Clouds, Aerosol, Radiation – Development of INtegrated Algorithms for the EarthCARE Mission (CARDINAL)

Contract nr. 4000134661/21/NL/AD

Product Definition Document (PDD)

Product AC-TC
Product format version 11.60

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CHANGE LOG

Reason for change	Issue	Revision	Date
A-TC and C-TC have been updated. References to M-TC removed.	1	1	27/05/2016
Updated after TRR1	1	2	07/09/2016
Updated after ARv1	2	0	21/11/2016
Updated after TRR2	2	1	27/02/2017
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Updated §6.3 et §6.4	4	1	29/09/2018
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Version for CARDINAL AR-A	9	0	30/08/2021
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CARDINAL AR-C	10	0	01/09/2022
After AR-C	10	1	11/10/2022
CARDINAL AR-E	11	0	30/10/2023
After LRR	11	2	3/5/2024
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For PRR-1	11	4	05/03/2025
For PRR-2	11	5	24/09/2025
After PRR-2	11	60	20/11/2025

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1 PURPOSE AND SCOPE

This document provides the format description for AC-TC EarthCARE data product, containing the synergetic lidar/radar classification of the EarthCARE signals. This target classification makes the most of the combination of both instruments.

It is applicable to *AC-TC* format version *11.60*.

This algorithm ingests ATLID and CPR target classifications (L2a) data in order to create a combined target classification field. This product is compatible both in terms of conventions and in terms of product format with the L2a Radar-only (C-TC) and L2a-Lidar-only (A-TC) products. The AC-TC product is used in the synergistic radar-lidar retrieval ACM-CAP.

This is document contains input and output data description related to AC-*TC* processor. Open issues are indicated by TBC/TBD/TBW.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

Table 1: Applicable Documents

Ref.	Code	Title	Issue
[AD 0] [SOW]	EC-SOW-ESA-SYS-0587	EarthCARE Level 2 Processor Scientific Developments: Generic Work Description Document	2.0
[AD 1]	EC-RS-ESA-SY-0152	EarthCARE Ground Processors General Requirements Baseline	4.0
[AD 2]	EC.ICD.ASD.SY.00005	EarthCARE Product Definitions. Vol. 1: Common Product Definitions	11.0
[AD 3]	AC-TC_ATBD	AC-TC Algorithm Theoretical Basis Document (ATBD)	11.00
[AD 4]	EACA-GSEG-EOPG-TN-15-0001	EarthCARE PDGS Generic IPF Interface Specifications	1.4
[AD 5]	EC-ICD-ESA-SYS-555	EarthCARE Product Definitions Vol. 8: ECMWF meteorological fields (X-MET)	5.0

2.2 Reference documents

Table 2: Reference Documents

Ref.	Code	Title	Issue
[RD1]	EC.ICD.ASD.SY.00005	EarthCARE Product Definitions, Vol. 1: Common Product Definition	8.0
[RD2]	EC-TN-ESA-SYS-0380	EarthCARE Production Model	6.0
[RD3]	EC-ICD-ESA-SYS-0314	EarthCARE ESA Product List	5.0
[RD4]	EC-RS-ESA-SYS-0012	EarthCARE Mission Requirements Document	5.0
[RD5]	A-PRO_A-TC_PDD	ATLID L2a target classification Product Definition Document (PDD)	11.20
[RD6]	C-PRO_C-TC-PDD	CPR Target classification Product Description Document (PDD)	11.20

3 PRODUCT OVERVIEW

This product facilitates the application of other synergetic algorithms. Principally, it identifies the nature of the targets in each pixel and highlights those that are bad or ambiguous, thereby informing subsequent algorithms where they should perform a retrieval (e.g. an ice cloud algorithm is only applied to pixels containing ice cloud) and in some cases the confidence that they should assign to the observations at each pixel. In addition to facilitating application of other algorithms, it can also be used to derive cloud fraction and cloud overlap on arbitrary model-type grids.

In addition to standard geo-location variables, this product contains:

- Target classification fields indicating the occurrence of the various types of target that are possible: ice particles, liquid cloud droplets, rain or drizzle, melting ice, insects, aerosols, the surface of the earth, or combinations of the above. In some cases it is possible to further sub-classify this information, for example presenting the different types of aerosol present, and distinguishing “warm rain” (that originating from collision and coalescence of droplets within liquid clouds) from “cold rain” (that originating from melting ice). The format needs to be flexible enough that combinations of types can be reported for the same pixel, while being easy to interpret by the user. Furthermore, it is important to communicate not only whether a particular type is present or not, but when it is impossible to tell because of attenuation of a particular instrument (this is mainly at lidar level).

- “Instrument detection status” fields for radar and lidar, indicating whether the instrument can see some particulate target or something else. It is important to note that this contains what the instrument actually saw, not what it would be expected to see. So at the ground we would normally see a few range gates containing “ground detected” with “totally extinguished” below. If the ground signal is obscured by multiple scattering or total extinction by cloud, then this is reported as a different number, so users who wish to use the ground return only use actual observations of it.

For ease of use, the radar-lidar classification information is presented in a form which is as similar as possible to the L2a radar-only and lidar-only products developed throughout the joint algorithm development effort for EarthCARE.

The target classification will be reported on a grid spacing of 1km horizontal by 100m vertical (ie. X-JSG- horizontal resolution is coming from the radar horizontal spacing and vertical resolution from the lidar vertical grid).

4 INPUT LIST

This product is created from the input file given in Table 3.

Table 3: AC-TC input files

A-TC	ATLID Target Classification
C-TC	CPR Target Classification
X-MET	Meteorological fields limited to EarthCARE swath (temperature, relative humidity, height, wet bulb temperature, tropopause height, surface altitude)

5 PRODUCT CHARACTERISTICS

5.1 Overview

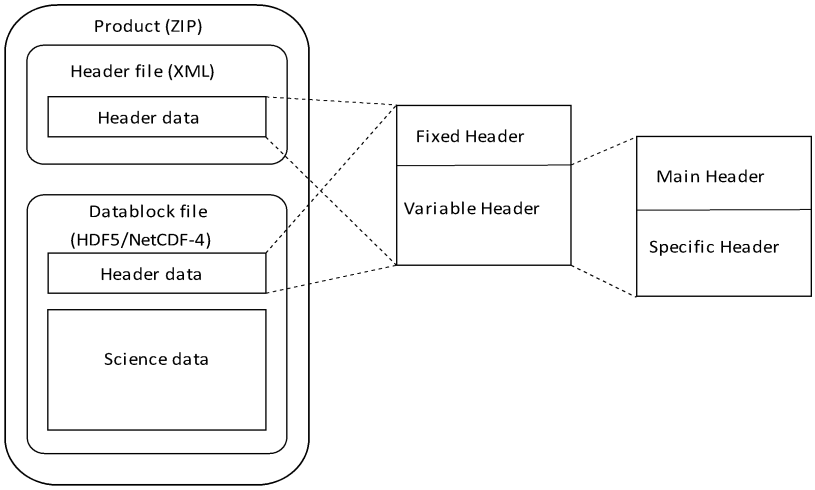
Identifier	***AC-TC***	
Descriptive name	Synergetic Target Classification	
Product level	*2b*	
File name pattern	*ECA_EXAA_AC__TC__2B_YYYYMMDDThhmmssZ_YYYYMMDDThhmmssZ_vvvvvf*	
Format version	*11.60*	
Metaformat	NetCDF4/HDF5	
Granularity	1 frame (= 1/8 orbit) per file	
Frame margin	*0* km	
File size	5.0 MB per frame with compression	
	horizontal	*vertical*
Spatial extent	*5000 km*	*-0.5* km to *20* km
Spatial sampling	JSG (approx. *1 k*m along-track)	JSG (approx. *100* m)
Spatial resolution	JSG (approx. *1 k*m along-track)	JSG (approx. *100* m)
Data volume per day	600 MB with compression	

The output will be provided at the joint standard grid. The true resolution can differ per pixel depending which of the instruments detects the pixel.

6 PRODUCT FORMAT

6.1 Overview

The product format follows the conventions in [RD1], [RD2], and [RD3]. In particular, each product consists of two files, a NetCDF4/HDF5 data block file and an XML header file, packaged into a zip archive (zip without compression). For convenience, a copy of the header data is provided in the data block file as well. These header parameters are defined in [RD3] and in section 6.2.1 below. They should not be confused with headers internally generated by HDF5/NetCDF-4 for describing the file structure.



The overall structure of the data block file is shown below. The hierarchical structure is reflected in the XML header file by nesting of XML tags (see [RD1]).

Element			**Format reference**
Header data	Fixed Header		[RD3]
	Variable Header	Main Product Header	[RD3]
		Specific Product Header	this doc, section 6.2.1
Science data			this doc, section 6.2.2

6.2 Detailed format

This shows the full product format in tabular form (Table 5 to Table 10), listing groups and variables with their names, units, dimensions, data types, and descriptions. The tables are preceded by a definition of the dimensions used (see Table 4).
Only the specific product header and science data are defined here. Refer to [RD3] for the definitions of fixed and main product header.

Table 4 : Dimensions

Dimension	Description	Number of elements (*typical*)
along_track	Horizontal grid points (equivalent to time)	5000
JSG_height	Vertical grid points	205

Table 5: Input files

Name	Data type	Dimensions	Description	Notes	Units
AC-TC file	string	-	ATLID target classification file		-
C-TC file	string	-	CPR target classification file		-
X-MET file	string	-	Meteorological fields file		-
Configuration file	string	-	List of configuration settings of the algorithm e.g. classification etc. …		-

6.2.1 *Specific Product Header*

The Specific Product Header (SPH) contains input filenames of the processor AC-TC and the parameters of the configuration file.

6.2.2 *Science Data*

6.2.2.1 1D and 2D Coordinate variables

The 1D and 2D coordinate variables are listed in Table 6.

Table 6: Coordinate variables

Variable	Description	Units	Dim	Type
time	UTC time at JSG pixel	s since 2000-1-1 00:00:00.0 0:00	along_track	double
latitude	Latitude at the ground of the along track JSG	degree_north	along_track	double
longitude	Longitude at the ground of the along track JSG	degree_east	along_track	double
elevation	Terrain elevation of pixel centre above WGS84 ellipsoid	m	along_track	float
height	Height of pixel centres above WGS84 ellipsoid	m	along_track, JSG_height	float
geoid_offset	Offset between geoid EGM96 and ellipsoid WGS84 in metres	m	along_track	double

6.2.2.2 Data variables

A summary of all data variables is given here, while in the following sections more detailed descriptions of key detection status and target classification variables is provided.

Table 7 AC-TC parameter table

Variable	Description	Units	Dim	Type
land_flag		-	along_track	byte
temperature	Atmospheric temperature from X-MET on JSG	K	along_track, JSG_height	float
pressure	Atmospheric pressure from X-MET on JSG	Pa	along_track, JSG_height	float
synergetic_target_classification	High resolution ATLID-CPR target classification	-	along_track, JSG_height	byte
synergetic_target_classification_medium_resolution	Medium resolution ATLID-CPR target classification	-	along_track, JSG_height	byte
synergetic_target_classification_low_resolution	Low resolution ATLID-CPR target classification	-	along_track, JSG_height	byte
ATLID_target_classification	-3 = no data -2 = surface -1 = attenuated 0 = clear	-	along_track, JSG_height	byte

	1 = liquid cloud (warm) 2 = liquid cloud (supercooled) 3 = ice cloud 10 = dust 11 = sea salt 12 = continental pollution 13 = smoke 14 = dusty smoke 15 = dusty mix 20 = STS (PSC I) 21 = NAT (PSC II) 22 = stratospheric ice 25 = stratospheric ash 26 = stratospheric sulfate 27 = stratospheric smoke 101 = unknown aerosol; low probability (no class assigned) 102 = unknown aerosol; outside of parameter space 104 = unknown stratospheric aerosol; low probability (no class assigned) 105 = unknown stratospheric aerosol target; outside of parameter space 106 = unknown PSC; low probability (no class assigned) 107 = unknown PSC; outside of parameter space			
ATLID_target_classification_medium_resolution	As above	-	along_track, JSG_height	byte
ATLID_target_classification_low_resolution	As above	-	along_track, JSG_height	byte
ATLID_detection_status	-3 = missing data -2 = surface or below -1 = attenuated region 0 = clear 1 = liquid cloud or aerosol targets	-	along_track, JSG_height	byte
CPR_target_classification	CPR target classification after interpolation onto the JSG	-	along_track, JSG_height	byte
CPR_detection_status	-1 = no data 0 = surface and sub-surface 1 = clear 2 = totally extinguished	-	along_track, JSG_height	byte

	3 = likely extinguished 4 = target detected, no reliable measurements 5 = target detected, only reflectivity reliable 6 = target detected, reflectivity enhanced by multiple scattering 7 = target detected, only Doppler reliable 8 = target detected, both reflectivity and Doppler reliable 9 = clutter separated from the cloud/precipitation return or clear 10 = clutter not separated from the lowest hydrometeor layer detected 11 = uncertain 12 = second-trip echo			
CPR_ATLID_status	-4: no information -3: subsurface (radar-lidar) -2: subsurface (lidar only) -1: subsurface (radar only) 0: unassigned 1: clear (radar-lidar) 2: clear (lidar only) 3: clear (radar only) 4: target (radar-lidar) 5: target (lidar only) 6: target (radar only)	-	along_track, JSG_height	byte
CPR_ATLID_ medium_resolution_status	As above	-	along_track, JSG_height	byte
CPR_ATLID_low_resolution_status	As above	-	along_track, JSG_height	byte
quality_status	0 = high confidence (surface) 1 = high confidence (clear) 2 = high confidence (synergistic hydrometeors) 3 = high confidence (lidar-only hydrometeors 4 = moderate confidence (aerosols) 5 = moderate confidence (stratosphere) 6 = moderate confidence (clear, lidar-only) 7 = moderate confidence (stratosphere, lidar-only)	-	along_track, JSG_height	byte

	8 = moderate confidence (hydrometeors) 9 = moderate confidence (clear) 10 = low confidence (clear) 11 = low confidence (hydrometeors) 12 = low confidence (unknown) 13 = low confidence (radar artefact) 14 = low confidence (extinguished) 15 = low confidence (surface) 16 = no data			
quality_medium_resolution _status_	As above	-	along_track, JSG_height	byte
quality_low_resolution_status	As above	-	along_track, JSG_height	byte
insect_detection_status	-3: no data -2: hydrometeors -1: no insects detected (ATLID obscured) 0: no insects detected (ATLID clear) 1: possible insects in clutter 2: possible insects 3: likely insects in clutter 4: likely insects	-	along_track, JSG_height	byte

6.2.2.3 Instrument detection status (8-bit signed integers)

The instrument detection status is given in Table 7.

Table 8: Instrument status description

Name	Description	Dim	Notes
ATLID_detection_status (corresponds to mie_detection_status in [RD5])	**LIDAR detection status:** -3 = missing data -2 = surface or below -1 = attenuated region 0 = clear 1 = liquid cloud or aerosol targets	along_track, JSG_height	
CPR_detection_status (corresponds to detection_status in [RD6])	**RADAR detection status:** -1 = no data 0 = surface and sub-surface 1 = clear 2 = totally extinguished 3 = likely extinguished 4 = target detected, no reliable measurements 5 = target detected, only reflectivity reliable 6 = target detected, reflectivity enhanced by multiple scattering	along_track, JSG_height	

	7 = target detected, only Doppler reliable 8 = target detected, both reflectivity and Doppler reliable 9 = clutter separated from the cloud/precipitation return or clear 10 = clutter not separated from the lowest hydrometeor layer detected 11 = uncertain 12 = second-trip echo		

6.2.2.4 Radar and LIDAR target classifications - synergy

The target classification for both the radar and LIDAR as the synergetic target classification are in Table 8.

Table 9: Description of the ATLID and CPR target classifications

Name	Description	Dim	Notes
ATLID_target_classification (corresponds to classification in [RD5])	**LIDAR target classification**: -3 = no data -2 = surface -1 = attenuated 0 = clear 1 = liquid cloud (warm) 2 = liquid cloud (supercooled) 3 = ice cloud 10 = dust 11 = sea salt 12 = continental pollution 13 = smoke 14 = dusty smoke 15 = dusty mix 20 = STS (PSC I) 21 = NAT (PSC II) 22 = stratospheric ice 25 = stratospheric ash 26 = stratospheric sulfate 27 = stratospheric smoke 101 = unknown aerosol; low probability (no class assigned) 102 = unknown aerosol; outside of parameter space 104 = unknown stratospheric aerosol; low probability (no class assigned) 105 = unknown stratospheric aerosol target; outside of parameter space 106 = unknown PSC; low probability (no class assigned) 107 = unknown PSC; outside of parameter space	along_track, JSG_height	
CPR_target_classification (corresponds to hydrometeor_classification in [RD6])	**RADAR target classification**: -1= no data 0 = surface and sub-surface 1 = clear 2 = no drizzling liquid cloud 3 = lightly drizzling liquid clouds 4 = heavy drizzle and warm rain	along_track, JSG_height	

	5 = cold rain 6 = melting snow 7 = rimed snow 8 = snow 9 = ice cloud 10= stratospheric cloud 11= insects or artifacts 12= heavy rain likely 13 = heavy mixed-phase precipitation likely 14 = heavy rain 15 = heavy mixed-phase precipitation 16 = removed clutter, rain likely 17 = removed clutter, snow likely 18 = removed clutter, cloud likely 19 = removed clutter, clear likely 20 = uncertain		
synergetic_target_classification	See Table 9 for description and values of the synergetic target classification		

The target classifications for LIDAR in case of low and medium resolution are also used. They appear in the AC-TC product as **ATLID_target_classification_low_resolution** and **ATLID_target_classification_medium_resolution**. They correspond respectively to **classification_low_resolution** and **classification_medium_resolution** in [RD5].
The corresponding synergetic target classifications are:
synergetic_target_classification_low_resolution and
synergetic_target_classification_medium_resolution.

6.2.2.5 Synergetic target classification

The synergetic classification is defined in Table 9.

Table 10: Description of the AC-TC

Value AC-TC	Description	Units N/A	Dim along_track, height	Type byte	Comment
-1	unknown				
0	ground				
1	clear				
2	possible rain (clutter)				
3	possible snow (clutter)				
4	possible cloud (clutter)				
5	heavy rain				
6	heavy mixed-phase precipitation				
7	no rain or ice (possible liquid)				
8	liquid cloud				

9	drizzling liquid cloud				
10	warm rain				
11	cold rain				
12	melting snow				
13	snow (possible liquid)				
14	snow (no liquid)				
15	rimed snow (possible liquid)				
16	rimed snow and supercooled liquid				
17	snow and supercooled liquid				
18	supercooled liquid				
19	ice cloud (possible liquid)				
20	ice and supercooled liquid				
21	ice cloud (no liquid)				
22	stratospheric ice				
23	STS (PSC type I)				
24	NAT (PSC type II)				
25	insects				
26-31	tropospheric aerosol types				
32-34	stratospheric aerosol types				

Table 9 is also valid for the low and medium synergetic classification.

6.2.2.6 Radar-LIDAR status

The Radar-LIDAR status is the variable **CPR_ATLID_status** in the AC-TC product. It contains the information given in Table 10. This table reflects ambiguities brought by the lack of information given by the instruments.

Table 11: radar-LIDAR status

CPR_ATLID_status	Description	Units N/A	Dim along_track, height	Type byte	Comment
0	nominal				data provided by both instrument
1	CPR data; ATLID extinguished				
2	CPR data; no ATLID data				
3	no CPR data; ATLID data				
4	no CPR data; ATLID extinguished				

5	no data for CPR and ATL				

6.2.2.7 Quality status

The quality status, described in Table 12, builds upon the CPR_ATLID_status to report the confidence with which target classifications can be made. These variables are reported at the three resolutions corresponding to the A-TC classification: **quality_status**, **quality_ medium_resolution_status** and **quality_low_resolution_status**

Table 12 Quality status variable description

value	definition	Units N/A	Dim along_track, height	Type byte	long_definition
0	High confidence (surface)				ATLID and CPR detect surface
1	High confidence (clear)				ATLID and CPR both clear
2	High confidence (synergistic hydrometeors)				ATLID and CPR both detect hydrometeors
3	High confidence (lidar-only hyd.)				ATLID detects hydrometeors, CPR clear
4	Moderate confidence (aerosols)				ATLID detects aerosol, CPR clear
5	Moderate confidence (stratosphere)				ATLID detects stratospheric targets, CPR clear (but still has data)
6	Moderate confidence (clear, lidar-only)				ATLID clear, no CPR data
7	Moderate confidence (stratosphere, lidar-only)				ATLID stratospheric targets, no CPR data
8	Moderate confidence (hydrometeors)				CPR detects hydrometeors, ATLID extinguished
9	Moderate confidence (clear)				CPR clear, ATLID extinguished
10	Low confidence (clear)				CPR clear, ATLID data missing
11	Low confidence (hydrometeors)				CPR detects hydrometeors, ATLID data missing
12	Low confidence (unknown)				ATLID unclassified, CPR clear or missing
13	Low confidence (radar artefact)				CPR detection but ATLID clear (radar artefact or insects)

14	Low confidence (extinguished)				ATLID and CPR both extinguished or obscured by clutter
15	Low confidence (surface)				ATLID and CPR disagree on surface
16	No data				ATLID and CPR data are missing

6.2.3 Insect detection status

Experience with in-flight EarthCARE data has shown that the CPR frequently detects flying insects within 1 to 3 km of the surface, at temperatures warmer than 0°C. These targets are usually classified as cloud or drizzle in C-TC, so it is only by using synergistic information from A-TC that a confident detection of "likely insects" can be made, i.e. when ATLID detects aerosols or clear sky. When ATLID is extinguished or obscured by cloud layers aloft, weak CPR detections near the surface over land are flagged as "possible insects". In the radar surface clutter, "likely insects in clutter" is assigned below a region of "likely insects" where ATLID is available to confirm cloud-free skies, while "possible insects in clutter" is assigned in contiguous regions of surface clutter where ATLID is obscured.

Table 13 Quality status variable description

value	definition	Units N/A	Dim along_track, height	Type byte	long_definition
-3	No data				No CPR data
-2	hydrometeors				CPR detects unambiguous hydrometeors
-1	No insects detected (ATLID obscured)				No insects detected by CPR but ATLID not available to confirm cloud-free
0	No insects detected (ATLID clear)				No insects detected by CPR and ATLID confirms cloud-free
1	Possible insects in clutter				CPR clutter with nearby possible insects but ATLID cannot confirm cloud-free
2	Possible insects				CPR detection may be insects but ATLID cannot confirm cloud-free
3	Likely insects in clutter				CPR clutter with nearby likely insects and ATLID can confirm cloud-free
4	Likely insects				CPR detection likely insects and ATLID confirms cloud-free

Note that at present, the likely detection of insects is not used to update the "synergetic_target_classification" classification, which will still include the classification of liquid cloud and drizzle made by C-TC. The insect detection status is still being verified and will undergo further improvement.

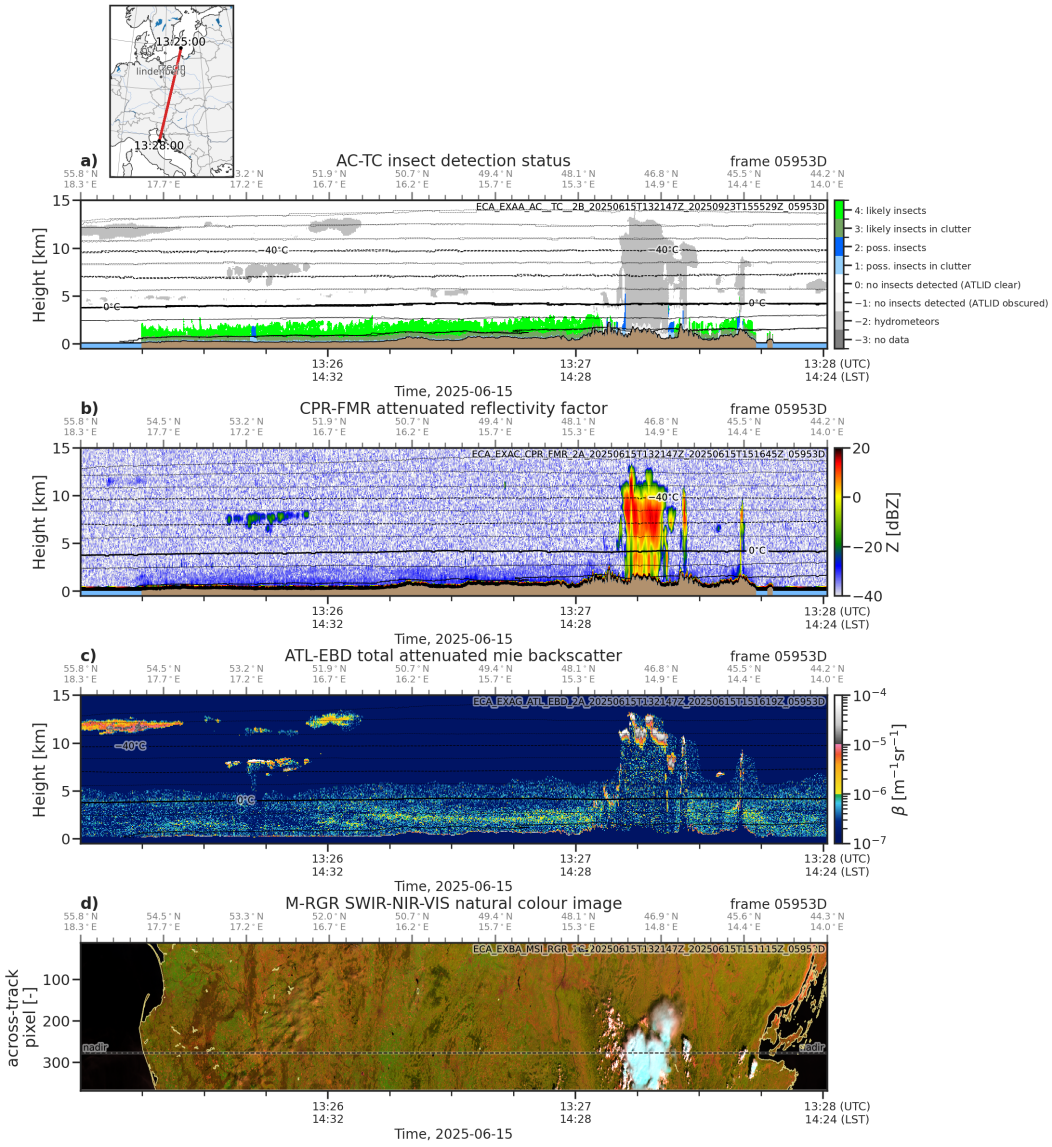


Figure 6-1 Example of insect detection status derived from combined CPR and ATLID information. This example includes widespread insects over Europe, which have been verified against detections made by CloudNet radar sites at Lindenberg and L'Aquila.

6.3 Datablock file example (CDL header): the Halifax scene

This shows the structure (declarations of dimensions, variables, attributes, groups, and types) of the datablock file in network Common Data form Language (CDL) as produced by running the command `ncdump -h` on the data product file:

```
netcdf ECA_EXAA_AC__TC__2B_20241231T183449Z_20250924T095736Z_39316D {

// global attributes:
                        string :Conventions = "CF-1.6" ;
                        string :title = "" ;
                        string :history = "20250924T095735.780798 /home/ecsim/ac-tc/test/../src/AC-TC JobOrder.test11.xml" ;

group: HeaderData {

  group: FixedProductHeader {
    variables:
            string File_Name ;
            string File_Description ;
            string Notes ;
            string Mission ;
            string File_Class ;
            string File_Type ;
            string File_Version ;
```

```
  group: Source {
   variables:
            string System ;
            string Creator ;
            string Creator_Version ;
            string Creation_Date ;
   } // group Source

  group: Validity_Period {
   variables:
            string Validity_Start ;
            string Validity_Stop ;
   } // group Validity_Period
  } // group FixedProductHeader

group: VariableProductHeader {

  group: MainProductHeader {
   variables:
            string productName ;
            string originalProductName ;
            string missionID ;
            string fileClass ;
            string fileCategory ;
            string productType ;
            string productLevel ;
            string sensingStartTime ;
            string sensingStopTime ;
            byte degradedProductQualityFlag ;
            string description ;
            string processorName ;
            short processorMajorVersion ;
            short processorMinorVersion ;
            short executableMajorVersion ;
            short executableMinorVersion ;
            short formatMajorVersion ;
            short formatMinorVersion ;
            byte subsettedProduct ;
            string acquisitionStation ;
            string processingCentre ;
            string processingStartTime ;
            string processingStopTime ;
            uint orbitNumber ;
            string frameID ;
            string ANXTime ;
            double ANXLongitude ;
            string stateVectorSource ;
            string stateVectorTime ;
            double xPosition ;
            double yPosition ;
            double zPosition ;
            double xVelocity ;
            double yVelocity ;
            double zVelocity ;
            double orbitSemiMajorAxis ;
            double orbitEccentricity ;
            double orbitInclination ;
            double perigeeArgument ;
            double rightAscension ;
            double meanAnomaly ;
            string frameStartTime ;
            string frameStopTime ;
            double frameStartMargin ;
            double frameStopMargin ;

    group: frameStartCoordinates {
     variables:
            float geographicLatitude ;
            float geographicLongitude ;
    } // group frameStartCoordinates

    group: frameStopCoordinates {
     variables:
            float geographicLatitude ;
            float geographicLongitude ;
    } // group frameStopCoordinates
   } // group MainProductHeader

  group: SpecificProductHeader {
```

```
    variables:
            string InputFileList ;
            string ConfigurationParameters ;

    group: QualityStatistics {
      } // group QualityStatistics
    } // group SpecificProductHeader
  } // group VariableProductHeader
 } // group HeaderData

group: ScienceData {
  dimensions:
            along_track = 5109 ;
            JSG_height = 221 ;
  variables:
            double time(along_track) ;
                    time:long_name = "Time from ATLID" ;
                    time:definition = "Time" ;
                    time:units = "seconds since 2000-1-1 00:00:00.0 0:00" ;
            double latitude(along_track) ;
                    latitude:long_name = "Latitude" ;
                    latitude:definition = "Latitude" ;
                    latitude:units = "degree_north" ;
            double longitude(along_track) ;
                    longitude:long_name = "Longitude" ;
                    longitude:definition = "Longitude" ;
                    longitude:units = "degree_east" ;
            double geoid_offset(along_track) ;
                    geoid_offset:long_name = "Geoid offset" ;
                    geoid_offset:definition = "Offset between geoid EGM96 and ellipsoid WGS84 in metres" ;
                    geoid_offset:units = "m" ;
            float elevation(along_track) ;
                    elevation:long_name = "surface elevation" ;
                    elevation:definition = "Terrain elevation of pixel centers above WGS84 ellipsoid" ;
                    elevation:units = "m" ;
            float tropopause_height(along_track) ;
                    tropopause_height:long_name = "tropopause height" ;
                    tropopause_height:definition = "Tropopause height from A-PRO" ;
                    tropopause_height:units = "m" ;
            byte land_flag(along_track) ;
                    land_flag:long_name = "Land flag" ;
                    land_flag:definition = "0: sea, 1: land" ;
                    land_flag:units = "-" ;
            float height(along_track, JSG_height) ;
                    height:long_name = "Height from JSG" ;
                    height:definition = "Height of pixel centers above WGS84 ellipsoid" ;
                    height:units = "m" ;
            float temperature(along_track, JSG_height) ;
                    temperature:long_name = "Temperature" ;
                    temperature:definition = "Atmospheric temperature from X-MET on JSG" ;
                    temperature:units = "K" ;
            float pressure(along_track, JSG_height) ;
                    pressure:long_name = "Pressure" ;
                    pressure:definition = "Atmospheric pressure from X-MET on JSG" ;
                    pressure:units = "Pa" ;
            byte synergetic_target_classification(along_track, JSG_height) ;
                    synergetic_target_classification:long_name = "Synergetic target classification" ;
                    synergetic_target_classification:plot_range = -1b, 33b ;
                    synergetic_target_classification:plot_colors = "#c5c9c7\n #a2653e\n #ffffff\n #ff474c\n #0504aa\n #009337\n #840000\n #042e60\n #d8dcd6\n #ffff84\n #f5bf03\n #f97306\n #ff000d\n #5539cc\n #2976bb\n #0d75f8\n #014182\n #017b92\n #06b48b\n #aaff32\n #6dedfd\n #01f9c6\n #7bc8f6\n #d7fffe\n #a2cffe\n #04d9ff\n #7a9703\n #b2996e\n #ffbacd\n #d99b82\n #947e94\n #856798\n #ac86a8\n #59656d\n #76424e\n #363737" ;
                    synergetic_target_classification:definition = "-1: unknown\n 0: ground\n 1: clear\n 2: possible rain (clutter)\n 3: possible snow (clutter)\n 4: possible cloud (clutter)\n 5: heavy rain\n 6: heavy mixed-phase precipitation\n 7: no rain or ice (possible liquid)\n 8: liquid cloud\n 9: drizzling liquid cloud\n 10: warm rain\n 11: cold rain\n 12: melting snow\n 13: snow (possible liquid)\n 14: snow (no liquid)\n 15: rimed snow (possible liquid)\n 16: rimed snow and supercooled liquid\n 17: snow and supercooled liquid\n 18: supercooled liquid\n 19: ice cloud (possible liquid)\n 20: ice and supercooled liquid\n 21: ice cloud (no liquid)\n 22: stratospheric ice\n 23: STS (PSC Type I)\n 24: NAT (PSC Type II)\n 25: insects\n 26: dust\n 27: sea salt\n 28: continental pollution\n 29: smoke\n 30: dusty smoke\n 31: dusty mix\n 32: stratospheric ash\n 33: stratospheric sulfate\n 34: stratospheric smoke" ;
            byte synergetic_target_classification_low_resolution(along_track, JSG_height) ;
                    synergetic_target_classification_low_resolution:long_name = "Low resolution of synergetic target classification" ;
                    synergetic_target_classification_low_resolution:comment = "Low resolution of synergetic target classification: merging low resolution lidar and radar classifications" ;
                    synergetic_target_classification_low_resolution:definition = "-1: unknown\n 0: ground\n 1: clear\n 2: possible rain (clutter)\n 3: possible snow (clutter)\n 4: possible cloud (clutter)\n 5: heavy rain\n 6: heavy mixed-phase precipitation\n 7: no rain or ice (possible liquid)\n 8: liquid cloud\n 9: drizzling liquid cloud\n 10: warm rain\n 11: cold rain\n 12: melting snow\n 13: snow (possible liquid)\n 14: snow (no liquid)\n 15: rimed snow (possible liquid)\n 16: rimed snow and supercooled liquid\n 17: snow and supercooled liquid\n 18: supercooled liquid\n 19: ice cloud (possible liquid)\n 20: ice and supercooled liquid\n 21: ice cloud (no liquid)\n 22: stratospheric ice\n 23: STS (PSC Type I)\n 24: NAT (PSC Type II)\n 25: insects\n 26: dust\n 27: sea salt\n 28: continental pollution\n 29: smoke\n 30: dusty smoke\n 31: dusty mix\n 32: stratospheric ash\n 33: stratospheric sulfate\n 34: stratospheric smoke" ;
```

synergetic_target_classification_low_resolution:plot_range = -1b, 33b ;
synergetic_target_classification_low_resolution:plot_colors = "#c5c9c7\n #a2653e\n #ffffff\n #ff474c\n #0504aa\n #009337\n #840000\n #042e60\n #d8dcd6\n #ffff84\n #f5bf03\n #f97306\n #ff000d\n #5539cc\n #2976bb\n #0d75f8\n #014182\n #017b92\n #06b48b\n #aaff32\n #6dedfd\n #01f9c6\n #7bc8f6\n #d7fffe\n #a2cffe\n #04d9ff\n #7a9703\n #b2996e\n #ffbacd\n #d99b82\n #947e94\n #856798\n #ac86a8\n #59656d\n #76424e\n #363737" ;
byte synergetic_target_classification_medium_resolution(along_track, JSG_height) ;
synergetic_target_classification_medium_resolution:long_name = "Medium resolution of synergetic target classification" ;
synergetic_target_classification_medium_resolution:comment = "Medium resolution of synergetic target classification: merging medium resolution lidar and radar classifications" ;
synergetic_target_classification_medium_resolution:definition = "-1: unknown\n 0: ground\n 1: clear\n 2: possible rain (clutter)\n 3: possible snow (clutter)\n 4: possible cloud (clutter)\n 5: heavy rain\n 6: heavy mixed-phase precipitation\n 7: no rain or ice (possible liquid)\n 8: liquid cloud\n 9: drizzling liquid cloud\n 10: warm rain\n 11: cold rain\n 12: melting snow\n 13: snow (possible liquid)\n 14: snow (no liquid)\n 15: rimed snow (possible liquid)\n 16: rimed snow and supercooled liquid\n 17: snow and supercooled liquid\n 18: supercooled liquid\n 19: ice cloud (possible liquid)\n 20: ice and supercooled liquid\n 21: ice cloud (no liquid)\n 22: stratospheric ice\n 23: STS (PSC Type I)\n 24: NAT (PSC Type II)\n 25: insects\n 26: dust\n 27: sea salt\n 28: continental pollution\n 29: smoke\n 30: dusty smoke\n 31: dusty mix\n 32: stratospheric ash\n 33: stratospheric sulfate\n 34: stratospheric smoke" ;
synergetic_target_classification_medium_resolution:plot_range = -1b, 33b ;
synergetic_target_classification_medium_resolution:plot_colors = "#c5c9c7\n #a2653e\n #ffffff\n #ff474c\n #0504aa\n #009337\n #840000\n #042e60\n #d8dcd6\n #ffff84\n #f5bf03\n #f97306\n #ff000d\n #5539cc\n #2976bb\n #0d75f8\n #014182\n #017b92\n #06b48b\n #aaff32\n #6dedfd\n #01f9c6\n #7bc8f6\n #d7fffe\n #a2cffe\n #04d9ff\n #7a9703\n #b2996e\n #ffbacd\n #d99b82\n #947e94\n #856798\n #ac86a8\n #59656d\n #76424e\n #363737" ;
byte ATLID_target_classification(along_track, JSG_height) ;
ATLID_target_classification:long_name = "ATLID target classification" ;
ATLID_target_classification:definition = "-3: no data\n -2: surface\n -1: attenuated\n 0: clear\n 1: liquid cloud (warm)\n 2: liquid cloud (supercooled)\n 3: ice cloud\n 10: dust\n 11: sea salt\n 12: continental pollution\n 13: smoke\n 14: dusty smoke\n 15: dusty mix\n 20: STS (PSC I)\n 21: NAT (PSD II)\n 22: stratospheric ice\n 25: stratospheric ash\n 26: stratospheric sulphate\n 27: stratospheric smoke\n 101: unknown aerosol; low probability (no class assigned)\n 102: unknown aerosol; outside of parameter space\n 104: unknown stratospheric aerosol; low probability (no class assigned)\n 105: unknown stratospheric aerosol; outside of parameter space\n 106: unknown PSC; low probability (no class assigned)\n 107: unknown PSC; outside of parameter space" ;
ATLID_target_classification:plot_range = -3b, 107b ;
byte ATLID_target_classification_low_resolution(along_track, JSG_height) ;
ATLID_target_classification_low_resolution:long_name = "Low resolution of ATLID target classification" ;
ATLID_target_classification_low_resolution:comment = "Low resolution is 101 JSG pixels along track" ;
ATLID_target_classification_low_resolution:definition = "-3: no data\n -2: surface\n -1: attenuated\n 0: clear\n 1: liquid cloud (warm)\n 2: liquid cloud (supercooled)\n 3: ice cloud\n 10: dust\n 11: sea salt\n 12: continental pollution\n 13: smoke\n 14: dusty smoke\n 15: dusty mix\n 20: STS (PSC I)\n 21: NAT (PSD II)\n 22: stratospheric ice\n 25: stratospheric ash\n 26: stratospheric sulphate\n 27: stratospheric smoke\n 101: unknown aerosol; low probability (no class assigned)\n 102: unknown aerosol; outside of parameter space\n 104: unknown stratospheric aerosol; low probability (no class assigned)\n 105: unknown stratospheric aerosol; outside of parameter space\n 106: unknown PSC; low probability (no class assigned)\n 107: unknown PSC; outside of parameter space" ;
ATLID_target_classification_low_resolution:plot_range = -3b, 107b ;
byte ATLID_target_classification_medium_resolution(along_track, JSG_height) ;
ATLID_target_classification_medium_resolution:long_name = "Medium resolution of ATLID target classification" ;
ATLID_target_classification_medium_resolution:comment = "Medium resolution is 11 JSG pixels along track" ;
ATLID_target_classification_medium_resolution:definition = "-3: no data\n -2: surface\n -1: attenuated\n 0: clear\n 1: liquid cloud (warm)\n 2: liquid cloud (supercooled)\n 3: ice cloud\n 10: dust\n 11: sea salt\n 12: continental pollution\n 13: smoke\n 14: dusty smoke\n 15: dusty mix\n 20: STS (PSC I)\n 21: NAT (PSD II)\n 22: stratospheric ice\n 25: stratospheric ash\n 26: stratospheric sulphate\n 27: stratospheric smoke\n 101: unknown aerosol; low probability (no class assigned)\n 102: unknown aerosol; outside of parameter space\n 104: unknown stratospheric aerosol; low probability (no class assigned)\n 105: unknown stratospheric aerosol; outside of parameter space\n 106: unknown PSC; low probability (no class assigned)\n 107: unknown PSC; outside of parameter space" ;
ATLID_target_classification_medium_resolution:plot_range = -3b, 107b ;
byte ATLID_detection_status(along_track, JSG_height) ;
ATLID_detection_status:long_name = "ATLID detection status" ;
ATLID_detection_status:definition = "-3: missing data\n -2: surface or below\n -1: attenuated region\n 0: clear\n 1: liquid cloud or aerosol targets" ;
ATLID_detection_status:plot_range = -3b, 1b ;
byte CPR_target_classification(along_track, JSG_height) ;
CPR_target_classification:long_name = "CPR target classification" ;
CPR_target_classification:definition = "-1: no data\n 0: surface and sub-surface\n 1: clear\n 2: no drizzling liquid cloud\n 3: lightly drizzling liquid clouds\n 4: heavy drizzle and warm rain\n 5: cold rain\n 6: melting snow\n 7: rimed snow\n 8: snow\n 9: ice\n 10: stratospheric cloud\n 11: insects or artifacts\n 12: heavy rain likely\n 13: heavy mixed-phase precipitation likely\n 14: heavy rain\n 15: heavy mixed-phase precipitation\n 16: removed clutter, rain likely\n 17: removed clutter, snow likely\n 18: removed clutter, cloud likely\n 19: removed clutter, clear likely\n 20: uncertain" ;
CPR_target_classification:plot_range = -1b, 20b ;
byte CPR_detection_status(along_track, JSG_height) ;
CPR_detection_status:long_name = "CPR detection status" ;
CPR_detection_status:definition = "-1: no data\n 0: surface and sub-surface\n 1: clear\n 2: totally extinguished\n 3: likely extinguished\n 4: target detected, no reliable measurements \n 5: target detected, only reflectivity reliable\n 6: target detected, reflectivity enhanced by multiple scattering\n 7: target detected, only Doppler reliable\n 8: target detected, both reflectivity and Doppler reliable\n 9: clutter separated from the cloud/precipitation return or clear\n 10: clutter not separated from the lowest hydrometeor layer detected\n 11: uncertain\n 12: second-trip echo" ;
CPR_detection_status:plot_range = -1b, 6b ;
byte CPR_ATLID_status(along_track, JSG_height) ;
CPR_ATLID_status:long_name = "CPR ATLID status" ;
CPR_ATLID_status:definition = "-4: no information\n -3: subsurface (radar-lidar)\n -2: subsurface (lidar only)\n -1: subsurface (radar only)\n 0: unassigned\n 1: clear (radar-lidar)\n 2: clear (lidar only)\n 3: clear (radar only)\n 4: target (radar-lidar)\n 5: target (lidar only)\n 6: target (radar only)" ;
CPR_ATLID_status:plot_range = 0b, 5b ;
byte CPR_ATLID_low_resolution_status(along_track, JSG_height) ;
CPR_ATLID_low_resolution_status:long_name = "CPR ATLID low resolution status" ;
CPR_ATLID_low_resolution_status:comment = "Low resolution is 101 JSG pixels along track" ;

CPR_ATLID_low_resolution_status:definition = "-4: no information\n -3: subsurface (radar-lidar)\n -2: subsurface (lidar only)\n -1: subsurface (radar only)\n 0: unassigned\n 1: clear (radar-lidar)\n 2: clear (lidar only)\n 3: clear (radar only)\n 4: target (radar-lidar)\n 5: target (lidar only)\n 6: target (radar only)" ;
CPR_ATLID_low_resolution_status:plot_range = 0b, 5b ;
byte CPR_ATLID_medium_resolution_status(along_track, JSG_height) ;
CPR_ATLID_medium_resolution_status:long_name = "Medium resolution CPR ATLID status" ;
CPR_ATLID_medium_resolution_status:comment = "Medium resolution is 11 JSG pixels along track" ;
CPR_ATLID_medium_resolution_status:definition = "-4: no information\n -3: subsurface (radar-lidar)\n -2: subsurface (lidar only)\n -1: subsurface (radar only)\n 0: unassigned\n 1: clear (radar-lidar)\n 2: clear (lidar only)\n 3: clear (radar only)\n 4: target (radar-lidar)\n 5: target (lidar only)\n 6: target (radar only)" ;
CPR_ATLID_medium_resolution_status:plot_range = 0b, 5b ;
byte quality_status(along_track, JSG_height) ;
quality_status:long_name = "quality status" ;
quality_status:definition = "0: high confidence (surface)\n 1: high confidence (clear)\n 2: high confidence (synergistic hydrometeors)\n 3: high confidence (lidar-only hydrometeors)\n 4: moderate confidence (aerosol)\n 5: moderate confidence (stratosphere)\n 6: moderate confidence (clear, lidar-only)\n 7: moderate confidence (stratosphere, lidar-only)\n 8: moderate confidence (hydrometeors)\n 9: moderate confidence (clear)\n 10: low confidence (clear)\n 11: low confidence (hydrometeors)\n 12: low confidence (unknown)\n 13: low confidence (radar artefact)\n 14: low confidence (extinguished)\n 15: low confidence (surface)\n 16: no data" ;
quality_status:long_definition = "0: ATLID and CPR detect surface\n 1: ATLID and CPR both clear\n 2: ATLID and CPR both detect hydrometeors\n 3: ATLID hydrometeors, CPR clear\n 4: ATLID aerosol, CPR clear\n 5: ATLID stratospheric target, CPR clear\n 6: ATLID clear, no CPR data\n 7: ATLID stratospheric target, no CPR data\n 8: CPR hydrometeors, ATLID extinguished; possible embedded liquid\n 9: CPR clear, ATLID extinguished; possible liquid or aerosols\n 10: CPR clear, ATLID data missing\n 11: CPR hydrometeors, ATLID data missing\n 12: ATLID unclassified; CPR clear or missing\n 13: CPR hydrometeors, ATLID clear; radar artefact or insects\n 14: ATLID and CPR extinguished or obscured\n 15: ATLID sees higher surface than CPR\n 16: ATLID and CPR data missing" ;
quality_status:plot_range = 0b, 10b ;
quality_status:plot_colors = "#a2653e\n #ffffff\n #75bbfd\n #d0fefe\n #ff000d\n #01ff07\n #ffffe4\n #c7fdb5\n #0165fc\n #fdfdfe\n #d8dcd6\n #04d9ff\n #929591\n #7a9703\n #03012d\n #cfaf7b\n #bf00bf" ;
byte quality_low_resolution_status(along_track, JSG_height) ;
quality_low_resolution_status:long_name = "Low resolution quality status" ;
quality_low_resolution_status:comment = "Low resolution is 101 JSG pixels along track" ;
quality_low_resolution_status:definition = "0: high confidence (surface)\n 1: high confidence (clear)\n 2: high confidence (synergistic hydrometeors)\n 3: high confidence (lidar-only hydrometeors)\n 4: moderate confidence (aerosol)\n 5: moderate confidence (stratosphere)\n 6: moderate confidence (clear, lidar-only)\n 7: moderate confidence (stratosphere, lidar-only)\n 8: moderate confidence (hydrometeors)\n 9: moderate confidence (clear)\n 10: low confidence (clear)\n 11: low confidence (hydrometeors)\n 12: low confidence (unknown)\n 13: low confidence (radar artefact)\n 14: low confidence (extinguished)\n 15: low confidence (surface)\n 16: no data" ;
quality_low_resolution_status:long_definition = "0: ATLID and CPR detect surface\n 1: ATLID and CPR both clear\n 2: ATLID and CPR both detect hydrometeors\n 3: ATLID hydrometeors, CPR clear\n 4: ATLID aerosol, CPR clear\n 5: ATLID stratospheric target, CPR clear\n 6: ATLID clear, no CPR data\n 7: ATLID stratospheric target, no CPR data\n 8: CPR hydrometeors, ATLID extinguished; possible embedded liquid\n 9: CPR clear, ATLID extinguished; possible liquid or aerosols\n 10: CPR clear, ATLID data missing\n 11: CPR hydrometeors, ATLID data missing\n 12: ATLID unclassified; CPR clear or missing\n 13: CPR hydrometeors, ATLID clear; radar artefact or insects\n 14: ATLID and CPR extinguished or obscured\n 15: ATLID sees higher surface than CPR\n 16: ATLID and CPR data missing" ;
quality_low_resolution_status:plot_range = 0b, 10b ;
quality_low_resolution_status:plot_colors = "#a2653e\n #ffffff\n #75bbfd\n #d0fefe\n #ff000d\n #01ff07\n #ffffe4\n #c7fdb5\n #0165fc\n #fdfdfe\n #d8dcd6\n #04d9ff\n #929591\n #7a9703\n #03012d\n #cfaf7b\n #bf00bf" ;
byte quality_medium_resolution_status(along_track, JSG_height) ;
quality_medium_resolution_status:long_name = "Medium resolution quality status" ;
quality_medium_resolution_status:comment = "Medium resolution is 11 JSG pixels along track" ;
quality_medium_resolution_status:definition = "0: high confidence (surface)\n 1: high confidence (clear)\n 2: high confidence (synergistic hydrometeors)\n 3: high confidence (lidar-only hydrometeors)\n 4: moderate confidence (aerosol)\n 5: moderate confidence (stratosphere)\n 6: moderate confidence (clear, lidar-only)\n 7: moderate confidence (stratosphere, lidar-only)\n 8: moderate confidence (hydrometeors)\n 9: moderate confidence (clear)\n 10: low confidence (clear)\n 11: low confidence (hydrometeors)\n 12: low confidence (unknown)\n 13: low confidence (radar artefact)\n 14: low confidence (extinguished)\n 15: low confidence (surface)\n 16: no data" ;
quality_medium_resolution_status:long_definition = "0: ATLID and CPR detect surface\n 1: ATLID and CPR both clear\n 2: ATLID and CPR both detect hydrometeors\n 3: ATLID hydrometeors, CPR clear\n 4: ATLID aerosol, CPR clear\n 5: ATLID stratospheric target, CPR clear\n 6: ATLID clear, no CPR data\n 7: ATLID stratospheric target, no CPR data\n 8: CPR hydrometeors, ATLID extinguished; possible embedded liquid\n 9: CPR clear, ATLID extinguished; possible liquid or aerosols\n 10: CPR clear, ATLID data missing\n 11: CPR hydrometeors, ATLID data missing\n 12: ATLID unclassified; CPR clear or missing\n 13: CPR hydrometeors, ATLID clear; radar artefact or insects\n 14: ATLID and CPR extinguished or obscured\n 15: ATLID sees higher surface than CPR\n 16: ATLID and CPR data missing" ;
quality_medium_resolution_status:plot_range = 0b, 10b ;
quality_medium_resolution_status:plot_colors = "#a2653e\n #ffffff\n #75bbfd\n #d0fefe\n #ff000d\n #01ff07\n #ffffe4\n #c7fdb5\n #0165fc\n #fdfdfe\n #d8dcd6\n #04d9ff\n #929591\n #7a9703\n #03012d\n #cfaf7b\n #bf00bf" ;
byte insect_detection_status(along_track, JSG_height) ;
insect_detection_status:long_name = "insect detection status" ;
insect_detection_status:definition = "-3: no data\n -2: hydrometeors\n -1: no insects detected (ATLID obscured)\n 0: no insects detected (ATLID clear)\n 1: possible insects in clutter\n 2: possible insects \n 3: likely insects in clutter\n 4: likely insects" ;
insect_detection_status:long_definition = "-3: no CPR data\n -2: CPR detects unambiguous hydrometeors\n -1: no insects detected by CPR but ATLID cannot confirm cloud-free\n 0: no insects detected by CPR and ATLID can confirm cloud-free\n 1: CPR clutter with nearby possible insects but ATLID cannot confirm cloud-free\n 2: CPR detection may be insects but ATLID cannot confirm cloud-free\n 3: CPR clutter with nearby likely insects and ATLID can verify cloud-free\n 4: CPR detection likely insects and ATLID confirms cloud-free" ;
insect_detection_status:plot_range = -3b, 4b ;
} // group ScienceData
}