Polar Pathfinder - Extended CDR (01B-24b) User Guide

1. Document Purpose

1.1 Intent

This document is intended for users who wish to use the *Polar Pathfinder - Extended CDR*. Users are not expected to be experts in the data. This document summarizes essential information needed to understand the context of the dataset observations and issues that affect its fitness for purpose. References at the end of this document provide additional resources and information.

1.2 Dataset information

Dataset name and version:	*Polar Pathfinder - Extended CDR*
Digital Object Identifier (DOI):	*http://doi.org/10.25921/AE96-0E57*
Email address:	*cryosphere_contacts@noaa.gov*

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2. Revisions

2.1 Document revision history

The table below lists document revision history by document revision version, date, and summary of changes.

Revision Number	Date	Summary of changes
0	01/08/2026	First release of user guide describing version v02r00.

2.2 Dataset history

The *Polar Pathfinder - Extended CDR* v1.0 product released in October of 2015. In February of 2019, *Polar Pathfinder - Extended CDR* v2.0 released providing two new variables: *ice thickness* and *ice age.* Once the *Polar Pathfinder FCDR* v2.0 extended to the Visible Infrared Imaging Radiometer Suite (VIIRS) Global Area Coverage (VGAC) data the *Polar Pathfinder - Extended CDR* v2.0 adopted this new input to generate APP-x like VPP-x data. As of July 2023, this product includes APP-x and VPP-x from the *Polar Pathfinder - Extended CDR* v2.0 APP and VPP data, respectively.

3. CDR Overview

3.1 Summary of the dataset

The *Polar Pathfinder - Extended Climate Data Record (CDR)*, utilizes the data from the Advanced Very High-Resolution Radiometer (AVHRR) and the Visible Infrared Imaging Radiometer Suite (VIIRS) instruments on the NOAA and Joint Polar Satellite System (JPSS) satellite series. It has several geophysical variables that quantify properties of the surface and atmosphere in the Arctic and Antarctic from 1982–present. The data products are mapped to a 25 km Equal-Area Scalable Earth (EASE) grid at two local solar times: 04:00 and 14:00 for the Arctic, and 02:00 and 14:00 for the Antarctic. This TCDR provides a high-quality CDR for use in polar climate research, climate monitoring, and numerical model verification.

The *Polar Pathfinder - Extended CDR* contains 20 geophysical variables. All of them have undergone various degrees of validation, though not all are considered CDR quality. The variables are (those considered to be of CDR-quality are identified with an asterisk):

- Surface temperature, all-sky, snow, ice, and land*
- Surface albedo, all-sky*
- Sea ice thickness*
- Surface type
- Cloud mask*
- Cloud particle thermodynamic phase
- Cloud optical depth

- Cloud particle effective radius
- Cloud temperature
- Cloud pressure
- Cloud type
- Downwelling shortwave radiation at the surface*
- Downwelling longwave radiation at the surface*
- Upwelling shortwave radiation at the surface*
- Upwelling longwave radiation at the surface*
- Upwelling shortwave radiation at the TOA*
- Upwelling longwave radiation at the TOA*
- Downwelling net shortwave radiation at the TOA
- Shortwave cloud radiative forcing at the surface
- Longwave cloud radiative forcing at the surface

3.2 File naming convention

The table below lists the TCDR file naming convention.

File Description	TCDR tar file of twice daily data files (historical and operational)
File Name Pattern	<ShortName>_v02r00_d<SingleDateTime>_c<CreateDateTime>.tar.gz
File Name Field Definitions	• <ShortName> = shortened product name: Polar-APP-X • v02r00 = product version (major change/reprocessing of POR) and revision (minor change) number: “v02r00” • d<YYYYmmdd> = Date of the data in the file identified with a ‘d’, formatted as year, month and day. • c<YYYYmmdd> = Creation date of the file identified with a ‘c’ followed by the year, month and day • .tar.gz = extension for tar file with compression
File Name Examples	Polar-APP-X_v02r00_d19821031_c20140606.tar.gz Each tar file contains 4 netCDF-4 files for the data of both poles at both local solar times. For example, ‘Polar-APP-X_v02r00_d19821031_c20140606.tar.gz’ contains 4 files of ‘Polar-APP-X_v02r00_Nhem_0400_d19821031_c20140606.nc’, ‘Polar-APP-X_v02r00_Shem_0200_d19821031_c20140606.nc’, ‘Polar-APP-X_v02r00_Nhem_1400_d19821031_c20140606.nc’, and ‘Polar-APP-X_v02r00_Shem_1400_d19821031_c20140606.nc’ when it is uncompressed and untarred for AVHRR data based TCDR, otherwise, the ‘APP-X’ will be replaced by ‘VPP-X’ for VIIRS data based TCDR.
File Format	tar file containing netCDF-4 files
File Compression	GNU Compression
File Size (Range)	Tar and compressed files APP-X/VPP-X: 4-16MB *Size difference due to resolution difference and data compression.
File Count (Rate)	1 file per day

File Rename/Repackage Instructions	No

3.3 File Format

NOAA Climate Data Records (CDRs) are provided in netCDF format. More information on this format is provided by Unidata. Most every programming language and several stand-alone software packages (both free and paid) can process netCDF data.

3.4 Spatial Coverage

This CDR dataset is mapped to a 25 km Equal-Area Scalable Earth (EASE) grid covering the area from 48.4ºN latitude to the North Pole for the Arctic, and the area from -53.2ºS to the South Pole for the Antarctic.

3.5 Temporal Coverage

This CDR dataset is generated every day at two local solar times (LST): 04:00 and 14:00 for the Arctic, and 02:00 and 14:00 for the Antarctic. Using local solar time rather than standard UTC times provides better information on diurnal differences at all locations.

4. CDR production

4.1 Observational data sources (input data)

The *Polar Pathfinder - Extended CDR* uses the *Polar Pathfinder FCDR* data products as its primary input. The *Polar Pathfinder - Extended CDR* is remapped from the 5 km FCDR to the 25 km EASE grid at two local solar times (LST): 04:00 and 14:00 for the Arctic, and 02:00 and 14:00 for the Antarctic. The gridding is done by selecting every fifth pixel in the *Polar Pathfinder FCDR* (not averaging), yielding an effective 25 km resolution. AVHRR Global Area Coverage (GAC) and VIIRS Global Area Coverage (VGAC) data (see the *Polar Pathfinder FCDR* User Guide) are used to generate the *Polar Pathfinder FCDR*. The NOAA polar orbital satellites have been used for the generation of this *Polar Pathfinder FCDR* and *Polar Pathfinder - Extended CDR* as listed in the below table.

NOAA satellite	Time range	Note
NOAA-7	01/01/82-12/31/84	
NOAA-9	01/01/85-11/07/88	
NOAA-11	11/08/88-12/31/94	
NOAA-14	01/01/95-12/31/00	
NOAA-16	01/01/01-08/09/05	NOAA-16 has Channel 3A/3B switching
NOAA-18	08/10/05-12/31/2014	On 08/05/05, automatic 3A/3B channel switching was disabled. Channel 3B is permanently on NOAA-18.
NOAA-19	1/1/2015-08/11/2025	Due to severe orbital drift, AVHRR GAC data is no longer provided.
NOAA-20	1/5/2012-present	

Five-channel data from AVHRR/VIIRS are needed for most geophysical parameter retrievals as listed in the table below.

CH	TIROS-N	NOAA-6,8,10	NOAA-7,9,11,12,14	NOAA-15 and onward	Suomi NPP, NOAA-20, and NOAA-21	GAC/VGAC nadir resolution (km)
	AVHRR/1	AVHRR/1	AVHRR/2	AVHRR/3	VIIRS	4.0
1	0.55-0.90 μm	0.58-0.68 μm	0.58-0.68 μm	0.58-0.68 μm	0.60-0.68 μm	4.0
2	0.725-1.10 μm	0.725-1.10 μm	0.725-1.10 μm	0.725-1.00 μm	0.85-0.88 μm	4.0
3A				1.58-1.64 μm		4.0
3B	3.55-3.93 μm	3.55-3.93 μm	3.55-3.93 μm	3.55-3.93 μm	3.61-3.79 μm	4.0
4	10.50-11.50 μm	10.50-11.50 μm	10.30-11.30 μm	10.30-11.30 μm	10.26-11.26 μm	4.0
5	Ch4 repeated	Ch4 repeated	11.50-12.50 μm	11.50-12.50 μm	11.06-12.96 μm	4.0

4.2 Other data sources (ancillary data)

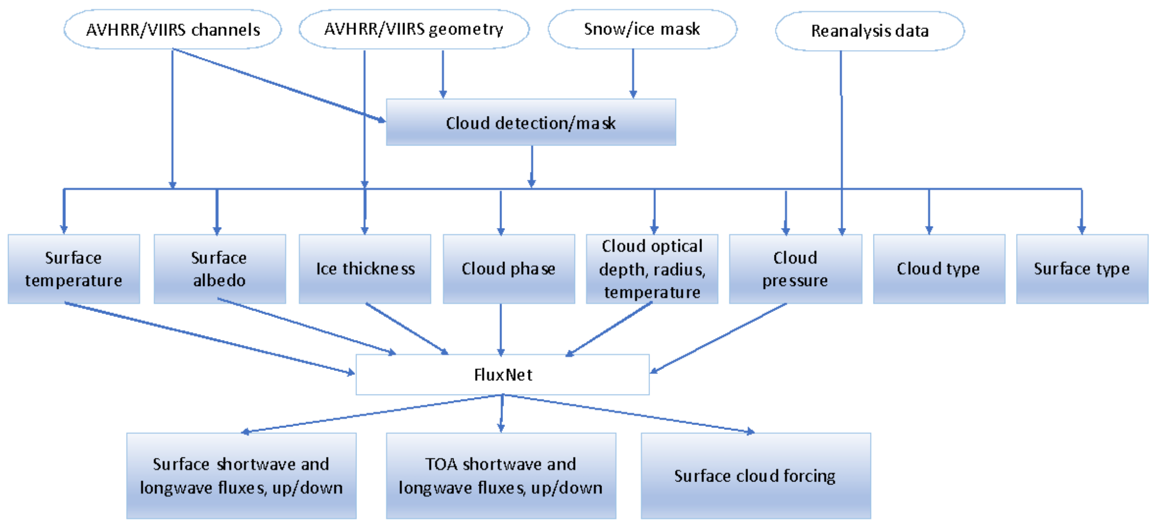
The following lists and briefly describes the ancillary data required for *Polar Pathfinder - Extended CDR*. These are supplied by reanalysis products. Currently NCEP/NCAR Reanalysis and the NASA MERRA products are employed for near-real-time and historical CDR processes, respectively.

- Surface air pressure
- Surface air Temperature
- Surface Humidity
- Surface Wind
- Atmospheric temperature profiles
- Atmospheric humidity profiles

4.3 High-level processing overview

Polar Pathfinder - Extended CDR processing starts with input from the standard *Polar Pathfinder FCDR* product (see the *Polar Pathfinder FCDR* User Guide) and ancillary data. Cloud detection is then performed, as the cloud mask feeds into most of the other algorithms. Cloud properties and surface temperature and albedo are then retrieved. Cloud and surface properties are used as input to a parameterization of a radiative transfer model (a neural network) to calculate radiative fluxes and cloud radiative forcing, and also used as input to an ice thickness model called *One-dimensional Thermodynamic Ice Model* (OTIM) to estimate ice thickness. All variables are then output. The overall processing for *Polar Pathfinder - Extended CDR* is shown in the figure below. The blue boxes indicate output parameters.

Polar Pathfinder TCDR Processing Overview



5. Using the CDR

5.1 Known or recommended applications

This CDR provides a comprehensive set of variables that can be used to study and monitor weather and climate changes, trends, and interactions within the Arctic and Antarctic climate systems, especially for the recent dramatic changes in Arctic sea ice and the Antarctic ice sheets. The importance of monitoring the climate of the polar regions has never been greater. Specifically, this CDR can be used for detecting long-term trends of Arctic and Antarctic climate parameters, investigating the feedback mechanisms and interactions within the polar climate system, monitoring and predicting sea ice changes in the polar regions, and verifying and validating regional and global weather and climate models, potentially leading to improvements in weather and climate predictions.

5.2 Uncertainty Quantification

The CDR dataset is created from the *Polar Pathfinder FCDR* dataset that is based on the AVHRR/VIIRS five-channel data. Uncertainties in AVHRR/VIIRS channel data, such as calibration inaccuracies, will inevitably propagate into the *Polar Pathfinder FCDR* dataset and eventually affect the *Polar Pathfinder – Extended CDR* dataset as well. The table below lists the estimated AVHRR 5 channel uncertainties from different authors. Brest and Rossow (1997) estimated the uncertainties in the five AVHRR visible and infrared channels.

	Visible Channels (1, 2)	Thermal Channels (3, 4, 5)
Rao and Chen (1993, 1995, 1998, 1999)	0.7% (1), 1.5% (2)	---
Walton et al. (1998)	---	0.37 K, 0.15 K and 0.17 K.
Brest and Rossow (1997)	±3-5%	±1-2 K

Most of the *Polar Pathfinder – Extended CDR* parameters were compared with field campaign and meteorological station measurements. The table below gives the bias and uncertainty (root-mean-square error) of the main variables as a quantitative assessment of the error budget.

Quantity*	***Bias#***	***RMSE$***
Surface temperature	0.20 K	1.98 K
Surface broadband albedo	-0.05	0.10
Downwelling shortwave radiation flux at the surface	9.8 W/m^2	34.4 W/m^2
Downwelling longwave radiation flux at the surface	2.1 W/m^2	22.4 W/m^2
Upwelling shortwave radiation flux at the surface	4.4 W/m^2	26.6 W/m^2
Upwelling longwave radiation flux at the surface	1.9 W/m^2	9.4 W/m^2
Ice thickness	-0.11 m	0.22 m
Cloud Particle Phase	95% correct typing	
Cloud fraction	0.14 (absolute)	0.26 (absolute)

**: Satellite-derived quantities are for the 25 x 25 km^2 area centered on the ship during the SHEBA (Surface Heat Budget of the Arctic Ocean campaign, 1997-1998. Bias is defined as the difference between satellite-derived quantities and SHEBA ship measurements. RMSE stands for Root Mean Square Error.*

5.3 Limitations and Caveats

The following list contains the current assumptions and proposed mitigation strategies.

- Atmospheric profile and wind speed data are available from NCEP/NCAR, NASA MERRA or other reanalysis data products. If no profile data are available, it is a valid assumption as used by other researchers that surface air temperature generally is about 0.5 ~ 2 degree higher than ice/snow surface temperature depending on the cloud condition, and relative humidity is about 90% over ice/snow, and wind speed of 5~10 m/s. But wind speed should be observed or simulated to guarantee the results to be realistic.
- Snow data including map and depth data need to be known beforehand. In case no snow data is available as it is now, an estimation of about 20 cm snow depth will be used in terms of year and month from a regression from climatological snow depth data.
- Land mask maps are also needed to identify different surface types.
- All of the static ancillary data is available at the pixel level.

- The current temporal and spatial coverages of the *Polar Pathfinder – Extended CDR* may limit its applications to the research focused on local small spatial scale studies such as the characterization of sea ice leads, and small time scale studies such as hourly changes in surface temperature. The *Polar Pathfinder – Extended CDR* is not appropriate for studies of mid- and low-latitude areas.

A significant gap in the dataset exists due to failures with NOAA-13 and the AVHRR scan motor on NOAA-11 on September 13, 1994. Therefore, *-APP-X data is missing from August 29, 1994 until January 19, 1995, when NOAA-14 AVHRR data becomes available. Due to various anomalies with the NOAA-16 AVHRR scan motor, *-APP-X data from September 17, 2003, to August 7, 2005 should be used with caution.

6. References

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