

**EarthCARE Level-3 Global Gridded Product  
(L3\_GRD)  
Description Document**

Document History

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# 1. Introduction

The Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) mission (Illingworth et al., 2015; Wehr et al., 2023) aims to improve our understanding of aerosol–cloud–radiation interactions and to enhance climate prediction capabilities through more rigorous evaluation of numerical weather prediction and climate models. The EarthCARE satellite, launched in May 2024, carries four complementary instruments: the Cloud Profiling Radar (CPR), the ATmospheric LIDar (ATLID), the Multi-Spectral Imager (MSI), and the BroadBand Radiometer (BBR). These instruments provide synergistic observations of cloud and aerosol vertical structure, horizontal distribution, and radiative properties, enabling comprehensive characterization of atmospheric processes that influence the Earth’s climate system. The unique combination of active and passive observations provides valuable constraints for model evaluation and process studies.

To promote broader scientific use of EarthCARE observations and to facilitate statistical analyses across a wide range of spatial and temporal scales, JAXA has developed the EarthCARE Level-3 global gridded product (L3\_GRD). The L3\_GRD contains gridded cloud and precipitation statistics, including environmental parameters, cloud microphysical properties, and particle-type classifications. The gridded framework facilitates efficient statistical analyses of cloud characteristics, allowing users to investigate climatological distributions, regional variations, seasonal cycles, and cloud–environment relationships. In addition, the product supports systematic and quantitative comparisons between EarthCARE observations and numerical model simulations, thereby contributing to model evaluation and improvement.

This document summarizes Version 1 of the L3\_GRD. The selection of variables and product structure has been developed in collaboration with EarthCARE data users and the climate modeling community to maximize its usefulness for a broad range of EarthCARE science and model evaluation applications.

Key features of the L3\_GRD product include:

- Monthly mean gridded statistics
- Global coverage
- Horizontal resolution of  $2.5^{\circ} \times 2.5^{\circ}$
- Vertical resolution of 500 m
- Cloud, environmental, dynamical, and radiative statistics
- Statistics suitable for climate model evaluation

## 2. Data processing

### 2.1. Input variables

The JAXA EarthCARE Level-2 (L2) products (CPR\_ECO, MSI\_CLP, ACM\_CLP, and ALL\_RAD) are used as inputs to the L3\_GRD. The input variables for the L3\_GRD are listed in detail in Table 1. CPR\_ECO, and MSI\_CLP are single-sensor products derived from observations by CPR, and MSI, respectively. ACM\_CLP and ALL\_RAD are multi-sensor synergistic products generated from the combined use of CPR, ATLID, and MSI observations, and CPR, ATLID, MSI, and BBR observations, respectively.

**Table 1: Input variables for the L3\_GRD.**

| CPR_ECO (ver. Cc) |                                                     |                                                                                                                                                                                                                                                                                                                         |
|-------------------|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| No.               | Input parameter name                                | Description                                                                                                                                                                                                                                                                                                             |
| 1                 | mirror_echo_flag_1km                                | Mirror Echo Flag (1 km integration, 0: free from mirror contamination, 0x01 (1): clutter possible, 0x11 (17): clutter certain, 0x02 (2): mirror images possible, 0x22 (34): mirror images certain, 0x04 (4): MS tails possible, 0x44 (68): MS tails certain, 0x08 (8): artifact possible, 0x88 (136): artifact certain) |
| MSI_CLP (ver. Ca) |                                                     |                                                                                                                                                                                                                                                                                                                         |
| No.               | Input parameter name                                | Description                                                                                                                                                                                                                                                                                                             |
| 4                 | cloud_top_temperature                               | Cloud top temperature                                                                                                                                                                                                                                                                                                   |
| ALL_RAD (ver. Bb) |                                                     |                                                                                                                                                                                                                                                                                                                         |
| No.               | Input parameter name                                | Description                                                                                                                                                                                                                                                                                                             |
| 5                 | radiative_flux_shortwave_downward_toa_all_sky_1km   | Downward shortwave radiative flux at top of atmosphere for all-sky.                                                                                                                                                                                                                                                     |
| 6                 | radiative_flux_shortwave_upward_toa_all_sky_1km     | Upward shortwave radiative flux at top of atmosphere for all-sky.                                                                                                                                                                                                                                                       |
| 7                 | radiative_flux_shortwave_downward_boa_all_sky_1km   | Downward shortwave radiative flux at bottom of atmosphere for all-sky.                                                                                                                                                                                                                                                  |
| 8                 | radiative_flux_shortwave_upward_boa_all_sky_1km     | Upward shortwave radiative flux at bottom of atmosphere for all-sky.                                                                                                                                                                                                                                                    |
| 9                 | radiative_flux_longwave_upward_toa_all_sky_1km      | Upward longwave radiative flux at top of atmosphere for all-sky.                                                                                                                                                                                                                                                        |
| 10                | radiative_flux_longwave_downward_boa_all_sky_1km    | Downward longwave radiative flux at bottom of atmosphere for all-sky.                                                                                                                                                                                                                                                   |
| 11                | radiative_flux_longwave_upward_boa_all_sky_1km      | Upward longwave radiative flux at bottom of atmosphere for all-sky.                                                                                                                                                                                                                                                     |
| 12                | radiative_flux_shortwave_downward_toa_clear_sky_1km | Downward shortwave radiative flux at top of atmosphere for clear-sky.                                                                                                                                                                                                                                                   |
| 13                | radiative_flux_shortwave_upward_toa_clear_sky_1km   | Upward shortwave radiative flux at top of atmosphere for clear-sky.                                                                                                                                                                                                                                                     |
| 14                | radiative_flux_shortwave_downward_boa_clear_sky_1km | Downward shortwave radiative flux at bottom of atmosphere for clear-sky.                                                                                                                                                                                                                                                |
| 15                | radiative_flux_shortwave_upward_boa_clear_sky_1km   | Upward shortwave radiative flux at bottom of atmosphere for clear-sky.                                                                                                                                                                                                                                                  |
| 16                | radiative_flux_longwave_upward_toa_clear_sky_1km    | Upward longwave radiative flux at top of atmosphere for clear-sky.                                                                                                                                                                                                                                                      |

|    |                                                        |                                                                             |
|----|--------------------------------------------------------|-----------------------------------------------------------------------------|
| 17 | radiative_flux_longwave_downward_boa_clear_sky_1km     | Downward longwave radiative flux at bottom of atmosphere for clear-sky.     |
| 18 | radiative_flux_longwave_upward_boa_clear_sky_1km       | Upward longwave radiative flux at bottom of atmosphere for clear-sky.       |
| 19 | radiative_flux_shortwave_downward_toa_cloudy_sky_1km   | Downward shortwave radiative flux at top of atmosphere for cloudy-sky.      |
| 20 | radiative_flux_shortwave_upward_toa_cloudy_sky_1km     | Upward shortwave radiative flux at top of atmosphere for cloudy-sky.        |
| 21 | radiative_flux_shortwave_downward_cloudy_all_sky_1km   | Downward shortwave radiative flux at bottom of atmosphere for cloudy-sky.   |
| 22 | radiative_flux_shortwave_upward_boa_cloudy_sky_1km     | Upward shortwave radiative flux at bottom of atmosphere for cloudy-sky.     |
| 23 | radiative_flux_longwave_upward_toa_cloudy_sky_1km      | Upward longwave radiative flux at top of atmosphere for cloudy-sky.         |
| 24 | radiative_flux_longwave_downward_boa_cloudy_sky_1km    | Downward longwave radiative flux at bottom of atmosphere for cloudy-sky.    |
| 25 | radiative_flux_longwave_upward_boa_cloudy_sky_1km      | Upward longwave radiative flux at bottom of atmosphere for cloudy-sky.      |
| 26 | radiative_flux_shortwave_downward_toa_pristine_sky_1km | Downward shortwave radiative flux at top of atmosphere for pristine-sky.    |
| 27 | radiative_flux_shortwave_upward_toa_pristine_sky_1km   | Upward shortwave radiative flux at top of atmosphere for pristine-sky.      |
| 28 | radiative_flux_shortwave_downward_boa_pristine_sky_1km | Downward shortwave radiative flux at bottom of atmosphere for pristine-sky. |
| 29 | radiative_flux_shortwave_upward_boa_pristine_sky_1km   | Upward shortwave radiative flux at bottom of atmosphere for pristine-sky.   |
| 30 | radiative_flux_longwave_upward_toa_pristine_sky_1km    | Upward longwave radiative flux at top of atmosphere for pristine-sky.       |
| 31 | radiative_flux_longwave_downward_boa_pristine_sky_1km  | Downward longwave radiative flux at bottom of atmosphere for pristine-sky.  |
| 32 | radiative_flux_longwave_upward_boa_pristine_sky_1km    | Upward longwave radiative flux at bottom of atmosphere for pristine-sky.    |

#### ACM\_CLP (ver. Bb)

| No. | Input parameter name                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 33  | surface_elevation                     | Representative surface elevation (m) from the WGS84 surface at each ray                                                                                                                                                                                                                                                                                                                                                                               |
| 34  | land_water_flag                       | Land-water flag (0: water, 1: land) This flag is a copy of AUX-2DH.                                                                                                                                                                                                                                                                                                                                                                                   |
| 35  | radar_lidar_flag_1km                  | CPR-ATLID cloud mask flag (1km) (-1: no n-cloud echo (smoke possible), 1: radar only, 2: lidar only, 3: radar and lidar)                                                                                                                                                                                                                                                                                                                              |
| 36  | cloud_mask_1km                        | CPR-ATLID-MSI synergy cloud mask (-9: missing, 0: clear, 1: cloudy)                                                                                                                                                                                                                                                                                                                                                                                   |
| 37  | cloud_particle_type_cpr_atlid_msi_1km | CPR-ATLID-MSI synergy cloud particle type (1km) (0: clear, 1: warm water, 2: supercooled water, 3: 3D ice, 4: 2D plate, 5: mixture of 3D ice and 2D plate, 6: liquid drizzle, 7: mixed-phase drizzle, 8: rain, 9: snow, 10: water + liquid drizzle, 11: water + rain, 12: mixed phase, 13: unknown, 14: melting layer, 15: non-cloud echo 1 (insects etc), 16: fully attenuated (both CPR and ATLID) (not used), 17: non-cloud echo (smoke possible)) |
| 38  | water_effective_radius_1km            | Effective radius of liquid water cloud (1 km)                                                                                                                                                                                                                                                                                                                                                                                                         |
| 39  | liquid_water_content_1km              | Liquid water content (1 km)                                                                                                                                                                                                                                                                                                                                                                                                                           |

|    |                                            |                                                                                         |
|----|--------------------------------------------|-----------------------------------------------------------------------------------------|
| 40 | ice_effective_radius_1km                   | Effective radius of ice cloud (1 km)                                                    |
| 41 | ice_water_content_1km                      | Ice water content (1 km)                                                                |
| 42 | optical_thickness_1km                      | Optical thickness for water + Ice clouds (1 km)                                         |
| 43 | cloud_phase1_1km                           | Phase of cloud effective radius1 (1 km) 0: not retrieved, 1: liquid, 2: ice, (-9) clear |
| 44 | cloud_phase2_1km                           | Phase of cloud effective radius2 (1 km) 0: not retrieved, 1: liquid, 2: ice, (-9) clear |
| 45 | total_cloud_ice_number_concentration_1km   | Total number concentration of ice cloud                                                 |
| 46 | total_cloud_water_number_concentration_1km | Total number concentration of water cloud                                               |
| 47 | cloud_doppler_velocity_1km                 | Cloud Doppler velocity (1 km)                                                           |
| 48 | total_cloud_terminal_velocity_1km          | Total cloud particle terminal velocity (1 km)                                           |
| 49 | cloud_air_velocity_1km                     | Cloud air velocity (1 km)                                                               |
| 50 | ice_water_path_1km                         | Ice water path (1 km)                                                                   |
| 51 | liquid_water_path_1km                      | Cloud water path (1 km)                                                                 |
| 52 | cloud_radar_reflectivity_1km               | Attenuated radar reflectivity factor (1 km)                                             |
| 53 | GRID_pressure_1km                          | Pressure (1 km)                                                                         |
| 54 | GRID_relativeHumidity_1km                  | Relative humidity (1 km)                                                                |
| 55 | GRID_specificHumidity_1km                  | Specific humidity (1 km)                                                                |
| 56 | GRID_temperature_1km                       | Temperature (1 km)                                                                      |

## 2.2. Regridding Procedure

The JAXA EarthCARE L2 products listed in Table 1 are regridded onto the L3\_GRD grid, which has a horizontal resolution of  $2.5^\circ \times 2.5^\circ$  and a vertical resolution of 500 m. The regridded data are then averaged monthly to generate the L3\_GRD. This spatial aggregation is designed to facilitate comparisons with climate model outputs.

## 2.3. Quality Control

Quality control (QC) is applied to cloud microphysical variables, cloud classifications, and dynamical quantities derived from CPR observations.

The QC procedure uses the CPR-ATLID cloud mask (radar\_lidar\_flag\_1km). If a radar-detected cloud layer extends above the highest cloud layer detected by ATLID within the same atmospheric column, the radar-only cloud region above the ATLID cloud top is removed. This procedure effectively suppresses CPR mirror-image artifacts that occasionally generate false cloud echoes above the true cloud top.

For Doppler velocity statistics, only cloudy samples with radar reflectivity greater than or equal to  $-20$  dBZ are used. This threshold minimizes contamination by noisy Doppler velocity retrievals in low signal-to-noise ratio regions.

## 2.4. File Format

The L3\_GRD is distributed in netCDF4 format. The file name follows the convention:

ECA\_J\_L3\_\_GRD\_yyyymm\_V01.nc

where:

- ECA denotes the EarthCARE mission.
- J indicates that the product is generated by JAXA.
- L3 indicates the processing level (Level-3).
- GRD denotes the gridded product.
- yyyymm represents the year and month of the data (e.g., 202605 for May 2026).
- V01 indicates the product version.
- .nc is the netCDF file extension.

## 2.5. L3 Product Structure

The L3\_GRD is stored in netCDF4 format and organized into thematic groups (Table 2). Each group contains aggregated monthly statistics derived from JAXA EarthCARE L2 products. For most continuous variables, three statistical quantities are provided:

- Count
- Sum
- Mean

For categorical variables, both occurrence counts and occurrence fractions are provided.

**Table 2: NetCDF Group Structure.**

| Group name   | Contents                                                            |
|--------------|---------------------------------------------------------------------|
| environment  | Environmental variables                                             |
| cloud_frac   | Cloud occurrence statistics                                         |
| microphysics | Cloud properties                                                    |
| cfad         | Contoured Frequency by Altitude Diagram statistics                  |
| cfed         | Contoured Frequency by Temperature Diagram statistics               |
| joint_hist   | Joint histograms of reflectivity, Doppler velocity, and temperature |
| radiation    | Radiative flux statistics                                           |

## 3. Dimensions and Coordinate Variables

The following dimensions and coordinate variables are included in L3\_GRD.

Dimensions are described below:

```
dimensions:  
    time = UNLIMITED ; // (1 currently)  
    lat = 72 ;
```

```

lon = 144 ;
height = 40 ;
z_bin = 60 ;
vd_bin = 200 ;
vd_hist_4d_bin = 200 ;
temp_bin = 24 ;
z_edge = 61 ;
vd_edge = 201 ;
vd_hist_4d_edge = 201 ;
temp_edge = 25 ;
phase_type = 4 ;
cloud_type = 18 ;
rlflag_type = 4 ;
bnds = 2 ;
particle_type = 14 ;

```

Variables related to coordinates are described below:

```

double time(time) ;
    time:units = "days since 1970-01-01 00:00:00" ;
    time:calendar = "gregorian" ;
    time:standard_name = "time" ;
float lat(lat) ;
    lat:_FillValue = -9999.f ;
    lat:units = "degrees_north" ;
    lat:long_name = "latitude bin center" ;
    lat:standard_name = "latitude" ;
    lat:axis = "Y" ;
    lat:bounds = "lat_bnds" ;
float lon(lon) ;
    lon:_FillValue = -9999.f ;
    lon:units = "degrees_east" ;
    lon:long_name = "longitude bin center" ;
    lon:standard_name = "longitude" ;
    lon:axis = "X" ;
    lon:bounds = "lon_bnds" ;
float height(height) ;
    height:_FillValue = -9999.f ;
    height:units = "m" ;
    height:long_name = "height bin center" ;
    height:standard_name = "height" ;
    height:axis = "Z" ;
    height:positive = "up" ;
    height:bounds = "height_bnds" ;
float lat_bnds(lat, bnds) ;
    lat_bnds:_FillValue = -9999.f ;
    lat_bnds:units = "degrees_north" ;
    lat_bnds:long_name = "latitude bounds" ;
float lon_bnds(lon, bnds) ;
    lon_bnds:_FillValue = -9999.f ;
    lon_bnds:units = "degrees_east" ;
    lon_bnds:long_name = "longitude bounds" ;
float height_bnds(height, bnds) ;
    height_bnds:_FillValue = -9999.f ;
    height_bnds:units = "m" ;
    height_bnds:long_name = "height bounds" ;
float z_bin(z_bin) ;
    z_bin:_FillValue = -9999.f ;
    z_bin:units = "dBZ" ;
    z_bin:long_name = "reflectivity bin center" ;
float vd_bin(vd_bin) ;
    vd_bin:_FillValue = -9999.f ;
    vd_bin:units = "m s-1" ;
    vd_bin:long_name = "Doppler velocity bin center" ;

```

```

float vd_hist_4d_bin(vd_hist_4d_bin) ;
    vd_hist_4d_bin:_FillValue = -9999.f ;
    vd_hist_4d_bin:units = "m s-1" ;
    vd_hist_4d_bin:long_name = "Doppler velocity bin center for 4D histogram" ;
float temp_bin(temp_bin) ;
    temp_bin:_FillValue = -9999.f ;
    temp_bin:units = "K" ;
    temp_bin:long_name = "temperature bin center" ;
float z_edge(z_edge) ;
    z_edge:_FillValue = -9999.f ;
    z_edge:units = "dBZ" ;
    z_edge:long_name = "reflectivity bin edge" ;
float vd_edge(vd_edge) ;
    vd_edge:_FillValue = -9999.f ;
    vd_edge:units = "m s-1" ;
    vd_edge:long_name = "Doppler velocity bin edge" ;
float vd_hist_4d_edge(vd_hist_4d_edge) ;
    vd_hist_4d_edge:_FillValue = -9999.f ;
    vd_hist_4d_edge:units = "m s-1" ;
    vd_hist_4d_edge:long_name = "Doppler velocity bin edge for 4D histogram" ;
float temp_edge(temp_edge) ;
    temp_edge:_FillValue = -9999.f ;
    temp_edge:units = "K" ;
    temp_edge:long_name = "temperature bin edge" ;

```

Although the L3\_GRD contains only a single monthly record in each file, the time dimension is retained as an explicit dimension with length one, as shown by the variable definitions described in Sections 4 onward. This design choice facilitates the use of standard netCDF analysis tools and workflows, allowing users to easily concatenate multiple monthly files and perform temporal statistics using commonly available software packages.

## 4. Environment Group

### 4.1 Overview

The environment group contains atmospheric thermodynamic variables, surface characteristics, and ancillary variables derived from ACM\_CLP and CPR\_ECO products.

### 4.2 Variables and Data Description

```

group: environment {
    variables:
        float land_water_fraction(time, lat, lon) ;
            land_water_fraction:_FillValue = -9999.f ;
            land_water_fraction:units = "1" ;
            land_water_fraction:long_name = "Fraction of land/water flag derived
            from ACM_CLP" ;
            land_water_fraction:coordinates = "time lat lon" ;
        float mean_surface_elevation(time, lat, lon) ;
            mean_surface_elevation:_FillValue = -9999.f ;
            mean_surface_elevation:units = "m" ;
            mean_surface_elevation:long_name = "Mean surface elevation derived
            from ACM_CLP" ;
            mean_surface_elevation:coordinates = "time lat lon" ;
        int count_temperature(time, lat, lon, height) ;
            count_temperature:units = "1" ;
            count_temperature:long_name = "Count of temperature derived from

```

```

        ACM_CLP" ;
        count_temperature:coordinates = "time lat lon height" ;
float sum_temperature(time, lat, lon, height) ;
    sum_temperature:_FillValue = -9999.f ;
    sum_temperature:units = "K" ;
    sum_temperature:long_name = "Sum of temperature derived from
ACM_CLP" ;
    sum_temperature:coordinates = "time lat lon height" ;
float mean_temperature(time, lat, lon, height) ;
    mean_temperature:_FillValue = -9999.f ;
    mean_temperature:units = "K" ;
    mean_temperature:long_name = "Mean temperature derived from
ACM_CLP" ;
    mean_temperature:coordinates = "time lat lon height" ;
int count_pressure(time, lat, lon, height) ;
    count_pressure:units = "1" ;
    count_pressure:long_name = "Count of pressure derived from
ACM_CLP" ;
    count_pressure:coordinates = "time lat lon height" ;
float sum_pressure(time, lat, lon, height) ;
    sum_pressure:_FillValue = -9999.f ;
    sum_pressure:units = "Pa" ;
    sum_pressure:long_name = "Sum of pressure derived from ACM_CLP" ;
    sum_pressure:coordinates = "time lat lon height" ;
float mean_pressure(time, lat, lon, height) ;
    mean_pressure:_FillValue = -9999.f ;
    mean_pressure:units = "Pa" ;
    mean_pressure:long_name = "Mean pressure derived from ACM_CLP" ;
    mean_pressure:coordinates = "time lat lon height" ;
int count_relative_humidity(time, lat, lon, height) ;
    count_relative_humidity:units = "1" ;
    count_relative_humidity:long_name = "Count of relative humidity
derived from ACM_CLP" ;
    count_relative_humidity:coordinates = "time lat lon height" ;
float sum_relative_humidity(time, lat, lon, height) ;
    sum_relative_humidity:_FillValue = -9999.f ;
    sum_relative_humidity:units = "1" ;
    sum_relative_humidity:long_name = "Sum of relative humidity derived
from ACM_CLP" ;
    sum_relative_humidity:coordinates = "time lat lon height" ;
float mean_relative_humidity(time, lat, lon, height) ;
    mean_relative_humidity:_FillValue = -9999.f ;
    mean_relative_humidity:units = "1" ;
    mean_relative_humidity:long_name = "Mean relative humidity derived
from ACM_CLP" ;
    mean_relative_humidity:coordinates = "time lat lon height" ;
int count_specific_humidity(time, lat, lon, height) ;
    count_specific_humidity:units = "1" ;
    count_specific_humidity:long_name = "Count of specific humidity
derived from ACM_CLP" ;
    count_specific_humidity:coordinates = "time lat lon height" ;
float sum_specific_humidity(time, lat, lon, height) ;
    sum_specific_humidity:_FillValue = -9999.f ;
    sum_specific_humidity:units = "kg kg-1" ;
    sum_specific_humidity:long_name = "Sum of specific humidity derived
from ACM_CLP" ;
    sum_specific_humidity:coordinates = "time lat lon height" ;
float mean_specific_humidity(time, lat, lon, height) ;
    mean_specific_humidity:_FillValue = -9999.f ;
    mean_specific_humidity:units = "kg kg-1" ;
    mean_specific_humidity:long_name = "Mean specific humidity derived
from ACM_CLP" ;
    mean_specific_humidity:coordinates = "time lat lon height" ;
int count_rho(time, lat, lon, height) ;
    count_rho:units = "1" ;

```

```

        count_rho:long_name = "Count of air density derived from ACM_CLP" ;
        count_rho:coordinates = "time lat lon height" ;
float sum_rho(time, lat, lon, height) ;
    sum_rho:_FillValue = -9999.f ;
    sum_rho:units = "kg m-3" ;
    sum_rho:long_name = "Sum of air density derived from ACM_CLP" ;
    sum_rho:coordinates = "time lat lon height" ;
float mean_rho(time, lat, lon, height) ;
    mean_rho:_FillValue = -9999.f ;
    mean_rho:units = "kg m-3" ;
    mean_rho:long_name = "Mean air density derived from ACM_CLP" ;
    mean_rho:coordinates = "time lat lon height" ;
int64 count_ground_clutter_height(time, lat, lon) ;
    count_ground_clutter_height:units = "1" ;
    count_ground_clutter_height:long_name = "Count of ground clutter
    height derived from ACM_CLP " ;
    count_ground_clutter_height:coordinates = "time lat lon" ;
float sum_ground_clutter_height(time, lat, lon) ;
    sum_ground_clutter_height:_FillValue = -9999.f ;
    sum_ground_clutter_height:units = "m" ;
    sum_ground_clutter_height:long_name = "Sum of ground clutter height
    derived from ACM_CLP" ;
    sum_ground_clutter_height:coordinates = "time lat lon" ;
float mean_ground_clutter_height(time, lat, lon) ;
    mean_ground_clutter_height:_FillValue = -9999.f ;
    mean_ground_clutter_height:units = "m" ;
    mean_ground_clutter_height:long_name = "Mean ground clutter height
    derived from ACM_CLP" ;
    mean_ground_clutter_height:coordinates = "time lat lon" ;
} // group environment

```

### 4.3 Derived Variables

The land-water fraction is defined as

$$Land\ Water\ Fraction = \frac{N_{land}}{N_{obs}},$$

where  $N_{land}$  is the number of observations classified as land and  $N_{obs}$  is the total number of valid observations in each grid box, using the ACM\_CLP land\_water\_flag variable.

Air density is calculated as

$$\rho = \frac{p}{R_d T_v},$$

where

$$T_v = T(1 + 0.61q)$$

and  $p$  is pressure (Pa),  $R_d = 287.05$  (J kg<sup>-1</sup> K<sup>-1</sup>),  $T$  is temperature (K), and  $q$  is specific humidity (kg kg<sup>-1</sup>).

Ground clutter height is defined as the maximum altitude flagged as clutter by the CPR mirror echo flag and subsequently averaged within each grid box.

## 5. Cloud Fraction Group

### 5.1 Overview

The cloud\_frac group contains three-dimensional and column-integrated cloud occurrence statistics derived from the ACM\_CLP cloud\_mask and radar\_lidar\_flag variables.

### 5.2 Variables and Data Description

```
group: cloud_frac {
  variables:
    *int obs_count_3d(time, lat, lon, height) ;
        obs_count_3d:units = "1" ;
        obs_count_3d:long_name = "Count of observed samples (clear and
        cloudy) at each altitude with QC derived from ACM_CLP" ;
        obs_count_3d:coordinates = "time lat lon height" ;
    *int cloud_count_3d(time, lat, lon, height) ;
        cloud_count_3d:units = "1" ;
        cloud_count_3d:long_name = "Count of cloudy samples at each altitude
        with QC derived from ACM_CLP" ;
        cloud_count_3d:coordinates = "time lat lon height" ;
    *float cloud_fraction_3d(time, lat, lon, height) ;
        cloud_fraction_3d:FillValue = -9999.f ;
        cloud_fraction_3d:units = "1" ;
        cloud_fraction_3d:long_name = "Cloud fraction at each altitude with
        QC derived from ACM_CLP derived from ACM_CLP" ;
        cloud_fraction_3d:coordinates = "time lat lon height" ;
    int obs_count_2d(time, lat, lon) ;
        obs_count_2d:units = "1" ;
        obs_count_2d:long_name = "Count of observed columns (clear and
        cloudy) derived from ACM_CLP" ;
        obs_count_2d:coordinates = "time lat lon" ;
    int cloud_column_count_2d(time, lat, lon) ;
        cloud_column_count_2d:units = "1" ;
        cloud_column_count_2d:long_name = "Count of cloudy columns derived
        from ACM_CLP" ;
        cloud_column_count_2d:coordinates = "time lat lon" ;
    float cloud_fraction_2d(time, lat, lon) ;
        cloud_fraction_2d:FillValue = -9999.f ;
        cloud_fraction_2d:units = "1" ;
        cloud_fraction_2d:long_name = "Column cloud fraction derived from
        ACM_CLP" ;
        cloud_fraction_2d:coordinates = "time lat lon" ;
    int radar_lidar_cloud_mask_count(time, lat, lon, height, rlflag_type) ;
        radar_lidar_cloud_mask_count:units = "1" ;
        radar_lidar_cloud_mask_count:long_name = "Total count of CPR-ATLID
        cloud mask; 0: non-cloud echo (smoke possible), 1: CPR only, 2:
        ATLID only, 3: CPR and ATLID derived from ACM_CLP" ;
        radar_lidar_cloud_mask_count:coordinates = "time lat lon height
        rlflag_type" ;
    float radar_lidar_cloud_mask_fraction(time, lat, lon, height, rlflag_type) ;
        radar_lidar_cloud_mask_fraction:FillValue = -9999.f ;
        radar_lidar_cloud_mask_fraction:units = "1" ;
        radar_lidar_cloud_mask_fraction:long_name = "Occurrence frequency of
        CPR-ATLID cloud mask; 0: non-cloud echo (smoke possible), 1: CPR
        only, 2: ATLID only, 3: CPR and ATLID derived from ACM_CLP" ;
        radar_lidar_cloud_mask_fraction:coordinates = "time lat lon height
        rlflag_type" ;
} // group cloud_frac
```

Variables marked with (\*) are subject to the quality-control procedure described in Section 2.4.

### 5.3 Derived Variables

For the 3D cloud fraction,

$$Cloud\ Fraction_{3D} = \frac{Cloud\ Count_{3D}}{Observation\ Count_{3D}}.$$

For the column cloud fraction,

$$Cloud\ Fraction_{2D} = \frac{Cloud\ Column\ Count_{2D}}{Observation\ Count_{2D}}.$$

A column is considered cloudy when at least one cloudy voxel is detected within the atmospheric column.

## 6. Microphysics Group

### 6.1 Overview

The microphysics group includes cloud microphysical properties, cloud particle classifications, cloud-top temperature, and dynamical parameters derived primarily from ACM\_CLP, and MSI\_CLP.

### 6.2 Variables and Data Description

```
group: microphysics {
  variables:
    *int count_liquid_water_content(time, lat, lon, height) ;
        count_liquid_water_content:units = "1" ;
        count_liquid_water_content:long_name = "Count of liquid water
        content with QC derived from ACM_CLP" ;
        count_liquid_water_content:coordinates = "time lat lon height" ;
    *float sum_liquid_water_content(time, lat, lon, height) ;
        sum_liquid_water_content:_FillValue = -9999.f ;
        sum_liquid_water_content:units = "g m-3" ;
        sum_liquid_water_content:long_name = "Sum of liquid water content
        with QC derived from ACM_CLP" ;
        sum_liquid_water_content:coordinates = "time lat lon height" ;
    *float mean_liquid_water_content(time, lat, lon, height) ;
        mean_liquid_water_content:_FillValue = -9999.f ;
        mean_liquid_water_content:units = "g m-3" ;
        mean_liquid_water_content:long_name = "Mean liquid water content
        with QC derived from ACM_CLP" ;
        mean_liquid_water_content:coordinates = "time lat lon height" ;
    *int count_ice_water_content(time, lat, lon, height) ;
        count_ice_water_content:units = "1" ;
        count_ice_water_content:long_name = "Count of ice water content
        with QC derived from ACM_CLP" ;
        count_ice_water_content:coordinates = "time lat lon height" ;
    *float sum_ice_water_content(time, lat, lon, height) ;
        sum_ice_water_content:_FillValue = -9999.f ;
        sum_ice_water_content:units = "g m-3" ;
        sum_ice_water_content:long_name = "Sum of ice water content with QC
        derived from ACM_CLP" ;
        sum_ice_water_content:coordinates = "time lat lon height" ;
    *float mean_ice_water_content(time, lat, lon, height) ;
        mean_ice_water_content:_FillValue = -9999.f ;
        mean_ice_water_content:units = "g m-3" ;
        mean_ice_water_content:long_name = "Mean ice water content with QC
```

```

        derived from ACM_CLP" ;
        mean_ice_water_content:coordinates = "time lat lon height" ;
int count_liquid_water_path(time, lat, lon) ;
    count_liquid_water_path:units = "1" ;
    count_liquid_water_path:long_name = "Count of liquid water path
derived from ACM_CLP" ;
    count_liquid_water_path:coordinates = "time lat lon" ;
float sum_liquid_water_path(time, lat, lon) ;
    sum_liquid_water_path:_FillValue = -9999.f ;
    sum_liquid_water_path:units = "g m-2" ;
    sum_liquid_water_path:long_name = "Sum of liquid water path derived
from ACM_CLP" ;
    sum_liquid_water_path:coordinates = "time lat lon" ;
float mean_liquid_water_path(time, lat, lon) ;
    mean_liquid_water_path:_FillValue = -9999.f ;
    mean_liquid_water_path:units = "g m-2" ;
    mean_liquid_water_path:long_name = "Mean liquid water path derived
from ACM_CLP" ;
    mean_liquid_water_path:coordinates = "time lat lon" ;
int count_ice_water_path(time, lat, lon) ;
    count_ice_water_path:units = "1" ;
    count_ice_water_path:long_name = "Count of ice water path derived
from ACM_CLP" ;
    count_ice_water_path:coordinates = "time lat lon" ;
float sum_ice_water_path(time, lat, lon) ;
    sum_ice_water_path:_FillValue = -9999.f ;
    sum_ice_water_path:units = "g m-2" ;
    sum_ice_water_path:long_name = "Sum of ice water path derived from
ACM_CLP" ;
    sum_ice_water_path:coordinates = "time lat lon" ;
float mean_ice_water_path(time, lat, lon) ;
    mean_ice_water_path:_FillValue = -9999.f ;
    mean_ice_water_path:units = "g m-2" ;
    mean_ice_water_path:long_name = "Mean ice water path derived from
ACM_CLP" ;
    mean_ice_water_path:coordinates = "time lat lon" ;
*int count_water_effective_radius(time, lat, lon, height) ;
    count_water_effective_radius:units = "1" ;
    count_water_effective_radius:long_name = "Count of water effective
radius with QC derived from ACM_CLP" ;
    count_water_effective_radius:coordinates = "time lat lon height" ;
*float sum_water_effective_radius(time, lat, lon, height) ;
    sum_water_effective_radius:_FillValue = -9999.f ;
    sum_water_effective_radius:units = "micrometer" ;
    sum_water_effective_radius:long_name = "Sum of water effective
radius with QC derived from ACM_CLP" ;
    sum_water_effective_radius:coordinates = "time lat lon height" ;
*float mean_water_effective_radius(time, lat, lon, height) ;
    mean_water_effective_radius:_FillValue = -9999.f ;
    mean_water_effective_radius:units = "micrometer" ;
    mean_water_effective_radius:long_name = "Mean water effective radius
with QC derived from ACM_CLP" ;
    mean_water_effective_radius:coordinates = "time lat lon height" ;
*int count_ice_effective_radius(time, lat, lon, height) ;
    count_ice_effective_radius:units = "1" ;
    count_ice_effective_radius:long_name = "Count of ice effective
radius with QC derived from ACM_CLP" ;
    count_ice_effective_radius:coordinates = "time lat lon height" ;
*float sum_ice_effective_radius(time, lat, lon, height) ;
    sum_ice_effective_radius:_FillValue = -9999.f ;
    sum_ice_effective_radius:units = "micrometer" ;
    sum_ice_effective_radius:long_name = "Sum of ice effective radius
with QC derived from ACM_CLP" ;
    sum_ice_effective_radius:coordinates = "time lat lon height" ;
*float mean_ice_effective_radius(time, lat, lon, height) ;

```

```

mean_ice_effective_radius:_FillValue = -9999.f ;
mean_ice_effective_radius:units = "micrometer" ;
mean_ice_effective_radius:long_name = "Mean ice effective radius
with QC derived from ACM_CLP" ;
mean_ice_effective_radius:coordinates = "time lat lon height" ;
*int count_total_cloud_water_number_concentration(time, lat, lon, height) ;
count_total_cloud_water_number_concentration:units = "1" ;
count_total_cloud_water_number_concentration:long_name = "Count of
total water number concentration with QC derived from ACM_CLP" ;
count_total_cloud_water_number_concentration:coordinates = "time lat
lon height" ;
*float sum_total_cloud_water_number_concentration(time, lat, lon, height) ;
sum_total_cloud_water_number_concentration:_FillValue = -9999.f ;
sum_total_cloud_water_number_concentration:units = "m-3" ;
sum_total_cloud_water_number_concentration:long_name = "Sum of total
water number concentration with QC derived from ACM_CLP" ;
sum_total_cloud_water_number_concentration:coordinates = "time lat
lon height" ;
*float mean_total_cloud_water_number_concentration(time, lat, lon, height) ;
mean_total_cloud_water_number_concentration:_FillValue = -9999.f ;
mean_total_cloud_water_number_concentration:units = "m-3" ;
mean_total_cloud_water_number_concentration:long_name = "Mean total
water number concentration with QC derived from ACM_CLP" ;
mean_total_cloud_water_number_concentration:coordinates = "time lat
lon height" ;
*int count_total_cloud_ice_number_concentration(time, lat, lon, height) ;
count_total_cloud_ice_number_concentration:units = "1" ;
count_total_cloud_ice_number_concentration:long_name = "Count of
total ice number concentration with QC derived from ACM_CLP" ;
count_total_cloud_ice_number_concentration:coordinates = "time lat
lon height" ;
*float sum_total_cloud_ice_number_concentration(time, lat, lon, height) ;
sum_total_cloud_ice_number_concentration:_FillValue = -9999.f ;
sum_total_cloud_ice_number_concentration:units = "m-3" ;
sum_total_cloud_ice_number_concentration:long_name = "Sum of total
ice number concentration with QC derived from ACM_CLP" ;
sum_total_cloud_ice_number_concentration:coordinates = "time lat lon
height" ;
*float mean_total_cloud_ice_number_concentration(time, lat, lon, height) ;
mean_total_cloud_ice_number_concentration:_FillValue = -9999.f ;
mean_total_cloud_ice_number_concentration:units = "m-3" ;
mean_total_cloud_ice_number_concentration:long_name = "Mean total
ice number concentration with QC derived from ACM_CLP" ;
mean_total_cloud_ice_number_concentration:coordinates = "time lat
lon height" ;
*int phase1_count(time, lat, lon, height, phase_type) ;
phase1_count:units = "1" ;
phase1_count:long_name = "Cloud particle phase count; 0: clear 1:
not retrieved, 2: liquid, 3: ice with QC derived from ACM_CLP" ;
phase1_count:coordinates = "time lat lon height phase_type" ;
*float phase1_fraction(time, lat, lon, height, phase_type) ;
phase1_fraction:_FillValue = -9999.f ;
phase1_fraction:units = "1" ;
phase1_fraction:long_name = "Cloud particle phase occurrence
fraction; 0: clear 1: not retrieved, 2: liquid, 3: ice with QC
derived from ACM_CLP" ;
phase1_fraction:coordinates = "time lat lon height phase_type" ;
*int phase2_count(time, lat, lon, height, phase_type) ;
phase2_count:units = "1" ;
phase2_count:long_name = "Precipitable particle phase count; 0:
clear 1: not retrieved, 2: liquid, 3: ice with QC derived from
ACM_CLP" ;
phase2_count:coordinates = "time lat lon height phase_type" ;
*float phase2_fraction(time, lat, lon, height, phase_type) ;
phase2_fraction:_FillValue = -9999.f ;

```

```

        phase2_fraction:units = "1" ;
        phase2_fraction:long_name = "Precipitable particle phase occurrence
        fraction; 0: clear 1: not retrieved, 2: liquid, 3: ice with QC
        derived from ACM_CLP" ;
        phase2_fraction:coordinates = "time lat lon height phase_type" ;
    *int cloud_type_count(time, lat, lon, height, cloud_type) ;
        cloud_type_count:units = "1" ;
        cloud_type_count:long_name = "Cloud type count; 0:clear, 1:warm
        water, 2:supercooled water, 3:3d ice, 4:2d plate, 5:mixture of 3d
        ice and 2d plate, 6:liquid drizzle, 7:mixed-phase drizzle, 8:rain,
        9:snow, 10:water+liquid drizzle, 11:water+rain, 12:mixed-phase,
        13:unknown, 14:melting layer, 15:non-cloud echo1 (insect etc.),
        16:fully attenuated (both CPR and ATLID), 17:non-cloud echo2 (smoke
        possible) with QC derived from ACM_CLP" ;
        cloud_type_count:coordinates = "time lat lon height cloud_type" ;
    *float cloud_type_fraction(time, lat, lon, height, cloud_type) ;
        cloud_type_fraction:_FillValue = -9999.f ;
        cloud_type_fraction:units = "1" ;
        cloud_type_fraction:long_name = "Cloud type occurrence fraction;
        0:clear, 1:warm water, 2:supercooled water, 3:3d ice, 4:2d plate,
        5:mixture of 3d ice and 2d plate, 6:liquid drizzle, 7:mixed-phase
        drizzle, 8:rain, 9:snow, 10:water+liquid drizzle, 11: water+rain,
        12:mixed-phase, 13:unknown, 14:melting layer, 15:non-cloud echo1
        (insect etc.), 16:fully attenuated (both CPR and ATLID), 17:non-
        cloud echo2 (smoke possible) with QC derived from ACM_CLP" ;
        cloud_type_fraction:coordinates = "time lat lon height cloud_type" ;
    int count_optical_thickness(time, lat, lon) ;
        count_optical_thickness:units = "1" ;
        count_optical_thickness:long_name = "Count of optical thickness
        derived from ACM_CLP" ;
        count_optical_thickness:coordinates = "time lat lon" ;
    float sum_optical_thickness(time, lat, lon) ;
        sum_optical_thickness:_FillValue = -9999.f ;
        sum_optical_thickness:units = "1" ;
        sum_optical_thickness:long_name = "Sum of optical thickness derived
        from ACM_CLP" ;
        sum_optical_thickness:coordinates = "time lat lon" ;
    float mean_optical_thickness(time, lat, lon) ;
        mean_optical_thickness:_FillValue = -9999.f ;
        mean_optical_thickness:units = "1" ;
        mean_optical_thickness:long_name = "Mean optical thickness derived
        from ACM_CLP" ;
        mean_optical_thickness:coordinates = "time lat lon" ;
    *int vd_count(time, lat, lon, height) ;
        vd_obs_count:units = "1" ;
        vd_obs_count:long_name = "Count of Doppler velocity with QC derived
        from ACM_CLP" ;
        vd_obs_count:coordinates = "time lat lon height" ;
    *float vd_sum(time, lat, lon, height) ;
        vd_sum:units = "m s-1" ;
        vd_sum:long_name = "Sum of Doppler velocity with QC derived from
        ACM_CLP" ;
        vd_sum:coordinates = "time lat lon height" ;
    *float vd_mean(time, lat, lon, height) ;
        vd_mean:_FillValue = -9999.f ;
        vd_mean:units = "m s-1" ;
        vd_mean:long_name = "Mean Doppler velocity with QC derived from
        ACM_CLP" ;
        vd_mean:coordinates = "time lat lon height" ;
    *int vt_count(time, lat, lon, height) ;
        vt_count:units = "1" ;
        vt_count:long_name = "Count of terminal velocity with QC derived
        from ACM_CLP" ;
        vt_count:coordinates = "time lat lon height" ;
    *float vt_sum(time, lat, lon, height) ;

```

```

        vt_sum:FillValue = -9999.f ;
        vt_sum:units = "m s-1" ;
        vt_sum:long_name = "Sum of terminal velocity with QC derived from
        ACM_CLP" ;
        vt_sum:coordinates = "time lat lon height" ;
*float vt_mean(time, lat, lon, height) ;
        vt_mean:FillValue = -9999.f ;
        vt_mean:units = "m s-1" ;
        vt_mean:long_name = "Mean terminal velocity with QC derived from
        ACM_CLP" ;
        vt_mean:coordinates = "time lat lon height" ;
*int va_count(time, lat, lon, height) ;
        va_count:units = "1" ;
        va_count:long_name = "Count of air velocity with QC derived from
        ACM_CLP" ;
        va_count:coordinates = "time lat lon height" ;
*float va_sum(time, lat, lon, height) ;
        va_sum:FillValue = -9999.f ;
        va_sum:units = "m s-1" ;
        va_sum:long_name = "Sum of air velocity with QC derived from
        ACM_CLP" ;
        va_sum:coordinates = "time lat lon height" ;
*float va_mean(time, lat, lon, height) ;
        va_mean:FillValue = -9999.f ;
        va_mean:units = "m s-1" ;
        va_mean:long_name = "Mean air velocity with QC derived from
        ACM_CLP" ;
        va_mean:coordinates = "time lat lon height" ;
int count_cloud_top_temperature(time, lat, lon) ;
        count_cloud_top_temperature:units = "1" ;
        count_cloud_top_temperature:long_name = "Count of cloud top
        temperature derived from MSI_CLP" ;
        count_cloud_top_temperature:coordinates = "time lat lon" ;
float sum_cloud_top_temperature(time, lat, lon) ;
        sum_cloud_top_temperature:FillValue = -9999.f ;
        sum_cloud_top_temperature:units = "K" ;
        sum_cloud_top_temperature:long_name = "Sum of cloud top temperature
        derived from MSI_CLP" ;
        sum_cloud_top_temperature:coordinates = "time lat lon" ;
float mean_cloud_top_temperature(time, lat, lon) ;
        mean_cloud_top_temperature:FillValue = -9999.f ;
        mean_cloud_top_temperature:units = "K" ;
        mean_cloud_top_temperature:coordinates = "time lat lon" ;
        mean_cloud_top_temperature:long_name = "Mean cloud top temperature
        derived from MSI_CLP" ;
} // group microphysics

```

Variables marked with (\*) are subject to the quality-control procedure described in Section 2.4.

### 6.3 Derived Variables

Several occurrence-fraction variables are derived from the corresponding occurrence counts. For a given category  $i$ , the occurrence fraction is defined as

$$Fraction(i) = \frac{Count(i)}{N_{obs}},$$

where  $Count(i)$  is the number of samples belonging to category  $i$  and  $N_{obs}$  is the total number of valid observations within the corresponding grid box.

For example, cloud type fraction and cloud phase fraction are calculated using the above definition.

## 7. CFAD Group

### *7.1 Overview*

The cfad group contains Contoured Frequency by Altitude Diagram (CFAD) statistics for radar reflectivity and Doppler velocity. CFADs describe the vertical distribution of measurement frequency as a function of altitude and the selected radar variable.

### *7.2 Variables and Data Description*

```
group: cfad {
  variables:
    *int z_cfad_count(time, height, z_bin) ;
        z_cfad_count:units = "1" ;
        z_cfad_count:long_name = "Reflectivity CFAD count with QC derived
        from ACM_CLP" ;
    *int vd_cfad_count(time, height, vd_bin) ;
        vd_cfad_count:units = "1" ;
        vd_cfad_count:long_name = "Doppler velocity CFAD count with QC
        derived from ACM_CLP" ;
} // group cfad
```

Variables marked with (\*) are subject to the quality-control procedure described in Section 2.4.

## 8. CFED Group

### *8.1 Overview*

The cfed group contains Contoured Frequency by Temperature Diagram (CFED) statistics for radar reflectivity and Doppler velocity. CFEDs describe the distribution of measurement frequency as a function of atmospheric temperature and the selected radar variable.

### *8.2 Variables and Data Description*

```
group: cfed {
  variables:
    *int z_cfed_count(time, temp_bin, z_bin) ;
        z_cfed_count:units = "1" ;
        z_cfed_count:long_name = "Reflectivity CFED count with QC derived
        from ACM_CLP" ;
    *int vd_cfed_count(time, temp_bin, vd_bin) ;
        vd_cfed_count:units = "1" ;
        vd_cfed_count:long_name = "Doppler velocity CFED count with QC
        derived from ACM_CLP" ;
} // group cfed
```

Variables marked with (\*) are subject to the quality-control procedure described in Section 2.4.

## 9. Joint Histogram Group

### 9.1 Overview

The joint\_hist group contains multidimensional histograms that describe the statistical relationships among radar reflectivity, Doppler velocity, and atmospheric temperature.

### 9.2 Variables and Data Description

```
group: joint_hist {
  variables:
    *int z_vd_temp_hist(time, z_bin, vd_bin, temp_bin) ;
        z_vd_temp_hist:units = "1" ;
        z_vd_temp_hist:long_name = "Reflectivity-Doppler velocity-
        temperature joint histogram with QC with QC derived from ACM_CLP" ;
    *uint vd_hist(time, lat, lon, height, vd_hist_4d_bin) ;
        vd_hist:units = "1" ;
        vd_hist:long_name = "Doppler velocity histogram for each latitude,
        longitude, and height grid with QC derived from ACM_CLP" ;
} // group joint_hist
```

Variables marked with (\*) are subject to the quality-control procedure described in Section 2.4.

The variable z\_vd\_temp\_hist stores a three-dimensional joint histogram of radar reflectivity, Doppler velocity, and atmospheric temperature.

The variable vd\_hist stores Doppler velocity histograms for each latitude, longitude, and height grid box, enabling regional analysis of cloud dynamical properties.

## 10. Radiation Group

### 10.1 Overview

The radiation group contains monthly statistics of radiative fluxes derived from the ALL\_RAD product. The statistics are provided separately for:

- All-sky conditions
- Clear-sky conditions
- Cloudy-sky conditions
- Pristine-sky conditions

Fluxes are reported for:

- Top of atmosphere (TOA)
- Bottom of atmosphere (BOA)

and for both shortwave (SW) and longwave (LW) radiation components.

### 10.2 Variables and Data Description

```
group: radiation {
```

variables:

```
int count_lw_down_boa_all_sky(time, lat, lon) ;
    count_lw_down_boa_all_sky:units = "1" ;
    count_lw_down_boa_all_sky:long_name = "Count of longwave downward
    flux at BOA for all sky derived from ALL_RAD" ;
    count_lw_down_boa_all_sky:coordinates = "time lat lon" ;
float sum_lw_down_boa_all_sky(time, lat, lon) ;
    sum_lw_down_boa_all_sky:_FillValue = -9999.f ;
    sum_lw_down_boa_all_sky:units = "W m-2" ;
    sum_lw_down_boa_all_sky:long_name = "Sum of longwave downward flux
    at BOA for all sky derived from ALL_RAD" ;
    sum_lw_down_boa_all_sky:coordinates = "time lat lon" ;
float mean_lw_down_boa_all_sky(time, lat, lon) ;
    mean_lw_down_boa_all_sky:_FillValue = -9999.f ;
    mean_lw_down_boa_all_sky:units = "W m-2" ;
    mean_lw_down_boa_all_sky:long_name = "Mean longwave downward flux at
    BOA for all sky derived from ALL_RAD" ;
    mean_lw_down_boa_all_sky:coordinates = "time lat lon" ;
int count_lw_down_boa_clear_sky(time, lat, lon) ;
    count_lw_down_boa_clear_sky:units = "1" ;
    count_lw_down_boa_clear_sky:long_name = "Count of longwave downward
    flux at BOA for clear sky derived from ALL_RAD" ;
    count_lw_down_boa_clear_sky:coordinates = "time lat lon" ;
float sum_lw_down_boa_clear_sky(time, lat, lon) ;
    sum_lw_down_boa_clear_sky:_FillValue = -9999.f ;
    sum_lw_down_boa_clear_sky:units = "W m-2" ;
    sum_lw_down_boa_clear_sky:long_name = "Sum of longwave downward flux
    at BOA for clear sky derived from ALL_RAD" ;
    sum_lw_down_boa_clear_sky:coordinates = "time lat lon" ;
float mean_lw_down_boa_clear_sky(time, lat, lon) ;
    mean_lw_down_boa_clear_sky:_FillValue = -9999.f ;
    mean_lw_down_boa_clear_sky:units = "W m-2" ;
    mean_lw_down_boa_clear_sky:long_name = "Mean longwave downward flux
    at BOA for clear sky derived from ALL_RAD" ;
    mean_lw_down_boa_clear_sky:coordinates = "time lat lon" ;
int count_lw_down_boa_cloudy_sky(time, lat, lon) ;
    count_lw_down_boa_cloudy_sky:units = "1" ;
    count_lw_down_boa_cloudy_sky:long_name = "Count of longwave downward
    flux at BOA for cloudy sky derived from ALL_RAD" ;
    count_lw_down_boa_cloudy_sky:coordinates = "time lat lon" ;
float sum_lw_down_boa_cloudy_sky(time, lat, lon) ;
    sum_lw_down_boa_cloudy_sky:_FillValue = -9999.f ;
    sum_lw_down_boa_cloudy_sky:units = "W m-2" ;
    sum_lw_down_boa_cloudy_sky:long_name = "Sum of longwave downward
    flux at BOA for cloudy sky derived from ALL_RAD" ;
    sum_lw_down_boa_cloudy_sky:coordinates = "time lat lon" ;
float mean_lw_down_boa_cloudy_sky(time, lat, lon) ;
    mean_lw_down_boa_cloudy_sky:_FillValue = -9999.f ;
    mean_lw_down_boa_cloudy_sky:units = "W m-2" ;
    mean_lw_down_boa_cloudy_sky:coordinates = "time lat lon" ;
    mean_lw_down_boa_cloudy_sky:long_name = "Mean longwave downward flux
    at BOA for cloudy sky derived from ALL_RAD" ;
int count_lw_down_boa_pristine_sky(time, lat, lon) ;
    count_lw_down_boa_pristine_sky:units = "1" ;
    count_lw_down_boa_pristine_sky:long_name = "Count of longwave
    downward flux at BOA for pristine sky derived from ALL_RAD" ;
    count_lw_down_boa_pristine_sky:coordinates = "time lat lon" ;
float sum_lw_down_boa_pristine_sky(time, lat, lon) ;
    sum_lw_down_boa_pristine_sky:_FillValue = -9999.f ;
    sum_lw_down_boa_pristine_sky:units = "W m-2" ;
    sum_lw_down_boa_pristine_sky:long_name = "Sum of longwave downward
    flux at BOA for pristine sky derived from ALL_RAD" ;
    sum_lw_down_boa_pristine_sky:coordinates = "time lat lon" ;
float mean_lw_down_boa_pristine_sky(time, lat, lon) ;
    mean_lw_down_boa_pristine_sky:_FillValue = -9999.f ;
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        mean_lw_down_boa_pristine_sky:units = "W m-2" ;
        mean_lw_down_boa_pristine_sky:long_name = "Mean longwave downward
        flux at BOA for pristine sky derived from ALL_RAD" ;
        mean_lw_down_boa_pristine_sky:coordinates = "time lat lon" ;
int count_lw_up_boa_all_sky(time, lat, lon) ;
    count_lw_up_boa_all_sky:units = "1" ;
    count_lw_up_boa_all_sky:long_name = "Count of longwave upward flux
    at BOA for all sky derived from ALL_RAD" ;
    count_lw_up_boa_all_sky:coordinates = "time lat lon" ;
float sum_lw_up_boa_all_sky(time, lat, lon) ;
    sum_lw_up_boa_all_sky:_FillValue = -9999.f ;
    sum_lw_up_boa_all_sky:units = "W m-2" ;
    sum_lw_up_boa_all_sky:long_name = "Sum of longwave upward flux at
    BOA for all sky derived from ALL_RAD" ;
    sum_lw_up_boa_all_sky:coordinates = "time lat lon" ;
float mean_lw_up_boa_all_sky(time, lat, lon) ;
    mean_lw_up_boa_all_sky:_FillValue = -9999.f ;
    mean_lw_up_boa_all_sky:units = "W m-2" ;
    mean_lw_up_boa_all_sky:long_name = "Mean longwave upward flux at BOA
    for all sky derived from ALL_RAD" ;
    mean_lw_up_boa_all_sky:coordinates = "time lat lon" ;
int count_lw_up_boa_clear_sky(time, lat, lon) ;
    count_lw_up_boa_clear_sky:units = "1" ;
    count_lw_up_boa_clear_sky:long_name = "Count of longwave upward flux
    at BOA for clear sky derived from ALL_RAD" ;
    count_lw_up_boa_clear_sky:coordinates = "time lat lon" ;
float sum_lw_up_boa_clear_sky(time, lat, lon) ;
    sum_lw_up_boa_clear_sky:_FillValue = -9999.f ;
    sum_lw_up_boa_clear_sky:units = "W m-2" ;
    sum_lw_up_boa_clear_sky:long_name = "Sum of longwave upward flux at
    BOA for clear sky derived from ALL_RAD" ;
    sum_lw_up_boa_clear_sky:coordinates = "time lat lon" ;
float mean_lw_up_boa_clear_sky(time, lat, lon) ;
    mean_lw_up_boa_clear_sky:_FillValue = -9999.f ;
    mean_lw_up_boa_clear_sky:units = "W m-2" ;
    mean_lw_up_boa_clear_sky:long_name = "Mean longwave upward flux at
    BOA for clear sky derived from ALL_RAD" ;
    mean_lw_up_boa_clear_sky:coordinates = "time lat lon" ;
int count_lw_up_boa_cloudy_sky(time, lat, lon) ;
    count_lw_up_boa_cloudy_sky:units = "1" ;
    count_lw_up_boa_cloudy_sky:coordinates = "time lat lon" ;
    count_lw_up_boa_cloudy_sky:long_name = "Count of longwave upward
    flux at BOA for cloudy sky derived from ALL_RAD" ;
float sum_lw_up_boa_cloudy_sky(time, lat, lon) ;
    sum_lw_up_boa_cloudy_sky:_FillValue = -9999.f ;
    sum_lw_up_boa_cloudy_sky:units = "W m-2" ;
    sum_lw_up_boa_cloudy_sky:coordinates = "time lat lon" ;
    sum_lw_up_boa_cloudy_sky:long_name = "Sum of longwave upward flux at
    BOA for cloudy sky derived from ALL_RAD" ;
float mean_lw_up_boa_cloudy_sky(time, lat, lon) ;
    mean_lw_up_boa_cloudy_sky:_FillValue = -9999.f ;
    mean_lw_up_boa_cloudy_sky:units = "W m-2" ;
    mean_lw_up_boa_cloudy_sky:long_name = "Mean longwave upward flux at
    BOA for cloudy sky derived from ALL_RAD" ;
    mean_lw_up_boa_cloudy_sky:coordinates = "time lat lon" ;
int count_lw_up_boa_pristine_sky(time, lat, lon) ;
    count_lw_up_boa_pristine_sky:units = "1" ;
    count_lw_up_boa_pristine_sky:long_name = "Count of longwave upward
    flux at BOA for pristine sky derived from ALL_RAD" ;
    count_lw_up_boa_pristine_sky:coordinates = "time lat lon" ;
float sum_lw_up_boa_pristine_sky(time, lat, lon) ;
    sum_lw_up_boa_pristine_sky:_FillValue = -9999.f ;
    sum_lw_up_boa_pristine_sky:units = "W m-2" ;
    sum_lw_up_boa_pristine_sky:long_name = "Sum of longwave upward flux
    at BOA for pristine sky derived from ALL_RAD" ;

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        sum_lw_up_boa_pristine_sky:coordinates = "time lat lon" ;
float mean_lw_up_boa_pristine_sky(time, lat, lon) ;
    mean_lw_up_boa_pristine_sky:_FillValue = -9999.f ;
    mean_lw_up_boa_pristine_sky:units = "W m-2" ;
    mean_lw_up_boa_pristine_sky:long_name = "Mean longwave upward flux
at BOA for pristine sky derived from ALL_RAD" ;
    mean_lw_up_boa_pristine_sky:coordinates = "time lat lon" ;
int count_lw_up_toa_all_sky(time, lat, lon) ;
    count_lw_up_toa_all_sky:units = "1" ;
    count_lw_up_toa_all_sky:long_name = "Count of longwave upward flux
at TOA for all sky derived from ALL_RAD" ;
    count_lw_up_toa_all_sky:coordinates = "time lat lon" ;
float sum_lw_up_toa_all_sky(time, lat, lon) ;
    sum_lw_up_toa_all_sky:_FillValue = -9999.f ;
    sum_lw_up_toa_all_sky:units = "W m-2" ;
    sum_lw_up_toa_all_sky:long_name = "Sum of longwave upward flux at
TOA for all sky derived from ALL_RAD" ;
    sum_lw_up_toa_all_sky:coordinates = "time lat lon" ;
float mean_lw_up_toa_all_sky(time, lat, lon) ;
    mean_lw_up_toa_all_sky:_FillValue = -9999.f ;
    mean_lw_up_toa_all_sky:units = "W m-2" ;
    mean_lw_up_toa_all_sky:long_name = "Mean longwave upward flux at TOA
for all sky derived from ALL_RAD" ;
    mean_lw_up_toa_all_sky:coordinates = "time lat lon" ;
int count_lw_up_toa_clear_sky(time, lat, lon) ;
    count_lw_up_toa_clear_sky:units = "1" ;
    count_lw_up_toa_clear_sky:long_name = "Count of longwave upward flux
at TOA for clear sky derived from ALL_RAD" ;
    count_lw_up_toa_clear_sky:coordinates = "time lat lon" ;
float sum_lw_up_toa_clear_sky(time, lat, lon) ;
    sum_lw_up_toa_clear_sky:_FillValue = -9999.f ;
    sum_lw_up_toa_clear_sky:units = "W m-2" ;
    sum_lw_up_toa_clear_sky:long_name = "Sum of longwave upward flux at
TOA for clear sky derived from ALL_RAD" ;
    sum_lw_up_toa_clear_sky:coordinates = "time lat lon" ;
float mean_lw_up_toa_clear_sky(time, lat, lon) ;
    mean_lw_up_toa_clear_sky:_FillValue = -9999.f ;
    mean_lw_up_toa_clear_sky:units = "W m-2" ;
    mean_lw_up_toa_clear_sky:long_name = "Mean longwave upward flux at
TOA for clear sky derived from ALL_RAD" ;
    mean_lw_up_toa_clear_sky:coordinates = "time lat lon" ;
int count_lw_up_toa_cloudy_sky(time, lat, lon) ;
    count_lw_up_toa_cloudy_sky:units = "1" ;
    count_lw_up_toa_cloudy_sky:long_name = "Count of longwave upward
flux at TOA for cloudy sky derived from ALL_RAD" ;
    count_lw_up_toa_cloudy_sky:coordinates = "time lat lon" ;
float sum_lw_up_toa_cloudy_sky(time, lat, lon) ;
    sum_lw_up_toa_cloudy_sky:_FillValue = -9999.f ;
    sum_lw_up_toa_cloudy_sky:units = "W m-2" ;
    sum_lw_up_toa_cloudy_sky:long_name = "Sum of longwave upward flux at
TOA for cloudy sky derived from ALL_RAD" ;
    sum_lw_up_toa_cloudy_sky:coordinates = "time lat lon" ;
float mean_lw_up_toa_cloudy_sky(time, lat, lon) ;
    mean_lw_up_toa_cloudy_sky:_FillValue = -9999.f ;
    mean_lw_up_toa_cloudy_sky:units = "W m-2" ;
    mean_lw_up_toa_cloudy_sky:long_name = "Mean longwave upward flux at
TOA for cloudy sky derived from ALL_RAD" ;
    mean_lw_up_toa_cloudy_sky:coordinates = "time lat lon" ;
int count_lw_up_toa_pristine_sky(time, lat, lon) ;
    count_lw_up_toa_pristine_sky:units = "1" ;
    count_lw_up_toa_pristine_sky:long_name = "Count of longwave upward
flux at TOA for pristine sky derived from ALL_RAD" ;
    count_lw_up_toa_pristine_sky:coordinates = "time lat lon" ;
float sum_lw_up_toa_pristine_sky(time, lat, lon) ;
    sum_lw_up_toa_pristine_sky:_FillValue = -9999.f ;

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sum_lw_up_toa_pristine_sky:units = "W m-2" ;
sum_lw_up_toa_pristine_sky:long_name = "Sum of longwave upward flux
at TOA for pristine sky derived from ALL_RAD" ;
sum_lw_up_toa_pristine_sky:coordinates = "time lat lon" ;
float mean_lw_up_toa_pristine_sky(time, lat, lon) ;
mean_lw_up_toa_pristine_sky:_FillValue = -9999.f ;
mean_lw_up_toa_pristine_sky:units = "W m-2" ;
mean_lw_up_toa_pristine_sky:long_name = "Mean longwave upward flux
at TOA for pristine sky derived from ALL_RAD" ;
mean_lw_up_toa_pristine_sky:coordinates = "time lat lon" ;
int count_sw_down_boa_all_sky(time, lat, lon) ;
count_sw_down_boa_all_sky:units = "1" ;
count_sw_down_boa_all_sky:long_name = "Count of shortwave downward
flux at BOA for all sky derived from ALL_RAD" ;
count_sw_down_boa_all_sky:coordinates = "time lat lon" ;
float sum_sw_down_boa_all_sky(time, lat, lon) ;
sum_sw_down_boa_all_sky:_FillValue = -9999.f ;
sum_sw_down_boa_all_sky:units = "W m-2" ;
sum_sw_down_boa_all_sky:long_name = "Sum of shortwave downward flux
at BOA for all sky derived from ALL_RAD" ;
sum_sw_down_boa_all_sky:coordinates = "time lat lon" ;
float mean_sw_down_boa_all_sky(time, lat, lon) ;
mean_sw_down_boa_all_sky:_FillValue = -9999.f ;
mean_sw_down_boa_all_sky:units = "W m-2" ;
mean_sw_down_boa_all_sky:long_name = "Mean shortwave downward flux
at BOA for all sky derived from ALL_RAD" ;
mean_sw_down_boa_all_sky:coordinates = "time lat lon" ;
int count_sw_down_boa_clear_sky(time, lat, lon) ;
count_sw_down_boa_clear_sky:units = "1" ;
count_sw_down_boa_clear_sky:long_name = "Count of shortwave downward
flux at BOA for clear sky derived from ALL_RAD" ;
count_sw_down_boa_clear_sky:coordinates = "time lat lon" ;
float sum_sw_down_boa_clear_sky(time, lat, lon) ;
sum_sw_down_boa_clear_sky:_FillValue = -9999.f ;
sum_sw_down_boa_clear_sky:units = "W m-2" ;
sum_sw_down_boa_clear_sky:long_name = "Sum of shortwave downward
flux at BOA for clear sky derived from ALL_RAD" ;
sum_sw_down_boa_clear_sky:coordinates = "time lat lon" ;
float mean_sw_down_boa_clear_sky(time, lat, lon) ;
mean_sw_down_boa_clear_sky:_FillValue = -9999.f ;
mean_sw_down_boa_clear_sky:units = "W m-2" ;
mean_sw_down_boa_clear_sky:long_name = "Mean shortwave downward flux
at BOA for clear sky derived from ALL_RAD" ;
mean_sw_down_boa_clear_sky:coordinates = "time lat lon" ;
int count_sw_down_boa_cloudy_sky(time, lat, lon) ;
count_sw_down_boa_cloudy_sky:units = "1" ;
count_sw_down_boa_cloudy_sky:long_name = "Count of shortwave
downward flux at BOA for cloudy sky derived from ALL_ " ;
count_sw_down_boa_cloudy_sky:coordinates = "time lat lon" ;
float sum_sw_down_boa_cloudy_sky(time, lat, lon) ;
sum_sw_down_boa_cloudy_sky:_FillValue = -9999.f ;
sum_sw_down_boa_cloudy_sky:units = "W m-2" ;
sum_sw_down_boa_cloudy_sky:long_name = "Sum of shortwave downward
flux at BOA for cloudy sky derived from ALL_RAD" ;
sum_sw_down_boa_cloudy_sky:coordinates = "time lat lon" ;
float mean_sw_down_boa_cloudy_sky(time, lat, lon) ;
mean_sw_down_boa_cloudy_sky:_FillValue = -9999.f ;
mean_sw_down_boa_cloudy_sky:units = "W m-2" ;
mean_sw_down_boa_cloudy_sky:long_name = "Mean shortwave downward
flux at BOA for cloudy sky derived from ALL_RAD" ;
mean_sw_down_boa_cloudy_sky:coordinates = "time lat lon" ;
int count_sw_down_boa_pristine_sky(time, lat, lon) ;
count_sw_down_boa_pristine_sky:units = "1" ;
count_sw_down_boa_pristine_sky:long_name = "Count of shortwave
downward flux at BOA for pristine sky derived from ALL_RAD" ;

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        count_sw_down_boa_pristine_sky:coordinates = "time lat lon" ;
float sum_sw_down_boa_pristine_sky(time, lat, lon) ;
    sum_sw_down_boa_pristine_sky:_FillValue = -9999.f ;
    sum_sw_down_boa_pristine_sky:units = "W m-2" ;
    sum_sw_down_boa_pristine_sky:coordinates = "time lat lon" ;
    sum_sw_down_boa_pristine_sky:long_name = "Sum of shortwave downward
    flux at BOA for pristine sky derived from ALL_RAD" ;
float mean_sw_down_boa_pristine_sky(time, lat, lon) ;
    mean_sw_down_boa_pristine_sky:_FillValue = -9999.f ;
    mean_sw_down_boa_pristine_sky:units = "W m-2" ;
    mean_sw_down_boa_pristine_sky:long_name = "Mean shortwave downward
    flux at BOA for pristine sky derived from ALL_RAD" ;
    mean_sw_down_boa_pristine_sky:coordinates = "time lat lon" ;
int count_sw_down_toa_all_sky(time, lat, lon) ;
    count_sw_down_toa_all_sky:units = "1" ;
    count_sw_down_toa_all_sky:long_name = "Count of shortwave downward
    flux at TOA for all sky derived from ALL_RAD" ;
    count_sw_down_toa_all_sky:coordinates = "time lat lon" ;
float sum_sw_down_toa_all_sky(time, lat, lon) ;
    sum_sw_down_toa_all_sky:_FillValue = -9999.f ;
    sum_sw_down_toa_all_sky:units = "W m-2" ;
    sum_sw_down_toa_all_sky:long_name = "Sum of shortwave downward flux
    at TOA for all sky derived from ALL_RAD" ;
    sum_sw_down_toa_all_sky:coordinates = "time lat lon" ;
float mean_sw_down_toa_all_sky(time, lat, lon) ;
    mean_sw_down_toa_all_sky:_FillValue = -9999.f ;
    mean_sw_down_toa_all_sky:units = "W m-2" ;
    mean_sw_down_toa_all_sky:long_name = "Mean shortwave downward flux
    at TOA for all sky derived from ALL_RAD" ;
    mean_sw_down_toa_all_sky:coordinates = "time lat lon" ;
int count_sw_down_toa_clear_sky(time, lat, lon) ;
    count_sw_down_toa_clear_sky:units = "1" ;
    count_sw_down_toa_clear_sky:long_name = "Count of shortwave downward
    flux at TOA for clear sky derived from ALL_RAD" ;
    count_sw_down_toa_clear_sky:coordinates = "time lat lon" ;
float sum_sw_down_toa_clear_sky(time, lat, lon) ;
    sum_sw_down_toa_clear_sky:_FillValue = -9999.f ;
    sum_sw_down_toa_clear_sky:units = "W m-2" ;
    sum_sw_down_toa_clear_sky:long_name = "Sum of shortwave downward
    flux at TOA for clear sky derived from ALL_RAD" ;
    sum_sw_down_toa_clear_sky:coordinates = "time lat lon" ;
float mean_sw_down_toa_clear_sky(time, lat, lon) ;
    mean_sw_down_toa_clear_sky:_FillValue = -9999.f ;
    mean_sw_down_toa_clear_sky:units = "W m-2" ;
    mean_sw_down_toa_clear_sky:long_name = "Mean shortwave downward flux
    at TOA for clear sky derived from ALL_RAD" ;
    mean_sw_down_toa_clear_sky:coordinates = "time lat lon" ;
int count_sw_down_toa_cloudy_sky(time, lat, lon) ;
    count_sw_down_toa_cloudy_sky:units = "1" ;
    count_sw_down_toa_cloudy_sky:coordinates = "time lat lon" ;
    count_sw_down_toa_cloudy_sky:long_name = "Count of shortwave
    downward flux at TOA for cloudy sky derived from ALL_ " ;
float sum_sw_down_toa_cloudy_sky(time, lat, lon) ;
    sum_sw_down_toa_cloudy_sky:_FillValue = -9999.f ;
    sum_sw_down_toa_cloudy_sky:units = "W m-2" ;
    sum_sw_down_toa_cloudy_sky:long_name = "Sum of shortwave downward
    flux at TOA for cloudy sky derived from ALL_RAD" ;
    sum_sw_down_toa_cloudy_sky:coordinates = "time lat lon" ;
float mean_sw_down_toa_cloudy_sky(time, lat, lon) ;
    mean_sw_down_toa_cloudy_sky:_FillValue = -9999.f ;
    mean_sw_down_toa_cloudy_sky:units = "W m-2" ;
    mean_sw_down_toa_cloudy_sky:coordinates = "time lat lon" ;
    mean_sw_down_toa_cloudy_sky:long_name = "Mean shortwave downward
    flux at TOA for cloudy sky derived from ALL_RAD" ;
int count_sw_down_toa_pristine_sky(time, lat, lon) ;

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        count_sw_down_toa_pristine_sky:units = "1" ;
        count_sw_down_toa_pristine_sky:long_name = "Count of shortwave
        downward flux at TOA for pristine sky derived from ALL_RAD" ;
        count_sw_down_toa_pristine_sky:coordinates = "time lat lon" ;
float sum_sw_down_toa_pristine_sky(time, lat, lon) ;
    sum_sw_down_toa_pristine_sky:_FillValue = -9999.f ;
    sum_sw_down_toa_pristine_sky:units = "W m-2" ;
    sum_sw_down_toa_pristine_sky:long_name = "Sum of shortwave downward
    flux at TOA for pristine sky derived from ALL_RAD" ;
    sum_sw_down_toa_pristine_sky:coordinates = "time lat lon" ;
float mean_sw_down_toa_pristine_sky(time, lat, lon) ;
    mean_sw_down_toa_pristine_sky:_FillValue = -9999.f ;
    mean_sw_down_toa_pristine_sky:units = "W m-2" ;
    mean_sw_down_toa_pristine_sky:long_name = "Mean shortwave downward
    flux at TOA for pristine sky derived from ALL_RAD" ;
    mean_sw_down_toa_pristine_sky:coordinates = "time lat lon" ;
int count_sw_up_boa_all_sky(time, lat, lon) ;
    count_sw_up_boa_all_sky:units = "1" ;
    count_sw_up_boa_all_sky:long_name = "Count of shortwave upward flux
    at BOA for all sky derived from ALL_RAD" ;
    count_sw_up_boa_all_sky:coordinates = "time lat lon" ;
float sum_sw_up_boa_all_sky(time, lat, lon) ;
    sum_sw_up_boa_all_sky:_FillValue = -9999.f ;
    sum_sw_up_boa_all_sky:units = "W m-2" ;
    sum_sw_up_boa_all_sky:long_name = "Sum of shortwave upward flux at
    BOA for all sky derived from ALL_RAD" ;
    sum_sw_up_boa_all_sky:coordinates = "time lat lon" ;
float mean_sw_up_boa_all_sky(time, lat, lon) ;
    mean_sw_up_boa_all_sky:_FillValue = -9999.f ;
    mean_sw_up_boa_all_sky:units = "W m-2" ;
    mean_sw_up_boa_all_sky:long_name = "Mean shortwave upward flux at
    BOA for all sky derived from ALL_RAD" ;
    mean_sw_up_boa_all_sky:coordinates = "time lat lon" ;
int count_sw_up_boa_clear_sky(time, lat, lon) ;
    count_sw_up_boa_clear_sky:units = "1" ;
    count_sw_up_boa_clear_sky:long_name = "Count of shortwave upward
    flux at BOA for clear sky derived from ALL_RAD" ;
    count_sw_up_boa_clear_sky:coordinates = "time lat lon" ;
float sum_sw_up_boa_clear_sky(time, lat, lon) ;
    sum_sw_up_boa_clear_sky:_FillValue = -9999.f ;
    sum_sw_up_boa_clear_sky:units = "W m-2" ;
    sum_sw_up_boa_clear_sky:long_name = "Sum of shortwave upward flux at
    BOA for clear sky derived from ALL_RAD" ;
    sum_sw_up_boa_clear_sky:coordinates = "time lat lon" ;
float mean_sw_up_boa_clear_sky(time, lat, lon) ;
    mean_sw_up_boa_clear_sky:_FillValue = -9999.f ;
    mean_sw_up_boa_clear_sky:units = "W m-2" ;
    mean_sw_up_boa_clear_sky:long_name = "Mean shortwave upward flux at
    BOA for clear sky derived from ALL_RAD" ;
    mean_sw_up_boa_clear_sky:coordinates = "time lat lon" ;
int count_sw_up_boa_cloudy_sky(time, lat, lon) ;
    count_sw_up_boa_cloudy_sky:units = "1" ;
    count_sw_up_boa_cloudy_sky:long_name = "Count of shortwave upward
    flux at BOA for cloudy sky derived from ALL_RAD" ;
    count_sw_up_boa_cloudy_sky:coordinates = "time lat lon" ;
float sum_sw_up_boa_cloudy_sky(time, lat, lon) ;
    sum_sw_up_boa_cloudy_sky:_FillValue = -9999.f ;
    sum_sw_up_boa_cloudy_sky:units = "W m-2" ;
    sum_sw_up_boa_cloudy_sky:long_name = "Sum of shortwave upward flux
    at BOA for cloudy sky derived from ALL_RAD" ;
    sum_sw_up_boa_cloudy_sky:coordinates = "time lat lon" ;
float mean_sw_up_boa_cloudy_sky(time, lat, lon) ;
    mean_sw_up_boa_cloudy_sky:_FillValue = -9999.f ;
    mean_sw_up_boa_cloudy_sky:units = "W m-2" ;
    mean_sw_up_boa_cloudy_sky:long_name = "Mean shortwave upward flux at

```

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        BOA for cloudy sky derived from ALL_RAD" ;
        mean_sw_up_boa_cloudy_sky:coordinates = "time lat lon" ;
int count_sw_up_boa_pristine_sky(time, lat, lon) ;
        count_sw_up_boa_pristine_sky:units = "1" ;
        count_sw_up_boa_pristine_sky:coordinates = "time lat lon" ;
        count_sw_up_boa_pristine_sky:long_name = "Count of shortwave upward
        flux at BOA for pristine sky derived from ALL_RAD" ;
float sum_sw_up_boa_pristine_sky(time, lat, lon) ;
        sum_sw_up_boa_pristine_sky:_FillValue = -9999.f ;
        sum_sw_up_boa_pristine_sky:units = "W m-2" ;
        sum_sw_up_boa_pristine_sky:long_name = "Sum of shortwave upward flux
        at BOA for pristine sky derived from ALL_RAD" ;
        sum_sw_up_boa_pristine_sky:coordinates = "time lat lon" ;
float mean_sw_up_boa_pristine_sky(time, lat, lon) ;
        mean_sw_up_boa_pristine_sky:_FillValue = -9999.f ;
        mean_sw_up_boa_pristine_sky:units = "W m-2" ;
        mean_sw_up_boa_pristine_sky:long_name = "Mean shortwave upward flux
        at BOA for pristine sky derived from ALL_RAD" ;
        mean_sw_up_boa_pristine_sky:coordinates = "time lat lon" ;
int count_sw_up_toa_all_sky(time, lat, lon) ;
        count_sw_up_toa_all_sky:units = "1" ;
        count_sw_up_toa_all_sky:long_name = "Count of shortwave upward flux
        at TOA for all sky derived from ALL_RAD" ;
        count_sw_up_toa_all_sky:coordinates = "time lat lon" ;
float sum_sw_up_toa_all_sky(time, lat, lon) ;
        sum_sw_up_toa_all_sky:_FillValue = -9999.f ;
        sum_sw_up_toa_all_sky:units = "W m-2" ;
        sum_sw_up_toa_all_sky:long_name = "Sum of shortwave upward flux at
        TOA for all sky derived from ALL_RAD" ;
        sum_sw_up_toa_all_sky:coordinates = "time lat lon" ;
float mean_sw_up_toa_all_sky(time, lat, lon) ;
        mean_sw_up_toa_all_sky:_FillValue = -9999.f ;
        mean_sw_up_toa_all_sky:units = "W m-2" ;
        mean_sw_up_toa_all_sky:long_name = "Mean shortwave upward flux at
        TOA for all sky derived from ALL_RAD" ;
        mean_sw_up_toa_all_sky:coordinates = "time lat lon" ;
int count_sw_up_toa_clear_sky(time, lat, lon) ;
        count_sw_up_toa_clear_sky:units = "1" ;
        count_sw_up_toa_clear_sky:long_name = "Count of shortwave upward
        flux at TOA for clear sky derived from ALL_RAD" ;
        count_sw_up_toa_clear_sky:coordinates = "time lat lon" ;
float sum_sw_up_toa_clear_sky(time, lat, lon) ;
        sum_sw_up_toa_clear_sky:_FillValue = -9999.f ;
        sum_sw_up_toa_clear_sky:units = "W m-2" ;
        sum_sw_up_toa_clear_sky:long_name = "Sum of shortwave upward flux at
        TOA for clear sky derived from ALL_RAD" ;
        sum_sw_up_toa_clear_sky:coordinates = "time lat lon" ;
float mean_sw_up_toa_clear_sky(time, lat, lon) ;
        mean_sw_up_toa_clear_sky:_FillValue = -9999.f ;
        mean_sw_up_toa_clear_sky:units = "W m-2" ;
        mean_sw_up_toa_clear_sky:long_name = "Mean shortwave upward flux at
        TOA for clear sky derived from ALL_RAD" ;
        mean_sw_up_toa_clear_sky:coordinates = "time lat lon" ;
int count_sw_up_toa_cloudy_sky(time, lat, lon) ;
        count_sw_up_toa_cloudy_sky:units = "1" ;
        count_sw_up_toa_cloudy_sky:long_name = "Count of shortwave upward
        flux at TOA for cloudy sky derived from ALL_RAD" ;
        count_sw_up_toa_cloudy_sky:coordinates = "time lat lon" ;
float sum_sw_up_toa_cloudy_sky(time, lat, lon) ;
        sum_sw_up_toa_cloudy_sky:_FillValue = -9999.f ;
        sum_sw_up_toa_cloudy_sky:units = "W m-2" ;
        sum_sw_up_toa_cloudy_sky:long_name = "Sum of shortwave upward flux
        at TOA for cloudy sky derived from ALL_RAD" ;
        sum_sw_up_toa_cloudy_sky:coordinates = "time lat lon" ;
float mean_sw_up_toa_cloudy_sky(time, lat, lon) ;

```

```

        mean_sw_up_toa_cloudy_sky:_FillValue = -9999.f ;
        mean_sw_up_toa_cloudy_sky:units = "W m-2" ;
        mean_sw_up_toa_cloudy_sky:long_name = "Mean shortwave upward flux at
        TOA for cloudy sky derived from ALL_RAD" ;
        mean_sw_up_toa_cloudy_sky:coordinates = "time lat lon" ;
    int count_sw_up_toa_pristine_sky(time, lat, lon) ;
        count_sw_up_toa_pristine_sky:units = "1" ;
        count_sw_up_toa_pristine_sky:long_name = "Count of shortwave upward
        flux at TOA for pristine sky derived from ALL_RAD" ;
        count_sw_up_toa_pristine_sky:coordinates = "time lat lon" ;
    float sum_sw_up_toa_pristine_sky(time, lat, lon) ;
        sum_sw_up_toa_pristine_sky:_FillValue = -9999.f ;
        sum_sw_up_toa_pristine_sky:units = "W m-2" ;
        sum_sw_up_toa_pristine_sky:long_name = "Sum of shortwave upward flux
        at TOA for pristine sky derived from ALL_RAD" ;
        sum_sw_up_toa_pristine_sky:coordinates = "time lat lon" ;
    float mean_sw_up_toa_pristine_sky(time, lat, lon) ;
        mean_sw_up_toa_pristine_sky:_FillValue = -9999.f ;
        mean_sw_up_toa_pristine_sky:units = "W m-2" ;
        mean_sw_up_toa_pristine_sky:long_name = "Mean shortwave upward flux
        at TOA for pristine sky derived from ALL_RAD" ;
        mean_sw_up_toa_pristine_sky:coordinates = "time lat lon" ;
} // group radiation

```

## 11. Notation

### *11.1 Difference in sample numbers in L3\_GRD monthly data*

All sensors onboard EarthCARE entered Readiness For Collaborative Observation (RFCO) on 10 August 2024. Therefore, the L3\_GRD monthly dataset for August 2024 was generated using approximately 20 days of valid observations. In addition, during periods when the CPR instrument was temporarily suspended, the corresponding L2 products were not generated. In the L3 processing, frames without valid L2 data are excluded, and only valid data are used for statistical calculations. The number of valid samples can be confirmed from the data count provided for each variable. Users should therefore pay careful attention to the sample counts when performing statistical analyses and interpreting the results.

### *11.2 Inhomogeneity of Doppler velocity accuracy*

The monthly averaged Doppler velocity measured by the CPR is provided as `vd_mean` in the "microphysics" group. This variable is quality-controlled as described in Section 2.3; a reflectivity threshold of  $> -20$  dBZ is applied to exclude regions with a low signal-to-noise ratio.

However, the Doppler velocity data contain slightly elevated noise, and may exhibit stripe patterns in latitude-altitude maps, as shown in Fig. 1. These artifacts are associated with inaccuracies in the IQ offset during the early observation period prior to 4 December 2024, when the IQ offset correction was improved.

Furthermore, CPR has three different observation modes (20 km, 18 km, and 16 km modes) with different pulse repetition frequencies, resulting in different accuracy of Doppler velocity

measurement. Before 8 July 2025, the 20 km and 16 km modes were used below and above 60 degree latitude, respectively. From 8 July 2025 to 26 November 2025, the 18 km mode was used instead of the 20 km mode to improve Doppler measurement accuracy. Since 26 November 2025, the latitude range covered by the 16 km mode has been extended to 40 degree latitude. The Doppler velocity accuracy characteristics of each observation mode before the IQ offset update are summarized in Imura et al. (2026).

Users should therefore exercise caution when comparing data acquired before and after December 2024, as there is an inhomogeneity in data quality between these periods.

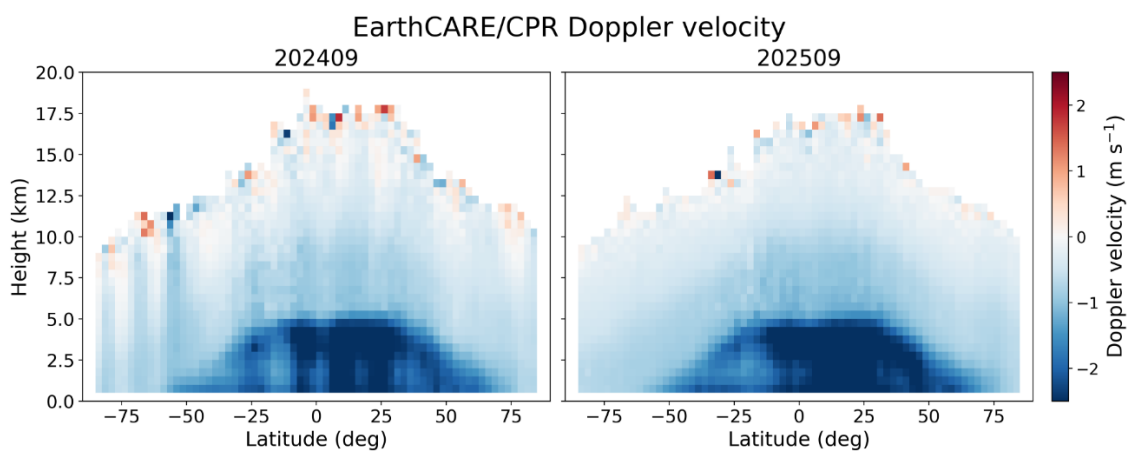


Figure 1. Latitude-altitude cross sections of monthly mean Doppler velocity ( $\text{m s}^{-1}$ ) derived from L3\_GRD for September 2024 (left) and September 2025 (right).

## 12. Reference

Illingworth, A. J., Barker, H. W., Beljaars, A., Ceccaldi, M., Chepfer, H., Clerbaux, N., Cole, J., Delanoë, J., Domenech, C., Donovan, D. P., Fukuda, S., Hidakata, M., Hogan, R. J., Huenerbein, A., Kollias, P., Kubota, T., Nakajima, T., Nakajima, T. Y., Nishizawa, T., Ohno, Y., Okamoto, H., Oki, R., Sato, K., Satoh, M., Shephard, M. W., Velázquez-Blázquez, A., Wandinger, U., Wehr, T., and van Zadelhoff, G.-J.: The EarthCARE satellite: The next step forward in global measurements of clouds, aerosols, precipitation, and radiation, *B. Am. Meteor. Soc.*, 96, 1311–1332, <https://doi.org/10.1175/BAMS-D-12-00227.1>, 2015.

Imura, Y., Aoki, S., Kubota, T., Nakatsuka, H., Ohno, Y., and Okamoto, H.: Observation modes of EarthCARE/CPR with different Doppler measurement accuracy: evaluation of their applicability, *Atmos. Meas. Tech.*, 19, 5617–5631, <https://doi.org/10.5194/amt-19-5617-2026>, 2026.

Wehr, T., Kubota, T., Tzeremes, G., Wallace, K., Nakatsuka, H., Ohno, Y., Koopman, R., Rusli, S., Kikuchi, M., Eisinger, M., Tanaka, T., Taga, M., Deghaye, P., Tomita, E., and Bernaerts, D.: The EarthCARE mission –

science and system overview, *Atmos. Meas. Tech.*, 16, 3581–3608, <https://doi.org/10.5194/amt-16-3581-2023>, 2023.