ODATIS CLIMATE INDICATORS

WET TROPOSPHERE CORRECTION DERIVED FROM WATER VAPOUR CLIMATE DATA RECORDS

PRODUCT USER MANUAL

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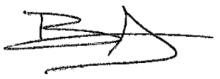
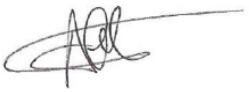
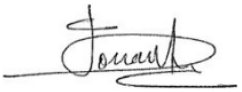
Written by :	Anne Barnoud	Magellium	16/11/2022	
Checked by :	Michaël Ablain	Magellium	16/11/2022	
Approved by :	Joël Dorandeu	Magellium	16/11/2022	

Document reference:	GIECCO-DT-083-MAG_WTC_from_WV_CDR_PUM
Edition.Revision:	1.0
Date Issued:	16/11/2022
Data Set Version:	V1

Document evolution sheet

Ed.	Rev.	Date	Purpose evolution	Comments
1	0	26/10/2020	Creation of document	

Contents

List of tables

1. Introduction

1.1. Scope

The standard global mean sea level (GMSL) record provided by AVISO+ uses the microwave radiometer (MWR) wet troposphere correction (WTC) which has a much better accuracy than WTC provided by operational models at the local scale. However due to lack of stability over time (Legeais et al., 2014), the MWR WTC is one of the most important contributors to the uncertainty on the GMSL record (Ablain et al., 2019; Guérou et al., 2022). To overcome the lack of long term stability of the MWR WTC, an alternative WTC computed from water vapour climate data records (CDRs) can be used (Barnoud et al., submitted).

The product contains the global mean WTC (GMWTC) combining the high frequencies (below 1 year) from the MWR and the low frequencies (above 1 year) derived from the water vapour CDRs. This solution is therefore stable over long periods of time and accurate over short time scales. The product also contains a GMSL record solution using the CDR-derived WTC and the correction to apply to the standard GMSL record computed with the MWR WTC to replace the latter by the combined MWR/CDR WTC for a more stable solution.

This document is the Product User Manual (PUM) of the product of WTC derived from water vapour CDRs. This is the primary document that users should read before handling the product. It provides an overview of processing algorithms and technical content of the product.

1.2. Document structure

In addition to this introduction, the PUM is organised as follows:

- Section 2 summarises the input data and algorithms involved in the derivation of the wet troposphere correction from water vapour data,
- Section 3 describes the content of the distributed product file,
- Section 4 explains how to access and use the data.

1.3. References

- Ablain, M., Meyssignac, B., Zawadzki, L., Jugier, R., Ribes, A., Spada, G., Benveniste, J., Cazenave, A., and Picot, N.: Uncertainty in satellite estimates of global mean sea-level changes, trend and acceleration, Earth Syst. Sci. Data, 11, 1189–1202, https://doi.org/10.5194/essd-11-1189-2019, 2019.
- Barnoud, A., Picard, B., Meyssignac, B., Marti, F., Ablain, M., and Roca, R.: Reducing the uncertainty in the satellite altimetry estimates of global mean sea level using highly stable water vapour climate data records, submitted.
- Guérou, A., Meyssignac, B., Prandi, P., Ablain, M., Ribes, A., and Bignalet-Cazalet, F.: Current observed global mean sea level rise and acceleration estimated from satellite altimetry and the associated uncertainty, All Depths/Remote Sensing/All Geographic Regions/Sea level/Oceans and climate, https://doi.org/10.5194/egusphere-2022-330, 2022.
- Legeais, J.-F., Ablain, M., and Thao, S.: Evaluation of wet troposphere path delays from atmospheric reanalyses and radiometers and their impact on the altimeter sea level, Ocean Sci., 10, 893–905, https://doi.org/10.5194/os-10-893-2014, 2014.

1.4. Acronyms

Table 1 lists the acronyms that are used in this document.

Acronym	Description
CDR	Climate data record
CM SAF	Satellite application facility on climate monitoring
DOI	Digital object identifier
GMSL	Global mean sea level
GMWTC	Global mean wet troposphere correction
HF	High frequencies
HOAPS	Hamburg ocean-atmosphere fluxes and parameters from satellite
L2P	Level-2+
LF	Low frequencies
MWR	Microwave radiometer
NetCDF	Network common data form
PUM	Product user manual
REMSS	Remote sensing systems
WTC	Wet troposphere correction

Table 1: List of acronyms.

2. Data and algorithm

2.1. Input data

The CDR-derived WTC product is based on the Level-2+ along-track altimetry products version 2021 (L2P 2021) distributed on the AVISO+ website (https://www.aviso.altimetry.fr).

We use water vapour CDRs from two datasets:

- REMSS V7.0 dataset providing data until 2021 (available at http://www.remss.com/measurements/atmospheric-water-vapor/tpw-1-deg-product/),
- HOAPS CM SAF V4.0 dataset providing data until 2014 (available at https://wui.cmsaf.eu).

2.2. Algorithm

The description of the computation of the alternative wet tropospheric correction for altimetry data using water vapour climate data records is detailed in Barnoud et al. (submitted). We recall here the main steps of the computation:

- spatio-temporal linear interpolation of the total column water vapour (TCWV) data along the tracks of the altimetry Level-2+ products,
- conversion of the TCWV to wet tropospheric correction (WTC) using the polynomial formula (Equation 1) and the coefficients provided by Barnoud et al. (submitted),
- gridding of wet troposphere corrections (MWR-based and CDR-derived) and sea level anomalies over 3°x1° (longitude x latitude) grids,
- computation of global mean wet troposphere corrections (GMWTC) and global mean sea level (GMSL) computed between -66° and +66° using the same method as the standard GMSL approach described on AVISO+ website (https://www.aviso.altimetry.fr/msl/),
- filtering of the low frequencies (above 1 year) of the GMWTCs,
- combination of the MWR high frequencies (HF) (MWR full series minus MWR low frequencies (LF) computed at the previous step) and CDR low frequencies to get a combined GMWTC,
- computation of the GMSL by replacing the GMWTC MWR low frequencies by the GMWTC CDR low frequencies.

$$WTC = (a_0 + a_1 TCWV + a_2 TCWV^2 + a_3 TCWV^3) TCWV \qquad \text{Equation 1}$$

3. Product description

3.1. File format and naming convention

The product is delivered as Network Common Data Form version 4 (netCDF4) file with metadata attributes compliant with version 1.8 of the Climate & Forecast conventions (CF V1.8).

The product file follows the naming standard:

WTC_from_WV_CDR_<version>.nc

where <version> is the two-digit version number, starting with 'V1' for the first release of the product. The extension ".nc" is the standard NetCDF extension.

Example: WTC_from_WV_CDR_v1.nc

3.2. Product content

3.2.1. Dimensions

One dimension is defined:

- time

3.2.2. Variables

Table 2 describes the variables included in the product file. For both the REMSS and HOAPS CDRs, the file provides:

- the combined MWR/CDR GMWTC (gmwtc_remss and gmwtc_hoaps),
- the GMSL computed with the combined MWR/CDR GMWTC (gmsl_with_gmwtc_remss and gmsl_with_gmwtc_hoaps),
- the correction to be applied to the GMSL computed from the AVISO+ L2P 2021 data using the MWR WTC to replace the latter by the combined MWR/CDR GMWTC (correction_gmwtc_remss and correction_gmwtc_hoaps).

Hence, the GMSL computed using the combined MWR/CDR GMWTCs can be obtained by subtracting the correction (correction_gmwtc_remss or correction_gmwtc_hoaps) to the GMSL computed using the MWR WTC.

The combined MWR/CDR GMWTC gmwtc_remss and gmwtc_hopas are provided so that it can be used to replace the GMWTC in any GMSL time series computed using a WTC other than the MWR one (e.g. using the ECMWF operational WTC model).

Variable(dimensions)	Description	Unit	Type
time(time)	Time	days since 1950-01-01 00:00:00 UTC	double
gmwtc_remss(time)	GMWTC combining MWR HF values and REMSS CDR LF values	meters	double
correction_gmwtc_remss (time)	Correction to apply to the GMSL to replace the MWR WTC with the combined MWR/REMSS CDR WTC	meters	double
gmsl_with_gmwtc_rems s(time)	GMSL computed using the combined MWR/REMSS CDR WTC	meters	double
gmwtc_hoaps(time)	GMWTC combining MWR HF values and HOAPS CDR LF values	meters	double
correction_gmwtc_hoaps (time)	Correction to be applied to the GMSL to replace the MWR WTC with the combined MWR/HOAPS CDR WTC	meters	double
gmsl_with_gmwtc_hoaps (time)	GMSL computed using the combined MWR/HOAPS CDR WTC	meters	double

Table 2: Description of the variables of the CDR-derived WTC product (NetCDF file).

Note that the uncertainty of the combined MWR/CDR GMWTC (gmwtc_remss and gmwtc_hoaps) is estimated at 0.05 mm/yr (Barnoud et al., submitted).

4. How to access and use the CDR-derived WTC product?

4.1. Downloading

The data product (NetCDF file) and associated documentation can be found and downloaded on the AVISO+ webpage:
https://www.aviso.altimetry.fr/en/data/products/auxiliary-products/wet-troposphere-correction-from-water-vapour-climate-data-records.html

Once downloaded, NetCDF data can be browsed and used through a number of software, like:

- ncBrowse: https://www.pmel.noaa.gov/epic/java/ncBrowse/
- NetCDF Operator (NCO): http://nco.sourceforge.net/
- Panoply: https://www.giss.nasa.gov/tools/panoply/
- IDL, Matlab, GMT, Python…

Useful information on UNIDATA: http://www.unidata.ucar.edu/software/netcdf/

4.2. Dataset DOI

The product is referenced with the following digital object identifier (DOI):
10.24400/527896/a01-2022.018

4.3. Citing and referencing

When using the CDR-derived WTC product, please refer to Barnoud et al. (submitted) and acknowledge "The CDR-derived WTC product was produced by Magellium, Fluctus and LEGOS and distributed on the AVISO+ ODATIS portal (https://www.aviso.altimetry.fr) with support from CNES (https://doi.org/10.24400/527896/a01-2022.018 version 1).".

4.4. Support

For any technical issues or additional information related to the CDR-derived WTC product, users are advised to contact the project team:

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