Multi-parameter Retrieval User Guide

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Version V0.2 (May 15, 2024)

Change record

- 2024-05-15: Fixed capitalization in references
- 2024-03-20: First version of this user guide.

Contents

1 Introduction

This Document is intended for users of the multi-parameter retrieval product from the University of Bremen, Institute of Environmental Physics (IUP), available at https:seaice.uni-bremen.de.
These data are retrieved via inversion of a forward model using optimal estimation (Rückert et al., 2023) which is applied to microwave radiometer data of the sensors AMSR-E (Advanced Microwave Scanning Radiometer for EOS) on the NASA satellite Aqua, and AMSR2 (Advanced Microwave Scanning Radiometer 2) on the JAXA satellite GCOM-W1.
The retrieval product includes integrated water vapor (also called precipitable water), liquid water path, sea ice concentration, multi-year ice fraction, snow depth, snow-ice interface temperature and snow-air interface temperature as well as sea-surface temperature and wind speed (over open ocean). The parameters are retrieved simultaneously and are self-consistent. Over open ocean, the provided snow depth, snow-ice interface temperature and snow-air interface temperature are given by the a priori data and contain no additional information from the satellite measurements, likewise, over sea ice, sea-surface temperature and wind speed are given by the a priori data. The product is available for freezing conditions, that is, from October until May, and for the Arctic only.
The multi-parameter retrieval product is a research product providing several parameters and the retrieval uncertainty given by the inversion method. Its performance has partly been evaluated in Rückert et al. (2023) but there are still unknown uncertainties in addition to the ones provided. Use with caution. Please reach out to us if you compare this product to others, as we are interested in characterizing the uncertainties of our product better!

2 Input Data

Details about the input data from the two sensors AMSR-E and AMSR2 are specified in 1 Both

Sensor	Data	Level	Version	Time Range	Source
AMSR-E	brightness temp.	2A	4	2002-06-01 - 2011-10-04	NASA/JAXA[a]
AMSR2	brightness temp.	1R	2220220	2012-07-02 – today	JAXA[b]

[a] NASA National Snow and Ice Data Center Distributed Active Archive Center (Ashcroft and Wentz, 2019)
[b] JAXA G-Portal, https://gportal.jaxa.jp, and Maeda et al. (2016)

Table 1: *Input data for the multi-parameter retrieval algorithm. Note: Level = Processing Level, temp. = temperature.*

sensors are conically-scanning multifrequency total-power microwave radiometer observing at constant looking angle (55°), therefore, the scan lines are circle segments. The sensors measure the brightness temperature (i. e., microwave radiance) at several frequency channels at both horizontal (H) and vertical (V) polarization. The frequency channels relevant here are 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz.
The input data come as two files per orbit (i.e., two half-orbits) and contain the measured values in all channels for each satellite footprint and the geographical location of each footprint – this is called swath data. Swath data from both products (Level 1R in case of AMSR2 and Level 2A in case of AMSR-E) contain geolocated brightness temperatures at different frequencies that are resampled to a common (coarser) resolution: 75 km × 43 km (AMSR-E) and 62 km × 35 km (AMSR2).

3 Processing Chain

The main steps of the processing chain are the following:

- Reading swath data, AMSR-E L2A or AMSR2 L1R data
- Applying the multi-parameter retrieval algorithm to the swath data of brightness temperatures, resulting in swath-wise sets of nine parameters and their uncertainties
- Resampling (gridding) all swath data of one calendar day (UTC) into the Equal-Area Scalable Earth (EASE) grid with a spatial resolution of 25 km
- Saving the gridded data as maps in image format and as quantitative data in NetCDF format.

3.1 Multi-parameter retrieval algorithm

The forward model and inversion algorithm (optimal estimation method) are described in detail in Rückert et al. (2023). The retrieval requires prior information in terms of an a priori state for each satellite measurements which is based on climatologies and an a priori covariance matrix. In addition the uncertainty of the forward model and the measurements is included in the inversion scheme in terms of an effective error covariance. These auxiliary data is described in Rückert et al. (2023). In addition to the parameters (maximum a posteriori solution) each parameter comes with a retrieval uncertainty provided by the entries of the retrieved covariance matrix.

3.2 Gridding

All swath ice concentration data of one calendar day (with respect to UTC) are resampled (gridded) using the *resample_gauss* routine provided by the software package *pyresample* (Hoese et al., 2023). The data are weighted by a Gaussian with a provided σ of 5 km, a radius of 12.5 km and 12 neighbors. The data is gridded to the Equal-Area Scalable Earth (EASE) grid at 25 km grid spacing (about the grids, see https://nsidc.org/data/user-resources/help-center/guide-ease-grids). The EPSG code[1] is 6931.

3.3 Masking: Land and Erroneous Data

Land Mask The land mask for the data is inherent in AMSR-E and AMSR2 swath data: footprints with a non-zero land fraction are excluded. For the coastlines and land mask in the maps (the figures) the land mask and coastlines provided by the software *cartopy* (Met Office, 2010/2015) are used.

Erroneous Data There are two known cases in which the retrieval fails: either there is no convergence in the iterative procedure which is part of the inversion scheme or the retrieval runs into an upper limit, characterized by a snow depth of 50 cm. Both cases are excluded before the data is gridded.

[1] See http://www.epsg-registry.org/

4 Validation and Uncertainty Characterisation

The multi-parameter retrieval algorithm has been validated by comparison with in-situ observations from the MOSAiC expedition (https://mosaic-expedition.org/). For integrated water vapor a more extensive validation against radiosonde data has been performed, and selected parameters (snow depth, integrated water vapor, cloud liquid water and sea ice concentration) have been compared with retrievals using other satellite algorithms.
The optimal estimation method used for the inversion provides not only the most likely solution but also a retrieval uncertainty. These uncertainties are also included in the data product.

5 Product Description

The product comes in two formats (detail below):

- NetCDF file (ending with .nc) containing the gridded parameter data and its uncertainty
- image files (PNG) showing maps of each parameter and its uncertainty

Data access is via HTTP or FTP, see https://seaice.uni-bremen.de. The archive directory structure and file naming is best explained by an example:
`/mnt/web/data/MultiParameter/AMSR2/EASE_25/netcdf/2023/mpr_retrieval_amsr_20230524_ease_2`

where

AMSR2 : Sensor; `AMSR2` or `AMSR-E`

EASE_25 : Grid name and resolution in kilometer

netcdf : data format, `netcdf` or `figures`

2023 : Year

mpr_retrieval_amsr : Algorithm (multi-parameter retrieval, mpr) and sensor (amsr)

20230524 : Year, month and day in the format `YYYYMMDD`

ease_25 : grid resolution again

v0.2 : data product version

5.1 NetCDF

The NetCDF files contain the 2-dimensional fields of each parameter and its uncertainty at 25 km grid spacing. They also contain the needed projection and grid information. The NetCDF file follow the Climate and Forecast (CF) Metadata Conventions. A list of the variable names can be found in Table 2

5.2 Maps

The maps are produced using the software *cartopy* (Met Office, 2010/2015) adding coast lines, land and geographic grid lines to the parameter data. Different colour maps for each parameter are used. Example maps of one day are shown in Figure 1. Land is coloured grey. Note that the maps are not meant for quantitative data analysis.

name	long name	standard name (CF convention)
snd	snowdepth	surface_snow_thickness
iwv	integrated water vapor	atmosphere_mass_content_of_water_vapor
sic	sea ice concentration	sea_ice_area_fraction
myif	multi-year ice fraction	-
lwp	liquid water path	atmosphere_mass_content_of_cloud_liquid_water
tsi	snow-ice interface temperature	sea_ice_surface_temperature
tsa	snow-air interface temperature	surface_temperature
sst	sea surface temperature	sea_surface_temperature
wsp	wind speed	wind_speed
lon	longitude	longitude
lat	latitude	latitude
var_snd	variance of snd	-
var_iwv	variance of iwv	-
var_sic	variance of sic	-
var_myif	variance of myif	-
var_lwp	variance of lwp	-
var_tsi	variance of tsi	-
var_tsa	variance of tsa	-
var_sst	variance of sst	-
var_wsp	variance of wsp	-
crs	variable containing grid mapping information	

Table 2: *List of variables included in the NetCDF file*

6 First access

An example Jupyter notebook is available to access this dataset to make it easily accessible.

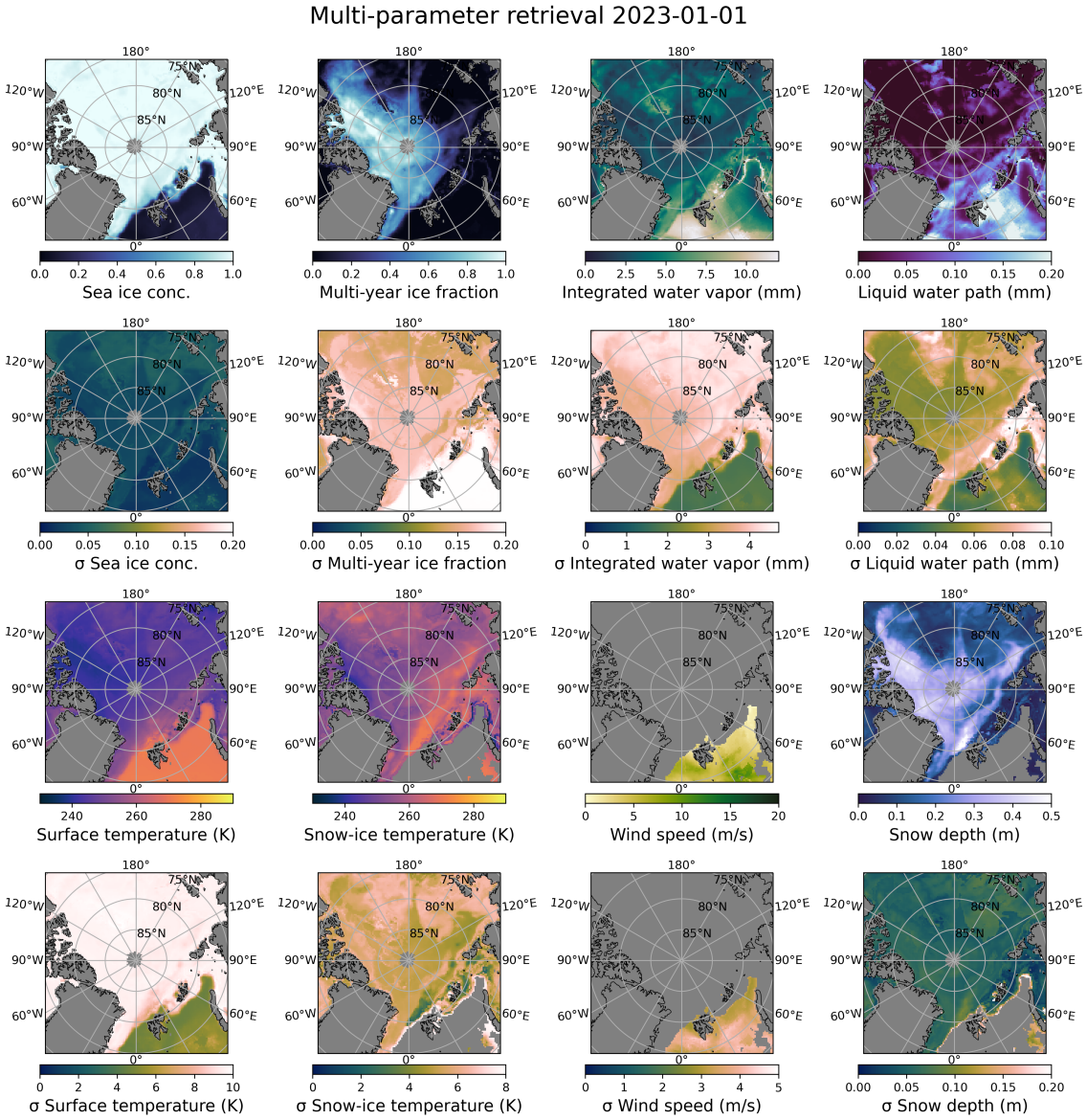

Figure 1: *Maps of retrieved parameters and their retrieved uncertainties for January 1, 2023.*

References

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