THE SATELLITE SNOW PRODUCTS INTERCOMPARISON AND EVALUATION EXERCISE

SNOWPEX+

an interational initative under the umbrella of Global Cryosphere Watch / WMO

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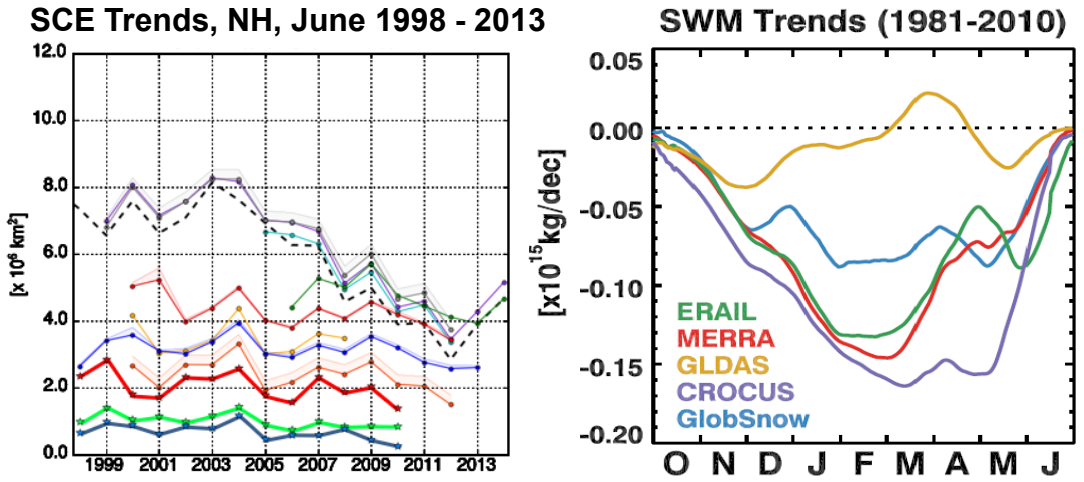
enveo Canada FMI SYKE esa

SnowPEx+ 2020 - 2022

Motivation:

- New Satellites & Sensors
- New / Improved Snow Algorithms and Product
- Consolidation of trends of seasonal snow
- Period 10 / 2014 – 09 / 2020



Activities:

- Perform **validation and intercomparison** of **Snow Cover Extent (SCE)** and **Snow Water Equivalent (SWE)** products with continental to global coverage
- ISSPI-3 workshop engaging the international snow community
- Contribute to the **advancement of procedures for snow monitoring** from EO data
- Consolidate the estimation of **trends in seasonal snow coverage**

SnowPEx – ISSPI Workshops

ISSPI-3, February 2021

56 Participants from Europe, North America and Asia

SnowPEx+ - participating Snow Cover Extent products

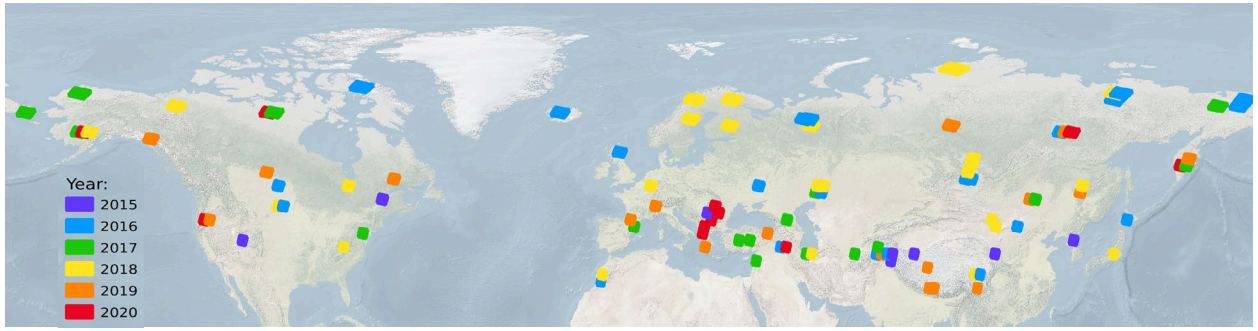
Product Name	Sensor(s)	Thematic Parameter	Spatial extent	Pixel Sp.	Frequency	Period	Product provider
CGLOPS NHEMI SCE	Suomi-NPP VIIRS	**FSCG**	NH	1 km	Daily	Jan 2018 - present	ENVEO
CryoClim SCE (in prep.)	AVHRR GAC and SMMR+SSM/I	**SCEG**, QUMSCEG	Global	5km	daily	1982 – 2015, 2015 – 2020 in prep.	NR
SPIReS (TBC)	Any multispectral sensor covering VSWIR, tested w MODIS & Landsat 8 OLI, Sentinel-2a/b next. Also configured for spectrometer, bands weighted by atmospheric transmittance.	**FSCG**, QUMFSCG	Sierra Nevada	0.463 km	daily	2001 - 2019	UCSB
MODSCAG, MODDRFS (TBC)	Terra, MODIS	**FSCV**, **FSCG**, QUMFSCV, QUMFSCG	West US CA Rockies, AL, HMA, North Pole, SA	0.463 km	daily	2000 - 2020	UCSB, JPL
snow_cci FSC MODIS/SLSTR	MODIS, continued SENTINEL-3 SLSTR	**FSCV**, **FSCG**, QUMFSCV, QUMFSCG	Global	1 km	daily	Feb 2000 – Dec 2019 (2020)	ENVEO
GMASI (TBC)	AVHRR (METOP/NOAA), SSMI/SSMIS DMSP F8…19	**SCEV**, QUMSCEV	Global	4 km	daily	1987 - present	NOAA/NESDIS
EUMETSAT H SAF H32	Metop AVHRR	**SCEV**	Global	1 km	daily	2015 - present	FMI
IMS01	Various GOES, Himawari, and Meteosat channels, AVHRR, VIIRS, AMSR, ASCAT, AMSU, SSMI, Radarsat, radar, ground station and other in situ observations	**SCEV**, QUMSCEV	NH	1 km	daily	2014 - present	NOAA
IMS04		**SCEV**, QUMSCEV	NH	4 km	daily	2004 - present	NOAA
IMS24		**SCEV**, QUMSCEV	NH	24 km	daily	1997 - present	NOAA
JASMES SNWCFR JXAM5 A5C	AVHRR onboard TIROS-N, NOAA series, MODIS onboard Aqua	**SCEV**, QUMSCEV	Global	5 km	Daily, weekly, half-monthly	Nov 1978 - present	JAXA
JASMES SNWCFR JXAM5 M5C	AVHRR onboard TIROS-N, NOAA series, MODIS onboard Terra and Aqua	**SCEV**, QUMSCEV	Global	5 km	Daily, weekly, half-monthly	Nov 1978 – present	JAXA
JASMES SNWCFR JXM10	MODIS onboard Terra and Aqua	**SCEV**, QUMSCEV	Global	5 km	Daily, weekly, half-monthly	Feb 2000 – present	JAXA
MOD10A1 (in prep.)	Terra, MODIS	**SCEV**, QUMSCEV	Global	0.5 km	daily	Feb 2000 - present	NASA, SSAI
VNP10A1 (in prep.)	Suomi-NPP, VIIRS	**SCEV**, QUMSCEV	Global	0.375 km	daily	Jan 2012 - present	NASA, SSAI

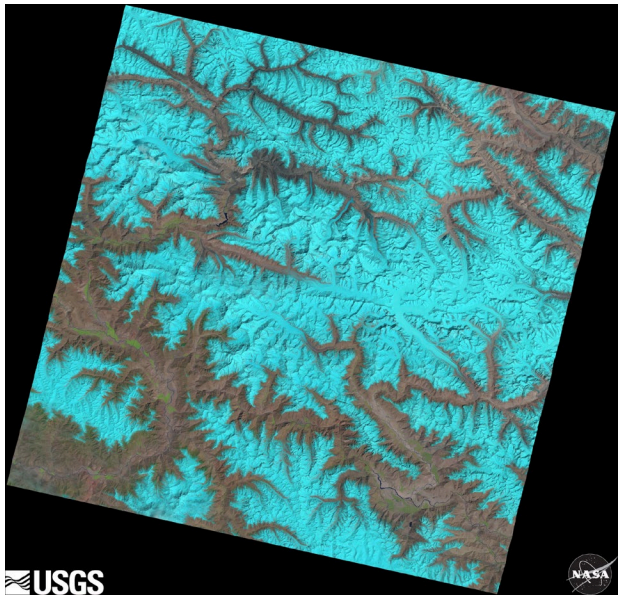
SnowPEx+ - participating SWE products

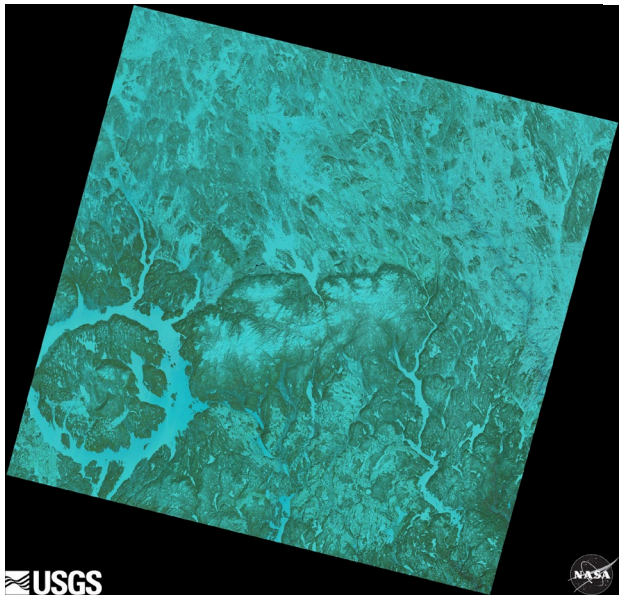
Family	Sub-family	Product (reference or contact)
Earth Observation (4)	Standalone (**1**)	JAXA AMSR2 (Kelley et al. 2003, in prep)
	Surface snow depth assimilation (**3**)	GlobSnow v3BC (Pulliainen et al. 2020; Luojus et al. 2021) Snow CCI v1 (Luojus et al. 2021) Snow CCI v2 (kari.luojus@fmi.fi)
Reanalysis (land-atmosphere coupled) (5)	Atmospheric-historical (**1**)	20CRv3 (Slivinski et al. 2019)
	Surface snow depth assimilation (**4**)	ERA5 (Hersbach et al. 2019) ERA5-Snow Single Layer (patricia.rosnay@ecmwf.int) ERA5-Snow Multi Layer (gabriele.arduini@ecmwf.int) JRA55 (Kobayashi et al. 2015)
Reanalysis + Snow Model (5)	Temperature Index Model (**1**)	Brown-ERA5 (Brown et al. 2003)
	Complex snow model (**4**)	Crocus_ERAint (Brun et al., 2013) Crocus_ERA5 (bertrand.decharme@meteo.fr) ERA5-land (Munoz-Sabater et al., in prep) MERRA2 (Gelaro et al. 2017)
	GRACE assimilation (**1**)	GLDASv2.2 (Li et al. 2018)
Interpolated surface observations (1)	Infill: temp and precip observations (**1**)	U. Arizona [CONUS only] (Zeng et al., 2018)

Spatial and temporal distribution of validation data set

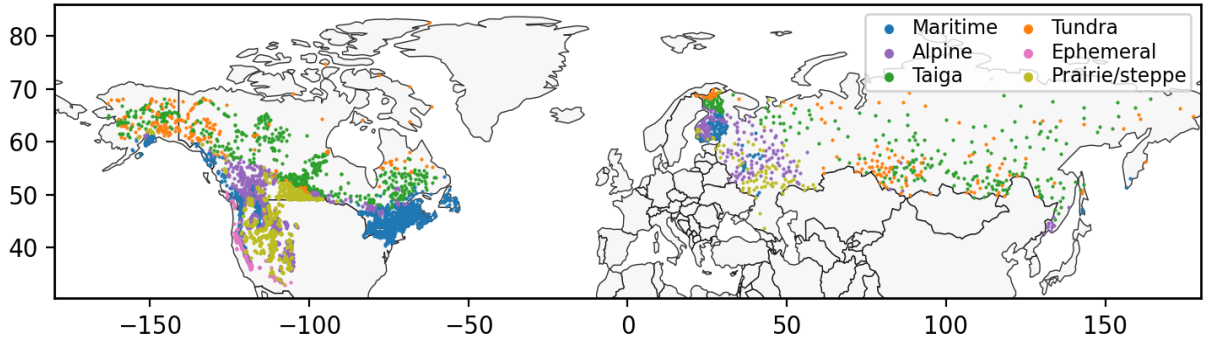
148 spatially and temporally distributed Landsat 8 scenes selected for the generation of reference snow maps

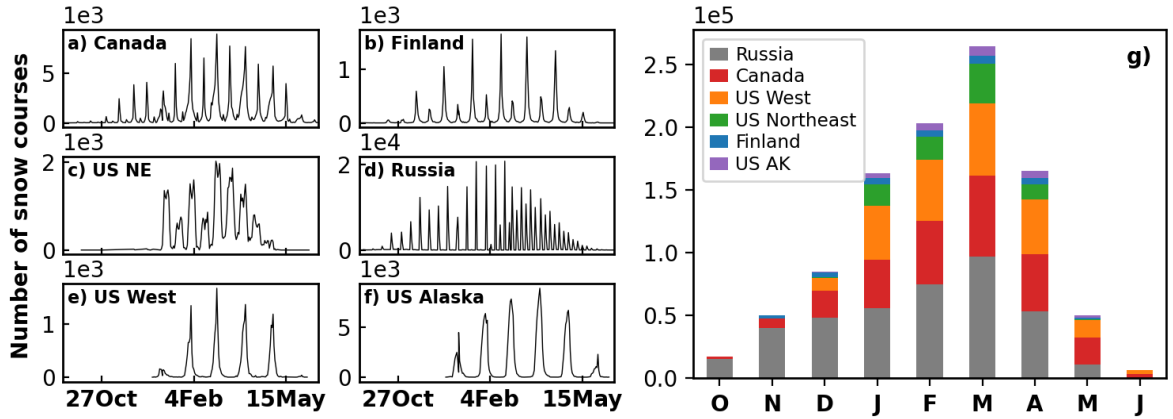






In-situ snow data, are available for Russia, Finland, Canada, US and China

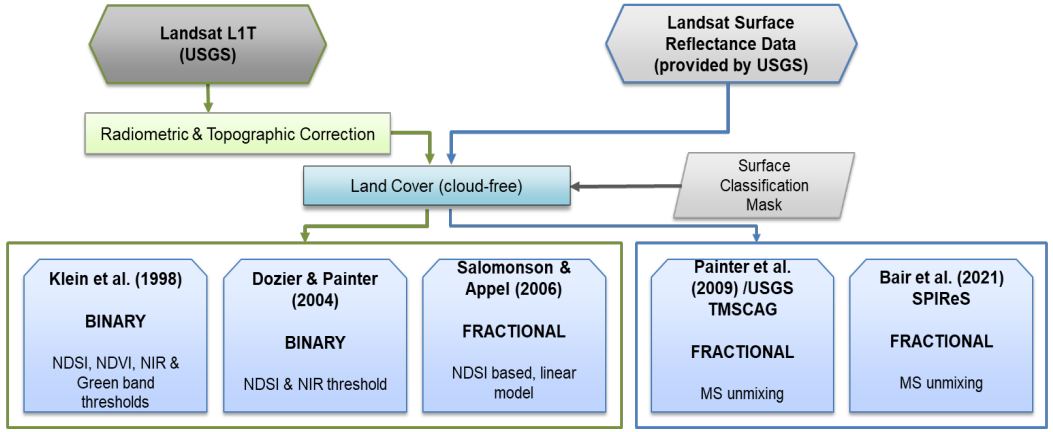




Snow course data distribution by day of year (**a-f**) and month (**g**)

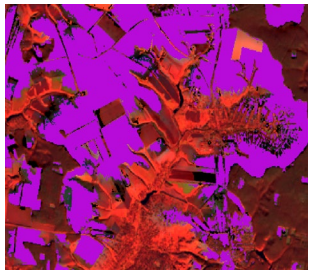
Focus group for high resolution reference snow maps

International focus group aiming to improve the reference snow data set from high resolution optical satellite data intercomparing and evaluating modern retrieval algorithms (ENVEO, SYKE, Univ. Colorado, Univ. California, USGS, TAG LLC, Univ. Arizona)



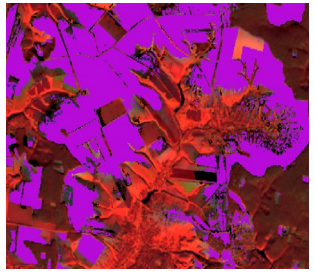
Snowmaps from Landsat 8:

NDSI, NDVI, NIR & VIS thresholds



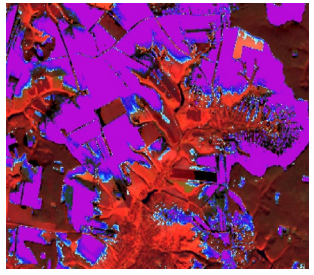
Klein et al. (1998)

NDSI & NIR threshols



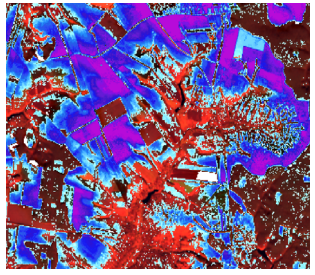
Dozier & Painter (2004)

Linear model using NDSI



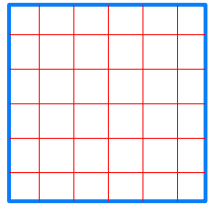
Salomonson & Appel (2006)

SPIReS (MS unmixing)

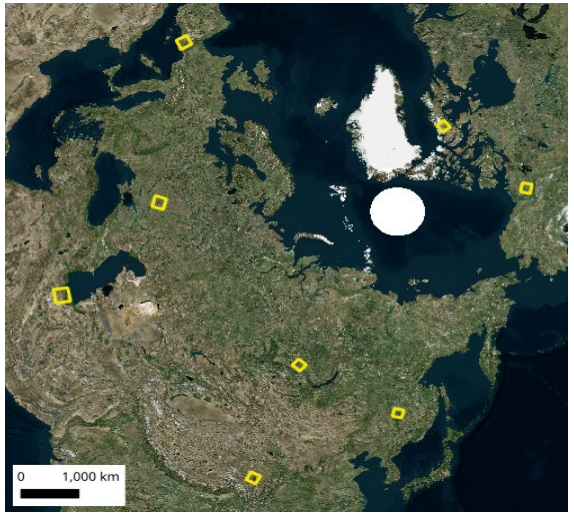


Bair et al. (2021)

Evaluation of snowmaps from Landsat 8 (30m) with binary snowmaps from Worldview (~5m)*

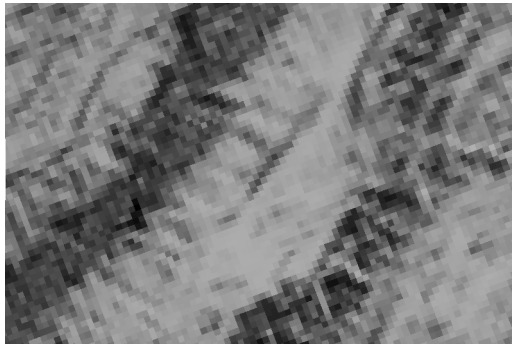


Distribution of comparison data over the Northern Hemisphere:



Example Teheran:

L8



WV2

* Analogue to study by Stillinger & Bair (2020), doi: 10.5281/zenodo.4031446

Conclusions and Way Forward

- The international snow community is actively contributing to the exercise:
  - 12 satellite based SCE products (global, hemispheric)
  - 8 SWE products from satellites and process models
- International focus group was established to discuss retrieval algorithms for HR sensors (Landsat, Sentinel-2) which leads to an improved reference snow data set
- Insitu snow measurements provided by various organisations in Europe, US / Canada, Russia, and China
- Results of SnowPEx+ expected by Q4 2022.

Recommendations:

The community identified the need to perform SnowPEx experiments for

- snow in complex terrain (mountain areas / heterogenous land cover
- further parameters of the snow pack (melt, grain size, albedo, snow water equivalent in mountains)