MEaSUREs ITS_LIVE Antarctic Quarterly 1920 m Ice Shelf Height Change and Basal Melt Rates, 1992-2017, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Paolo, F., A. S. Gardner, C.A. Greene, and N.-J. Schlegel. 2024. *MEaSUREs ITS_LIVE Antarctic Quarterly 1920 m Ice Shelf Height Change and Basal Melt Rates, 1992-2017, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/SE3XH9RXQWAM. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0792

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This ITS_LIVE data set, part of the Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program, consists of quarterly, 1920 m resolution estimates of Antarctic ice shelf surface height change, basal melt rate, thickness, surface mass balance, firn air content, and associated errors, from 17 March 1992 through 16 December 2017.

The data were generated from four European Space Agency (ESA) satellite radar altimetry missions spanning 26 years—ERS-1 (1991–1996) and ERS-2 (1995–2003)[1], Envisat (2002–2010), and CryoSat-2 (2010–2017)—using a novel data fusion approach and the Glacier Energy and Mass Balance model (GEMB) to estimate firn air content and surface mass balance.

1.1 Parameters

Surface height change
Basal melt rate
Thickness
Firn air content
Surface mass balance (also referred to as surface mass budget)

1.2 File Information

1.2.1 Format

NetCDF-4

1.2.2 File Contents

Surface height change, basal melt rate, thickness, firn air content, surface mass balance, and error estimates are stored in 32-bit floating-point arrays with dimensions of 104 × 2916 × 2916, where 104 = the number of quarters between 17 March 1992 – 16 December 2017. Means of the quarterly estimates for basal melt rate, thickness, firn air content, and surface mass balance are provided in 2916 × 2916 arrays.

The data file also includes ice shelf identifiers[2] for each grid cell, the start time for each quarter (in days since 1 January 1950), georeferenced coordinate space variables (x, y), and a “crs” variable with a complete description of the coordinate reference system.

[1]European Remote Sensing satellites 1 and 2.
[2]From MEaSUREs Antarctic Boundaries for IPY 2007-2009 from Satellite Radar, Version 2

Table 1 contains names and descriptions of all the variables:

Table 1. Table with Header Row

Variable Name	Description
ID	Ice shelf identifiers
crs	Description of coordinate reference system
fac fac_err fac_mean	Firn air content (m) Firn air content error (m) Firn air content mean (m)
height_change height_change_err	Height change relative to 2014 (m) Height change error (m)
melt melt_err melt_mean	Basal melt rate (m/yr) Basal melt rate error (m/yr) Basal melt rate mean (m/yr)
smb smb_err smb_mean	Surface mass budget (m/yr) Surface mass budget error (m/yr) Surface mass budget mean (m/yr)
thickness thickness_err thickness_mean	Ice shelf thickness (m) Ice shelf thickness error (m) Ice shelf thickness mean (m)
time	Quarter state date in days since 1 Jan 1950
x	x-coordinate (m), center of grid cell
y	y-coordinate (m), center of grid cell

1.2.3 Naming Convention

This data set consists of the following file:

File Name

NSIDC-0792_19920317-20171216_V01.0.nc

Naming Convention

NSIDC-0792_[start date]-[end date]_V[nn.n].nc

The above start and end dates refer to 17 March 1992 and 16 December 2017, in the YYYYMMDD date format. “V[nn.n]” indicates the major and minor version number (V01.0 is Version 1.0, the initial release) and “nc” is the NetCDF file extension.

1.3 Spatial Information

1.3.1 Coverage

N: 54° S

S: 90° S

E: 180° E

W: 180° W

1.3.2 Resolution

1920 m

1.3.3 Geolocation

The following tables provide information for geolocating this data set

Table 2. Geolocation Details

Geographic coordinate system	World Geodetic System 1984 ensemble
Projected coordinate system	WGS 84 / Antarctic Polar Stereographic
Central Meridian	0°
Latitude of true origin	-71°
Scale factor at longitude of true origin	1
Datum	WGS_1984
Ellipsoid/spheroid	WGS 84
Units	meter
False easting	0
False northing	0
EPSG code	3031
PROJ4 string	+proj=stere +lat_0=-90 +lat_ts=-71 +lon_0=0 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs +type=crs
Reference	https://epsg.org/crs_3031/WGS-84-Antarctic-Polar-Stereographic.html

Table 3. Grid Details

Grid cell size (x, y pixel dimensions)	1920 m × 1920 m
Number of rows	2916
Number of columns	2916
Nominal gridded resolution	1920 m
Grid rotation	0
ulxmap – x-axis map coordinate of the center of the upper-left pixel	-2798407.5 m
ulymap – y-axis map coordinate of the center of the upper-left pixel	2798407.5 m

1.4 Temporal Information

1.4.1 Coverage

17 March 1992 – 16 December 2017

1.4.2 Resolution

Quarterly (approximately 3 calendar months)

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Antarctica's floating ice shelves act as a buttress that helps slow the flow of grounded ice into the ocean. Ice shelf thinning and grounding line retreat have reduced this buttressing effect and initiated rapid drawdowns in key unstable areas of the Antarctic Ice Sheet, which has lead to sea-level rise. Data that quantify spatial and temporal patterns in recent ice shelf loss will be needed to identify areas that are undergoing significant change.

2.2 Acquisition

Observed height changes were obtained from the following satellite products:

- ERS-1 and ERS-2: REprocessing of Altimeter Products for ERS (GDR): 1991 to 2003 (REAPER), as described in Brockley et al., 2017
- Envisat: RA-2 Geophysical Data Record (GDR) v2
- CryoSat-2: ESA L1b Baseline-C product

Ice shelf boundaries were constructed from a combination of Landsat imagery and ICESat data (see Depoorter et al., 2013), updated for later epochs with data from MEaSUREs InSAR-Based Antarctica Ice Velocity Map, Version 2.

2.3 Processing

The following sections summarize how these data were produced. Detailed descriptions are available in Paolo et al. (2023).

2.3.1 Ice Shelf Surface Height

Surface heights were derived from radar altimeter return waveforms using the standard 30% threshold retracker ICE-1 (Bamber, 1994), available for all missions except for CryoSat-2. Heights were derived from CryoSat-2 using the in-house retracker for the SAR Interferometric (SARIn) mode described in Nilsson et al., 2016. The data providers then modeled and removed the static topography, applied a series of geophysical corrections, and modeled the firn air content and surface mass balance.

2.3.1.1 Static Topography

Static topography was removed using a method similar to Nilsson et al. (2016), McMillan et al. (2014), and Wouters et al. (2015), but with some fundamental differences to better accommodate underlying topographical changes at spatial scales smaller than 1 km. These differences include treating ascending and descending orbits as independent data sets; filtering ground tracks to remove potential anomalous height measurements; solving for static topography independently on each data set.

In addition, inversion cells (i.e., search centroid and radii) were set following clusters of repeat tracks (along-track processing), leaving the gridding procedure for a later stage when the optimal spatial and temporal scales of each estimated quantity could be best determined. As such, inversion cell sizes vary linearly with latitude (8–15 km) to account for changes to data density as the spacing of satellite ground tracks changes with latitude.

Finally, to avoid including signals from grounded ice and ice front change in the analysis—as well as errors resulting from changes in ice shelf boundaries—all data were excluded within 1) a 3 km buffer around ice shelf perimeters, and 2) an additional 3 km buffer (6 km total) from ice shelf fronts.

2.3.1.2 Geophysical Corrections

The following geophysical corrections were applied:

- Dry troposphere, wet troposphere, ionosphere, solid earth tide, and pole tide (provided with the data)
- Surface slope
- Inverse barometer
- Ocean tides
- Mean sea level and trend
- Surface scattering

2.3.1.3 Firn air and surface mass balance

GEMB snow-densification parameters were calibrated to improve the agreement between modeled snow-density profiles and observations after Ligtenberg et al. (2011) and Gardner et al. (2023). The model was then forced following a relaxation simulation (Gardner et al., 2023) with 3-hourly ERA5 reanalysis data for 1979–2017. The resulting daily spatial estimates of firn air content and surface mass balance were converted to monthly estimates and then linearly interpolated onto a constant 5 km grid for the ice shelf melt rate analysis and to estimate model uncertainties.

2.3.2 Data Fusion

To account for input sources from multiple satellites with different error characteristics and spatial distribution, the data were fused using an optimal interpolation approach and four key metrics chosen to produce continuous fields at a 3 km posting every 3 months: distance between observations; distance of observations to grid nodes (i.e., prediction points); observation errors; and along-track long-wavelength correlated errors estimated empirically to minimize the variance of the interpolated field.

2.3.3 Thickness Change and Basal Melt Rate

Melt rates were estimated using an Eulerian frame of reference and two key steps designed to improve upon previous work (e.g., Adusumilli et al., 2020; Paolo et al., 2018): 1) inverting height to thickness and then 2) solving the mass balance equation[3].

2.4 Quality, Errors, and Limitations

Formal error estimates for all parameters are included in the data file. For a complete description of the approaches used and details about data quality, see “Section 3.7 | Uncertainty Quantification” and “Section 3.8 | Quality Assessment” in Paolo et al. (2023).

[3]“Section 3.3 | Thickness change and basal melt rate inversion” in Paolo et al. (2023) details the equations used to estimate ice shelf basal melting from measured surface height.

3 VERSION HISTORY

Version 1.0 (initial release)

4 RELATED DATA SETS

MEaSUREs Antarctic Boundaries for IPY 2007-2009 from Satellite Radar, Version 2

MEaSUREs InSAR-Based Antarctica Ice Velocity Map, Version 2

MEaSUREs InSAR-Based Ice Velocity of the Amundsen Sea Embayment, Antarctica, Version 1

5 RELATED WEBSITES

ITS_LIVE at NSIDC

6 REFERENCES

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7 DOCUMENT INFORMATION

7.1 Publication Date

August 2024

7.2 Date Last Updated

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