H SAF Snow Products, Quality Assessment and Case Studies

Zuhal Akyurek [(1)], Ali Nadir Arslan [(2)], Francesco Avanzi [(3)], Simone Gabellani [(3)], Cagri Karaman [(1)], Semih Kuter [(4)], Niilo Siljamo [(2)], Burak Simsek [(2)], Matias Takala [(2)], Cemal Melih Tanis [(2)], Alexander Toniazzo [(5)] ***

(1) Middle East Technical University, Turkey

(2) Finnish Meteorological Institute, Finland

(3) CIMA Research Foundation, Italy

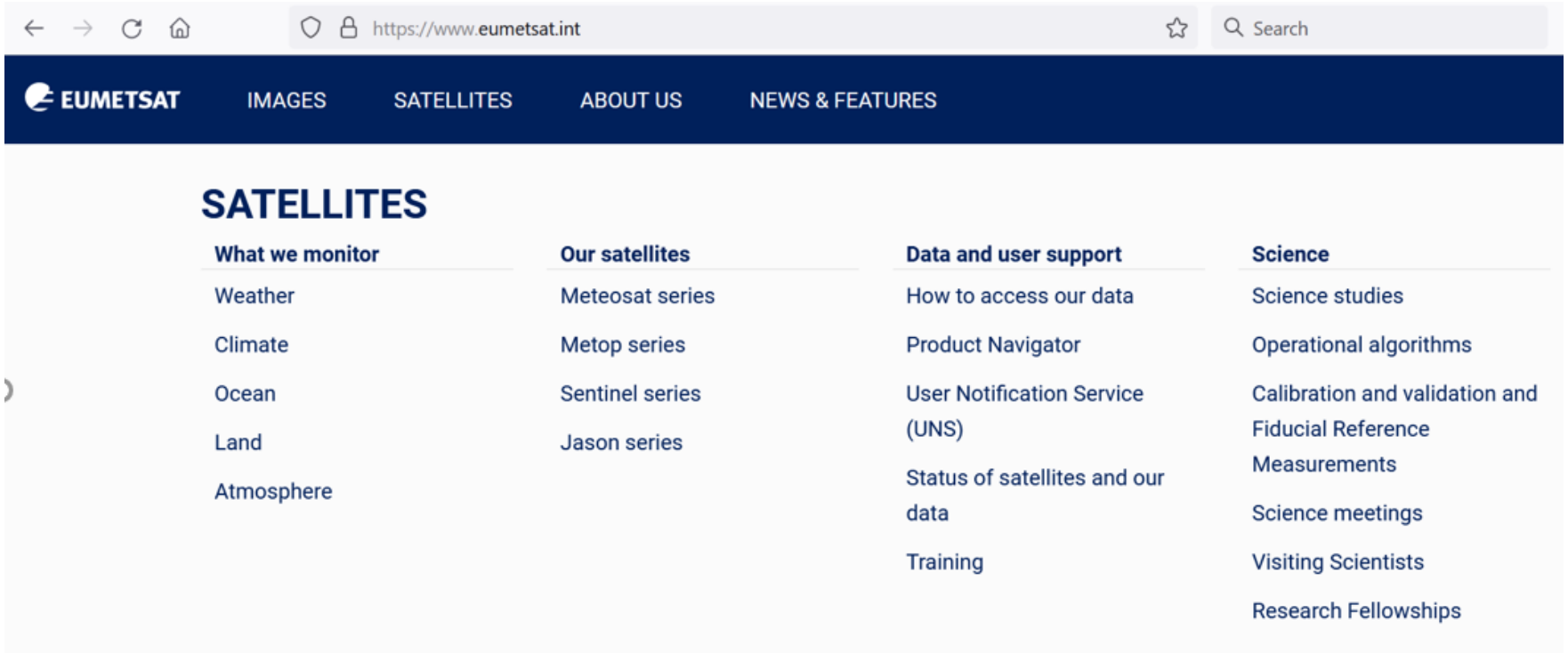
(4) Cankiri Karatekin University, Turkey

(5) Department of Civil Protection, Italy

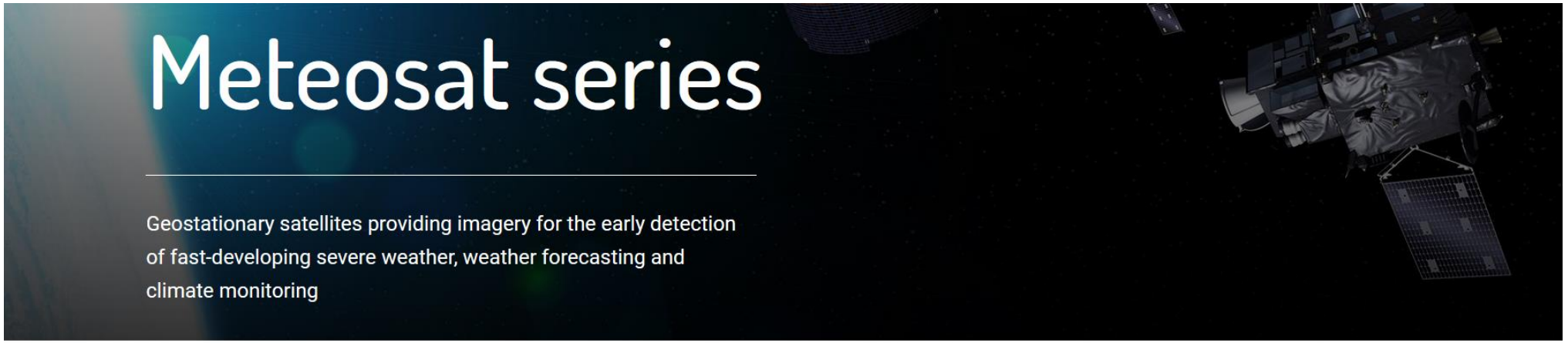
Presented by
Ali Nadir Arslan, Zuhal Akyurek and Alexander Toniazzo

EUMETSAT Satellites

European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)



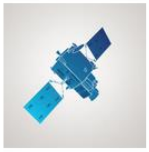
EUMETSAT Satellites



Meteosat geostationary satellite series

Meteosat Second Generation

Current operational geostationary satellite data.



Meteosat Third Generation

Next generation evolution of imaging and sounding data.

Meteosat First Generation (retired)

Historical geostationary satellite data from 1977 to 2017.

EUMETSAT Satellites

CURRENT SATELLITES

Meteosat-11

Lifetime: 15/07/2015 – 2033
Position: 0° 36,000 km
Services: **0° Service** including **Data Collection Service** and **Web Imagery**. Replaced Meteosat-10 at 0° on 20 February 2018.

Meteosat-10

Lifetime: 05/07/2012 – 2030
Position: 9.5°E 36,000 km
Services: **Rapid Scanning Service**. Replaced Meteosat-9 RSS on 20 March 2018.

Meteosat-9

Lifetime: 22/12/2005– 2025
Position: 3.5° E 36,000 km
Services: **Rapid Scanning Service** gap filling and back-up spacecraft since 20 March 2018.

Meteosat-8

Lifetime: 28/08/2002 – 2022
Position: 41.5° E 36,000 km
Services: **Indian Ocean Data Coverage Service**, including **Data Collection Service** and **Web Imagery**. Replaced Meteosat-7 on 01 February 2017.

FUTURE SATELLITES

MTG I1

Planned launch date: Late 2022
Details: Imaging (FCI, LI, DCS, GEOSAR)

MTG S1

Planned launch date: Early 2024
Details: Sounding (IRS, UVN)

MTG I2

Planned launch date: 2025
Details: Imaging (FCI, LI)

MTG I3

Planned launch date: Around 10 years after MTG-I1
Details: Imaging (FCI, LI)

MTG S2

Planned launch date: Around 10 years after MTG-S1
Details: Sounding (IRS, UVN)

MTG I4

Planned launch date: Around 10 years after MTG-I3
Details: Imaging (FCI, LI)

EUMETSAT Satellites

Metop series

Polar-orbiting satellites providing global data for weather forecasts up to 10 days and climate monitoring

Metop satellites series

Metop

Metop-B and C are a series of polar orbiting meteorological satellites.

Metop - Second Generation

Metop-SG is EUMETSAT's next generation of polar-orbiting satellites.

EUMETSAT Satellites

CURRENT SATELLITES

Metop-B

Lifetime: From 17/09/2012
Position: Low Earth Orbit
Services: Global Data Service, Regional Data Service, Direct Readout Service, Real-time imagery.

Metop-C

Lifetime: From 07/11/2018
Position: Low Earth Orbit
Services: Global Data Service, Regional Data Service, Direct Readout Service, Real-time imagery.

FUTURE SATELLITES

Metop-SG A1

Planned Launch date: Q2 2024
Details: 823–848 km, Sounding and Optical Imaging, METimage, IASI-NG, MWS, Sentinel-5, 3MI, RO

Metop-SG B1

Planned Launch date: Q4 2024
Details: 823–848 km, Microwave imaging and sounding, SCA, MWI, ICI, RO, ADCS-4

Metop-SG A2

Planned Launch date: 2031
Details: 823–848 km, Sounding and Optical Imaging, METimage, IASI-NG, MWS, Sentinel-5, 3MI, RO

Metop-SG B2

Planned Launch date: 2032
Details: 823–848 km, Microwave imaging and sounding, SCA, MWI, ICI, RO, ADCS-4

Metop-SG A3

Planned Launch date: 2038
Details: 823–848 km, Sounding and Optical Imaging, METimage, IASI-NG, MWS, Sentinel-5, 3MI, RO

Metop-SG B3

Planned Launch date: 2039
Details: 823-848 km, Microwave imaging and sounding, SCA, MWI, ICI, RO, ADCS-4

EUMETSAT Satellites

Sentinel satellite series

Sentinel-3

Dedicated Copernicus satellite mission delivering a variety of high-quality ocean measurements.

Sentinel-4

Copernicus Sentinel-4 will monitor key air quality trace gases and aerosols over Europe at high spatial resolution.

Sentinel-5

Copernicus Sentinel-5 will be the polar-orbiting atmospheric monitoring mission.

Sentinel-6

The Sentinel-6 Michael Freilich radar altimeter mission provides high-precision measurements of global sea-level.

EUMETSAT Satellites

Jason series

Satellite providing global sea surface height observations for climate monitoring and ocean and seasonal forecasts

Jason satellite series

Jason-3

Jason-3 altimeter data is used by the Copernicus Marine Environment Monitoring Service (CMEMS).

Sentinel-6

The Sentinel-6 Michael Freilich radar altimeter mission provides high-precision measurements of global sea-level.

EUMETSAT Satellites

SEVIRI is the main MSG payload and produces 12 channels imaging in visible and IR range.
Normally the SEVIRI instrument onboard the MSG satellites scan the full earth disc every 15 minutes.
Rapid scanning scans a third of the earth disc the every five minutes

The Flexible Combined Imager (FCI), on the MTG, measures in 16 channels in the visible and infrared spectrum

The nominal coverage of the prime MSG service — the geostationary service from the MSG satellite located at 0 degrees longitude — includes the whole of Europe, the Atlantic Ocean, all of Africa and at locations where the elevation to the satellite is greater than or equal to 10°.

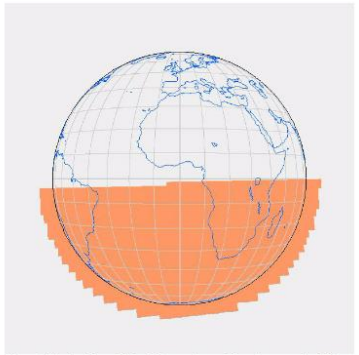


Figure 1: Animation of the FCI scanning pattern in support of the full disc scanning service (FDSS)

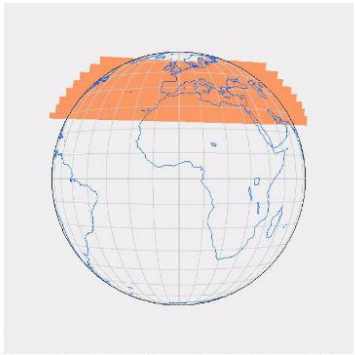


Figure 2: Animation of the FCI scanning pattern in support of the rapid scanning service (RSS)

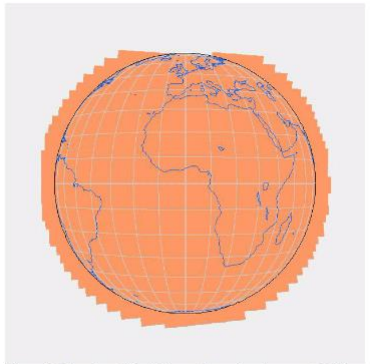


Figure 1: Animation of the FCI scanning pattern in support of the full disc scanning service (FDSS)

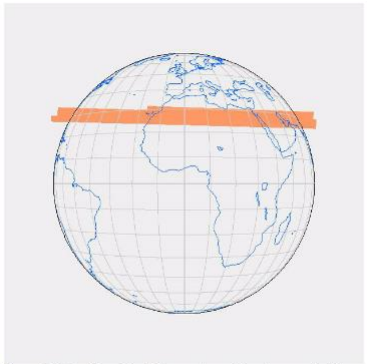


Figure 2: Animation of the FCI scanning pattern in support of the rapid scanning service (RSS)

EUMETSAT Satellites

Metop: The Advanced Very High Resolution Radiometer (AVHRR) multi-purpose imaging instrument

Metop-SG: METimage is a multi-spectral (visible and IR) imaging passive radiometer

Metop-SG: METimage will provide continuity to the AVHRR

Metop-SG: The Microwave Imager (MWI) is a conically scanning radiometer, capable of measuring thermal radiance emitted by the Earth, at high spatial resolution in the microwave region of the electromagnetic spectrum.

Snow Products

Product Identification			Product Requirements					
Product ID	Product Name	Product Acronym	Type	Operational Satellite Input Data	Other Operational Input Data	Characteristics and Methods	Dissemination Means	Dissemination Format
SNOW								
H10	Snow extent (snow mask) by VIS/IR radiometry	SE-E-SEVIRI	NRT	SEVIRI on MSG	Geostationary Nowcasting Cloud Mask and Type (MSG), GNWCCT, GNWCCMa	Multichannel (VIS, NIR, IR) analysis, European Domain	FTP - EUMETCast	HDF5
H12	Effective snow cover by VIS/IR radiometry	E SC-E	NRT	AVHRR on Metop		Multichannel (VIS, NIR, IR) analysis, European Domain	FTP - EUMETCast	GRIB
H31	Snow extent for flat land (snow mask) by VIS/NIR of SEVIRI	SE-D-SEVIRI-F	NRT	SEVIRI on MSG		Multichannel (VIS, NIR, IR) analysis	FTP - EUMETCast	HDF5
H32	Snow extent for flat land (snow mask) by VIS/NIR of AVHRR	SE-G-AVHRR	NRT	AVHRR on Metop, and AVHRR on NOAA, if feasible		Multichannel (VIS, NIR, IR) analysis	FTP - EUMETCast	HDF5
H34	Snow extent (snow mask) by VIS/IR radiometry	SE-D-SEVIRI	NRT	SEVIRI on MSG	Geostationary Nowcasting Cloud Mask and Type (MSG), GNWCCT, GNWCCMa	Multichannel (VIS, NIR, IR) analysis, Full Disc	FTP - EUMETCast	HDF5
H35	Effective snow cover by VIS/IR radiometry	ESC-H	NRT	AVHRR on Metop		Multichannel (VIS, NIR, IR) analysis, Northern Hemisphere	FTP - EUMETCast	GRIB
H43	Snow extent (snow mask) by VIS/NIR of MTG FCI	SE-D-FCI	NRT	FCI on MTG		Multichannel (VIS, NIR, IR) analysis, Full Disc	FTP - EUMETCast	NetCDF
H11	Snow status (dry/wet) by MW radiometry	WS-E	NRT	SSMI/S on DMSP F17, F18. AMSR-2 on GCOM-W1 (at SSMI/S end of life) GMI on GPM (spare)	H10 (SE-E-SEVIRI)	Multichannel (MW) analysis, European Domain	FTP - EUMETCast	GRIB
H13	Snow water equivalent by MW radiometry	SWE-E	NRT	SSMI/S on DMSP F17, F18.		Multichannel (MW) analysis, European Domain	FTP- EUMETCast	GRIB

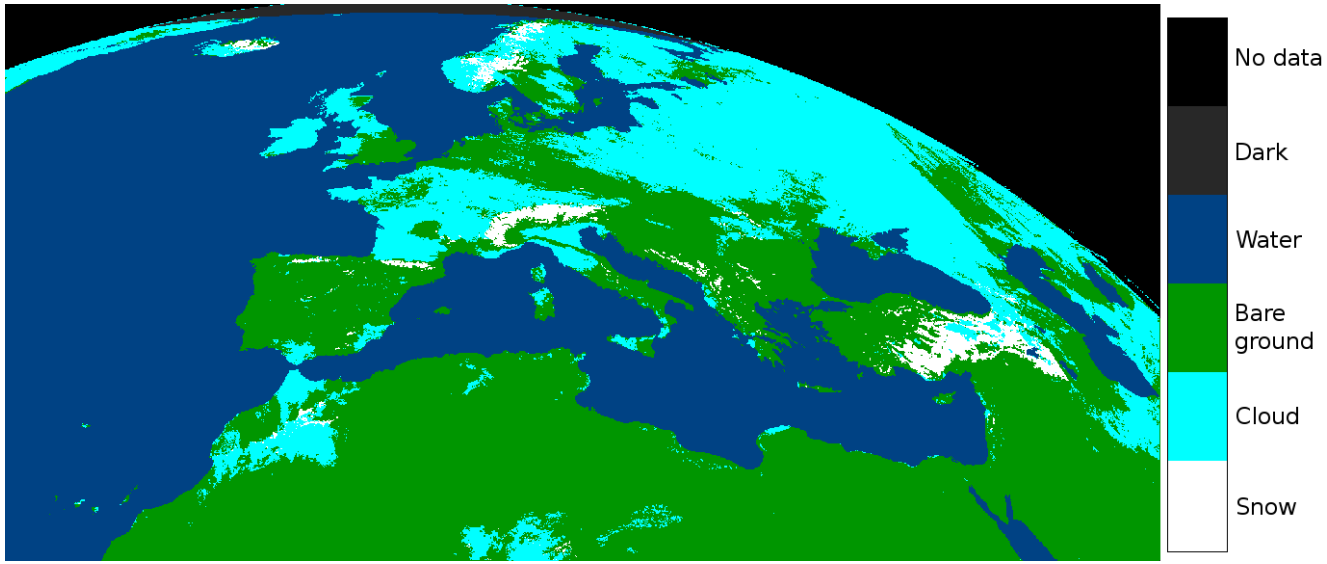
Snow Products

Product Identification			Product Requirements					
Product ID	Product Name	Product Acronym	Type	Operational Satellite Input Data	Other Operational Input Data	Characteristics and Methods	Dissemination Means	Dissemination Format
H65	New Global (hemispherical) SWE 25 km resolution	SWE-H	NRT	SSMI/S on DMSP F17, F18.		Multichannel (MW) analysis, Northern Hemisphere	FTP- EUMETCast	NetCDF
H85	Snow extent (snow mask) by EPS-SG	SE-G-EPS-SG	NRT	METimage on Metop-SG		Multichannel (VIS, NIR, IR) analysis	FTP - EUMETCast	NetCDF
H86	ESC-G-MI Effective Snow Cover by EPS-SG	ESC-H-EPS-SG	NRT	METimage on Metop-SG		Multichannel (VIS, NIR, IR) analysis, Northern Hemisphere	FTP - EUMETCast	NetCDF
H66	SWE Northern Hemisphere by microwave radiometer	LEO/GEO day-2 NRT SWE-PE	NRT	SSMI/S on DMSP F17, F18.		Multichannel (MW) analysis, European Domain, 5km resolution	FTP - EUMETCast	NetCDF
H243	Snow extent (snow mask) by VIS/NIR of MTG FCI	SE-D-FCI	NRT	FCI on MTG		Multichannel (VIS, NIR, IR) analysis, Full Disc	FTP - EUMETCast	NetCDF
H285	Snow extent (snow mask) by EPS-SG	SE-G-EPS-SG	NRT	METimage on Metop-SG		Multichannel (VIS, NIR, IR) analysis	FTP - EUMETCast	NetCDF
H665	New Global (hemispherical) SWE 25 km resolution	SWE-H	NRT	MWI		Multichannel (MW) analysis, Northern Hemisphere	FTP- EUMETCast	NetCDF
H666	SWE Northern Hemisphere by microwave radiometer	LEO/GEO day-2 NRT SWE-PE	NRT	MWI		Multichannel (MW) analysis, European Domain, 5km resolution	FTP - EUMETCast	NetCDF

H10 Snow extent by VIS/IR radiometry

- Geostationary orbit MSG/SEVIRI
- Daily Operational
- HSAF Pan-European Area product
- Snow/Land/cloud/water
- 0.05 degrees lat/lon grid
- Available since December 2008
- Validation with ground observations and Sentinel data continues
- It will be superseded by H34

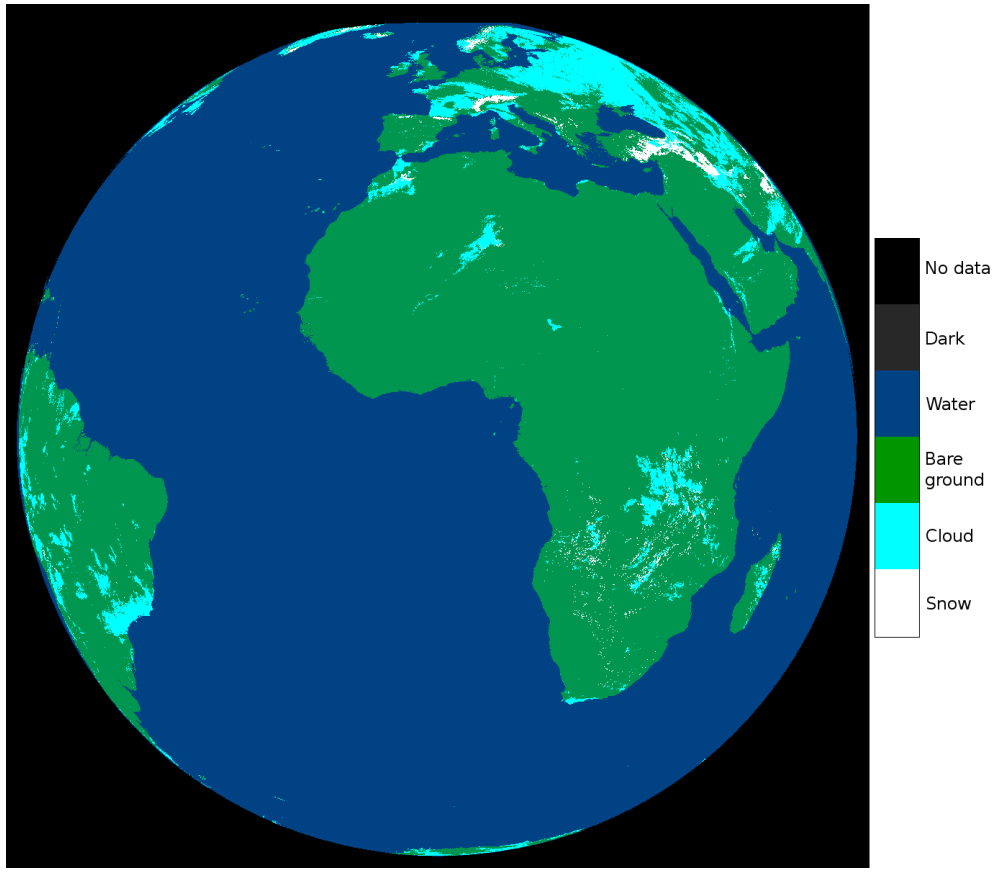
H10 Snow extent by VIS/IR radiometry 30 January 2018



H34 Snow extent by VIS/IR radiometry

- Geostationary orbit
- Daily Pre-Operational
- Full MSG/SEVIRI disk product
- Snow/Land/cloud/water
- 0.05 degrees lat/lon grid
- Available since December 2017
- Validation with ground observations and Sentinel data continues

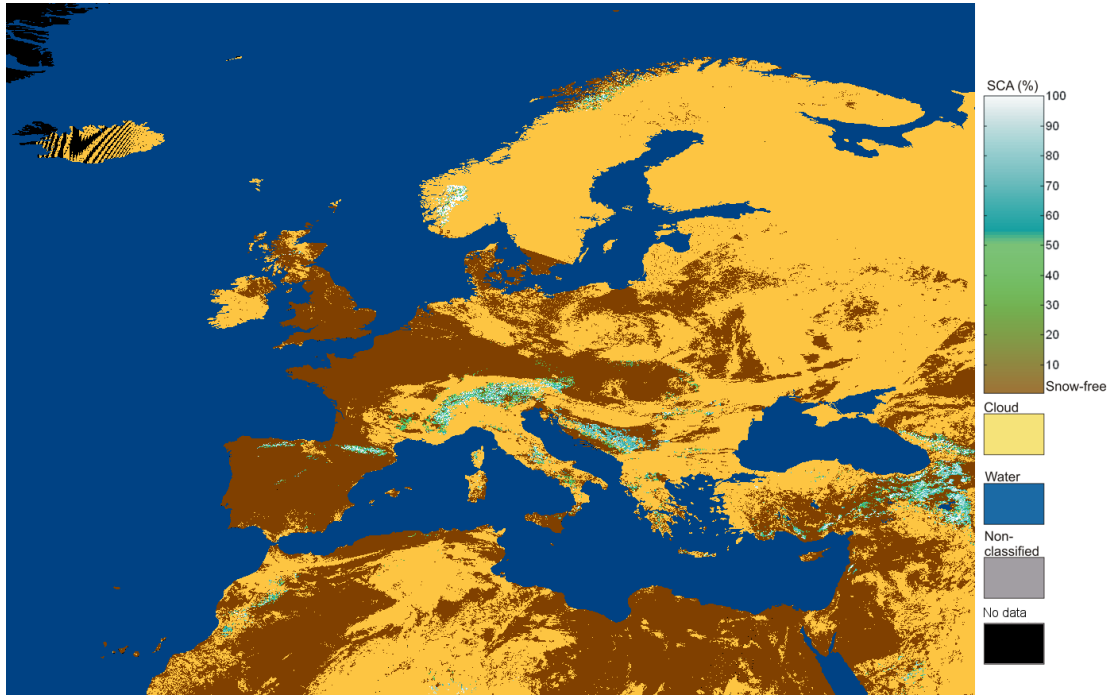
H34 Snow extent by VIS/IR radiometry 30 January 2018



H12 Effective Snow cover by VIS/IR radiometry

- Polar orbit METOP-AVHRR
- Daiy Operational
- Pan-European Area product
- Effective Snow Cover/Land/cloud/water/unclassified
- 0.01 degrees lat/lon grid
- Available since March 2008
- Validation with Sentinel data continues
- It will be superseded by H35

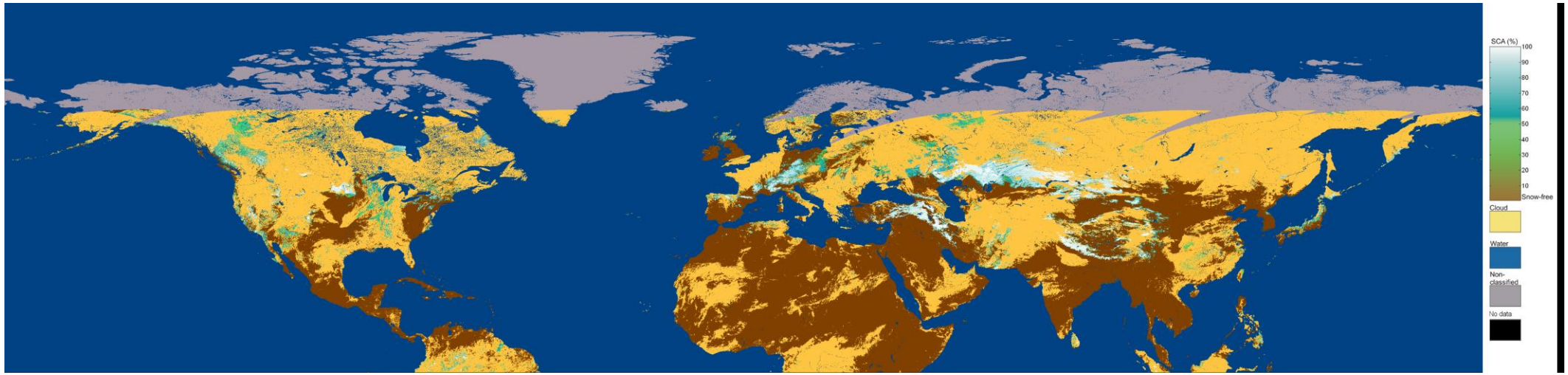
H12 Effective Snow cover by VIS/IR radiometry 24 Feb 2018



H35 Effective Snow cover by VIS/IR radiometry

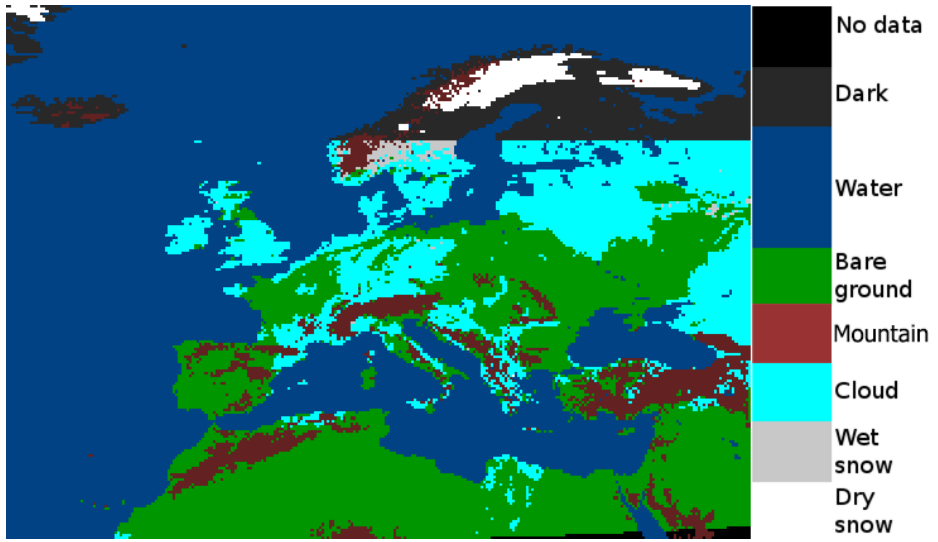
- Polar orbit METOP-AVHRR
- Daily Pre-Operational, Available since March 2018
- Daily Northern Hemisphere product
- Effective Snow Cover/Land/cloud/water/unclassified
- 0.01 degrees lat/lon grid
- Validation with Sentinel data continues

H35 Effective Snow cover by VIS/IR radiometry 4 Feb 2019



H11 (WS-E) Snow status (dry/wet) by MW radiometry

- Polar orbit microwave data on top of geostationary optical product
- H10 and microwave data (SSMI/S) as input
- HSAF Pan-European Area Flat Regions
- 0.25 degrees lat/lon grid
- Dry snow / Wet snow / Bare land / Cloud / Dark / Water / Nodata
- Able to detect snow presence under clouds and polar darkness (only if the snow is dry)
- Available since 2012
- Updated and operational since 2018
- Validation with ground observations continues

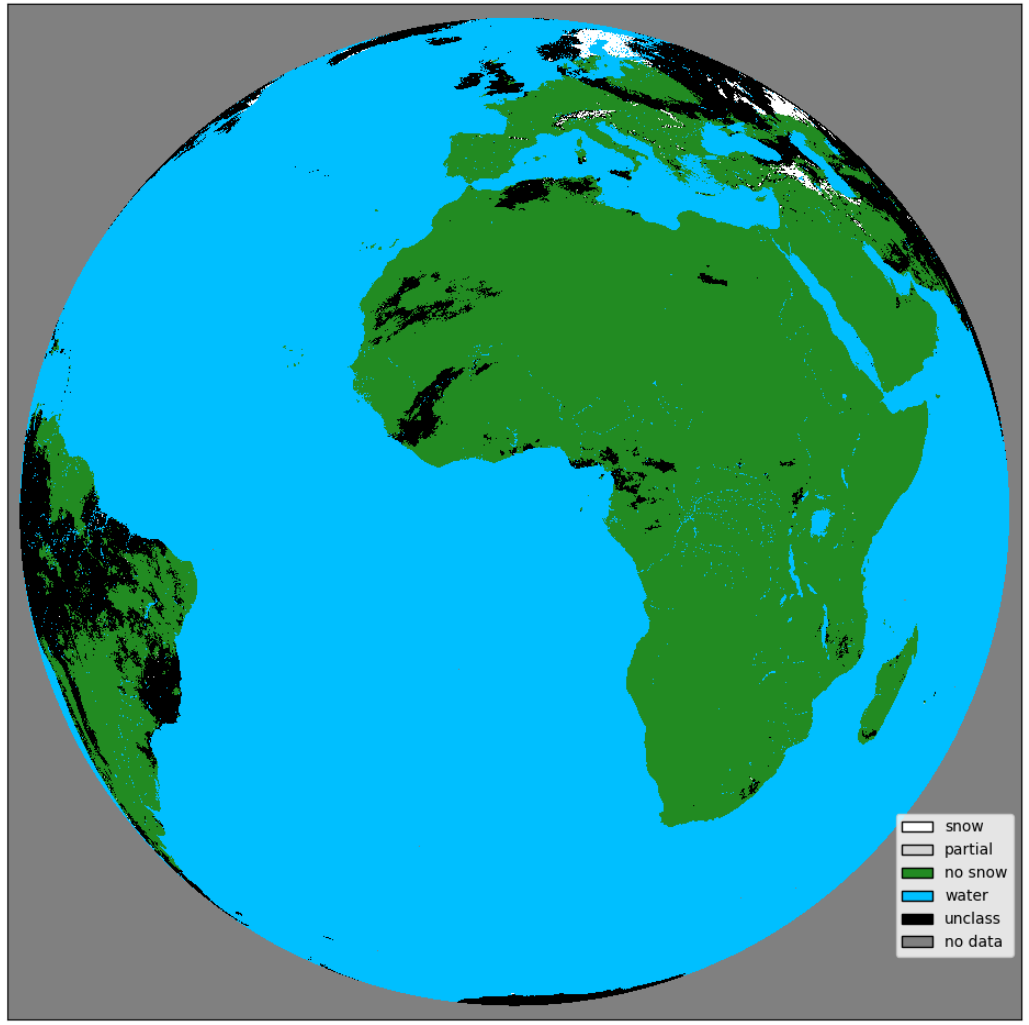


10.11.2021

H31 (MSG/SEVIRI) Snow Extent

- Geostationary orbit
- Operational
- Daily full MSG/SEVIRI disk product
- Especially for flatland areas
- No snow/snow/partial snow/water/unclassified
- available since 2008
- Excellent validation results vs weather station observations
- See: Siljamo, N., & Hyvärinen, O. (2011). New Geostationary Satellite–Based Snow-Cover Algorithm, Journal of Applied Meteorology and Climatology, 50(6), 1275-1290
- Also: Siljamo, N. (2020). Empirical Approach to Satellite Snow Detection. University of Helsinki

MSG/SEVIRI snow cover 22.3.2019



H43 (MTG/FCI) Snow Extent (Day 1)

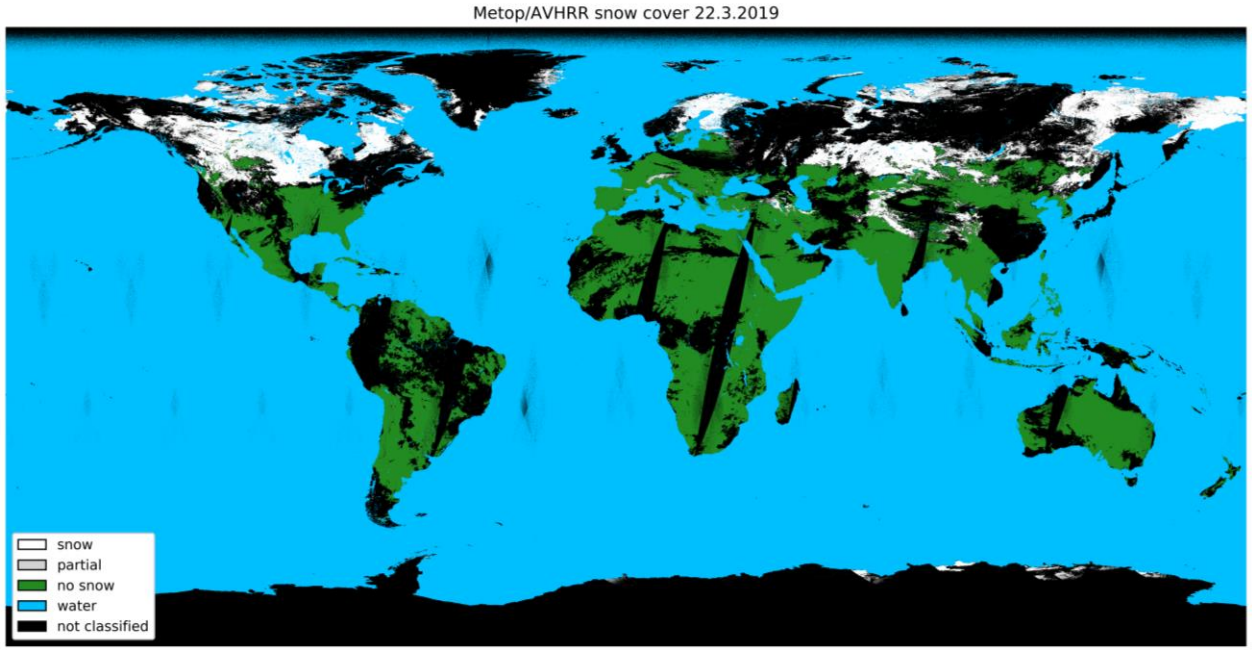
- Geostationary orbit
- In development
- Daily full MTG/FCI disk product
- Satellite grid
- Three variants (flatland/mountain/merged)
- No snow/snow/water/unclassified (clouds, darkness etc)
- Day 1 product, will be available when MTG/FCI operational

H243 (MTG/FCI) Snow Extent (Day 2)

- Geostationary orbit
- In development
- Daily full MTG/FCI disk product
- Satellite grid
- Three variants (flatland/mountain/merged)
- No snow/snow/water/unclassified (clouds, darkness etc)
- Day 2 product, algorithm development begins when actual MTG/FCI data available

H32 (Metop/AVHRR) Snow Extent

- Polar orbit
- Operational
- Daily global product (0.01x0.01 degree lat-lon)
- No snow/snow/partial snow/water/unclassified
- available since 2015
- Excellent validation results vs weather station observations
- See: Siljamo, N., Hyvärinen, O., Riihelä, A., & Suomalainen, M. (2020). MetOp/AVHRR Snow Detection Method for Meteorological Applications, Journal of Applied Meteorology and Climatology, 59(12), 2001-2019
- Also: Siljamo, N. (2020). Empirical Approach to Satellite Snow Detection. University of Helsinki



H85 (Metop-SG/METimage) Snow Extent (Day 1)

- Polar orbit
- In development
- Daily global product (0.01x0.01 degree lat-lon)
- No snow/snow/partial snow/water/unclassified
- Day 1 product, available when Metop-SG/METimage operational

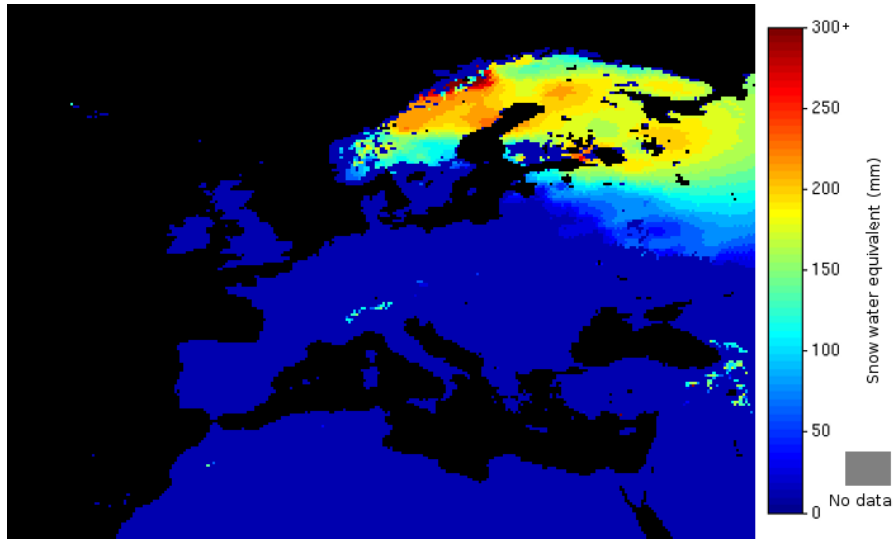
H285 (Metop-SG/METimage) Snow Extent (Day 2)

- Polar orbit
- In development
- Daily global product (0.01x0.01 degree lat-lon)
- No snow/snow/partial snow/water/unclassified
- Day 2 product, algorithm development begins when actual Metop-SG/METimage data available
- Will be based on empirical approach/machine learning

H13 Snow Water Equivalent

Cycle: Daily
Coverage: 25 ° W – 45 ° E, 25 ° N – 75 ° N
Grid/Projection: Equidistant cylindrical
Resolution: 0.25 ° x 0.25 °
Formats: gzip compressed GRIB2, PNG quicklook image

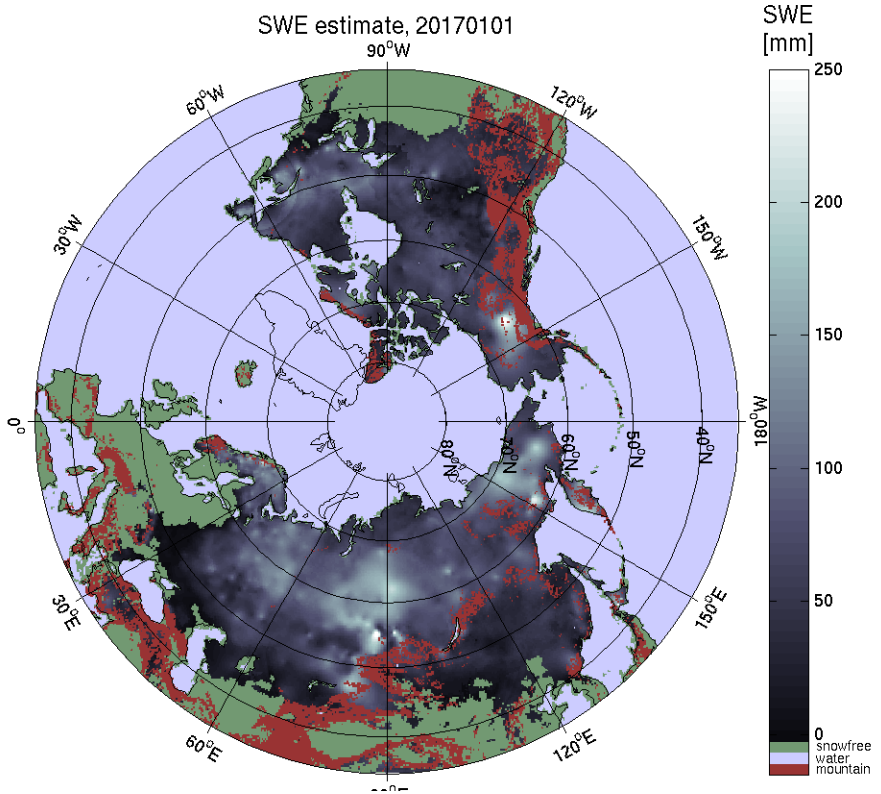
Operational status: **Operational**



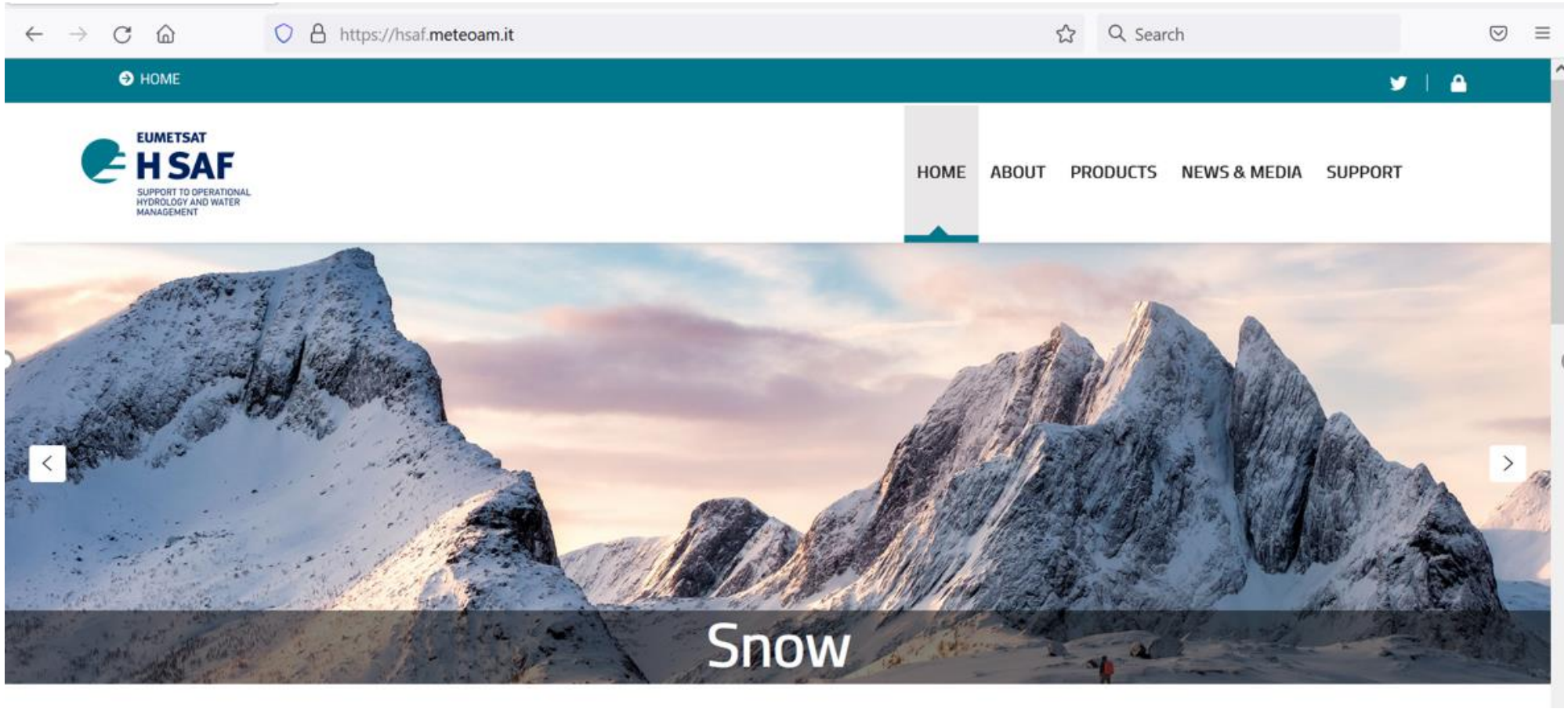
H65 Snow Water Equivalent

Cycle: Daily
Coverage: Northern Hemispherical
Grid/Projection: “EASE-Grid” - Lambert's equal-area
Resolution: 25 km x 25 km
Formats: HDF5, PNG quicklook image

Operational status: **In development**

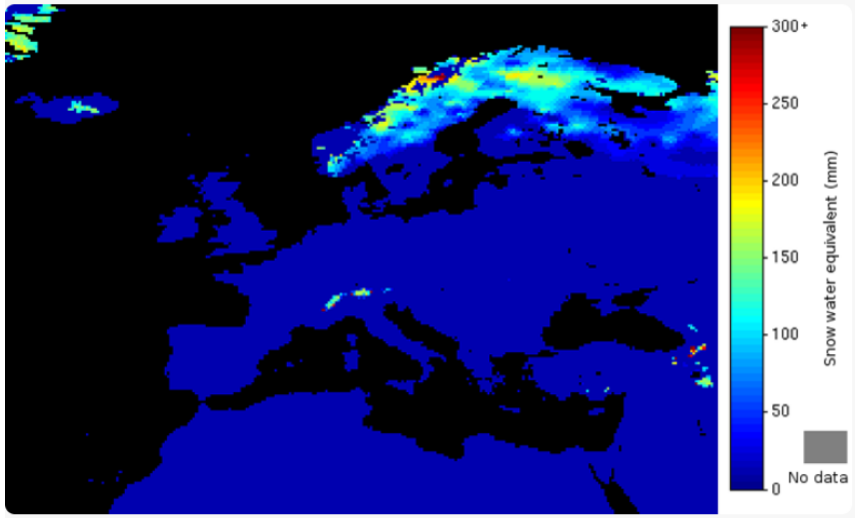


Snow Products –Detailed -Webpage



Snow Products –Detailed -Webpage

HOME / PRODUCTS / SNOW



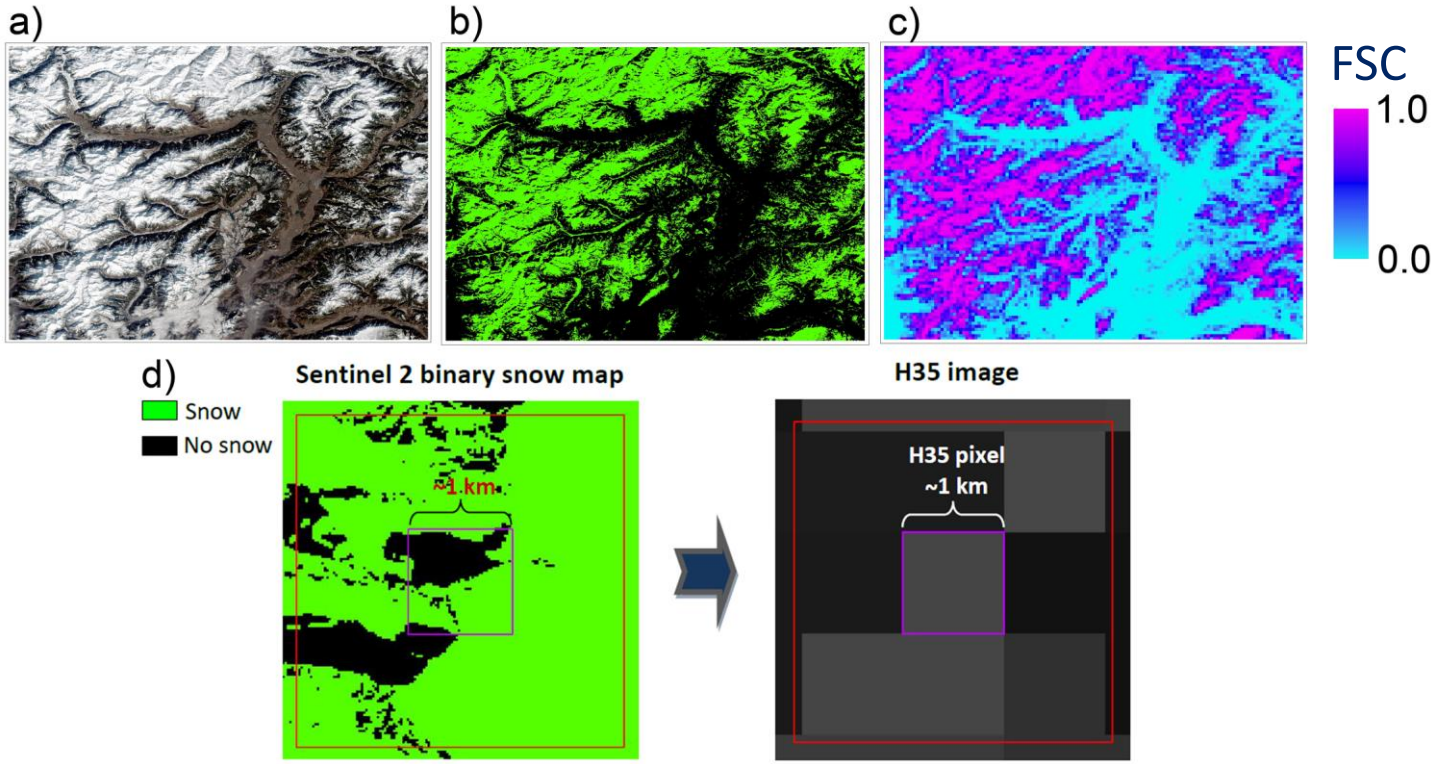
SWE-E (H13)

Maps of snow water equivalent derived from MW measurements sensitive to snow thickness and density. The algorithm is based on assimilating MW brightness temperatures of several channels at frequencies with different penetration in snow, into a first-guess field built by the (sparse) network of stations measuring snow depth.

ATBD PUM PVR

DETAIL DOWNLOAD

Reference FSC maps are generated from binary classified Sentinel-2 images at 20 m by **Sen2Cor v2.08**:



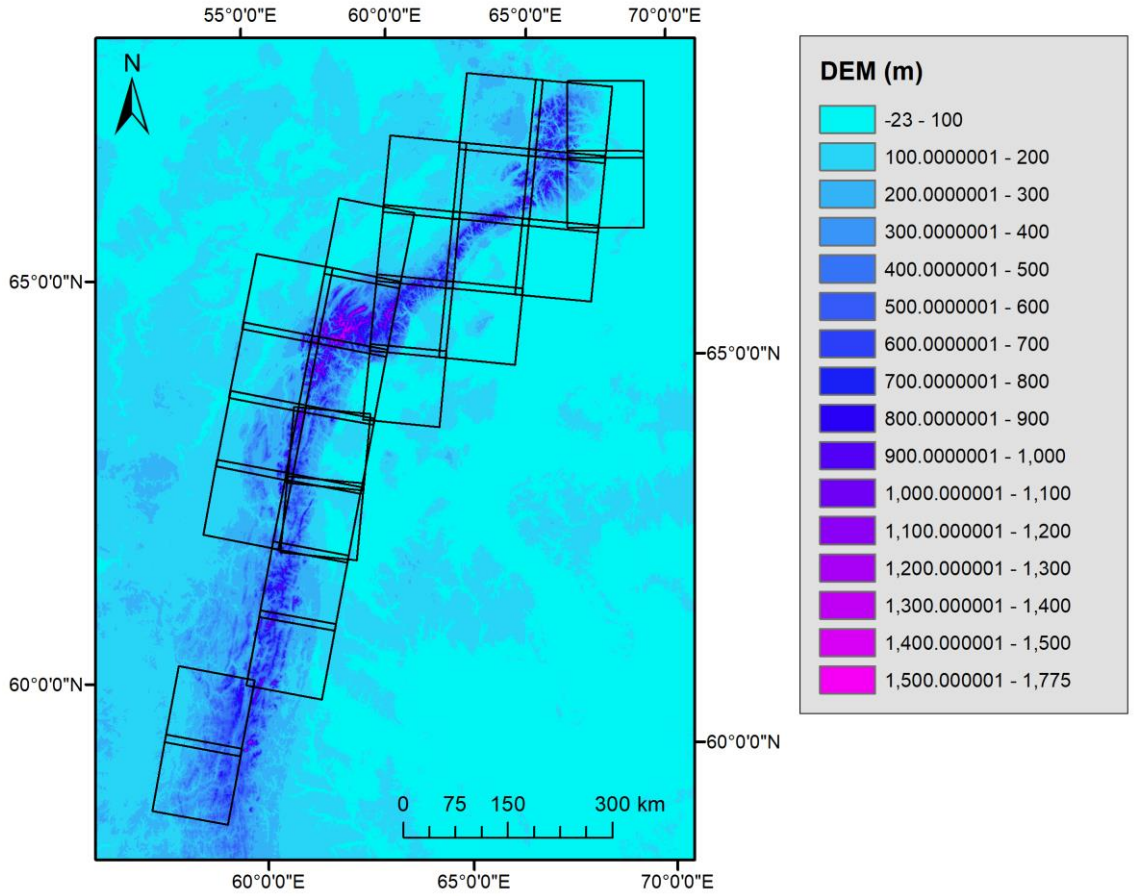
T32TPS Alps - 23 Feb 2019:
a) Sentinel 2 real color RGB image,
b) Sentinel 2 binary snow map (Snow: ▭ No snow: ▬),
c) Sentinel 2-derived reference FSC map, and
d) Calculation of reference FSC for an H35 pixel.

Predictor Variables:
AVHRR Bands 1, 2, 3a, 4, 5, NDSI and NDVI

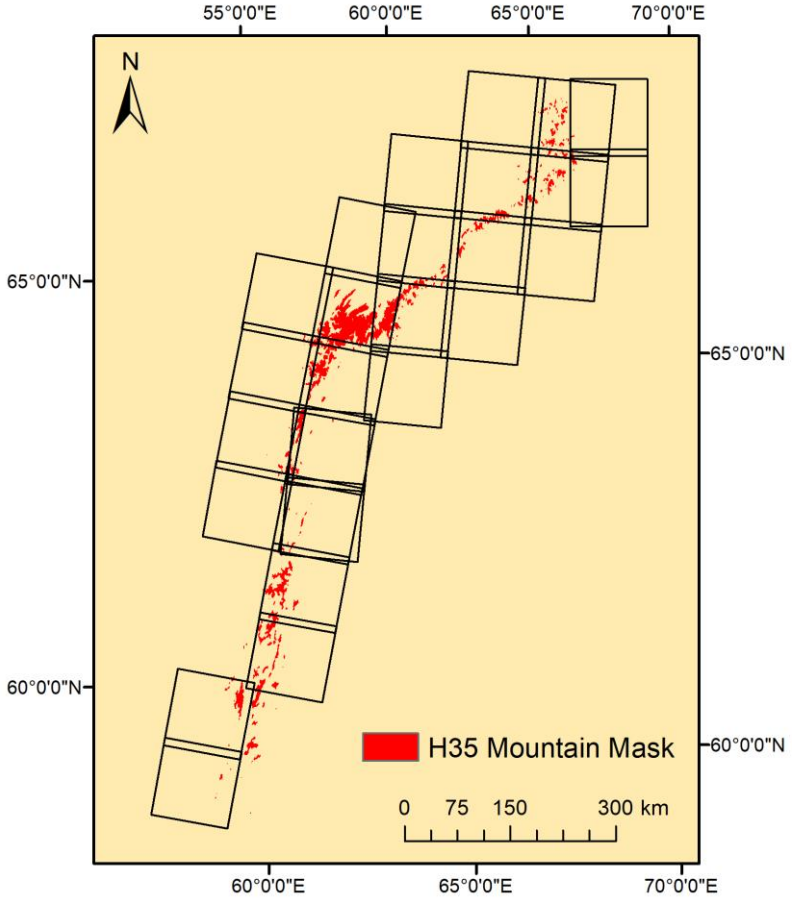
Response Variable:
FSC value

- **H35 vs. Sentinel 2 over the Ural Mountain Range for Nov 2018 - Nov 2019**

Positions of Sentinel 2 tiles and DEM



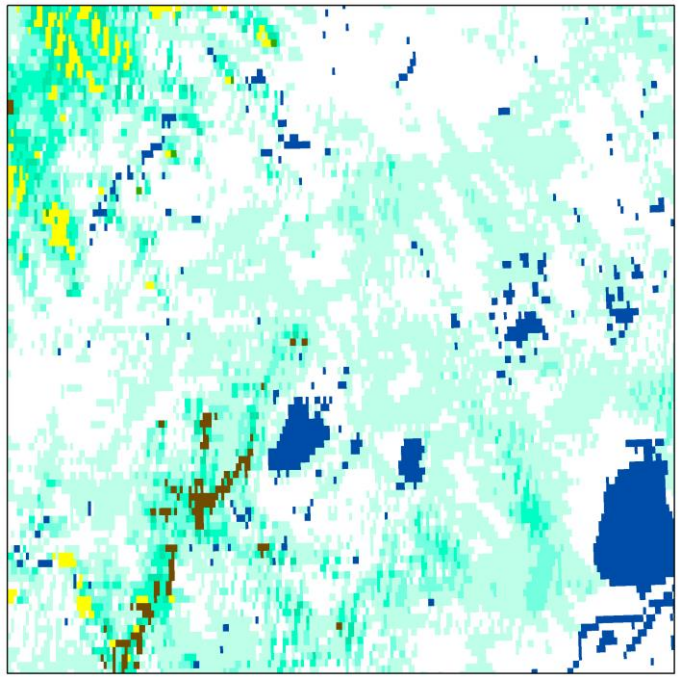
H35 Mountain Mask



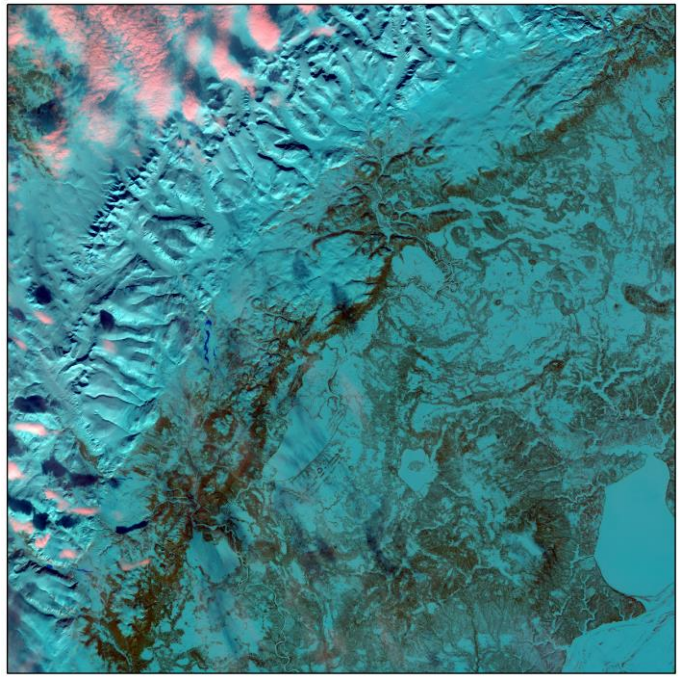
H35 vs. Sentinel 2 over the Ural Mountain Range for Nov 2018 - Nov 2019

T41WNP - 25 Mar 2019

MARS-H35

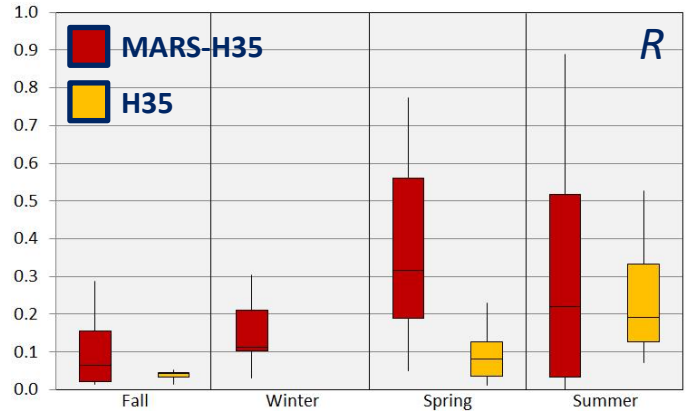


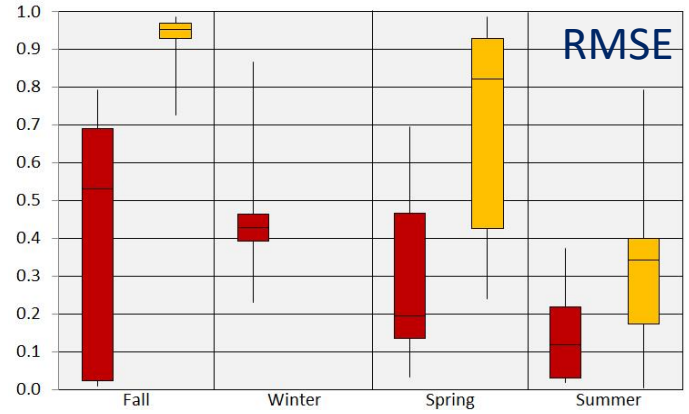
Sentinel 2 False Color RGB



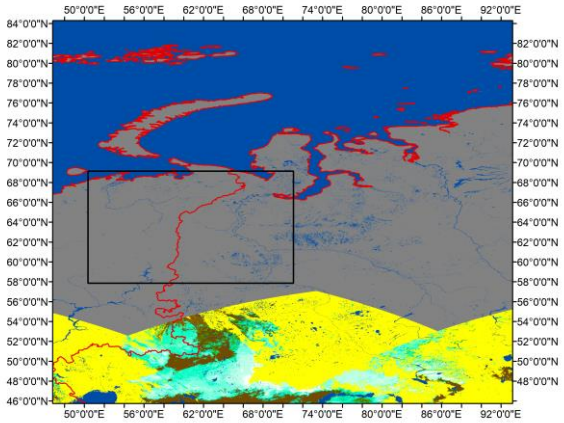
R: Band 11, G: Band 8A, B: Band 3

273 Sentinel 2 images over 28 tiles

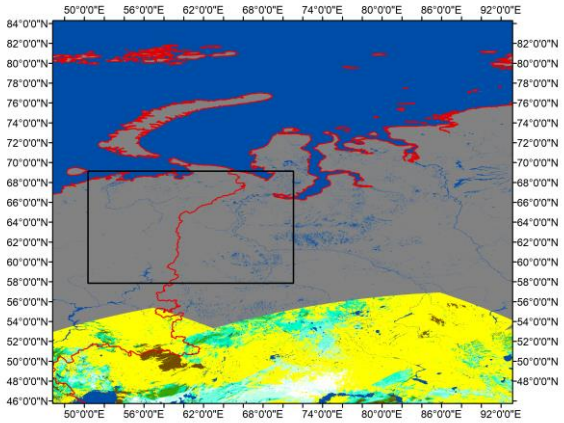




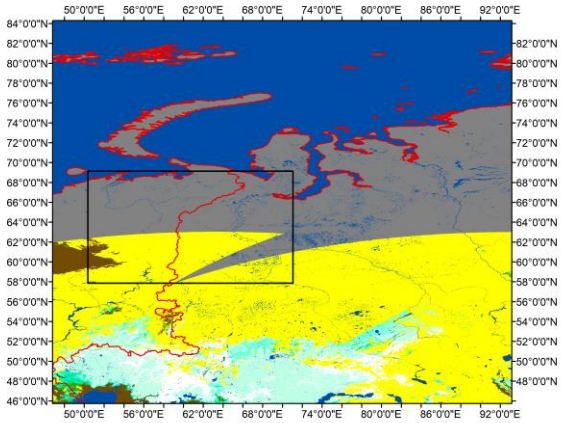
- **H35 over the Ural Mountain Range for Nov 2018 - Nov 2019**
  - Main limitations in comparison with Sentinel 2 imagery:
    - Viewing geometry
    - Cloud contamination



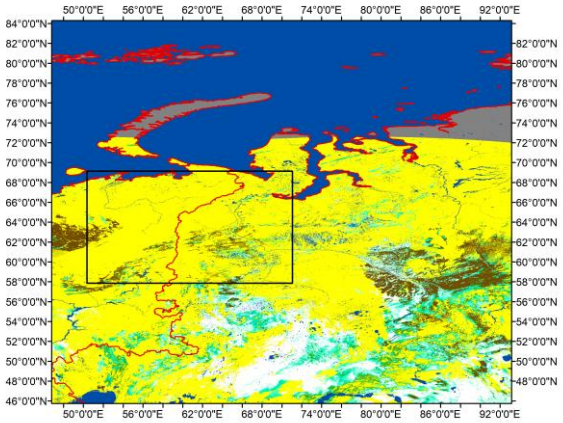
2 Dec 2018



1 Jan 2019

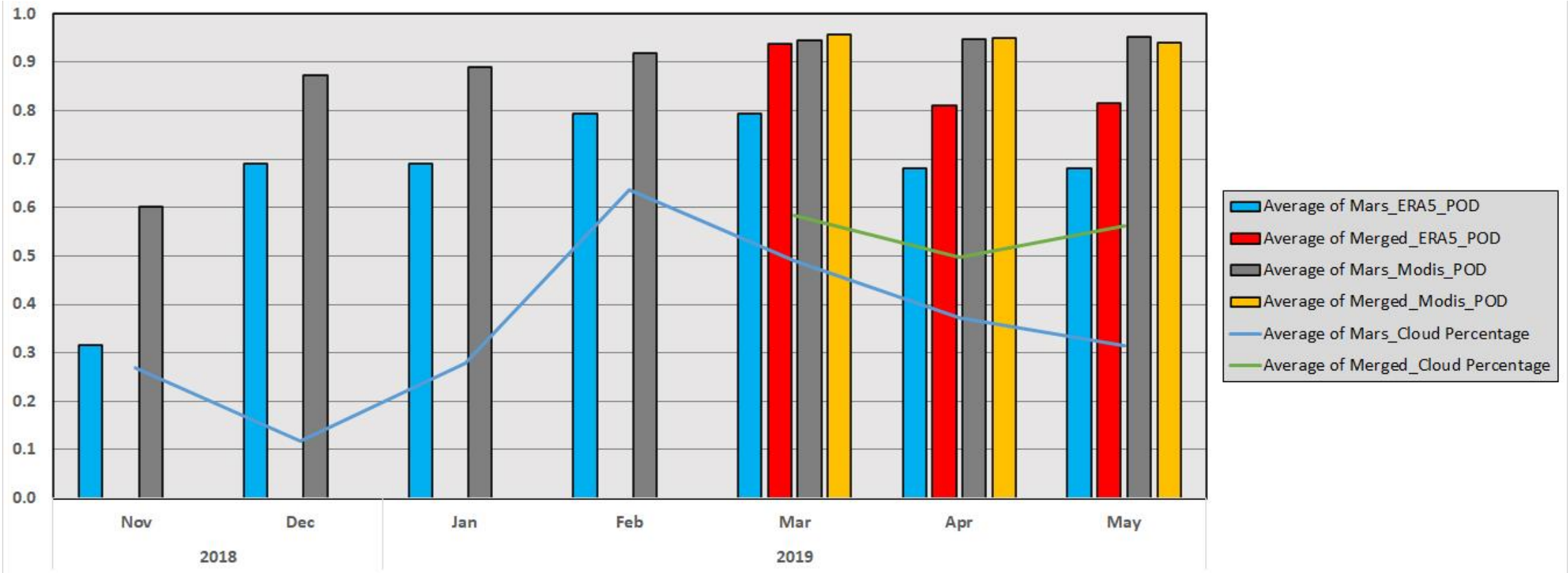


1 Feb 2019

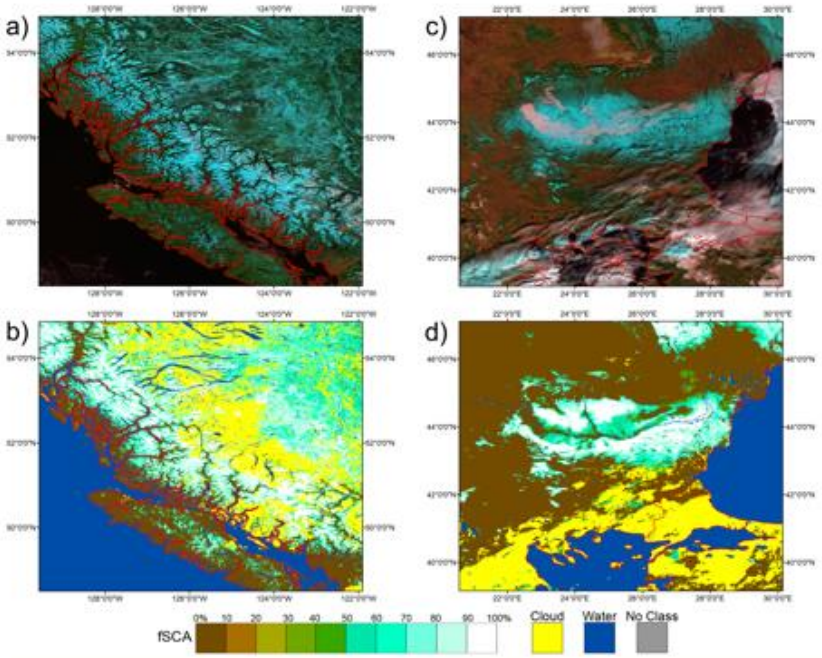


1 Mar 2019

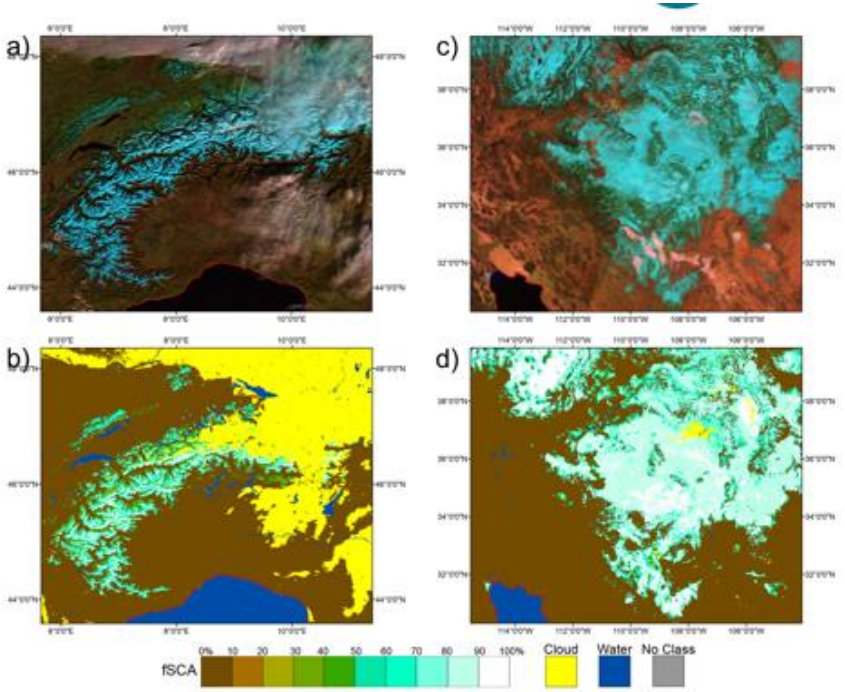
- **H35 vs. ERA5-Land & MODIS over the Ural Mountain Range for Nov 2018 - May 2019**
  - ERA5-Land: 9 km
  - MODIS MOD10A1: 0.5 km



- **Validation of MARS-H35 FSC Model for 2018-2019 Snow Season**



a) MODIS false-color RGB image and b) MARS-H35 image over **British Columbia**, Canada on 2 Mar 2019; c) MODIS false-color RGB image and d) MARS-H35 image over **south-eastern Bulgaria** on 2 Dec 2018.



3 Jan 2019: a) MODIS false-color RGB image and b) MARS-H35 image over **European Alps**; c) MODIS false-color RGB image and d) MARS-H35 image over **Phoenix, Arizona**.