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glaciers cci

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Document status sheet

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Executive Summary

This Glaciers_cci System Specification Document (SSD) specifies the characteristics of an operational ECV production system from a developers point of view. It reflects on the requirements of the Glaciers_cci System Requirements Document (SRD) and thus takes a look on the Glaciers_cci processing system in a potential second phase with potential for the time beyond.

The Glaciers_cci processing system covers different processing modules that are technically self standing. The modules rely on different input data and processing steps and the available prototype implementations are on different implementation levels. Furthermore the products have different production intervals and varying needs on the infrastructure.

To best address the modular structure of the processing system we propose a distributed processing system to produce the glacier area, elevation change and velocity products in the next development phase. The methodology is based on the existing prototypes.

Different implementation approaches are foreseen for the products. The glacier area product is acquired by a community effort using the glacier area macro-module described in the DPM and prototype. In a second step, with available Landsat 8 and Sentinel-2 data, the processor should be developed towards a higher degree of automation and a reduced dependence on COTS software. For the glacier elevation change product (DEM differencing), a toolbox performing the co-registration of two DEMs is foreseen to aid in the compilation of elevation change data available from the various satellites and techniques used. For the equivalent product from altimetry sensors the prototype allows to process the full archive of RA and ICESat altimeter data. In addition, the system can be used to test the Sentinel-3 and ICESat-2 data and will potentially be extended to process Cryosat 2 data. For glacier velocity a on-demand service is foreseen. The user shall be able to decide himself from which image pairs (and consequently where and for which period) velocity information shall be produced and made available. The data processing algorithms will be made available to the community in a special package.

The data distribution is foreseen through the web portals of the key community and from Glaciers_cci, as well as via the GLIMS (glacier area and velocity) and WGMS databases (elevation change products).

1. Introduction

1.1 Purpose and Scope

This document is version 0 of deliverable D5.2, the System Specification Document (SSD) of the Glaciers_cci project requested in the Statement of Work (SoW) [AD 1]. The SSD incorporates the requirements described in the System Requirements Document (SRD) [AD 4] and specifies the characteristics of an operational ECV production system from a developer's point of view.

The system design is based on experience with the prototype developed and applied in phase 1 of Glaciers_cci. The prototype is documented in the System Prototype Description (SPD) [RD 6], the Input and Output Data Definition (IODD) [RD 4], and the Detailed Processing Model (DPM) [RD 5]. Important information about the system can also be found in the System Verification Report [RD 7]. While the IODD and the DPM will also be applicable to phase 2 with their main content, the sustainable system will be developed based on the SPD to meet the specifications provided in this SSD. The use of the prototype within the Glaciers_cci processing system (PS) is one of the topics of this SSD.

According to the SoW [AD 1], the SSD shall include:

- a specification of the purpose of an operational ECV production system and its intended use
- an overview of the context of the system, defining all significant interfaces among system components and crossing the system's boundaries
- a definition of the fundamental operations to be performed within the system to accept and process the inputs and to process and generate the outputs
- a description of major constraints of the system
- a description of operational scenarios for the system including data sources, valid ranges of values, timing considerations, operator requirements, and special interfaces
- specification of the environmental characteristics of where the system will be installed
- specification of the growth, expansion, and capability characteristics of the system.
- description of the life cycle sustainment activities to be executed during the life cycle of the system
- a trade-off analysis of different technical solutions for a system concept taking into the account the requirements in the SRD, the prototype development described in the SPD and cost, performance, and operational constraints

1.2 Applicable and Reference Documents

List of Applicable Documents

ID	Title	Issue	Date
[AD 1]	ESA Climate Change Initiative Statement of Work		
[AD 2]	Glaciers_cci proposal		
[AD 3]	Glaciers_cci URD	1.1	11.10.2011
[AD 4]	Glaciers_cci SRD	1.0	12.07.2012
[AD 5]	Glaciers_cci SPD	0.5	13.02.2013

List of Referenced Documents

ID	Title	Issue	Date
[RD 1]	ESA CCI Project Guidelines, EOP-DTEX-EOPS-TN-10-0002	1.0	5.11.2010
[RD 2]	Glaciers_cci DARD	1.0	20.11.2011
[RD 3]	Glaciers_cci ATBDv2	1.1	13.02.2013
[RD 4]	Glaciers_cci IODDv1	0.5	21.11.2012
[RD 5]	Glaciers_cci DPMv1	0.5	8.11.2012
[RD 6]	Glaciers_cci PSD	1.0	20.11.2011
[RD 7]	Glaciers_cci SVR	0.4	18.03.2013

1.3 Document Overview

This document is organised along the requirements given in the SoW as follows: Section 2 gives an overview of the Glaciers_cci processing system. It describes its purpose and intended use as well as the main requirements, functions and components. Section 3 shows the main operational scenarios. Section 4 discusses the necessary infrastructure and Section 5 highlights the functional design from different perspectives, the users, system operators and developers view. Section 6 summarises information about the system life cycle design, implementation and maintenance costs and performance. Finally Section 7 connects this document to the SRD by tracing the system requirements of the SRD to sections of this document.

2. Overview of the Glaciers_cci processing system

This section gives an overview of the processing system (PS) with its main modules, functions and components. It also summarises its designated use and the system requirements.

2.1 Purpose

The Glaciers_cci PS generates products and supports the process of algorithm improvement, reprocessing and validation. It provides products and services to the glacier community supporting their climate change impact asessment over a wide range of scales. The PS will be used by the Glaciers_cci consortium but can also by applied by other interested parties. The PS aims at providing glacier related products such as glacier outlines, elevation changes, and velocity based on state of the art technology using the best suited and available EO data and algorithms. The products are produced in a transparent and documented way, with accompanying meta-data, documentation and validation reports.

The products are used by the two key science bodies WGMS and GLIMS within the Global Terrestrial Network for Glaciers (GTN-G). Additional users on global to regional scales are the glaciological and hydrological modelling communities who will use the generated data in their applications. The creation of a globally complete and detailed glacier inventory is a major action item (T.2.1) in the GCOS implementation plan. In this regard, the products will also serve the UNFCCC by providing baseline data for various modelling approaches (e.g. the sea-level contribution of glaciers and ice caps) that are relevant for forthcoming IPCC reports.

2.2 Context

The PS can be understood as a value-adding layer between the data provider and the users (Fig. 1). There are interfaces to the different user communities, which receive products and can provide feedback. Another interface is with the EO data providers. Depending on the PS, EO data are obtained from the providers at Level 1 or 2 and are ingested into the PS [RD 4]. Another interface is towards third-party sources to receive ancillary and validation datasets.

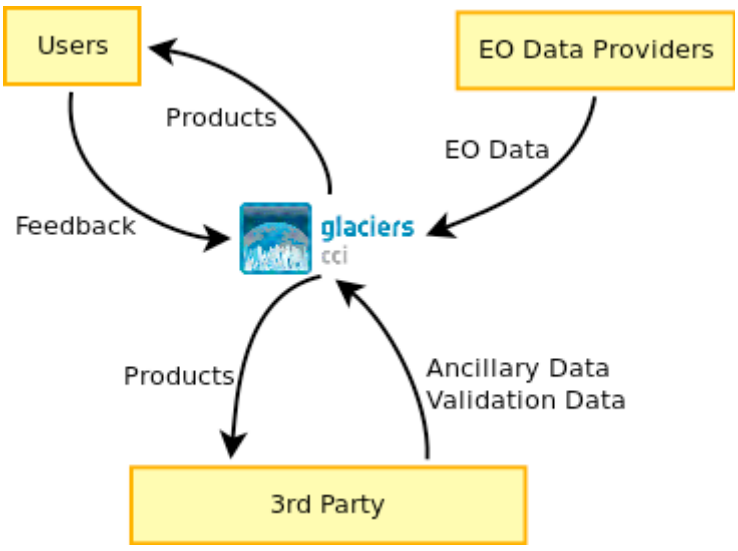

Fig. 1: Principle context of Glaciers_cci processing system.

2.3 Requirements

System requirements are compiled in the Glaciers_cci SRD [AD 4]. The document lists system requirements grouped into functional, operational and performance requirements many with impact on the system design. Section 7 provides the complete matrix of forward tracing from requirements to sections.

High level requirements are to generate the Glaciers_cci products (GL-FUN-0010 , GL-FUN-0060), in collaboration with the GLIMS community (GL-INT-0030). The processing line shall be well defined and flexible for future updates and adaptations (better algorithms, new input data) (GL-FUN-0040). The available data shall be frequently reported and properly disseminated to the interested user communities (GL-INT-0050).

The main scenario is different for the different products and linked modules. While for glacier area the focus is on the production of a comprehensive global glacier inventory, the other products are addressing more regional needs. All products will benefit from future available sensors such as the Sentinels and therefore will need to incorporate this new data in the development. The functional scope of the system is not restricted to the reprocessing, validation and improvement cycle, though this is its main purpose. Also functions to make output products and documentation available to users are in the scope.

2.4 Fundamental Operations

Requirements in this section are:

→ GL-INT-1010 Long-term storage
→ GL-INT-1140 Self-standing documentation
→ GL-FUN-2210 Reprocess products
→ GL-FUN-2211 Reprocess with new data
→ GL-OPE-6410 Glacier Inventory
→ GL-OPE-6411 Complete set of parameters

The PS provides three high level functions:

- Production
- Dissemination
- Life Cycle Management

In the following we will discuss the fundamental operations of the PS with regard to these 3 functions. For production the focus is on repeated reprocessing of complete products. Necessary functions are:

1. Storage to gather and store inputs, intermediate products, output products and auxiliary data;
2. Processors to produce output products from the input data;
3. Processing Control;
4. Quality Control of the intermediate and output products;
5. Comparison with reference data;
6. Documentation of the processing using meta-data;
7. Ingestion of new input data and auxiliary data.

In general we distinguish between the pre-processing, the main processing and the post-processing functionality covering the preparation of the input data, the processor itself, and the product generation steps, respectively.

For dissemination the focus is on the service for the GTN-G community. The products are consequently distributed through existing and in development platforms of WGMS (http://www.wgms.ch) and GLIMS (http://www.glims.org/). Functions are:

- Online Data Access
- Data and Processing Information
- Project Information
- Long-term Preservation
- Feedback Handling
- Validation Support
- For Velocity a processing initiation function must exist

Life Cycle Management is crucial for the attractivness of the provided service. Small effort should be necessary to implement an improved processor handling improved algorithms and data of new sensors. Consequently fundamental necessary operations are:

- Test environment (for new processors)
- Access to (test or benchmark) input data (for tests and comparison)
- Version Management (→ this is linked to the point "Documentation of the Processing in Meta-data")

2.5 The modules of the PS

Unlike most of the other CCI projects, Glaciers_cci produces different products that rely on completely different processing chains in terms of input and ancillary data and the processor. The processing chains for each product are named macro-modules. In [RD 5] the following macro-modules contribute to the PS:

1. Glacier area
2. Elevation change: DEM Differencing
3. Elevation change: Altimetry
4. Velocity from microwave sensors
5. Velocity from optical sensors

As the ESA strategy is to develop the most efficient, consistent and sustainable system addressing the needs of the corresponding community. We aim at investigating synergies among the modules especially for the interfaces but potentially also with other cci-projects if the system benefits. Hence, in the following we have to address both levels in the SSD, the module level and the system level.

2.6 High-level architecture of the PS

The functions and modules listed in the previous section are implemented as functional components. In this section we show the high level architecture of Glaciers_cci on this subsystem level.

The high level architecture follows the diagram shown in Figure 1 of [AD4]. If data are available, uptake can be through the CCI Common Data Access portal. If not, the currently used web-based services of satellite data providers (e.g. GLOVIS, EOLI-SA) and those listed in [RD-2] will be used. Data are then processed in the product generation modules and

distributed through the CCI Common Basic Services that are in the case of Glaciers_cci pointing to the GLIMS/WGMS databases. Within this document we focus on the product generation modules, further described in Section 3.2. This section will be added in SSDv1.

2.7 Major constraints

Here we have to distinguish between constraints related to the technical feasibility and the status of the implementation. We will indicate areas where we see potential to change the constraint level through development. A current apparent shortcoming is the extensive use of COTS software for the data processing. Though this is not a principle problem as those parties currently creating the products (e.g. the GLIMS community) have such software on their own and can adapt the documented way of processing to their respective hardware / software set-up. However, processing solutions that are based on freely available software are possible for some of the products and will be further investigated in phase 2.

Potential major constraints are:

- Performance of the system in terms of processing time and/or data needs
- System Portability
- Input Data availability
- System development status
- Funding

This section will be complemented in SSDv1.

3. Operational scenarios

This section covers the operational scenarios, namely the user data and documentation access, processing and validation of the CDR, and algorithm improvement. The roles are:

- User (GL-INT-0030)
- Developer (Development Team) (GL-OPE-6430)
- Operator
- Validator (Validation Team)

3.1 User information and data access

Users access the Glaciers_cci data products using the GLIMS/WGMS web sites as well as the Glaciers_cci homepage (GL-INT-0050, GL-INT-5020, GL-INT-5010). These are also the entry points for meta-data, documentation (GL-INT-1140), a catalogue, data services, and the DEM-differencing toolbox (GL-FUN-0010). The website provides also a forum (GL-FUN-0160) and an issue tracking system. This approach is common for all Glaciers_cci products and needs to be designed and implemented in the future. For the velocity modules, the website also provides the possibility to select a satellite scene pair that will be used to produce the velocity product based on a process initiation form.

3.2 Processing

Here processing covers all steps from data retrieval, pre-processing, classification, and product generation. Data retrieval covers extraction of the input (and auxiliary) data from the data provider, data format conversion for transfer to the PS, and geoid corrections where applicable (e.g. for ICESat data). Pre-processing covers all steps necessary for the later processing such as re-projection and coordinate transformations, mosaicing, etc. Finally, product generation includes the calculation of values in the selected region, filtering, output format generation, meta-data production, etc.

As mentioned earlier, the processing for the different Glaciers_cci products is done in specific modules. Common for all modules is that the design is based on the prototypes described in the SPD [AD 5] and therefore not repeated here. However, it has to be noted that at this stage the prototypes cover mainly the core of the processing, the classification part, while the data retrieval and the standardised product generation is done manually or is not implemented yet. The related development effort and strategy is discussed in Section 6.1.

For glacier area and elevation change (altimetry) the processor modules process a pre-defined set of input data to produce the corresponding products that are made available to the community through the product archive. The processing is initiated and controlled by the production operator.

The elevation change (DEM differencing) module is a toolbox that can be downloaded from the website and run on the clients computer using data the user already owns (GL-FUN-0010). This allows the user to produce products also from licensed elevation data that cannot be shared or used outside his facility. This approach also takes into account the large variability in characteristics of available elevation data that requires user / expert interaction at various processing stages.

The velocity modules follow a different strategy. To allow interested clients to choose the time span of interest for a glacier/area the production is initiated at the client site by selecting an image pair from a candidate list. After the processor is applied, the resulting products are stored in the respective product archives (GLIMS/WGMS), to be also accessible to other clients.

During CCI, the EO team is in charge of the processor development and implementation. It also implements improvements such as new versions of processors and if necessary a modified workflow. The team tests and validates new algorithms and decides about upgrades to be implemented in the PS. Activities contributing to a processor upgrade are:

- Identification of new requirements
- Resulting in a new or modified processor
- Reprocessing
- Validation and comparison with the former product versions

3.3 Validation

The validation team is in charge of the Glaciers_cci system and product validation (GL-RAM-3110). The validation is done separately for the different PS modules. It covers:

- System (module) validation (after an upgrade or new installation)
- Product validation and quality control
- In case of multi-sensor usage cross-comparison

The PS provides tools that facilitate these tasks such as

- Benchmark test data (GL-OPE-6611, GL-FUN-6710)
- Test tools (GL-OPE-6610)
- Verification Report (GL-RAM-6612)
- Feedback functionality

4. Infrastructure

There are some fundamental decisions that determine how the PS and the corresponding infrastructure will develop and look like:

- To what extent shall the PS use and build on the module prototypes?
- To what extent shall the PS be unified or distributed?
- Which PS and module functions shall be shared among the modules?
- Shall the system be implemented in an existing infrastructure or an existing data centre?
- Shall the system run completely virtualised in a cloud?
- Shall the middleware be used, and which one?
- Which functions and subsystems are candidates for sharing with other ECVs?

This section describes the trade-off for these questions. The discussion may not be complete in its alternatives but tries to discuss solutions that are viable.

Will be complemented in SSDv1.

5. Functional design

Here we will discuss and present the major functional blocks of the Glaciers_cci PS.

5.1 User interface / Services for the user

The Glaciers_cci website is the entry point for users and external evaluators to assess information, meta-data and data services. The provided user services are the functions and interfaces that a user needs, to be able to interact with the PS.

Requirements addressed by this section are:
→ GL-FUN-0050 Report available data
→ GL-FUN-0160 User Feedback Functionality
→ GL-FUN-5010 Website
→ GL-FUN-5020 Data access through internet

The Glaciers_cci user services includes the functional aspects:
- Access to the data generated by the PS
- Access to tools provided by the PS
- Access to the document archive
- Access to the velocity processing initiation

At this stage it is foreseen to host and distribute the Glaciers_cci products through the GLIMS/WGMS data archives and websites. It has to be defined to what degree also the other services for the user can be hosted at these places. The portal is preferably implemented using a Content Management System (CMS). Some of the desired functionality is directly available in the CMS portal software (forum, documentation management, etc.) while other components can be stand-alone services or even remote web-resources. All of the distributed functional components are connected using links from the central portal. The other user-accessible services are catalogues, data access via FTP and/or other protocols and the version control system (software repository). The LDAP-based user management is necessary for access authentication allowing the same credentials for all provided user services.

5.2 Data processors

The data processors cover the necessary tools to produce the different Glaciers_cci products. Each product has its own processor.

Requirements:
→ GL-FUN-0040 Flexible production
→ GL-FUN-6020 Data overwrite

Component	Purpose	Content	Implementation
Data processor Glacier Area	Generate L2/L3 Glaciers_cci Area Product	Input Data	Existing processor, derived automated processor
Data Processor Elevation Change Altimetry	Generate L2/L3 Glaciers_cci Elevation Change Product	Input Data	Extension

Data Processor Elevation Change DEM differencing	Generate L2/L3 Glaciers_cci Elevation Change Product	Input Data	Toolbox
Velocity microwave	Generate L2/L3 Glaciers_cci Velocity Product	Input Data	Extension
Velocity optical	Generate L2/L3 Glaciers_cci Velocity Product	Input Data	Extension

5.3 Data management

The data management includes the components, archive and an inventory.

Requirements:

→ GL-FUN-0040 Flexible production
→ GL-FUN-1011 External data connection check
→ GL-FUN-1020 Unique identifier
→ GL-FUN-1030 Store data in structured way
→ GL-FUN-1050 Data loss
→ GL-FUN-2120 Data format
→ GL-RAM-2230 Traceability

Component	Purpose	Content	Implementation
Archive	Stores products, meta-data, processing logs, auxiliary data, validation, processor software bundles, in a structured directory tree, makes them available	Products Meta-data Logs Validation Data Software	WGMS/GLIMS database
Inventory	Handles product entries and collections, attributes of products like QA information, extensional collections (lists) of product entries and intentional collections (logical selection criteria like type and time)	Product entries	WGMS/GLIMS database

5.4 Processing management

Production requires automated workflows and requests with status and reporting to the operators. It includes production and quality control steps.
Requirements addressed by this section are:

Component	Purpose	Content	Implementation
Production control	Handles production requests, manages workflows, manages resources processing capacity and storage space		Extension of processor modules

→ GL-RAM-2160 Configurable
→ GL-RAM-3110 Quality Control during processing
→ GL-FUN-4010 PS has logging mechanism
→ GL-RAM-4040 Event reporting
→ GL-INT-4110 Processing Status
→ GL-RAM-5520 Data import logging

5.5 Update management

Important aspects in the context of update management are Software Modularity, Software Version Concept, Version Control, Version Numbering.

Requirements:
→ GL-OPE-6330 Development under version control
→ GL-OPE-6340 Decoupled from own research

The software of the PS and the processing algorithms code are under version control. The software repository contains the actual processing code and all prior versions. All software changes are updated directly in the repository. Version numbering of the processor is reflected in the repository by tags. Subversion is a good candidate for version control. Together with Redmine it is a complete FOSS version control and issue tracking system.

Component	Purpose	Content	Implementation
Software Repository	Stores all versions of the processor code in a transparent way, with branches, authorship	Code	Subversion Redmine Tools

5.6 Documentation management

The documentation contains the PS documentation consisting of manuals, specifications and reports, as well as the product documentation consisting of product specifications, manual and validation reports. At this stage no advanced functionality such as collaborative editing etc. seems to be necessary so that the basic functionality of any FOSS CMS might be sufficient for this task.

Requirements addressed by this section are:
→ GL-FUN-1140 Product Description
→ GL-RAM-6420 Self-standing documentation

Component	Purpose	Content	Implementation
Documentation Management	Stores documentation in a structured and transparent way	Documentation	WGMS/GLIMS platform

6. Development, life cycle, performance, cost

This section discusses the system development in the future, potential development strategies, efforts and costs. The development is driven by several factors such as the availability of new technology, faster algorithms, new scientific findings and improved product algorithms, new available EO data, and user needs.

Requirements addressed by this section are:
→ GL-FUN-0110 Sentinel-1/2/3, LDCM
→ GL-FUN-0120 TanDEM-X, new global DEM
→ GL-OPE-6620 Freeze prototype
→ GL-OPE-6320 Minimize maintenance and cost
→ GL-OPE-6330 Development under version control
→ GL-OPE-6340 Development decoupled from research
→ GL-OPE-6410 Development plan
→ GL-OPE-6411 Development
→ GL-OPE-6430 Science team

6.1 Development

Development is needed to bring the existing prototypes of the PS modules on a higher operational level satisfying the requirements listed in the previous sections and to add the missing components such as the components for the user services, data handling, life cycle management, archiving etc.

Requirements addressed by this section are:
→ GL-RAM-2160 Variables
→ GL-OPE-6340 Development decoupled from research
→ GL-OPE-6620 Freeze prototype
→ GL-FUN-6710 Verification of implementation

Here we summarise the tools that can be adapted, configured and integrated as well as need to be developed for the PS in the next phases (to be complemented in SSDv1).

Name	Usage	Remarks
Subversion	Version control	FOSS
Redmine	Issue tracking	FOSS
Glacier area processor prototype	Glacier outline production	Based on closed source COTS
	Base for the development of an automated processor	Implementation from scratch needed
DEM differencing processor prototype	Base for DEM differencing toolbox	DEM co-registration tool free/public from GUIO; rest to be developed.
Altimetry processor prototype	Base for altimetry processor	Needs to be further developed to process CS2, S3 and ICESat2 data

Velocity (optical) processor prototype	Base for velocity (optical) processor	Algorithm prototype free from GUIO; refinement and implementation needed.
Velocity (microwave) processor prototype	Base for velocity (microwave) processor	COTS with source code

6.1.1 Glacier area

The aim of the glacier area product is a complete worldwide inventory of glacier outlines. The prototype covers all necessary processing steps. It is operator and COTS software based. The necessary processing resources are gained exploring community resources by following a distributed processing approach based on a people network.

To address the new upcoming data of the Sentinels, the module prototype is used to implement an automated processing line that is able to produce the global inventory on a regular base.

6.1.2 Elevation change: DEM Differencing

The aim of the DEM differencing module is to provide a toolbox for the community that allows to produce elevation change products by DEM differencing. The toolbox is based on the module prototype and distributed through the GLIMS/WGMS website.

6.1.3 Elevation change: Altimetry

The aim of the Altimetry module is to process the altimetry data of the full archive of RA and ICESat altimeter data for which the prototype module is built and reprocess the RA dataset using data from the ESA REAPER project once it is available.

In a second step that processor is enhanced to utilise CS2 data and later also S3 and ICESat2 data and to allow cross-calibration of the various sensors.

6.1.4 Velocity from microwave sensors

The aim of the Velocity (microwave) module is to produce the glacier velocity map from a given radar image pair. The production of velocity products can be started on the Glaciers_cci website by selecting an image pair.

6.1.5 Velocity from optical sensors

The aim of the Velocity (optical) module is to produce the glacier velocity map from a given optical image pair. The production of velocity products can be started on the Glaciers_cci website by selecting an image pair.

6.2 Life cycle

The PS needs to be incrementally adapted to integrate new functional extensions, improved algorithms and input datasets. New EO data make adaptations necessary and most likely also have an impact on the hardware infrastructure. The life cycle plan cannot be static as it is not foreseeable. Currently the following driving factors are identified:

- Availability of the existing processor module prototypes
- Functional extension of the system
- New workflows

- Improved algorithms
- New Sensors (e.g. Landsat 8, Sentinel-1,-2,-3)
- Hardware improvements
- Dependencies on 3rd parties (other ECVs, data providers, new users)

Requirements:
→ GL-FUN-1010 Long-term storage
→ GL-FUN-1020 Unique identifier
→ GL-FUN-1030 Structured storage
→ GL-FUN-2210 Reprocess Products
→ GL-FUN-2211 Reprocess Products
→ GL-OPE-6330 PS shall be under version control
→ GL-RAM-6610 Test tools
→ GL-RAM-6611 Verification

6.3 Performance

In the SRD no specific requirements are present concerning the processing time performance.

There exist requirements on disk space that are modest:
→ GL-SIZ-1110 Space for input data
→ GL-SIZ-1120 Space for auxiliary data
→ GL-SIZ-1130 Space for output data
→ GL-FUN-2220 Storage not bottleneck
→ GL-FUN-2310 Reprocess within 10 years

A dramatic increase is however to be taken into account when moving to a more frequent observation schedule and with the availability of large Sentinel archives for the glacier velocity product.

6.4 Cost

This section will be complemented in SSDv1.

Requirements addressed by this section are:
→ GL-OPE-6320 Min maintenance and cost

7. Requirements traceability

Id	Title	Reference
GL-FUN-0010	The Glaciers_cci system provides tools to generate a global glacier inventory. Tools should allow to complement and improve the existing inventory but also to revisit the inventory every 10 years.	§3
GL-INT-0020	Its creation shall be coordinated with advice from a strategic operations team. This team need to be in close contact with all relevant high-level organizations (e.g. GTN-G (WGMS, GLIMS, NSIDC), GTOS/GCOS, CEOS, GCW).	§3
GL-INT-0030	The global GLIMS community shall play an active role in its creation according to a given set of guidelines and advice from the strategic operations team. They shall also give feedback from implementation to the strategic team.	§3
GL-FUN-0040	The system shall also implement a data production line that is sufficiently flexible to continously update and extend the database (e.g. with data from new sensors or better acquisitions).	§5.2, §5.3
GL-INT-0050	The available data shall be frequently reported and properly disseminated to the interested user communities.	§5.1, §3.1
GL-FUN-0060	The Glaciers_cci system shall generate 3 types of products: 1. Glacier Area (AREA) 2. Glacier Elevation Change (ELC) 3. Glacier Velocity (VEL)	§2
GL-FUN-0110	The PS shall include Sentinel 2, LDCM and Sentinel-1 products.	§6
GL-FUN-0120	The PS shall include a global elevation data set and TanDEM-X products when available.	§6
GL-FUN-0160	The PS shall provide a user feedback functionality.	§3.1, §5.1
GL-FUN-1010	All data stored in the system shall be available for the long-term (at least 15 years).	§2.4, §6.2
GL-FUN-1011	If input data is retrieved directly from a third party ground segment the PS has to ensure that links are maintained and functionality is regularly checked.	§2.4, §5.3
GL-FUN-1020	Product shall be uniquely identified.	§5.3, §6.2
GL-FUN-1030	PS shall store data in a structured way using type, revision, date.	§5.3, §6.2
GL-RAM-1050	PS shall provide means against data loss of its input and output products.	§5.3
GL-SIZ-1110	The PS shall provide storage space for its input products of about 5 TB.	§6.3
GL-SIZ-1120	The PS shall provide storage space for its auxiliary data of about 2 TB.	§6.3
GL-SIZ-1130	The PS shall provide storage space for its output products of about 5 TB.	§6.3
GL-FUN-1140	To facilitate the use of these data by the climate research community a self-standing 6-8 pages explanation of the products shall be generated. This shall detail the algorithm, input data, description of the processing steps, geophysical data product content, flags, meta-data, data format, grid, software tools for decoding and exploiting the data.	§2.4, §3.1, §5.6
GL-FUN-2110	The PS shall produce glacier outlines (inventory data) compliant with the GLIMS database (GDB) format specifications.	§2.2
GL-FUN-2111	The PS shall produce elevation changes in agreement with WGMS (sheets D and EEE) requirements.	§2.2

Id	Title	Reference
GL-FUN-2112	The PS shall produce velocity information over glaciers in agreement with GDB or the WGMS requirements. (TBD)	§2.2
GL-FUN-2120	The PS shall produce the area product (global map of glacier-covered area) in netCDF format and compliant with the CF meta-data standards.	§5.3
GL-FUN-2130	The PS shall use the input data as outlined in the DARD.	§6
GL-FUN-2140	The glacier area product shall be produced according to the guidelines given in Paul et al. (2009).	§2.2
GL-OPE-2150	A hierarchical approach shall be taken to the production of the glacier products based on their complexity, data availability and contribution to the worldwide glacier inventory. Priority is on data availability, contribution (community request), complexity.	§5.4
GL-RAM-2160	Where possible, calibration and other values should be configurable to facilitate easier processing updates	§5.4, §6.1
GL-FUN-2170	The PS shall include the generation of consistent quantified errors and biases per pixel for the subsequent use of the glacier products in climate impact studies and water resource management models.	§5.2
GL-FUN-2210	The PS shall have the capability to reprocess already successfully processed products as well as products generated with errors in a transparent and comparable way.	§2.4, §6.2
GL-FUN-2211	The PS shall have the capability to reprocess already successfully processed products with new data for change assessment.	§2.4, §6.2
GL-FUN-2220	The PS shall store its input data optimised for reprocessing, i.e. in such a way that storage is not a bottleneck for reprocessing.	§6.3
GL-RAM-2230	All output products will contain sufficient information to ensure full traceability of any product to all inputs involved in its generation.	§5.3
GL-FUN-2310	The PS shall allow processing of the full AREA product within 10 years.	§6.3
GL-RAM-3110	Strict quality control procedures shall be followed during processing: the production shall be interrupted and the implementation checked and corrected if the resulting products do not meet previously agreed (scientific) quality standards. This shall include internal quantitative validation tests for each processing step.	§5.4
GL-FUN-4010	The PS has a logging mechanism	§5.4
GL-RAM-4020	The following events and parameters must be reported per task: a) start of processing b) end of processing c) significant processing events d) termination status (terminated safely, aborted etc)	§5.4
GL-RAM-4040	The following significant processing events shall be reported: a) input data missing, corrupt or invalid b) product cannot be fully produced c) product generation failed	§5.4
GL-INT-4110	The PS provides information of the processing status: a) Status (in progress, finished, stopped) b) Progress c) Errors	§5.4
GL-INT-5010	The PS provides a Web site presenting the objectives of the project and describing data access.	§3.1, §5.1
GL-INT-5020	Data access shall be through the Internet.	§3.1, §5.1

Id	Title	Reference
GL-INT-5510	There is a possibility to inject new input data into the system	§6.1
GL-RAM-5520	Data import is logged.	§5.4
GL-FUN-6010	The PS has an interface for commanding all the subsystems, including archive and data services. This commanding interface can be a command line interface (CLI) or graphical user interface (GUI).	
GL-FUN-6020	The operational processor shall not overwrite existing data. Versioning shall be used instead.	§3.2, §5.2
GL-OPE-6310	Software re-use shall be limited as much as possible to Public Domain software	§6.1
GL-OPE-6320	The PS design shall ensure minimal maintenance and operational costs.	§6.4
GL-OPE-6330	Development of the PS shall be under version control.	§5.5, §6.2
GL-OPE-6340	The system should be decoupled from the own research.	§5.5
GL-INT-6340	The PS shall have the capability and interfaces to extend for future adaptations.	§6.1
GL-OPE-6410	Development of the system shall be based on the outcomes of Task 2 and the requirements specified in Task 1 and used to generate the baseline products for the worldwide glacier inventory.	§2.4
GL-OPE-6411	The system shall be developed including all the necessary steps for the production of each product with the potential to produce the complete set of parameters for each glacier.	§2.4
GL-RAM-6420	The system developed shall be detailed as a separate self-standing document providing an overview of the system and its components, functionality of the system and its subsystems, inputs, outputs, resource key interfaces, and resource requirements.	§5.6
GL-OPE-6430	The PS development shall be overseen by a science team that drives the development process interacts with the GLIMS community and is using the system to improve and evaluate methods and algorithms.	§3, §6.1
GL-OPE-6610	Each PS installation includes a set of test tools, data and benchmark data to test PS integrity (end-to-end, interfaces)	§3.3, §6.2
GL-OPE-6611	The verification is regarded as successful, when all tests agree within TBD limits.	§3.3, §6.2
GL-RAM-6611	The verification shall be documented in a Verification Report. It shall contain the chosen approach and the justification, the selected verification data set and the verification results.	§3.3, §6.2
GL-OPE-6620	If a module is based on a prototype, the prototype state has to be frozen until it is implemented.	§6.1
GL-FUN-6710	Verification of the correct implementation of the prototype system against the algorithms developed in Task 2 is a fundamental part of the process.	§3.3, §6.1

Acronyms

AD	Applicable Document
ALT	Altimetry
ATBD	Algorithm Theoretical Basis Document
CCI	Climate Change Initiative
CDR	Climate Data Record
CMS	Content Management System
DARD	Data Access Requirements Document
dDEM	DEM differencing
DEM	Digital Elevation Model
ECV	Essential Climate Variable
ELC	Elevation Change
ELCSS	European Committee for Space Standardisation
EO	Earth Observation
ESA	European Space Agency
ESRIN	European Space Research Institute
FOSS	Free and Open Source Software
GCOS	Global Climate Observing System
GDB	GLIMS Database
GLIMS	Global Land Ice Measurements from Space
IPR	Intellectual Property Rights
LDAP	Lightweight Directory Access Protocol
LPDAAC	Land Processes Distributed Active Archive Center
MW	Microwave
NSIDC	National Snow and Ice Data Center
OC	Ocean Colour
OPT	optical
PS	Processing System
PSD	Product Specification Document
RA	Radar Altimeter (ERS-1 and ERS-2)
RD	Reference Document
SAR	Synthetic Aperture Radar
SLC	Single Look Complex Radar Image
SoW	Statement of Work
SRD	System Requirements Document
URD	User Requirements Document
USGS	United States Geological Survey
UUID	Universally Unique Identifier
VEL	Velocity
WGMS	World Glacier Monitoring Service