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 ~15 GB)
4. Two Digital Elevation Models (preferably ArcticDEM and AeroDEM; (Korsgaard et al., 2016; Porter et al., 2022)
5. Surface change rate (Khan, 2023)
6. Bedrock Topography from BedMachine v4 Morlighem et al., 2017, 2021)
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., (2024).

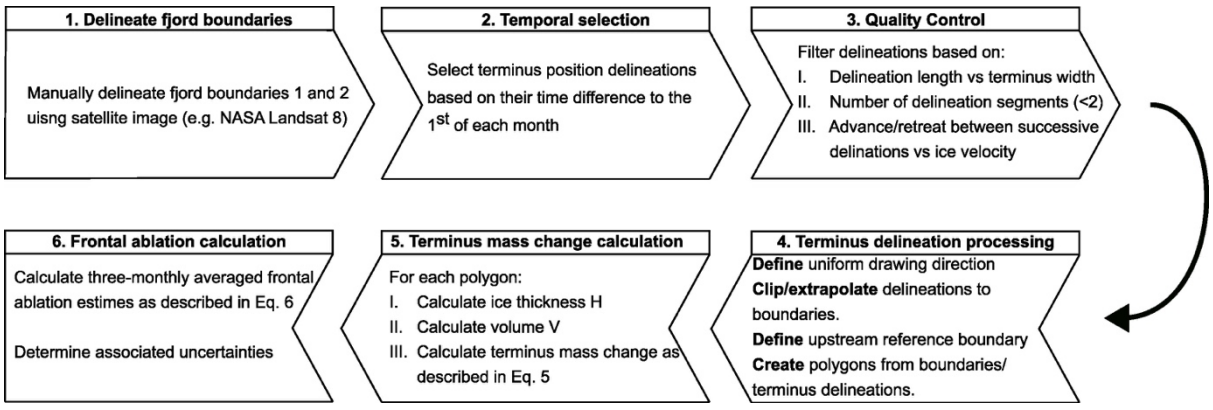

Figure 1: Schematic workflow for the calculation of frontal ablation estimates from observational data.

Example

The "Data" folder contains all input data for tidewater glaciers discussed in Fahrner et al., (2024) except for DEMs and satellite images due to their large file size. We provide a satellite image and DEM for Helheim Glacier, SW Greenland so that the processing chain can be run and tested. 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.

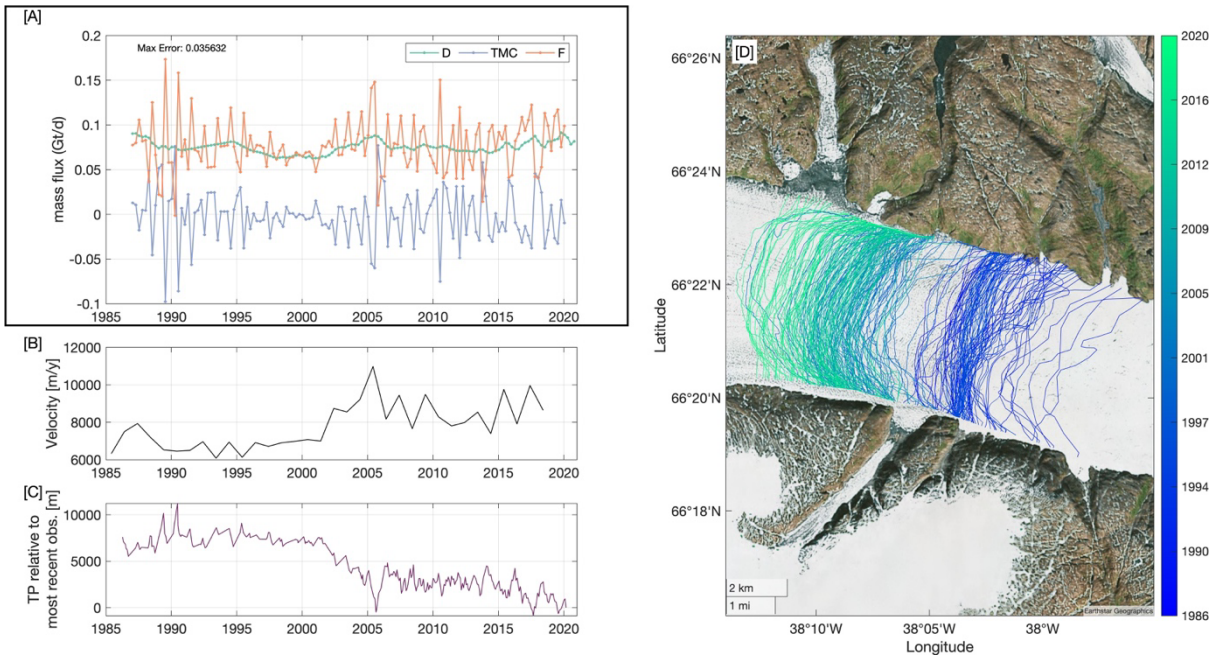

Figure 2: Example of output data for Helheim Glacier, SE Greenland. A) Three-monthly averaged frontal ablation estimates (orange), ice discharge (green) and terminus associated mass change (TMC, blue). Maximum error is shown (for details Fahrner et al., (2024). B) Annual flow velocity in m/yr from NASA ITS_LIVE data B) Terminus position (TP) relative to most recent observation along the centerline. Panels B) and C) are only shown for comparison and are not part of the dataset. D) Terminus positions used to calculate frontal ablation estimates, color-coded by date.

Output

The resulting data of frontal ablation estimates for each glacier is provided as Matlab and ESRI Shapefile. The full dataset as described in Fahrner et al., (in prep.) is also provided as NetCDF and Geopackage.

- **Glacier name** – Name of each glacier investigated in this study [unitless]
- **F** – Three-month-average frontal ablation estimates during time intervals [Gt/d]
- **F_Uncertainty** – three-month-average frontal ablation uncertainty for time intervals [Gt/d]
- **F_Max_Uncertainty** – Maximum uncertainty over total time period [Gt/d]
- **Date** – Midpoint of time intervals on which output data is defined [yyyy-mm-dd]

- **D** – Three-month-average discharge during time intervals [Gt/d]
- **D_Uncertainty** – Three-month-average discharge uncertainty for time interval [Gt/d]
- **TMC** – Terminus mass change (dM/dt) during time intervals [Gt/d]
- **TMC _Uncertainty** – Three-month-average terminus mass change uncertainty during time intervals [Gt/d]
- **Rho** – Ice density (ρ_i; constant) [km]
- **L** – Interpolated terminus change over time (L) [km]
- **Delta_L_W** – Delineation and terminus width uncertainty ($\delta\mathrm{L}/\delta\mathrm{W}$; constant) [km]
- **H** – Mean ice thickness along the centerline (H) [km]
- **Delta H** – Ice thickness uncertainty with constant ArcticDEM/AeroDEM uncertainties of 0.1 m and 6 m, respectively ($\delta\mathrm{H}$) [km]
- **W** – Terminus 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) [d]Figure 1: Flow chart showing the calculation of ice thickness.

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

- **FA_Img** – Folder containing graphs as shown in Figure 2
- **FA_Mat –** Folder containing frontal ablation estimates in Matlab format. Variables included are outlined above.
- **VOL_Mat** – Folder containing volume estimates in Matlab format. Variables included are:
    - observation date,
    - polygon area [km^2]
    - mean ice thickness [km]
    - polygon volume [km^3]
    - polygon mass [Gt]
- **TerminusMassPolygons** – Folder containing Vol_Mat data as shapefiles for visual quality control.
- **TMC_Error_Mat** – Folder containing uncertainty estimates of terminus mass change (TMC).
- **TerminusPositions_Final** – Folder containing terminus positions used for calculation of frontal ablation estimates (i.e. after temporal filtering, quality control, extrapolation/cropping)
- **TerminusPositions_QC** – Folder containing terminus positions after quality control.

References

Goliber, S. and Black, T., (2021) *TermPicks: A century of Greenland glacier terminus data for use inmachine learning applications (Version 1)*. Available at: https://zenodo.org/records/5117931.

Khan, S.A., (2023) *Greenland Ice Sheet Surface Elevation Change*. Available at: https://doi.org/10.22008/FK2/GQJJEA.

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