Tidewater Glacier Frontal Ablation Calculation Tool (TG_FACT)

This processing chain and the associated dataset is described in Fahrner et al. (in prep.).

When using this processing chain please use the citation provided in the repository.

The processing chain will automatically calculate monthly, three-monthly or annual frontal ablation estimates for Greenlandic tidewater glaciers.

Input data

1. TermPicks Terminus delineations (Goliber and Black, 2021)
2. Satellite image (for manual delineation of fjord walls).
3. Glacier velocity (code will automatically download ITS_LIVE velocities for the period 2008-2018; ~7 GB)
4. Two Digital Elevation Models (preferably ArcticDEM v4.1 strips and AeroDEM; (Korsgaard et al., 2016; Porter et al., 2022)
5. Surface change rate (Khan, 2023)
6. Bedrock Topography from BedMachine v5 (Morlighem et al., 2017, 2022)
7. Solid Ice Discharge (Mankoff et al., 2020)

Processing Steps

The processing chain follows the workflow outline in Figure 1. For a detailed description of the processing steps, please refer to Fahrner et al., (in prep.).

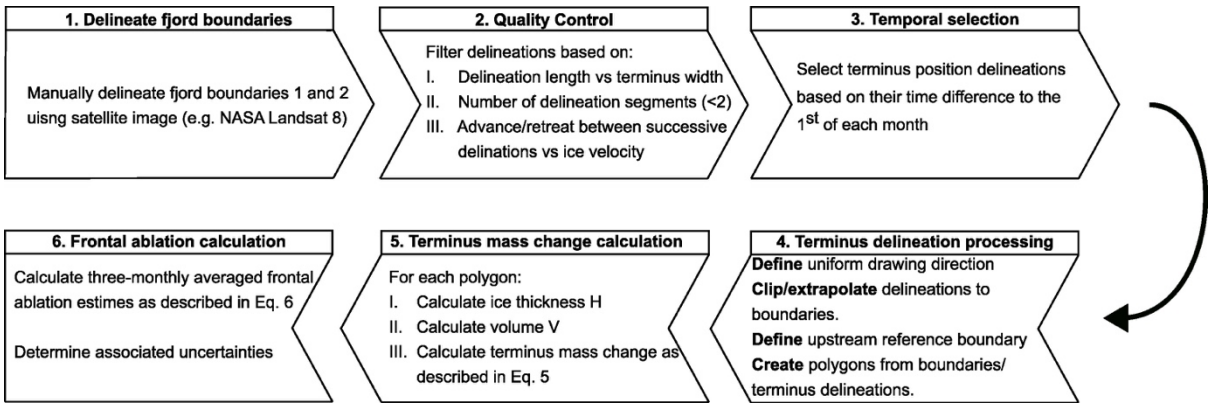

Figure 1: Schematic workflow for the calculation of frontal ablation estimates from observational data.

Example

The "Data" folder contains all input data (Bedmachine v5 bedrock topography and associated uncertainty, glacier centerlines, fjord and upstream boundaries, solid ice discharge, surface elevation change rates) for the 49 tidewater glaciers discussed in Fahrner et al., (2024) except for ArcticDEM v4.1 strips, AeroDEMs and satellite images due to their large file size. We provide a satellite image, ArcticDEM v4.1 strip and AeroDEM for Helheim Glacier, SE Greenland so that the processing chain can be run and tested. Once the files are unzipped, make sure that the *Code, Data and Results folder* as well as the *TG_Fact_Runfile.m* are in the same directory. To run the processing chain, open the TG_Fact_Runfile.m and run the file in Matlab. The processing chain will calculate frontal ablation estimates, plot the data as a graph (Figure 2), and provide the output data with the below specified variables.

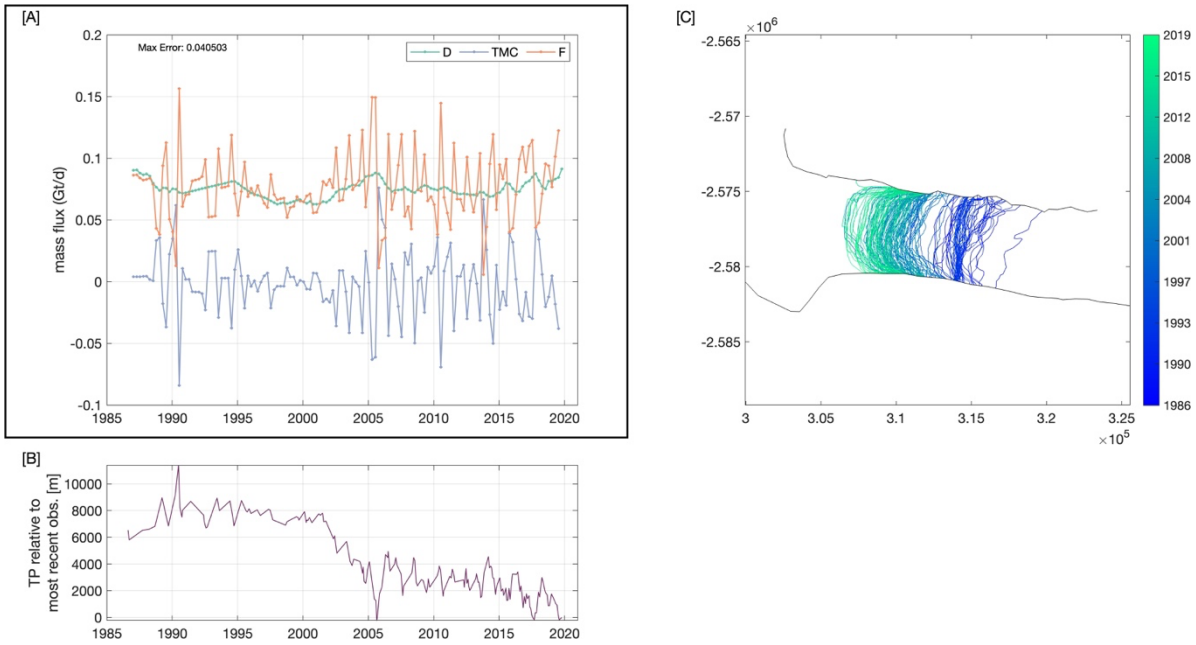

Figure 2: Example of output data for Helheim Glacier, SE Greenland. A) Example of frontal ablation estimates (orange), terminus mass change (blue) and ice discharge (green) for Helheim Glacier, SE Greenland. B) Terminus position change relative to the most recent observation. C) Processed terminus delineations used for the calculation of frontal ablation estimates shown in A) colour-coded by date. Black lines show the manually delineated fjord walls.

Output

The output data of the processing chain is made available in Matlab (.mat), Shapefile (.shp) and NetCDF (.nc) format within the results folder. Each file contains additional data that is necessary to calculate frontal ablation estimates as well as the associated uncertainties.

The variables in the NetCDFfile are as follows:

- **Time** – Midpoint of time intervals on which output data is defined [days since 01/01/1950]
- **Name** – Name of each glacier investigated in this study [unitless]
- **PolarX** – Polar Stereographic X Coordinate (EPSG:3413) [m]
- **PolarY** – Polar Stereographic Y Coordinate (EPSG:3413) [m]
- **Lat** – Latitude (EPSG:4326) [degrees]
- **Lon** – Longitude (EPSG:4326) [degrees]
- **F** – Three-month-average frontal ablation estimates during time intervals [Gt/d]
- **F_Max_U** – Maximum uncertainty over total time period [Gt/d]
- **F_U** – three-month-average frontal ablation uncertainty for time intervals [Gt/d]
- **D** – Three-month-average solid ice discharge during time intervals [Gt/d]
- **D_U** – Three-month-average solid ice discharge uncertainty for time interval [Gt/d]
- **TMC** – Terminus mass change (dM/dt) during time intervals [Gt/d]
- **TMC_U** – Three-month-average terminus mass change uncertainty during time intervals [Gt/d]
- **L** – Interpolated terminus change over time (L) [km]
- **Delta_L_W** – Delineation and fjord width uncertainty ($\delta L/\delta W$; constant) [km]
- **H** – Mean ice thickness in the polygon; maximum during the ovbservation period (H) [km]
- **Delta H** – Ice thickness uncertainty with constant ArcticDEM/AeroDEM uncertainties of 0.1 m and 6 m, respectively (δH) [km]
- **Rho** – Ice density (ρ_i; constant) [kg/km^3]
- **W** – Mean fjord width (W) [km]
- **Bedrock_U** – Mean uncertainty in bedrock topography along the centerline [km]
- **TI** – Time interval over which data are averaged ($t_2 - t_1$; 90 days for the results presented here)

The variables in the shapefile and geopackage are as follows:

- **Date** – Midpoint of time intervals on which output data is defined [days since 01/01/1950]
- **Name** – Name of each glacier investigated in this study [unitless]
- **Lat** – Latitude (EPSG:4326) [degrees]
- **Lon** – Longitude (EPSG:4326) [degrees]
- **F** – Three-month-average frontal ablation estimates during time intervals [Gt/d]
- **F_Max_U** – Maximum uncertainty over total time period [Gt/d]
- **F_U** – three-month-average frontal ablation uncertainty for time intervals [Gt/d]
- **D** – Three-month-average solid ice discharge during time intervals [Gt/d]
- **D_U** – Three-month-average solid ice discharge uncertainty for time interval [Gt/d]
- **TMC** – Terminus mass change (dM/dt) during time intervals [Gt/d]
- **TMC_U** – Three-month-average terminus mass change uncertainty during time intervals [Gt/d]
- **L** – Interpolated terminus change over time (L) [km]
- **Delta_L_W** – Delineation and fjord width uncertainty ($\delta L/\delta W$; constant) [km]

- **H** – Mean ice thickness in the polygon; maximum during the ovbservation period (H) [km]
- **Delta H** – Ice thickness uncertainty with constant ArcticDEM/AeroDEM uncertainties of 0.1 m and 6 m, respectively (δH) [km]
- **Rho** – Ice density (ρ_i; constant) [kg/km^3]
- **W** – Mean fjord width (W) [km]
- **Bedrock_U** – Mean uncertainty in bedrock topography along the centerline [km]
- **TI** – Time interval over which data are averaged ($t_2 - t_1$; 90 days for the results presented here)
- **Geometry** – Point geometry in Polar Stereographic Coordinate Reference System (EPSG:3413 [m])

Within the "Results" folder, additional files can be accessed, namely:

- **Plots** – Folder containing graphs as shown in Figure 2
- **F_Mat –** Folder containing frontal ablation estimates as well as all variables outlined above in Matlab format.
- **V_Mat** – Folder containing volume estimates in Matlab format. Variables included are:
    - **Date** – Observation date,
    - **A** – Polygon area [km^2]
    - **H** – Mean ice thickness [km]
    - **V** – Polygon volume [km^3]
    - **M** – Polygon mass [Gt]
- **TMC_U_Mat** – Folder containing terminus mass change (TMC) uncertainties in Matlab format.
- **TerminusMassPolygons** – Folder containing volume data as shapefiles for visual quality control.
- **TerminusPositions_Final** – Folder containing terminus positions used for calculation of frontal ablation estimates (i.e. after quality control, temporal filtering, extrapolation/cropping).

The latest data product (Version 6) containing frontal ablation estimates for all 49 tidewater glaciers discussed in Fahrner et al. (in prep.) can be found at https://doi.org/10.5281/zenodo.10076252

References

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Porter, C. et al. ArcticDEM – Strips, Version 4.1, *Harvard Dataverse, V1,* [15/10/2024], *https://doi.org/10.7910/DVN/C98DVS,* (2022).