EUMETSAT
H SAF

VALIDATION of H-SAF SNOW PRODUCTS

Alexander Toniazzo

Civil Protection Italy - Rome

SUMMARY

- **Snow Products in H-SAF**

- **Validation results, performances and limitations**

- **Discussion and questions**

Snow Products in H-SAF

Legacy products over European area - operational

- H10 Snow detection – Snow cover

- H11 Snow status (wet/dry)

- H12 Effective (Fractional) Snow Cover FSC

- H13 Snow Water Equivalent SWE

Global and hemispherical products:

- H34 and H35 new products (Snow det. and FSC) Pre-op

- H31 and H32 ex L-Saf products (Snow det.) Op

Ground Station Network

**Weather stations
and snow
detection: manual
and automatic**

SWE Stations

Country	Type	Number of Stations
Finland	Synoptic	190
Turkey	Synoptic	85
Italy	Snow/Avalanche	264
Poland	Synoptic	595
Germany	Synoptic	1863
Belgium	Teleclim	84
TOTAL		3081
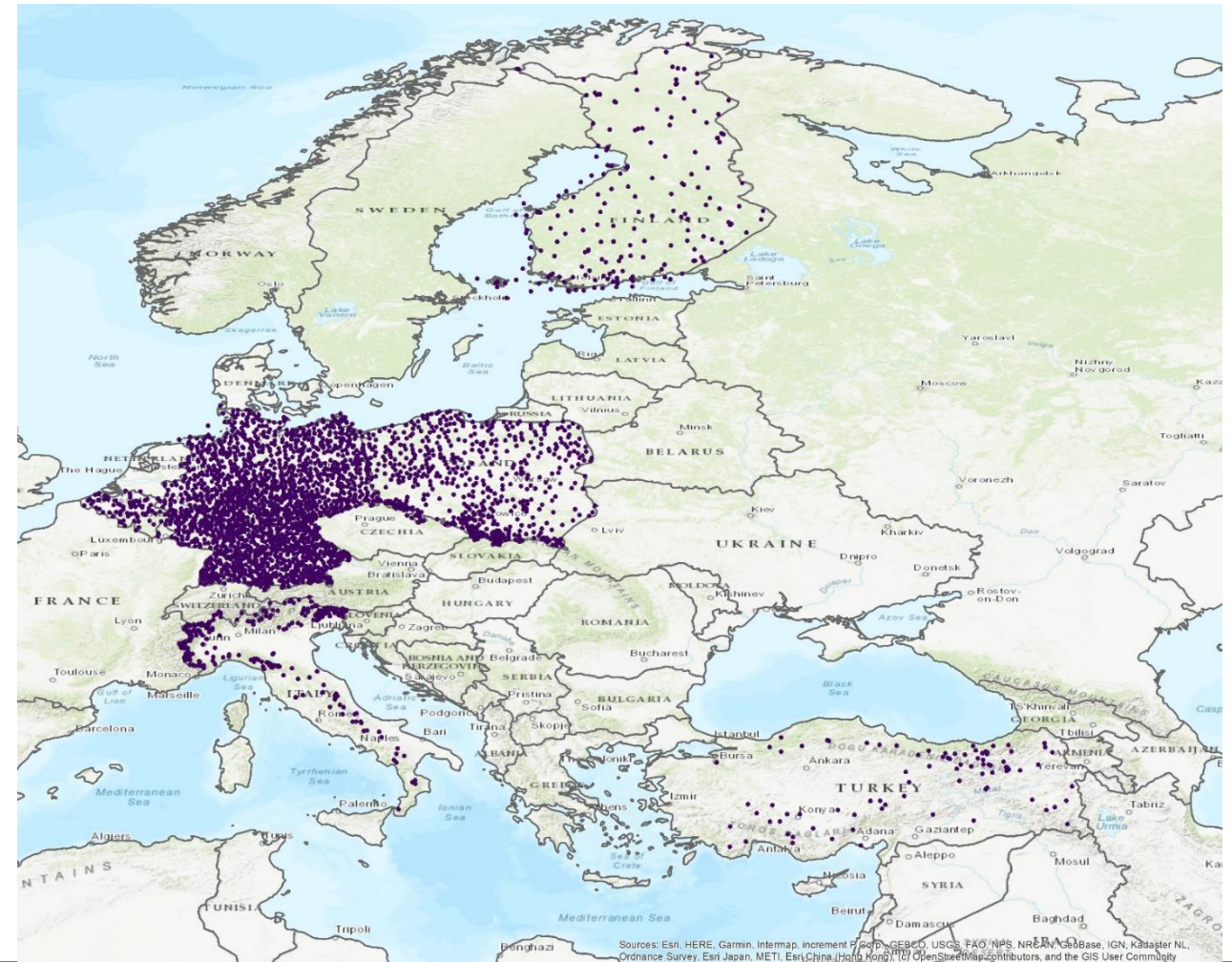
Ground Station Network

Weather stations: manual and automatic

In some countries WMO Weather Stations are used, in other counties dedicated Snow Station Networks provide the data for validation.

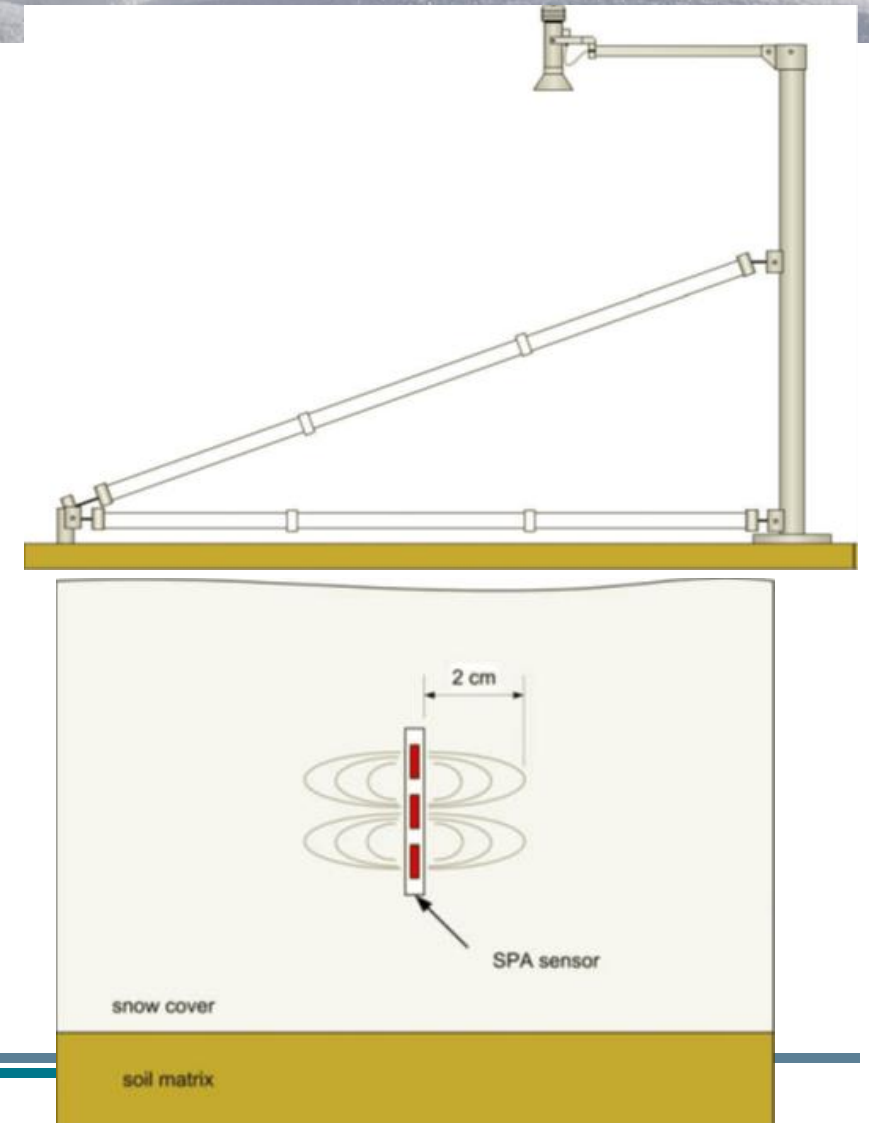*Snow field in the Italian Alps with an Automatic Snow and Meteorological Station*

Ground Station Network

SWE Stations
For validating SWE high quality ground data is used.

Example of Ground Station in Turkey –
Snow Pack Analyser (SPA).

The complete SPA System consists of two (2) SPA sensing bands with one installed horizontally 10 cm above the ground and the other installed at an angle (referred to as the sloping band), an impedance analyzer, an ultra-sonic snow depth sensor and mounting accessories to assure proper tension of the SPA bands. Each of the SPA bands sends frequencies into the snow pack and measures the complex impedance. Snow consists of ice, air and water. Each of these elements have different dielectric constants and when the band sends out the measuring frequencies it is able to read the returned value to determine the percentage of liquid water, ice and the remaining value as air.

Validation – Snow detection

•H10 (H31) H32 and H34:

Validation methodology - Confusion matrix:
Hits n11, False alarms n01
Misses n10, Correct negatives n00

$$\begin{bmatrix} n_{11} & n_{01} \\ n_{10} & n_{00} \end{bmatrix}$$

POD

FAR

$$POD = \frac{n_{11}}{n_{11} + n_{10}} \tag{1}$$

$$FAR = \frac{n_{01}}{n_{11} + n_{01}} \tag{2}$$

$$POFD = \frac{n_{01}}{n_{01} + n_{00}} \tag{3}$$

$$ACC = \frac{n_{11} + n_{00}}{n_{11} + n_{00} + n_{10} + n_{01}} \tag{4}$$

$$CSI = \frac{n_{11}}{n_{11} + n_{10} + +n_{01}} \tag{5}$$

$$HSS = \frac{2 \times (n_{11} \times n_{00} - n_{01} \times n_{10})}{[(n_{11} + n_{10}) \times (n_{10} + n_{00}) + (n_{11} + n_{01}) \times (n_{01} + n_{00})]} \tag{6}$$

Validation results H10

- H10 in OR10 snow season 2019-20:

POD slightly out of spec for Flat/Forest areas, but fully compliant for Mountainous areas. Problems arise in H10 if snow is scarce and snow cover is not homogeneous in space and time, as was in winter 2019/20 in central Europe.

Statistical scores for H10 over mountainous and flat areas period 1.10.2019-31.5.2020

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

H-SAF Accuracy requirements for H10 in Flat/Forest areas				
Product requirements				H10
Score	threshold	target	optimal	total
POD	0.80	0.85	0.99	0.74
FAR	0.20	0.15	0.05	0.27

H-SAF Accuracy requirements for H10 in Mountainous areas				
Product requirements				H10
Score	threshold	target	optimal	total
POD	0.60	0.70	0.99	0.70
FAR	0.30	0.20	0.05	0.22

Validation results H10

•H10 in OR10 snow season 2019-20:

Validation has been performed over Belgium, Finland, Germany, Italy, Poland and Turkey.
The results are showed separately for flat and mountainous areas to provide complete error information on the product performances related to the orography.

Statistical scores for H10 over mountainous and flat areas period 1.10.2019-31.5.2020

flat area	Belgium	Finland	Germany	Poland	Average
numbers of obs	2113	6910	1920	10331	--
pod	1.00	0.94	0.53	0.48	0.74
far	0.21	0.22	0.31	0.35	0.27
csi	0.79	0.74	0.43	0.38	0.59
pofd	0.00	0.18	0.02	0.03	0.06
acc	1.00	0.87	0.88	0.91	0.92

mountainous	Italy	Germany	Poland	Turkey	Average
numbers of obs	1717	1464	974	8299	--
pod	0.55	0.76	0.57	0.91	0.70
far	0.08	0.60	0.09	0.10	0.22
csi	0.52	0.35	0.54	0.83	0.56
pofd	0.10	0.24	0.22	0.50	0.27
acc	0.67	0.56	0.62	0.84	0.67

Validation results H10

- H10 in OR8 snow season 2017-18

Statistical scores for H10 over mountainous and flat areas period 1.10.2017-31.5.2018

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

H-SAF Accuracy requirements for H10 in Flat/Forest areas				
Product requirements				H10
Score	threshold	target	optimal	total
POD	0.80	0.85	0.99	0.80
FAR	0.20	0.15	0.05	0.14

H-SAF Accuracy requirements for H10 in Mountainous areas				
Product requirements				H10
Score	threshold	target	optimal	total
POD	0.60	0.70	0.99	0.75
FAR	0.30	0.20	0.05	0.21

Validation H10 discussion

Problems arise in H10 if snow is scarse and snow cover is not homogeneous in space and time, as was in winter 2019/20 in central Europe.

H 34: full disk extension of H10 (to superseed H10)
validation strategy as in H10 is used, with ground data of the same countries.
For extra H-SAF areas a new validation scheme using Sentinel2 data with European and extra-European target areas is used (CIMA).

H32: hemispherical Snow Detection Product ex L-SAF
Same strategy as in H34, with ground data over Europe and Satellite data (CIMA) over extra-European areas. Results are very good (High resolution)

Validation H11 Snow status (wet/dry)

H-SAF Accuracy requirements for H11			
Product requirements			
Score	threshold	target	optimal
POD	0.60	0.80	0.90
FAR	0.20	0.10	0.05

Finland	ott-19	nov-19	dic-19	gen-20	feb-20	mar-20	apr-20	mag-20	Total
numbers of obs	121	248	516	342	367	465	323	261	2643
pod	0.90	0.99	1.00	1.00	0.93	0.81	0.74	0.24	0.87
far	0.71	0.11	0.19	0.13	0.02	0.12	0.10	0.23	0.12
csi	0.08	0.88	0.81	0.87	0.91	0.73	0.69	0.23	0.78
pofd	0.69	1.00	1.00	1.00	0.53	0.65	0.49	0.10	0.63
acc	0.99	0.88	0.81	0.87	0.91	0.74	0.71	0.51	0.79

H11 is validated with a temperature proxy – so no measure about wetness of snow is made.

In areas where there is a homogenous and stable snow cover product H11 can be considered reliable.

If a clear snow melting period - that is areas with snow cover going from dry to wet in H11 - is detected by the product, the data is valuable and usable for those hydrological applications, in which snow melting is an important factor.

Validation H11 discussion

- H11 is restricted to flat areas in Nordic countries. Validation is performed only in in Finland, with an updated validation scheme since 2018.

- In the mean, product H11 satisfies the requirements, with results of POD between target and optimal and FAR between threshold and target.

- Validation group strongly recommends using product H11 in Nordic areas only during the winter and if snow cover is known to be sufficiently homogenous.

Validation H12 Effective (Fractional) SC

Since 2018 new satellite-based data validation, using Sentinel 2 high resolution data (20 m) in selected target areas (mountain and flat areas) CIMA.

H-SAF Accuracy requirements ESC Products			
Score	threshold	target	optimal
Flat/Forested areas RMSE	40%	20%	10%
Mountainous areas RMSE	50%	30%	10%

Validation in 2018 OR8

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

Scores	Aosta Valley	Pyrenees	Caucasus	Turkey
RMSE	48.47 %	49,36 %	43,41 %	19,88 %

Validation H12 and H35 discussion

- In all areas H12 product meets the RMSE-based accuracy requirements.

- CIMA study: threshold RMSE for mountainous areas not exceeded in any validation area, but values are just above threshold (very difficult mountainous terrain selected).

- Turkey study: values are much better and are between target and optimal. In areas where snow cover is more homogeneous in space and in time, H12 product has better performances, even in mountainous areas.

H 35: northern hemispheric extension of H12 (to superseed H12 in future)
Same validation strategy of H12 (CIMA)

Validation H13 Snow Water Eq.

H13: operational   Data from Poland, Finland, Turkey, Germany.
Thresholds are RMSE in mm of SWE.

Area	Threshold	Target	Optimal
flat (RMSE)	40 mm	20 mm	10 mm
mountain (RMSE)	45 mm	25 mm	15 mm

Between target and optimal	Between threshold and target	Threshold exceeded by < 50 %	Threshold exceeded by ≥ 50 %

Validation in 2021 OR10

H-SAF Accuracy requirements for H13								
Product requirements				RMSE (mm)				
	threshold	target	optimal	AVERAGE	Poland	Finland	Turkey	Germany
N. samples					441	597	2848	1637
Mountainous	45 mm	25 mm	15 mm	39.2 mm			39.2 mm	
Flat Area	40 mm	20 mm	10 mm	23.5 mm	9.5 mm	36.7 mm		24.2 mm

EUMETSAT
H SAF

Validation H13 details

Detail over Finland and Turkey

General underestimation of SWE when values are larger than 150 mm.
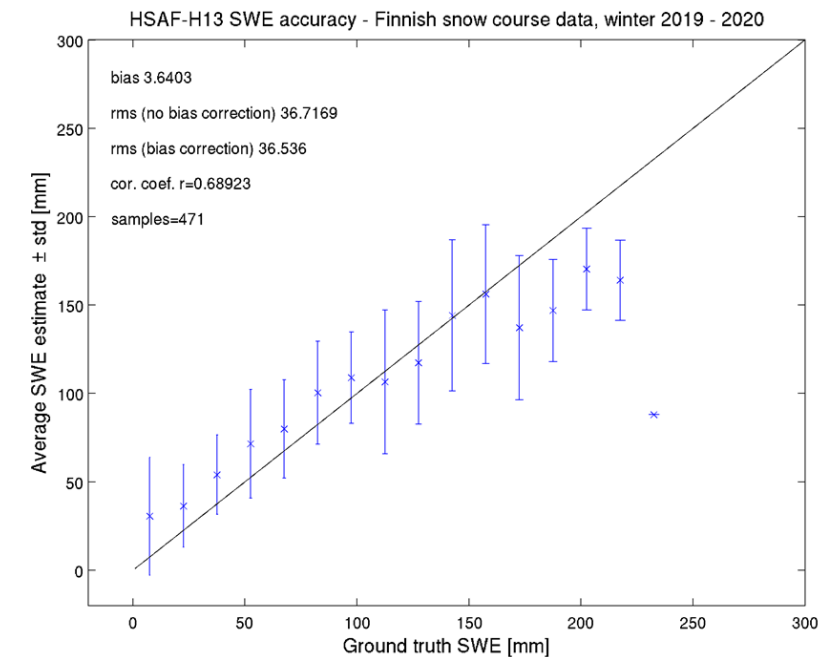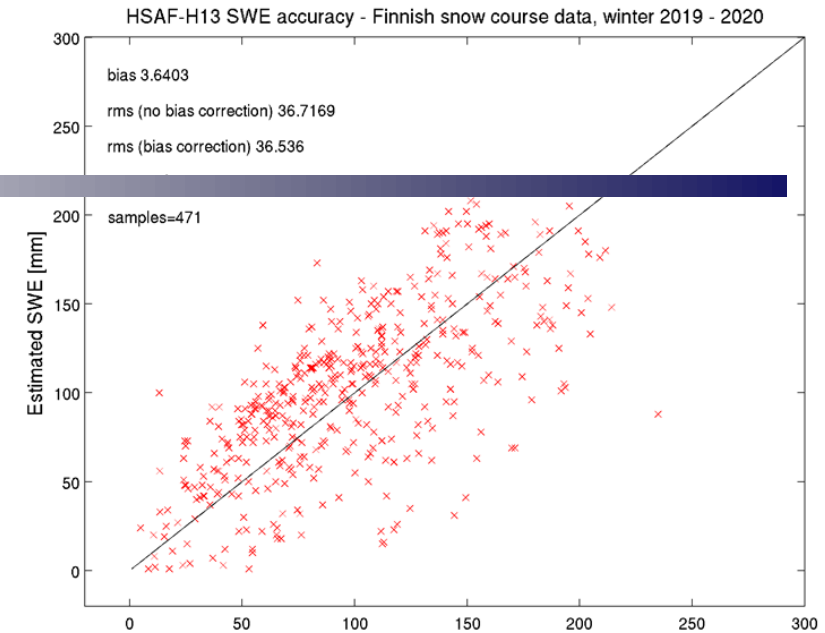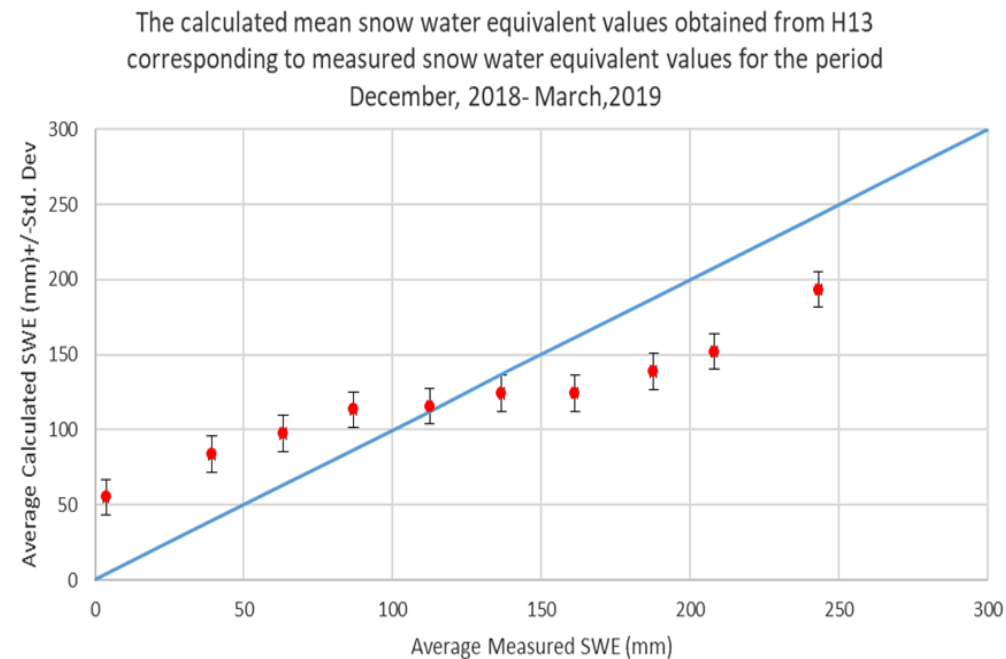
Validation H13 discussion

- H13 satisfies the Product Requirements, with <u>RMSE between threshold and target</u> values.

- Since the SWE product is developed for dry snow conditions, <u>validation period</u> is selected as December to March (or to April). In Finland, where snow cover is more stable, the whole period October-May is evaluated.

- <u>Best performance</u> are obtained in flat areas.

- Turkish and Finnish studies: <u>general underestimation</u> of SWE when values are larger than 150 mm, slight <u>overestimate</u> below.

RECAP

1. Snow Detection Products (Snow Cover) H10, H34, H32
   - Best performances in flat areas, were snow cover is more homogeneous
   - Problems arise in non homogeneous snow cover (space and time)
   - Validation with ground data very difficult (filtering needed). Better performances with high resolution satellite data (CIMA)

2. Snow Status (Dry/Wet) H11: Validation suggest use only in Nordic areas (flat). Validation very difficult due to proxi data (temperature)

3. Fractional/Effective Snow Cover H12 and H35: Validation results good in flat areas, acceptable in mountainous areas, due to problems of resolution (complex terrain) and not homogeneous snow cover in mountains

4. SWE Products H13: Performances are better in flat areas (RMSE 10-20 mm), in mountainous areas RMSE around 40 mm. Underestimate if more than 100 cm snow.

Eumetrain EW 2021

EUMETSAT
H SAF

Thank You!

Snow Event Week | EUMETrain | 22-26 November 2021