EARTH OBSERVATION CLIMATE INFORMATION SERVICE

Quick Start Guide

Ice Sheet Surface Elevation

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1. Quick Start: Land Ice product

The following will provide you with sufficient information to quickly get to grips with the Land Ice dataset products and to gain some familiarity with the information available.

1.1 What products are available?

Ice sheet surface elevation change are provided as NetCDF files. There are separate files for the Greenland Ice Sheet and the Antarctic Ice Sheet, example filenames are provided in Table 1.

Product name and acronym	Filename example	Version
Surface elevation change (SEC)	EOCIS-GIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-199202-199702-fv1.nc (Greenland file) EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-199111-199611-fv1.nc (Antarctica file)	V1.0

Table 1 Dataset Products covered in this document

1.2 Summary information

Product Name	**Surface elevation change**
Main observed variable(s)	Ice sheet surface elevation
Geographical range of dataset	Greenland and Antarctica
Temporal range of dataset	1991-present
Spatial resolution / gridding	5 km^2
Temporal sampling characteristics	Monthly
Level of processing	L3 gridded data
Main auxiliary content	Uncertainties; surface type class; basin identification
Dataset citation	Shepherd, Andrew, et al. "Trends in Antarctic Ice Sheet elevation and mass." Geophysical Research Letters 46.14 (2019): 8174-8183. McMillan, M., et al. (2016), A high-resolution record of Greenland mass balance, Geophys. Res. Lett., 43, doi:10.1002/2016GL069666 .
Dataset journal reference	NA

Table 2 Summary Information for surface elevation change product

1.2.1 Variables summary information

Variable name	Description	Units
Surface elevation change (sec)	Rate of ice sheet surface elevation change	Metres per year (m/yr)
Uncertainty (sec_uncertainty)	Uncertainty in surface elevation change.	Metres per year (m/yr)
Latitude (lat)	Latitude at centre of grid cell	Degrees north
Longitude (lon)	Longitude at centre of grid cell	Degrees east
Surface_type	Surface type identifier, for use in discriminating different surfaces types within the SEC grid: ocean, ice_free_land, grounded_ice, floating_ice lake_vostok.	NA
Basin_id	Glacialogical basin identification number (http://imbie.org/imbie-3/drainage-basins/)	NA
x	Cartesian x-coordinate - easting, of centre of each grid cell	Metres (m)
y	Cartesian y-coordinate - northing, of centre of each grid cell	Metres (m)
Start time	The start time of the 5yr time slice period used to calculate surface elevation change, in decimal years	Years
End time	The end time of the 5yr time slice period used to calculate surface elevation change, in decimal years	Years

Table 3 Summary information for each variable for Land Ice

1.3 What can these products be used for?

Surface elevation change

The elevation change product can be used to explore the spatial and temporal variation in surface elevation change over Greenland and Antarctica. This product can be used to investigate 30-year height trends across the ice sheets and can be subset by ice sheet drainage basins. Ice sheet surface elevation change is indicative of mass change.

Limitations

The spatial and temporal sampling of both data products are limited by the orbital characteristics of the satellite missions used to determine them. A data gap will occur at the poles for the earlier satellite missions, ERS-1, ERS-2 and Envisat (1992-2010), as they have a latitudinal limit of 81°. The pole hole reduces for CryoSat-2 (2010-present) with a latitudinal limit of 88°. It is also to be expected that the older missions will have higher uncertainties because they were ocean focused missions not designed to monitor ice sheets. CryoSat-2 was the first Cryosphere-specific mission.

1.4 Where to find these products for download

The land-ice datasets will be made available through the EOCIS website.

1.5 Using downloaded data

Examples of tools and code using the ice sheet products are provided under the following categories:

- Ingest/Read data
- Display/Viewing
- Re-gridding/formatting
- Data reduction / sub setting

1.5.1 Import Data

Ice sheet products are provided as NetCDF files using the latest CF metadata conventions (CF-1.10), and standard tools can therefore be used to read them.

An example code in python of ingesting/reading the gridded elevation change data is shown below:

```
"""Example of reading the elevation change product from an example EOCIS surface
elevation change file over Antarctica:
'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc"""

import xarray as xr

# Step 1: Read the NetCDF file
filename = 'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc'
data = xr.open_dataset(filename)

# Step 2: Print useful information about the data
print(data)
```

Example output:

```
<xarray.Dataset>
Dimensions:                (time_period: 1, ny: 968, nx: 1128)
Coordinates:
    lat                    (ny, nx) float64 ...
    lon                    (ny, nx) float64 ...
Dimensions without coordinates: time_period, ny, nx
Data variables:
    sec                    (time_period, ny, nx) float32 ...
    sec_uncertainty        (time_period, ny, nx) float32 ...
    x                      (nx) float32 ...
    y                      (ny) float32 ...
    grid_projection        |S1 ...
    surface_type           (ny, nx) float32 ...
    basin_id               (ny, nx) float32 ...
    start_time             (time_period) float32 ...
    end_time               (time_period) float32 ...
    cell_time_lengths      (time_period, ny, nx) float32 ...
    cell_start_times       (time_period, ny, nx) float32 ...
    cell_end_times         (time_period, ny, nx) float32 ...
Attributes: (12/38)
    title:                      5yr Ice Sheet Surface Elevation Change at 5.0km r...
    institution:                Centre for Polar Observation and Modelling (CPOM)
    creator_email:              cpom@northumbria.ac.uk
    creator_name:               Alan Muir, Jennifer Maddalena (CPOM)
    creator_url:                http://www.cpom.org.uk
    comment:                    This data was prepared as a part of the EOCIS pro...
```

1.5.2 Viewing data

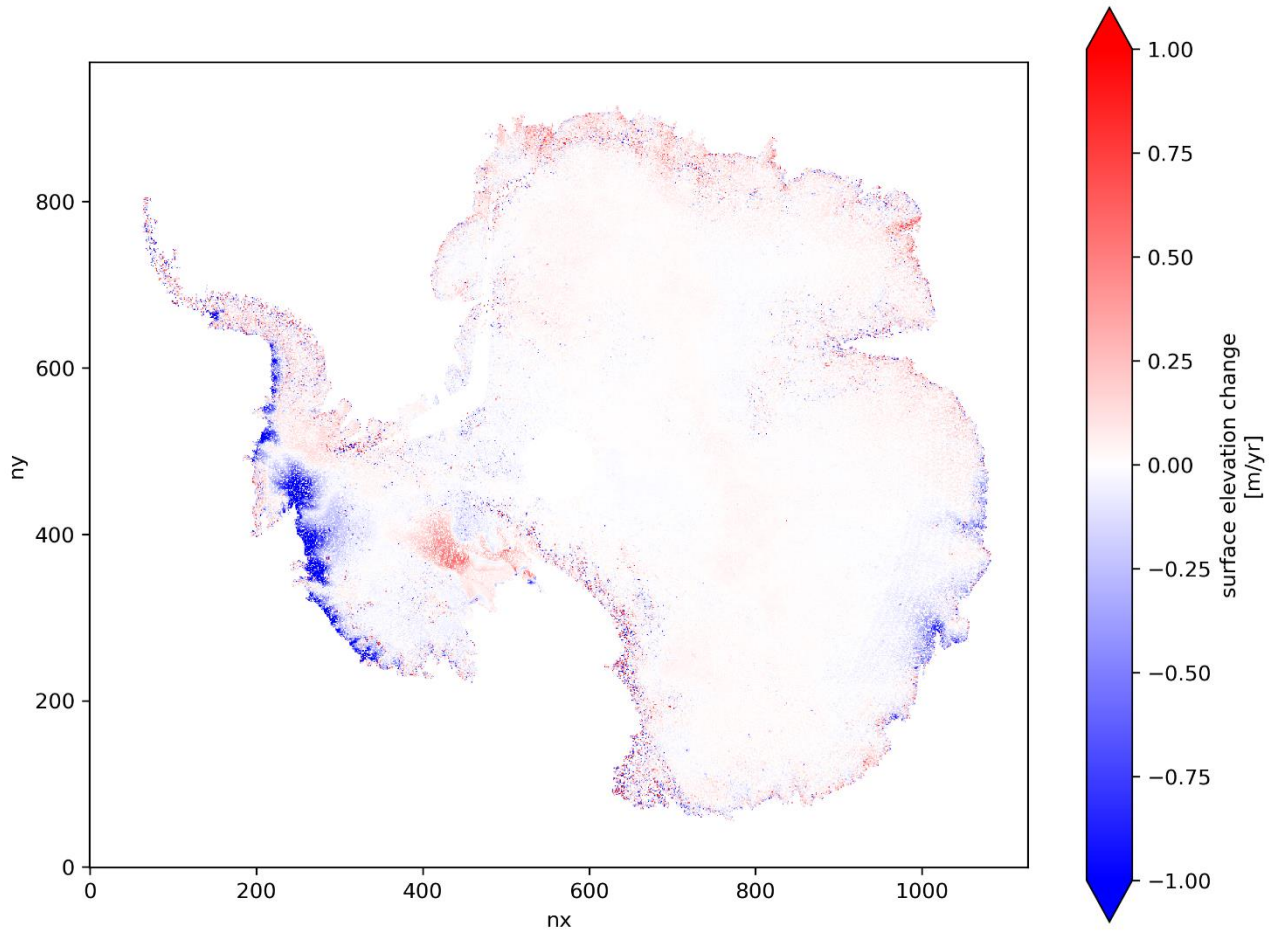
An example code in python of viewing the gridded elevation change data is shown below:

```
"""Example of plotting the elevation change product from an example EOCIS surface
elevation change file over Antarctica:
'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc"""

import xarray as xr
import matplotlib.pyplot as plt

# Step 1: Read the NetCDF file
filename = 'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc'
data = xr.open_dataset(filename)

# Step 2: Plot the surface elevation change variable
fig = plt.figure(figsize=(10, 8), dpi=300)
ax = data.sec[0].plot.imshow(vmax = 1, vmin = -1, cmap = 'bwr')
ax.axes.set_aspect('equal')
plt.show()
```



1.5.3 Re-Gridding/Formatting

The Land Ice data product is delivered in the EPSG:3413 (NSIDC Sea Ice Polar Stereo North) map projection for Greenland and in the EPSG:3031 (Polar Stereo South) for Antarctica. Information about the map projections can be found at https://epsg.io/3413 and https://epsg.io/3031.

The code below re-grids to a coarser resolution (from 5 x 5 km grid to 25 x 25 km grid) in python.

```
"""Example of regridding elevation change product from an example EOCIS surface
elevation change file over Antarctica:
'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc"""

import xarray as xr
import matplotlib.pyplot as plt

# Step 1: Read the NetCDF file
filename = 'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc'
data = xr.open_dataset(filename)

# Step 2: Regrid to coarser spatial resolution e.g. from 5 x 5 km to 25x25 km grid, 5x
coarser.
data_coarse = data.coarsen(nx=5, ny=5, boundary='pad').mean()

# Step 3: Plot regridded product
fig = plt.figure(figsize=(10, 8), dpi=300)
```

```
ax = data_coarse.sec[0].plot.imshow(vmax = 1, vmin = -1, cmap = 'bwr')
ax.axes.set_aspect('equal')
plt.show()
```

1.5.4 Data Reduction/Subsetting

The code below subsets a section of West Antarctica in python and plots the results.

```
"""Example of subsetting elevation change product from an example EOCIS surface
elevation change file over Antarctica:
'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc"""

import xarray as xr
import matplotlib.pyplot as plt

# Step 1: Read the NetCDF file
filename = 'EOCIS-AIS-L3C-SEC-MULTIMISSION-5KM-5YEAR-MEANS-200910-201410-fv1.nc'
data = xr.open_dataset(filename)

# Step 2: Subset the data
subset = data.sec.sel(ny=slice(300,500), nx=slice(180,400))

# Step 3: Plot subsetting surface elevation change
fig = plt.figure(figsize=(10, 8), dpi=300)
ax = subset[0].plot.imshow(vmax = 1, vmin = -1, cmap = 'bwr')
ax.axes.set_aspect('equal')
plt.show()
```

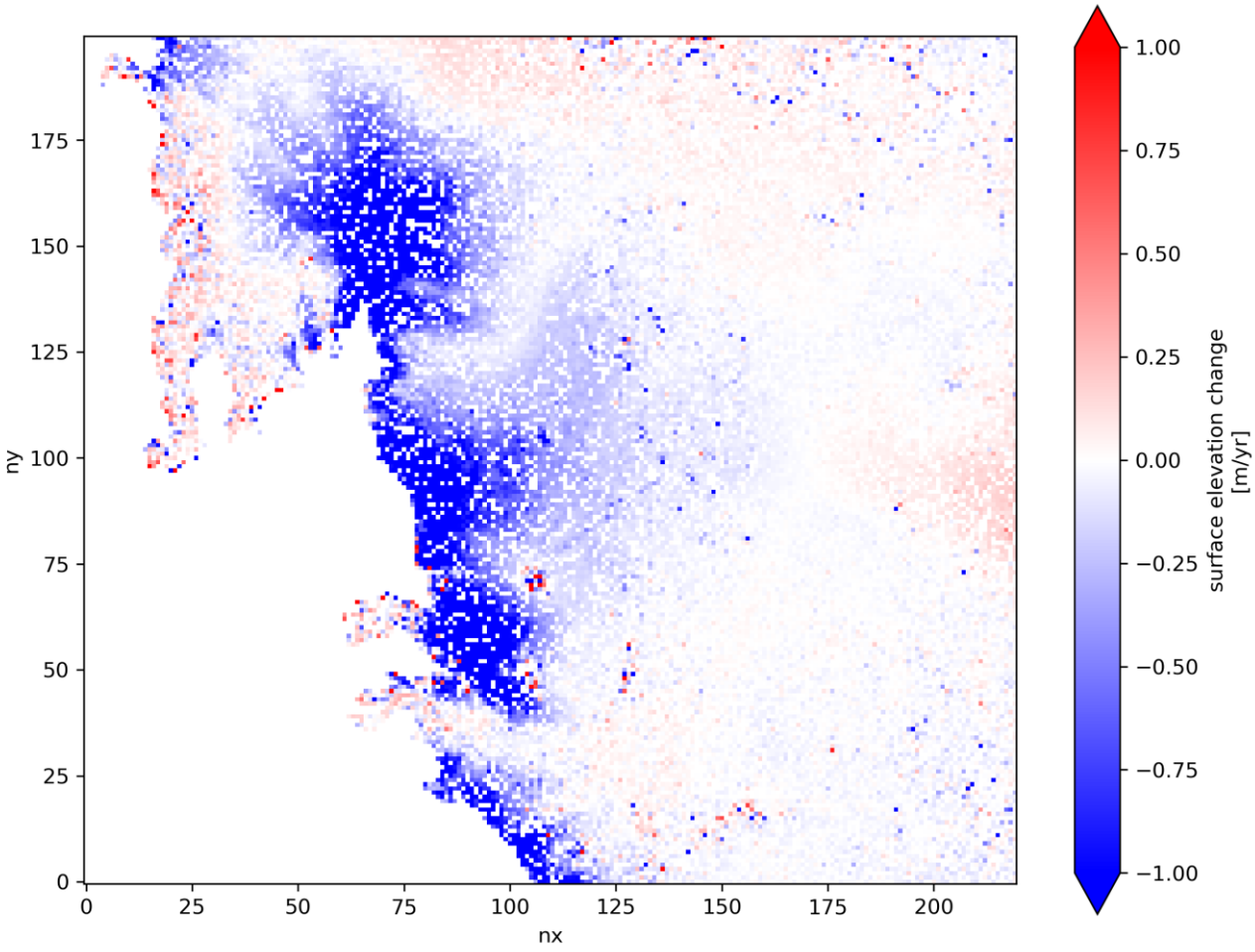
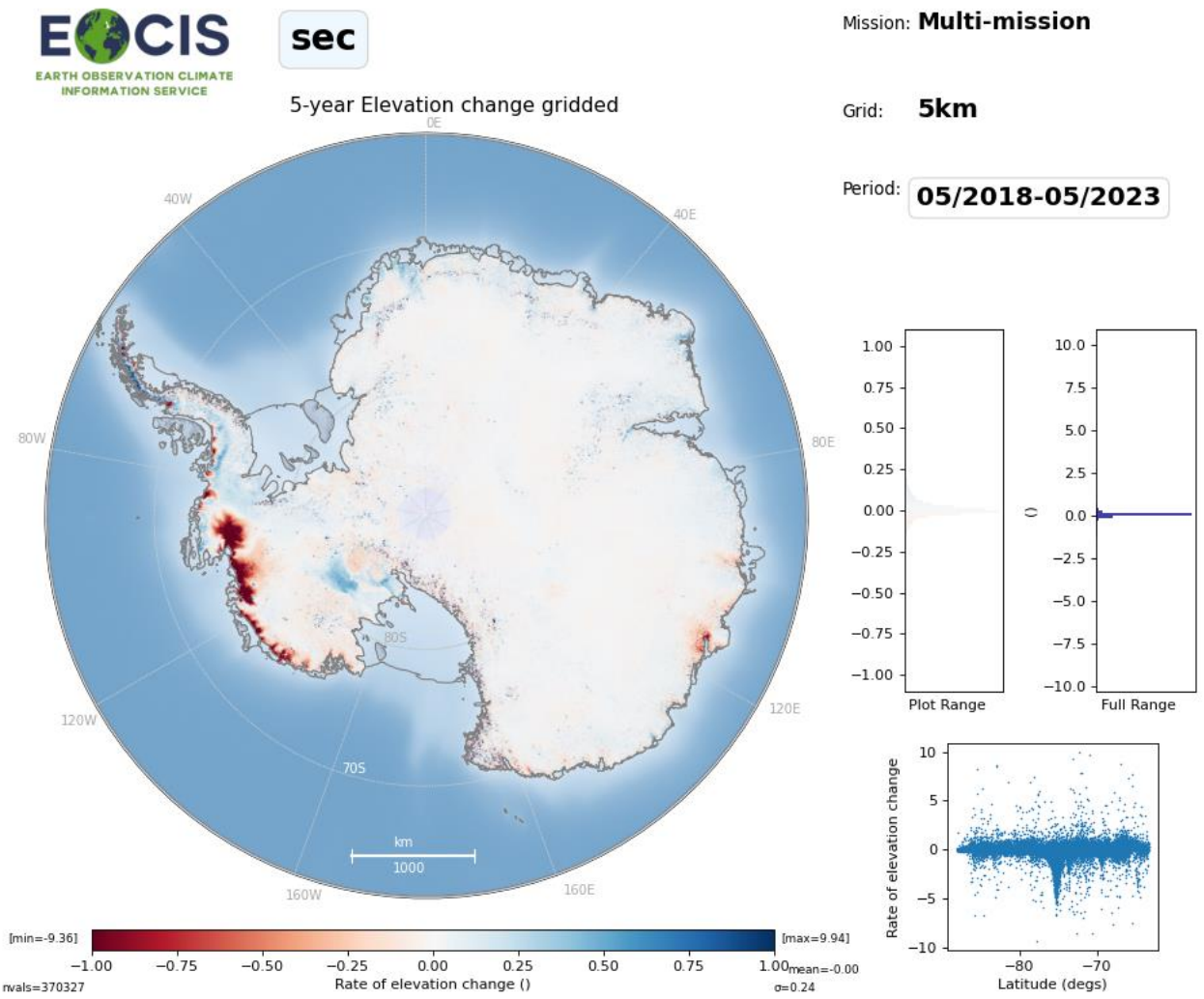


Figure 1: Illustration of surface elevation change spatial subset over West Antarctica.

1.6 Interactive visualisation / data access

Online data browsing and visualization tools will be provided once land-ice data portal is complete.

A typical product visualization of the whole Antarctic ice sheet surface elevation change is shown below:



1.7 Your obligations when using these products

By accessing the ice sheet products, you agree to cite the dataset digital object identifier (doi) and corresponding journal article describing the dataset every time you publish results obtained in whole or in part by use of UK EOCIS products. These citations are given under Summary Information.

The reference to the dataset should mention "created by the UK Earth Observation Climate Information Service". The product name and acronym in Table 1 and should be used to avoid confusion and enable traceability.

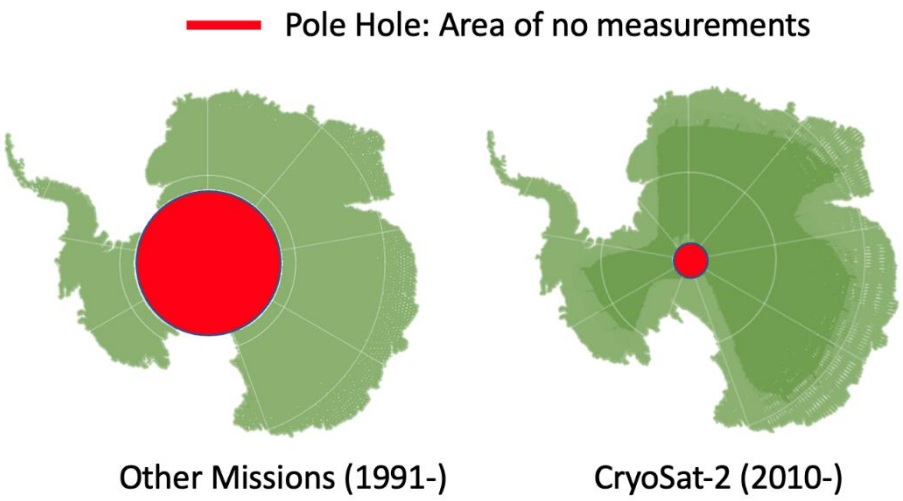
1.8 Further Information

Ice sheet surface elevation change is measured using radar altimetry data from ESA satellite missions in orbit since 1991.

Mission	Years Operational	Altimetry Product Version Used as Input
ERS-1	1991-1996	ESA ERS-1 FDR4ALT v1.0

ERS-1	1996-2003	ESA ERS-2 FDR4ALT v1.0
ENVISAT	2002-2012	ESA ENVISAT FDR4ALT v1.0
CryoSat-2	2010 - current	ESA CryoTEMPO Baseline-B

All missions except from CryoSat-2 operate in an orbit which limits measurements to below approximated 82°N and S. This creates a hole around the pole where no ice sheet measurement is possible. The exception to this is CryoSat-2 which operates up to 88°N and S, leaving only a very small pole hole. This orbital measurement limit mainly affects Antarctica. The Greenland ice sheet is predominantly located below 82°N.



Another issue related to the satellite orbit is the density of the measurements. The polar orbit converges towards the pole providing a high density of measurement near the pole hole. The orbit density decreases towards the equator, and so the southern region of Greenland (which reaches approximately 60° N) has relatively sparse coverage.

EOCIS ice sheet elevation products contain monthly gridded measurements on a 5km polar stereographic grid, for every month between 1991 and the current month (-1). Each monthly measurement covers the change over the previous 5 year period.

History of modifications / Change Log

Version	Date	Changes	Person
0.1	28-Apr-2023	Initial Draft	JM, AM
1.1	31-Aug-2023	Examples ingesting/reformatting data added.	JM
2.0	25-Apr-2024	Created separate quick start guides for 'Elevation change' and 'Mass balance' products. Updated file names (Table 1) and python coding examples (Section 1.5).	JM

Related Documents / Reference Documents

Document	Author	Reference
UK EOCIS Quick Start Guide V2.0 Mass Balance	JM	

Acronyms and/or Abbreviations

Acronym / Abbreviation	Definition

General definitions

Term	Definition
Surface elevation change	Rate of elevation change
Mass balance	Rate of mass change