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

USER GUIDE

How to Cite These Data

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

Mouginot, J., B. Scheuchl, and E. Rignot. 2017. *MEaSUREs Antarctic Boundaries for IPY 2007-2009 from Satellite Radar, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/AXE4121732AD. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/nsidc-0709

National Snow and Ice Data Center

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1 DATA DESCRIPTION

The Antarctic maps in this data set include:

- Antarctic ice shelves
- Antarctic coastline
- Antarctic basin map as defined for the Ice sheet Mass Balance Inter-comparison Exercise (IMBIE) 2016
- Refined Antarctic basin map that is consistent with the IMBIE 2016 basin map but provides more detailed basins

1.1 Parameters

The data set is an integrated product that provides detailed mappings of the location of the Antarctic Ice Sheet grounding line, ice shelf pinning points (e.g. nunataks, ice rises, and ice rumples and denoted by the attribute "Islands" in the Ice Boundaries shapefile), the coastline and two versions of basins. This product can be used as a mask to define grounded ice, floating ice and/or the Antarctic coastline.

The basins provide further information at two levels of detail. Basins_IMBIE_Antarctica_v02 are the basins used for the Ice sheet Mass Balance Inter-comparison Exercise (IMBIE) 2016 (Rignot Basins); whereas, Basins_Antarctica_v02 provides a further refined set of basins that is consistent with Basins_IMBIE_Antarctica_v02. Antarctica is separated into the West Antarctic Ice Sheet (WAIS), the East Antarctic Ice Sheet (EAIS), and the Antarctic Peninsula (AP) based on historical definitions plus information from modern-day DEM and ice velocity data. AP is limited by the Ronne Ice Shelf to the east and the George VI Ice Shelf to the west. WAIS and EAIS are divided along the Transantarctic range; WAIS drains into the Ronne Ice Shelf, EAIS drains into the Filchner Ice Shelf. Within these three ice sheet regions, subregions A, B, C, Cp, etc. are defined based on historical nomenclature (Giovinetto and Zwally, 2000) plus modern DEM and ice velocity data, and adjusted to match the drainage boundaries of the major ice shelves.

The primary attributes for each shapefile are listed below in Table 1.

The file IceBoundaries_Antarctica contains all information in a single file (i.e. all layers merged). Separate files are provided for those interested in a subset of the information.

Table 1. Primary Data Attributes for Shapefiles

File Name	Data Field	Description
Coastline_Antarctica_v02	Name	Coastline
GroundingLine_Antarctica_v02	Name	Grounded

File Name	Data Field	Description
	Type	Grounded ice (GR), floating ice (FL), and islands (IS)
IceShelf_Antarctica_v02	Name	Names for Antarctic floating glacial ice (ice shelves and ice tongues)
	Regions	Regions refers to the separation in East Antarctica (East), West Antarctica (West) and the Antarctic Peninsula (Peninsula).
	Type	Type refers to grounded ice (GR), floating ice (FL), and islands (IS).
Basins_IMBIE_Antarctica_v02	Name	Name of the basin (based on historical nomenclature, see subregion) as used by IMBIE 2016 (Rignot Basins)
	Regions	Regions refers to the separation in East Antarctica (East), West Antarctica (West) and the Antarctic Peninsula (Peninsula). In addition, the region, Islands, is provided.
	Subregions	Subregions are defined based on historical nomenclature (Giovinetto and Zwally, 2000) plus modern DEM and ice velocity data, and adjusted to match the drainage boundaries. **Note:** Xp (X prime)=X' ; Xpp(X double prime)=X'' *
	Type	Type refers to grounded ice (GR), floating ice (FL), and islands (IS)
Basins_Antarctica_v02	Name	Name of the basin (based on the glacier, ice stream, ice shelf, or coast)
	Regions	Regions refers to the separation in East Antarctica (East), West Antarctica (West) and the Antarctic Peninsula (Peninsula).
	Subregions	Subregions are defined based on historical nomenclature (Giovinetto and Zwally, 2000) plus modern DEM and ice velocity data, and adjusted to match the drainage boundaries. **Note**: no special characters are possible: *Xp=X' ; Xpp=X''
	Type	Type refers to grounded ice (GR), floating ice (FL), and islands (IS)
	Asso_Shelf	Name of ice shelf associated with the basin (see also IceShelf_Antarctica_v02). **Note**: there can be multiple ice shelves associated with a single basin.

File Name	Data Field	Description
IceBoundaries_Antarctica_v02	Name	Names for Antarctic floating glacial ice (ice shelves and ice tongues), single label for all grounded ice, single label for all islands
	Regions	Regions refers to the separation in East Antarctica (East), West Antarctica (West) and the Antarctic Peninsula (Peninsula). In addition, the region, Islands, is provided.
	Subregions	Subregions are defined based on historical nomenclature (Giovinetto and Zwally, 2000) plus modern DEM and ice velocity data, and adjusted to match the drainage boundaries. Note: no special characters are possible: *Xp=X' ; Xpp=X''
	Type	Type refers to grounded ice (GR), floating ice (FL), and islands (IS)
	Asso_Shelf	Name of ice shelf associated with the basin (see also IceShelf_Antarctica_v02). Note: there can be multiple ice shelves associated with a single basin, which are separated by the character "/".

*Some GIS applications do not allow for special characters.

The coding for the GeoTIFF raster is:

- 0 for the ocean
- 125 for the floating glacial ice (ice shelves and ice tongues)
- 255 for the grounded ice

To view a sample of the data, refer to the Spatial Coverage section, Figure 2f.

1.2 File Information

1.2.1 Format

This data set consists of four ESRI shapefiles and a raster mask provided in GeoTIFF (.tif) and bitmap (.bmp) formats.

The ESRI shapefiles consist of five file types:

- .shp – main file that stores the feature geometry
- .shx – index file that stores the index of the feature geometry
- .dbf – dBASE table that stores the attribute information of features
- .prj – file that stores the coordinate system information

The raster image is a 500 m resolution mask of Antarctica created from the boundaries: grounding line, coastline, and ice shelves described in the shapefiles.

1.2.2 Directory Structure

Data are available via HTTPS: https://n5eil01u.ecs.nsidc.org/MEASURES/NSIDC-0709.002/

This directory contains the following folders:

Table 2. Top-Level HTTPS Directory Structure

Folder Name	Description
IceBoundaries_Antarctica	merged shapefile product that represents the coastline, floating glacial ice (ice shelves and ice tongues), grounded ice, IMBIE 2016 basins, as well as refined basins
IceShelf_Antarctica	floating glacial ice (ice shelves and ice tongues) boundaries shapefile
Coastline_Antarctica	coastline shapefile (all features in IceBoundaries_Antarctica merged together)
GroundingLine_Antarctica	grounded ice (grounding line) shapefile (all grounded features merged together)
Basins_IMBIE_Antarctica	Basins as prepared for the Ice sheet Mass Balance Inter-comparison Exercise (IMBIE) 2016
Basins_Antarctica	Refined basins from IMBIE
Mask_Antarctica	GeoTIFF and bitmap files containing the ice shelf mask

1.2.3 Naming Convention

This section describes the file naming convention for this data set (Table 3).

Example:
IceShelf_Antarctica_v02.shp
IceShelf_Antarctica_v02.dbf
IceShelf_Antarctica_v02.prj
IceShelf_Antarctica_v02.shx

Naming Convention: XXXXXXXXXX_Antarctica_v02.ext

Table 3. Naming Convention

Variables	Description
XXXXXXXXXX	Type of data: CoastLine GroundingLine IceBoundries IceShelf Mask
Antarctica	Geographic location
v02	Version 2
.ext	File type: .dbf .prj .shp .shx .tif .bmp

1.2.4 File Size

The shapefiles in this data set range from approximately 0.1 KB to 2,081 KB. The GeoTIFF (.tif) raster mask is 2.1 MB, and the bitmap (.bmp) raster mask is 119.7 MB.

1.2.5 Volume

Total volume of the data set is approximately 138 MB.

1.3 Spatial Information

1.3.1 Coverage

The data provide an outline for 1,553,978 km^2 of Antarctic Ice Shelves (floating glacier ice) or 99.52 percent of the total ice shelf area for Antarctica (Rignot et al. 2013).

Southernmost Latitude: 90° S
Northernmost Latitude: 60° S
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

1.3.1.1 Spatial Coverage Maps

Figure 1 provides an overview of the information contained in this product and available in full in the file IceBoundaries_Antarctica_v02.shp. Partial information is available in separate shapefiles (Figure 2 a-e) and a raster mask (Figure 2f). See Table 1 for a more detailed description.

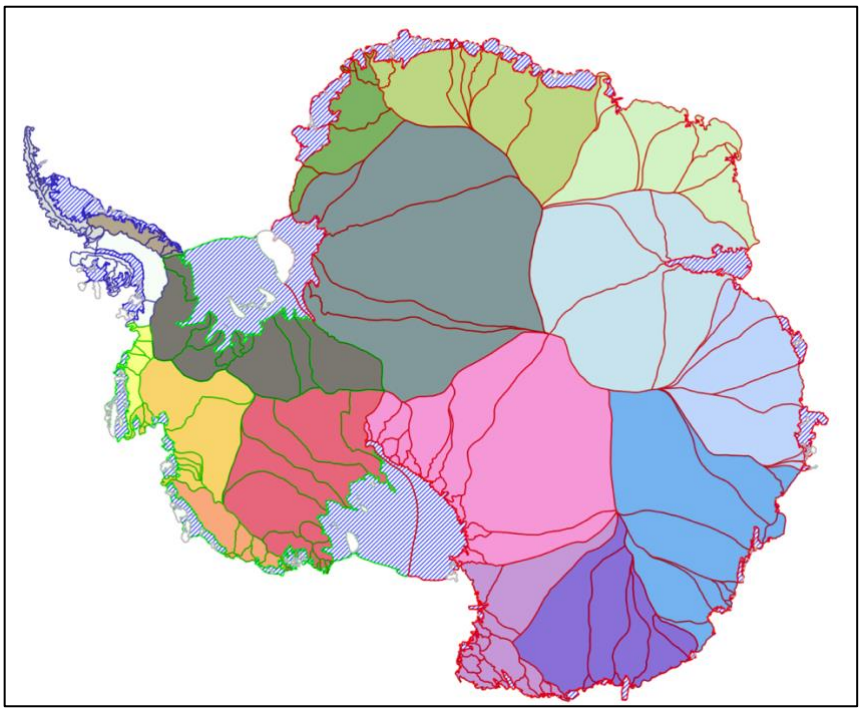

Figure 1. Antarctic Boundaries v02.shp overview. The shapefile includes the coastline, the gorunding line, an ice shelf mask (striped), as well as IMBIE and refined basins. Also provided is a regional separation in East Antarctica (red lines), West Antarctica (green lines), and the Antarctic Peninsula (dark blue lines).

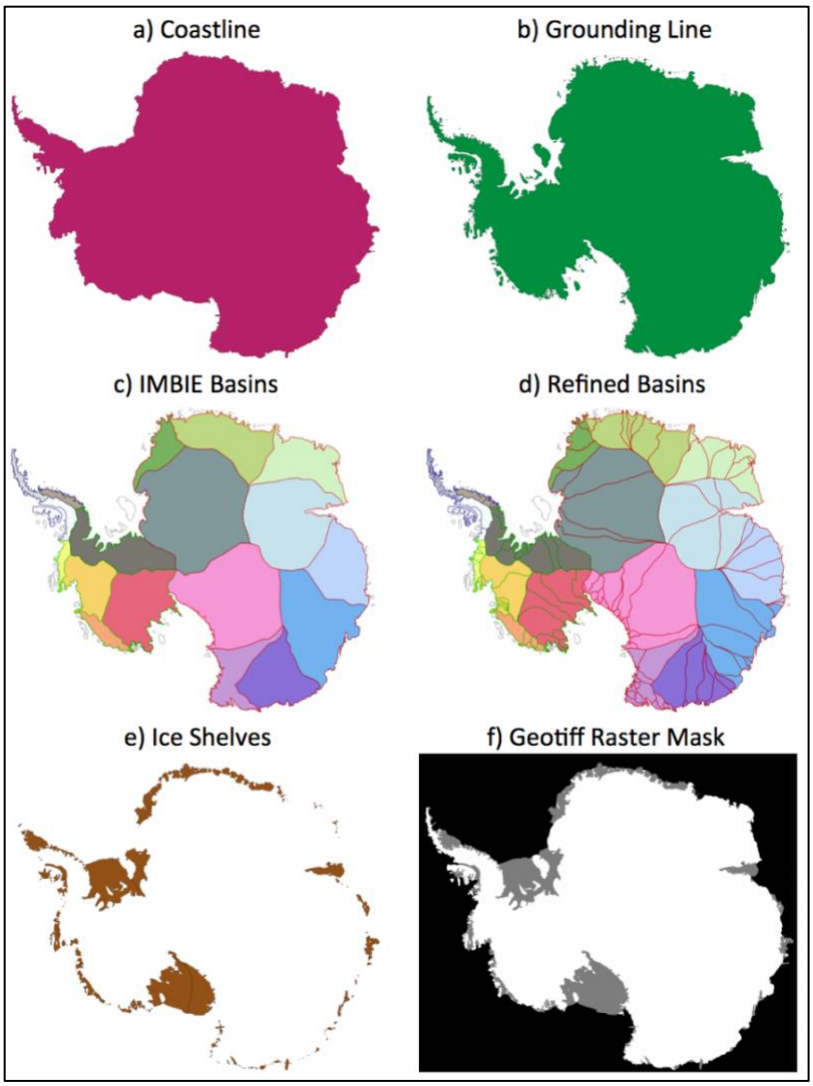

Figure 2. Shapefile Spatial Coverage Maps (a-e) and GeoTIFF raster map (f). Each file is available separately, the full information content is provided in the file IceBoundaries_Antarctica_v02.shp

1.3.2 Resolution

Spatial resolution varies for each sensor. See Table 4 for the associated approximate resolutions.

Table 4. Spatial Accuracy of Boundaries by Satellite/Sensor

Satellite/Sensor	Approximate Resolution
ERS-1, ERS-2/SAR	50 m
RADARSAT-1/SAR	35 m
RADARSAT-2/SAR	46 m
ALOS/PALSAR	120 m
COSMO-SkyMed/SAR	25 m

Satellite/Sensor	Approximate Resolution
Sentinel-1A/C-SAR	50 m
ENVISAT/ASAR	30 m
LANDSAT-8/OLI	30 m
TERRA/MODIS	250 m
AQUA/MODIS	250 m

1.3.3 Projection and Grid Description

The shapefiles and GeoTIFF file are provided in Polar Stereographic projection ESPG:3031.

1.4 Temporal Information

1.4.1 Coverage

Data for InSAR grounding lines were obtained from multiple satellites between 1992 and 2015, for which the newest grounding line position was used. The data for the coastline mapping were acquired in 2008 and 2009

1.4.2 Resolution

22 years (264 months)

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The ice front can be determined from SAR satellite imagery. The grounding line refers to the location where an ice sheet detaches from the bedrock and starts floating in the ocean. This data set includes ice front and grounding line information for the entire Antarctic coastline, derived from a variety of satellite radar interferometry data. Mapping of the different boundaries was realized with QGIS v2.12.

2.2 Acquisition

Grounding lines for the Antarctic Ice Sheet were derived using differential satellite synthetic aperture radar interferometry (DInSAR) data from the Earth Remote Sensing Satellites 1 and 2 (ERS-1 and -2), RADARSAT and RADARSAT-2, the Advanced Land Observing System (ALOS) PALSAR for years 1992 to 2009, and Copernicus Sentinel-1A for years 2014 to 2015. Ice front

information was extracted from ALOS PALSAR data acquired during IPY in 2008 and 2009 and completed with MODIS Mosaic of Antarctica (**MOA**) 2009 (https://nsidc.org/data/nsidc-0593). A detailed description of the product and the methodology is provided in Rignot et al. 2011.

2.3 Data Sources

- See MEaSUREs Antarctic Grounding Line from Differential Satellite Radar Interferometry for details on grounding line acquisitions. Ice front data (coastline) were determined from ALOS/PALSAR and ENVISAT/ASAR amplitude images acquired in 2008 and 2009.
- See Rignot, et al. 2013 for more details on the delineation of the ice shelves.
- See MEaSUREs InSAR-Based Antarctica Ice Velocity Map and BEDMAP-2 to obtain the data sets used to define the glacier basins.

2.4 Quality, Errors, and Limitations

2.4.1 Quality Assessment

See Rignot et al. 2013 for a detailed description of the product and its quality. Details about grounding line position are provided in MEaSUREs Antarctic Grounding Line from Differential Satellite Radar Interferometry user guide. Based on geocoded SAR amplitude images from ALOS/PALSAR and ENVISAT/SAR geocoded at spacing of 150 m, it is estimated that the coastline is mapped with a precision of about 300 m.

In some places, coastline and grounding line are evolving rapidly, and as a result, this data set may not represent the current state. In addition, a few pinning points may be still missing.

Based on QGIS software, the shapefiles should be free of geometry errors; i.e. shapes should not overlap or intersect.

2.5 Instrumentation

2.5.1 Description

For information about the SAR systems used to construct the mosaics from which this data set is derived, see SAR Datasets / RADARSAT-1 | Alaska Satellite Facility, ERS - Earth Online - ESA , About ALOS - PALSAR, and ESA Copernicus Sentinel-1 site. For more information about the MODIS sensor onboard the TERRA and AQUA satellites, see NASA's website MODIS Web. See Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) for more information on the OLI sensor onboard the Landsat 8 satellite.

3 SOFTWARE AND TOOLS

Shapefiles can be readily accessed using GIS software such as ArcGIS and QGIS.

4 RELATED DATA SETS

ICESat-Derived Grounding Zone for Antarctic Ice Shelves
MEaSUREs InSAR-Based Antarctica Ice Velocity Map
MEaSUREs Antarctic Grounding Line from Differential Satellite Radar Interferometry
MEaSUREs Antarctic Boundaries for IPY 2007-2009 from Satellite Radar
MEaSUREs InSAR-Based Ice Velocity Maps of Central Antarctica: 1997 and 2009
MEaSUREs InSAR-Based Ice Velocity of the Amundsen Sea Embayment, Antarctica

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6 REFERENCES

Giovinetto, M.B., and H.J. Zwally, 2000. Spatial distribution of net surface accumulation on the Antarctic ice sheet. *Annals of Glaciology* 31: 171-178.

Khazendar, A., et al. 2016. Rapid submarine ice melting in the grounding zones of ice shelves in West Antarctica. *Nature Communications* 7: Art. #13243. doi: 10.1038/ncomms13243.

Li, X., E. Rignot, J. Mouginot, and B. Scheuchl. 2016. Ice flow dynamics and mass loss of Totten Glacier, East Antarctica from 1989 to 2015. *Geophysical Research Letters* 43(12): 6366-6373. doi: 10.1002/2016GL069173.

Li, X., E. Rignot, M. Morlighem, J. Mouginot, and B. Scheuchl. 2015. Grounding line retreat of Totten Glacier, East Antarctica, 1996 to 2013. *Geophysical Research Letters* 42: 8049–8056. doi: 10.1002/2015GL065701.

Mouginot, J., E. Rignot, and B. Scheuchl. 2012., Mosaicking of ice motion in Antarctica. *Remote Sensing* 4: 2753-2767. doi: 10.3390/rs4092753.

Rignot, E., J. Mouginot, M. Morlighem, H. Seroussi, and B. Scheuchl. 2014. Widespread, rapid grounding line retreat of Pine Island, Thwaites, Smith, and Kohler glaciers, West Antarctica, from 1992 to 2011. *Geophysical Research Letters* 41: 3502–3509. doi: 10.1002/2014GL060140.

Rignot, E., S. Jacobs, J. Mouginot, and B. Scheuchl. 2013. Ice-shelf melting around Antarctica. *Science* 341(6143): 266-270. doi: 10.1126/science.1235798.

Rignot, E., J. Mouginot, and B. Scheuchl. 2011. Ice Flow of the Antarctic Ice Sheet. *Science* 333(6048): 1427-1430. doi: 10.1126/science.1208336.

— 2011a. Antarctic Grounding Line Mapping from Differential Satellite Radar Interferometry. *Geophysical Research Letters* 38(10): Art. #L10504. doi: 10.1029/2011GL047109.

Rignot, E., et al. 2011. Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise. *Geophysical Research Letters* 38(5): Art. #L05503. doi: 10.1029/2011GL046583

Rignot, E. 2002. East Antarctic Glaciers and Ice Shelves Mass Balance from Satellite Data. *Annals of Glaciology* 34: 217-227.

Rignot, E., L. Padman, D. R. MacAyeal, and M. Schmeltz. 2000. Observations of ocean tides below the Filchner and Ronne Ice Shelves, Antarctica, using synthetic aperture radar interferometry: Comparison with tide model predictions. *Journal of Geophysical Research - Oceans* 105(C8): 19,615-19,6130.

Rignot, E. 1998. Hinge-line migration of Petermann Gletscher, north Greenland, detected using satellite-radar interferometry. *Journal of Glaciology* 44(148): 469-476.

— 1998a. Radar Interferometry Detection of Hinge-Line Migration on Rutford Ice Stream and Carlson Inlet, Antarctica. *Annals of Glaciology* 27: 25-32.

Rignot, E. 1996. Tidal flexure, ice velocities and ablation rates of Petermann Gletscher, Greenland. *Journal of Glaciology* 42(142): 476-485.

Scheuchl, B., J. Mouginot, E. Rignot, M. Morlighem, and A. Khazendar. 2016. Grounding line retreat of Pope, Smith, and Kohler Glaciers, West Antarctica, measured with Sentinel-1a radar interferometry data. *Geophysical Research Letters* 43: 8572–8579. doi: 10.1002/2016GL069287.

Scheuchl, B., J. Mouginot, and E. Rignot. 2012. Ice velocity changes in the Ross and Ronne sectors observed using satellite radar data from 1997 and 2009. *The Cryosphere* 6: 1019-1030. doi: 10.5194/tc-6-1019-2012.

Schmeltz, M., E. Rignot, and D. McAyeal. 2001. Ephemeral grounding as a signal of ice-shelf change. *Journal of Glaciology* 47(156): 71-77.

Shepherd, A., et al. 2012. A reconciled estimate of ice sheet mass balance. *Science* 338(6111): 1,183-1,189. doi: 10.1126/science.1228102.

7 DOCUMENT INFORMATION

7.1 Publication Date

March 2017

7.2 Date Last Updated

14 February 2018