HSAF Visiting Scientist Activity at FMI
Final Report

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1 Contents

2 Background

HSAF (Satellite Application Facility on Operational Hydrology and Water Management) Snow Cluster (SN-OBS) has been developing four different snow products (SN-OBS1, SN-OBS2, SN-OBS3 and SN-OBS4) which are Snow Recognition (SR), Snow Status (SS), Fractional Snow Cover (FSC) and Snow Water Equivalent (SWE). Finland and Turkey are responsible countries in this cluster for product generation. Finnish Meteorological Institute (FMI) from Finland side is responsible to develop algorithm for flat/forest areas where Turkish State Meteorological Services (TSMS) from Turkey is responsible for the mountainous areas. For the SR, FSC and SWE products, separate algorithms are under development in both institutions. On the other hand, SS product has been developing for the whole HSAF domain by FMI. Except for the SS product, all the others will be merged and distributed to end-users as one product at the end of the development phase.

3 Objectives

The main objective of this Visiting Scientist program is to concentrate on the mentioned merging activity; to search appropriate approach for merging the products and develop necessary tools. In addition to these, determination of the metadata standards is covered as well. The main goal of this activity is to develop appropriate merging algorithms and a proper code running and to obtain appropriate merged products.

4 Materials

To perform above objectives there are two main materials for leading VS activity one is products and the other is mountain mask. Different projections, resolutions and coverage are subjected for the products.

4.1 Mountain Mask

Middle Eastern Technical University (METU) HSAF team from Turkey prepared a mountain mask to delineate mountainous versus flat areas. This product and the methodology were already presented to the H-SAF community in the previous PT meetings. The initial mountain mask image is given at Figure 1.

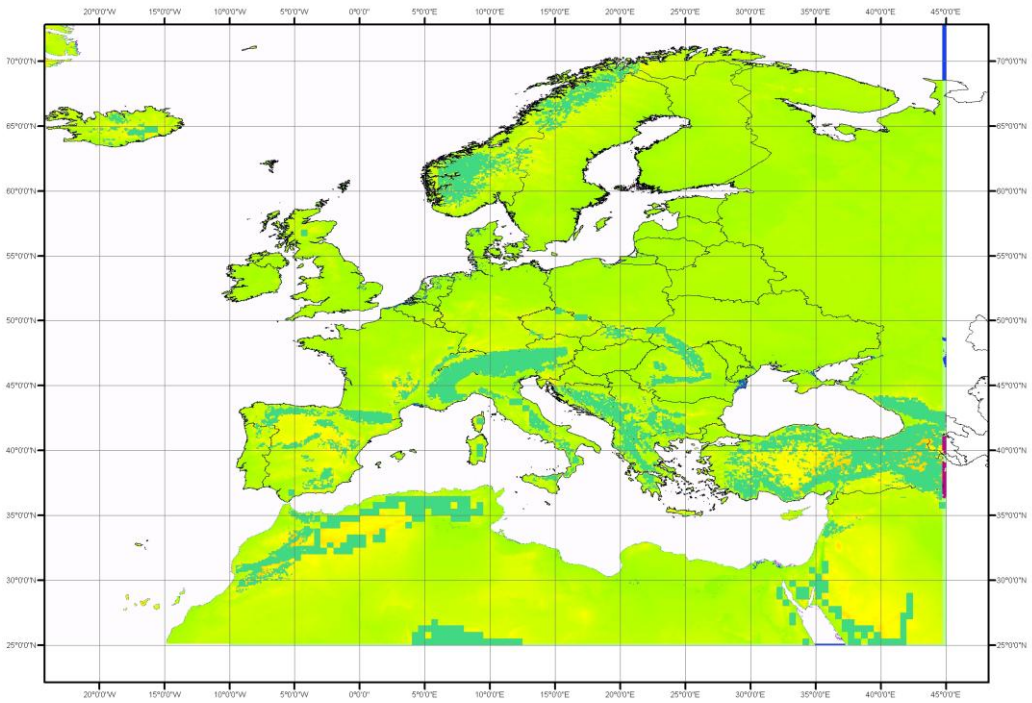

Figure 1. Mountain mask for HSAF domain. Dark green mountain, green and yellow flat.

SR and FSC products have completely different resolution and projection. Therefore two different mountain masks have been created with the same resolution, projection and coverage of mountain products, for SR and FSC. Mountain masks had been converted into HDF5 file format containing three data sets namely; mountain mask, latitudes and longitudes. Mountain mask dataset consist of zeros indicating flat areas and ones indicating mountain areas. The rest of the data provides the geographical coordinates.

4.2 Snow Products

There are total numbers of four snow products generated by the Snow cluster where SS will only be produced by FMI for the whole HSAF domain. The other products have been produced separately in

both institutes, TSMS and FMI. Some information is given below about the products.

4.2.1 Snow Recognition

Snow recognition products are derived from MSG SEVIRI data in 5 kilometer resolution. Daily Snow Recognition products are produced at the end of the day around at 17:00 GMT using 15 minutes cycles by FMI and TSMS. As an example the product quick-look images for Nov. 16, 2008 are given at Figure 2 and Figure 3 respectively.

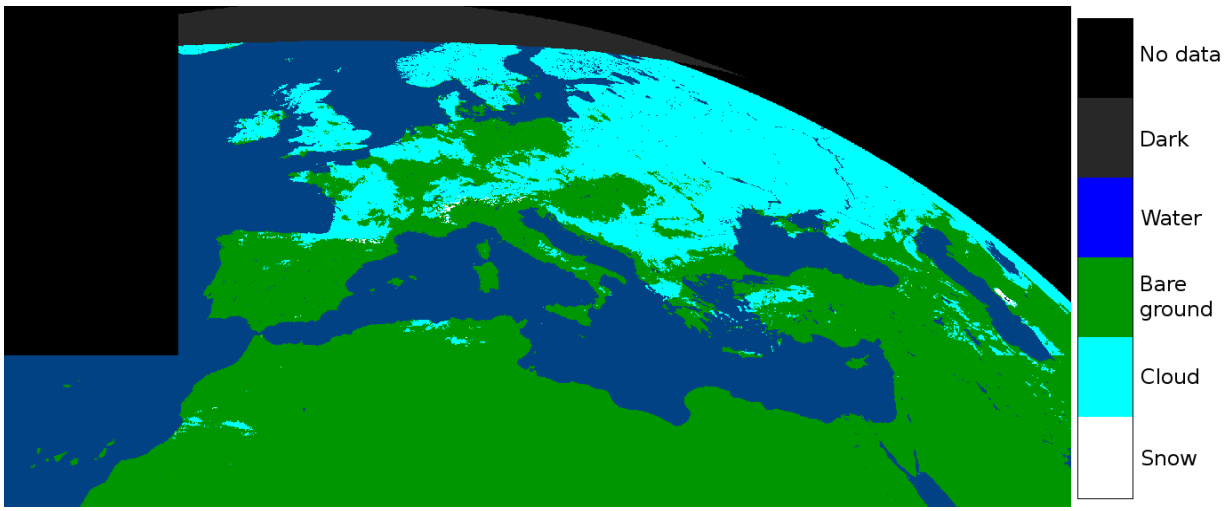

Figure 2. Daily Snow Recognition product by FMI, 16/11/2008.

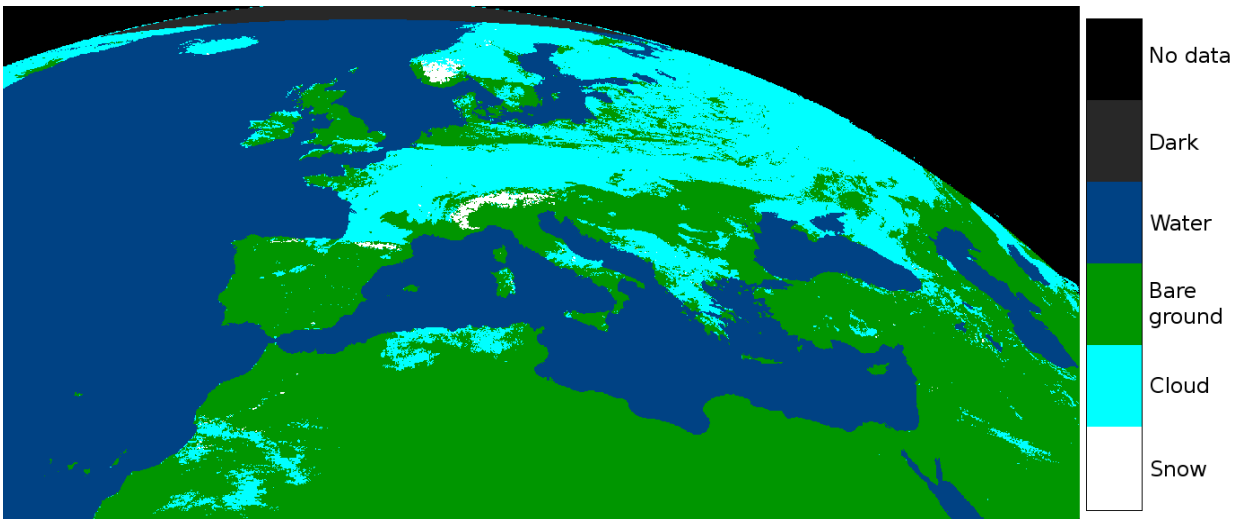

Figure 3. Daily Snow Recognition product by TSMS, 16/11/2008.

Both products are in HDF5 format but the merged products will be in GRIB2 format.

4.2.2 Fractional Snow Cover

Fractional Snow Cover is one of the other products derived from optical satellite sensor data from NOAA17 AVHRR. METOP and NOAA18 also will be used according to availability. Two or three passes of NOAA17 satellite covers within a day whole HSAF domain and daily FSC products is produced by using those passes by FMI for flat areas and by TSMS for mountain areas. Both products are in HDF5 format but the merged FSC products will be in GRIB2 format. As an example product quick-look images for the date Nov. 16, 2008 are given Figure 4 and Figure 5 respectively.

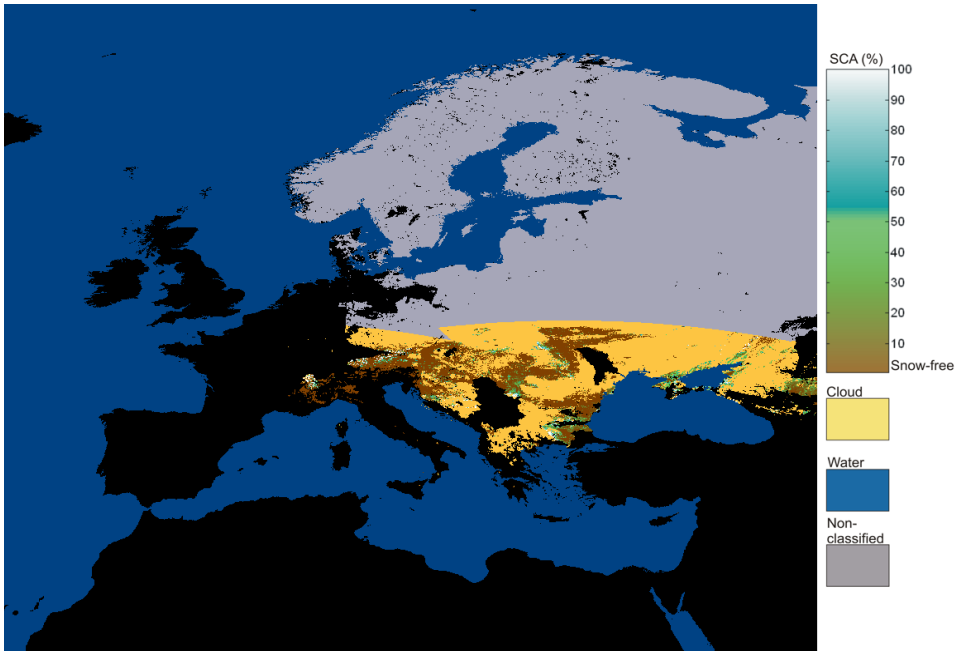

Figure 4. Daily Fractional Snow Cover product by FMI, 16/11/2008.

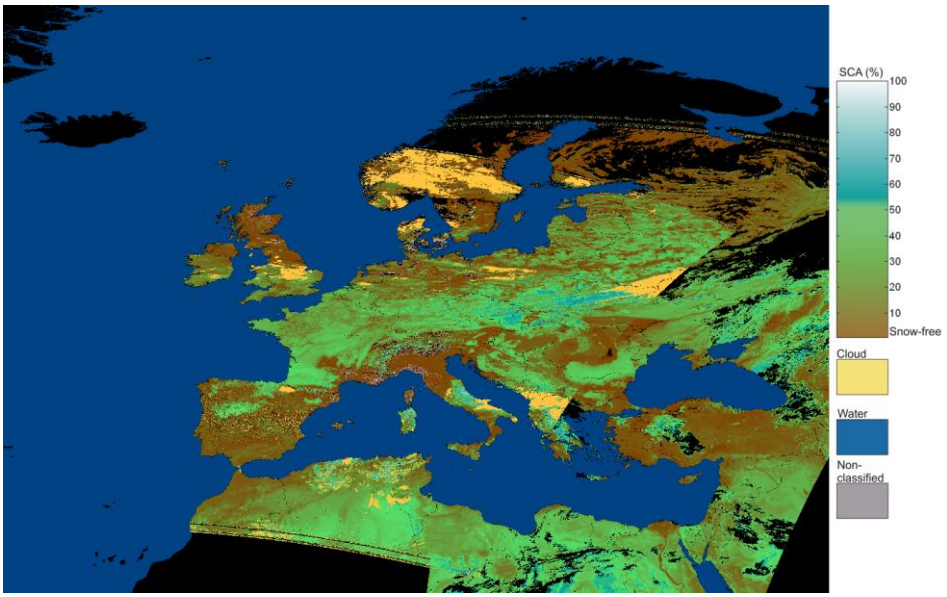

Figure 5. Daily Fractional Snow Cover product by TSMS, 16/11/2008.

4.2.3 Snow Water Equivalent

The last product (SN-OBS4) will be subjected to merge is Snow Water Equivalent (SWE) which is derived from Microwave data. During Visiting Scientist Program period, SWE product generation was not ready to produce SWE product for both institutes. Therefore, there is no sample product available and no progress has been done for this product. Meanwhile the same algorithm used for merging FSC product has been planned to be used for SWE product merging.

4.3 Metadata

One of the other aspects of VS activity is to determine appropriate metadata standards of Snow Products. Metadata files should include all necessary information that end user need. For this purpose, a metadata file belonging snow product produced by Finnish Environment Institute has taken as a base and below metadata files was created for SR and FSC products. The formats of the standard metadata are provided in Table 1 and 2.

Table 1. Standard Metadata format for SR products.

General information	
Data file name:	*h10_yyyymmdd_day.grb*
Collection name:	*Satellite Data*
Producer:	*FMI and TSMS*
Contact:	*support@hsaf.it*
Satellite Information	
Satellite sensor:	*METEOSAT 9*
Satellite spatial resolution:	*MSG Nominal Resolution*
Overpass time (UTM):	*yyyymmdd_hhmm - yyyymmdd_hhmm*
Temporal interval:	*15 min*
Product Information	
Description:	*Thematic Snow Recognition Map (SR)*
Holding name:	*SR*
Product processing time (UTM):	*yyyymmdd_hhmm*
Date of product delivery:	*yyyymmdd_hhmm*
Product spatial resolution:	*MSG Nominal Resolution*
Georeferencing information	
Projection information	
Projection name:	*Satellite_View (Geostationary Satellite Projection)*
Projection units:	*km*
Pixel size (x,y):	*3.1 3.1 km (Sub-satellite position)*
Spheroid/ellipsoid name:	*WGS84*
Longitude of central meridian:	*0.00000000*
Latitude of projection origin :	*0.00000000*
Location of coord in pixel:	*center*
Start Row:	*64*
End Row:	*979*
Start Col:	*1214*
End Col:	*3115*
Proj Params:	*+proj=nsper +lon_0=0.000000 +lat_0=0 +h=35785.859375 +a=6378.140000 +b=6356.754883*

Table 2. Standard Metadata format for FSC products.

General information	
Data file name:	*h12_yyyymmdd_day.grb*
Collection name:	*Satellite Data*
Producer:	*FMI and TSMS*
Contact:	*support@hsaf.it*
Satellite Information	
Satellite sensor:	*AVHRR (NOAA)*
Satellite spatial resolution:	*500m*
Overpass time (UTM):	*yyyymmdd_hhmm - yyyymmdd_hhmm*
Temporal interval:	*Variable (15 min - 2 h)*
Product Information	
Description:	*Percentage value of Snow Covered Area (SCA) in 0.05 * 0.05 deg grid*
Holding name:	*SCA percentage*
Product processing time (UTM):	*yyyymmdd_hhmm*
Date of product delivery:	*yyyymmdd_hhmm*
Product spatial resolution:	*0.05deg*
Georeferencing information	
Projection information	
Projection name:	*Geodetic*
Projection units:	*degrees*
Pixel size (x,y):	*0.05 0.05 deg*
Spheroid/ellipsoid name:	*WGS84*
Longitude of central meridian:	*10.00000000*
Latitude of projection origin:	*0.00000000*
Location of coord in pixel:	*center*
Upper left (lat/lon):	*70 -25*
Lower left (lat/lon):	*25 45*
Proj Params:	*+proj=eqc +lat_ts=0 + lon_0=0.000000*

5 Merging Approaches

At the beginning, the SR products are considered to have the identical spatial resolution and projection type by both institutes. First version of FMI SR product was identical with TSMS SR product. Because of an interSAF activity, FMI decided to use LandSAF SR product which has different resolution and projection type than the previous one. Concerning FSC products, both products have same projection and coverage but only difference is the resolution amount. The merging algorithm is concentrated to produce a solution for these differences.

5.1 Snow Recognition Merging Algorithm

The products from the institutions have different projection so that nearest neighborhood approach was selected for data co-location. The main idea of the merging algorithm is to minimize projection errors and try to reflect the strengths of the two algorithms in the final merged product. A mask based on digital elevation model (DEM) was used to separate the mountainous pixels from flat/forested areas. The merging algorithm finds the exact location of the non-mountainous pixels using this mask. These values are then replaced with the ones from the product for flat and forested areas.

The merging flow charts are given in Figure 6 and Figure 7.

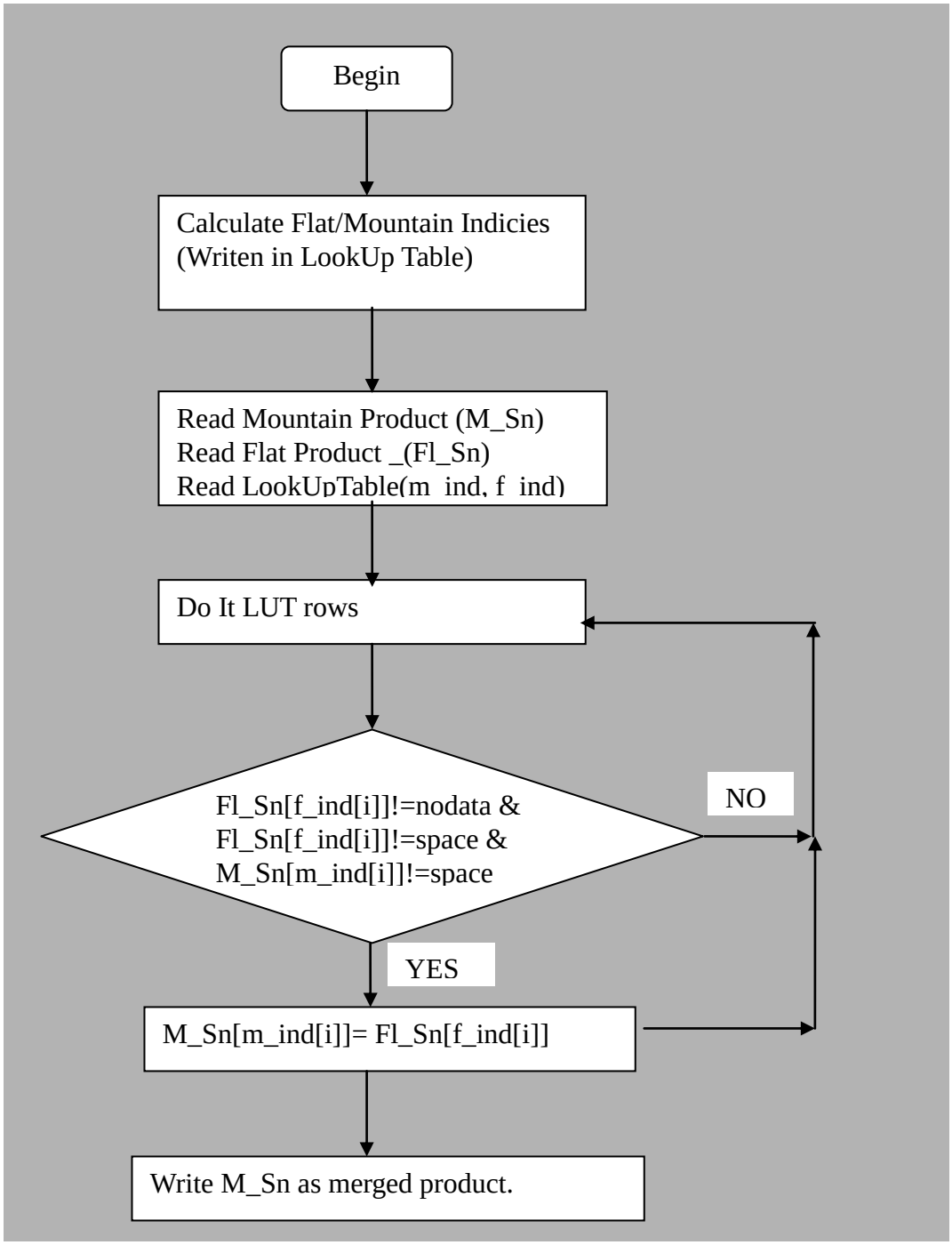

Figure 6. SNOBS1 Product Merging Flowchart.

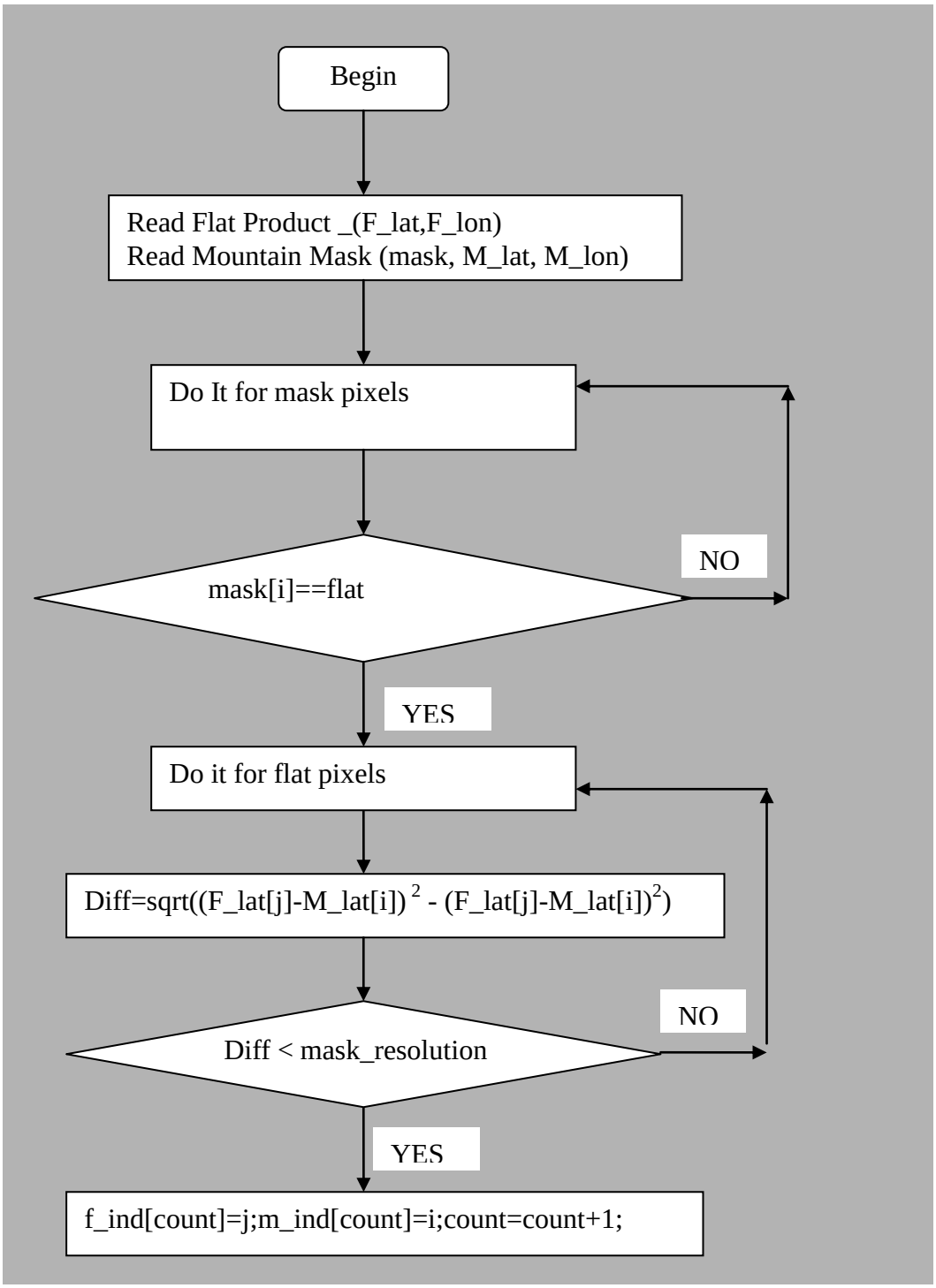

Figure 7. Look-Up Table Calculation Flowchart.

5.2 Fractional Snow Cover Merging

Fractional Snow Cover product merging algorithm is very simple comparing to SR merging because both institutions are using the same projection for product generation. On the other hand, the only difference occurs in the spatial resolution of the products.

At the beginning of the merging activity, METU HSAF team has prepared mountain mask files for each pixel of TSMS FSC product. This file has been converted into HDF5 file because of easy handling. The merging algorithm finds mountainous pixel of FMI product and put TSMS FSC values into it. The merged FSC product has same properties of FMI FSC product.

6 Merged Products & Visual Comparison

The merged products were found noticeably better than the stand-alone products according to visual comparison. Visual comparison has been performed for the period of November and December of 2009. While comparing the products separately to the RGB composites, it came apparent that flat/forest product underestimates the snow on mountainous regions, and the product for mountainous regions misclassified pixels on non-mountainous areas. With the merging, most of these errors are removed. As an example dated 15/11/2008 FMI, TSMS and merged products are given in Figure 8. For visual comparison, the RGB composite for the same date is given at Figure 9.

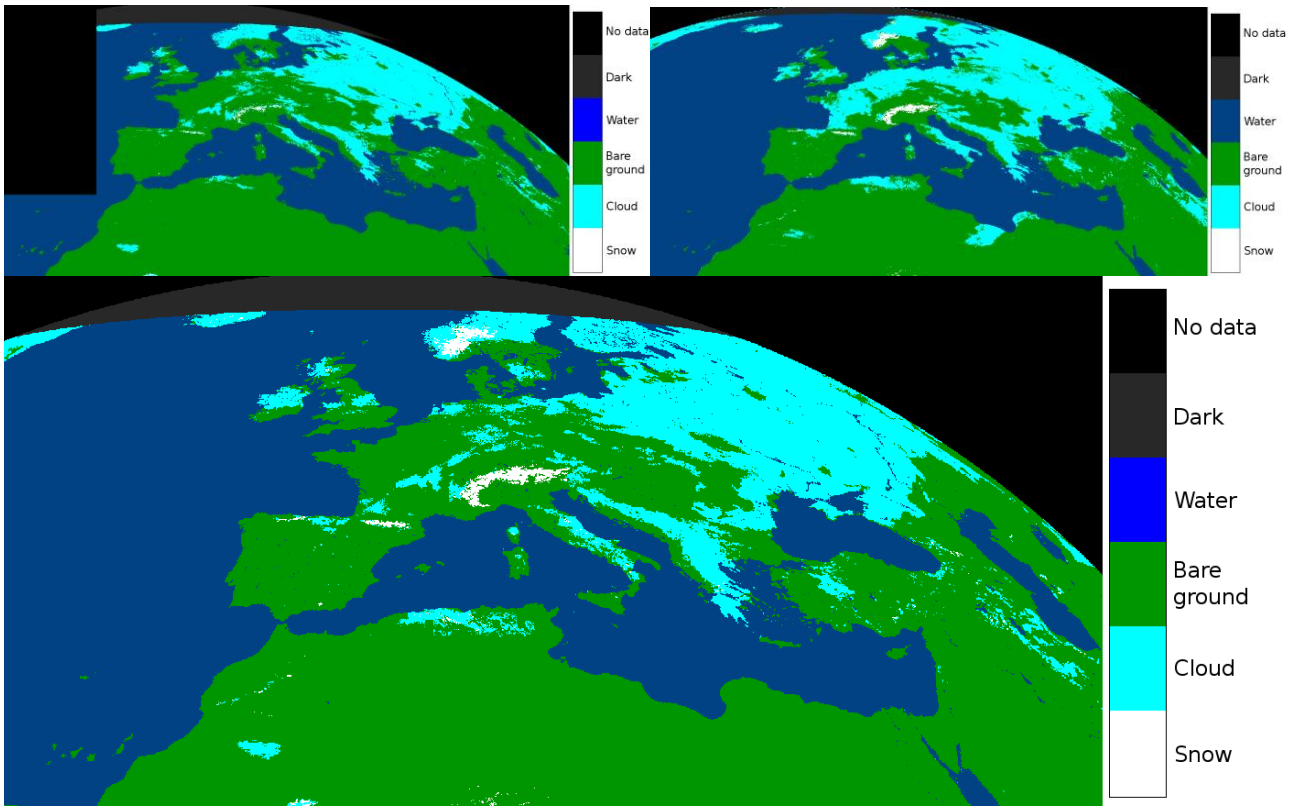

Figure 8. Snow recognition products dated 15/11/2008. Up left FMI's SR, up-right TSMS's SR and down merged SR product.

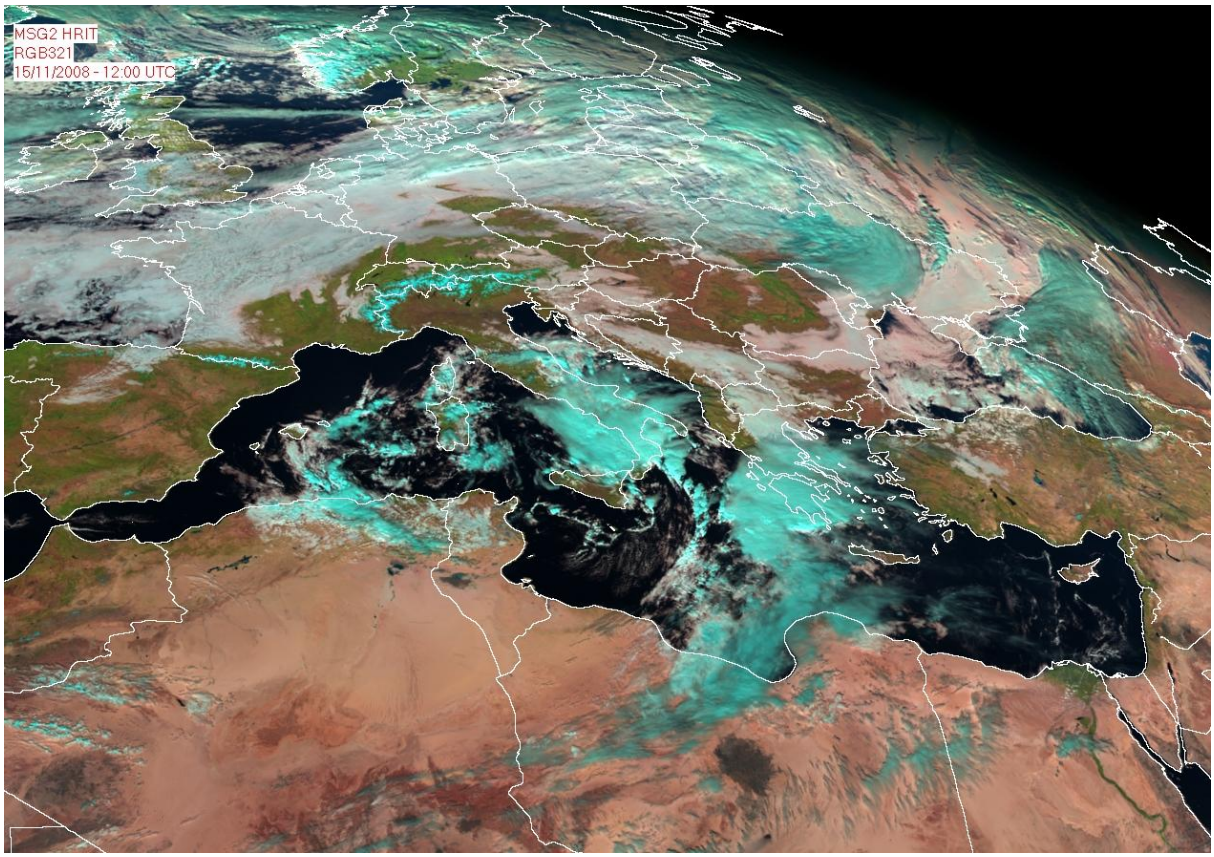

Figure 9. RGB 321 application dated 15/11/2008, 12:00 GMT.

7 Validation

Due to validate SR product against in-situ observation, synoptic observation from Turkey and Finland for November 2008 are considered. But not enough data was available for validation for the that period. Because cloud cover was dominant for nearly the whole period over Finland and less snowfall observed over Turkey. For this reason, data from some European countries such as, Norway, Austria and Slovakia are considered instead. But the dataset was decoded from GTS (Global Telecomunication System) files which may contain some problems and represent less reliability. This should be taken into consideration while examining the conclusions below.

The validation snow depth dataset has been collected from 858 synoptic and climate stations in Finland, Norway, Turkey, Austria and Slovakia. The distribution map of the stations is given Figure 10.

Figure 10. Distribution map of the snow depth stations with WMO indicator.

On the other hand, if the product pixel was assigned as cloud or no data then that observation was not included in the calculation even if the observation was snow.

This study should be only considered as readiness of the product validation.

7.1 Calculation of Metrics

First a,b,c and d values is calculated using Table 3.

Table 3. Contingency table representation for the snow recognition product validation

		Snow Cover Product	
		Snow Presence	None
In-situ Observation	Snow Presence	a	b
	None	c	d

After that statistical metrics is calculated using below equations.

$$POD = a / (a+b) \quad (1)$$

$$HR = (a+d) / (a+b+c+d) \quad (2)$$

$$CSI = a / (a+b+c) \quad (3)$$

$$FAR = c / (a+b+c+d) \quad (4)$$

$$SMR = b / (a+b+c+d) \quad (5)$$

7.2 Validation Results

According to previous experience, statistical metric results seems working well. In this case, after 10th of November, POD is fluctuation between 60-100 percentages(see Figure 11). HR is overall observed to be between 90-100 percentages because of very well recognition of bare land(Figure 12). CSI(Figure 13) also shows same pattern as POD and varies between 20-50 percentages. FAR(Figure 14) and SMR(Figure 15) seem to be very well but it is because of well recognition of bare land, not snow. Overall average of statitical metrics are given at Table 4.

Table 4. Overall average of the metrics.

	Average
POD	64.63
HR	96.47
CSI	26.60

FAR	2.99
SMR	0.54

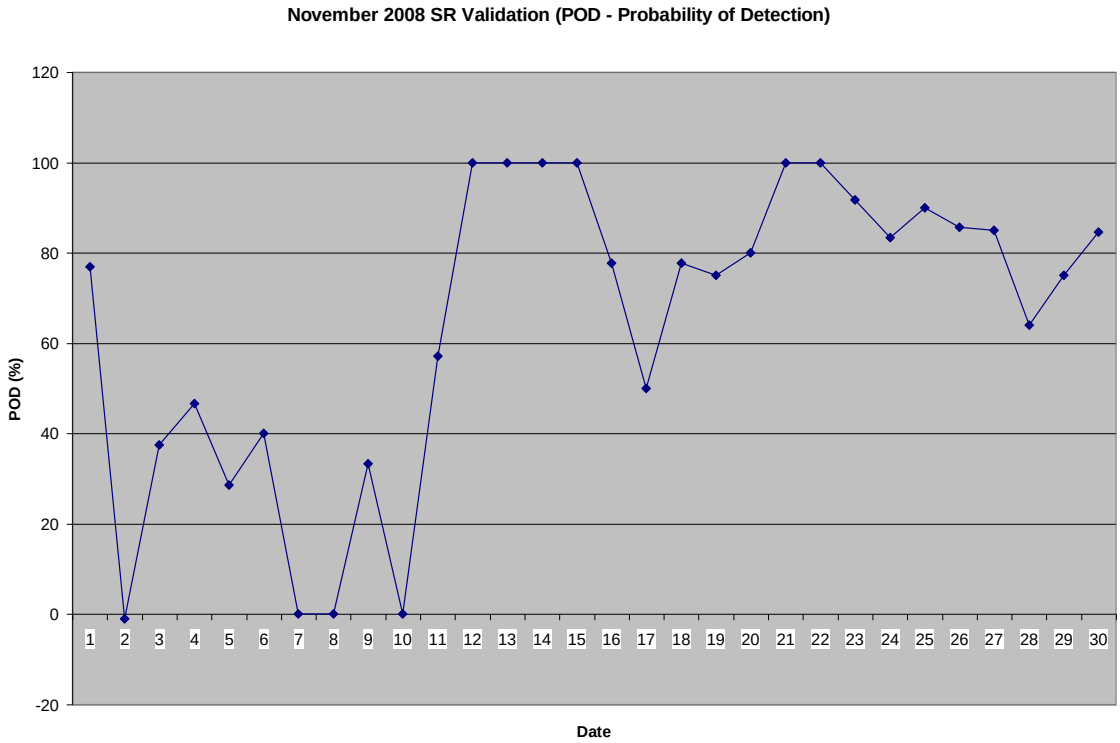

Figure 11. POD time series for November 2008.

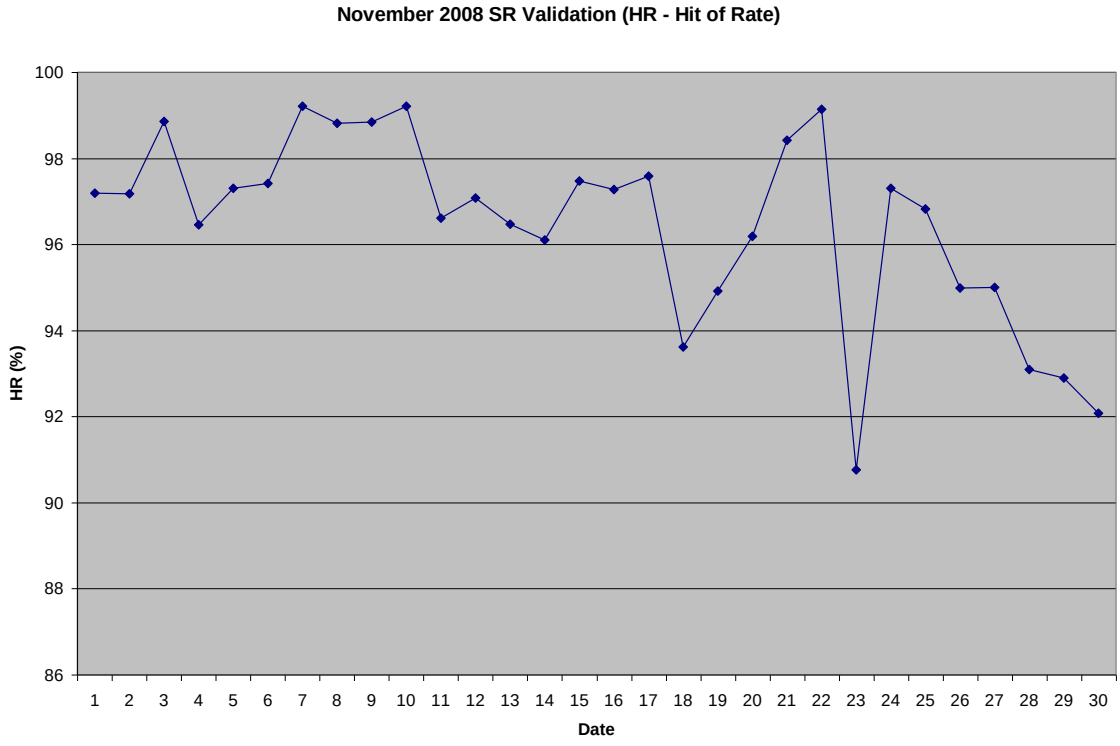

Figure 12. HR time series for November 2008.

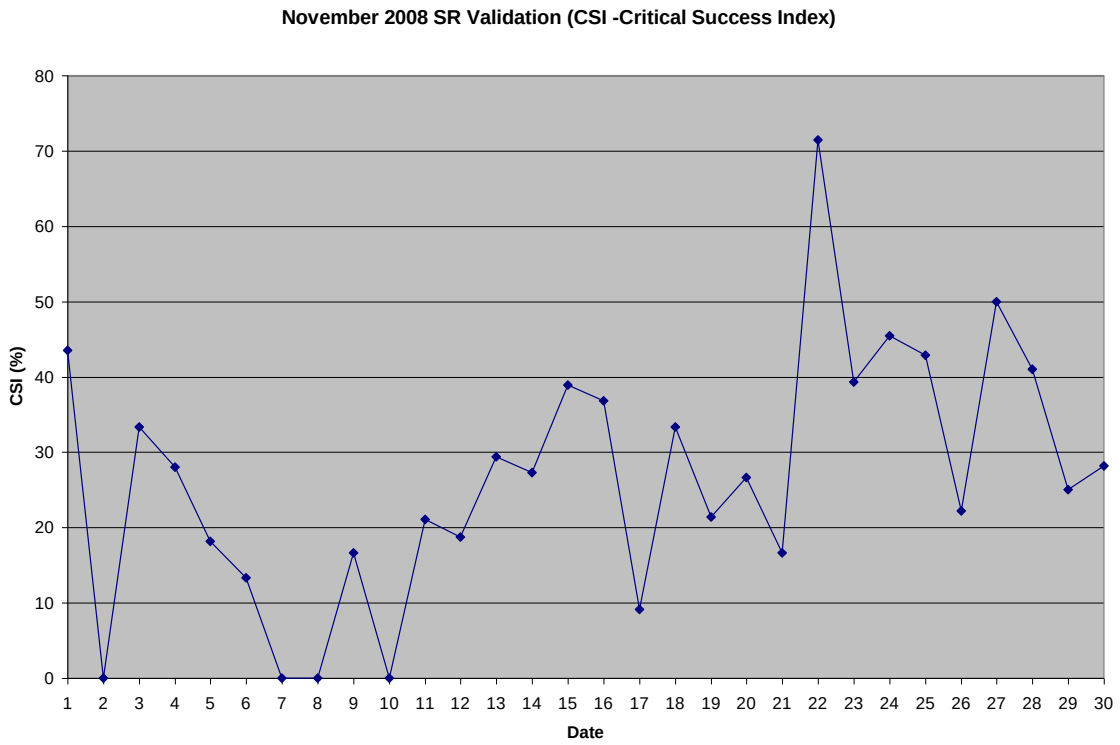

Figure 13. CSI time series for November 2008.

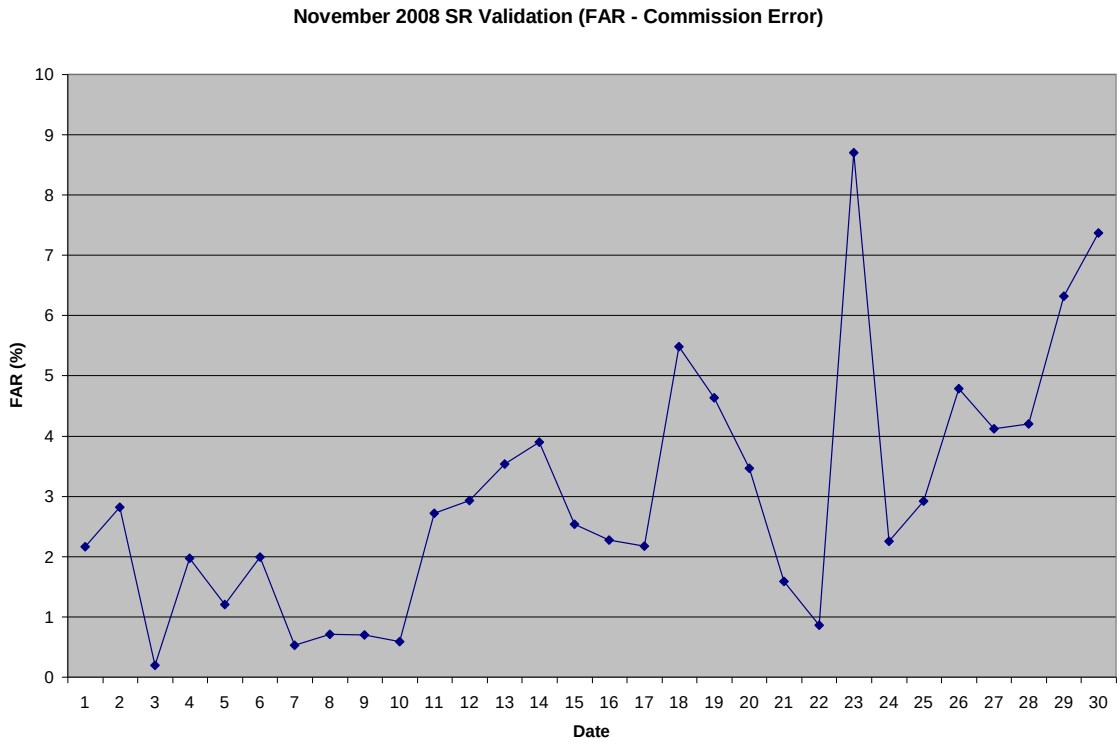

Figure 14. FAR time series for November 2008.

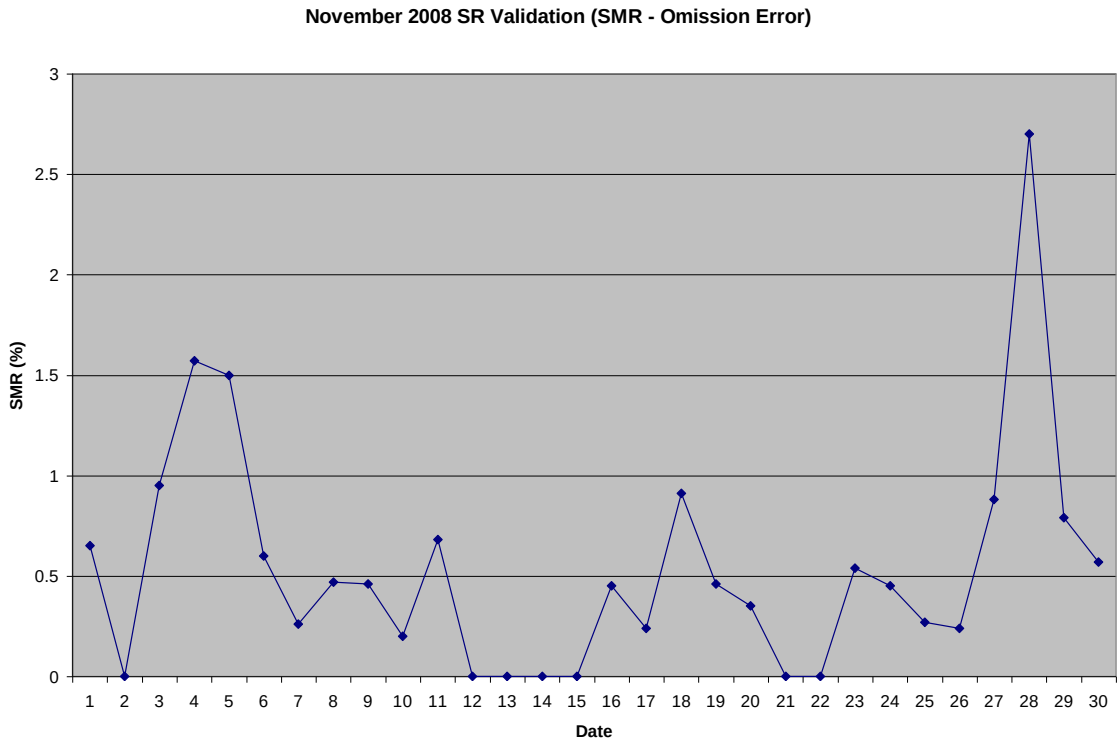

Figure 15. SMR time series for November 2008..

8 Conclusion and Discussion

During the 3 month VS period, SR and FSC product merging algorithms and necessary software tools have been developed. First test results have been put into FMI's ftp site for the consideration of the cluster members. Validation of merged products will be performed end of the snow year covering period of October 2008 – April 2009 for future work. Meanwhile for November 2008, merged SR product validation has been performed by comparing with the in-situ observations and results are discussed above. This validation study is limited and long term validation will be performed when larger datasets (in time domain) are available. Merging algorithm and validation study has been submitted to IGARSS 2009 Conference and accepted by the Scientific Committee. The abstract is attached at the end of this report. Similar merging algorithm will be used for SWE product when this product is available for use. Operational product merging system architecture has been planed and will be put into practice before mid 2009.

9 Acknowledgments

I appreciate FMI’s hospitality and co-operation during my visit and I take this opportunity to thank FMI’ staffs who are involved in this VS activity.

I would like to thank to METU HSAF and TSMS HSAF team members for their valuable contributions.

I also would like to thank to HSAF management and EUMETSAT to give this opportunity to myself.

Attachment A – Abstract for IGARSS 2009 Conference

Merging Flat/Forest and Mountainous Snow Products for Extended European Area

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[2] Turkish State Meteorological Service

Abstract

In the frame of EUMETSAT Hydrology and Water Management Satellite Application Facilities (H-SAF) project, two different approaches have been developed for snow products. One is focused on flat/forested areas and has been developed by Finnish Meteorological Institute (FMI) (originally for EUMETSAT Land-SAF), and the other one by Turkish State Meteorological Service (TSMS) for mountainous areas. Snow cover over mountainous areas and over flat/forest areas show completely different physical properties, thus usage of two separate algorithms makes it possible to get better results. On the other hand, the Project Plan of H-SAF states that the users should be offered unified snow products covering the H-SAF domain.

In this study we introduce a method for merging the two snow recognition products, and also discuss the first results from validation. The products have different projections and nearest neighbor approach was selected for data co-location. The main idea of the merging algorithm is to minimize projection errors and try to reflect the strengths of the two algorithms in the final merged product. A mask based on digital elevation model (DEM) was used to separate the mountainous pixels from flat/forested areas. The merging algorithm finds the exact location of the non-mountainous pixels using this mask. These values are then replaced the values from the product for flat and forested areas.

The method was first tested for the daily products of November 2008. The merged products were visually compared against METEOSAT RGB images. The merged products were found noticeably better than the stand-alone products according to visual comparison. While comparing the products separately to the RGB composites, it came apparent that flat/forest product underestimates the snow on mountainous regions, and the product for mountainous regions misclassified pixels on non-mountainous areas. With the merging, most of these errors are removed.

First validation results against in-situ observations are also presented.