

CloudSat Project

A NASA Earth System Science Pathfinder Mission

Cloudsat ECMWF-AUX Auxiliary Data Process Description and Interface Control Document

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1. Introduction

1.1. Overview

The ECMWF-AUX data set is an intermediate product that contains the set of ancillary ECMWF state variable data interpolated to each CloudSat cloud profiling radar (CPR) bin. These data are required for input to the 2B-GEOPROF, 2B-CLDCLASS, 2B-CWC-RO, 2B-CWC-RVOD, 2B-TAU, and 2B-FLXHR algorithms. The ECMWF -AUX product is created by the Generic-AUX Interpolate-to-Reference algorithm. The input data is obtained from the AN-ECMWF dataset provided by the European Center for Medium-Range Weather Forecasts. This document describes the interfaces between the input data sets and the Generic-AUX algorithm, the format of the ECMWF-AUX product, and quality assessment instructions for the Data Processing Center (DPC) operator. Details of the operation of the data sub-setting performed by the Generic-AUX algorithm can be found in the CORE Data Manipulation Routines document (see below).

1.2. Applicable Documents

- Level 1B CPR Process Description and Interface Control Document (v5.3), 27Jun07.
- CloudSat AN-ECMWF Ancillary Data Interface Control Document (7.0), 16JUL05.
- Cloudsat Data Processing Center System Description and Data Processing Plan, 29MAY01.
- The CORE Data Manipulation Routines – Process Description, 1JUN04.
- Cloudsat L3 Ground System-Science Data Processing, 22APR01.
- End-to-End Information System (EEIS), 19APR01.

2. Description of the Interpolation Process

The interpolate-to-reference algorithm uses two datasets: an independent dataset and a reference dataset. To produce the ECMWF-AUX product, AN-ECMWF is the independent dataset containing the atmospheric state variable data that will be interpolated to each CloudSat radar bin. The geolocation data from the 1B-CPR product comprise the reference dataset. Operating one CloudSat ray at a time, the interpolate-to-reference algorithm uses the reference and independent geolocation data to find the four bounding ECMWF grid points around the CloudSat ray. Then, for each radar bin in the ray, the height of the bin from the 1B-CPR data is used to find the bounding AN-ECMWF vertical levels at each of the grid points. A linear interpolation is performed to calculate the value of each AN-ECMWF data field of interest at the radar bin height for the four grid points. Then a bilinear interpolation is performed on the resulting four values to find the value of each data field at the location of the CPR ray. Because the AN-ECMWF data consists of grids that cover the earth for multiple forecast times, the

procedure described above is performed for the two forecast times that bound the time associated with the ray in question. A linear temporal interpolation is then performed on the values obtained for each forecast time, and the final result is the value of each AN-ECMWF data field of interest interpolated to the location and time of the radar bins.

When CloudSat bins occur below the lowest bin of one or more of the surrounding ECMWF grid points, the ECMWF data for those grid points are extrapolated to the level of the CloudSat bins. Ozone is kept constant, Temperature is increased at the lapse rate of 6.5 K/km, and Pressure is increased using the hypsometric equation.

3. Generic-AUX Algorithm Inputs

Input data for the Generic-AUX algorithm includes CloudSat 1B-CPR and AN-ECMWF data sets. Each 1B-CPR data file contains data for one orbit of the CloudSat spacecraft. The AN-ECMWF data will arrive via ftp at the DPC and is stored in GRIB format. The files will contain the atmospheric state variable data on a Cartesian grid covering the globe for multiple forecast times.

3.1 1B-CPR

Fields available in the 1B-CPR data set used by this algorithm include

(1) Seconds since the start of the granule.

Name in file: Profile_time	Range: 0 to 6000
Source: 1B-CPR 008	Missing value:
Field type (in file): REAL(4)	Missing value operator:
Field type (in algorithm): REAL(4)	Factor: 1
Dimensions: nray	Offset: 0
Units: seconds	MB: 0.139

Seconds since the start of the granule for each profile. The first profile is 0.

(2) TAI time for the first profile.

Name in file: TAI_start	Range: 0 to 6e+008
Source: 1B-CPR 008	Missing value:
Field type (in file): REAL(8)	Missing value operator:
Field type (in algorithm): REAL(8)	Factor: 1
Dimensions: <scalar>	Offset: 0
Units: seconds	MB: 0

The TAI timestamp for the first profile in the data file. TAI is International Atomic Time: seconds since 00:00:00 Jan 1 1993.

(3) Spacecraft Latitude

Name in file: Latitude	Range: -90 to 90
Source: 1B-CPR 008	Missing value:
Field type (in file): REAL(4)	Missing value operator:
Field type (in algorithm): REAL(4)	Factor: 1

Dimensions: nray **Offset:** 0
Units: degrees **MB:** 0.139

Spacecraft Geodetic Latitude.

(4) Spacecraft Longitude

Name in file: Longitude **Range:** -180 to 180
Source: 1B-CPR 008 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: nray **Offset:** 0
Units: degrees **MB:** 0.139

Spacecraft geodetic longitude

(5) Ray status range bin size

Name in file: RayHeader_RangeBinSize **Range:** 239.8 to 239.8
Source: 1B-CPR 008 **Missing value:** -9999
Field type (in file): REAL(4) **Missing value operator:** ==
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: <scalar> **Offset:** 0
Units: meters **MB:** 0

Spacing between samples in range in meters

Specifications for these fields can be found in

- Level 1B CPR Process Description and Interface Control Document (v5.3), 27JUN07.

3.2 AN-ECMWF

The AN-ECMWF data set will be provided by ECMWF in GRIB format and contain the following fields for interpolation by the Generic-AUX algorithm and use by the level 2 algorithms:

(6) Temperature

Name in file: T **Range:** to
Source: AN-ECMWF 001 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: **Offset:** 0
Units: K **MB:** 0

(7) Specific humidity

Name in file: Q **Range:** to
Source: AN-ECMWF 001 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: **Offset:** 0
Units: kg/kg **MB:** 0

(8) Ozone mass mixing ratio

Name in file: O3 **Range:** to
Source: AN-ECMWF 001 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: Offset: 0
Units: kg/kg **MB:** 0

(9) Surface pressure

Name in file: SP **Range:** to
Source: AN-ECMWF 001 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: Offset: 0
Units: Pa **MB:** 0

(10) Skin temperature

Name in file: SKT **Range:** to
Source: AN-ECMWF 001 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: Offset: 0
Units: K **MB:** 0

(11) Two-meter temperature

Name in file: 2T **Range:** to
Source: AN-ECMWF 001 **Missing value:**
Field type (in file): REAL(4) **Missing value operator:**
Field type (in algorithm): REAL(4) **Factor:** 1
Dimensions: Offset: 0
Units: K **MB:** 0

- Surface pressure (SP, GRIB number).
- Temperature (T, GRIB number).
- Specific humidity (Q, GRIB number).
- Ozone mass mixing ratio (O3, GRIB number).
- Skin temperature (SKT, GRIB number).
- Two-meter temperature (2T, GRIB number).

The CORE GRIB read routine constructs the Cartesian grid of geolocation points and the arrays of height above ground level for each data level at each grid point from the GRIB parameters. The same is done to generate pressure data. Specifications for the input fields can be found in

- CloudSat AN-ECMWF Ancillary Data Interface Control Document, 16MAY03.

4. Data Product Output Specifications

Each HDF-EOS 4 product file is built for the orbit specified by the input 1B-CPR data. Note that missing values only occur for bins that include or are below the Earth's surface. Bins that are above the Earth's surface will always contain valid data. The 1B-CPR geolocation data will always be present (interpolated if there is a problem with the satellite telemetry data), and the AN-ECMWF data does not contain missing values. The HDF-EOS format for the ECMWF-AUX file is as follows:

3.1 ECMWF-AUX 006 Fields

(1) Seconds since the start of the granule.

Name in file: Profile_time	Range: 0 to 6000
Source: 1B-CPR 006	Missing value:
Field type (in file): REAL(4)	Missing value operator:
Field type (in algorithm): REAL(4)	Factor: 1
Dimensions: nray	Offset: 0
Units: seconds	MB: 0.139

Seconds since the start of the granule for each profile. The first profile is 0.

(2) UTC seconds since 00:00 Z of the first profile

Name in file: UTC_start	Range: 0 to 86400
Source: 1B-CPR 006	Missing value:
Field type (in file): REAL(4)	Missing value operator:
Field type (in algorithm): REAL(4)	Factor: 1
Dimensions: <scalar>	Offset: 0
Units: seconds	MB: 0

The UTC seconds since 00:00 Z of the first profile in the data file.

(3) TAI time for the first profile.

Name in file: TAI_start	Range: 0 to 6e+008
Source: 1B-CPR 006	Missing value:
Field type (in file): REAL(8)	Missing value operator:
Field type (in algorithm): REAL(8)	Factor: 1
Dimensions: <scalar>	Offset: 0
Units: seconds	MB: 0

The TAI timestamp for the first profile in the data file. TAI is International Atomic Time: seconds since 00:00:00 Jan 1 1993.

(4) Spacecraft Latitude

Name in file: Latitude	Range: -90 to 90
Source: 1B-CPR 006	Missing value:
Field type (in file): REAL(4)	Missing value operator:
Field type (in algorithm): REAL(4)	Factor: 1
Dimensions: nray	Offset: 0
Units: degrees	MB: 0.139

Spacecraft Geodetic Latitude.

(5) **Spacecraft Longitude**

Name in file: Longitude	Range: -180 to 180
Source: 1B-CPR 006	Missing value:
Field type (in file): REAL(4)	Missing value operator:
Field type (in algorithm): REAL(4)	Factor: 1
Dimensions: nray	Offset: 0
Units: degrees	MB: 0.139

Spacecraft geodetic longitude

(6) **Height of the ECMWF data bins**

Name in file: EC_height	Range: -5000 to 30000
Source: ECMWF-AUX 006	Missing value: -9999
Field type (in file): INT(2)	Missing value operator: ==
Field type (in algorithm): INT(2)	Factor: 1
Dimensions: nbin	Offset: 0
Units: m	MB: 8.674

Idealized height of the ECMWF data bins where bin 105 is at 0 m MSL. Each profile uses the same height information.

(8) **Digital Elevation Map**

Name in file: DEM_elevation	Range: -9999 to 8850
Source: 1B-CPR 006	Missing value: 9999
Field type (in file): INT(2)	Missing value operator: ==
Field type (in algorithm): INT(2)	Factor: 1
Dimensions: nray	Offset: 0
Units: meters	MB: 0.069

Elevation in meters above Mean Sea Level. A value of -9999 indicates ocean. A value of 9999 indicates an error in calculation of the elevation.

(9) **ECMWF data extrapolation flag**

Name in file: Extrapolation_flag	Range:
Source: ECMWF-AUX 008	Missing value:
Field type (in file): INT(1)	Missing value operator:
Field type (in algorithm): INT(1)	Factor: 1
Dimensions: nbin,nray	Offset: 0
Units:	MB: 4.337

The extrapolation flag is a bit field that indicates areas where ECMWF data are extrapolated to fill in CPR bins that occur below the lowest ECMWF layers between grid points.

- Bit 0: CPR bin below ground
- Bit 1: Data from Northeast grid point missing
- Bit 2: Data from Northwest grid point missing
- Bit 3: Data from Southwest grid point missing
- Bit 4: Data from Southeast grid point missing

(10) Atmospheric pressure

Name in file: Pressure
Source: ECMWF-AUX 006
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nbin,nray
Units: Pa

Range:
Missing value: -999
Missing value operator: ==
Factor: 1
Offset: 0
MB: 17.349

(11) Temperature

Name in file: Temperature
Source: ECMWF-AUX 006
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nbin,nray
Units: K

Range:
Missing value: -999
Missing value operator: ==
Factor: 1
Offset: 0
MB: 17.349

(12) Specific humidity

Name in file: Specific_humidity
Source: ECMWF-AUX 006
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nbin,nray
Units: kg/kg

Range:
Missing value: -999
Missing value operator: ==
Factor: 1
Offset: 0
MB: 17.349

(13) Ozone

Name in file: Ozone
Source: ECMWF-AUX 006
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nbin,nray
Units: kg/kg

Range:
Missing value: -999
Missing value operator: ==
Factor: 1
Offset: 0
MB: 17.349

(14) Surface pressure

Name in file: Surface_pressure
Source: ECMWF-AUX 006
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nray
Units: Pa

Range:
Missing value: -999
Missing value operator: ==
Factor: 1
Offset: 0
MB: 0.139

(15) Skin temperature

Name in file: Skin_temperature
Source: ECMWF-AUX 006
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nray
Units: K

Range:
Missing value: -999
Missing value operator: ==
Factor: 1
Offset: 0
MB: 0.139

Skin temperature.

(16) Two-meter temperature

Name in file: Temperature_2m

Range:

Source: ECMWF-AUX 006	Missing value: -999
Field type (in file): REAL(4)	Missing value operator: ==
Field type (in algorithm): REAL(4)	Factor: 1
Dimensions: nray	Offset: 0
Units: K	MB: 0.139

Two-meter air temperature.

5. Operator Instructions

The ECMWF-AUX product will require minimal quality assessment activities to be performed by the DPC operator. Automated warnings or errors will be generated by the system should an error occur during the execution of the Generic-AUX algorithm. These exceptions should be handled according to the operator instructions for the Generic-AUX process. Periodic visualization of the fields in the ECMWF-AUX product will be performed to ensure proper code operation.

6. Changes Since Algorithm Version 5.1

- The primary change is the input of the latest 1B-CPR product (generated by 1B-CPR algorithm version 5.3). That product eliminates the granule overlap seen at the beginning and end of each file. Granules now start with the first profile on or after the equator on the descending pass and end with the last profile before the equator on the following descending pass.
- Fixed a bug in the calculation of the profile height field for the source ECMWF grid data. The bug resulted in small errors in the altitude of each level, causing fluctuations in the atmospheric state parameters. This was only noticeable when the 2B-FLXHR algorithm produced heating rates from the temperature profiles.
- The Height field (nbin x nray) field was replaced by the idealized EC_height field (nbin).
- Changes to this document include the addition of ECMWF-AUX usage by the 2B-CWC-RO and 2B-CWC-RVOD algorithms in section 1.

7. Acronym List

AGL	Above Ground Level
CORE	CloudSat Operational and Research Environment
CPR	Cloud Profiling Radar
DPC	Data Processing Center
ECMWF	European Center for Medium-Range Weather Forecasts

EOS	Earth Observing System
GRIB	Gridded Binary data format
HDF	Hierarchical Data Format
MSL	Mean Sea Level