

SYKE Product Portfolio

Satellite data products for monitoring environment

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SEN3APP Stakeholder Workshop, Apr 18th 2016

SEN3APP Northern Hemisphere Fractional Snow Cover (FSC) (FMI/SYKE)



- Built on GlobSnow-heritage (Snow Data record based on SCAMod method applied to ERS-2/ATSR-2 and Envisat/AATSR-data) → transferring to NPP Suomi/VIIRS (later to Sentinel-3)
- The processing system and data archives are located National Satellite Data Centre at FMI-Sodankylä Facility
 - NRT processing used NPP Suomi/VIIRS, 2013 →
- AOI products (continental, regional, national) may be extracted from the NH snow maps
- The SCAMod algorithm is for direct Fractional Snow Cover retrieval, and is particularly designed to retrieve snow information also in forest areas

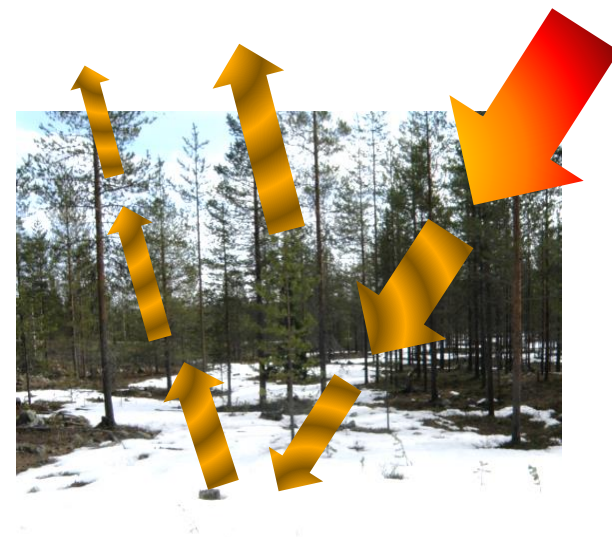
SCAmod

$$\rho_{\lambda,obs}(FSC) = \underbrace{(1-t_{\lambda}^2) * \rho_{\lambda,forest}}_{\text{Volume scattering}} + \underbrace{t_{\lambda}^2 * [FSC * \rho_{\lambda,snow} + (1-FSC) * \rho_{\lambda,ground}]}_{\text{Surface scattering}}$$

$$FSC = \frac{\frac{1}{t_{\lambda}^2} * \rho_{\lambda,obs}(FSC) + (1 - \frac{1}{t_{\lambda}^2}) * \rho_{\lambda,forest} - \rho_{\lambda,ground}}{\rho_{\lambda,snow} - \rho_{\lambda,ground}}$$

- Fractional snow (FSC) in forested and non-forested areas
- Reflectance model: forest canopy effect into the observed reflectance is compensated through pre-determined canopy *transmissivity*
- Uses green band 550nm for snow detection
- Metsämäki et. al (2005 and 2012)

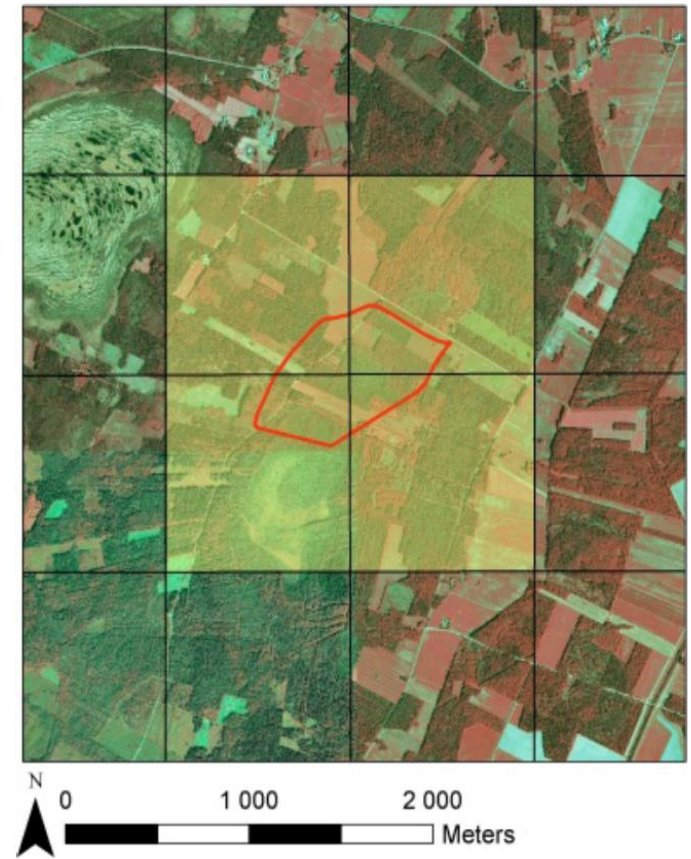
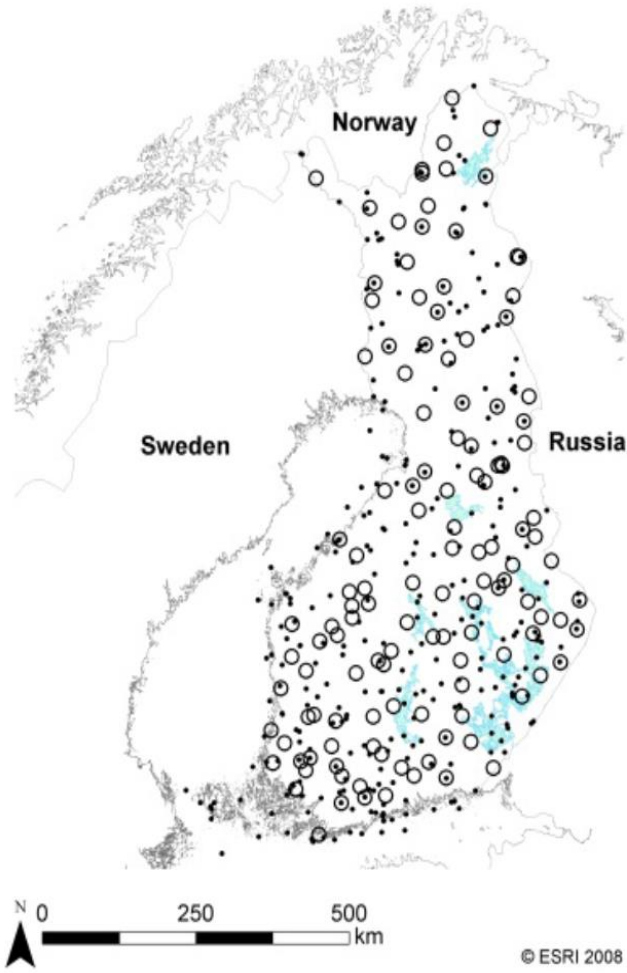
$\rho_{\lambda,obs}(FSC)$ observed reflectance from unit area
 $\rho_{\lambda,snow}$ wet snow reflectance
 $\rho_{\lambda,ground}$ snow-free ground reflectance
 $\rho_{\lambda,forest}$ forest canopy reflectance
 \hat{t}_{λ} forest canopy transmissivity for unit area
 FSC fraction of snow covered area



NH FSC (NPP Suomi/VIIRS)- Specifications

Parameter	Pan European Snow Extent Service
Thematic variable	Snow Extent / Fractional Snow Extent
Thematic resolution	1 % of snow cover fraction (FSC)
Thematic range	0 to 100 % Snow cover per pixel
Thematic accuracy	20 % (RMSE of FSC)
Spatial coverage	Northern Hemisphere
Delivery time period	Full Year
Temporal frequency	Daily and weekly (merged daily)
Latency Time	<24 hours
Spatial resolution	500m (using S3)
Geometric accuracy	< 1 pixel
Projection/Datum	Geographical Lat-Lon / WGS 84
Sensor	Terra/MODIS NPP Suomi/VIIRS, (transition to Sentinel-3)
File format	GeoTiff
Processing	Sodankylä, FMI

Validation datasets: SYKE snow courses and FMI weather stations

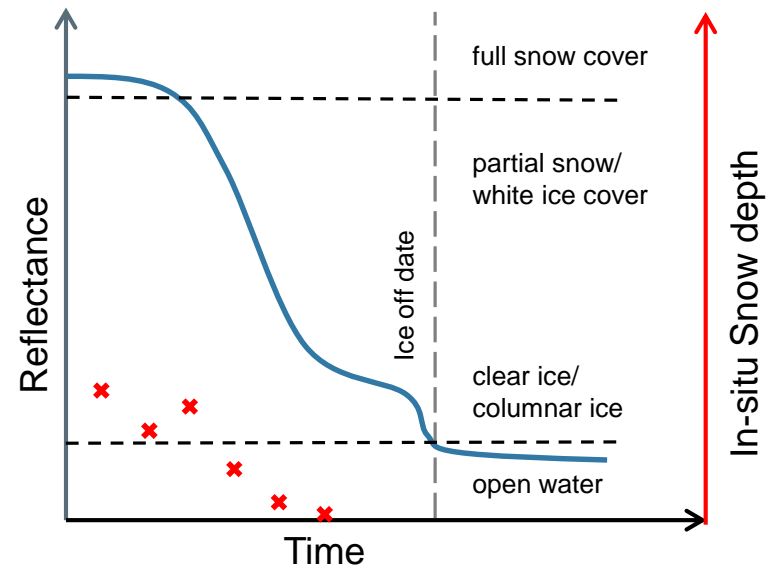


Validation results of the algorithm for 2003-2010 with ENVISAT/AATSR and Terra/MODIS data

- Validation against SYKE snow courses (direct comparison):
 - Too few observation pairs for AATSR-data
 - RMSE of 0.11 for SCAMod applied to Terra/MODIS (snow 0-1)
- Validation against Finnish weather station data with four categories for snow coverage (100%, 51-99%, 1-50%, 0%):
Overall accuracy
 - 65.1% for SCAMod applied to AATSR
 - 65.9% for SCAMod applied to MODIS
- The omission error for presence of snow – full or partial
 - 16.0% for $SCAMod_{AATSR}$,
 - 12.8% for $SCAMod_{MODIS}$

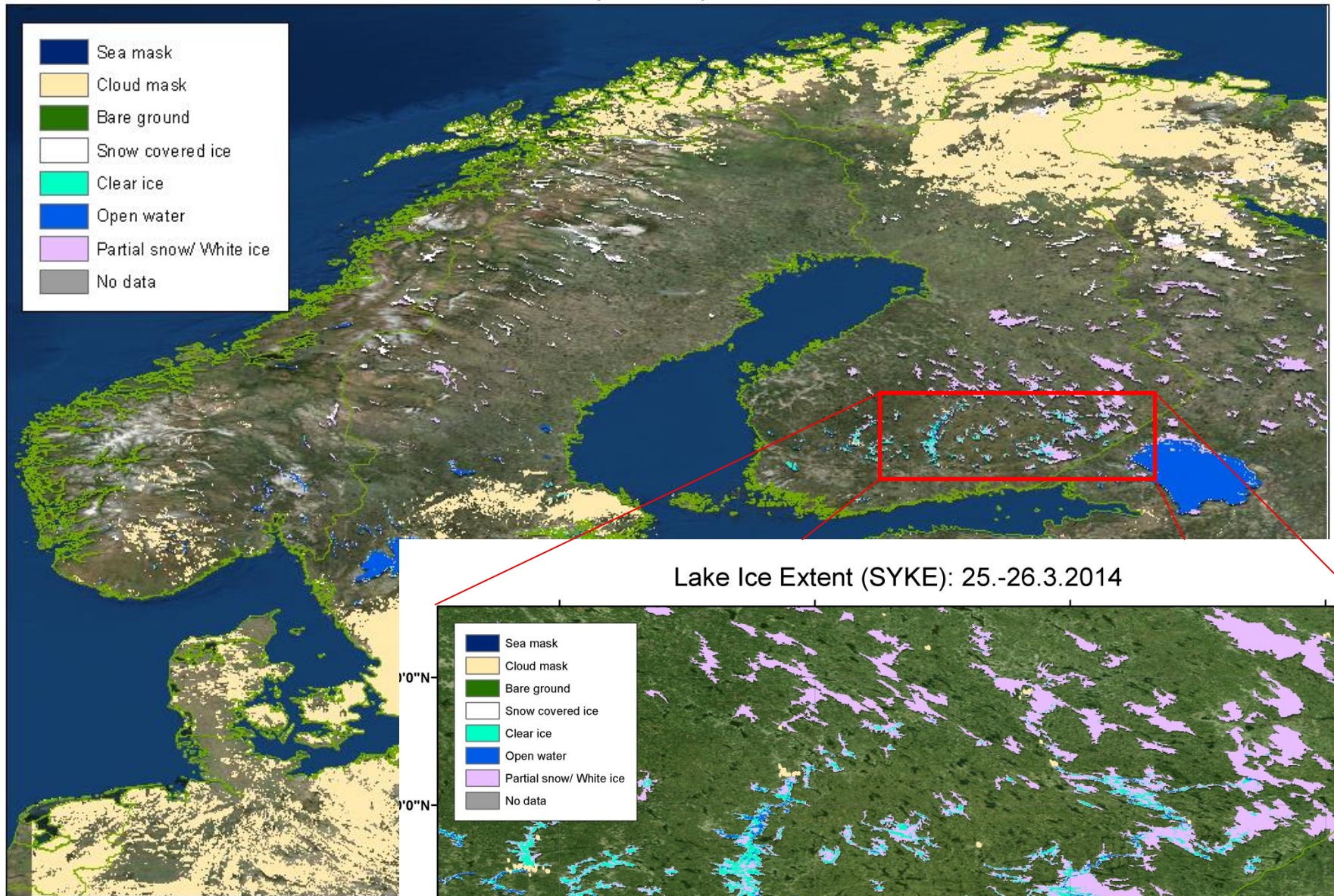
Lake Ice Extent

- Three class classification:
 - 1) Fully snow covered ice
 - 2) Partial snow/white ice cover
 - 3) Open water

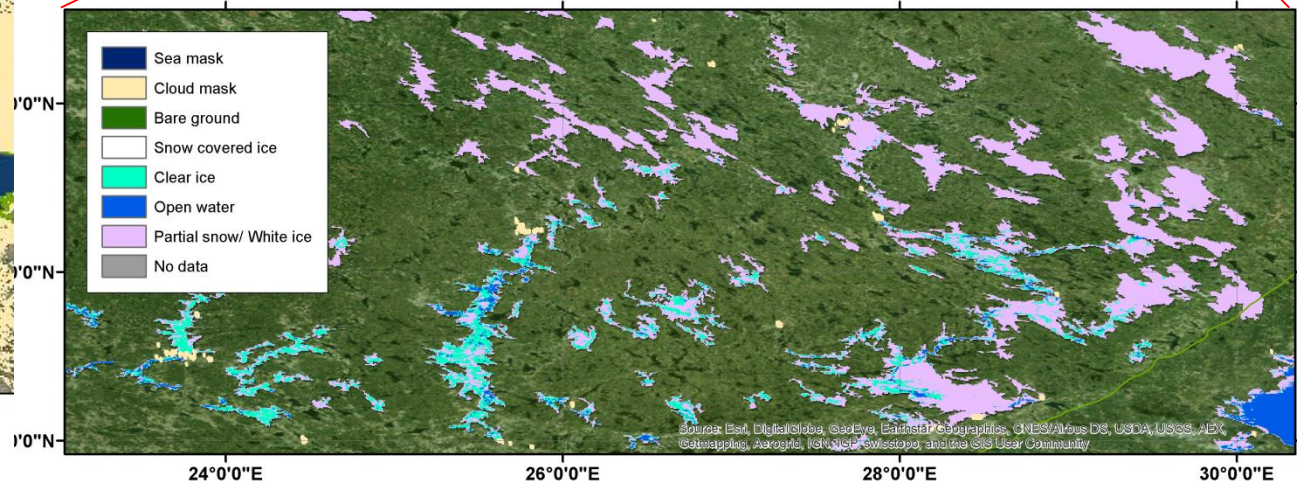


- Simple reference reflectance algorithm
 - Reference reflectances based on comparing in-situ measurements of snow depth on ice and ice phenology observations
- Easily transferred to different instruments
 - Sentinel-3
 - Sentinel-2: Missing the possibility of automated cloud masking in winter
- Hindered by clouds and polar night
- Cloud screening with SYKE developed cloud algorithm SCDA 2.0

Lake Ice Extent (SYKE): 25.-26.3.2014



Lake Ice Extent (SYKE): 25.-26.3.2014



Lake Ice Extent – Product Specifications

Parameter	Specification
Thematic variable	Lake Ice Extent
Thematic resolution	Three classes: 1) Full snow cover 2) Partial snow/white ice; Clear ice 3) Open water
Thematic range	see above
Thematic accuracy	Overall classification accuracy: 75%
Spatial coverage	Northern-Europe [72°N / 11°W to 35°N / 50°E] (can be extended to NH)
Delivery time period	Spring (Feb-Jun)
Temporal frequency	Daily
Latency time	<24 hours
Spatial resolution	300m (possibility for S-2 accuracy, but limited due to cloud detection difficulties)
Geometric accuracy	< 1 pixel
Projection/Datum	Geographical Latitude – Longitude / WGS 84
Sensor	Terra/MODIS
File format	Geotiff
Processing	Sodankylä, FMI

Lake Ice Extent –Validation

In-situ dataset	Freezing and breakup	Ice thickness and snow on ice thickness
Coverage	Finland	Finland
Unit	Date	cm
Accuracy	±1 day	±1 cm
Observation interval	Daily observations	3 per month (10th, 20th and 30th)
Areal extent	Entire observation period: 122 sites (changing network)	Entire observation period: 161 sites (changing network)
Temporal coverage	1753–2015	1912–2015

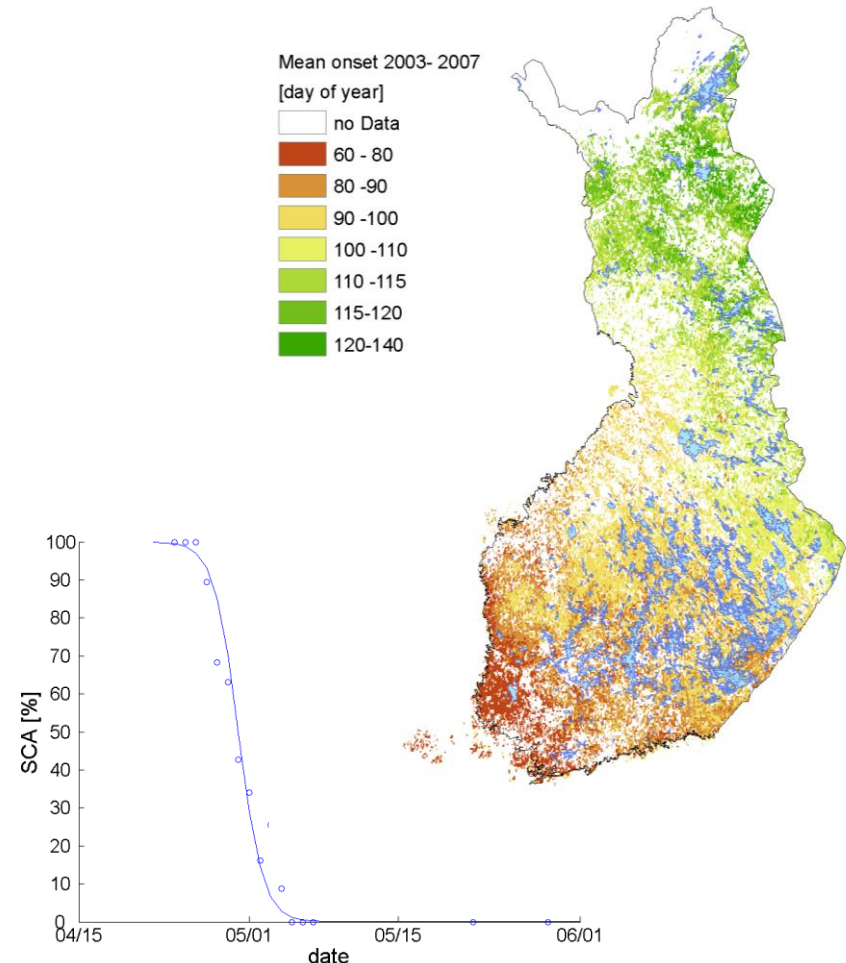
- Validation requires long time-series (to produce enough matchups)
- Validation of the methodology will be done initially with MODIS/VIIRS data
- Validation of Sentinel-3 based product can be done using HR and VHR imagery
 - Large NH Landsat –archive with SnowPEX -project
- Initial validation against operator interpreted HR (SPOT-4) imagery produced over all accuracy of: 74%

FSC and Lake Ice processing

- FMI runs the pre-processing module in NSDC-Sodankylä
 - TOA Reflectances
 - Cloud Masks
- SYKE controlled FSC and Lake Ice processes take the input from the same pre-processing chain

Phenology product

- The growing season for vegetation from satellite datasets:
 - Using time-series of environmental variables/indicators (FSC, NDVI, NDWI)
 - Start of growing season for coniferous and deciduous forests
 - *(End of growing season for coniferous and deciduous forests)*
 - *(Length of growing season)*
- Currently research oriented
- ➔ Development towards more operational status
- Available on request



Thank you for your attention.



Transmissivity is determined from reflectance observations when FSC=1 (100% snow cover)

$$\rho_{\lambda,obs}(FSC) = (1-t_{\lambda}^2) * \rho_{\lambda,forest} + t_{\lambda}^2 * [FSC * \rho_{\lambda,snow} + (1-FSC) * \rho_{\lambda,ground}] ,$$



$$t_{\lambda}^2 = \frac{\rho_{\lambda}(FSC = 1) - \rho_{\lambda,forest}}{\rho_{\lambda,snow} - \rho_{\lambda,forest}}$$

Transmissivity determined from MODIS band4 (550nm) reflectance data for several training areas → average class-wise transmissivities gained

