PREFIRE Data User Guide

Auxiliary Meteorology (AUX-MET)

Version R01

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Kyle Mattingly
Erin Hokanson Wagner
Tim Michaels
Aronne Merrelli

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1 Introduction

This user guide contains information for the PREFIRE data collections PREFIRE_SAT1_AUX-MET and PREFIRE_SAT2_AUX-MET, which are archived by the Atmospheric Science Data Center (ASDC) at the NASA Langley Research Center. These collections contain auxiliary meteorology data, matched and interpolated to PREFIRE observational ground footprints, which are used to produce Level 2 PREFIRE data products.

1.1 Mission Overview

The Science Mission Directorate (SMD) at NASA Headquarters selected the Polar Radiant Energy in the Far InfraRed Experiment (PREFIRE) as an Earth System Science Pathfinder (ESSP) Earth Venture Instrument (EVI-4) class Mission of Opportunity. Through spectrally resolved observations of radiances spanning the radiatively significant portions of the Mid- and Far-InfraRed (MIR and FIR), PREFIRE addresses two complementary hypotheses:

1. Time-varying errors in both FIR surface emissivity and thermal radiation modulate estimates of energy exchanges between the surface and the atmosphere in the Arctic.
2. These terms are responsible for a large fraction of the spread in projected rates of change for Arctic surface, ocean, and atmosphere characteristics.

These hypotheses are addressed through five related objectives:

- O1.1 Quantify snow and ice FIR emissivity spectra and their variability on seasonal scales;
- O1.2 Quantify the FIR thermal radiation and its response to seasonal variations in cloud cover / water vapor;
- O1.3 Quantify variability in Arctic spectral surface emission and the thermal radiation across the FIR owing to transient cloud and water vapor and sub-daily surface phase-change processes;
- O2.2 Quantify thermal emission errors on projected rates of Arctic warming and sea ice loss;
- O2.3 Determine the impact of improved surface emissivity on modeled ice sheet dynamic processes on hourly scales.

PREFIRE uses broadband infrared (> 75% of surface emitted thermal radiation) radiance measurements made from the separate orbiting platforms (CubeSats) to address the science objectives. The PREFIRE payloads are two stand-alone instruments built at JPL using heritage from the Mars Climate Sounder and the Moon Mineralogy Mapper. The PREFIRE instruments are thermal infrared imaging spectro-radiometers with more than 50 spectral bands. Each PREFIRE instrument uses ambient temperature thermopile detectors and operates in a pushbroom mode with a point and stare mirror for viewing nadir (Earth), space, and a calibration target. PREFIRE data are calibrated with data from views of the internal calibration target and of space, which are viewed multiple times per orbit.

Soon after launch, the orbit altitude was approximately 531 km for both satellites. However, the PREFIRE CubeSats do not have station-keeping abilities and so their altitudes decrease with time. The current satellite altitude is recorded within the Auxiliary Meteorology (AUX-MET) data product files as the *sat_altitude* field (in the *Geometry* data group).

The PREFIRE project delivers space-based measurements of radiative fluxes, cloud masks, spectrally variant surface emissivity (ε_λ), and column water vapor (CWV). These are science products with the precision, resolution, and coverage needed to improve our understanding of polar energy balances and Earth-system effects over diurnal and seasonal cycles at scales that capture surface and cloud variability.

During its approximately one-year baseline mission, PREFIRE will capture the natural variability in Arctic and Antarctic CWV and surface temperature. PREFIRE reduces uncertainties in the surface and atmospheric components of the polar energy budget.

1.2 Data Overview

PREFIRE Auxiliary Meteorology (AUX-MET) data are contained in two collections: PREFIRE_SAT1_AUX-MET and PREFIRE_SAT2_AUX-MET. The data are provided in distinct data collections because the two PREFIRE-TIRS instruments each have different mission timeframes, observational ground footprints, characterizatics, and known issues. Please be sure to read about these differences below.

All Level 1 through Level 3 and Auxiliary PREFIRE data products are produced by the PREFIRE Science Data Processing System (SDPS), located at the University of Wisconsin-Madison. Level 0 data are ingested approximately four times per day for each satellite. Level 1A and 1B Radiance (1A-RAD, 1B-RAD) data products are nominally processed on a delay of at least four days from ingest of the Level 0 science data, allowing for data sent from the spacecraft out of chronological order to be incorporated. The AUX-MET data products require the observational ground footprint information from the 1B-RAD granules, and are therefore nominally processed just after the 1B-RAD data product granules are produced (the additionally required GEOS-IT meteorological analysis data are typically available with a delay of less than a day from real time).

1.2.1 Spatial characteristics

The PREFIRE-TIRS instruments collect data continuously in a pushbroom mode, with an integration time of 0.7 seconds for each data frame. Each data frame contains a spectral measurement from each cross-track scene collected simultaneously. Within this continuous data collection, there are planned interruptions due to calibration cycles or data downlinks, and there are also occasional interruptions due to unplanned instrument operations changes or outages. Each calibration cycle takes ~18.7 seconds for PREFIRE-TIRS1 and ~9.7 seconds for PREFIRE-TIRS2, which implies a gap of approximately 27 and 14 data frames, respectively. Data downlinks create data gaps of up to 13 minutes, and the exact length varies.

Within the orbital swath there are eight distinct tracks of data associated with the eight separate spatial scenes for each PREFIRE-TIRS. The approximate scene footprint sizes are 11.8 km x 34.8 km (cross-track x along-track), with gaps between each scene of approximately 24.2 km. The swath itself is ~264 km across. Note that the scene footprint and swath sizes quoted here are for the orbit altitude soon after launch. However, the footprint size will slowly become smaller as the orbit altitude decreases with time. Do not assume constant footprint or swath dimensions.

PREFIRE-TIRS spatial footprints overlap each other in the along-track dimension. Assuming that no data are missing, any given point along the orbit swath will be observed by up to about 7 overlapping footprints in the along-track direction. The number of footprints that overlap a given footprint will slowly become smaller during the mission, as the satellites’ orbital altitudes decrease. Do not assume an integer number of overlapping footprints.

A single data file or granule consists of data collected during approximately one orbit, beginning and ending near the equator to avoid granule borders over the polar regions. Data files are NetCDF4 format and approximately 60–70 MB in size. These data collections are archived at the ASDC DAAC and can be found at https://asdc.larc.nasa.gov/project/PREFIRE/PREFIRE_SAT1_AUX-MET_R01 and https://asdc.larc.nasa.gov/project/PREFIRE/PREFIRE_SAT2_AUX-MET_R01.

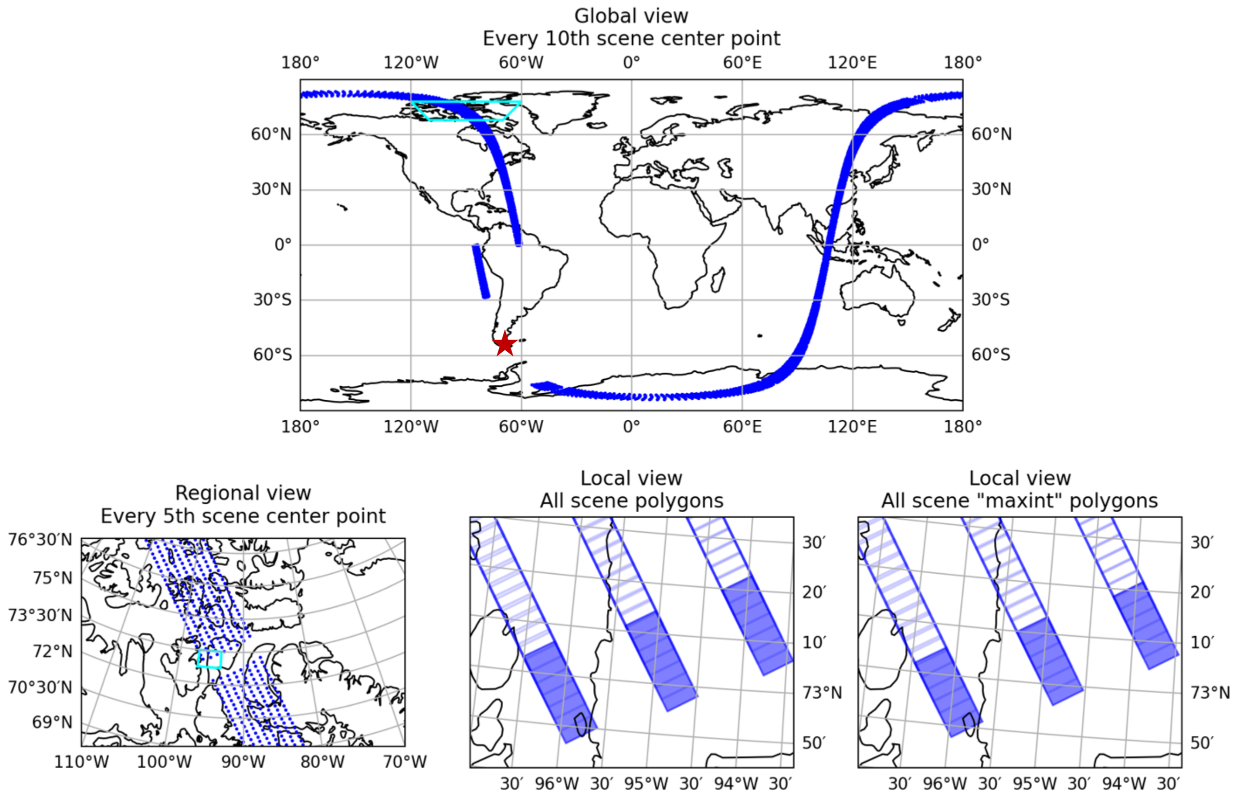

Figure 1-1. An example geolocated orbit (top panel) and focused regional and local plots (bottom panels). The global plot was selected to illustrate a data gap due to a data downlink at the Punta Arenas, Chile ground station, from approximately -70°S to -30°S on the ascending pass at the end of the granule. The zoomed in regional view (lower left) shows the data within the small cyan box in the global plot, and illustrates a smaller data gap due to instrument calibration. The local views (lower middle and right) show the actual scene ground footprint polygons, for the cyan box denoted in the regional view. The first scene's polygon is filled blue, to illustrate the shape of the full field of view (FOV) for one data integration. During the 0.7 second integration time, the satellite moves along track slightly more than 5 km, which means the leading and trailing edges of the instantaneous FOV have translated forward by the same amount. The lower right plot shows the "max integration" footprint polygon, which includes the interior portion of the scene footprint that was within the sensor field of view for the entire integration period.

1.3 Purpose

The PREFIRE AUX-MET product contains auxiliary data from the NASA Goddard Earth Observing System for Instrument Teams (GEOS-IT) meteorological analysis and other geospatial datasets matched in space and time to PREFIRE-TIRS FOVs. These auxiliary data are used as prior information for the Level 2 retrieval algorithms and to provide contextual information for scientific analysis of PREFIRE data.

2 Product Description

PREFIRE Auxiliary Meteorology data consist of GEOS-IT meteorological analysis and other geospatial data matched and interpolated to PREFIRE observational ground footprints. Inputs to the AUX-MET algorithm are as follows:

1. Level 1B Radiance data (collections PREFIRE_SAT1_1B-RAD and PREFIRE_SAT2_1B- RAD)
2. The GEOS-IT meteorological analysis datafiles
3. The Copernicus Atmosphere Monitoring Service (CAMS) EGG4 reanalysis
4. The NOAA STAR JPSS VIIRS International Geosphere-Biosphere Programme (IGBP) annual surface classification
5. The Scientific Committee on Antarctic Research (SCAR) Antarctic Digital Database (ADD) Antarctic coastlines shapefile

2.1 Algorithm description

Four auxiliary datasets are matched to PREFIRE fields of view using the AUX-MET algorithm.

(1) The GEOS-IT product is a stable global meteorological reanalysis dataset that is generated for NASA's Instrument Teams with about 50 km spatial resolution. GEOS-IT temporal resolution is 1-hourly for single-level fields and 3-hourly for the fields provided on the 72 terrain-following vertical model levels.

Because the GEOS-IT spatial resolution is somewhat coarser than the size of TIRS FOVs, GEOS-IT fields are linearly interpolated to TIRS FOV center points. The spatial interpolation from the GEOS-IT cubed sphere grid to TIRS FOV centers is performed using the ESMPy Python interface to the Earth System Modeling Framework (ESMF) regridding utility. The temporal interpolation from the GEOS-IT 1-hourly or 3-hourly collections to TIRS FOV times is performed internally in the AUX-MET algorithm code.

For vertical profile variables, an adjustment is made at the near-surface levels to correct for the difference between the actual surface altitude (contained in the 1B-RAD *Geometry* group) and the altitude of the lowest GEOS-IT model level. After recalculating the pressures of the terrain-following GEOS-IT model levels using the actual surface altitude, the near-surface data are interpolated (extrapolated) to the corrected near-surface pressure levels in cases where the actual surface elevation is higher (lower) than the GEOS-IT surface elevation. As a final step, GEOS-IT vertical profile variables are vertically interpolated from the 72 terrain-following model levels to the 101 fixed pressure levels required by the principal component-based radiative transfer model (PCRTM) that some of the Level 2 algorithms use. Each final PCRTM temperature value is a linear combination of the last valid temperature value in the surface-corrected GEOS-IT temperature profile, and a temperature that was linearly extrapolated to the next PCRTM level. The linear combination prevents the extrapolation from introducing an unrealistically-large temperature change in the PCRTM layer straddling the surface pressure level. For all other profile variables besides temperature, the value at the first GEOS-IT level above the surface is simply copied to the PCRTM below-surface levels.

(2) The Copernicus Atmosphere Monitoring Service (CAMS) EGG4 reanalysis is used as a basis for estimates of partial CO_2 and CH_4 concentrations at TIRS FOVs (*xco2* and *xch4* in the *Aux-Met* data group). CAMS EGG4 data are available for the period 2003–2020 with 3-hourly temporal resolution and 0.75° latitude/longitude spatial resolution. To create extrapolated AUX-MET CO_2 and CH_4 estimates from this climatology during the PREFIRE mission period, a polynomial fit with linear and harmonic components is applied to zonally-averaged historical CO_2 and CH_4 values, and a B-spline representation is used to smooth the shapes of these linear and harmonic model coefficients across latitudes. The resulting estimated CO_2 and CH_4 values at TIRS FOVs vary as a function of latitude and time, where time incorporates the secular trend and seasonality.

(3) The International Geosphere-Biosphere Programme (IGBP) surface classification of each TIRS FOV is derived from the NOAA STAR JPSS VIIRS Surface Type data product. Due to the fine (30 arc-second) spatial resolution of this product, many pixels are contained with each TIRS FOV, so *VIIRS_surface_type* (in the *Aux-Met* data group) is provided as counts of VIIRS pixels per IGBP surface class within each TIRS FOV. The VIIRS surface type product is provided as annual files incorporating data from all available JPSS satellites for that year, and the AUX-MET code matches the TIRS FOV times to the appropriate year's VIIRS surface type file.

(4) The Scientific Committee on Antarctic Research (SCAR) Antarctic Digital Database (ADD) "Medium resolution vector polygons of the Antarctic coastline" shapefile dataset is used to calculate AUX-MET fractional Antarctic ice shelf (*antarctic_ice_shelf_fraction*) and land area (*antarctic_land_fraction*) within TIRS FOVs located poleward of 60°S latitude. The features labeled "ice shelf", "ice tongue", and "rumple" in the source shapefiles are all categorized as ice shelves by the AUX-MET algorithm. This dataset is typically updated either annually or twice a year to incorporate changes to Antarctica's ice shelves, and the AUX-MET code matches the TIRS FOV times to the nearest-in-time version of the shapefile.

As a final step in the AUX-MET processing, a "preliminary" merged surface type is calculated (*merged_surface_type_prelim* in the *Aux-Met* data group). This merged surface type incorporates information from the Antarctic land fraction (poleward of 60°S) and 1B-RAD land fraction (all other latitudes), VIIRS surface type, and GEOS-IT sea ice and snow cover to classify the TIRS FOV into one of eight surface type categories. The surface type is considered "preliminary" because a "final" surface type, incorporating additional satellite-derived sea ice and snow cover products (where/when available), is calculated in the AUX-SAT product. The full logic for determining the preliminary surface type for each TIRS FOV is shown in the flow chart below (Figure 2-1).

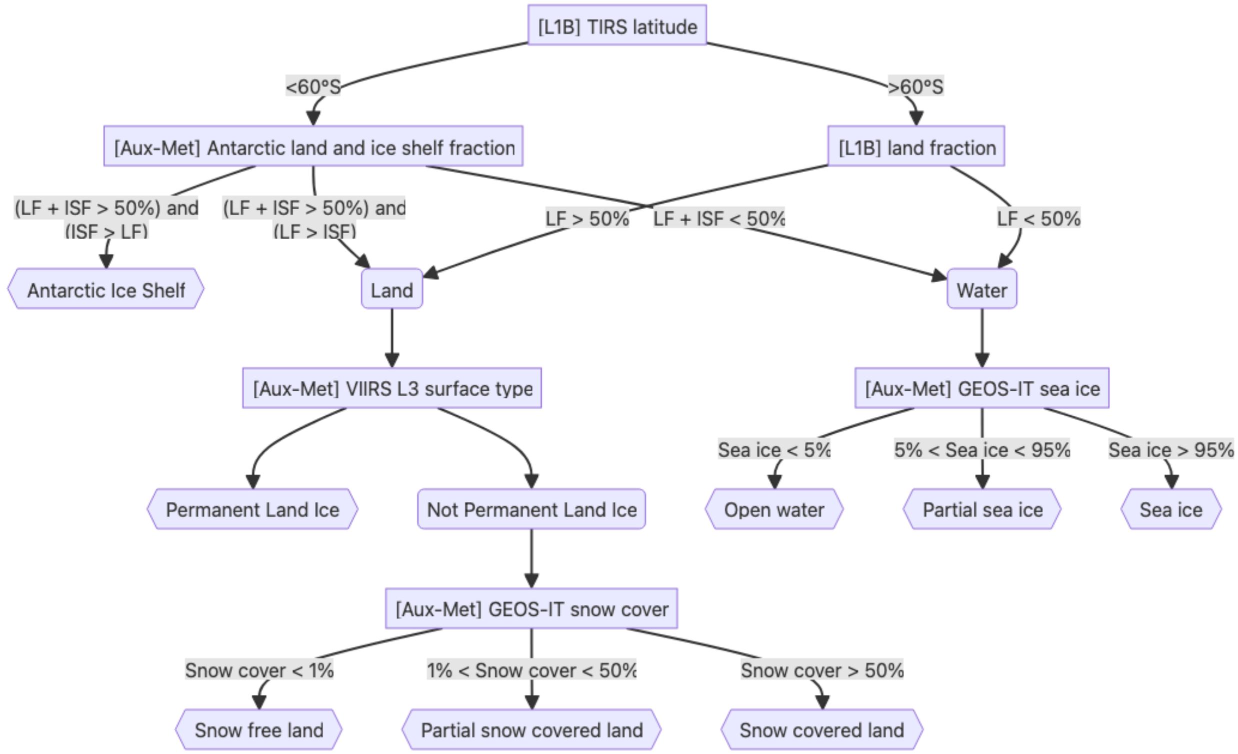

Figure 2-1. Flow chart showing PREFIRE AUX-MET "preliminary" surface type determination method. Square boxes represent data sources and gray-shaded text indicates one or more conditions applied to these data sources. Boxes with rounded edges are intermediate surface type classifications and hexagons are the final output of the algorithm that is stored as the "preliminary" surface type (*merged_surface_type_prelim*) in the AUX-MET data product. Figure 2-2 illustrates what this field looks like when plotted on a map.

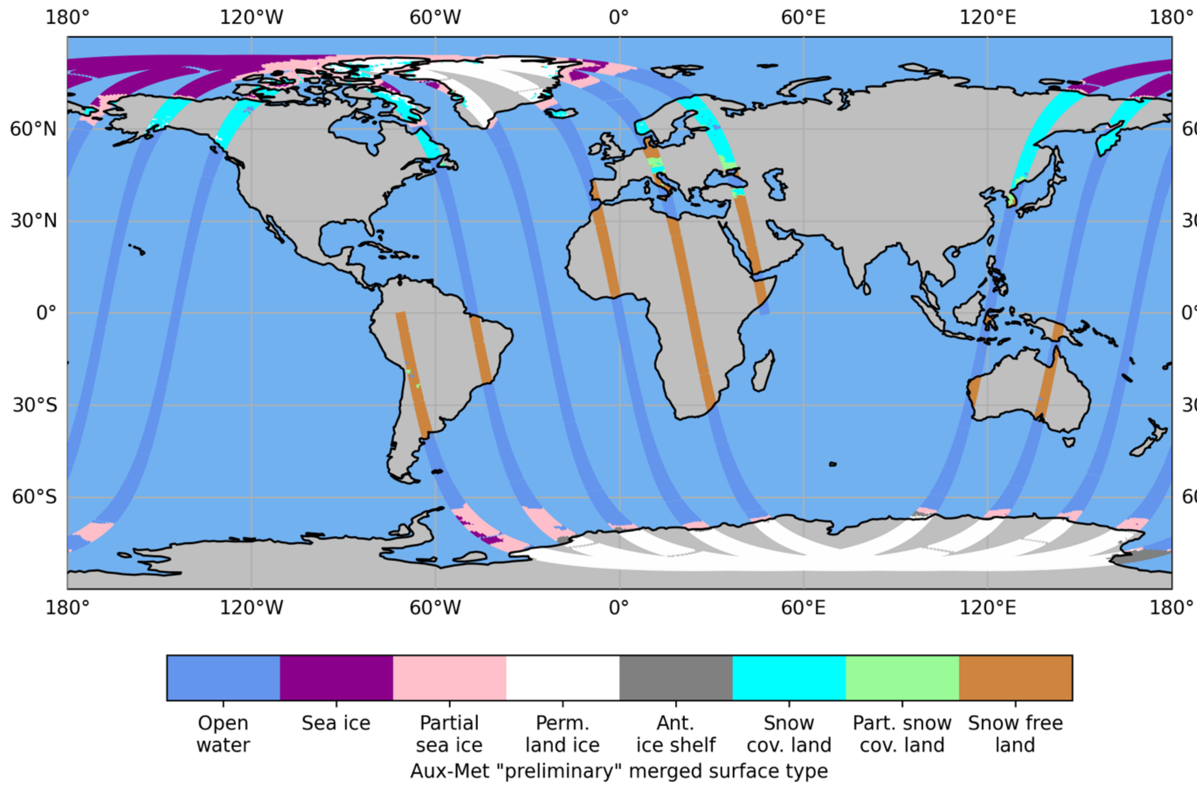

Figure 2-22. “Preliminary” merged surface type from five PREFIRE-SAT2 AUX-MET granules on 2025-01-07.

To further illustrate the spatial distribution of values within the AUX-MET data product, AUX-MET skin temperature (*skin temp* in the *Aux-Met* data group) is plotted here at global (Fig. 2-3) and regional (Fig. 2-4) scales. <u>In particular, note that the AUX-MET granules provide no information outside the PREFIRE-TIRS FOVs.</u>

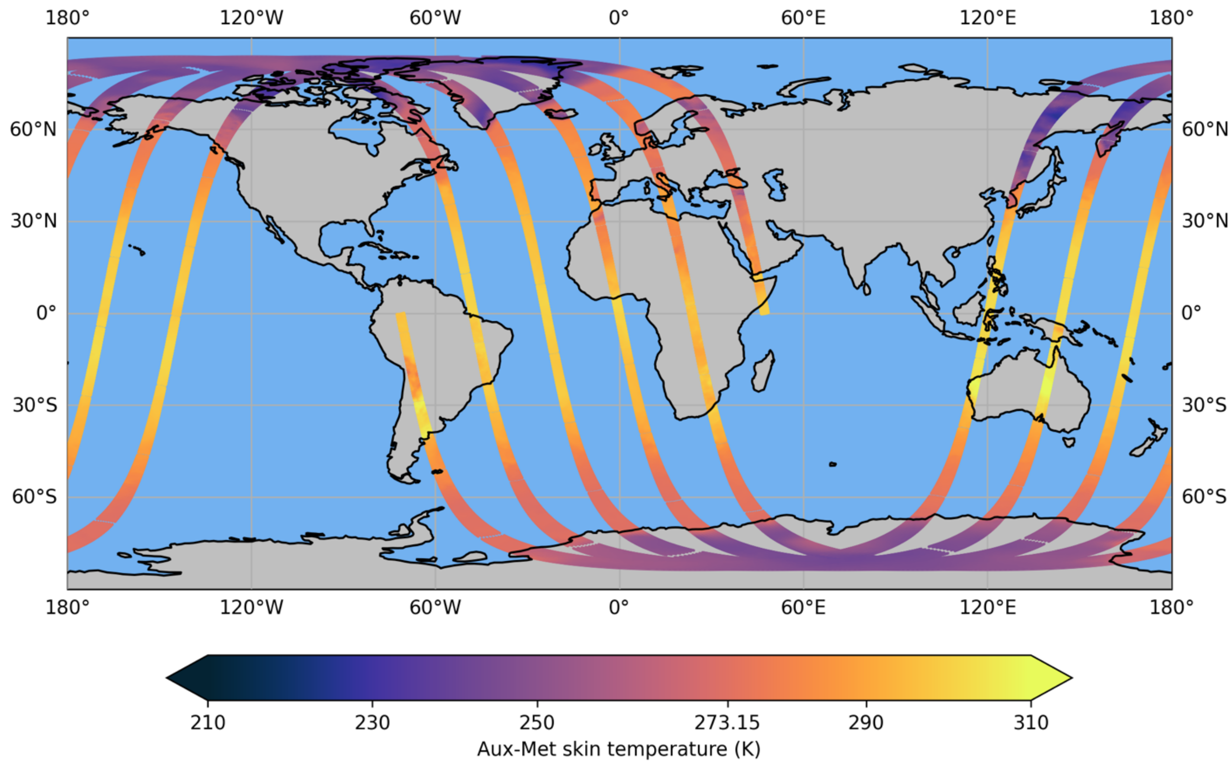

Figure 2-3. Skin temperature from five PREFIRE-SAT2 AUX-MET granules on 2025-01-07.

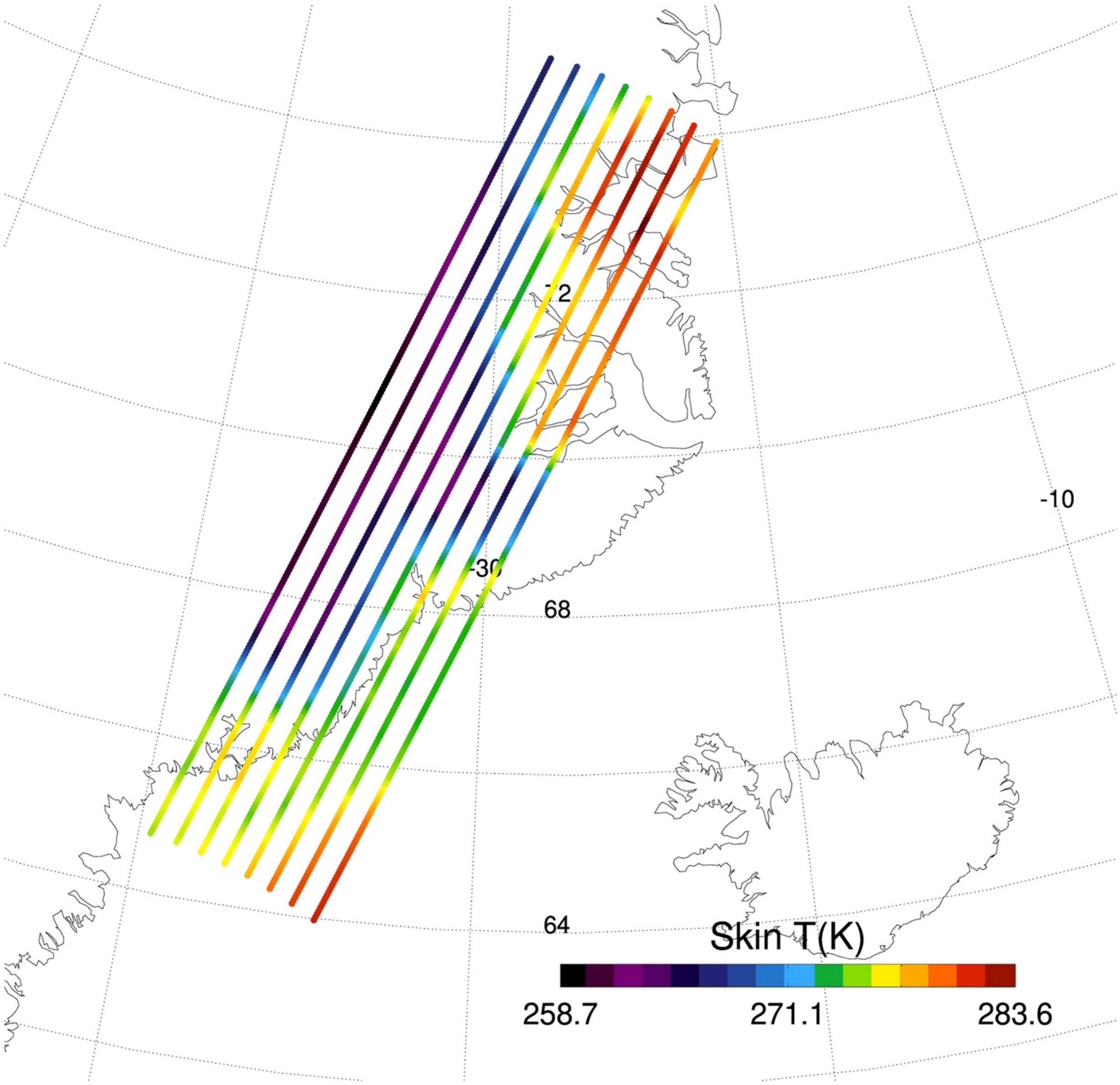

Figure 2-4. Skin temperature from an example granule segment along the east coast of Greenland from PREFIRE-SAT2 AUX-MET granule ID 00659 on 2024-07-07.

2.2 File Specifications

2.2.1 File naming convention

File names for this collection follow the following convention:

PREFIRE_SAT*<satID>*_*<product ID>* _*<collection version>*_*<internal product version>*_*<YYYYMMDDhhmmss>*_*<granule-ID>*.nc

For example, a representative Auxiliary Meteorology (AUX-MET) product granule collected by PREFIRE-SAT1 on June 1, 2024 would have the following filename:

PREFIRE_SAT1_AUX-MET_R01_P00_20240601185321_00123.nc

2.2.2 File format

PREFIRE AUX-MET data product files are created in NetCDF4 format with standard metadata. These files can be read with standard NetCDF libraries available in all popular scripting languages and many data visualization programs.

2.2.3 Quality flag and bitflags conventions

Because AUX-MET data are the result of matching external data sources to PREFIRE-TIRS observation geometry, no unique quality flags are required in the AUX-MET product. Where PREFIRE-TIRS geolocation data are missing in the upstream 1B-RAD product, AUX-MET data will also be missing.

2.2.4 Variables

The variable specifications for this collection are described below, with one table devoted to each top-level data group in the NetCDF4 file: *Geometry*, *Aux-Met*. Note that the *Geometry* group, including all variables, is propagated to every downstream Auxiliary and Level 2 data product from the Level 1B Radiance product (1B-RAD).

2.2.5 Variable dimensions

A summary of all array dimensions is given in Table 2-1. The *xtrack* dimension is equal to the number of cross-track scenes (8, for both instruments), the *spectral* dimension is equal to the number of spectral channels (63, for both instruments), and the *atrack* dimension is equal to the number of along-track Earth observation data frames in the product. The number of along-track frames varies from orbit to orbit, depending on the timing of downlink contacts, calibration data, and other rarer events. Generally, the maximum is around 7700–7900 frames in one product file, with substantially fewer in granules containing downlinks or unplanned instrument/spacecraft events.

Table 2--1

Dimension	**Abbreviation**
Along track	*atrack*
Cross track	*xtrack*
Vertical coordinates	*zlevels*
IGBP classes	*n_igbp_classes*
UTC parts	*UTC_parts* (= 7)
FOV (footprint) vertices	*FOV_vertices* (= 4)

Dimension label	**Definition (C-order)**
1D	(*atrack*)
1Dz	(*zlevels*)
2D	(*atrack, xtrack*)
3D	(*atrack, xtrack, zlevels*)
3Di	(*atrack, xtrack, n_igbp_classes*)

2.2.5.1 *Geometry* group

The *Geometry* data group consists of all timing, observation geometry, and geolocation variables produced during Level 1B processing (see Table 2-2). This data group and its contents will be replicated within any relevant downstream product (e.g., Level 2 data products), rather than stored as a separate geometry file.

Users of NetCDF software packages that try to automatically decode times should be aware that these packages may incorrectly interpret the *ctime* variable as a UTC time. The *ctime* variable is a count of total fractional SI seconds since the epoch 2000-01-01T00:00:00 UTC (i.e., no leap second adjustments since that epoch), while the UTC time standard is adjusted to account for all leap seconds. For example, when the PREFIRE *Geometry* group is read by the open_dataset function of the Python xarray package using the default decode_times=True argument, the resulting *ctime* values (with datetime64 data type) will differ from the *time_UTC_values* variable by the number of leap seconds that occurred between 2000-01-01T00:00:00 UTC and the observation time. Users of xarray and other packages that exhibit this behavior are recommended to use *ctime* along with *ctime_minus_UTC* to calculate UTC times if desired, and/or consult *time_UTC_values* to verify the correct UTC timestamps of PREFIRE observations.

For example, for an xarray dataset, a datetime64 DataArray could be computed as follows:

```
import xarray as xr
ds = xr.open_dataset({path_to_1B-RAD_product}, group='Geometry')
ds['UTC_dt64'] = ds['ctime'] – ds['ctime_minus_UTC']
```

Further details on the handling of leap seconds in the CF NetCDF Metadata Conventions can be found in Section 4.4.1 of the CF-1.9 Conventions: https://cfconventions.org/Data/cf-conventions/cf-conventions-1.9/cf-conventions.html#calendar.

Table 2--2

Variable Name	Type	Dimen-	Units	Description

		sion		
obs_ID	int64	2D		unique integer identifier for each TIRS look YYYYMMDDhhmmsstbd, composed of UTC date (YYYYMMDD) and time (hhmmss) at TIRS image integration midpoint, t = tenths of seconds [0–9], b = satellite number [1–2], d = scene number [1–8]
ctime	float64	1D	seconds	continuous time since the epoch 2000-01-01T00:00:00 UTC (i.e., similar to TAI) at the midpoint of each TIRS image integration
ctime_minus_UTC	int8	1D	seconds	continuous time minus UTC (i.e., leap seconds since the ctime epoch) at the midpoint of each TIRS image integration
time_UTC_values	int16	2Du	various	UTC datetime at the midpoint of each TIRS image integration, represented as an integer array. Array parts: year, month, day, hour, minute, second, millisecond
latitude	float32	2D	degrees_ north	topography-corrected latitude of FOV centroid
longitude	float32	2D	degrees_ east	topography-corrected longitude of FOV centroid
vertex_latitude	float32	3Dv	degrees_ north	topography-corrected latitude for each of the four vertices/corners (arranged counterclockwise starting at the trailing-left corner) of a 4-sided polygon that closely approximates the geolocated FOV (orbital motion taken into account)
vertex_longitude	float32	3Dv	degrees_ east	topography-corrected longitude for each of the four vertices/corners (arranged counterclockwise starting at the trailing-left corner) of a 4-sided polygon that closely approximates the geolocated FOV (orbital motion taken into account)
land_fraction	float32	2D		land_area / total_area (remainder is water_area) within the FOV, according to the Digital Elevation Model (DEM)
elevation	float32	2D	m	mean topographic elevation within the FOV
elevation_stdev	float32	2D	m	standard deviation of topographic elevation within the FOV
viewing_zenith_angle	float32	2D	degrees	viewing zenith angle at the FOV

				centroid
viewing_azimuth_angle	float32	2D	degrees	viewing azimuth angle at the FOV centroid (zero is north, clockwise-positive looking down from the zenith)
solar_zenith_angle	float32	2D	degrees	solar zenith angle at the FOV centroid
solar_azimuth_angle	float32	2D	degrees	solar azimuth angle at the FOV centroid (zero is north, clockwise-positive looking down from the zenith)
solar_distance	float64	2D	km	distance from FOV centroid to the solar barycenter
subsat_latitude	float32	1D	degrees_north	sub-satellite latitude
subsat_longitude	float32	1D	degrees_east	sub-satellite longitude
sat_altitude	float32	1D	km	satellite altitude above the reference ellipsoid (at the sub-satellite point)
sat_solar_illumination_flag	int8	1D		flag specifying whether the spacecraft is illuminated by the sun; 0=no, 1=partial, 2=full
geoloc_quality_bitflags	uint16	2D		integer composed of bit flags that contain info about the quality of the overall geolocation of each along-track frame of scenes
maxintgz_verts_lat	float32	3Dv		latitude (topography-corrected) for each of the four vertices/corners (arranged counterclockwise starting at the trailing-left corner) of a 4-sided polygon that closely approximates the geolocated zone with the maximum TIRS image integration time
maxintgz_verts_lon	float32	3Dv		longitude (topography-corrected) for each of the four vertices/corners (arranged counterclockwise starting at the trailing-left corner) of a 4-sided polygon that closely approximates the geolocated zone with the maximum TIRS image integration time
orbit_phase_metric	float32	1D	degrees	orbit phase angular metric (range of 0-360 degrees, varying approximately linearly with time), defined as 0 deg at the ascending node (northward equator crossing) of the satellite orbit, 180 deg at the descending node, and so on
satellite_pass_type	int8	1D		flag specifying which type of satellite pass each frame is mostly/all part of. −1 = descending, 1 = ascending

2.2.5.2 *Aux-Met* group

Table 2--3

Variable Name	**Type**	**Dim-ension**	**Units**	**Description**
elevation_correction	float32	2D	m	difference between 1B-RAD surface topographic elevation and interpolated surface elevation from gridded meteorological analysis dataset
below_surface_flag	int8	3D		flag for PCRTM pressure levels that are below the surface elevation for a given FOV: (0) above surface, (1) below surface
land_surface_temp	float32	2D	K	land surface temperature, including snow (populated only for FOVs where met analysis land fraction > 0)
skin_temp	float32	2D	K	surface skin temperature (available over all surfaces)
temp_2m	float32	2D	K	air temperature at 2 meters above the displacement height
temp_10m	float32	2D	K	air temperature at 10 meters above the displacement height
surface_phi	float32	2D	m^2/s^2	geopotential at the surface
land_fraction	float32	2D		land fraction (land area / total area) from met analysis
seaice_concentration	float32	2D		fractional sea ice concentration (sea ice area / total water area) ranging from 0 to 1
snow_cover	float32	2D		fractional snow cover (snow covered land area / total land area), populated only for FOVs where met analysis land fraction > 0
surface_pressure	float32	2D	hPa	air pressure at the surface
temp_profile	float32	3D	K	vertical air temperature profile
wv_profile	float32	3D	g/kg	vertical profile of specific humidity
total_column_wv	float32	2D	kg/m^2	total column water vapor
o3_profile	float32	3D	ppm	vertical profile of ozone concentration
pressure_profile	float32	1Dz	hPa	air pressure profile (fixed pressure levels)
altitude_profile	float32	3D	m	vertical profile of altitude (geopotential height) above the ground surface
u_profile	float32	3D	m/s	vertical profile of eastward wind component
v_profile	float32	3D	m/s	vertical profile of northward wind component
omega_profile	float32	3D	Pa/s	vertical profile of vertical pressure velocity
u_10m	float32	2D	m/s	eastward wind component at 10 m above the displacement height
v_10m	float32	2D	m/s	northward wind component at 10 m above the displacement height
xco2	float32	2D	ppm	carbon dioxide concentration extrapolated from CAMS EGG4 reanalysis
xch4	float32	2D	ppm	methane concentration extrapolated from

				CAMS EGG4 reanalysis
VIIRS_surface_type	int16	3Di		count of VIIRS pixels per IGBP surface class within this TIRS FOV (dimension n_igbp_classes is indexed in the same order as the 17 IGBP surface classes, e.g., the first index of that dimension references the count of VIIRS pixels of IGBP class 1), from the VIIRS annual blended surface type product
antarctic_land_fraction	float32	2D		land area fraction (land area / land + water + ice_shelf area) from BAS medium-resolution Antarctic coastlines dataset (populated only for FOVs < 60S latitude)
antarctic_ice_shelf_fraction	float32	2D		fractional ice shelf area (ice_shelf area / land + water + ice_shelf area) from BAS medium-resolution Antarctic coastlines dataset (populated only for FOVs < 60S latitude)
merged_surface_type_prelim	int8	2D		preliminary merged surface type using coastline data plus met analysis sea ice and snow cover data: 1=open water, 2=sea ice, 3=partial sea ice, 4=permanent land ice, 5=Antarctic ice shelf, 6=snow-covered land, 7=partial-snow-covered land, 8=snow-free land
merged_land_fraction_prelim_data_source	int8	2D		land fraction data source used to determine preliminary merged surface type: 1=Copernicus GLO-90 DEM, 2=BAS Antarctic med-res Antarctic coastline
merged_seaice_prelim_data_source	int8	2D		sea ice data source used to determine preliminary merged surface type: 7=GEOS-IT
merged_snow_prelim_data_source	int8	2D		snow cover data source used to determine preliminary merged surface type: 7=GEOS-IT

3 Updates Since Previous Version

None – this is the initial version.

4 Known Issues

Irregularities resulting from interpolation to fixed PCRTM vertical grid:

1. Users of the *temp_profile* variable (in the *Aux-Met* data group) should be aware that irregularities in the temperature profiles at near-surface levels can be introduced by the surface altitude correction and the interpolation to PCRTM fixed pressure levels. These

irregularities are likely to be most pronounced where a temperature inversion exists in the GEOS-IT profile and there is a substantial difference between the GEOS-IT surface elevation and the actual surface elevation contained in the 1B-RAD *Geometry* group. The *elevation_correction* variable in the AUX-MET product contains the difference between the 1B-RAD surface topography and the GEOS-IT surface, which can help identify vertical profiles where large surface corrections occurred. More generally, there is some loss of near-surface information in all vertical profile variables because the PCRTM fixed pressure level grid has coarser vertical resolution near the surface than the terrain-following GEOS-IT vertical levels.

2. Because the PCRTM fixed pressure levels range from 0.005 to 1100 hPa, some of these levels will be below the surface for all TIRS FOVs. The *below_surface_flag* in the AUX-MET product indicates the PCRTM fixed levels that are below the surface for each TIRS FOV.

Geolocation:

The GPS receiver on PREFIRE-SAT1 has performed poorly since launch, and the GPS receiver on PREFIRE-SAT2 ceased to function well at the end of August 2024. Because of the lack of continuously reliable GPS position and time data, the time-dependent orbital position and velocity vectors used for geolocation are based on orbital reconstructions. This uses publicly available orbit element sets (e.g., Two-Line Element sets (TLEs)) based on ranging observations by the United States Space Force and other entities. The precision and accuracy of the orbit reconstruction is currently undergoing evaluation. In addition, residual uncertainties exist due to pointing offsets from lack of precise knowledge of the spectrometer slit orientation relative to the spacecraft. These uncertainties will be addressed after the orbit reconstruction is evaluated and optimized. The current best estimate is that individual geolocated scenes could have along-track geolocation errors of up to 50 km with an average of approximately 30 km (less than the along-track dimension of a ground footprint). The cross-track geolocation error has not been quantified, but the error is likely to be less than the cross-track scene width (approximately 12 km), based on favorable spatial correlations with co-located geostationary imagery collected in the MIR atmospheric window.

As more PREFIRE-TIRS data are collected and analyzed, the quantification of the geolocation biases will improve. Further refinements of the geolocation algorithm are planned, which will reduce these errors in future 1B-RAD data and downstream data product releases.

Electronic pattern noise:

Electrical cross talk between adjacent FPA detectors was largely mitigated by alternating the wiring polarity in the readout integrated circuits. However, residual pattern noise has been noted in both the raw data and the calibrated radiances. This noise is highly temporally correlated and impacts all spectral channels.

This electrical noise manifests in two primary ways. First, “sawtooth-like” patterns can be visible in an individual spectral observation, where the even and odd spectral channels have different radiometric biases. These patterns are generally visible in spectral residuals (observation –

modeled radiance). Due to the temporal correlation this pattern could be visible in multiple consecutive frames. Second, "striping" is visible when data from a selected channel are viewed spatially, where specific spatial scenes are clearly biased relative to the other scenes. Again, due to the temporal correlation these stripes will continue along track for some time. No data flagging is performed related to this pattern noise effect, but future developments in the calibration algorithm are planned to further reduce this noise.

5 Resources

Information about the Goddard Earth Observing System for Instrument Teams (GEOS-IT) dataset can be found at the NASA Global Modeling and Assimilation Office website (last accessed 25 Mar 2025): https://gmao.gsfc.nasa.gov/GMAO_products/GEOS-IT/

Information about the VIIRS annual surface type product can be found at the NOAA NESDIS STAR JPSS website (last accessed 25 Mar 2025): https://www.star.nesdis.noaa.gov/jpss/st.php

Information about the Copernicus Atmospheric Monitoring Service (CAMS) EGG4 reanalysis can be found at the Copernicus Atmospheric Data Store website (last accessed 25 Mar 2025): https://ads.atmosphere.copernicus.eu/datasets/cams-global-ghg-reanalysis-egg4?tab=overview

For more information, contact Erin Hokanson Wagner at prefire-sdps.admin@office365.wisc.edu.

6 References

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- PREFIRE_SAT2_AUX-MET_R01: 10.5067/PREFIRE-SAT2/PREFIRE/AUX-MET_L4.R01
- PREFIRE_SAT1_AUX-MET_R01: TBD