can be used to quickly find the problem granules in a day
- Writes summaries of each day to a .csv file, which can then be loaded as a spreadsheet
- Both a “big picture” tool and a “deep dive” tool
- Flagpoll has helped us to identify the missing and problem granules in the beta dataset, which can be compared with a list of known CrIS data anomalies
- Plan to develop query-able database of statistics derived from QFs, metadata and products



	A	B	C	D	E	F	G
1	prefix	file_count	problem_files	min_defect_fovs	mean_defect_fo	median_defect_f	max_defect_fovs
2	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2012/111/SNDR.SNPP.CRIS.20120420T	238	1	0	0.02100840336	0	5
3	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2012/121/SNDR.SNPP.CRIS.20120430T	238	0	0	0	0	0
4	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/032/SNDR.SNPP.CRIS.20130201T	238	0	0	0	0	0
5	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/060/SNDR.SNPP.CRIS.20130301T	239	1	0	0.008368200837	0	2
6	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/088/SNDR.SNPP.CRIS.20130329T	240	0	0	0	0	0
7	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/091/SNDR.SNPP.CRIS.20130401T	218	1	0	0.02293577982	0	5
8	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/121/SNDR.SNPP.CRIS.20130501T	240	1	0	0.004166666667	0	1
9	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/152/SNDR.SNPP.CRIS.20130601T	240	2	0	0.0125	0	2
10	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/182/SNDR.SNPP.CRIS.20130701T	240	0	0	0	0	0
11	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/213/SNDR.SNPP.CRIS.20130801T	240	0	0	0	0	0
12	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/244/SNDR.SNPP.CRIS.20130901T	240	4	0	0.02916666667	0	3
13	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/274/SNDR.SNPP.CRIS.20131001T	240	0	0	0	0	0
14	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/305/SNDR.SNPP.CRIS.20131101T	218	0	0	0	0	0
15	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2013/335/SNDR.SNPP.CRIS.20131201T	240	1	0	0.004166666667	0	1
16	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/001/SNDR.SNPP.CRIS.20140101T	240	0	0	0	0	0
17	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/032/SNDR.SNPP.CRIS.20140201T	240	0	0	0	0	0
18	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/060/SNDR.SNPP.CRIS.20140301T	240	0	0	0	0	0
19	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/091/SNDR.SNPP.CRIS.20140401T	240	0	0	0	0	0
20	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/121/SNDR.SNPP.CRIS.20140501T	240	0	0	0	0	0
21	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/152/SNDR.SNPP.CRIS.20140601T	240	0	0	0	0	0
22	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/182/SNDR.SNPP.CRIS.20140701T	218	1	0	0.00458715963	0	1
23	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/213/SNDR.SNPP.CRIS.20140801T	240	1	0	0.02083333333	0	5
24	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/244/SNDR.SNPP.CRIS.20140901T	240	0	0	0	0	0
25	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/274/SNDR.SNPP.CRIS.20141001T	218	0	0	0	0	0
26	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/305/SNDR.SNPP.CRIS.20141101T	240	7	0	5.45	0	334
27	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2014/335/SNDR.SNPP.CRIS.20141201T	240	1	0	0.004166666667	0	1
28	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/001/SNDR.SNPP.CRIS.20150101T	218	4	0	7.247706422	0	484
29	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/032/SNDR.SNPP.CRIS.20150201T	240	1	0	0.008333333333	0	2
30	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/060/SNDR.SNPP.CRIS.20150301T	240	1	0	2.220833333	0	533
31	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/091/SNDR.SNPP.CRIS.20150401T	240	0	0	0	0	0
32	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/121/SNDR.SNPP.CRIS.20150501T	240	0	0	0	0	0
33	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/152/SNDR.SNPP.CRIS.20150601T	240	1	0	0.008333333333	0	2
34	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/182/SNDR.SNPP.CRIS.20150701T	219	0	0	0	0	0
35	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/213/SNDR.SNPP.CRIS.20150801T	240	0	0	0	0	0
36	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/230/SNDR.SNPP.CRIS.20150818T	240	0	0	0	0	0
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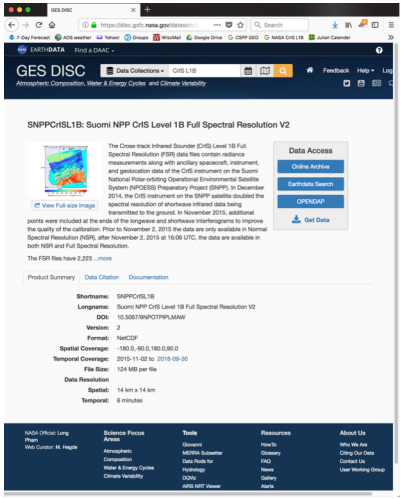
39	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/244/SNDR.SNPP.CRIS.20150901T	240	0	0	0	0	0
40	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/305/SNDR.SNPP.CRIS.20151101T	240	0	0	0	0	0
41	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/335/SNDR.SNPP.CRIS.20151201T	240	0	0	0	0	0
42	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2015/365/SNDR.SNPP.CRIS.20151231T0	36	0	0	0	0	0
43	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/001/SNDR.SNPP.CRIS.20160101T	239	0	0	0	0	0
44	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/002/SNDR.SNPP.CRIS.20160102T	240	0	0	0	0	0
45	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/003/SNDR.SNPP.CRIS.20160103T	240	0	0	0	0	0
46	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/004/SNDR.SNPP.CRIS.20160104T	240	1	0	0.004166666667	0	1
47	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/005/SNDR.SNPP.CRIS.20160105T	240	1	0	0.004166666667	0	1
48	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/006/SNDR.SNPP.CRIS.20160106T	180	1	0	0.04444444444	0	8
49	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/007/SNDR.SNPP.CRIS.20160107T	240	1	0	0.004166666667	0	1
50	iliad/cris/1b/data/11b/atmos_sips/v1.0beta3/2016/008/SNDR.SNPP.CRIS.20160108T	239	3	0	23.72803347	0	5400

NOAA-20 Activities

- November 2017: launch
- Feb 16, 2018 – engineering packet v114 uploaded, CrIS data quality stabilized. This will be the likely start date of the NOAA-20 product.
- First half of 2018: team members participated in instrument checkout (Flavio Iturbide, lead) and developed calibration parameters
- August 2018: engineering packet v115 uploaded. Evaluated L1B product and delivered V2.1 software in September.
- Currently assessing the v2.1 NOAA-20 product and updating documentation

How to Obtain the CrIS L1B Products

1. Visit GES DISC site: https://disc.gsfc.nasa.gov
2. Search “CrIS L1B”
3. Select the V2 SNPP CrIS L1B FSR or NSR dataset
4. Dataset page has multiple methods of data access and links to documentation.



Direct links:

- https://disc.gsfc.nasa.gov/datasets/SNPPCrISL1B_V2/summary
- https://disc.gsfc.nasa.gov/datasets/SNPPCrISL1BNSR_V2/summary

Software and product contact info:

- CrIS L1B Team: cris.l1b.support@ssec.wisc.edu
- Sounder SIPS: sounder.sips@jpl.nasa.gov