EUMETSAT HSAF SNOW COVER PRODUCTS: 10 Years On

Zuhal Akyurek[1], Ali Nadir Arslan[2], Kenan Bolat[3], Simone Gabellani[4], Semih Kuter[5], Gaia Piazzi[4,6], Silvia Puca[7], Burak Simsek[2], Matias Takala[2], Alexander Toniazzo[7]

(1) Department of Civil Engineering, Middle East Technical University, Ankara, Turkey, (2) Finnish Meteorological Institute (FMI), Helsinki, Finland, (3) Hidrosaf, METU Teknopolis, Ankara, Turkey, (4) CIMA Foundation, Hydrology and Hydraulics, Savona, Italy, (5) Department of Forest Engineering, Çankırı Karatekin University, Çankırı, Turkey, (6) IRSTEA, Hydrology Research Group, UR HYCAR, Antony, France, (7) National Civil Protection Department, Rome, Italy

*Names are in alphabetic order

Introduction

Reliable snow cover extent is of vital importance in order to have a comprehensive understanding for present and future climate, hydrological, and ecological dynamics. Development of methodologies to obtain reliable snow cover information by means of optical and microwave remote sensing (RS) has long been one of the most active research topics of the RS community. The H-SAF was established by the EUMETSAT Council on 3 July 2005; since then from development to operational phases several snow products have been disseminated. In this study EUMETSAT snow cover products namely H10, H12,H13,H34 and H35 are presented (Figures 1-5).

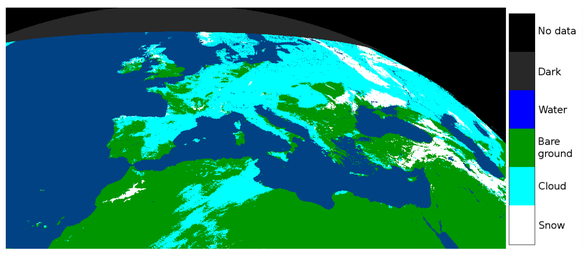


Figure 1. H10 product for 01.02.2018

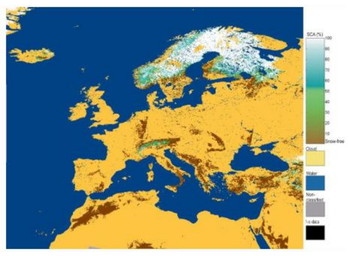


Figure 2. H12 product for 18.04.2019

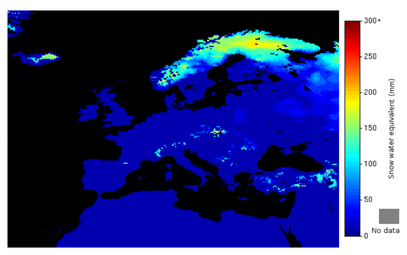


Figure 3. H13 product for 01.11.2020

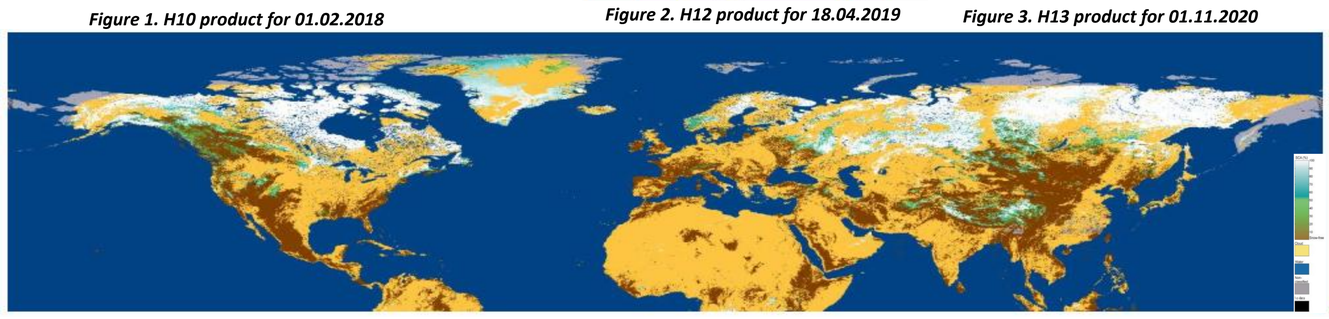


Figure 4. H35 product for 28.03.2019

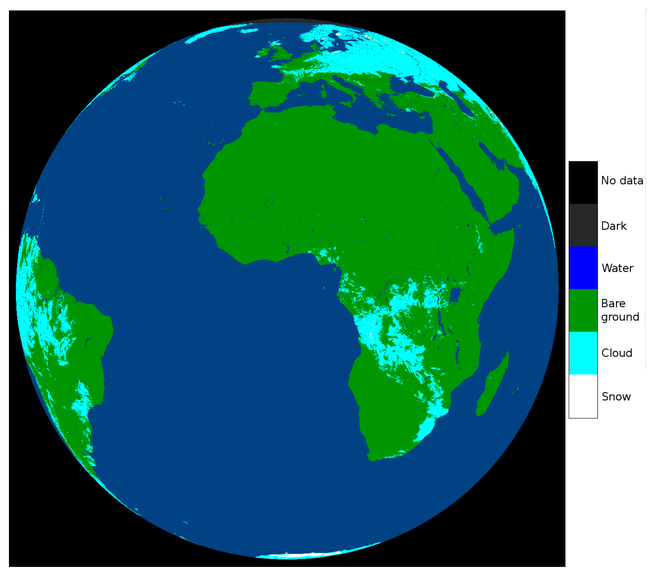


Figure 5. H34 product for 27.10.2017

HSAF snow cluster

HSAF snow cluster are composed of experts from the national meteorological and hydrological Institutes of Belgium, Bulgaria, Finland, Germany, Hungary, Italy, Poland, Slovakia and Turkey (Figure 6).

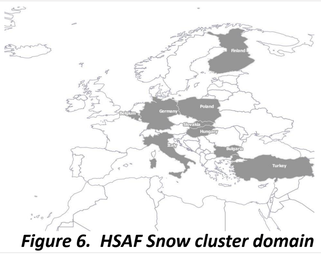


Figure 6. HSAF Snow cluster domain

Description of the products

H10 , H34 (Snow detection (snow mask) by VIS/IR radiometry), snow products are based on multi-channel analysis of the SEVIRI instrument onboard Meteosat satellites. H12 and H35 (Effective snow cover by VIS/NIR radiometry) snow products are based on visible and shortwave near infrared data of AVHRR instrument placed on NOAA and MetOp satellites. H13 (Snow water equivalent by MW radiometry) snow product is obtained from microwave sensors namely SSMI/S. Properties of each products are given in Table 1.

Mountain mask

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. Mountain mask used for H10 and H34 products is given in Figure 7 and the one for H12, H35 and H13 products is given in Figure 8.

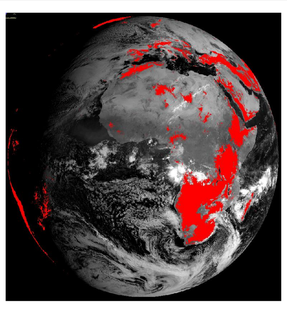


Figure 7. Mountain mask for H10 and H34 Products

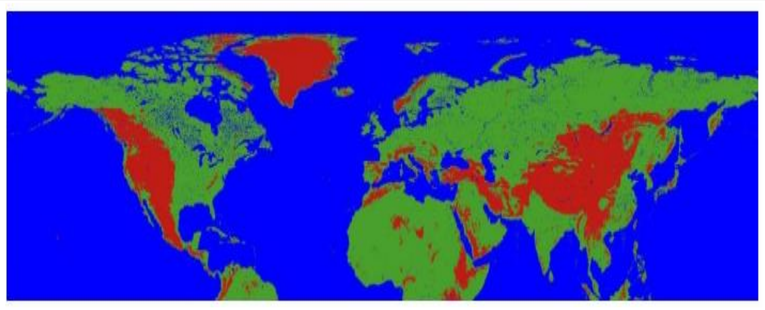


Figure 8. Mountain mask for H12, H35 and H13 products

Table 1. Product descriptions

Product Name	Description	Spatial Resolution	Size	Extent
H10	Snow detection (snow mask) by VIS/IR radiometry	0.05°	1001x1401	Europe
H12	Effective snow cover by VIS/IR radiometry AVHRR	0.01°	5000x7000	Europe
H13	Snow Water Equivalent by MW radiometry	0.25°	201x281	Europe
H34	superseding H10	0.05°	3601x7201	Full Disk
H35	superseding H12	0.01°	8999x35999	North Hemisphere

Table 2. Validation metrics

Score	Threshold	Target	Optimal
POD	0.80 / 0.60	0.85 / 0.70	0.99 / 0.99
FAR	0.20 / 0.30	0.15 / 0.20	0.05 / 0.05
	POD = a/(a + c)	**FAR = b/(a + b)**	

		Reference Dataset	
		Snow	No Snow
Analyzed dataset	Snow	a	b
	No Snow	c	d

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(Product_{ref,i} - Product_i\right)^2}{n}}$$

Algorithms

Snow cover products (H10 and H34) are based on a multi-channel retrieval algorithm using the MSG-SEVIRI data. It exploits the high reflectivity of snow in the visible spectrum and the low reflectivity at shorter wavelengths (Figure 9).

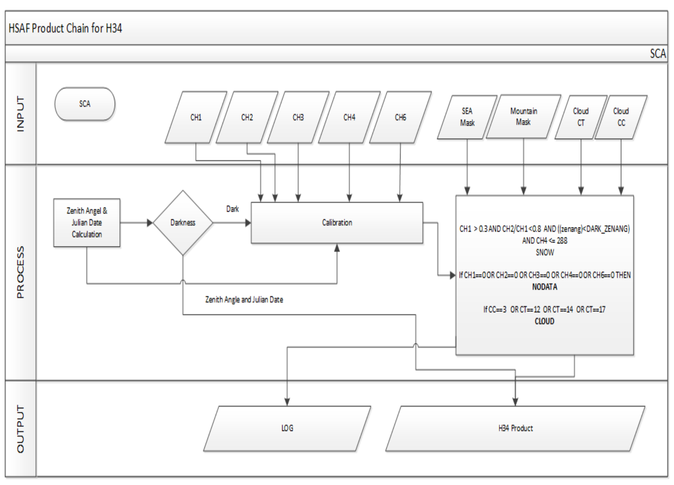


Figure 9. HSAF H10 and H34 snow cover algorithm for mountainous areas

Effective Snow Cover (H12 and H35) products employ visible and shortwave near infrared data. Topographic correction is performed for the mountainous areas (Figure 11).

Snow Water Equivalent product (H13) is obtained from microwave sensors namely SSMI/S. Algorithm for H13 uses the Helsinki University of Technology (HUT) snow emission model having slightly changes in the assimilation for flat/forest and mountainous areas (Figure 10)

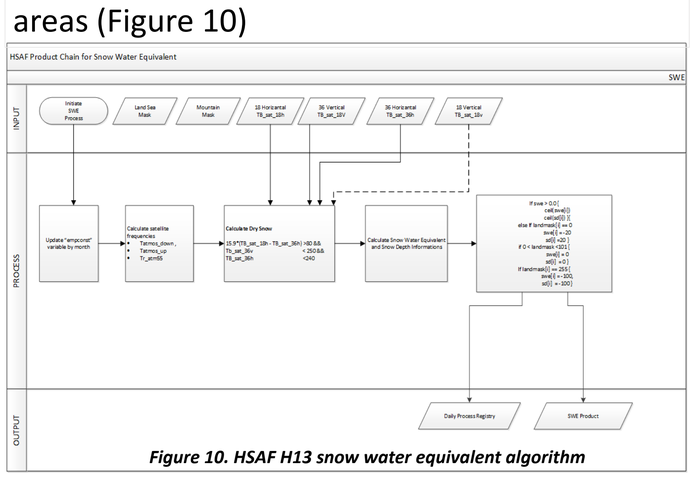


Figure 10. HSAF H13 snow water equivalent algorithm

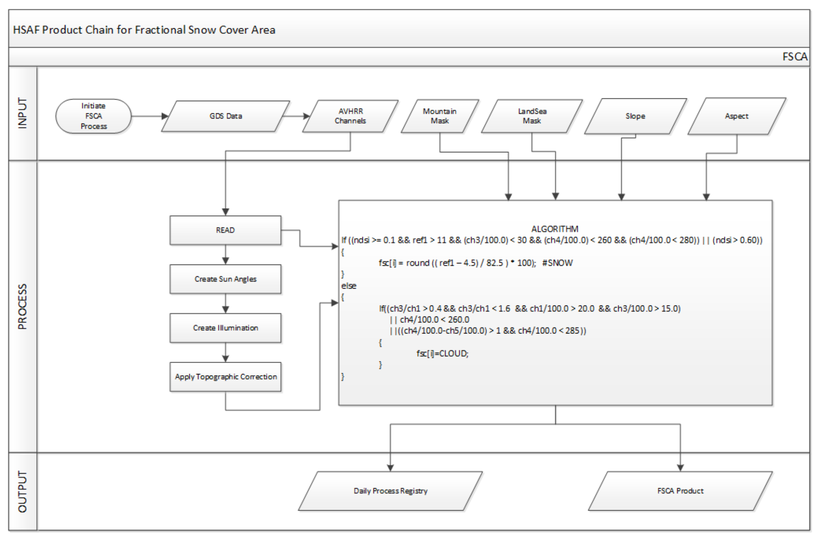


Figure 11. HSAF H12 and H35 fractional snow cover area algorithm

Validation results

Continuous validation of each product has been performed with ground and other sattelite's data. A common validation methodology has been applied for the products. The validation metrics used for optical products are given in Table 2. RMSE is used in validation of products H12 and H13 (Fig.12-Fig.15).

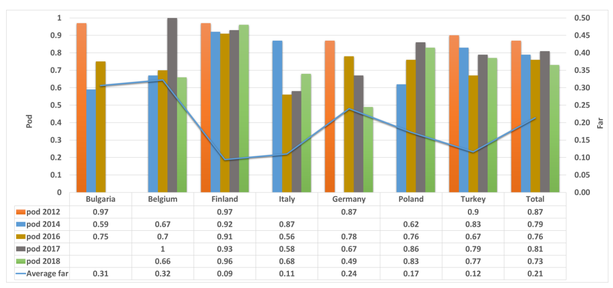


Figure 12 Results of continious validation study for H10 product

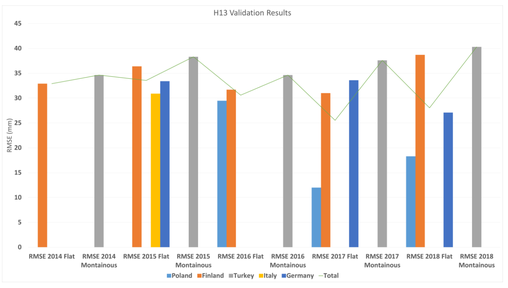


Figure 13 Results of continious validation study for H13 product

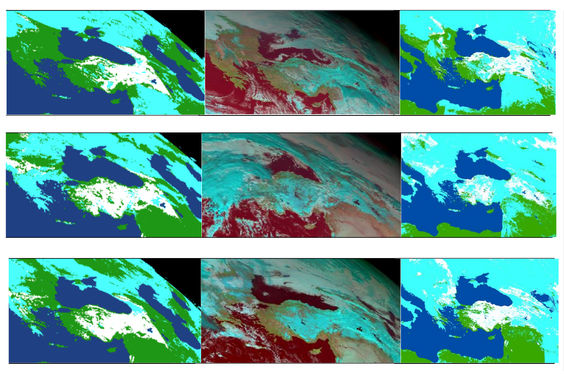


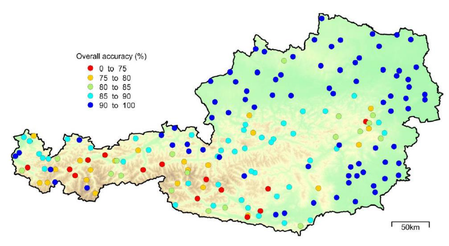
Figure 14. H10, SEVIRI RGB (532) and MOD10 A1 images of 18.12.2016 , 11.01.2017, 02.02.2017

	Threshold	Target	Optimal	Overall Product
Flat Area RMSE 2014	40%	20%	10 %	22.28%
Flat Area RMSE 2015	40%	20%	10 %	18.60%
Mountainous RMSE 2016	65%	45%	95 %	18.60%

	Aosta Valley	Pyrenees	Caucasus
RMSE 2017	48.47%	49.36%	43.41%

	Aosta Valley	Pyrenees	Caucasus	Turkey	Finland
RMSE 2018	48%	49%	43%	20%	15%

Figure 15. H12 Validation Results by using ground observations



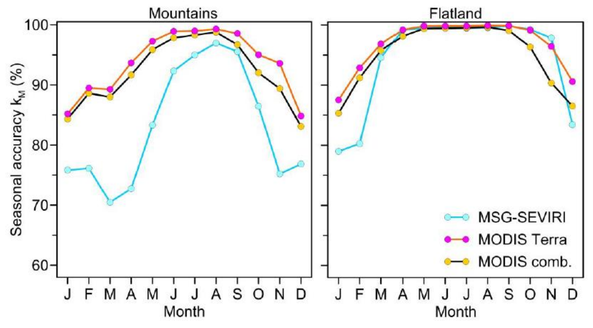


Figure 16. Seasonal frequency of snow mapping accuracy k_M for the MSG-SEVIRI, MODIS4 Terra and MODIS-combined products estimated for cloud-free days in the period April 2008 - June 2012. Left and right panels show the results for meteorological stations in the mountain 6 (97 stations) and flatland (81 stations) regions, respectively (Surer et al., 2014)

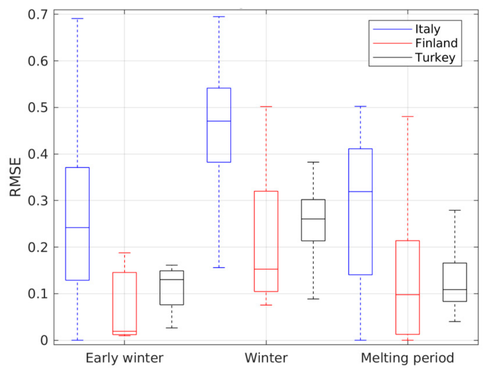


Figure 17. Seasonal RMSE of H12 using Sentinel -2 imagery (Piazzi et al., 2019)

References

- Piazzi, G.; Tanis, C.M.; Kuter, S.; Simsek, B.; Puca, S.; Toniazzo, A.; Takala, M.; Akyürek, Z.; Gabellani, S.; Arslan, A.N. ''Cross-Country Assessment of H-SAF Snow Products by Sentinel-2 Imagery Validated against In-Situ Observations and Webcam Photography'', *Geosciences*. *9*, 129, 2019.
- Surer,S., J. Parajka, and Z. Akyurek, "Validation of the operational MSG-SEVIRI snow cover product over Austria", Hydrol. Earth Syst. Sci. 18, 763–774, 2014