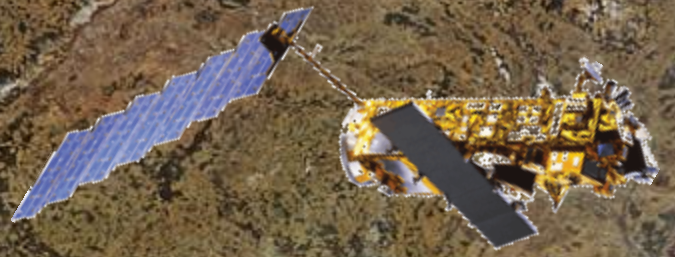
SENTINEL-1, 3 BASED SNOW PRODUCTS BY ENVEO



presented by **Gabriele Bippus**

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SEVENTH FRAMEWORK PROGRAMME

Snow Products prepared and provided by ENVEO

- *Alpine area:*
  - Multi-temporal Regional **Wet Snow Cover Maps** from *Sentinel-1 IWS* data
  - Daily **Fractional Snow Cover Maps** using synergistic *Sentinel-3 SLSTR/OLCI* data (current service based on MODIS Terra data, backup: NPP VIIRS)
- *Pan-European Area:*
  - Daily **Fractional Snow Cover Maps** using synergistic *Sentinel-3 SLSTR/OLCI* data (current service based on MODIS Terra data, backup: NPP VIIRS)

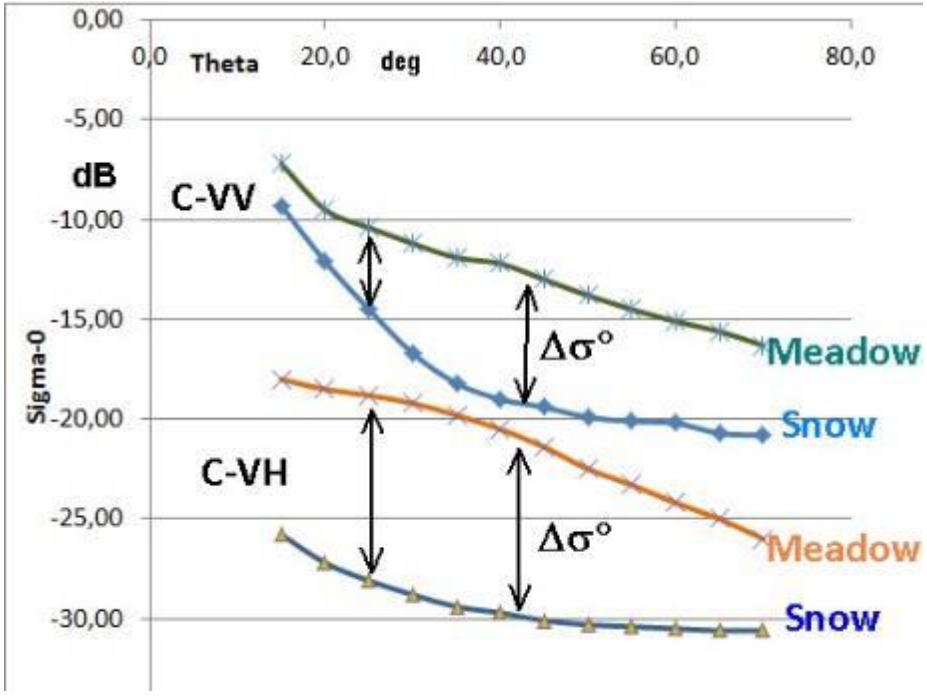
→ ***Sentinel data from ESA Scientific Data Hub***

Snow Products Specifications

Products	Sensor	Projection / Datum	Spatial Coverage	Spatial Resolution	Temporal Resolution	Delivery period	Latency time	File Format
Wet (melting) Snow Area	*Sentinel-1*	Geographic / WGS84	Alpine region	0.001 deg (ca 100 m)	Multi-temporal, depending on data availability	Melting Season	< 1 day	Raster (GeoTIFF, netCDF)
Fractional Snow Cover	Sentinel-3 (*MODIS*, VIIRS)	Geographic / WGS84	72°N/11°W-35°N/50°E	0.005 deg (ca 500 m)	Daily	Full Year	< 1 day	Raster (GeoTIFF, netCDF)
Fractional Snow Cover	Sentinel-3 (*MODIS*, VIIRS)	Geographic / WGS84, others (user defined)	Alpine region	0.003 deg (ca 250 m)	Daily	Full Year	< 1 day	Raster (GeoTIFF)

SAR Concept for Retrieval of Snowmelt Area

- Exploits the contrast of backscatter (σ°) between wet snow and snow-free surfaces (reduced σ° of wet snow)
- Applies the backscatter ratio ($\sigma^\circ_{\text{wet snow}}$/ $\sigma^\circ_{\text{snow-free}}$) to compensate for topographic effects (local incidence angle)
- Applies a segmentation procedure to separate the two surface types in σ° ratio images



Based on in-situ Scat data, Leutasch, Austria

Δσ° varies with incidence angle θ and polarization:

- Δσ°(VV) decreases for lower θ_i
- Noise floor (NESZ) may be problem for Δσ°(VH) at high θ_i

Solution:

Apply weighting function $W(\theta i)$ for fusion of Δσ°(VV) and Δσ°(VH)

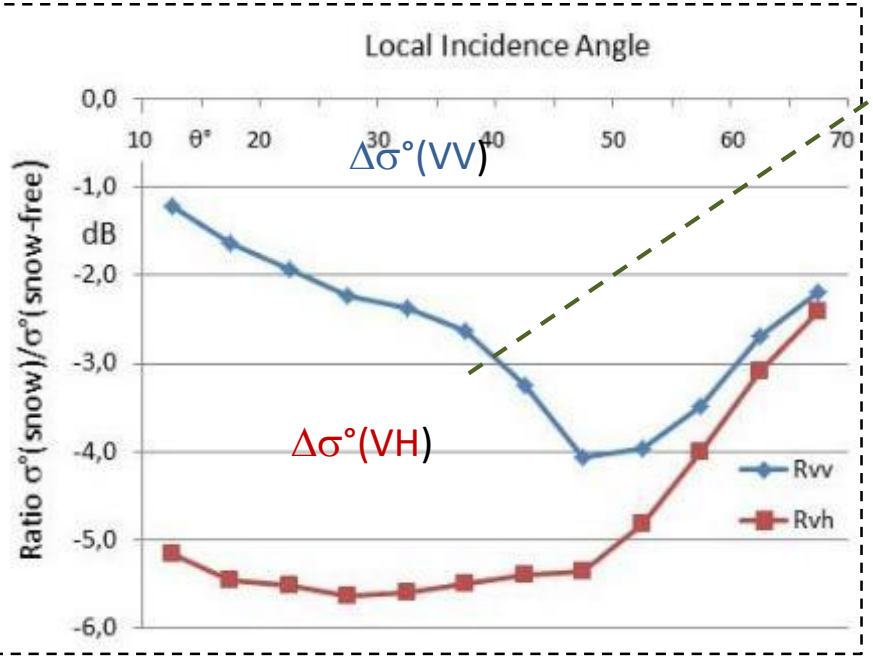
Nagler et al., 2016: Advancements for Snowmelt Monitoring by means of Sentinel-1 SAR, Remote Sensing, *accepted*.

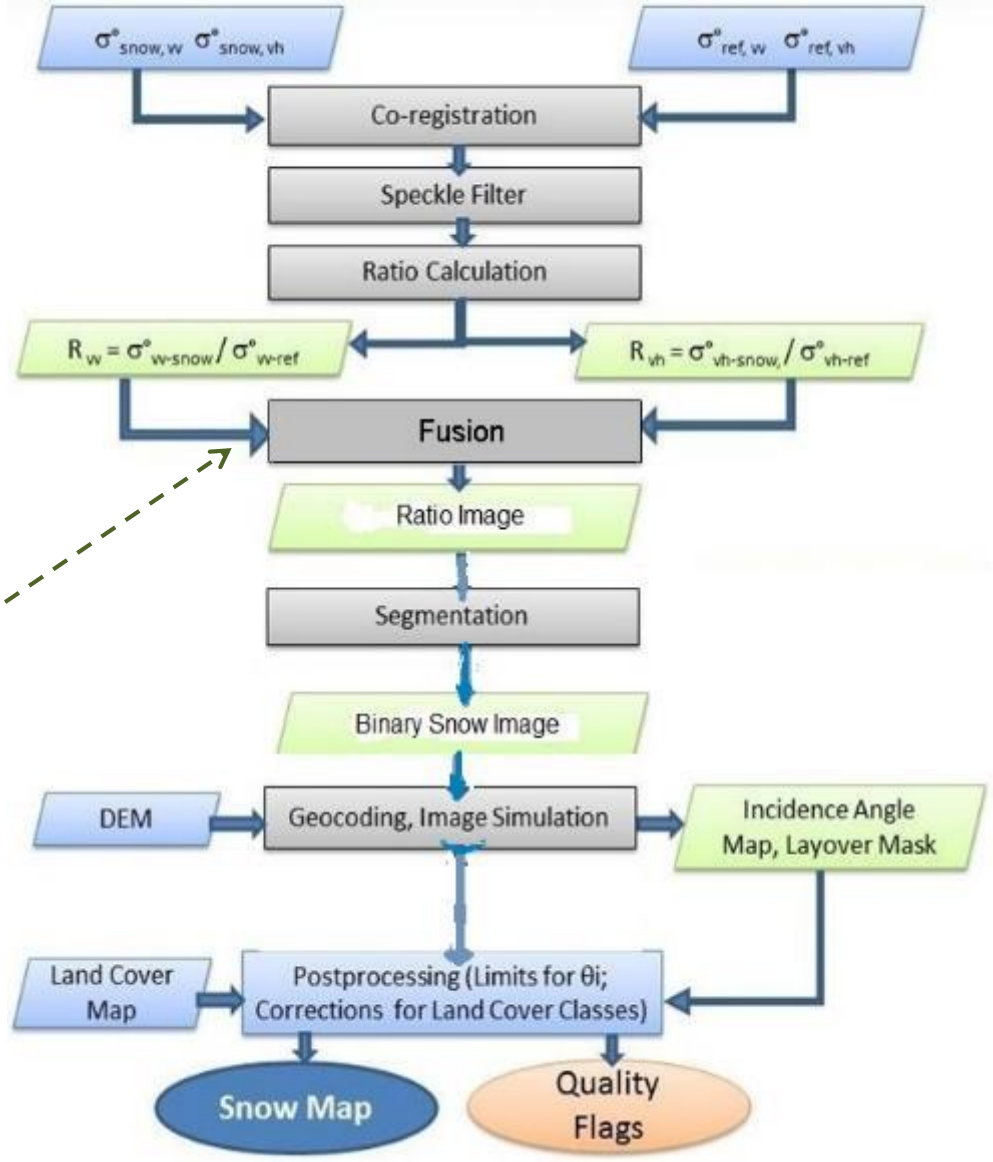
Retrieval of Snowmelt Area by S1 IW Mode Data

Flowline for Retrieval algorithm from Sentinel-1 **IW-mode data (SLC)**

SLC data *enable optimal speckle filtering, data fusion, segmentation and geocoding*

σ° ratio in IW mode data, for area in Eastern Alps, 2 June 2015

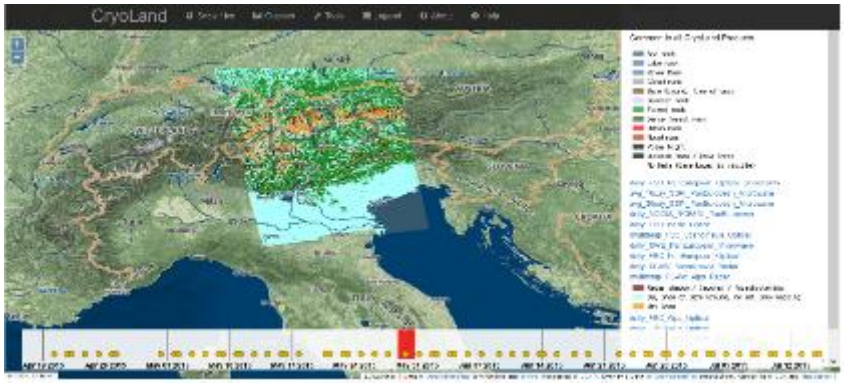




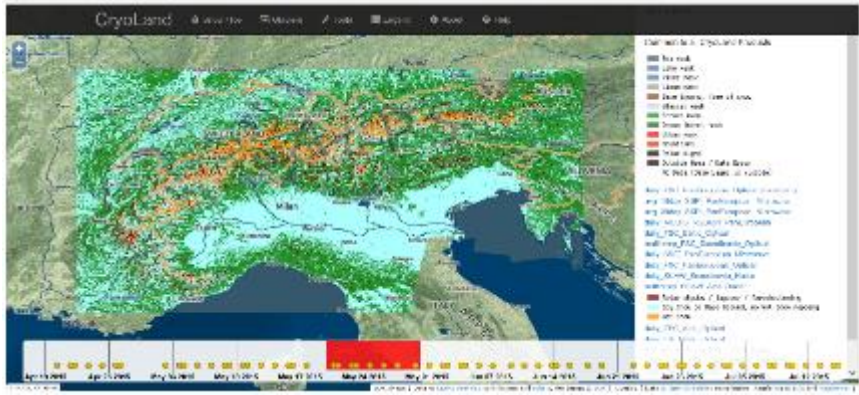
Current status of Alpine Wet Snow Cover Product

Products Specifications	Alpine
Domain	Full Alpine ridge and lowlands
Temporal resolution	Multi-temporal, depends on availability of Satellite data, currently 12 days per track, with Sentinel-1B 6 days per track
Projection	LatLon / WGS84, or as requested by users
Pixel size	0.001° (ca 100 m)
Latency time	< 1 day

Status	Alpine
Sensor	Sentinel-1 IW SLC SAR
Uncertainty information	Intercomparison with snow maps from high and medium resolution optical satellite data ongoing
Archive	Wet snow maps from snow melt season 2015
Processing status	Pilot service, pre-operational service in NRT planned to start in April 2016



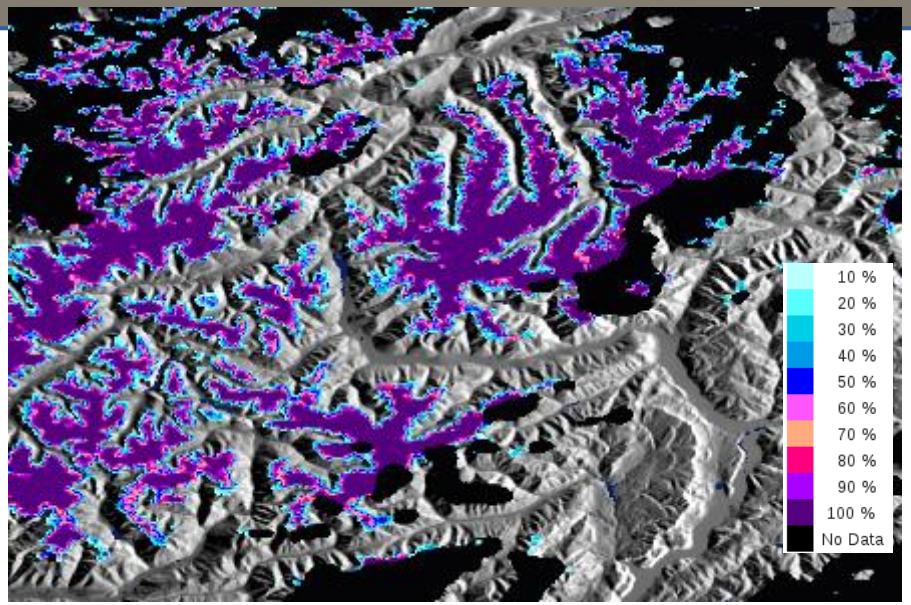
Alpine SCAW product (single track) from Sentinel-1 SAR data, 29/5/2015

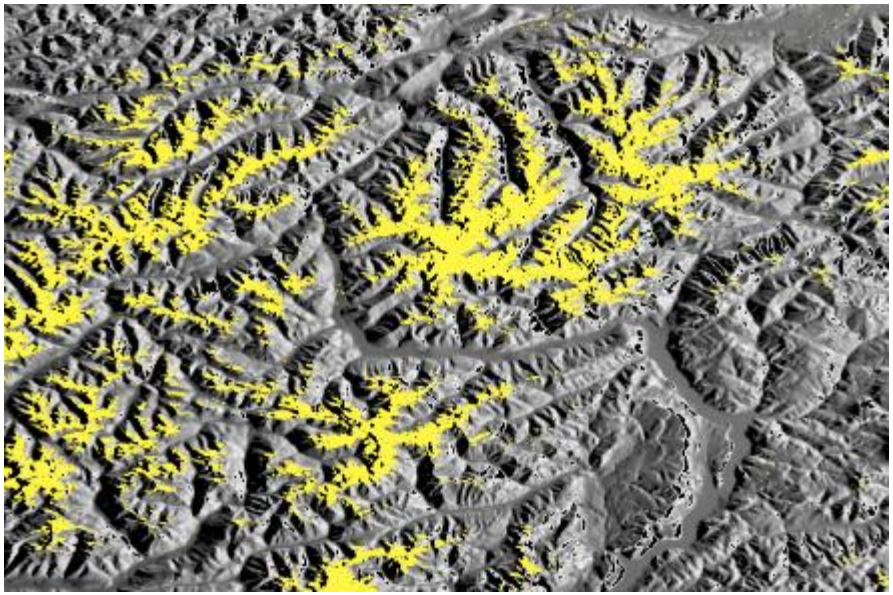


Alpine SCAW product (multiple tracks) from Sentinel-1 SAR data, 20/5/2015 - 29/5/2015
(S1A data of 9 days for full coverage of alpine area)

Products are accessible through the SEN3APP Portal, via CryoLand GeoPortal:
http://www.cryoland.eu

Comparison MODIS Snow Extent / S1 Snowmelt Area





MODIS, 17+18 May 2015, Map of Fractional Snow Extent (*grid size 250 m*)

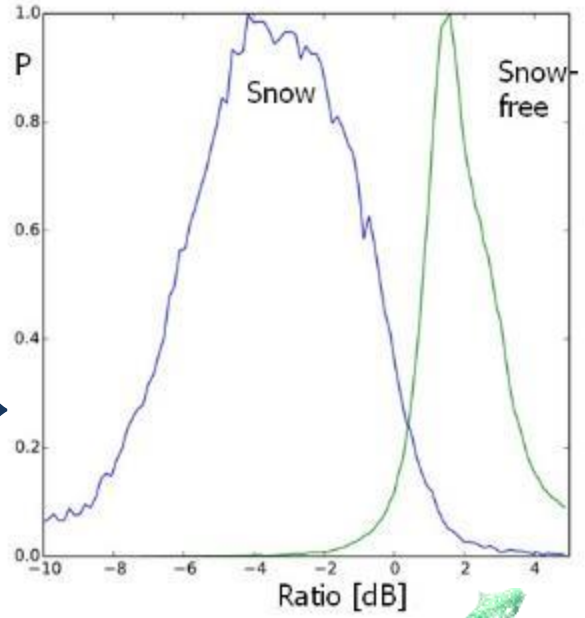
Confusion Matrix S1

Overall=89.51

MODIS	SC(S1)	SF(S1)
SC	83.96	16.04
SF	8.86	91.14

S1 Snow Melt Area
2015/05/17
100 m grid

→



Probability Δσ° for snow/snow free areas from MODIS

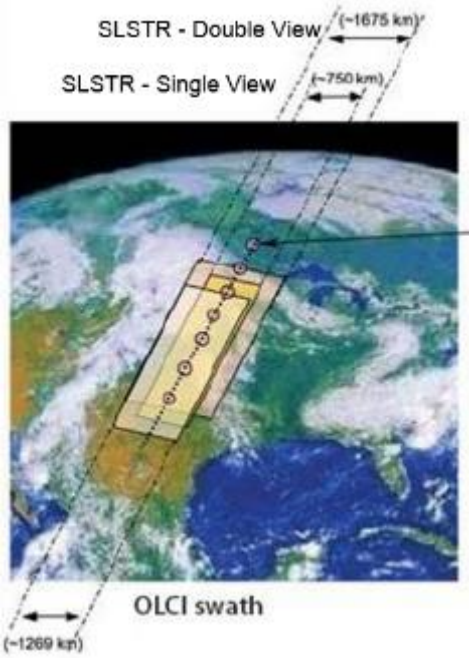
Concept for SENTINEL-3 Snow Mapping using SLSTR (AATSR) and OLCI (MERIS)

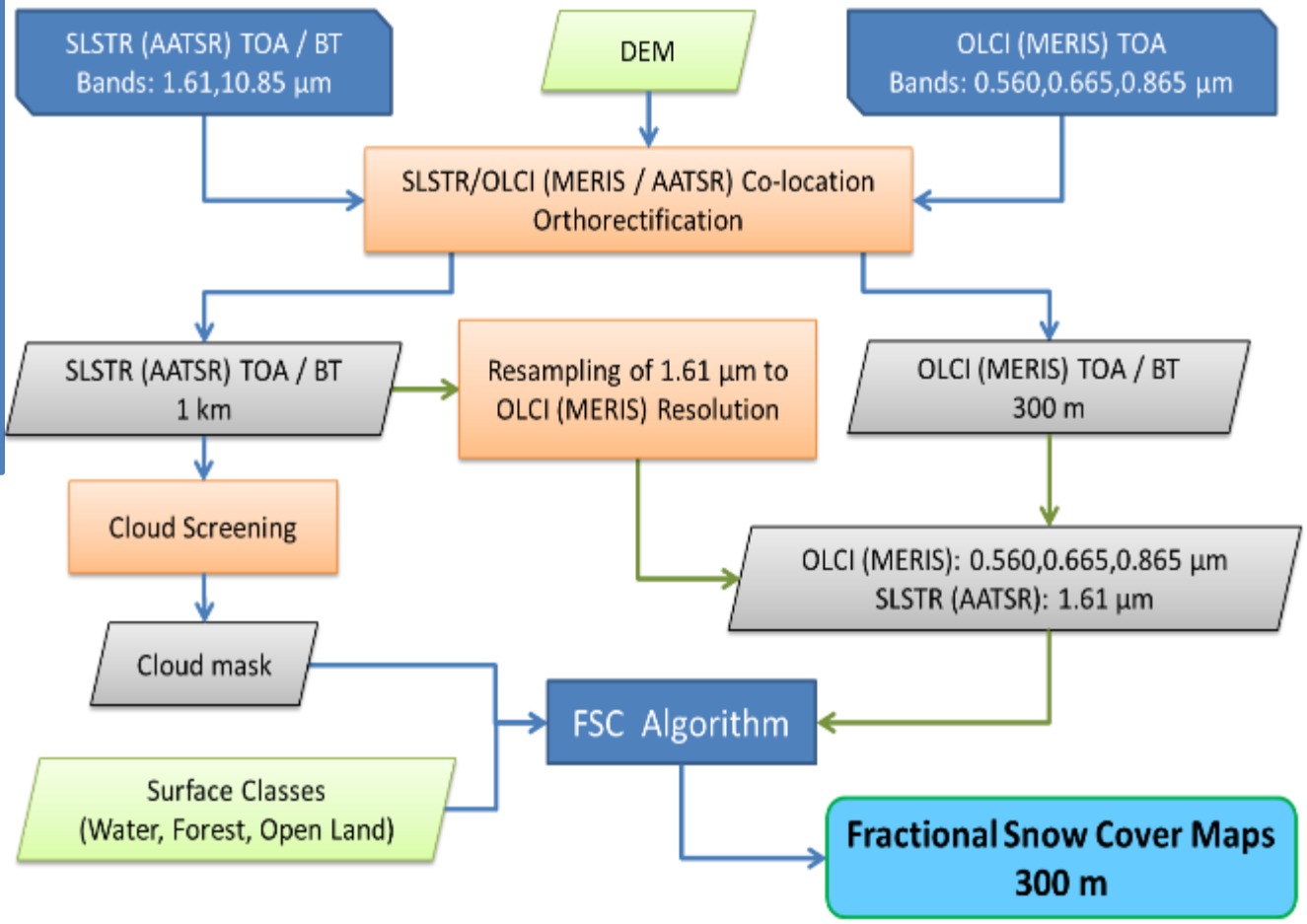
Sentinel-3:

SLSTR (follow on of AATSR):
0.5 – 1.6, -3.7 µm + TIR
500 m / 1 km

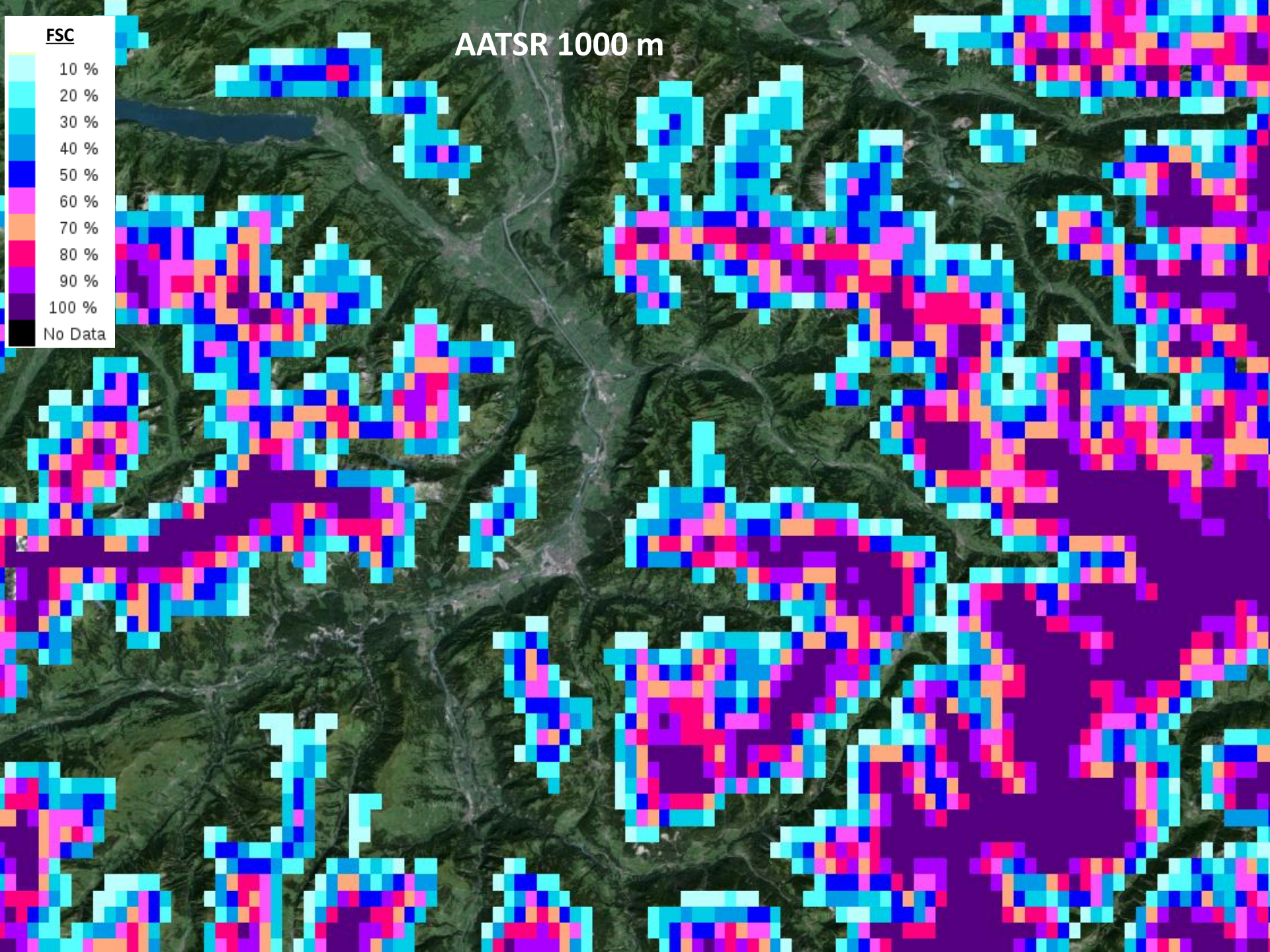
OLCI (follow on of MERIS):
0.4.-1.2 µm; 300 m

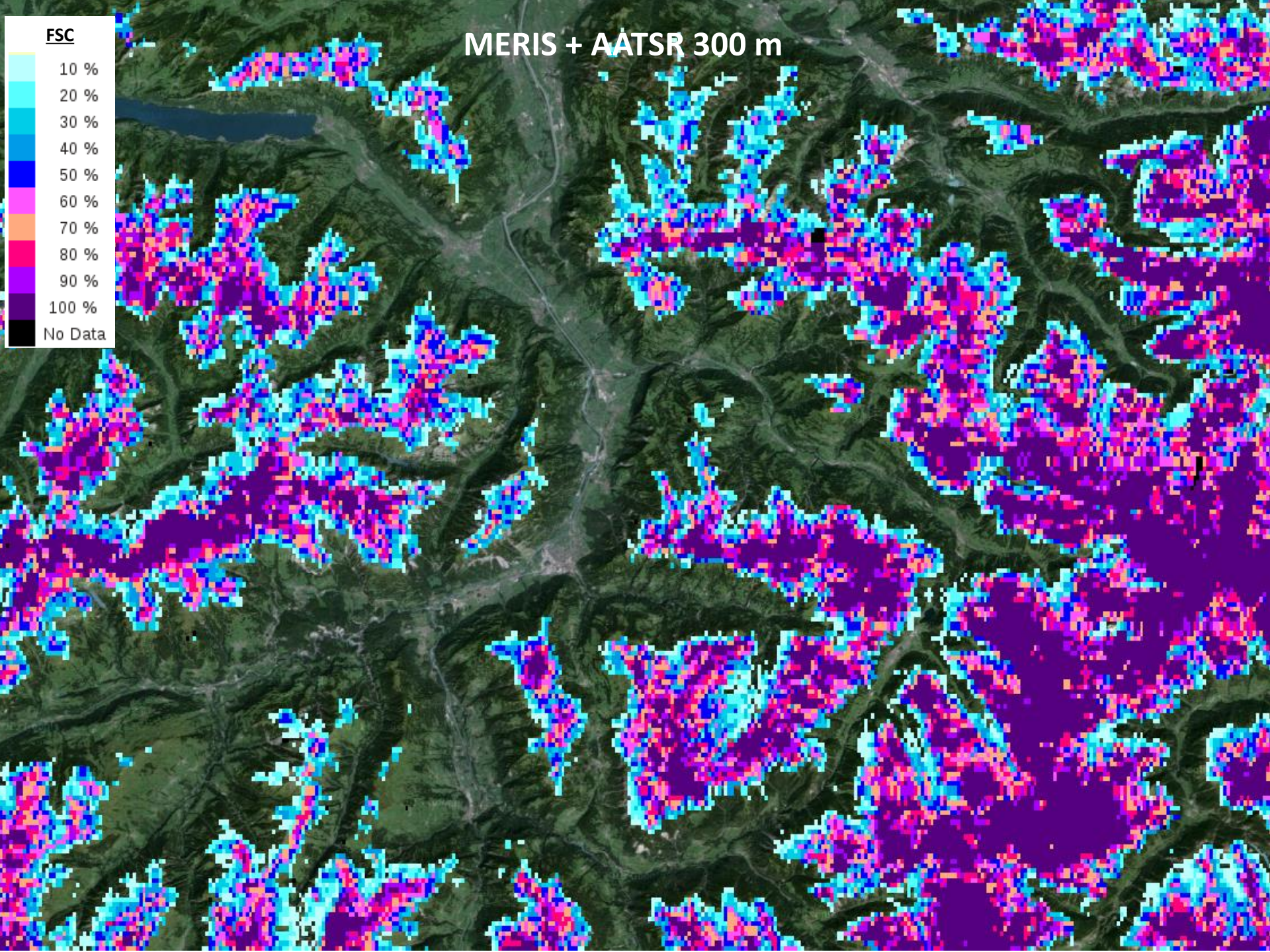
Daily Global Coverage





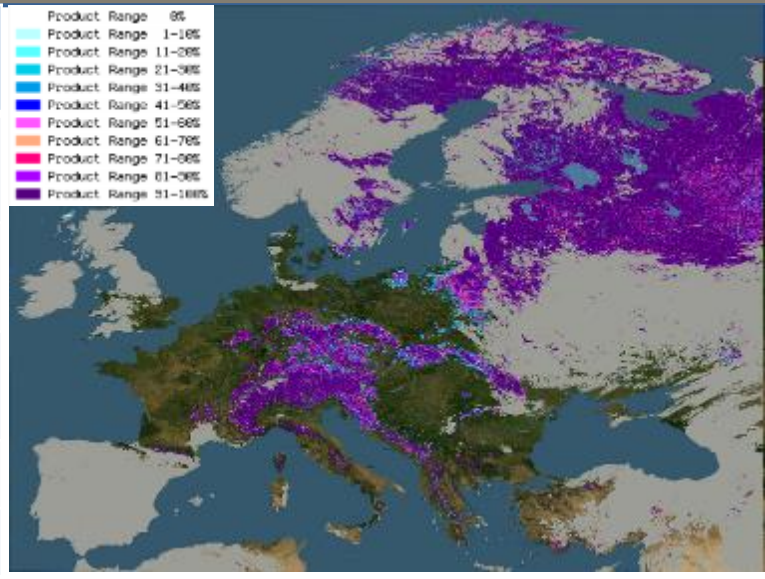
Fractional Snow Extent estimated using multi-spectral algorithm


FSC
10 %
20 %
30 %
40 %
50 %
60 %
70 %
80 %
90 %
100 %
No Data
AATSR 1000 m

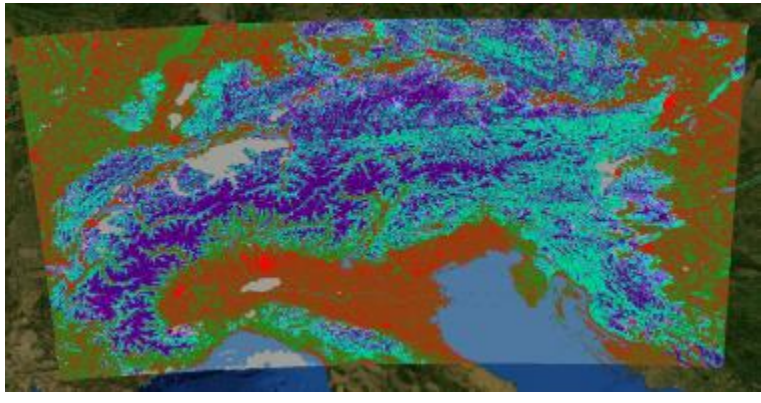

FSC
10 %
20 %
30 %
40 %
50 %
60 %
70 %
80 %
90 %
100 %
No Data
MERIS + AATSR 300 m

Current status of Pan-European & Alpine Fractional Snow Cover Products

Products Specifications	Pan-European	Alpine
Domain	72°N 11°W – 35°N 50°E	Full Alpine ridge and lowlands
Temporal resolution	1 day	1 day
Projection	LatLon/WGS84	LatLon / WGS84, or as requested by users
Pixel size	0.005° (ca 500 m)	0.0025° (ca 250 m)
Latency time	< 1 day	< 1 day
Status	**Pan-European**	**Alpine**
Sensor	MODIS (Backup: VIISR, Future: *Sentinel-3*)	MODIS (Backup: VIISR, Future: *Sentinel-3*)
Uncertainty information	Unbiased RMSE provided per pixel for each daily product, validation with snow maps from high and very high resolution optical satellite data	Periodic validation with snow maps from high resolution optical satellite data
Archive	Daily snow maps from 2000 – present	Daily snow maps from 01/10/2012 – present
Processing status	Fully operational in NRT	Fully operational in NRT



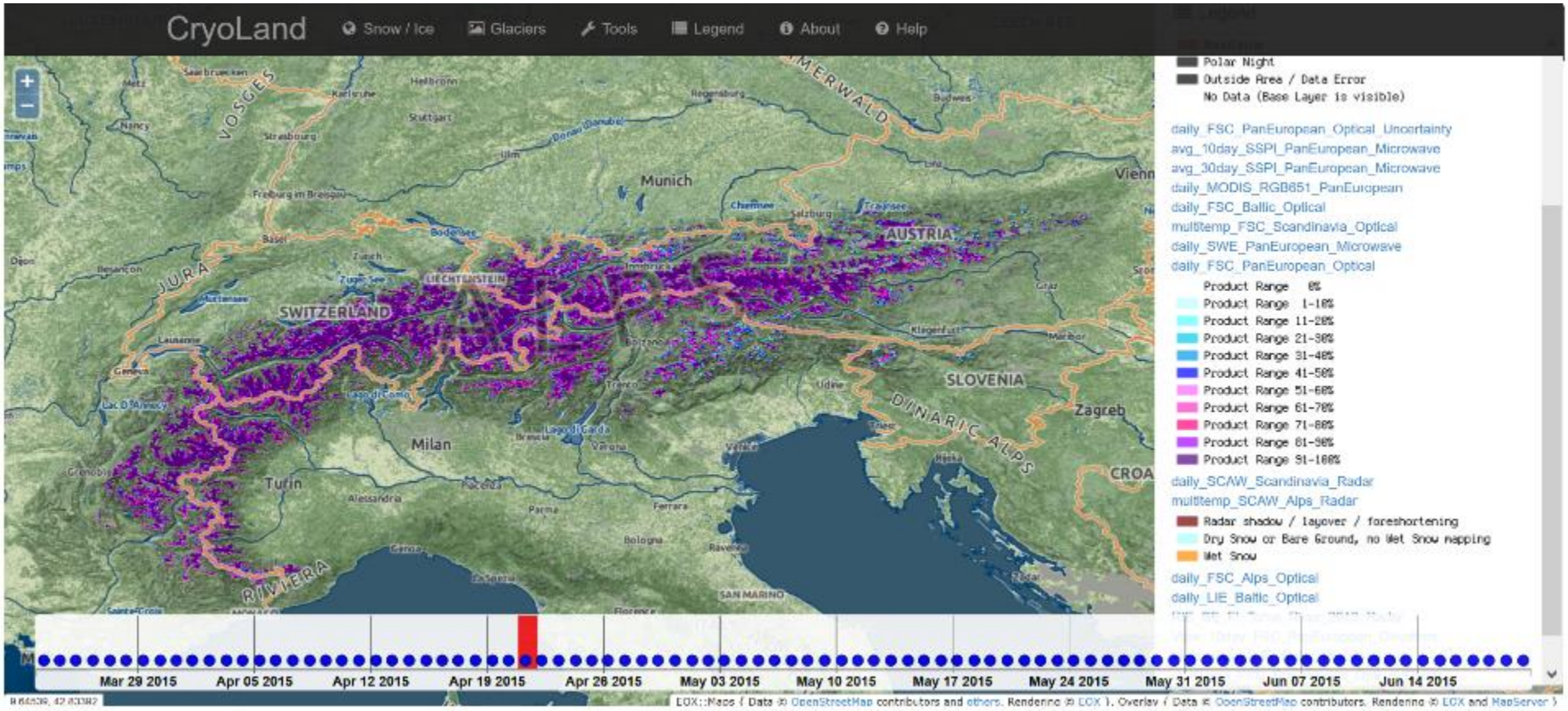
CryoLand pan-European FSC product, 4/3/2013



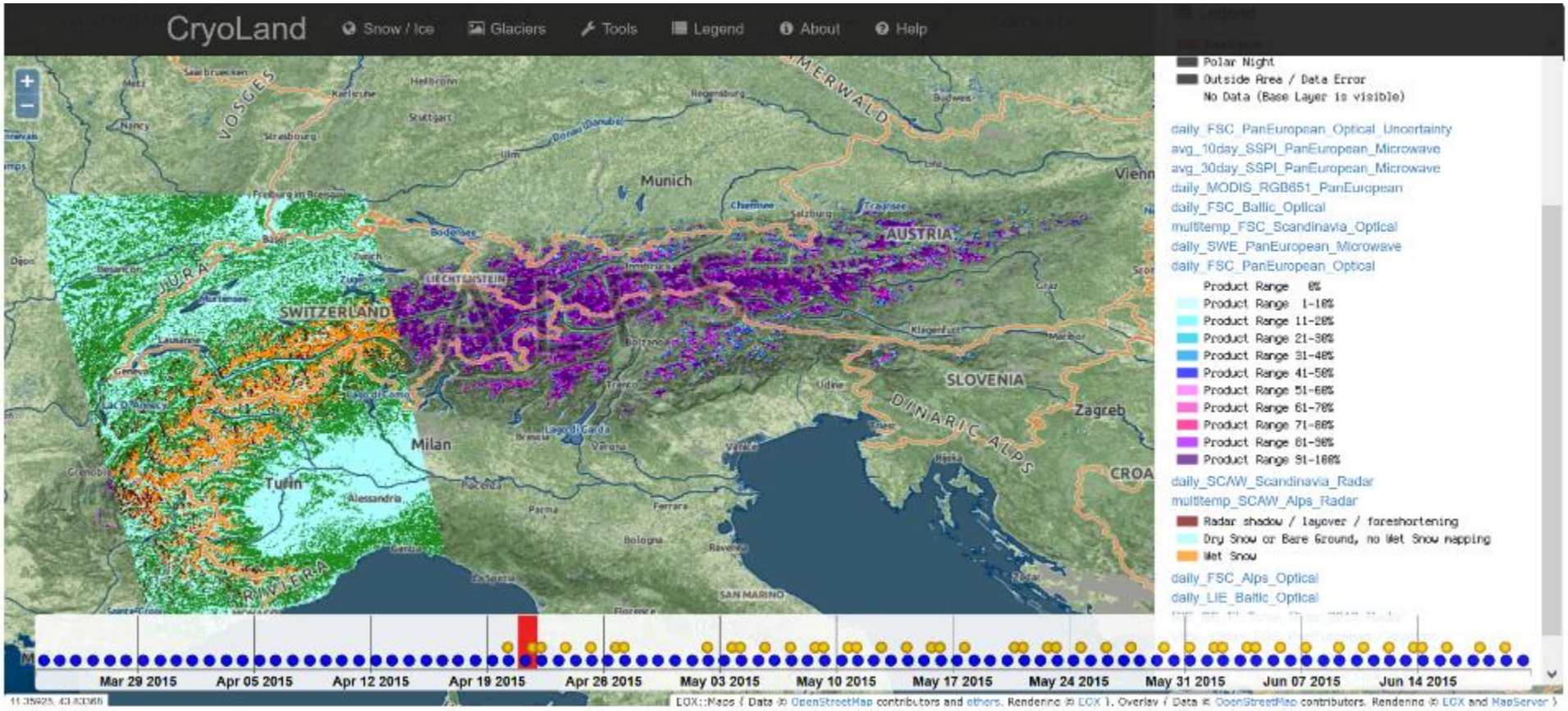
Operational version of the Alpine fractional snow cover map from Terra MODIS data, 4/3/2013

Products are accessible through the CryoLand GeoPortal: http://www.cryoland.eu

Combining fractional snow extent maps with melting snow area maps

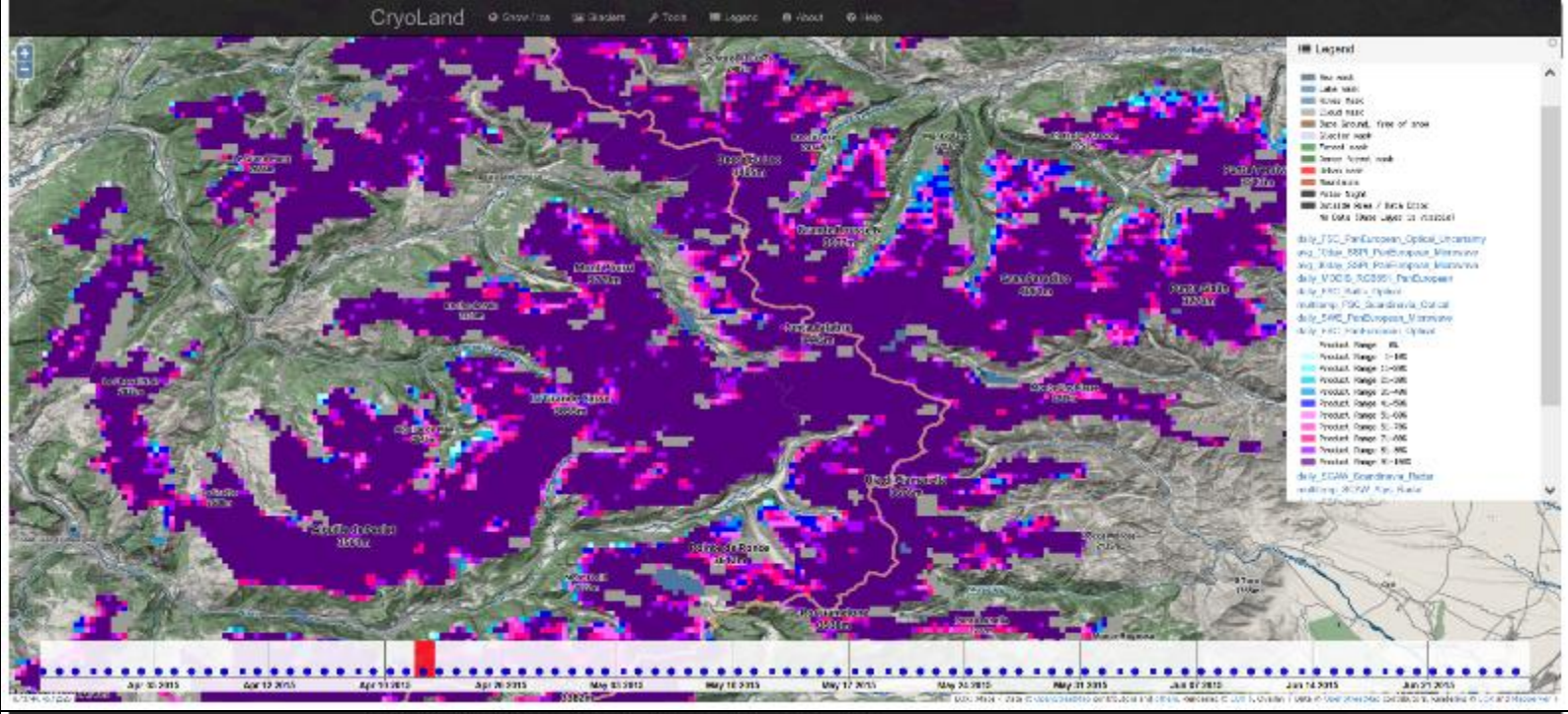


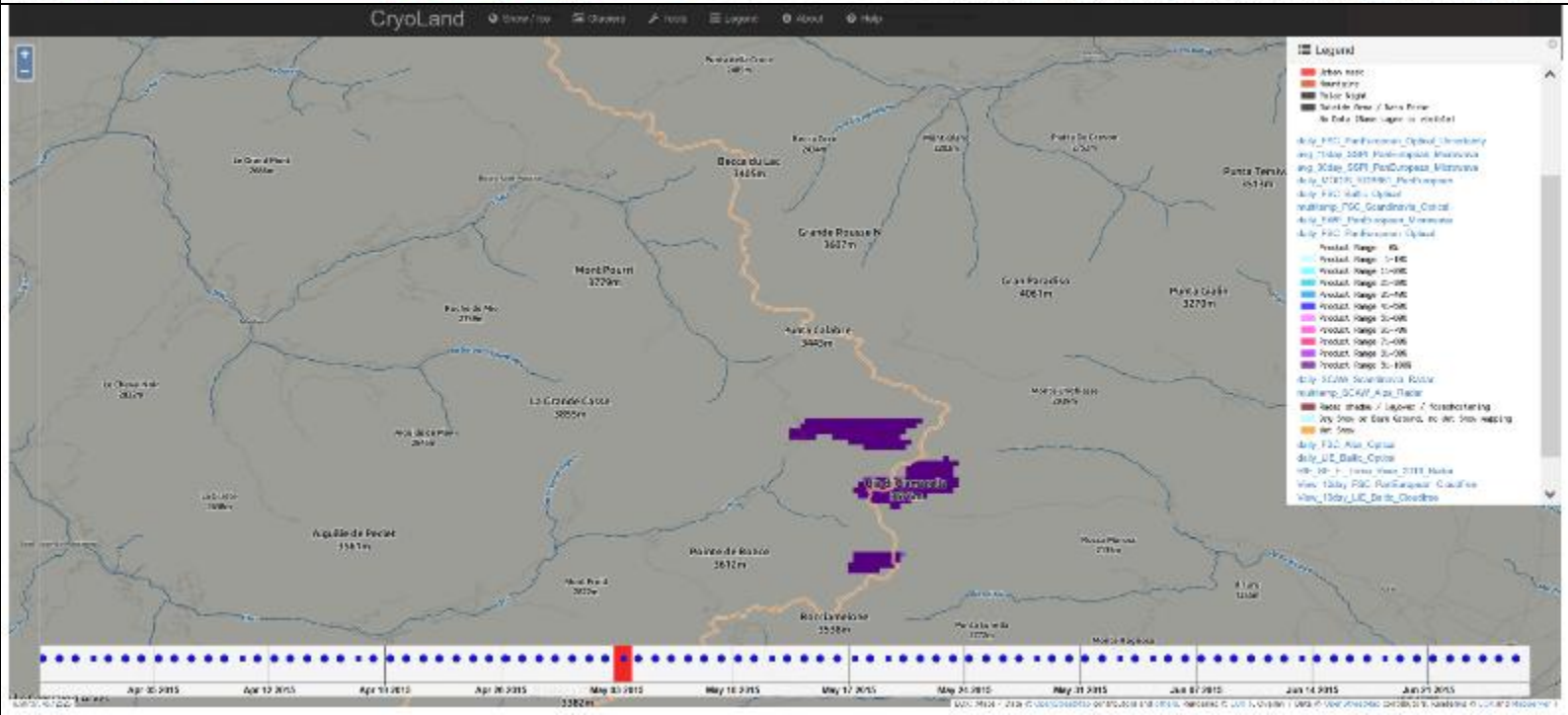
Combining fractional snow extent maps with melting snow area maps



Added value of combining snow products

Fractional Snow Cover (500 m)

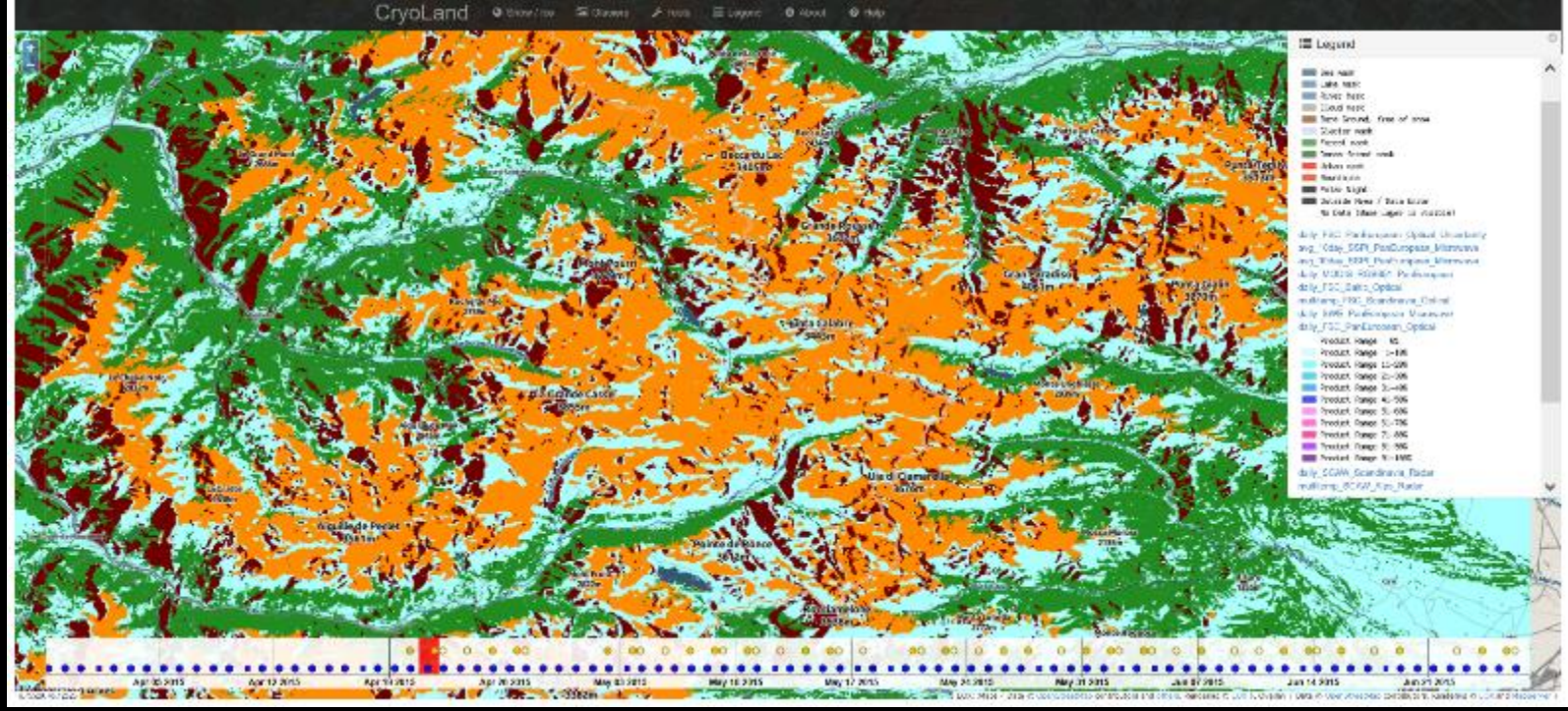


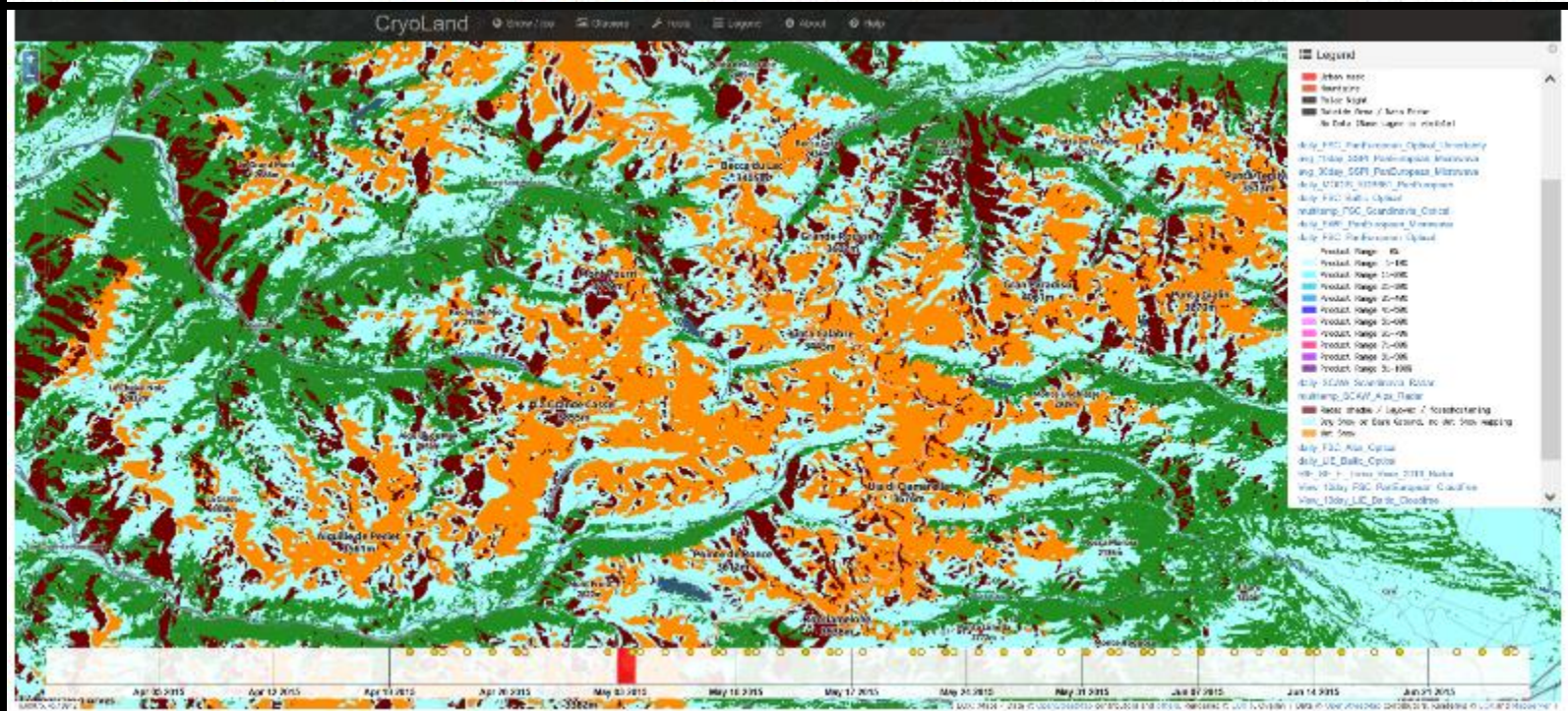


Added value of combining snow products

Fractional Snow Cover (500 m)

Wet Snow Cover (100 m)



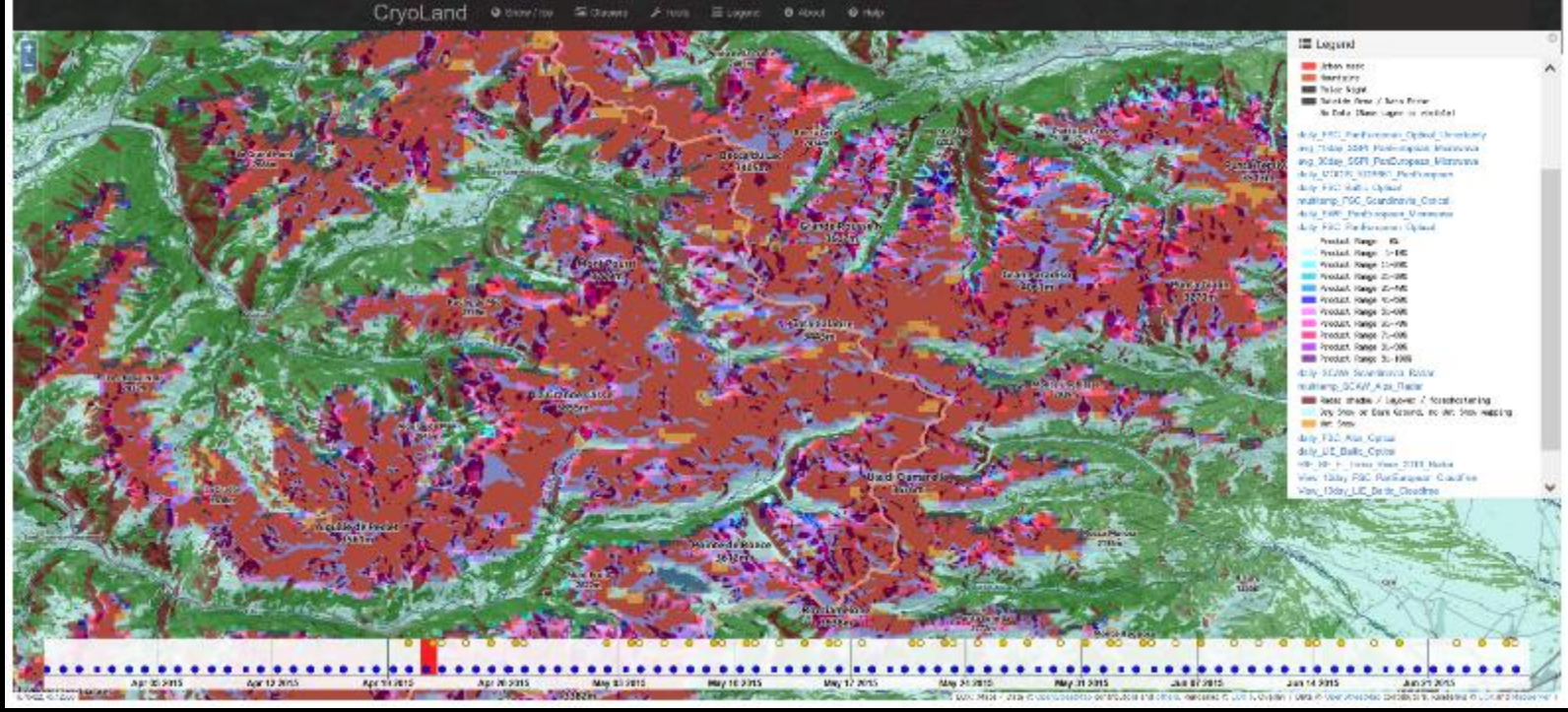


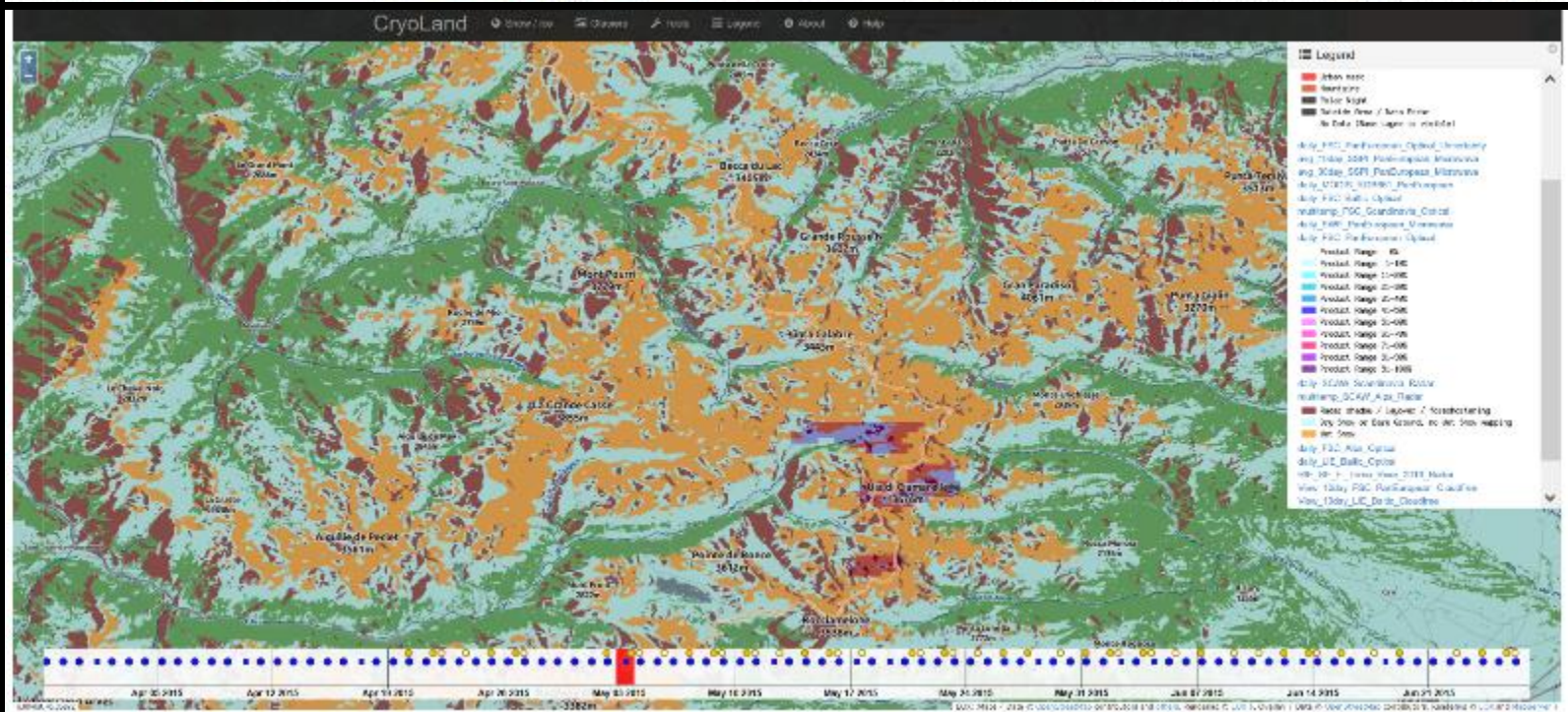
Added value of combining snow products

Fractional Snow Cover (500 m)

Wet Snow Cover (100 m)

Fractional Snow Cover overlaid with wet Snow Cover





Summary of status and ongoing work for snow products provided by ENVEO

- Existing processing lines adapted/improved for using Sentinel data as input (*ongoing*)
- Testing processing lines for snow product generation using archived satellite data with similar characteristics (*ongoing*)
- Implementation of tools for processing of Sentinel-1 data at ENVEO (**completed**)
- Improving algorithm for wet snow cover mapping using Sentinel-1 data (**completed**)
- Implementation of processing line for fractional snow cover mapping using VIIRS data as input (backup solution in case Terra MODIS fails, *ongoing*)
- Existing NRT services for daily Pan-European and Regional Fractional Snow Cover products based on MODIS data (future: Sentinel-3) are continuously running

ENVEO's planning for the future

- Pilot service of **wet snow cover products** for Alpine region:
  - start planned end of April 2016
  - products provided through the SEN3APP Portal CryoLand GeoPortal, http://neso1.cryoland.enveo.at/cryoclient/
- Testing of processing line for **fractional snow cover maps from Sentinel-3** data (access to S3 data needed)
- Testing processing lines for **high resolution snow maps from Sentinel-2 MSI** data for *evaluation and validation purposes* (ongoing)