HSAF Snow Event Week – 22 to 26 November 2021

DATES	SESSION	TIMESLOT (UTC TIME)	TITLE
Day 1	Afternoon Session	13:00 -13:30	Introduction of H SAF project by Silvia Puca
		13:30 -14:00	Introduction to Snow Products by Ali Nadir Arslan
Day 2	Morning Session	09:00-09:30	Optical RS Snow Products: Theory - Part I by Zuhal Akyurek
		09:30-10:00	Optical RS Snow Products: Theory - Part II by Zuhal Akyurek
	Afternoon Session	13:00 -13:30	Snow detection for flat land (snow mask) by VIS/NIR of SEVIRI (H31), Snow detection (snow mask) by VIS/IR radiometry (H34) (using products from juypiter notebook) - Part Iby Niilo Siljamo
		13:30 -14:00	Snow detection for flat land (snow mask) by VIS/NIR of SEVIRI (H31), Snow detection (snow mask) by VIS/IR radiometry (H34) (using products from juypiter notebook) - Part II by Kenan Bolat
Day 3	Morning Session	09:00-09:30	Snow detection for flat land (snow mask) by VIS/NIR of AVHRR (H32), Effective snow cover by VIS/IR radiometry (H35) (using products from juypiter notebook) - Part I by Niilo Siljamo
		09:30 -10:00	Snow detection for flat land (snow mask) by VIS/NIR of AVHRR (H32), Effective snow cover by VIS/IR radiometry (H35) (using products from juypiter notebook) - Part II by Semih Kuter and Burak Simsek
	Afternoon Session	13:00 -13:30	Microwave RS Snow Products: Theory - Part I by Ali Nadir Arslan
		13:30 -14:00	Microwave RS Snow Products: Theory - Part II by Ali Nadir Arslan
Day 4	Morning Session	09:00-09:30	Snow water equivalent by MW Radiometry (H13) and New Global (hemispherical) SWE 25 km Resolution (H65) (using products from juypiter notebook) - Part I by Matias Takala
		09:30 -10:00	Snow water equivalent by MW Radiometry (H13) and New Global (hemispherical) SWE 25 km Resolution (H65) (using products from juypiter notebook) - Part II by Matias Takala
	Afternoon Session	13:00 -13:30	Validation of snow products- results and performances by Alexander Toniazzo
		13:30 -14:00	Validation of new snow products using Copernicus Sentinel data by Simone Gabellani
Day 5	Morning Session	09:00-09:30	Impact Studies and Snow-Hydro validation Part I by Aynur Sensoy Sorman
		09:30 -10:00	Impact Studies and Snow-Hydrological validation Part II by Francesco Avanzi

Registration links are below ↓

Target Audience:

This event week is aimed to introduce the HSAF snow products and let the hydrological modellers get familiar to the HSAF snow products. Hydrological modellers, climate modellers should register the event.

- All the required codes and jupyter notebooks are going to be shared via github
- In order to run the notebooks "Python" should be installed beforehand into the operating system.
- All the steps are going to be carried out via jupyter notebooks. Basic programming language skills are required to edit or update the notebooks (if anyone wants to edit or update).

Objectives:

- Be aware of HSAF snow products
- Be able to use GitHub to access the application developed in order to download and analyse the snow products
- Be able to use the jupyter notebook
- Be able to download the HSAF snow products
- Be able to do basic spatial and temporal analysis with snow products

Key points of the event week:

- Familiarize with H SAF snow data
- Download the HSAF snow products (H31, H32, H34, H35, H13)
- Get in touch with data experts
- Learn how to play with / explore the data
- Raise questions including their work and examples
- Evaluate the added value of snow products through hydrological modelling
- Analyse hydro validation results
- Know the performances and the limitations of the various product

ABSTRACTS

Day 1 - Afternoon session

In this session, there will be an introduction to EUMETSAT H SAF project. The EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management (H SAF) started in 2005 and aims to provide remote sensing estimates of relevant hydrological parameters: instantaneous rain rate and cumulated rainfall, soil moisture at surface and in the root zone, snow cover and water equivalent. The project involves experts from 12 national meteorological and hydrological European Institutes of Austria, Belgium, Bulgaria, Finland, France, Germany, Hungary, Italy, Poland, Romania, Slovakia and Turkey, and from the European Centre

for Medium-range Weather Forecast (ECMWF). The operational goal of H SAF highlights the need to provide products with a reliable measure of their accuracy to make aware the potential users of the advantages and drawbacks of the use of the H SAF products in their operational activities, with this aim, within H SAF, three Validation Groups have been established: one for precipitation, one for soil moisture and one for snow products.

An overview of existing and future satellite-derived snow products will be provided.

Register for Session 1 Afternoon

Day 2 - Morning session

Snow on the ground differs from most of the Earth surfaces by its high reflectance or albedo in the visible and near-infrared wavelengths (0.350 to 1 µm). For longer, the snow's reflectance decreases significantly. In these wavelengths, snow is even less reflective than certain types of vegetation. Most of the incident radiation in these wavelengths is absorbed in the snowpack. These unique spectral characteristics are used in optical remote sensing to distinguish between snow and other types of surfaces. The numerous validation studies indicate that the satellite snow products have large snow mapping accuracy with respect to ground snow observations for cloud-free conditions, which varies between 69 and 94% in the winter seasons. The main limitation of existing optical platforms operating at a daily timescale is cloud coverage, which significantly reduces the availability of snow cover information.

In this session, algorithms used to retrieve HSAF snow products; snow mask (H31, H34) and effective snow cover area (H32, H35) from optical satellite data are presented. The challenges and the opportunities in retrieving snow cover maps from optical data are discussed.

Register for Session 2 Morning

Day 2 - Afternoon session

In this session, EUMETSAT HSAF snow products H31 and H34 are explained in detail.

H31 is a full disk snow mask product for flatland areas, which is retrieved from optical imaging radiometer Spinning Enhanced Visible and Infrared Imager (SEVIRI) onboard the geostationary Meteosat Second Generation (MSG) satellites operated by EUMETSAT. MSG/SEVIRI provides continuous imaging of the earth in 12 spectral channels with a repeat cycle of 15 min. The imaging spatial resolution is 3 km in nadir and degrades to 5 km over Europe. The snow cover retrieval algorithm used in the product is based on empirical approach which takes into account the highly variable nature of the snow-covered surface in satellite resolution. Validation results based on weather station observations (snow depth and the state of the ground observations) are very good.

H34 is a snow mask product, which is retrieved from optical imaging radiometer Spinning Enhanced Visible and Infrared Imager (SEVIRI) mounted aboard the geostationary Meteosat Second Generation (MSG) satellite operated by EUMETSAT. MSG-SEVIRI provides continuous imaging of the earth in 12 spectral channels with a repeat cycle of 15 min. The imaging spatial resolution is 3 km at sub-satellite point and degrades to 5 km over Europe. The snow cover mapping is based on a multi-channel retrieval algorithm. It exploits the high reflectivity of snow in the visible spectrum and the low reflectivity at shorter wavelengths. The snow cover retrieval algorithm differs for flat and mountainous regions. Considering the different characteristics of snow for

mountainous and flat areas, two different algorithms are used in producing the snow products for flat and mountainous areas, and then the products are merged to have a single snow product.

Register for Session 2 Afternoon

Day 3 - Morning session

In this session, EUMETSAT HSAF snow products H32 and H35 are explained in detail.

H32 is a global daily snow mask product, which is retrieved from the Advanced Very-High Resolution Radiometer (AVHRR) onboard the polar orbiting MetOp satellites operated by EUMETSAT. Metop/AVHRR provides daily global coverage on 5 channels. The spatial resolution is 1.1 km in nadir. The snow cover retrieval algorithm used in the product is based on empirical approach which takes into account the highly variable nature of the snow-covered surface in satellite resolution. Validation results based on weather station observations (snow depth and the state of the ground observations) are very good.

H35 is effective snow cover product, which is retrieved from optical imaging radiometer AVHRR mounted aboard NOAA and MetOP satellites. The third generation of AVHRR, i.e., AVHRR/3, is a multi-spectral scanning radiometer with three solar channels in the VIS/NIR region and three thermal infrared channels. It is currently onboard to NOAA-15, -18, -19 and MetOp-A, -B, -C satellites. The operational H35 is confined to the Northern Hemisphere The fractional snow cover (fSCA) value within a pixel is estimated by using the reflectance data obtained from AVHRR spectral bands. The final fSCA product has ~1 km spatial resolution and it incorporates snow cover fraction percentage from 0 to 100% as well as cloud and water classes. The product for flat/forested regions is generated by *Finnish Meteorological Institute* (FMI) and the product for mountainous areas is generated by *Turkish State Meteorological Service* (TSMS). Both products, thereafter, are merged at FMI. A full disk H35 product is an image of 8,999 rows by 35,999 columns (i.e., 324 M pixels approximately).

Register for Session 3 Morning

Day 3 - Afternoon session

During winter season, snow covers about 40 million km2 in the Northern hemisphere. Snow is a vital water resource in many regions of the world. Climatic changes, Earth's energy balance, water resources are strongly affected by the presence of snow. Knowledge of the amount of snow water equivalent from year to year is essential to estimate the effects of snow melt run-off. Knowing the snow characteristics helps to improve weather forecasts, to predict water supply for hydropower stations, and to anticipate flooding. Microwave sensors such as radiometers and radars are often used because of their usability under varying conditions, factors like clouds, rain and lack of light do not affect the measurement, the large penetration depth into the surface with increasing wavelength, sensitive to liquid water. Understanding of the relationship between microwave signatures and snow is very important for retrieving desired snowpack parameters such as snow density, snow water equivalent and snow wetness.

In this session, we will present a general introduction to microwave remote sensing covering radiometry, characteristics, microwave sensors and applications. We will also provide information on algorithms used to retrieve HSAF snow products from microwave sensors.

Register for Session 3 Afternoon

Day 4 - **Morning session**

The Snow Water Equivalent (SWE) is a parameter that describes the water content of snow mass. If snow would melt in its place the SWE tells the depth of the resulting water layer. Spaceborne microwave radiometers are well suited for the detection of SWE. Even though the spatial resolution of radiometer data is rather coarse (tens of kilometres) a polar orbiting satellite can cover most of the globe in 24h period. Unlike optical instruments radiometer depends only on natural thermal radiation of objects and doesn't require illumination from sun. In addition, radiometers are quite insensitive to weather phenomena. The EUMETSAT H SAF SWE products H13 and H65 are described in detail in this presentation. The products are merged products containing Finnish Meteorological Institute (FMI) contribution for flat lands and Turkish State Meteorological Service (TSMS) contribution for mountainous areas. Both products use Helsinki University of Technology (HUT) model as basis for the estimates. The FMI algorithm is a data assimilation algorithm combining ground-based snow depth measurements with spaceborne derived SWE estimates and the TSMS algorithm uses modified HUT model for mountains. The nominal resolution for H13 is 0.25° and for H65 25 km. Product H13 is provided for Europe in so called H-SAF area [25-75°N lat, 25°W-45°E long]. The upcoming product H65 will provided for Northern Hemisphere in EASE2 format. The products are validated against independent SWE snow course measurements.

In this session, practical examples of how to use the H13 product will be presented using Jupyter notebook.

Register for Session 4 Morning

Day 4 - Afternoon session

Information on snow properties is of critical relevance for a wide range of scientific studies and operational applications, mainly for hydrological purposes. However, ground-based monitoring of snow dynamics is a challenging task, especially over complex topography and under harsh environmental conditions. Remote sensing is a powerful resource providing snow observations at large scale.

In this session, the validation of the products will be discussed in detail. The presentation will begin with a brief recap on the various snow product types: snow detection, Snow status (D/W), Fractional SC and SWE. Some of these products are over European areas, whereas the new products developed during CDOP3 are global products of full disk satellite products.

Following there will be a short discussion about performances and limitations of each product, based on the Operational Reviews of the last years. Validation of these products requires a great effort due to sparse availability of snow observation, especially, over extra-European areas. Therefore, new validation strategies were developed. In the second part we will address the potential of using Sentinel-2 high-resolution imagery to

validate moderate-resolution snow products supplied by the Hydrological Satellite Facility (HSAF) Project of EUMETSAT.

The consistency of Sentinel-2 observations has been assessed against both in-situ snow measurements and webcam digital imagery and they can be used as reference data (Piazzi et al 2019). We will show the comparison of HSAF products and Sentinel 2 dataset in different region of the world with different snow seasonality.

Register for Session 4 Afternoon

Day 5 – Morning session

Increasing satellite technology offers new products for hydrological applications. The validation process is crucial for these products before them to be used in operational applications. The validation of satellite data sets can be done through the direct comparison with ground truth data or a reference satellite data. Another, indirect approach consists in using these datasets in models with different complexities and assess the realism of modelled outputs (so called "Hydro Validation"). EUMETSAT H SAF project provides daily snow products on snow recognition, fractional snow cover, snow status and snow water equivalent over complex topographies changing from flat land to mountainous areas.

In this two-part presentation, we will show examples of Hydro Validations. In part 1, we will discuss a blending approach to use SE-E-SEVIRI(H10) data together with Sentinel 2 and MODIS into a real-time, operational cryosphere modelling chain (S3M-Italy). We will compare open-loop simulations with simulations obtained assimilating H10 data to discuss the added value of this product for real time forecasting. In part 2, daily snow cover area (SCA) and snow water equivalent (SWE) data sets derived from SE-E-SEVIRI(H10) and SWE E(H13), respectively, are evaluated over the mountainous terrain of the Upper Euphrates Basin. First the impact of the snow cover area product is analysed and then hydro validation of both data sets are assessed through conceptual models SRM and HBV. Moreover, since the assimilation of snow products improves snow states of the models, lead time runoff and snow state forecast performance will be presented.

Register for Session 5 Morning