MEaSUREs ITS_LIVE Antarctic Annual 240 m Ice Sheet Extent Masks, 1997-2021, Version 1

USER GUIDE

How to Cite These Data

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

Greene, C. A., A. S. Gardner, N.-J. Schlegel, and A. D. Fraser. 2024. *MEaSUREs ITS_LIVE Antarctic Annual 240 m Ice Sheet Extent Masks, 1997-2021, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/9ZFX84T5GI6D. [Date Accessed].

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

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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 240 m Antarctic Ice Sheet extent masks at roughly annual resolution from 1997 through 2021. The ice masks were generated by combining data acquired by multiple satellite-borne optical, thermal, and radar sensors. The ice thickness and velocity data used to determine the presence of ice are also provided.

1.1 Parameters

Ice mask

Ice thickness

Ice component velocity

1.2 File Information

1.2.1 Format

NetCDF-4

1.2.2 File Contents

The ice mask is stored in a 24 x 18392 x 22896 (time × y-coordinate × x-coordinate) array. All the variables stored in the NetCDF file are described in Table 1:

Table 1. Variable Names and Descriptions

Name	Description	Dimensions
crs	String variable with complete description of coordinate reference system stored as attributes	—
ice_mask	Binary ice mask (0 = no ice, 1 = ice)	24 × 18392 × 22896
iceshelf_id	Ice shelf names stored as coded integers, with key written to “flag_meanings” attribute. See “Appendix A – Ice Shelves.”	18392 × 22896
thickness	Ice thickness (m)	18392 × 22896
thickness_source	Source of ice thickness data. See “Section 2.1.2 | Thickness.“	18392 × 22896
time	Days since 1950-01-01 00:00:00.0	24 × 1
v_source	Source of velocity data. See “Section 2.1.1 | Velocity.”	18392 × 22896
vx	Projected x-component of velocity (m/y)	18392 × 22896

Name	Description	Dimensions
vy	Projected y-component of velocity (m/y)	18392 × 22896
x	Projection x coordinate (m) at center of grid cell	22896 × 1
y	Projection y coordinate (m) at center of grid cell	18392 × 1

1.2.3 Naming Convention

This data set consists of the following NetCDF file:

NSIDC-0794_19971001-20210314_V01.0.nc

In designation “19971001-20210314” in the file name refers to the temporal coverage (i.e., 1 October 1997 – 14 March 2021) and “V01.0” specifies the major and minor version number. For example, V01.0 is Version 1.0 (the initial release).

1.3 Spatial Information

1.3.1 Coverage

N: 57.6° S
S: 90° S
E: 180° E
W: 180° W

1.3.2 Resolution

240 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)	18392 × 22896
Number of rows	18392
Number of columns	22896
Nominal gridded resolution	240 m
Grid rotation	0
ulxmap – x-axis map coordinate of the center of the upper-left pixel (XLLCORNER for ASCII data)	-2678287.5 m
ulymap – y-axis map coordinate of the center of the upper-left pixel (YLLCORNER for ASCII data)	2259727.5 m

1.4 Temporal Information

1.4.1 Coverage

1 October 1997

14 March 2000

1 October 2000

14 March 2001 – 14 March 2021

1.4.2 Resolution

Varies, but annual from 14 March 2000 through 14 March 2021

2 DATA PROCESSING

To produce these ice masks, data acquired by multiple satellite-borne optical, thermal, and radar sensors were combined and then constrained with manually selected coastlines to be consistent with observations of ice flow.

The following sections summarize the methods used to create this data set. For a complete description, see Greene et al. 2022. The data providers also maintain a GitHub repository that contains scripts, animations, and other assets users may find helpful.

2.1 Velocity and Thickness

The following sections describe how multiple velocity and thickness data sets were combined and extended to create grids covering the maximum known extents of the ice sheet without data gaps. See “Section 4 | Related Data Sets” for a list of the data sets referenced below. In addition, two variables – “v_source” and “thickness_source” – are included in the NetCDF file which indicate which source data set was used for each grid cell.

2.1.1 Velocity

Error-weighted averages were computed separately for x- and y-component velocities from the MEaSUREs ITS_LIVE Regional Glacier and Ice Sheet Surface Velocities, Version 1 (ITS_LIVE Antarctic) and MEaSUREs InSAR-Based Antarctica Ice Velocity Map, Version 2 data sets. Any remaining internal holes were filled using the MATLAB regionfill algorithm. Flow directions were then extrapolated beyond observed extents of the ice sheet by multiplying observed velocities by observed thicknesses (see “Section 2.1.2 | Thickness”) and an inpainting algorithm was used to fill the entire domain. Finally, speeds were propagated constantly along the hypothetical direction of flow.

2.1.2 Thickness

The ice thickness grid was primarily based on MEaSUREs BedMachine Antarctica, Version 2. To account for known data gaps in the BedMachine data set, grid cells in tidal regions with zero ice thickness were filled with the most recent available thickness data, starting with the Reference Elevation Map of Antarctica (Howatt et al., 2019); then Bedmap2 (Fretwell et al., 2013); then Antarctic 1 km Digital Elevation Model (DEM) from Combined ERS-1 Radar and ICESat Laser Satellite Altimetry, Version 1; and finally, Radarsat Antarctic Mapping Project Digital Elevation Model, Version 2.

Because BedMachine thicknesses have firn air content removed, surface elevations from other data sets were converted to an equivalent ice thickness by referencing elevations to the geoid, as needed, subtracting the mean firn air content estimated by the Glacier Energy and Mass Balance (Gardner et al., 2023), and then inverting for thickness. The resulting thicknesses were then extrapolated in the direction of flow, following the same technique used to extrapolate velocities.

2.2 Ice Shelf Masks

Using the MEaSUREs Antarctic Boundaries for IPY 2007–2009 from Satellite Radar, Version 2 data set, a gridded mask of 181 ice-shelf names was produced by dilating the boundaries of each ice shelf 100 km in all directions and then extrapolating along flowlines following the procedure described above for velocity and thickness. The resulting set of masks cover areas much larger than any observed ice-shelf extents, but are certain to fully capture changes at the ice front while providing extra tolerance in the grounding zone.

For a complete list of ice shelf IDs and names, see “Appendix A – Ice Shelves.”

2.3 Coastline Timeseries

To generate roughly annual coastlines from 1997 to 2021, coastline observations were manually selected from the data sources listed in the following table:

Table 4. Data Sources

Source	Years
Radarsat Antarctic Mapping Project (RAMP) Antarctic Mapping Mission-1 (Liu & Jezek, 2004)	1997
RAMP Modified Antarctic Mapping Mission	2000
Moderate Resolution Imaging Spectroradiometer (MODIS)-based fast-ice (Fraser et al., 2020)	2004, 2009, 2014
MODIS Mosaic of Antarctica	2000 – 2017, 2021
Sentinel-1A and -1B	2015 – 2021

Because the coastline masks from these data sets are not directly intercomparable, a composite mask was created on the ITS_LIVE Antarctic 240 m grid by adjusting each contributing data set according to the criteria described in “Methods | Combining datasets” in Greene et al. 2022.

By exploiting the offset between the MODIS and Sentinel 1a mosaic grids, and using known velocities to interpolate coastline migration between coarse-resolution grid postings and the ITS_LIVE Antarctic 240 m grid, the resulting ice masks achieve a higher resolution than their underlying source mosaics.

2.4 Quality, Errors, and Limitations

Islands that do not appear in every constituent dataset have been constrained to a constant, or nearly constant area where the algorithm introduces or otherwise allows a small amount of noise.

Furthermore, the manually delineated coastlines on which this data set is based reflect the notoriously difficult-to-delineate nature of Thwaites Glacier's ice shelf. Although the coastlines have been constrained to ensure that the rate of ice-front advance never exceeds realistic velocities, in some years the ice shelf takes the shape of an implausible compromise between the various input data sets.

Finally, users are encouraged to compare this coastline product to available satellite imagery wherever possible.

3 VERSION HISTORY

Version 1 (initial release)

4 RELATED DATA SETS

RAMP Antarctic Mapping Mission-1
RAMP Modified Antarctic Mapping Mission
MEaSUREs BedMachine Antarctica, Version 2
Antarctic 1 km Digital Elevation Model (DEM) from Combined ERS-1 Radar and ICESat Laser Satellite Altimetry, Version 1
Radarsat Antarctic Mapping Project Digital Elevation Model, Version 2
MODIS Mosaic of Antarctica 2003-2004 (MOA2004) Image Map, Version 1
MODIS Mosaic of Antarctica 2008-2009 (MOA2009) Image Map, Version 1
MODIS Mosaic of Antarctica 2013-2014 (MOA2014) Image Map, Version 1
MEaSUREs ITS_LIVE Regional Glacier and Ice Sheet Surface Velocities, Version 1
MEaSUREs InSAR-Based Antarctica Ice Velocity Map, Version 2
MEaSUREs Antarctic Boundaries for IPY 2007–2009 from Satellite Radar, Version 2
Seaice.dk (Sentinel-1A, -1B radar mosaics)
Circum-Antarctic landfast sea ice extent, 2000-2018 (MODIS-based fast-ice)

5 RELATED WEBSITES

GitHub Repository (maintained by data provider)
ITS_LIVE at NSIDC

6 REFERENCES

Fraser, A. D., Massom, R. A., Ohshima, K. I., Willmes, S., Kappes, P. J., Cartwright, J., & Porter-Smith, R. (2020). High-resolution mapping of circum-Antarctic landfast sea ice distribution, 2000–2018. In Earth System Science Data (Vol. 12, Issue 4, pp. 2987–2999). Copernicus GmbH. https://doi.org/10.5194/essd-12-2987-2020

Fretwell, P., Pritchard, H. D., Vaughan, D. G., Bamber, J. L., Barrand, N. E., Bell, R., Bianchi, C., Bingham, R. G., Blankenship, D. D., Casassa, G., Catania, G., Callens, D., Conway, H., Cook, A. J., Corr, H. F. J., Damaske, D., Damm, V., Ferraccioli, F., Forsberg, R., … Zirizzotti, A. (2013). Bedmap2: improved ice bed, surface and thickness datasets for Antarctica. In The Cryosphere (Vol. 7, Issue 1, pp. 375–393). Copernicus GmbH. https://doi.org/10.5194/tc-7-375-2013

Gardner, A. S., Schlegel, N.-J., & Larour, E. (2023). Glacier Energy and Mass Balance (GEMB): a model of firn processes for cryosphere research. In Geoscientific Model Development (Vol. 16, Issue 8, pp. 2277–2302). Copernicus GmbH. https://doi.org/10.5194/gmd-16-2277-2023

Greene, C. A., Gardner, A. S., Schlegel, N.-J., & Fraser, A. D. (2022). Antarctic calving loss rivals ice-shelf thinning. In Nature (Vol. 609, Issue 7929, pp. 948–953). Springer Science and Business Media LLC. https://doi.org/10.1038/s41586-022-05037-w

Howat, I. M., Porter, C., Smith, B. E., Noh, M.-J., & Morin, P. (2019). The Reference Elevation Model of Antarctica. In The Cryosphere (Vol. 13, Issue 2, pp. 665–674). Copernicus GmbH. https://doi.org/10.5194/tc-13-665-2019

Liu, H., & Jezek, K. C. (2004). A Complete High-Resolution Coastline of Antarctica Extracted from Orthorectified Radarsat SAR Imagery. In Photogrammetric Engineering & Remote Sensing (Vol. 70, Issue 5, pp. 605–616). American Society for Photogrammetry and Remote Sensing. https://doi.org/10.14358/pers.70.5.605

Mouginot, J., Scheuchl, B., & Rignot, E. (2017). MEaSUREs Antarctic Boundaries for IPY 2007-2009 from Satellite Radar, Version 2 [Dataset]. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/AXE4121732AD

7 DOCUMENT INFORMATION

7.1 Publication Date

August 2024

7.2 Date Last Updated

August 2024

APPENDIX A – ICE SHELVES

Ice shelf masks were dilated and extruded from Mouginot, 2017 using the MATLAB scripts iceshelf_mask_generator.m and flow_dem_extend.m. These scripts are available from GitHub at https://github.com/chadagreene/ice-shelf-geometry.

The following table lists the ice shelf IDs and names stored in the “iceshelf_id” variable:

Table A - 1

ID	Ice Shelf Name	ID	Ice Shelf Name
1	Abbot	92	Lauritzen
2	Abbot_1	93	Lazarev
3	Abbot_2	94	Lillie
4	Abbot_3	95	Liotard
5	Abbot_4	96	Mandible_Cirque
6	Abbot_5	97	Manhaul
7	Abbot_6	98	Marin
8	Ainsworth	99	Mariner
9	Alison	100	Marret
10	Amery	101	Matusevitch
11	Andreyev	102	May_Glacier
12	Arneb	103	McLeod
13	Astrolabe	104	Mendelssohn
14	Atka	105	Mertz
15	Aviator	106	Morse
16	Bach	107	Moscow_University
17	Barber	108	Moubray
18	Baudouin	109	Mulebreen
19	Borchgrevink	110	Myers
20	Brahms	111	Nansen
21	Britten	112	Nickerson
22	Brunt_Stancomb	113	Ninnis
23	Campbell	114	Nivl
24	Cape_Washington	115	Noll
25	Cheetham	116	Nordenskjold
26	Chugunov	117	Parker
27	Cirque_Fjord	118	Paternostro

28	Clarke_Bay
29	Commandant_Charcot
30	Conger_Glenzer
31	Cook
32	Cosgrove
33	Crosson
34	Dalk
35	Dawson_Lambton
36	Deakin
37	Dennistoun
38	Dibble
39	Dotson
40	Drury
41	Drygalski
42	Edward_VIII
43	Ekstrom
44	Eltanin_Bay
45	Erebus
46	Falkner
47	Ferrigno
48	Filchner
49	Fimbul
50	Fisher
51	Fitzgerald
52	Flatnes
53	Fox_Glacier
54	Fox_Ice_Stream
55	Francais
56	Frost
57	Gannutz
58	Garfield
59	GeikieInlet
60	George_VI
61	Getz
62	Getz_1
63	Getz_2

119	Perkins
120	Philbin_Inlet
121	Pine_Island
122	Porter
123	Pourquoi_Pas
124	Prince_Harald
125	Publications
126	Quar
127	Quatermain_Point
128	Rayner_Thyer
129	Rennick
130	Richter
131	Riiser-Larsen
132	Ronne
133	Rose_Point
134	Ross_East
135	Ross_West
136	Rund_Bay
137	Rydberg_Peninsula_1
138	Rydberg_Peninsula_2
139	Sandford
140	Shackleton
141	Shirase
142	Skallen
143	Slava
144	SmithInlet
145	Sorsdal
146	Stange
147	Sulzberger
148	Suter
149	Suvorov
150	Swinburne
151	Telen
152	Thomson
153	Thwaites
154	Tinker

64	Gillet
65	Hamilton
66	Hamilton_Piedmont
67	Hannan
68	Harbord_Glacier
69	Harmon_Bay
70	Hayes_Coats_Coast
71	Helen
72	Holmes
73	Holt
74	HornBluff
75	Hoseason
76	Hovde
77	Hull
78	Hummer_Point
79	Ironside
80	Jackson
81	Jelbart
82	Kirkby
83	Land
84	Larsen_A
85	Larsen_B
86	Larsen_C
87	Larsen_D
88	Larsen_D_1
89	Larsen_E
90	Larsen_F
91	Larsen_G

155	Totten
156	Tracy_Tremenchus
157	Tucker
158	Underwood
159	Utsikkar
160	Venable
161	Verdi
162	Vigrid
163	Vincennes_Bay
164	Voyeykov
165	Walgreen_Coast_1
166	Walgreen_Coast_2
167	Watt_Bay
168	West
169	Whittle
170	Wilkins
171	Williamson
172	Wilma_Robert_Downer
173	Withrow
174	Wordie_Airy_Rotz_Seller
175	Wordie_Cape_Jeremy
176	Wordie_Harriott
177	Wordie_Harriott_Headland
178	Wordie_Prospect
179	Wylde
180	Zelee
181	Zubchatyy
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