# Composite Arctic Total Water Vapour Data Set over Open Ocean, Sea Ice and Land Ice, based on AMSU-B and AMSR-E retrievals. User Guide

Institute of Environmental Physics, University of Bremen

*Arantxa M. Triana-Gómez, Christian Melsheimer, Georg Heygster, Gunnar Spreen*

Contact: melsheim@uni-bremen.de, aratri@uni-bremen.de

Version v1.0 (February 21, 2022)

## Contents

# 1 Introduction

This Document is intended for users of the composite AMSR-E/AMSU-B total water vapour (TWV) product from the University of Bremen, Institute of Environmental Physics (IUP). These data are retrieved with two algorithms, using microwave radiometer data from different sensor types. One retrieval over open ocean [10] using 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 other retrieval using data from AMSU-B (Advanced Microwave Sounding Unit-B) and MHS (Microwave Humidity Sounder) on board the NOAA (National Oceanic and Atmospheric Administration) 15 to 19 satellites and EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) Metop-A, Metop-B and Metop-C satellites. The AMSU-B/MHS algorithm was first implemented at IUP for the Arctic in [4], and the version used for this product is a modified one explained in the following sections.

# 2 Input data

Details of both algorithms used in the combined TWV product are specified in Table 1. Through this document, when we refer to AMSU-B/MHS TWV, the brightness temperature data used for the retrieval is always from from the Fundamental Climate Data Record [3], which provides an inter-satellite calibrated set of brightness temperatures as described in [2].

Table 1: Input data for the combined TWV product.

| Sensor used | Time Range | Source |
|---|---|---|
| AMSR-E/AMSR2 | 2002-06-01 - today | RSS Systems |
| AMSU-B/MHS | 1998-12-15 - today | IUP |

# 3 Processing chain

The main steps of processing the AMSU-B/MHS data are the following:

- Reading swath data of AMSU-B/MHS brightness temperatures.
- Applying the algorithm to the swath data of brightness temperatures. This involves resampling (gridding) all swath data of TWV of one calendar day (UTC) into latitude-longitude grids, and daily averaging of the TWV retrieval.
- Saving the gridded data in NetCDF and binary format.

For the composite algorithm i.e. the TWV values of the overlap in each daily data, a difference threshold $D = |TWV_1 - TWV_2|$ will be used, where $TWV_1$ is the AMSR-E/AMSR2 based retrieval and $TWV_2$ the AMSUB/MHS based one. If the difference between the retrieved values is smaller than 4 kg/m$^2$, a sigmoid function as presented in Figure 1 will be used to do a weighted average of both TWV values as shown in:

$$TWV_{comb} = s \cdot TWV_1 + (1 - s) \cdot TWV_2, \tag{1}$$

where $s$ is the sigmoid function, calculated as follows:.

$$s = 1 - \frac{1}{(1 + 3 \cdot \exp^{(-2 \cdot D)})^4} \quad (2)$$

When the difference $D$ is larger than 4 $kg/m^2$, the larger TWV value will be taken.

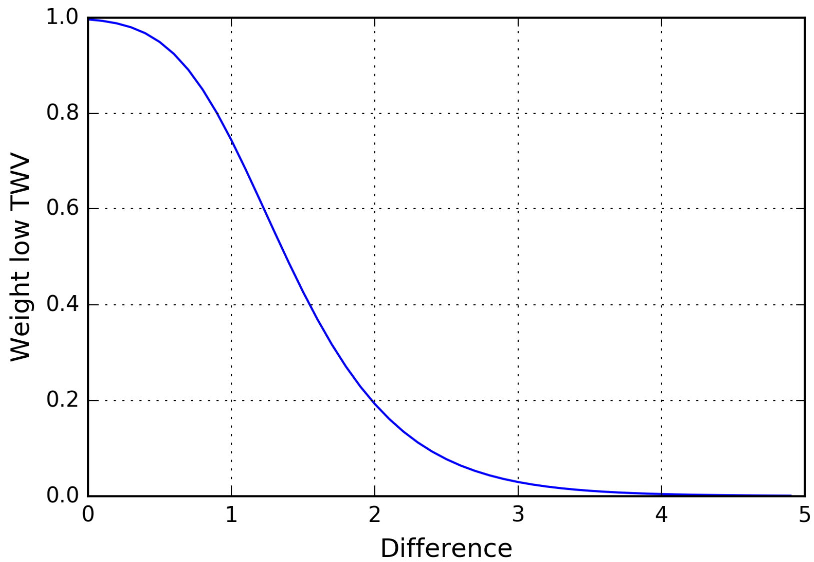


Figure 1: Weight of each TWV contribution dependent on the difference between retrievals.

### 3.1 AMSU-B/MHS algorithm

The key concept of this method is the use of several microwave channels of the AMSU-B/MHS sensors with similar surface emissivity but with different water vapor absorption. A detailed description of the algorithm can be found in [5] and [4]. A recent recent version of the algorithm, which includes a filter for TWV values influenced by ice clouds, is described in [8]. Additionally, for the version of the algorithm used in this product, a procedure was developed to merge the three "sub-algorithms" or retrieval regimes, that is, the three different channel triplets that are used for the retrieval, depending on the water vapour amount and the saturation of channels. Each sub-algorithm reaches its upper retrieval limit when the channel which is most sensitive to water-vapour becomes saturated. This procedure allows us to make better use of each sub-algorithm before it reaches saturation. To determine when to use each sub-algorithm in the range of overlap between them, an empirical error estimation was developed based on the comparison with radiosonde data. The standard deviation of the difference between AMSU-B TWV and the radiosonde TWV for each sub-algorithm was fitted to the corresponding water vapor values to provide an error fit function. Then, for the operating ranges of each sub-algorithm, a linear combination of each of them with the error fit used as weight to determine the final TWV value:

$$TWV = a \cdot TWV_1 + b \cdot TWV_2, \quad (3)$$

where the weights are $a = (error_1)^{-1}/[(error_1)^{-1} + (error_2)^{-1}]$ and $b = (error_2)^{-1}/[(error_1)^{-1} + (error_2)^{-1}]$

### 3.2 AMSR-E/AMSR2 algorithm

The Wentz and Meissner water vapour product [9] is retrieved worldwide using mainly the 22 GHz water vapour absorption line. It covers only the open water regions. A detailed description of the method can be found in [10].

## 4 Validation

Both datasets have been validated individually. For the TWV retrieved from AMSU-B/MHS you can refer to [7, 6, 1]. For the TWV retrieved from AMSR-E/AMSR2, see [9].

## 5 Product description

### 5.1 Png and NetCDF files

All daily maps are available in png and NetCDF format for discover and analysis, respectively.All files are generated using python and contain a 2-dimensional field of total water vapour at 0.25° grid spacing in a latitude-longitude (rows-columns) grid. The NetCDF files also contain the needed projection and grid information. They have the following name structure: TWV-version-yyyy-mm-dd.nc.

### 5.2 Data access and file structure

The png and NetCDF files can be found at the following link: `https://seaice.uni-bremen.de/data/WaterVapour/Composite/`. The file structure is as follows: The main folder contains

- year folders of TWV data sorted in month folders,
- latitude and longitude NetCDF files
- and a python script with functions to read the data.

### 5.3 Missing data

Between October of 2011 and June 2012, there is a data gap in the RSS retrieval, due to the gap between AMSR-E and AMSR2 datasets. For these months, we provide the AMSU-B/MHS retrieval as a partial dataset. A complete list of all the gaps in data from any of the datasets that form our composite can be found in the additional document "Missing data".

### 5.4 Data examples

Example maps of the individual and combined datasets for one day in 2008 are shown in Figure 2. Note that the maps are not meant for quantitative data analysis.

### 5.5 Acknowledgments

AMSR TWV data are produced by Remote Sensing Systems and were sponsored by the NASA AMSR-E Science Team and the NASA Earth Science MEaSUREs Program. Data is available at www.remss.com.

## References

[1] S. A. Buehler, S. Östman, C. Melsheimer, G. Holl, S. Eliasson, V. John, T. Blumenstock, F. Hase, G. Elgered, I. Pscheidt, S. Redl, and S. Steinke. A multi–instrument comparison of integrated water vapour measurements at a high latitude site. *Atmos. Chem. Phys.*, 12(10):10925–10943, 2012.

[2] R. Ferraro. AMSU-B/MHS Brightness Temperature - Climate Algorithm Theoretical Basis Document, NOAA Climate Data Record Program CDRP-ATBD-0801 rev. 1, 2016.

[3] R. Ferraro and H. Meng. NOAA climate data record (CDR) of Advanced Microwave Sounding Unit (AMSU)-B, version 1.0. [AMSU-B on board n17 2007-2009], 2016.

[4] C. Melsheimer and G. Heygster. Improved retrieval of total water vapor over polar regions from AMSU-B microwave radiometer data. *IEEE Trans. Geosci. Rem. Sens.*, 46:2307–2322, 2008.

[5] J. Miao. Retrieval of atmospheric water vapor content in polar regions using spaceborne microwave radiometry. *Alfred-Wegener Inst. Polar Marine Res., Bremerhaven, Germany*, 1998.

[6] M. Palm, C. Melsheimer, S. Noël, S. Heise, J. Notholt, J. Burrows, and O. Schrems. Integrated water vapour above Ny–Ålesund, Spitsbergen: a multi–sensor intercomparison. *Atmos. Chem. Phys.*, 10:1–12, 2010.

[7] A. Rinke, C. Melsheimer, L. Dethloff, and G. Heygster. Arctic total water vapour: Comparison of regional climate simulations with observations and simulated decadal trends. *J.Hydrometeorol.*, 10:113–129, 2009.

[8] A. M. Triana-Gómez, G. Heygster, C. Melsheimer, G. Spreen, M. Negusini, and B. H. Petkov. Improved water vapour retrieval from AMSU-B and MHS in the arctic. *Atmospheric Measurement Techniques*, 13(7):3697–3715, 2020.

[9] F. Wentz, C. Gentemann, and K. Hilburn. Three years of ocean products from AMSR-E: Evaluation and applications. *IEEE Trans. Geosci. Remote Sens.*, 2005.

[10] F. Wentz and T. Meissner. *AMSR ocean algorithm, Algorithm Theoretical Basis Document (ATBD). Version 2. Report number 121599A-1.* Remote Sensing Systems, Santa Rosa, CA, 2006, 2006.

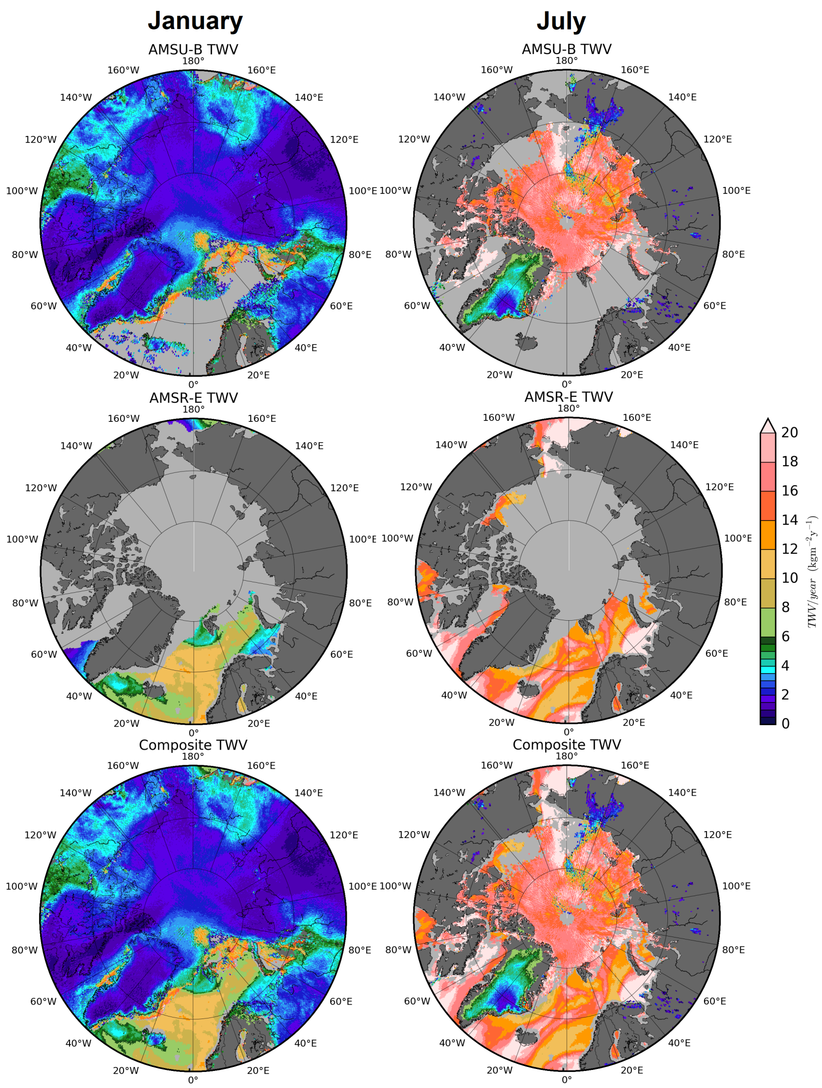


Figure 2: AMSU-B (top), AMSR-E (center) and combined (bottom) TWV retrievals for (left) winter (7 January, 2008), and (right) summer (7 July 2008)