TROPESS Methane Level 2 Summary Data Product User Guide

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1 Introduction

1.1 Overview and Document Scope

This document is to be used as a quick start user guide for using the TROPESS methane (CH4) Level 2 Summary Product Files.

1.2 Dataset Description

This user guide describes the TROPESS Level 2 Summary Product Files for CH4.

Table 1. Dataset Description

Product Information	Description
Parameters	See Table 2, in section 2.1
Data Product Provenance	Refer to ReadMe document, section 1.3.4 Algorithm Version
Approximate file size	8 MB CrIS, 13 MB AIRS
Spatial coverage	Nominally 50S to 70N coverage on a subset of observations.
Temporal coverage	Each L2 nominal Summary file contains 1 day of data
File format	Netcdf
Vertical sensitivity	CH4 has sensitivity between approximately 800 hPa and the tropopause with approximately 1 degree of freedom.
Data quality	The data have undergone a pre-quality check, which involves checks for retrieval convergence and vertical sensitivity. Consequently, all summary product data is of good quality.
Observational uncertainty	Kulawik et al. (2020): 30 ppb single, 17 ppb daily, 10 ppb seasonal errors
Validation Stage	AIRS CH4 is at validation level 3 based on NASA guidelines (see below). CrIS CH4 is at validation stage 1 https://science.nasa.gov/earth-science/earth-science-data/data-maturity-levels
Retrieval Levels	26 levels: from surface to top-of-atmosphere
FillValues	-999
Retrieval terminology	Retrieval terminology is defined in TES ATBD TROPESS_ATBDv1.1.pdf (nasa.gov)

1.3 Filename

The Summary Products adhere to the following filename convention:

[TROPESS]_ [Instrument-Platform]_[ProductLevel]_[ProductType]_[ProductName]_[DateStamp]_[AlgorithmName]_[AlgorithmVersion]_[ProcessingStrategy]_[FormatVersion].nc

Example:

TROPESS_AIRS-Aqua_L2_Summary_CH4_20200912_MUSES_R1p11_FS_F0p1.nc

2 Product File Contents and Parameter Description

2.1   Variables listed in the 2 Summary Products

All data fields in CH4 summary products are shown in Table 2.

Table 2. Data Fields

Data Field Name	Long_Name/Description	Type	Dimensions	Undefined Value	Units
longitude	longitude of earth view target center	float	target	-999.0	degrees_east
latitude	latitude of earth view target center	float	target	-999.0	degrees_north
time	Earth view target mid time as International Atomic Time (TAI) seconds since 1993-01-01 00:00:00	double	target	-999.0	seconds since 1993-01-01 00:00:00
datetime_utc	UTC expressed as an array of integers year, month, day, hour, minute, second	int	target, datetime_utc _dim	-999	1
year_fraction	Year plus fraction of the	double	target	-999.0	year

Data Field Name	Long_Name/Description	Type	Dimensions	Undefined Value	Units
	year				
altitude	Altitude at each target	float	target, level	-999.0	m
pressure	Atmospheric pressure used for retrieval at each target.	float	target, level	-999.0	hPa
target_id	Unique id that identifies observations across all product files.	long	target	-999	1
x	Volume mixing ratio (VMR) of Methane relative to dry air (includes bias correction)	double	target, level	-999.0	1
xa	A priori state, as volume mixing ratio (VMR) relative to dry air	float	target, level	-999.0	1
x_col_p	Column-averaged dry air mixing ratio of methane for the column from 826 hPa to top of Atmosphere (TOA)	double	target	-999.0	1e-9
x_col_p_error	Observational uncertainty of the partial column average VMR	double	target	-999.0	1e-9
ak_x_col_p	Linearized column averaging kernel for the	double	target, level	-999.0	1

Data Field Name	Long_Name/Description	Type	Dimensions	Undefined Value	Units
	partial column from 826 hPa to Top of Atmosphere (TOA). Applies to x_col				
pwf_col_p	Partial pressure weighting function. Set of coefficients used for calculating the column averaged from 826 hPa to Top of Atmosphere (TOA).	double	target, level	-999.0	1
pwf_col	Full pressure weighting function. Set of coefficients used for calculating the column averaged from the surface to Top of Atmosphere (TOA).	double	target, level	-999.0	1
air_frac_col_p	The fraction of the airmass taken up by the column from 826 hPa to Top of Atmosphere (TOA).	double	target	-999.0	1
land_flag	If target is over land == 1, otherwise == 0	Int	target	-999	N/A
day_night_flag	If target is during the day == 1, otherwise == 0	Int	target	-999	N/A

Data Field Name	Long_Name/Description	Type	Dimensions	Undefined Value	Units

3 How to Compare TROPESS CH$_4$ columns to aircraft or model fields

Comparisons between remotely sensed data and *in situ* measurements or vertically-resolved model fields should account for the vertical sensitivity of the remotely sensed measurement and its uncertainty.   Otherwise, the error will be larger than the observation error that is included is this product.

An observation operator, which explicitly accounts for this sensitivity and facilitates comparisons with models and independent data, is applied in the following manner:

1) Select the CH$_4$ profile using the model or aircraft fields (for the purpose of this demonstration called *x_true*).

2) Construct the operation operator as the following:
$$H(\cdot)=h^T x_a + a^T((\cdot)-x_a)$$

where: **h**, the pressure weighting function, denoted as pwf_col_p in the product file, x_a, the a priori profile; **a**, the column averaging kernel, denoted as ak_x_col_p in the product file,

3) Apply observation operator to the CH$_4$ "true" profile:
$$\hat{x}_{true}=H(x_{true})$$

4) Compare: $\hat{x}_{true}$ to the satellite result, $\hat{x}$, denoted as x_col_p in the product file. The difference
$$\epsilon=\hat{x}_{true}-\hat{x}$$

Now accounts for the prior information and limited sensitivity in the retrieval. Differences larger than the predicted error, denoted as x_col_p_error in the file, are statistically significant.

3.1 Evaluating the TROPESS CH$_4$ sensitivity

The column averaging kernel, called ak_x_col_p, incorporates both the pressure weighting function and the sensitivity of the retrieval to the distribution of the state.   To investigate the sensitivity alone, calculate

$$a\_norm = ak\_x\_col\_p/pwf\_col* air\_frac\_col\_p$$

The term a_norm is the sensitivity versus pressure. A value of 1 for a_norm means perfect sensitivity, whereas a value of 0 means no sensitivity.

4 References

4.1 Citing these data

Please cite the following references if you intend to use these data:

1. Kulawik, S. S., Worden, J. R., Payne, V. H., Fu, D., Wofsy, S. C., McKain, K., Sweeney, C., Daube Jr., B. C., Lipton, A., Polonsky, I., He, Y., Cady-Pereira, K. E., Dlugokencky, E. J., Jacob, D. J., and Yin, Y.: Evaluation of single-footprint AIRS CH4 profile retrieval uncertainties using aircraft profile measurements, Atmos. Meas. Tech., 14, 335–354, https://doi.org/10.5194/amt-14-335-2021, 2021.

5 Validation Summary

See L2 Standard Products User's Guide for Validation Summary.

Appendix A. Bias correction and quality flags

The data in the L2 Summary Products have been pre-filtered for quality and bias corrected. See L2 Standard Product Use's guides for definitions.

Appendix B. Retrieval levels

The table below contains the nominal retrieval levels. For each sounding, the surface pressure level is inserted into the retrieval levels set. Any retrieval levels below the surface pressure level are omitted.

Index	Pressure [hPa]
1	1040.0000
2	1000.0000
3	825.4020
4	681.2910
5	562.3420
6	464.1600
7	383.1170
8	316.2270
9	261.0160
10	215.4440
11	161.5610
12	121.1520
13	90.8518
14	68.1295
15	51.0896
16	38.3119
17	28.7299
18	21.5443
19	16.1560
20	12.1153
21	9.0851
22	6.8129
23	4.6416
24	1.6156
25	0.6813
26	0.1000

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