Level-4 9ka Greenland Ice Sheet Balance Velocity, Version 1

USER GUIDE

How to Cite These Data

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

MacGregor, J. A., M. Fahnestock, G. Catania, J. Paden, P. Gogineni, M. Morlighem, and W. Colgan. 2016. *Level-4 9ka Greenland Ice Sheet Balance Velocity, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/FZHPYHXJ4JGV. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/RDGBV4

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

1.1 Format

The data files are HDF5-compliant netCDF (.nc) format.

The data file is paired with an associated XML file. XML files contain point latitudes and longitudes, and file and campaign metadata.

1.2 File Naming Convention

Example file names:

RDGBV4_Greenland_1993_2013_01_balance_velocity_9ka.nc
RDGBV4_Greenland_1993_2013_01_balance_velocity_9ka.nc.xml

File naming convention:

RDGBV4_Location_YYYY_yyyy_0X_balance_velocity_9ka.nc

Table 1. File Naming Convention

Variable	Description
RDGBV4	Short name for Level-4 9ka Greenland Ice Sheet Balance Velocity data
Location	Location, e.g. Greenland
YYYY_yyyy	Temporal coverage of data collection from YYYY to yyyy, e.g. 1993_2013
0X	Data product version number, e.g. 01
balance_velocity	Ice sheet balance velocity
9ka	Temporal coveargе of the Level-4 data product, 9000 to 0 years before the present
xxx	Indicates file type, e.g. NetCDF (.nc), XML (.xml)

1.3 Spatial Coverage

Spatial coverage for the Level-4 9ka Greenland Ice Sheet Balance Velocity data includes Greenland, as noted by the spatial extents below:

Southernmost Latitude 58.91° N
Northernmost Latitude: 81.51° N
Westernmost Longitude: -88.33° W
Easternmost Longitude: 6.62° E

1.3.1 Spatial Resolution

5 km grid on EPSG:3413

1.3.2 Projection and Grid Description

Table 2 provides geolocation information for this data set.

Table 2. Geolocation Information

Projection	NSIDC Sea Ice Polar Stereographic North
Latitude of the origin	90°
Longitude of the origin (central meridian)	-45°
Standard parallel	70°
Scaling factor	1
False eastings	0
False northings	0
Ellipsoid	WGS84
Datum	WGS84
Units	Meters
EPSG code	3413

1.4 Temporal Coverage

These model results are derived from radar data collected over the Greenland Ice Sheet between 1993–2013. They make use of internal reflections that were dated to less than 9,000 years ago.

1.4.1 Temporal Resolution

The key model results constitute 9,000-year averages only.

1.5 Parameter or Variable

The key variables presented in this data set are the boundary conditions for the 9,000-year mean ice flux in the interior of the Greenland Ice Sheet, and then the resulting balance-velocity calculation for that period. Differences with readily available modern estimates of related variables (accumulation rate, surface speed) are provided. In the case of the boundary conditions, the variables were originally mapped onto a 1-km grid and then filtered to a 5-km grid. Lo/hi grids represent the 95% confidence bounds for those variables, and are based on separate gridding of the confidence bounds derived for along-track values.

1.5.1 Parameter Description

Table 3 provides information on the individual parameters provided in the netCDF data files.

Table 3. NetCDF File Description

Parameter	Description	Units
D	Characteristic number D qualifying the suitability of the local-layer approximation for a 9-ka old particle.	dimensionless
D1_mask	Mask where (D < 1) = 1, (D > 1) = 0 and (not on the Greenland Ice Sheet) = NaN	dimensionless
accumulation_rate	9-ka mean ice-equivalent accumulation rate (std/lo/hi)	m/a ice equivalent
accumulation_rate_difference	Difference between RACMO2 modern estimate of ice-equivalent accumulation rate and 9-ka mean (absolute/relative)	m/a ice equivalent
characteristic_length_accumulation_rate	Characteristic length of variability in accumulation rate along the 9-ka particle path	km
characteristic_length_thickness	Characteristic length of variability in ice thickness along the 9-ka particle path	km
deceleration_rate	1-D modeled deceleration rate due to LGP-Holocene viscosity contrast	m/a
depth_isochrone	Depth of 9-ka isochrone (std/uncert)	m
length_particle_path	Horizontal length of particle path traveled in 9 ka	km
shape_factor	Shape factor for portion of ice column between 0-9 ka (std/lo/hi)	dimensionless
shear_layer_thickness	Dansgaard–Johnsen basal shear layer thickness (std/lo/hi)	m
speed_balance	9-ka mean surface speed (std/lo/hi/ref)	m/a
speed_difference	Difference between modern surface speed and 9-ka mean (std/lo/hi)	m/a
vertical_strain_rate	Mean vertical strain rate for ice column between 0-9 ka (std/lo/hi)	1/a

Parameter	Description	Units
x	Projected x-dimension grid centered on Greenland	km
y	Projected y-dimension grid centered on Greenland	km

1.5.2 Sample Data Record

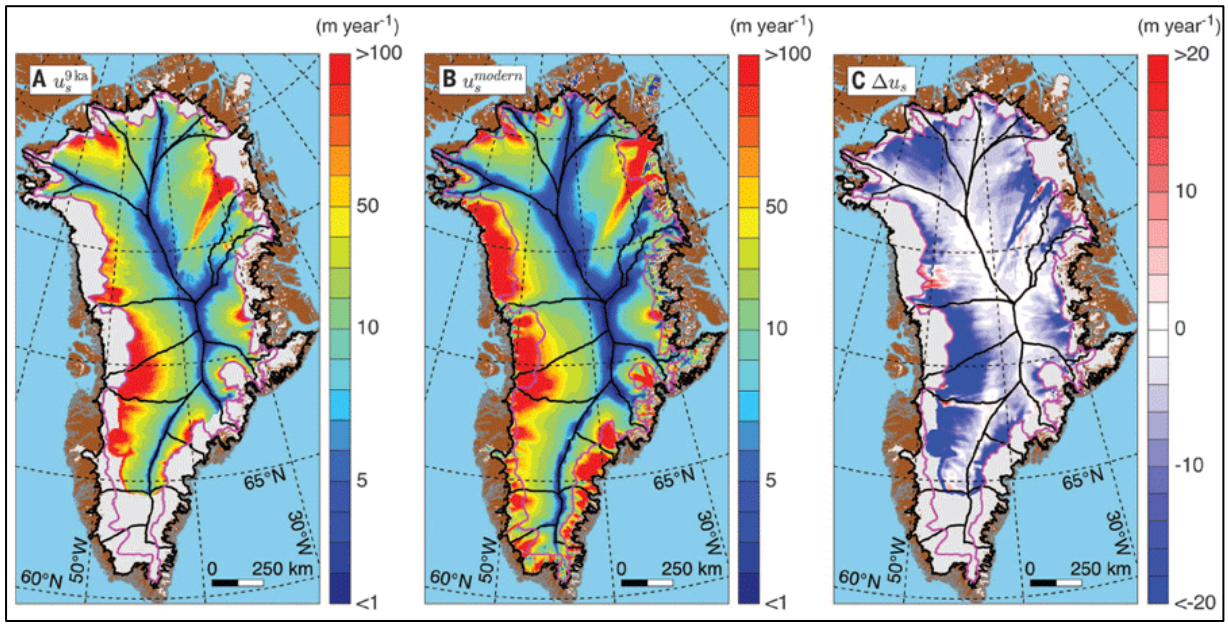

Figure 1. Holocene-averaged and modern surface speed across the Greenland Ice Sheet (MacGregor et al., 2016).

2 SOFTWARE AND TOOLS

2.1 Get Data

The following external links provide access to software for reading and viewing HDF5 and netCDF data files. Please be sure to review instructions on installing and running the programs.

HDF Explorer: Data visualization program that reads Hierarchical Data Format files (HDF, HDF-EOS and HDF5) and also netCDF data files.

Panoply netCDF, HDF and GRIB Data Viewer: Cross-platform application. Plots geo-gridded arrays from netCDF, HDF and GRIB data sets.

For additional tools, see the HDF-EOS Tools and Information Center.

3 QUALITY ASSESSMENT

The fundamental quality assessment step for this dataset came earlier, when originally tracing and dating the radar internal reflections used to model the 9-ka-average balance ice flux. See the *Radiostratigraphy and Age Structure of the Greenland Ice Sheet* data set for additional information. Following modeling of along-track depths, accumulation rates and strain rates, some manual removing of clearly anomalous model values was performed. Such values tended to be along the edge of the model domain, toward the coast, where fewer reflections could be mapped or where their dating was more uncertain.

4 DATA ACQUISITION AND PROCESSING

4.1 Theory of Measurements

See the *Radiostratigraphy and Age Structure of the Greenland Ice Sheet* data set, as well as MacGregor et al. (2016) and its Supplementary Materials for more information.

4.2 Data Acquisition Methods

See the *Radiostratigraphy and Age Structure of the Greenland Ice Sheet* data set for more information.

4.3 Derivation Techniques and Algorithms

Figure 2 illustrates the technique for recovering the age-bounded balance velocity.

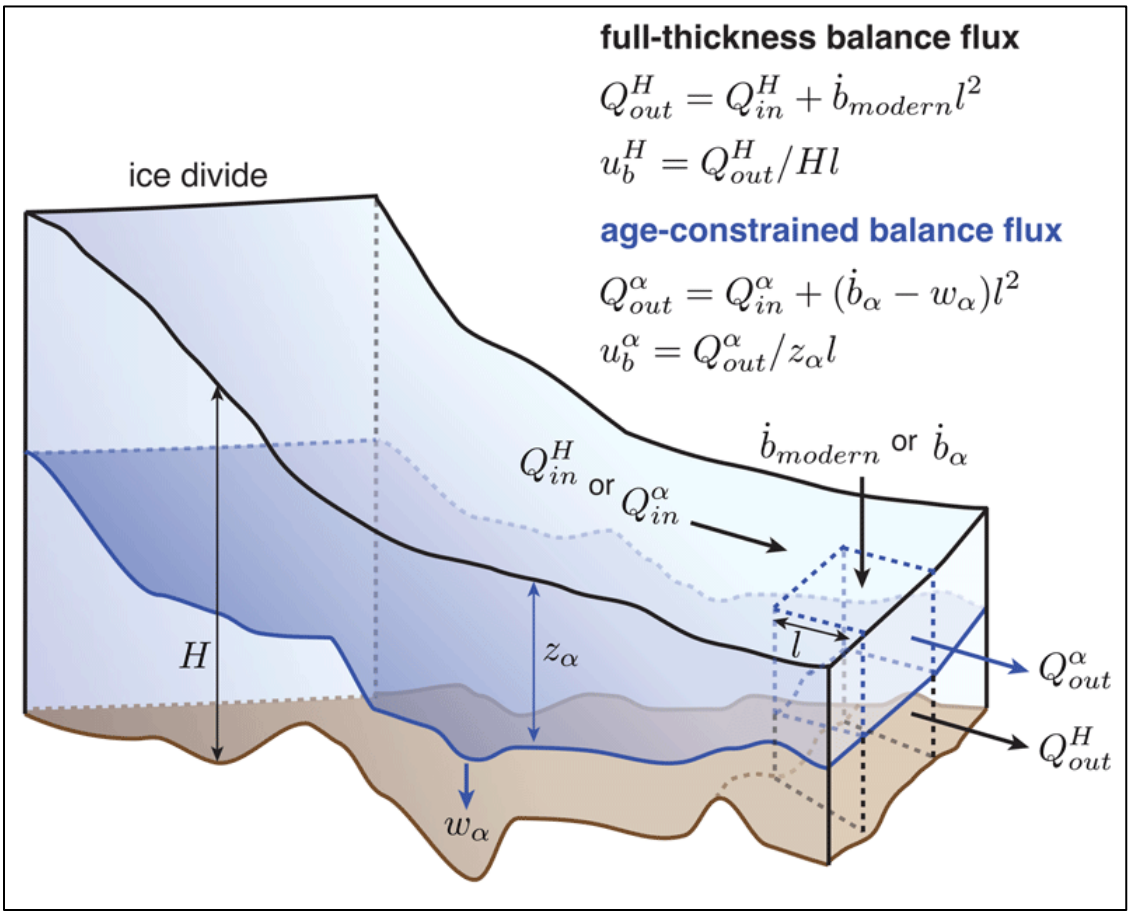

Figure 2. Schematic illustrating conventional (full-thickness) and Holocene-averaged balance-flux methods (schematic is not to scale).

The Holocene-averaged balance velocity is calculated by balancing the input and output ice fluxes, averaged over the period between α age and the present, through a horizontally square column of ice bounded vertically by the subaerial ice surface and the depth of the isochrone of α age. Both balance methods assume implicitly that the ice sheet is in steady state during the period represented by the portion of the ice column considered.

4.3.1 Processing Steps

First, the boundary conditions (depth to 9-ka isochrone, accumulation and vertical strain rate) were determined using a 1-D ice-flow model along the radar tracks (along-track) at 1-km intervals. These results were then gridded (ordinary kriging) onto a 1-km grid. Finally, they were filtered to a 5-km grid using a 2-D Gaussian with half-width depending on the local ice thickness.

4.3.2 Error Sources

The greatest direct source of uncertainty in the results is the original mapping and dating of the radar internal reflections. Second to that are the assumptions associated with the balance-velocity model, particularly the steady state assumption and the determination of the region where one-dimensional ice-flow models are acceptable. See the *Radiostratigraphy and Age Structure of the Greenland Ice Sheet* data set, as well as MacGregor et al. (2016) and its Supplementary Materials for more information.

4.4 Sensor or Instrument Description

See the *Radiostratigraphy and Age Structure of the Greenland Ice Sheet* data set for more information.

5 REFERENCES AND RELATED PUBLICATIONS

MacGregor, J. A., Colgan, W. T., Fahnestock, M. A., Morlighem, M., Catania, G. A., Paden, J. D., & Gogineni, S. P. (2016). Holocene deceleration of the Greenland Ice Sheet. Science, 351(6273), 590–593. https://doi.org/10.1126/science.aab1702

MacGregor, J. A., Fahnestock, M. A., Catania, G. A., Paden, J. D., Prasad Gogineni, S., Young, S. K., Rybarski, S. C., Mabrey, A. N., Wagman, B. M., & Morlighem, M. (2015). Radiostratigraphy and age structure of the Greenland Ice Sheet. Journal of Geophysical Research: Earth Surface, 120(2), 212–241. https://doi.org/10.1002/2014jf003215

5.1 Related Data Collections

Radiostratigraphy and Age Structure of the Greenland Ice Sheet
IceBridge BedMachine Greenland
MEaSUREs Greenland Ice Mapping Project (GIMP) Digital Elevation Model

5.2 Related Websites

IceBridge product web page at NSIDC
IceBridge web page at NASA
NASA Greenland Ice Sheet stratigraphy video
University of Texas Institute for Geophysics website

6 CONTACTS AND ACKNOWLEDGMENTS

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Acknowledgments
This work was supported by NSF (grants ARC 1107753, ARC 1108058, and ANT 0424589) and NASA (grants NNX12AB71G and NNX15AD55G). We thank the organizations (Center for Remote Sensing of Ice Sheets and Operation IceBridge) and innumerable individuals who aided in the collection and processing of radar data used in this study. Most of the early radar data used in this study were collected as part of NASA's Program for Arctic Regional Climate Assessment.

7 DOCUMENT INFORMATION

7.1 Publication Date

03 October 2016

7.2 Date Last Updated

02 November 2020