CLIMATE_SPACE: TIPPING ELEMENTS ACTIVITY

CryoTipping

Inventory Document

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VERSION HISTORY TABLE

Version	Author	Affected Section	Change	Status
1.0	All	All	Document Creation	

ACRONYMS AND ABBREVIATIONS

Abbreviation	Meaning
CCI+	Climate Change Initiative Plus
CMUG	Climate Modelling User Group
DLR	Deutsches Zentrum für Luft und Raumfahrt (German Aerospace Center)
ENVEO	Environmental Earth Observation Information Technology GmbH
EO	Earth Observation
ESA	European Space Agency
GLL	Grounding Line Location
IV	Ice Velocity
NU	Northumbria University
PISM	Parallel Ice Sheet Model
SEC	Surface Elevation Change
VILMA	VIscoelastic Lithosphere and MAntle
WP	Work Package

1. INTRODUCTION

1.1 Purpose and Scope

This document presents an inventory of all the relevant data sets and numerical models required to conduct the scientific studies for the CryoTipping Climate_Space: Tipping Elements Activity.

1.1 Overview of document

This inventory document consists of the following sections:

Section 2. Earth Observation Datasets

Section 3. Numerical Models

Section 4. References

2. EARTH OBSERVATION DATASETS

EO Variable	Description	Time period	Temporal resolution	Spatial resolution	Available from
SEC - Surface elevation change	Gridded time-series of ice sheet surface elevation change derived from satellite radar altimetry (ERS-1/2, ENVISAT, CryoSat-2). Elevation changes from each satellite mission are derived using a plane fit method and are then combined by adjusting for the bias occurring during periods of mission overlap following Shepherd et al. (2019).	1992 to present-day	140-day	5 km x 5 km	This dataset is produced as part of the AIS CCI+ project and is hosted at http://www.cpom.ucl.ac.uk/csopr/icesheets3/
IV - Ice velocity	Gridded time-series of ice sheet surface velocity derived from SAR satellite data. The velocity is retrieved using advanced offset tracking techniques. Velocity maps derived from repeat image pairs are stacked to produce monthly and annually averaged velocity mosaics. The algorithm and processing line are described in Wuite et al., (2025) and Nagler et al., (2015).	Sentinel-1: 2015 to present-day ALOS PALSAR: 2006-2011 ERS-1/ERS-2: 1992-1996	Annual and Monthly (S1: optionally 6-day and 12-day)	200 m x 200 m	These datasets are produced as part of the AIS CCI+ project and are (partly) hosted at https://cryoportal.enveo.at/ & https://catalogue.ceda.ac.uk/uuid/00fe090efc58446e8980992a617f632f/
GLL - Grounding	Time series of GLLs derived SAR	ERS-1/ERS-2	Annual	250 m	The datasets are

line location	satellite data (DInSAR method) starting with 1992 until the Sentinel-1 era. Vector data (ESRI shapefiles).	1992/93; Sentinel-1 A/B since 2015	product		produced in the AIS_CCI+ project hosted at https://cryoportal.enveo.at/ Additional published datasets from MEaSUREs (grounding line and grounding zone) for filling the gaps. Datasets produced from COSMO Sky-MED 2017/2018 (Millilo et al, 2019); ICEYE SAR in 2023 (Rignot et al, 2024)
GMB - Gravimetry mass balance	Gridded time-series of ice sheet mass balance derived from Earth's gravity field recorded by the Gravity Recovery and Climate Experiment (GRACE) and its follow-on satellite mission (GRACE-FO). The product relies on gravity field solutions (L2) of release 06 generated at the Center for Space Research (University of Texas at Austin). The mass change estimation is based on the tailored sensitivity kernel approach developed at TU Dresden. (Groh & Horwath, 2021)	2002 to present-day	Monthly	50 x 50 km	This dataset is produced as part of the AIS CCI+ project and is hosted at https://gravis.gfz.de/ais

3. NUMERICAL MODELS

Model	Description	Time period	Temporal resolution	Spatial resolution	Available from
PISM-VILMA	The Parallel Ice Sheet Model (PISM) is a thermomechanically-coupled ice flow model (Bueler & Brown, 2009, Winkelmann et al., 2011). Being parallelised and solving a hybrid of the shallow-ice and shallow-shelf approximations, it is numerically efficient and can integrate over millennial time scales. PISM includes a model for glacial isostatic rebound (Lingle Clark model, Bueler et al., 2007), and for sub-shelf melt (PICO, Reese et al., 2018). It has been employed to analyse tipping points in Antarctica (Garbe et al., 2020, Reese et al., 2023). Recently, PISM has been coupled to the 3D solid Earth and sea-level model VILMA, making it possible to conduct detailed studies of the interplay of vertical bedrock displacement, regional sea-surface height and grounding line retreat (Albrecht et al., 2024).	Last Glacial Maximum, deglaciation, Holocene to present-day	PISM: ~0.3yr VILMA: 2.5yr coupling time step: 100yr, possible: 1yr	PISM: 16km VILMA sea level: 0.18° (≤ 20 km), viscoelastic: 0.7° (≤ 78 km)	PISM code is freely available and is listed in the Research Software Directory at https://doi.org/10.5281/zenodo.10202029 (Khrulev et al., 2023). The coupling tool is freely available at https://github.com/talbrecht/pismvilma (Albrecht, 2024b) and can be downloaded from https://doi.org/10.5281/zenodo.12730723 together with the PISM version used in Albrecht et al. (2024). VILMA code will soon be publicly available.

Úa	Úa is a finite-element ice-flow model developed at the University of Northumbria. Úa has been employed to analyse tipping points in Pine Island glacier recent past (Reed et al., 2024) and future behaviour (Rosier et al., 2021).	Present-day to next centuries	Time step is adjusted dynamically based on convergence. Typically time steps are on the order of 0.001 when typing points are crossed, but much larger when approaching a steady state, e.g. 0.1 yr	Mesh resolution is typically adjusted dynamically with mesh resolution typically about 1km around grounding lines and evolving calving fronts.	Ua code is freely available (https://github.com/GHilmarG/UaSource)

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