



snowpex

*SnowPEX –
The Satellite Snow Product Intercomparison
and Evaluation Exercise*

3rd International Satellite Snow Products Intercomparison (ISSPI-3) Workshop Report

Deliverable D19

Prepared by

Gabriele Schwaizer, Thomas Nagler, Lars Keuris, ENVEO, Austria

Chris Derksen, Lawrence Mudryk, Colleen Mortimer, ECCO, Austria

Kari Luojus, FMI, Finland

Sari Metsämäki, SYKE, Finland

Issue / Revision: 1/0

Date: 03.12.2021



Document controlled by: Gabriele Schwaizer

SnowPEX+ Report

SUBJECT:

3rd International Satellite Snow Products Intercomparison (ISSPI-3)
Workshop Report

PROJECT COORDINATOR:

ENVEO

ISSUE / REVISION:

1/0

CONTRACTOR'S REF:

Deliverable D19

This deliverable provides a summary on the 3rd International Satellite Snow Product Intercomparison Workshop organized in the frame of the SnowPEX+ project.

AUTHORS:

G. SCHWAIZER, T. NAGLER, C. DERKSEN, K. LUOJUS, L. MUDRYK, S. METSÄMÄKI, L. KEURIS, C. MORTIMER

This page is intentionally left blank.

DOCUMENT CHANGE LOG

Issue / revision	Description	Date	Author(s)
1/0	First Version	03.12.2021	Schwaizer et al.

This page is intentionally left blank.

TABLE OF CONTENTS

1. ISSPI-3 WORKSHOP.....	1
1.1 Preparations.....	1
1.2 Organization.....	1
2. PARTICIPANTS	2
3. PRESENTATIONS	3
3.1 Presentations on SCE products participating in SnowPEX+	3
3.2 Presentations on SWE products participating in SnowPEX+	4
3.3 Presentations on Reference data sets	4
3.4 Presentations on product requirements and next steps	4
4. DISCUSSION.....	5
5. CONCLUSIONS	6
A ISSPI-3 AGENDA.....	7
B WEBEX CHAT	9

This page is intentionally left blank.

1. ISSPI-3 WORKSHOP

The 3rd International Satellite Snow Product Intercomparison (ISSPI-3) aimed on inform the international snow community on the SnowPEX+ activities and to initiate the compilation of hemispheric to global satellite snow products and of snow reference data available for the period October 2014 – September 2020.

1.1 Preparations

The ISSPI-3 workshop was prepared as virtual meeting, as the global COVID-19 crisis prohibited travelling and the organization of large physical meetings with participants from all around the world.

An online registration via the SnowPEX webpage (<https://snowpex.enveo.at>) was prepared, and information was sent to all participants of the ISSPI-1 and ISSPI-2 workshops as well as to the wider snow community. The workshop was also announced at the European Polar Science Week on 29 October 2020 and at the ESA Earth Observation for Water Cycle Science 2020 from 16 - 19 November 2020 and at the Snow International (SINTER) quarterly online meeting on 8 January 2021.

As part of the online registration, participants had the option to add a title for a presentation on a snow cover extent (SCE) or snow water equivalent (SWE) product or on reference (REF) data. For the presentation of the products and reference data sets, a template was provided to all presenters with instructions on the level of detail to be provided. For each session, all slides from all presenters were merged into each one presentation, which are provided via the SnowPEX webpage as PDF (agreed by all presenters).

1.2 Organization

The ISSPI-3 workshop was organized as virtual event. ESA hosted the Webex meeting and provided the also technical support for all participants as needed.

The workshop started as planned on Wednesday, 03.02.2021 at 16:00 CET. The detailed agenda is provided in annex A.

The Webex chat was used by the participants for raising questions, commenting to presentations or providing useful information for further readings. The chat messages addressed to all participants are provided in annex B.

The ISSPI-3 workshop was closed on 03 February 2021 at 19:15 CET.

2. PARTICIPANTS

Via the online registration tool, 65 valid registrations were made. Of these 65 registrations, 21 provided a title for a presentation.

Finally, 61 participants from 32 different affiliations located in Europe, US/Canada and Asia attended the ISSPI-3 workshop (Figure 2.1), and 20 presentations on satellite snow products and reference data were given (Table 2.1). Details on the presentations are given in Section 3.

Table 2.1: ISSPI-3 participants.

	# of participants	# of affiliations	Presentations		
			SCE products	SWE products	REF data
Europe	27	10	4	2	1
US/CA	26	17	6	3	3
Asia	8	5	1	0	0
TOTAL	61	32	11	5	4



Figure 2.1: Camera snapshot of some of the ISSPI-3 workshop participants.

3. PRESENTATIONS

After a presentation on the main objectives of SnowPEX+ and of the ISSPI-3 workshop by T. Nagler, presentations were given in the frame of three main sessions: SCE products participating in SnowPEX+, SWE products participating in SnowPEX+, and Reference data sets. Finally, requirements for the products to participated and an overview on the next steps were presented.

3.1 Presentations on SCE products participating in SnowPEX+

The following list, structured by author(s), affiliation and presentation title shows the SCE presentations given in this order:

1. David Robinson (Rutgers University): Rutgers Northern Hemisphere 24 km Weekly Snow Cover Extent, Sept 1980 onward
2. Walt Clark (U.S. National Ice Center, NOAA NWS OPC Ice Services Branch): Interactive Multisensor snow and Ice Mapping System (IMS)
3. Masahiro Hori (University of Toyama): JASMES Snow Cover Product (snwcfrr)
4. Thomas Nagler, Gabriele Schwaizer, Lars Keuris, (ENVEO) and Sari Metsämäki, and Kirsikka Heinilä, (SYKE): SNOW-CCI FSC Product
5. Peter Romanov (NOAA/NESDIS & NOAA-CREST/CUNY): Global Multisensor Automated Snow/Ice (GMASI)
6. George Riggs (SSAI): MODIS and VIIRS Snow Cover Products
7. Gabriele Schwaizer, Thomas Nagler, Lars Keuris (ENVEO) Sari Metsämäki (SYKE), Kari Luojus (FMI): Northern Hemisphere Snow Cover Extent of the Copernicus Global Land Monitoring Service
8. Karl Rittger (University of Colorado, Boulder), Thomas Painter (University of California, Los Angeles), Jeff Dozier (University of California, Santa Barbara): SCAG (snow cover and grain size)
9. Edward Bair, Timbo Stillinger, Jeff Dozier (UCSB): SPIReS
10. Rune Solberg (NR) and Mari Anne Killie (MET Norway): CryoClim
11. Matias Takala, Niilo Siljamo (Finnish Meteorological Institute): EUMETSAT H SAF products H10 / H31 (H32)

3.2 Presentations on SWE products participating in SnowPEX+

The following list, structured by author(s), affiliation and presentation title shows the SWE presentations given in this order:

1. Richard Kelly, University of Waterloo: JAXA Daily Snow Depth Product Satellite-based Microwave Snow Algorithm (SMSA)
2. Kari Luojus, J. Pulliainen, M. Takala, J. Lemmetyinen, M. Moisander, P. Venäläinen, et al. (FMI) C. Derksen, et al. (ECCC): ESA Snow CCI SWE
3. Chris Derksen (ECCC): Gridded Reanalysis-Driven SWE Products
4. Edward (Ned) Bair, UCSB; Karl Rittger, CUB: The Parallel Energy Balance Model
5. Patricia de Rosnay, Joaquin Munoz-Sabater, Hans Hersbach (ECMWF): ERA5 family: ERA5, ERA5-Land, ERA5-Snow SWE reanalysis and model products

3.3 Presentations on Reference data sets

The following list, structured by author(s), affiliation and presentation title shows the presentations on reference data given in this order:

1. Colleen Mortimer, Chris Derksen, Lawrence Mudryk (ECCC) Kari Luojus, Pinja Venäläinen, Mikko Moisander (FMI), Sari Metsämäki (SYKE): In Situ Reference Data
2. *Lars Keuris*, Thomas Nagler, Gabriele Schwaizer (ENVEO): High-Resolution Reference Data Set
3. Eunsang Cho (NASA GSFC, USA, University of Maryland), Jennifer Jacobs (University of New Hampshire), Carrie Vuyovich (NASA GSFC), Carrie Olheiser (NOAA National Operational Hydrologic Remote Sensing Center): 40-years airborne gamma radiation SWE
4. Christopher Crawford (U.S. Geological Survey Earth Resource Observation and Science Center) and David Selkowitz (Nevada Water Science Center): U.S. Geological Survey Landsat Fractional Snow Covered Area (fSCA)

3.4 Presentations on product requirements and next steps

Gabriele Schwaizer introduced the requested product specifications for the snow products to participated.

Thomas Nagler gave an overview on the next steps and activities planned in the project.

4. DISCUSSION

All snow products presenters agreed to participate in the SnowPEX+ activities and prepare the products according to the specifications. ENVEO reconfirmed that a technical note with the details on the requested product specifications will be sent to all product providers. ENVEO also offered to support the product providers with this step if needed. An FTP hosted by ENVEO will be set up to collect all the data. Each product provider will get a personal account to access and provide the product(s).

It was discussed and agreed that all snow products should be prepared and provided in the original map projection and pixel spacing.

The product intercomparisons for SCE products are planned to be made at 5 km pixel spacing. The product intercomparison for SWE products are planned on 25 km pixel spacing. The satellite snow product validation is planned in the original map projection and pixel spacing of each product.

Also, all owners of the reference data sets presented at the ISSPI-3 workshop agreed to provide the data for the SnowPEX+ validation activities. It was reconfirmed that the data will only be used in the frame of the SnowPEX+ activities, and that the data will not be shared with any third parties.

For the preparation of reference snow maps from high resolution optical satellite data, a focus group was initiated by ENVEO. The following participants showed interest and confirmed to contribute to the focus group under the lead of ENVEO:

- ENVEO: Thomas Nagler, Gabriele Schwaizer, Lars Keuris, Nico Mölg
- SYKE: Sari Metsämäki
- UCSB: Jeff Dozier, Karl Rittger, Ned Bair, Timbo Stillingner
- USGS: Chris Crawford
- TAG LLC: Igor Appel
- University of Arizona: Elzbieta Wisniewski

5. CONCLUSIONS

With the agreement of all satellite snow product providers and owners of snow reference data to participate and contribute to the SnowPEX+ activities, the main objective of the ISSPI-3 workshop was achieved. The presentations of the ISSPI-3 workshop are available at <http://snowpex.enveo.at/workshops.html> (agreed by all presenters).

As next steps, the data collection will be organized.

Also, the focus group initialized during the ISSPI-3 workshop will be further established by focus group meetings to discuss in more detail the main objectives and the next steps.

Another ISSPI workshop is planned to be organized when first intercomparison and validation results are available for discussion.

A ISSPI-3 AGENDA

Start time	End time	Topic	Presenter
16:00	16:10	Welcome	Nagler / ENVEO, Kern / ESA, Nitu / WMO
16:10	16:25	SnowPEX Achievements, Motivation for SnowPEX+ and goals	Nagler / ENVEO
Presentations of SCE products participating in SnowPEX+			Moderation: Luojus / FMI
16:25	16:30	Rutgers Northern Hemisphere 24 km Weekly SCE, Sept 1980 onward	Robinson / Rutgers University
16:30	16:35	IMS	Clark / US National Ice Center
16:35	16:40	JASMES	Hori / University of Toyama
16:40	16:45	Snow CCI SCFG & SCFV	Nagler / ENVEO
16:45	16:50	Global Multisensor Automated Snow/Ice Maps (GMASI)	Romanov / NOAA CREST
16:50	16:55	MODIS and VIIRS CMG products	Riggs / SSAI
16:55	17:00	GlobLand NHEMI SCE	Schwaizer / ENVEO
17:00	17:05	MODSCAG	Rittger / INSTAAR
17:05	17:10	SPIReS (generalized multispectral, regional)	Dozier / UCSB
17:10	17:15	CryoClim	Solberg / NR
17:15	17:20	EUMETSAT HSAF H10 / H31 Snow Extent	Takala / FMI
Presentations of SWE products participating in SnowPEX+			Moderation: Mudryk / ECCC
17:25	17:30	JAXA AMSR2	Kelly / University of Waterloo
17:30	17:35	Snow CCI SWE products	Luojus / FMI
17:35	17:40	Gridded SWE products	Derksen / ECCC
17:40	17:45	SWE from Parallel Energy Balance Model (ParBal)	Bair / UCSB,
17:45	17:50	ERA5 family of snow analyses	de Rosnay / ECMWF

17:50	18:00	Break	
Reference data sets			Moderation: Metsämäki / SYKE
18:00	18:10	Validation method and in-situ data	Mortimer / ECCC
18:10	18:15	Intercomparison method and HR reference data set	Keuris / ENVEO
18:15	18:20	40-year airborne gamma SWE product over the CONUS	Cho / NASA GSFC
18:20	18:25	USGS Landsat Fractional Snow Cover	Crawford / USGS
18:25	18:30	Landsat Fractional Snow Cover with ANN	Wisniewski / University of Arizona
Discussion and Outlook			
18:30	18:35	Requirements for snow products to participate	Schwaizer / ENVEO
18:35	18:55	Discussion	Nagler / ENVEO
18:55	19:00	Next steps and closing of meeting	Nagler / ENVEO

B WEBEX CHAT

Chat messages to all participants:

Sophie Roberge to all: 4:26 PM

I would like to ask a question about algorithms. It says there are algorithms improvements made. Is it regarding the ones regarding reference datasets (e.g. Landsat imagery)?

Jeff Key to all: 4:38 PM

IMS is a great product for validating other satellite-derived snow and ice masks (detection only), providing something close to "truth".

Sophie Roberge to all: 4:40 PM

I'm performing SCE using Klein algorithm on Landsat imagery. Is this one still up-to-date to monitor snow in forests?

Kari Luojus FMI to all: 4:40 PM

Yes, let's keep the discussion and questions on the chat, our schedule is a bit crowded for questions during the presentations. Thanks!

Jeff Dozier to all: 4:41 PM

The USGS product, which Chris Crawford will present, is currently the most up-to-date approach that has been applied at continental scale (western U.S.).

Sophie Roberge to all: 4:43 PM

Ok, then I will listen well on this presentation!

Karl Rittger to all: 4:52 PM

For Tommy: surprised to see that uncertainty for viewable and on the ground snow appear to be very similar. I'd expect larger uncertainties for on the ground snow cover.

Thomas Nagler / ENVEO to all: 4:53 PM

@karl: i open land (no forests) both products provide the same FSC and RMSE, in forested areas RMSE is higher, depends on the density of the forest

Simon Gascoin to all: 4:54 PM

Please everyone have a look at the Snow and Ice Products Focus Area Products and let us* know if your product is missing or not correctly described <https://lpvs.gsfc.nasa.gov/producers2.php?topic=snow> (*us: Chris Crawford and I - CEOS LPV leads for snow focus area)

Simon Gascoin to all: 4:55 PM

(only operational products)

Karl Rittger to all: 5:02 PM

George: Is the gap filled product created every day or just a historical record?

Karl Rittger to all: 5:15 PM

I should note that Kat Bormann contributes to the SCAG efforts. Sorry for leaving you off Kat!

Kat Bormann to all: 5:15 PM

Thanks Karl!!

Thomas Nagler / ENVEO to all: 5:24 PM

@Jeff: Can Spires be used to contribute to a LS/S2 snow referenc data set used in SnowPex ?

Timbo Stillingner to all: 5:28 PM

@Thomas: Yes, SPIReS can be used to contribute to LS/S2 reference dataset. We also have a workflow for quickly generating Worldview 2/3 reference FscA maps and existng fscA maps for validaiton are avabile as an example: <https://doi.org/10.5281/zenodo.4031446>

Timbo Stillingner to all: 5:29 PM

the WV2/3 fscA validaiton maps are derived from binary 1/2 meter pansharpned WV2/3 data

Mary Jo Brodzik to all: 5:47 PM

Kari: are you using the new enhanced-resolution passive microwave inputs?

Kat Bormann to all: 5:49 PM

Chris: ASO has a lot of mountain SWE estimates from snow depth observations

Kat Bormann to all: 5:49 PM

feel free to reach out: kat.j.bormann@airbornesnowobservatories.com

Kari Luojus FMI to all: 5:51 PM

Yes Mary Jo, we are using the enhanced-resolution input data (D.G. Long and D.L. Daum, "Spatial Resolution Enhancement of SSM/I Data," IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, No. 2, pp. 407-417, Mar. 1998.). We have acquired the data from NSIDC.

Mary Jo Brodzik to all: 5:52 PM

Awesome, glad to hear it!

Gabrielle De Lannoy to all: 5:54 PM

Another option for mountain snow estimates: Lievens, H., Demuzere, M., Marshall, H.P., Reichle, R., Brucker, L., Brangers, I., de Rosnay, P., Dumond, M., Girotto, M., Immerzeel W., Jonas, T., Kim, E., Koch, I., Marty, C., Saloranta, T., Schober, J., De Lannoy, G.J.M. (2019). Snow depth variability in the Northern Hemisphere mountains observed from space. Nature Communications, 10, 4629, <https://doi.org/10.1038/s41467-019-12566-y>.

Kari Luojus FMI to all: 5:57 PM

Thank you for producing the data Mary-Jo!! So we are using this: Brodzik, M. J., D. G. Long, M. A. Hardman, A. Paget, and R. Armstrong. 2016, Updated 2020. MEASUREs Calibrated Enhanced-Resolution Passive Microwave Daily EASE-Grid 2.0 Brightness Temperature ESDR, Version 1. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: <https://doi.org/10.5067/MEASURES/CRYOSPHERE/NSIDC-0630.001>

Christopher Derksen to all: 6:04 PM

Thanks for all the suggestions on mountain SWE. I will send a follow-up email.

Jeff Dozier to all: 6:13 PM

ASO and Sentinel-1 can estimate depth. Translation to SWE depends on an estimate of density. Moreover, density appears perhaps implicitly in the passive microwave retrievals. Is there important new work in modeling density, or does it all just go back to Kojima 1969?

Ned Bair to all: 6:14 PM

SLF's SNOWPACK/Alpine3D has a good densification model based on discrete elements

Christopher Derksen to all: 6:15 PM

I'm personally biased to this study: Sturm, M., B. Taras, G. Liston, C. Derksen, T. Jonas, and J. Lea. 2010. Estimating snow water equivalent using snow depth data and climate classes. *Journal of Hydrometeorology*. 11: 1380-1394.

Richard Kelly to all: 6:17 PM

We use the paper Chris identifies to bracket upper and lower bounds as a function of snow class. Then have a simple time-sequential densification model. It is a single layer for tractability in a global context.

Kat Bormann to all: 6:18 PM

Great question Jeff - any physically based modeling of snow density inevitably depends on precipitation input, which we all know is challenging to get right.

Ned Bair to all: 6:21 PM

I'm concerned about the focus on viewable snowcover in the reference datasets and the lack of products that penetrate the canopy, e.g. aerial lidar.

Jeff Dozier to all: 6:21 PM

Hanzer et al (including Lehning among the et al) say "whereas in SNOWPACK/Alpine3D it is modeled as a function of the wet-bulb temperature T_w (°C): "

Gabrielle De Lannoy to all: 6:22 PM

very interesting question indeed; we assimilate snow depth into a physically based model to get SWE, but you are right that the density modeling is a challenge.

Simon Gascoin to all: 6:22 PM

future thermal infrared missions with high revisit time may provide useful information to better constrain density (CNES/ISRO Thrishna, Copernicus LSTM)

Vincent Vionnet ECCO to all: 6:28 PM

@Jeff, the equation in Hanzer et al (2020) that depends on T_w is for the density of freshly produced technical snow. The snow density module in Snowpack is described in the original Snowpack papers from 2002.

Jeff Dozier to all: 6:30 PM

Thanks @Vincent. While I'm on the Webex, I don't want to VPN into my university to get to the journals. I will re-read the original papers.

Thomas Nagler / ENVEO to all: 6:34 PM

@Chris: can you process LS data with TMSCAG in different regions, environments etc, processing the SnowPEX ref dta set

Sophie Roberge to all: 6:38 PM

My question was referring to Lars presentation

Ned Bair to all: 6:42 PM

Important detail. What spatial resolution will the SCE and SWE intercomparison be conducted at?

Jeff Dozier to all: 6:42 PM

@Gabi: We want to avoid reprojecting multiple times because each reprojection involves resampling. Therefore, I would recommend that the map projection use whatever the input data has.

Karl Rittger to all: 6:49 PM

Dave and I have both published using the ground temperature sensors. the daily time step is great

Simon Gascoin to all: 6:50 PM

if you want to collect in situ snow fraction during your weekends you can use that app <https://play.google.com/store/apps/details?id=com.cesbio.SDK&hl=fr>

Michael Kern (ESA) to all: 6:51 PM

very cool Simon!

Kat Bormann to all: 6:51 PM

some work done using airborne lidar and corrections for under canopy: Kostadinov, T. S., Schumer, R., Hausner, M., Bormann, K. J., Gaffney, R., McGwire, K., Painter, T. H., Tyler, S., & Harpold, A. A. (2019). Watershed-scale mapping of fractional snow cover under conifer forest canopy using lidar. *Remote Sensing of Environment*, 222, 34–49. <https://doi.org/10.1016/j.rse.2018.11.037>

Ned Bair to all: 6:52 PM

Sounds good! Thanks for the link Kat.

Edward Kim to all: 6:55 PM

lots of good info in chat. will chat be saved and accessible after today?

Karl Rittger to all: 6:57 PM

Agree. We should strive for a single reprojection for "validation".

Sophie Roberge to all: 6:57 PM

I would like to participate in discussion on Landsat reference datasets

Michael Kern (ESA) to all: 6:57 PM

Ed, yes, I will save the chat

Edward Kim to all: 6:57 PM

great! thanks.

Christopher Crawford Ext to all: 6:57 PM

Totally agree with Jeff on resampling

Igor Appel to all: 6:58 PM

If you want to save chat info just copy and paste it for your enjoyment.

Jeff Dozier to all: 7:00 PM

For those who use MATLAB, I have a package that would just let you reproject on the fly as you analyze.

Simon Gascoin to all: 7:00 PM

a few validation datasets available here: Pléiades & SPOT 6/7 SCA, time lapse camera photographs, terrestrial lidar scans and crowd-sourced in situ measurements: <https://www.mdpi.com/2072-4292/12/18/2904>

Edward Kim to all: 7:06 PM

There are probably validation opportunities from SnowEx campaigns, past/present/future. After quality control, data is archived at NSIDC.

Edward Kim to all: 7:07 PM

https://nsidc.org/data/snowex/data_summaries

Karl Rittger to all: 7:07 PM

Here is the paper with the daily temperature sensor ground validation: <https://doi.org/10.1029/2019WR024914>

Ned Bair to all: 7:15 PM

I missed the spatial resolution that the intercomparison will be conducted at. Or is that "to be determined?"

Mary Jo Brodzik to all: 7:17 PM

Great meeting, thanks to all presenters! So nice to see all the work people are doing

Shuo Gao to all: 7:18 PM

Great meeting, thanks to all for presentations and discussions!

Eunsang Cho to all: 7:18 PM

Great thanks all for organizing and presenting!

Renee Mie Hansen to all: 7:19 PM

Great meeting, thank you!

Elzbieta Wisniewski Ext to all: 7:19 PM

thank you !

Sophie Roberge to all: 7:19 PM

Thank you. Good bye everybody

Simon Gascoin to all: 7:19 PM

thanks!