CryoLand

GMES Snow and Land Ice Service 2011-2015

Thomas Nagler
ENVEO IT GmbH

CryoLand is a Collaborative Project (2011-2015) funded by EU under the 7th Framework Programme (No:262925), Theme SPA.2010.1.1-01– Stimulating the development of downstream GMES services.

Overall Project Objectives

Develop, implement and validate an operational, sustainable service for monitoring snow and land ice as a Downstream Service within GMES in a value added chain with the Land Monitoring Core Service.

The project prepares the basis for a future cryospheric component of the GMES Land Monitoring Service.

Project Sub-Objectives

- Develop and validate a pan-European satellite-based snow and land ice service delivering highly needed products to the user society.
- Integrate and operationalise existing snow and land ice services
- Prepare the tools for offering snow and ice services world-wide
- Develop tools to utilize data from the GMES Sentinel Satellite Series for snow and ice applications
- Perform full verification and real time demonstration of the services
- Prepare the basis for the Cryosphere Component of a GMES Global Land Monitoring Service
- Products conform to INSPIRE/GEOSS standards
- Make products available via state-of-the-art online services
- Issue guidelines for stakeholders and for service deployment operations

CryoLand Project Partners

10 Partners from Austria, Finnland, Norway, Romania, Sweden, Switzerland

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Norwegian Computing Center
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National Meteorological Administration
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GAMMA Remote Sensing
Gümlingen. Switzerland
http://www.gamma-rs.ch

Swedish Meteorological & Hydrological Institute
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http://www.smhi.se

Project Building Blocks

The Service Requirements and Infrastructure Component

- User requirements
- Service / Products specifications
- Infrastructure for interfaces to users / public
- Specification for online download interfaces

The Product Development and Validation Component

- Improvement / Validation of products according to user needs
- Technical builds on existing techniques, which will be enhanced towards user needs
- Improved tools for GMES Sentinel satellite series

Service Qualification and Demonstration

- Set up interfaces to users
- Testing and qualification of services
- Preparation for transition from pre-operational service to selfsustained operational snow / ice monitoring service

User Support

- Establish close links with user community
- Perform User Trainings on CryoLand Services

enveo

Users of CryoLand Services

CryoLand User Group includes >60 Organisations from 12 Countries

Application Fields

- Hydropower companies
- Energy traders
- Road, Railway and River Authorities
- Geotechnical and Construction companies
- Avalanche warning centres
- Ecologists
- Hydrological services
- Meteorological services
- Climate monitoring institutions
- Reindeer herders
- Environmental agencies

CryoLand User group contributes to:

- Product and service Requirements
- Requirements for service interfaces

4 User WS held in 2011

- Consolidation of Product and Service Specification **WS 5/2012**
- Testing and Evaluation of services and products **(ongoing)**


CryoLand
Snow
Glaciers
Lake / River Ice
Products from
Satellite Data and In-situ Measurements

CryoLand Products

Specifications of products are done according to user needs which were assessed in workshops held in Vienna, Oslo, Saariselka, Bucharest in 2011 and consolidated in the user meeting in Stockholm in 2012

Snow Service - Main Products:
- Snow Cover Area (Fractional, Binary, different scales)
- Snow Water Equivalent (Coarse)
- Snow Wetness / Melting area
- Snow Temperature
- Surface Albedo

Main EO Data:
- Optical Satellite (MODIS, Sentinel S3)
- SAR (ERS, ENVISAT, Sentinel S1)
- Passive MW data (AMSR)

Glacier Service - Main Products:
- Glacier area / outlines
- Maps of snow / ice area
- Ice motion maps
- Glacier dammed lakes

Main EO Data:
- High Resolution MS Optical (SPOT)
- High Resolution SAR (TerraSAR-X, ERS, ENVISAT, S1)

Lake / River Ice - Main Products:
- Lake Ice and River Ice extent
- Temporal changes of ice extent
- Snow extent

Main EO data:
- SAR (ENVISAT, RadarSAT, TSX, S1)
- Optical Satellite data (SPOT, Landsat, S2)

Product Implementation Priority

Product Ranking specified together with users (User Meeting Stockholm, May 2012):

1 = high priority

highest user needs; mature algorithms adjusted to user needs, fully validated; implementation towards operational services.

2 = medium priority

interest by some users; *pilot products*; further development of algorithms and validation needed, implementation of pilot service.

3 = low priority

experimental algorithms, further development needed. Demonstration / Experimental products generated within project

CryoLand Snow Product Specifications

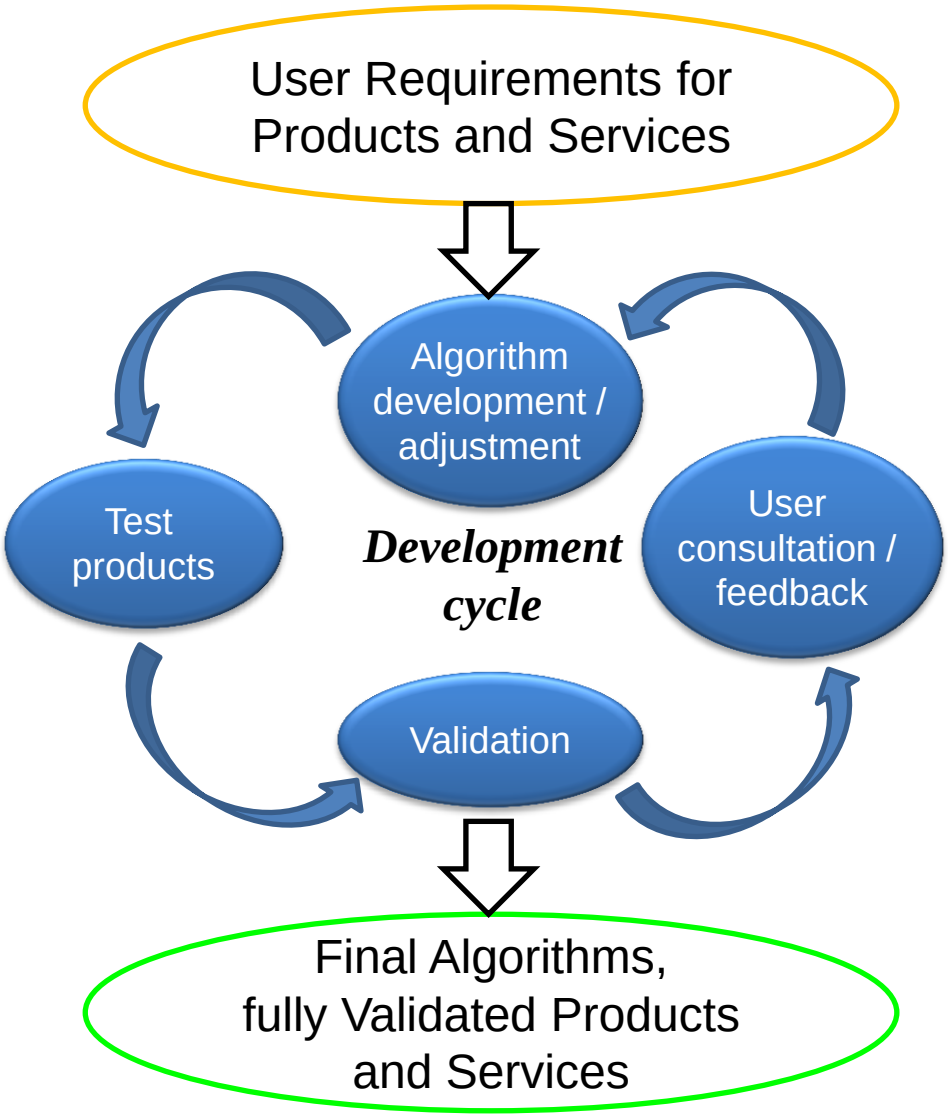
Product type	Spatial resolution	Temporal Coverage	Coverage	Latency time	Impl. Priority	EO sensors
Snow extent, pan-European	**500 (1000)m**	**Daily, full year**	**35N / 10W – 71N / 45E**	**<1 day**	**1**	**MODIS, Sentinel S1, S3**
Snow extent, regional	**250 m – 500 m**	**Daily, full year**	**Alps, Nordic, Baltic Sea area**	**<1 day**	**1**	**MODIS, ASAR (archived), Sentinel S1, S3**
Snow extent, local	**25 – 50 m**	**monthly, full year**	**Alpine valleys, small AOIs (on request)**	**<1 day**	**1**	**Sentinel 2, (Landsat)**
Snow Water Equivalent (Low res)	**10 – 25 km**	**Daily, dry snow season**	**Pan-European, Northern hemisphere**	**<1 day**	**1**	**SSMI/S, AMSR2**
Melting snow area	100 m	Daily, Spring/Summer/Fall/Winter	Regional, local	<1 day	2	ASAR (archived), Sentinel S1
Statistical snow Information	HRU / basin	Daily	Local	<1 day	2	--
Snow Surface Wetness	1000 m	Daily	Regional	<1 day	3	MODIS, Sentinel S3
Spectral Surface Albedo	250 m - 1000 m	Daily	Local, regional	<1 day	3	MODIS, Sentinel S3
Snow Surface Temperature	1000 m	Daily	Regional, local	<1 day	3	MODIS, Sentinel S3

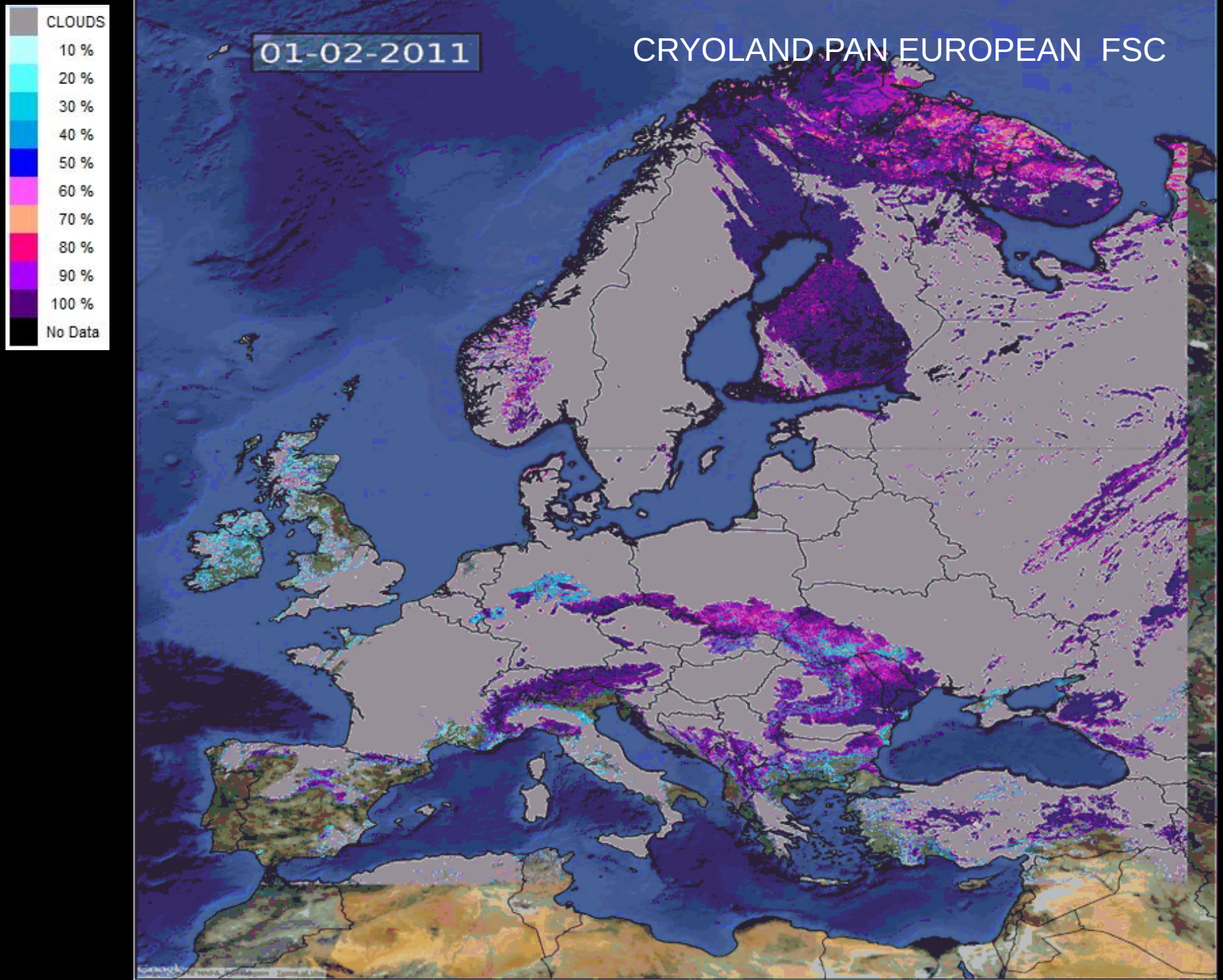
Approach for product and service improvement towards user needs

1. User requirements / dialogue for improved product requirements and specification

2. Algorithm development / adjustment to match user needs
3. Generation of test products and validation for different regions and periods
4. User consultation and feedback on product and services

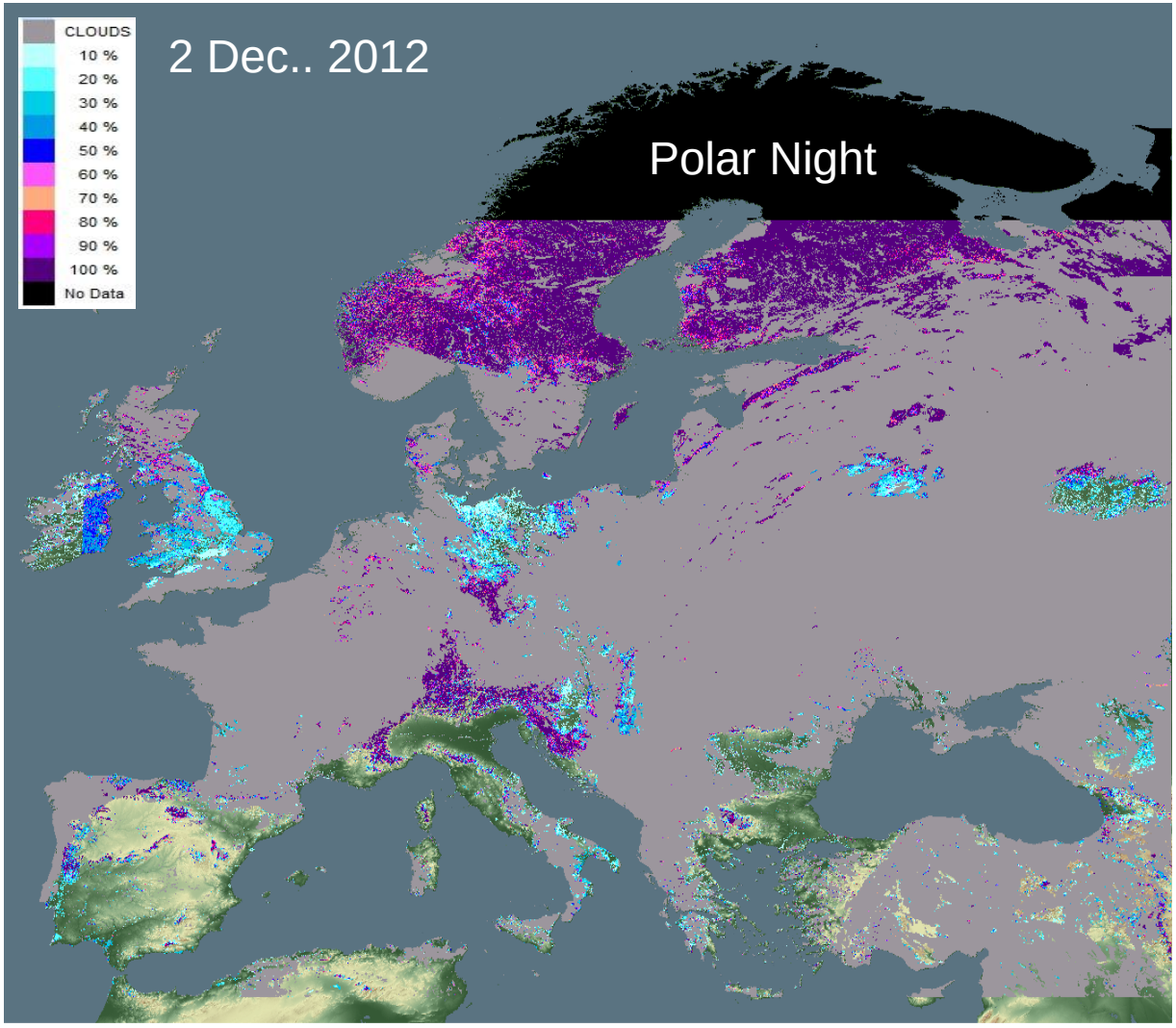
5. Final algorithms, fully validated products and services




CLOUDS
10 %
20 %
30 %
40 %
50 %
60 %
70 %
80 %
90 %
100 %
No Data
01-02-2011
CRYOLAND PAN EUROPEAN FSC

Pan European Snow Extent Product

- **Product Specifications:**
  - Domain:
    71°N 10°W – 35°N 45°E
  - Projection: LatLon/WGS84
  - Pixel size: 0.01° (ca 1km)
    (planned for 2013/14: 500 m)
  - Latency: < 1 day
- **Status**
  - Sensor: MODIS (Backup VIIRS, Sentinel-3)
  - Regional service integration, processing chain and portal implemented
  - NRT Pilot Service 2012/13:: Performance of 3 Algorithms is in evaluation
  - Operational NRT for Winter 2013/14



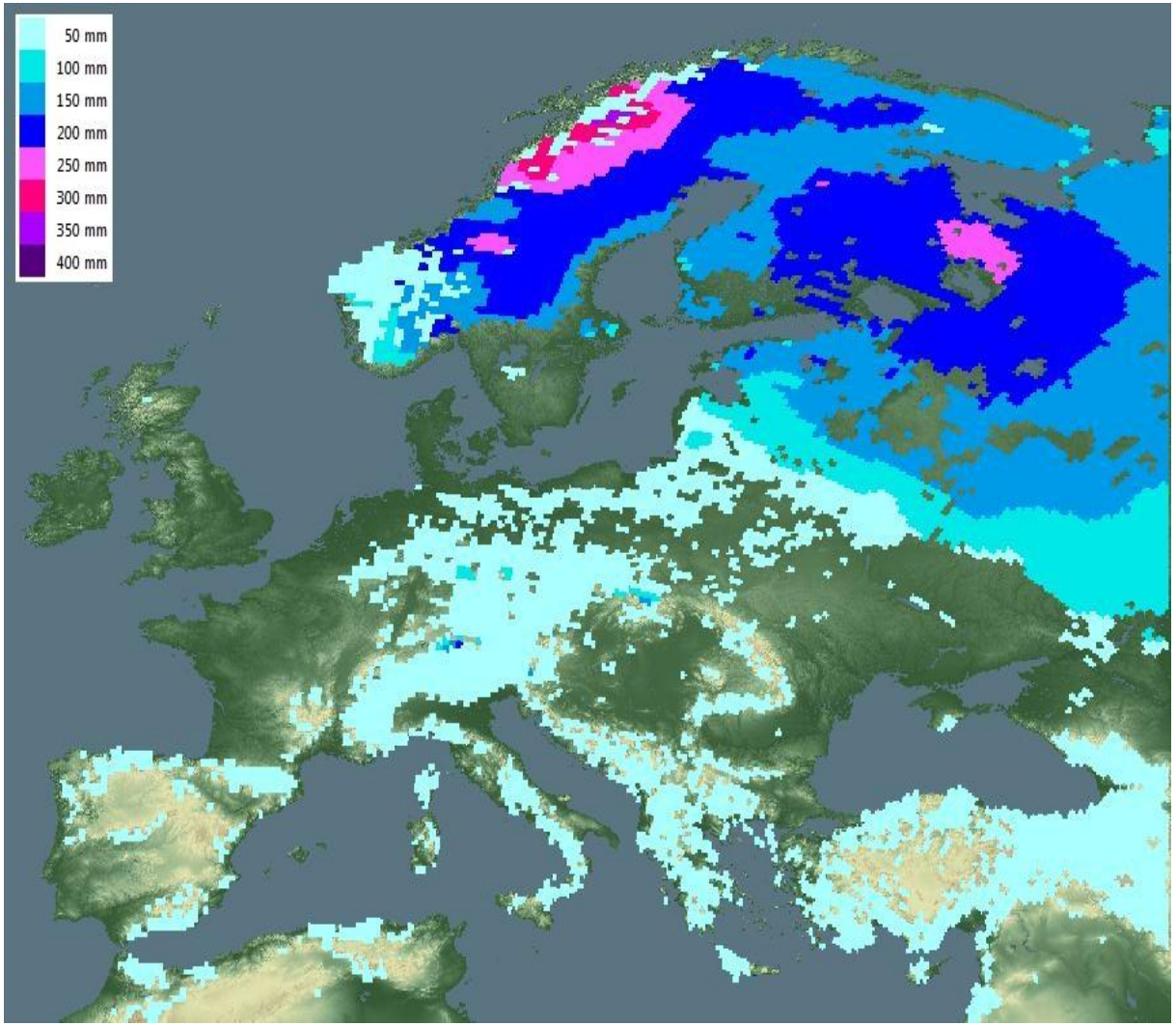
Pan European SWE Product

Draft requirements and specification:

- Projection: LatLon / WGS84
- Pixel size: 0.1 deg; ca 10 km
- Temporal resolution: Daily
- Latency: < 1 day

• Product status:

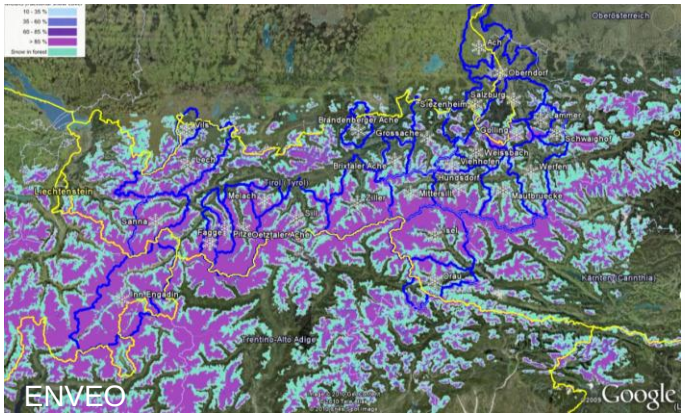
- Algorithm based on H-Saf and GlobSnow, new post-processing and data delivery
- Based on passive microwave observations and ECMWF weather station data



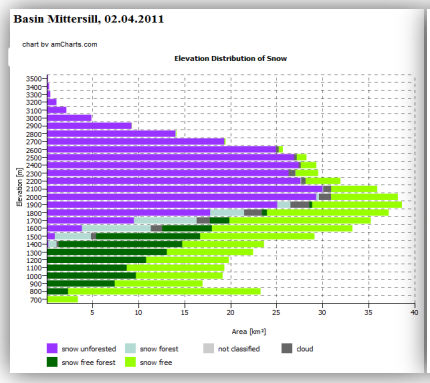
CryoLand SWE product, 15/2/2011

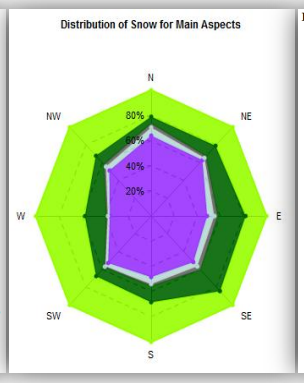
Regional Fractional Snow Cover Products

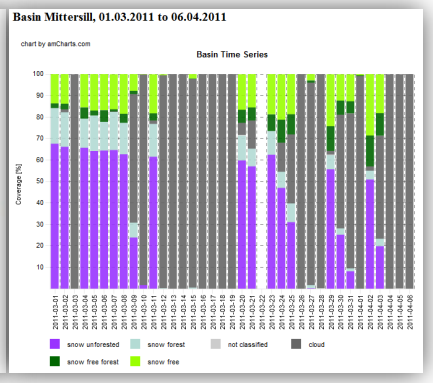
Alpine Areas 250 m (MS Unmixing)



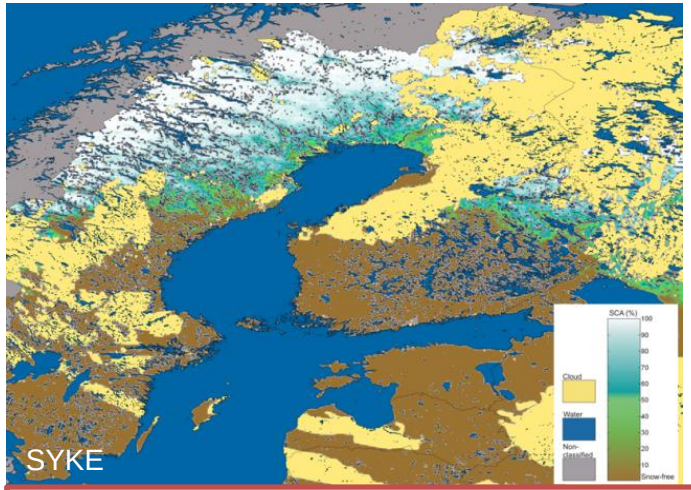
Generated for User Specified Basins (Processing on demand)



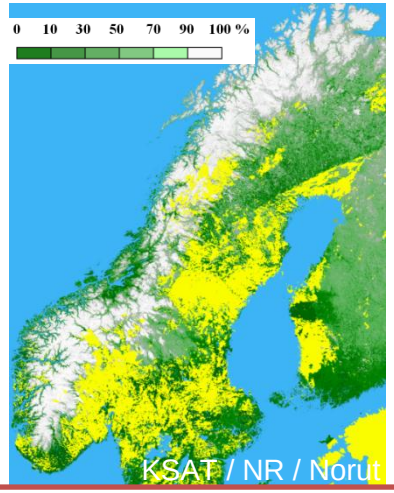




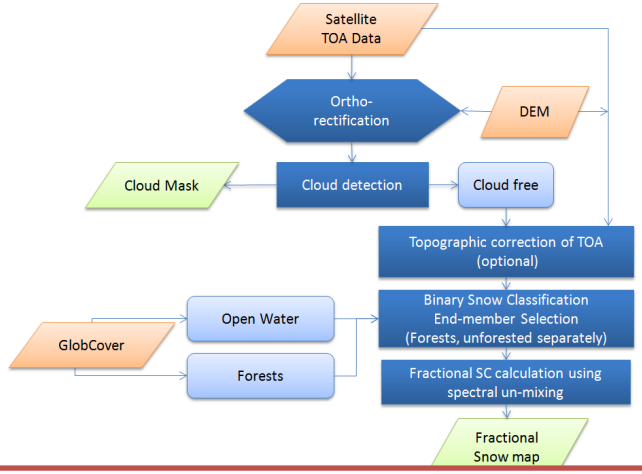
Boreal Forests 500 m (ScaMod)



Scandinavia (250m)



Automatic Processing Line



Products build on expertise of project partners developed in various other projects.
Projection: Geographic; UTM; Lambert EA/AT; Pixel size: 250 m-1km;
Sensor: MODIS; (VIIS; Sentinel-3);

Melting Snow Extent – Regional Alps, Scandinavia

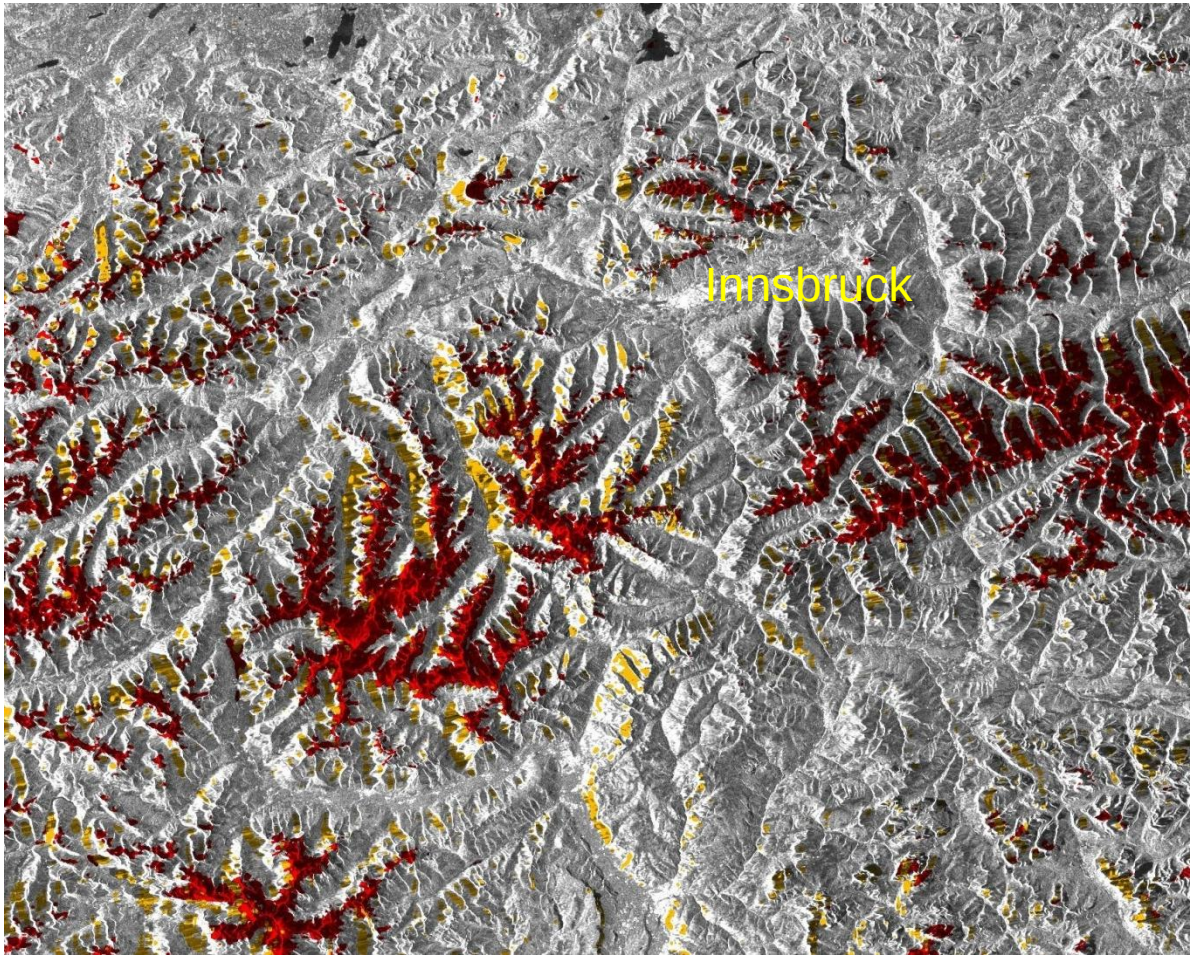
Binary map of wet snow from Multi-temporal SAR data

- 100 m pixel size
- Projection: Geographic, UTM, Lambert EA Austria

- Demonstration Products: Time series of Products uses archived ENVISAT ASAR data

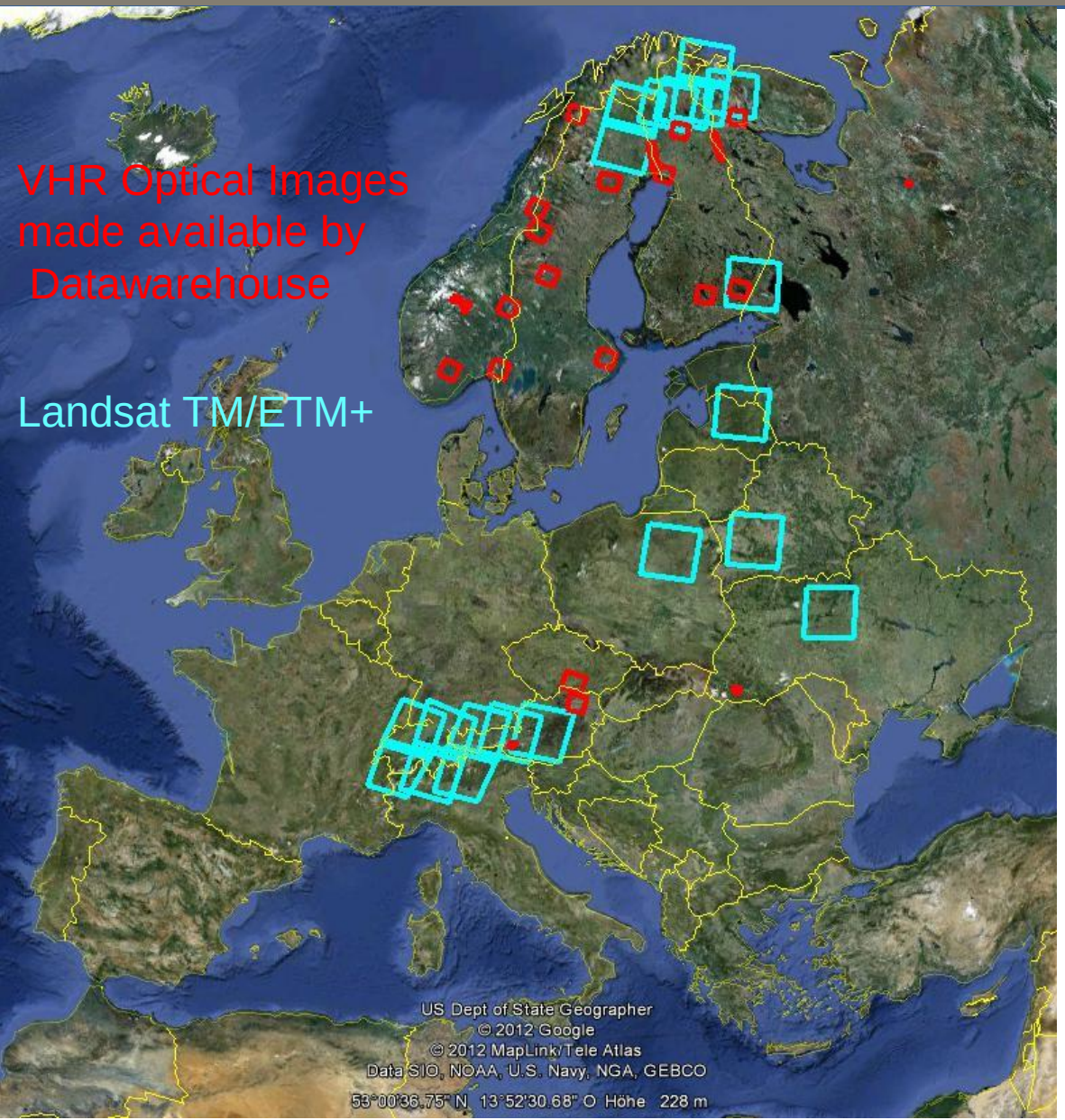
- NRT demonstration service with Sentinel-1 planed

- Capabilities of operational service for wet snow monitoring using Sentinel-1 data



9 June 2006, ENVISAT ASAR WSM.
Red – wet snow extent, Yellow – layover / foreshortening

Snow Extent Product Quality Assessment



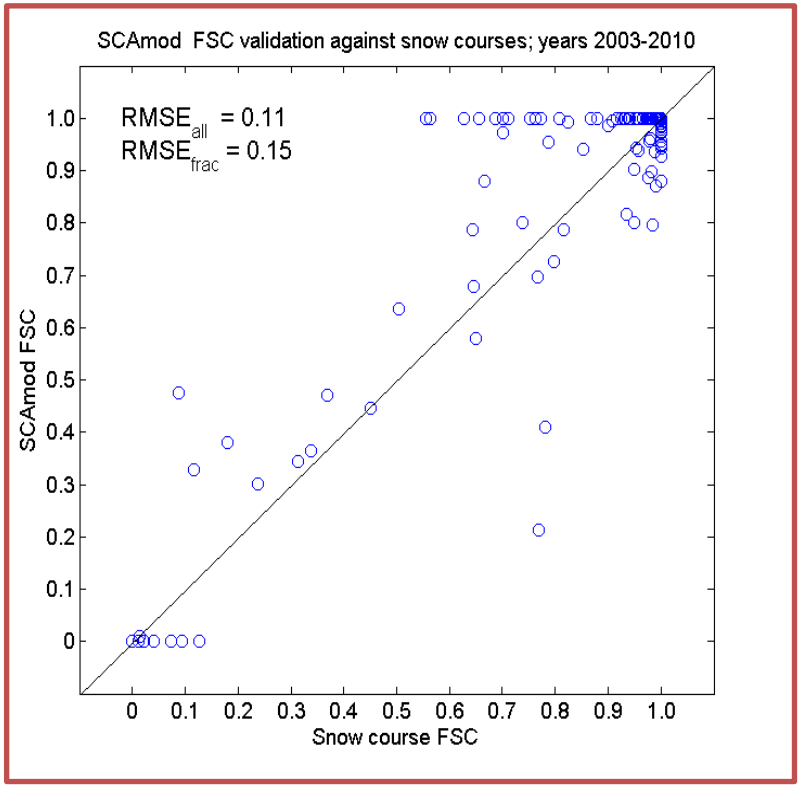
Quality Assessment of Snow Extent Products is performed in different environments:

- Fractional SE products from high resolution optical images:
  - Very High resolution images (IKONOS, SPOT5, Quickbird)
  - Landsat TM/ETM+
- In-situ snow transects measured operationally by SYKE in Finland

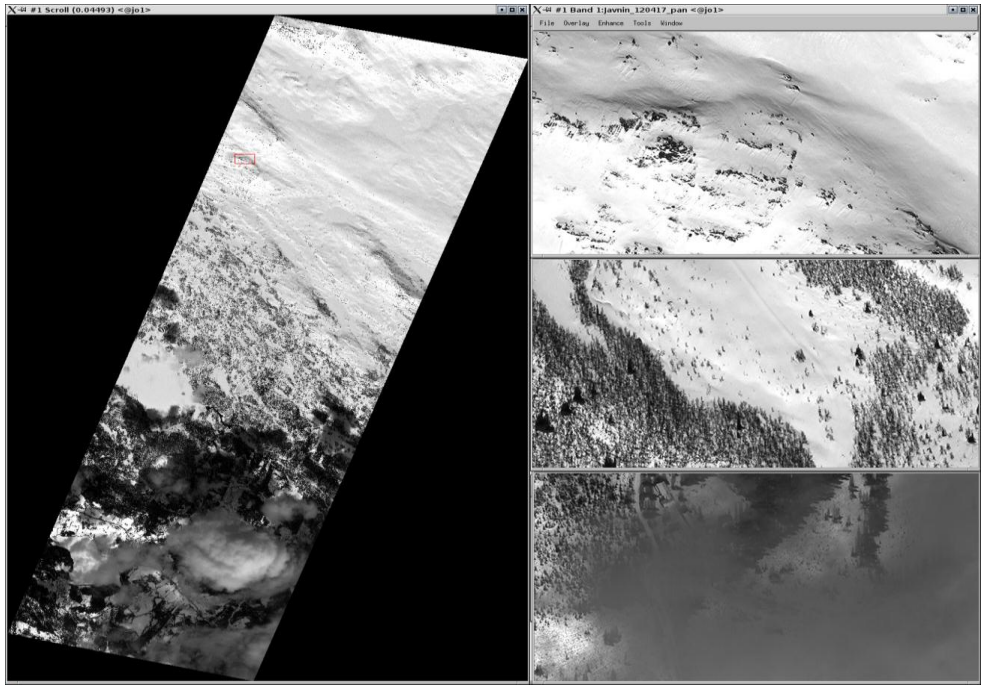
Accuracy assessment of SE products and services is still ongoing according to the planning of the project.

Accuracy Assessment of SE Products

MODIS SCAMOD –
Pan European Product
In-situ Snow transects
versus FSC

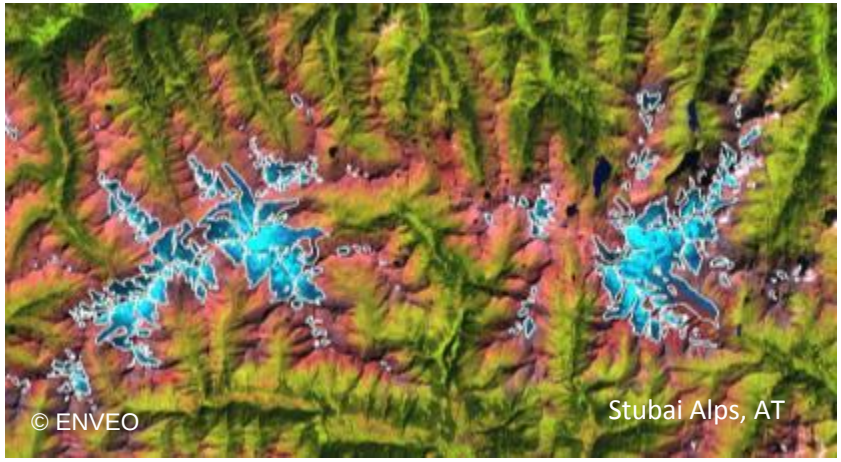


Very High resolution Images provide detailed snow information in mountains and forests (sparse->dense) and enable the quality assessment of CryoLand SE products in these areas.

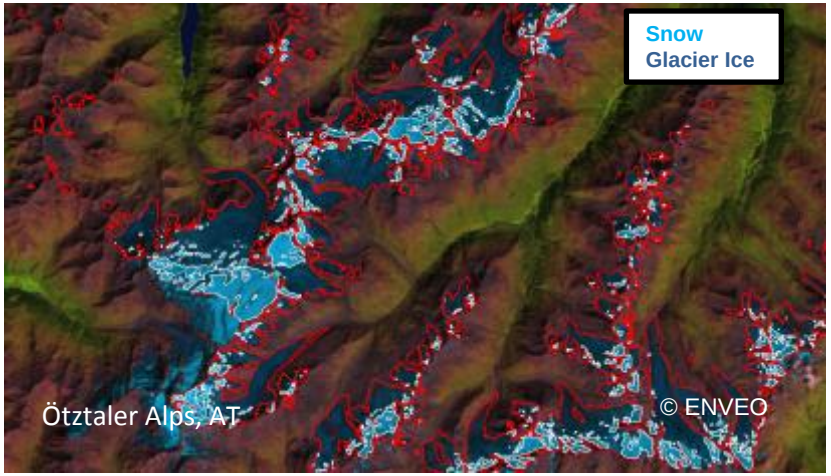


Glacier Products

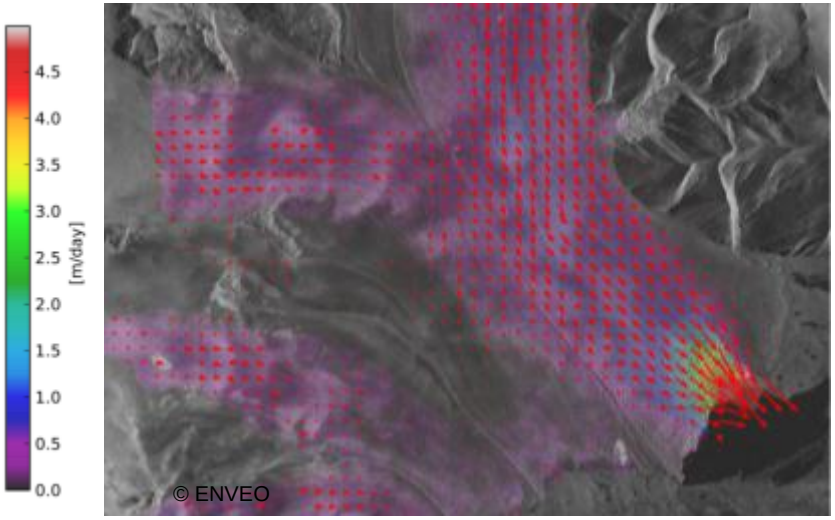
Glacier Outlines



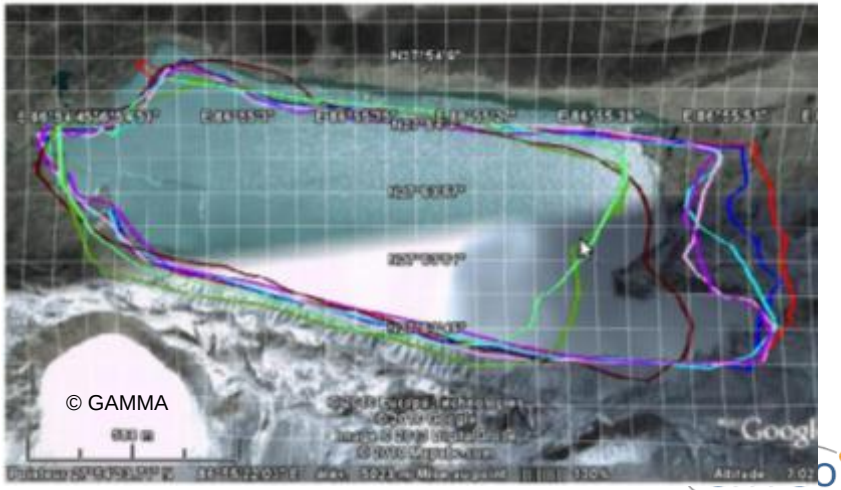
Snow and Glacier Ice areas



Ice Velocity Fields

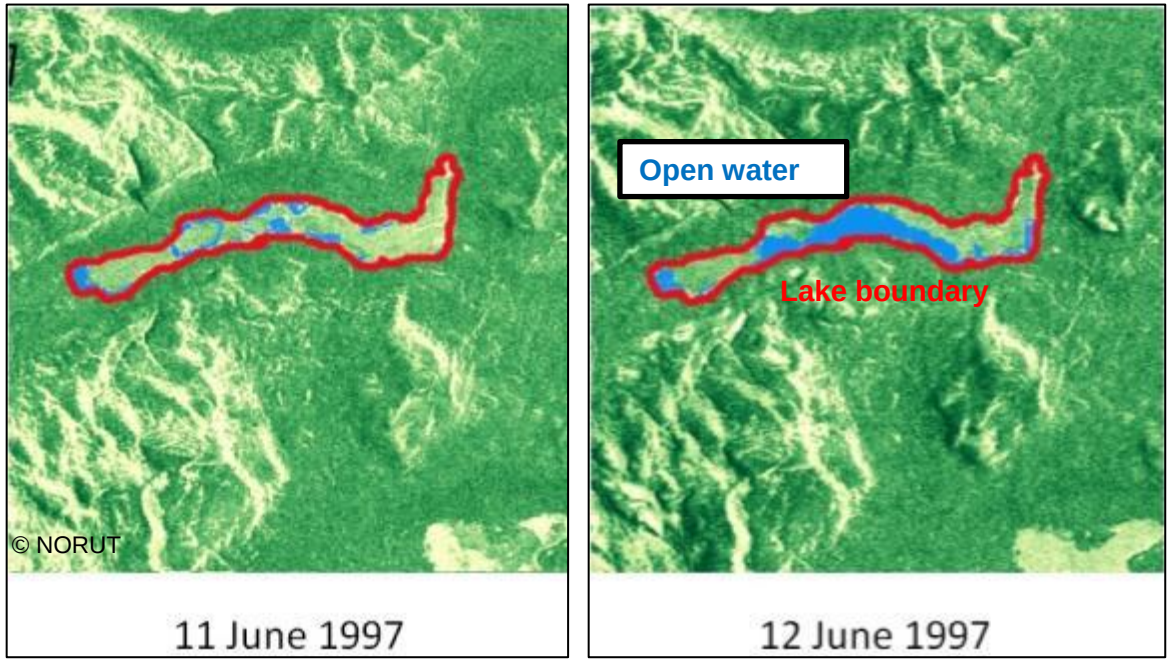


Extent of Glacier Dammed Lakes



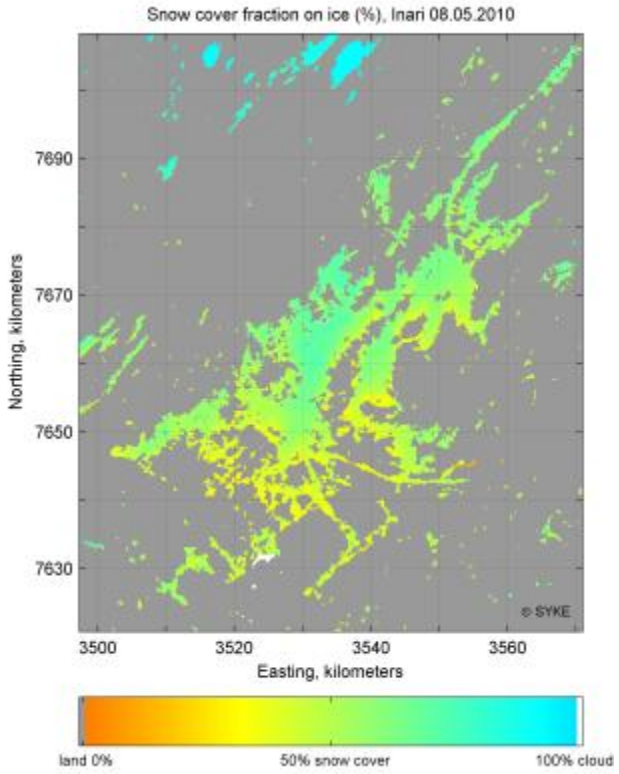
Lake / River Ice Prototype Products

Fresh Water Ice Extent and Temporal Changes



Break up of lake ice at the lake Nedre Heimdalsvatn, Norway: red - lake boundaries; blue – open water; green – lake ice.

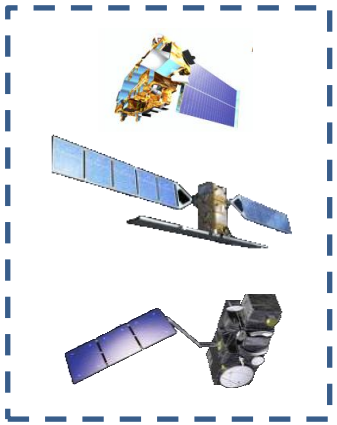
Snow Cover on Lake Ice



Snow covered area on lake ice
8 May 2010

Service Level Concept

Satellite EO



EO Data Providers

GMES Core Service Land

In-situ Data

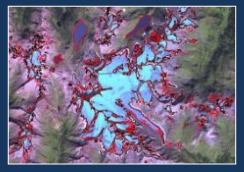
In-situ Data Providers

CryoLand

Product Providers

Snow

Glacier



Lake /River Ice

User

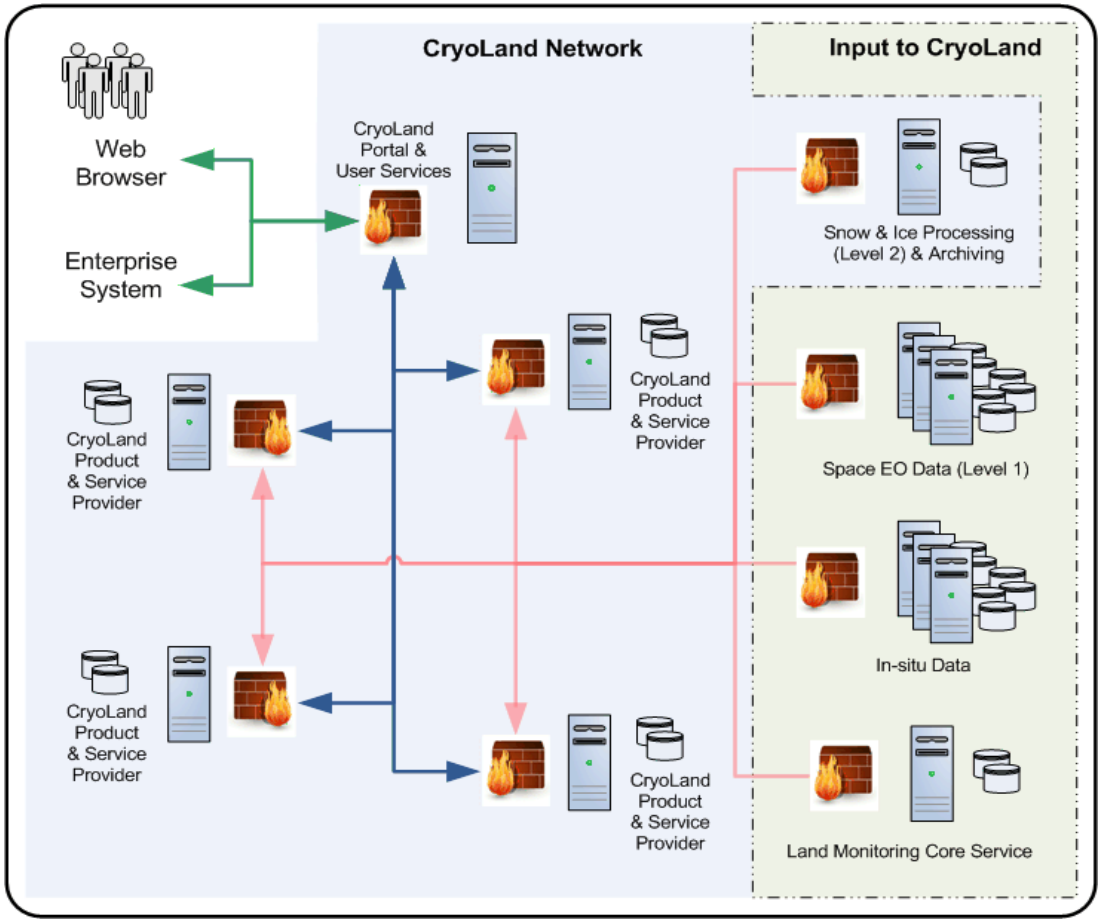
Data provided by the user

Production and Delivery

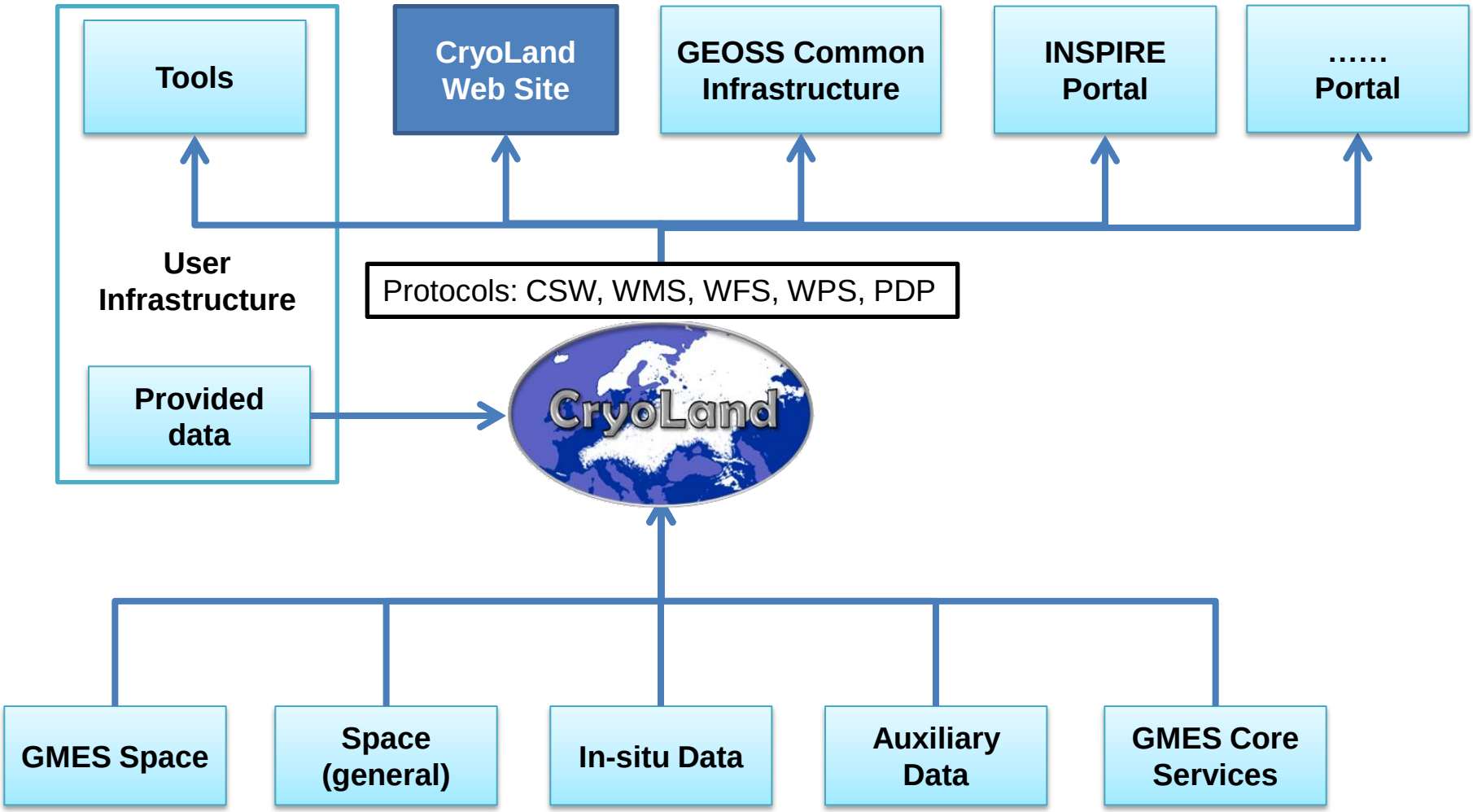
As a Downstream service CryoLand generates snow and ice products on user request.

The developed processing lines for snow, glacier and lake ice products are capable to generate time series.

CryoLand Multi-provider & Distributed Network



Product and Information Exchange



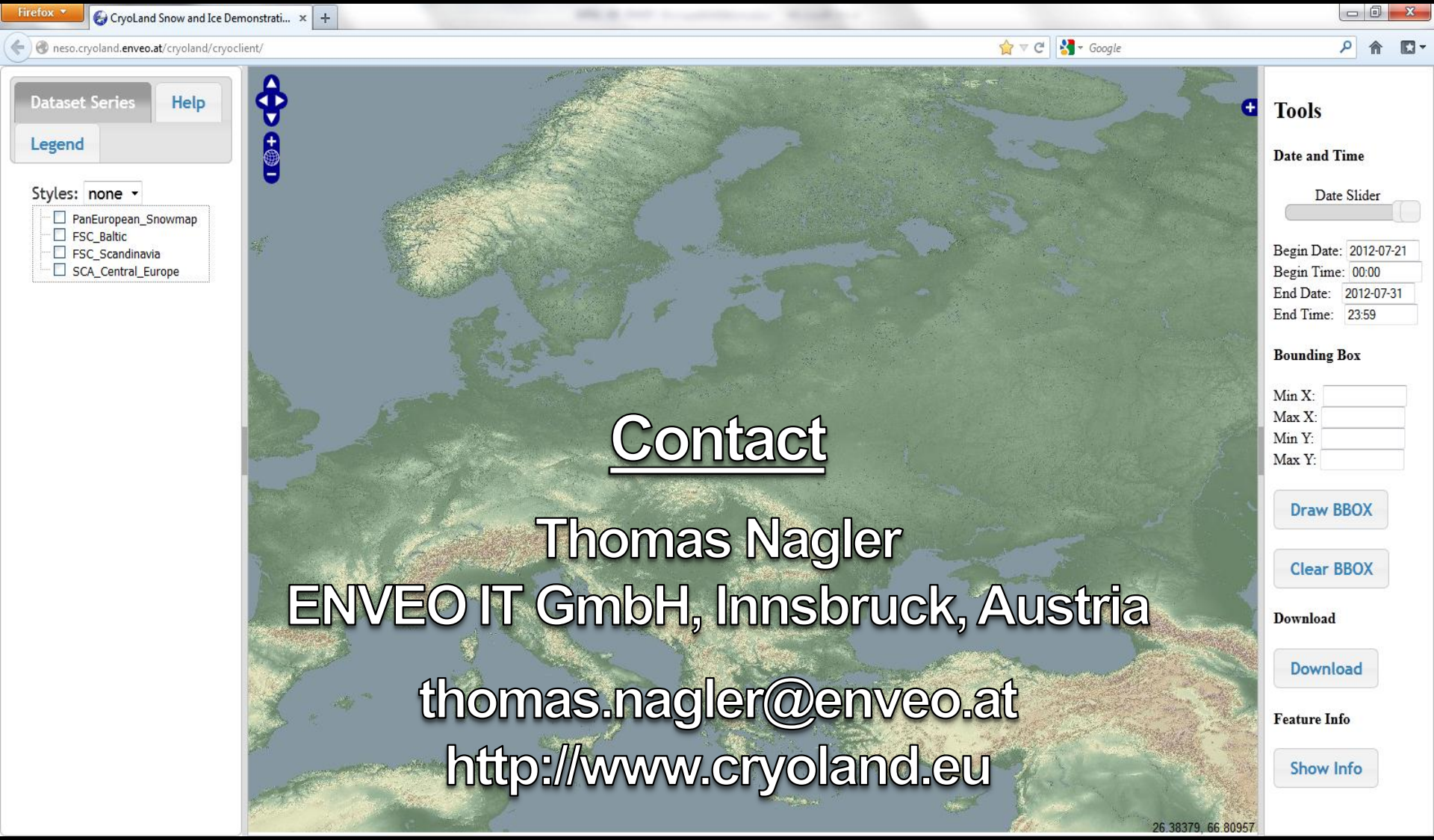
CryoLand Snow – Ongoing Activities

- NRT Time Pilot Service for Pan-European FSC and SWE winter 2012/2013. http://cryoland.eu
- Validation of SE products and products quality assessment
- User WS for evaluation of Pilot Services, planned for May 2013.
- Adaptation and implementation of algorithms to Sentinel Satellite Series.
- End-2-End testing and evaluating of CryoLand Services.
- CryoLand Demonstration of NRT Snow Services 2013/14, including pan-european and regional snow products, but also primary lake ice and glacier products.

Sustainability of Services after the Project

- CryoLand is designed as a downstream service providing services and products matching user needs. As a downstream service it is planned to be a self-standing service.

- CryoLand has the technical capabilities for covering the cryospheric component of the GMES land core services. It can be expanded towards global snow and land ice monitoring and can contribute to the generation of ECVs of snow, glaciers and lake ice, but so far no mandate to do this as a regular service.



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Product Implementation Order 2 / 2

Snow (highest priority):

- Snow Extent:
  - Regional
  - Local
  - Pan-European
- Snow Water Equivalent (low resolution)

Glacier (highest priority):

- Glacier Outlines

Lake / River Ice (highest priority):

- Lake / River Ice Extent and Lake Ice Concentration
- Fractional Snow Cover on Lake Ice

Snow:

- Melting Snow Area (medium)
- Statistical Snow Information Area (medium)
- Snow Surface Wetness (low)
- Spectral Surface Albedo (low)
- Snow Surface Temperature (low)
- Snow Grain Size (low)

Glacier:

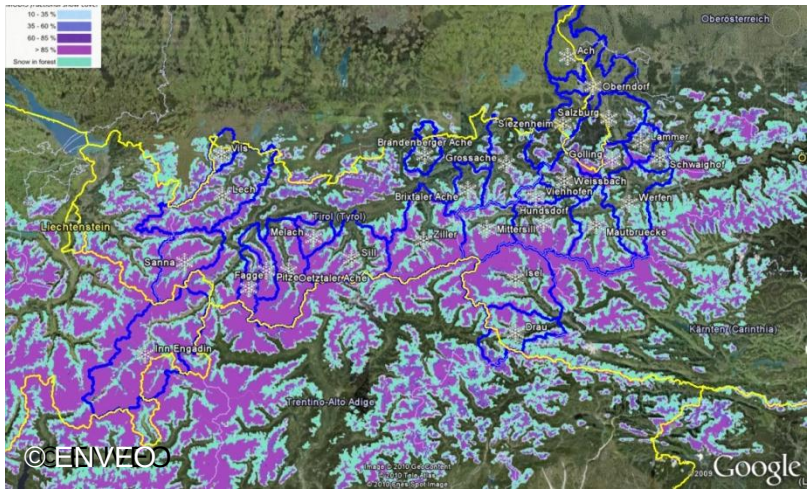
- Snow / Ice Area (medium)
- Glacier Lake (medium)
- Glacier Surface Velocity (low)

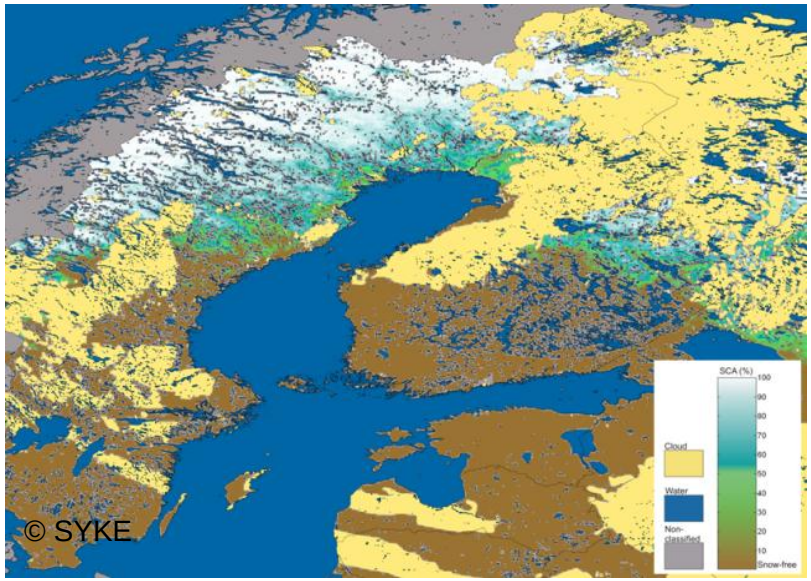
Lake / River Ice:

- First / Last day of Ice (medium)
- Snow Depth on Lake Ice (low)
- Lake Surface Temperature (low)
- River Ice Jam, Flood Inundation Area (low)

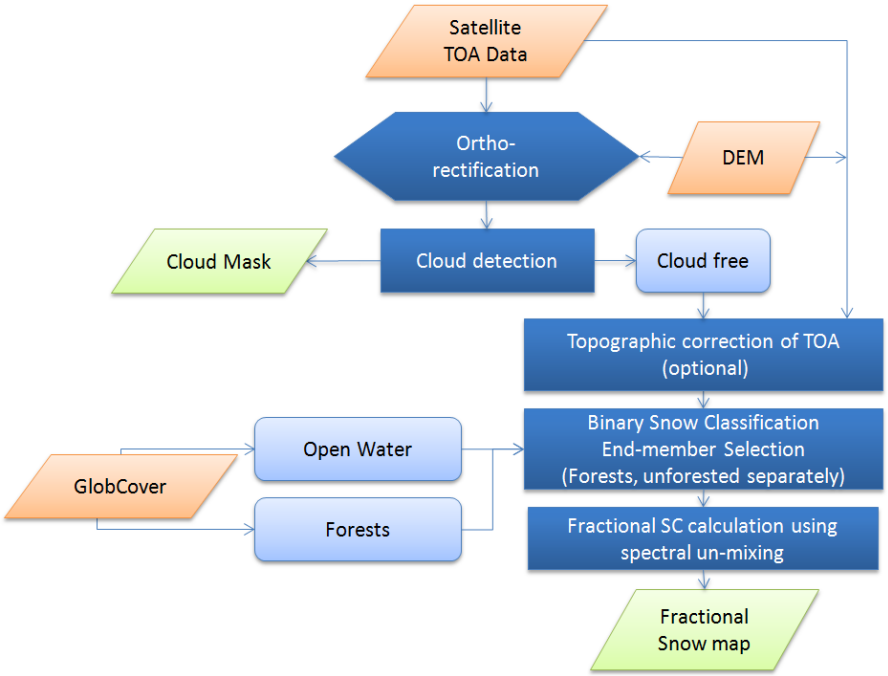
CryoLand Snow Regional

Fractional Snow Cover



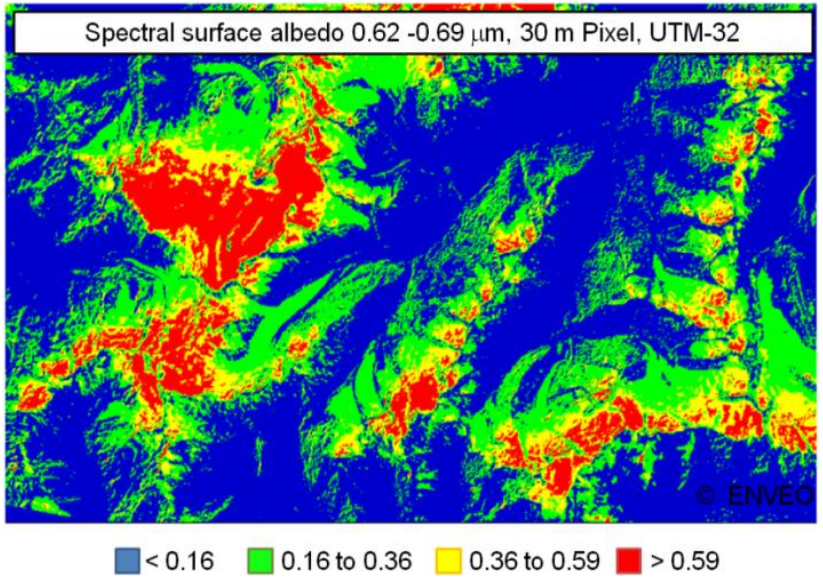


Regional Products applies algorithms developmet for this environement:
- Boreal Forest (SCAMOD)
- Mountain Regions (MS-Unmixing)
- Scaninavia: Linear Unmixing



Snow Surface Albedo (SSA)

- Draft requirements and specification:
  - AOI: local, regional
  - Projection:
    - LatLon / WGS84
    - UTM / WGS84
  - Pixel size: 250 m x 250 m
  - Temporal resolution: Daily
  - Latency: 1 day



Spectral surface albedo map derived from Landsat–5 TM data, covering the glaciated areas in Ötztal, Austria.

- Product status:
  - Processing chain specified
  - Sensor: MODIS, Landsat for local regions
  - Processing currently not active
  - Implementation planned for winter 2012 / 2013

Product Specification and Metadata Information

Product files are stored in one directory:

- Product volume file (.xml)
- Product data files (.tif, .shp)
- Browse product files (.jpg)
- Product metadata file (.xml)
- Product generation file (.txt)
- Product quality files (.tif)

Product Volume File:
provides a TOC of the files of a product, allows to check the completeness of the product.

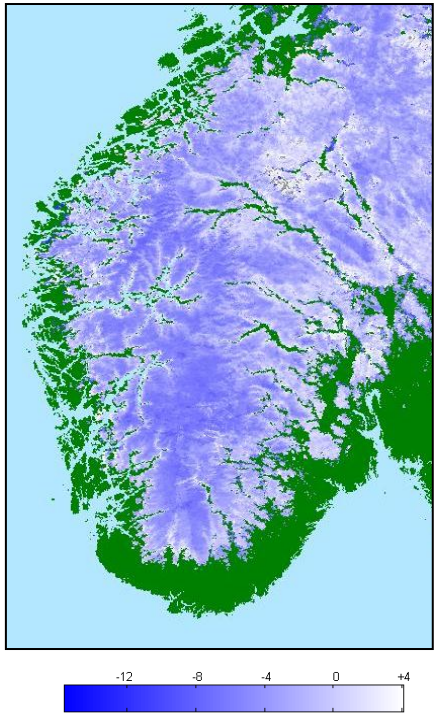
Product MDF follows INSPIRE directices:

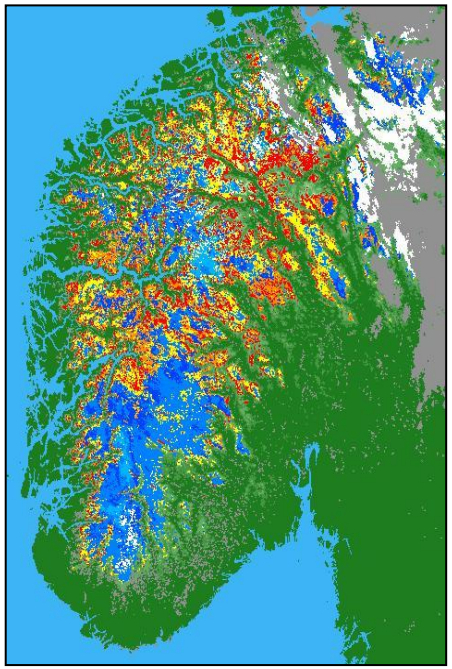
- File identification
- Classification of spatial data and services
- Keyword
- Geographic location
- Temporal reference
- Quality and validity
- Conformity
- Constraints related to access and use
- Responsible organisation
- Metadata on metadata

Detailed description of CryoLand Product Definition – in PDD / Deliverable D2.2

Regional Snow Products – Experimental

- Product specification:
  - AOI: Local, regional
  - Projection: LatLon / WGS84
  - Pixel size: 0.01° (ca 1 km)
  - Temporal resolution: Daily
  - Latency: 1 day
- Product status:
  - Sensors: MODIS, (VIIRS, Sentinel 3)
  - The algorithms are under extensive validation
  - Is provided on demand to interested users





White - dry, cold snow: SST < -2°C.
Yellow/orange - moist: -0.5°C < SST +0.5°C.
& Unchanged SGS. & Increasing SGS
Light/dark blue - dry/moist: -2°C < SST and -0.5°C
Red - wet: +0.5°C < +1.0°C