Ground-based validation of satellite snow products

Cemal Melih Tanış

Kari Luojus, Matias Takala

name.surname@fmi.fi

WP-2170

IDEAS-QA4EO Cal/Val Workshop #5, 11-13.06.2024.

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WP2170 – Snow Studies
Validation of satellite snow products

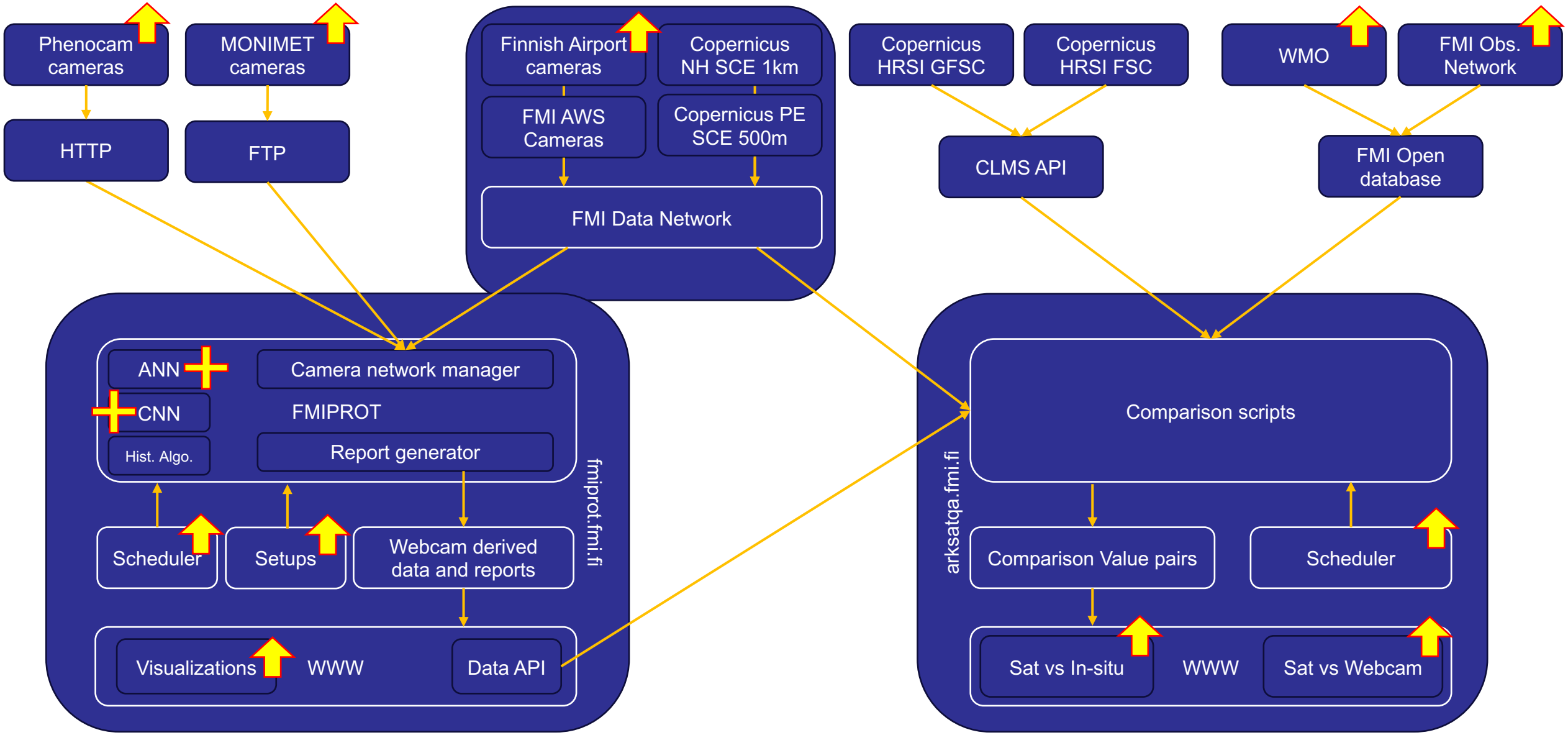
Motivation

- Products validated once or (sometimes) yearly, by producer/implementer and independent studies later
- Overall results in validation reports
- Temporal insight need (changing quality)
- Spatial insight need (regional quality)
- Reference ground data availability limited to snow depth (binary comparison)

WP2170 – Snow Studies
Validation of satellite snow products

Components

- Ground-based fit-for-purpose reference data: in-situ measured, and webcam derived
- Estimating snow cover from webcam imagery
- Near real time (daily) and vast scale comparisons
- Comparison filters and options
- Visualization on maps and tables



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Key Figures

- 4 Copernicus satellite products (1km NH, 500m Pan-EU, 60/20m Pan-EU)
  - Copernicus Land Monitoring Service – daily NH snow data
  - 2 EUMETSAT H SAF products underway
- 436 cameras in 5 camera networks (includes vegetation) in (mostly) Europe and North America
- 2500+ in-situ locations in NH
- ~3 years of data

Recent contributions

- Spatial coverage increase for webcams (all Phenocam available, ~400 cameras with changing availability trough time)
- ML derived snow cover from webcams (CNN and ANN, 3 Classes)
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- Temporal coverage increase from 2021 Autumn
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  - Camera data (Phenocam, MONIMET, airport)
- “Run once” processing chains (historical data)
  - Modified concept for webcam data processing chains
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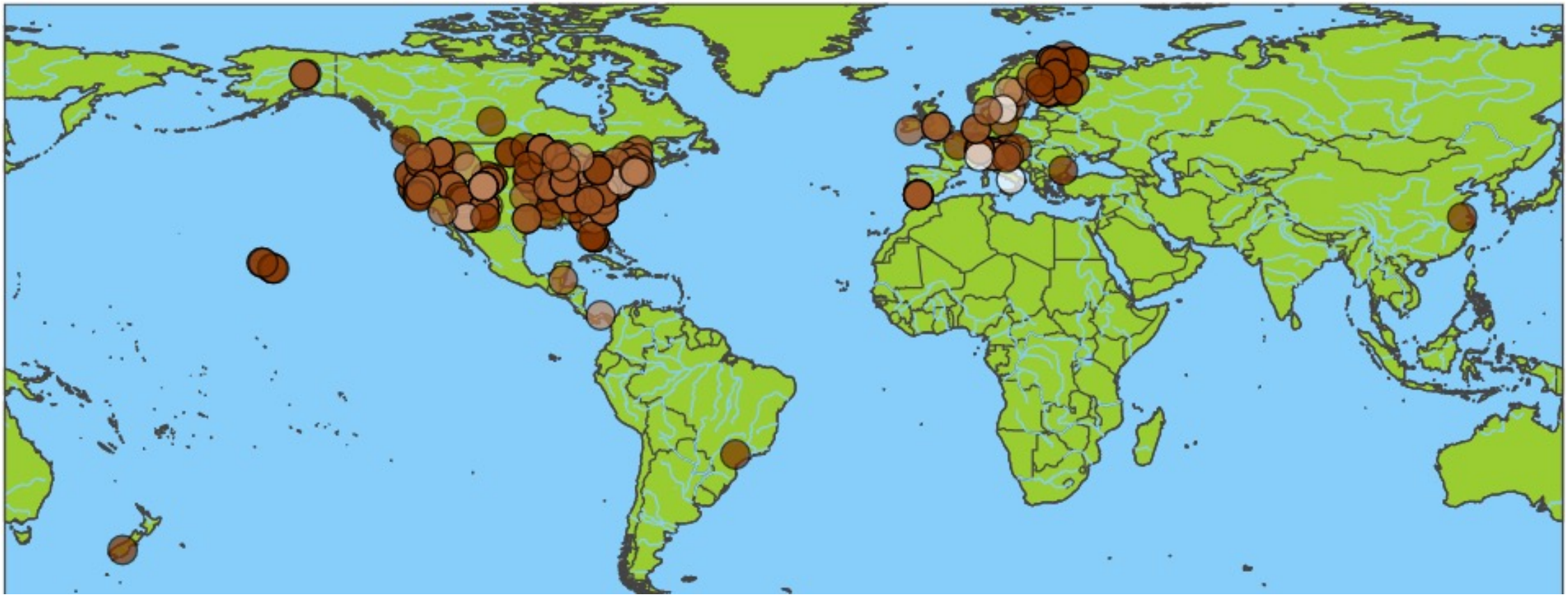
- (Editable) Multiclass contingency matrix for FSC vs FSC comparisons

Spatial coverage of webcam data
(September 2023)



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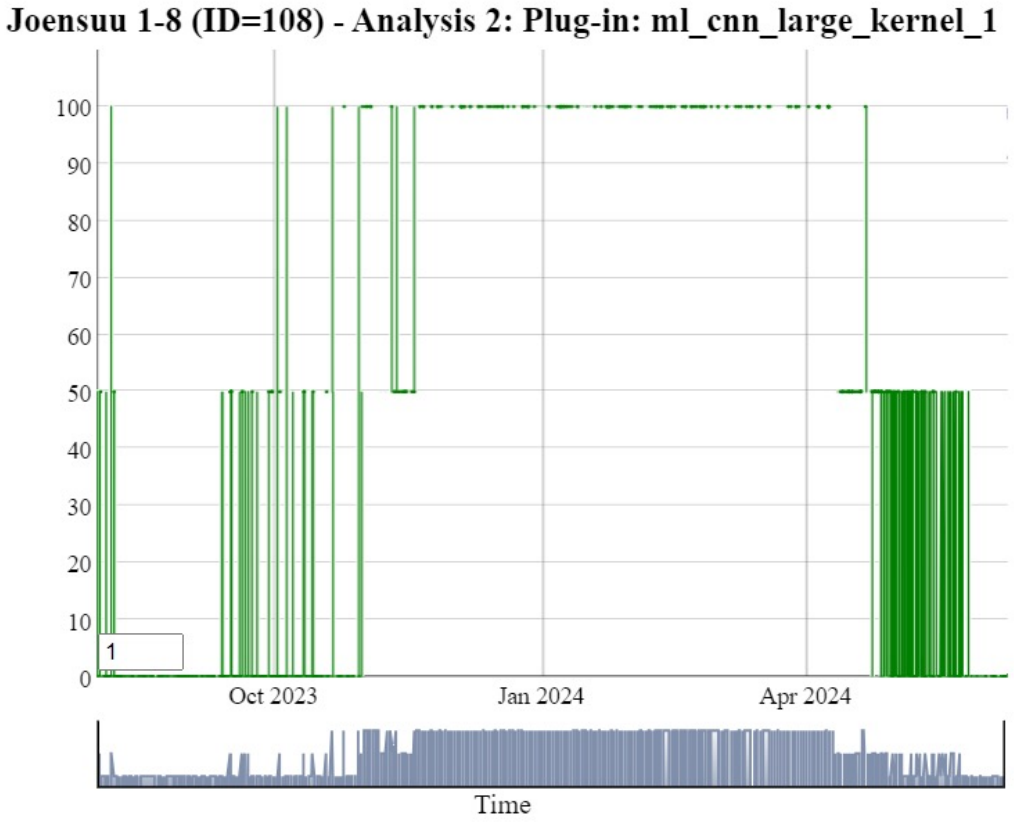
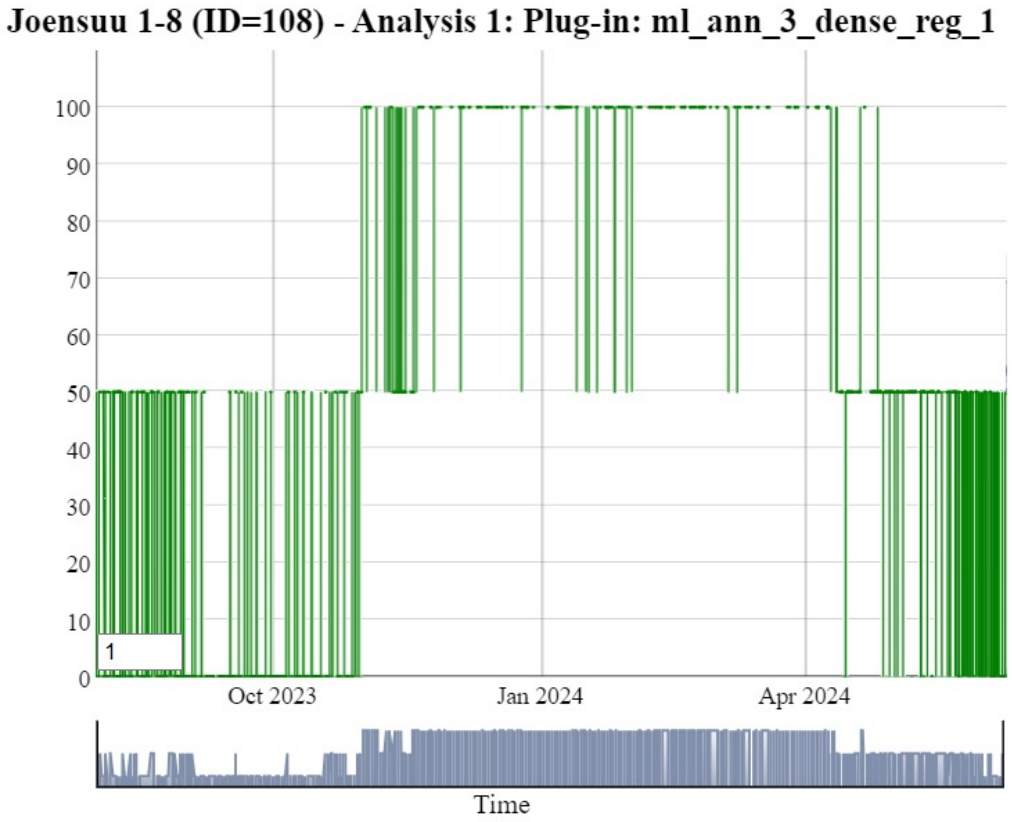
FSC Estimation with ML

- **Feasibility study**, with limited validation
- Neural networks trained with airport camera imagery
- 3 snow state classes: **no snow, partial snow, full snow**
- Image augmentation is used to filter and create imagery for training
- Low resolution training and classification, higher resolution possible with GPU
- Objects in views not filtered out (better accuracy possible)
- **84 – 94 % Accuracy** with CNN model (no cropping)





FSC Estimation with ML

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Operational Monitoring

- SC by ML (3Class)
- Snow Depth
- Fractional Snow Cover
- Vegetation Indices
- LumiPilotti Project
- Download Data

Campaigns

Status of setup collections

Results viewer

Snow cover (3 Class) monitoring with using ML

Status of setup collections

Collection name	Setups	Analyses Clock	Intervals	Last run time	API Access	Results
Snow cover monitoring with MONIMET using ML (NRT)	29	36	5 - 21	60 mins.	Start: 2024-04-28 18:00:02 EEST Finish: 2024-04-28 18:17:41 EEST	Yes	
Snow cover monitoring with MONIMET using ML (2023 ->)	29	40	22 - 4	21600 mins.	Start: 2024-04-24 23:00:01 EEST Finish: 2024-04-25 00:38:25 EEST	Yes	
Snow cover monitoring with MONIMET using ML (2022-2023)	29	40			Start: 2024-02-10 14:04:03 EET Finish: 2024-02-11 05:37:17 EET	Yes	
Snow cover monitoring with MONIMET using ML (2021-2022)	29	42			Start: 2024-02-11 05:38:03 EET Finish: 2024-02-11 22:01:13 EET	Yes	
Snow cover monitoring with Phenocam using ML Part 1 (NRT)	225	236	1 - 23	1440 mins.	Start: 2024-04-28 17:28:01 EEST Finish: Running now	Yes	
Snow cover monitoring with Phenocam using ML Part 1 (2023 ->)	225	268	22 - 4	21600 mins.	Start: 2024-04-26 23:00:02 EEST Finish: 2024-04-27 08:43:50 EEST	Yes	
Snow cover monitoring with Phenocam using ML Part 1 (2022-2023)	225	134			Start: 2024-02-19 13:04:02 EET Finish: 2024-02-25 04:59:55 EET	Yes	
Snow cover monitoring with Phenocam using ML Part 1 (2021-2022)	225	96			Start: 2024-02-19 13:04:04 EET Finish: 2024-02-24 23:46:12 EET	Yes	
Snow cover monitoring with Phenocam using ML Part 2 (NRT)	119	120	1 - 23	1440 mins.	Start: 2024-04-28 17:29:02 EEST Finish: Running now	Yes	
Snow cover monitoring with Phenocam using ML Part 2 (2023 ->)	119	128	22 - 4	21600 mins.	Start: 2024-04-26 23:00:02 EEST Finish: 2024-04-27 04:37:58 EEST	Yes	
Snow cover monitoring with Phenocam using ML Part 2 (2022-2023)	119	80			Start: 2024-02-24 23:46:12 EET Finish: 2024-02-25 16:51:04 EET	Yes	
Snow cover monitoring with Phenocam using ML Part 2 (2021-2022)	119	24			Start: 2024-02-25 04:59:55 EET Finish: 2024-02-25 16:47:57 EET	Yes	

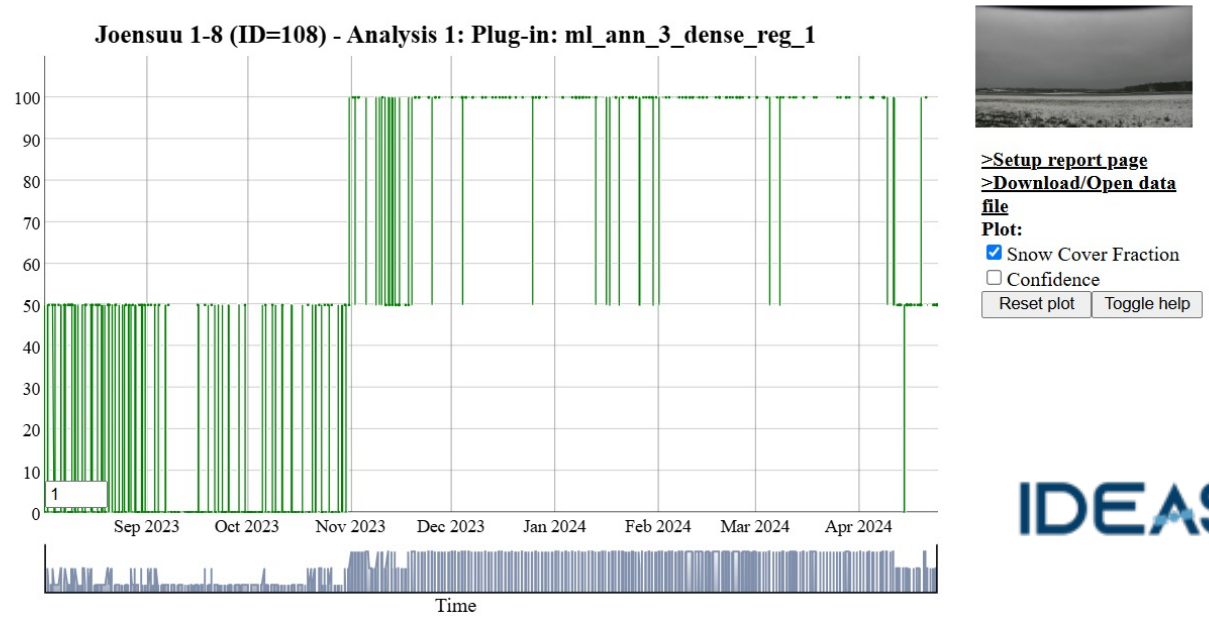
Results

2492 setups in 20 collections are defined for the campaign.

Collection: Snow cover monitoring with airport cameras using ML (2023 ->) (airports_ml_2023_)

Setup: joensuu

joensuu



>Setup report page
>Download/Open data file
Plot:
Snow Cover Fraction
Confidence
Reset plot | Toggle help

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Comparison / Visualization options

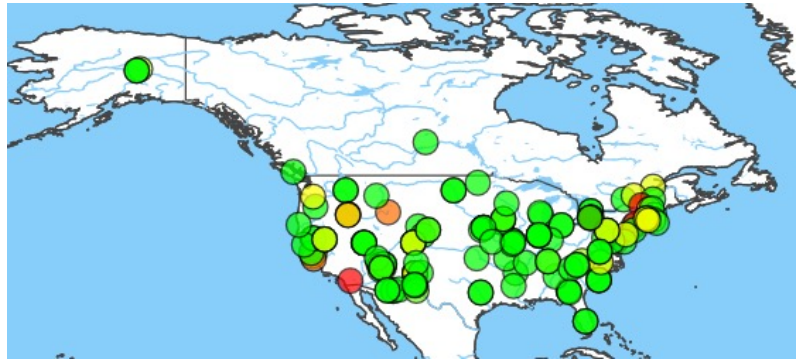
Satellite product:	Copernicus SCE NH 1km
Webcam algorithm:	Plug-in: ml_cnn_large_kernel_1
Start date:	2023-09-03
End date:	2023-10-02
Contingency matrix cat.:	4

Category ranges:	Min. (incl.)	Max. (excl.)
Category 1	0	10
Category 2	10	50
Category 3	50	90
Category 4	90	101

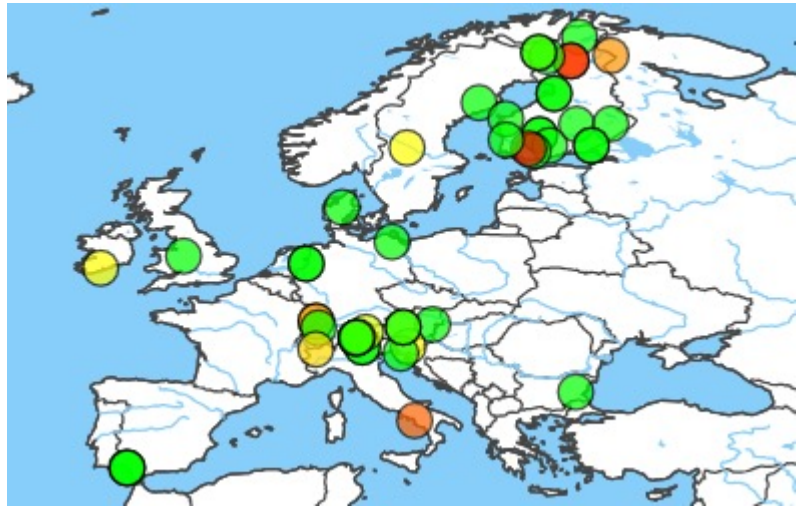
Apply

RMSE	#Points
31.56	547

/////Webcam ///// Satellite/////	Category 1	Category 2	Category 3	Category 4	Total	Commision errors
Category 1	415	11	89	30	545	0.24
Category 2	0	0	0	0	0	NaN
Category 3	0	0	0	0	0	NaN
Category 4	1	0	1	0	2	1.00
Total	416	11	90	30	547	0.24
Accuracy	**1.00**	**0.00**	**0.00**	**0.00**	**0.76**	



RMSE



RMSE

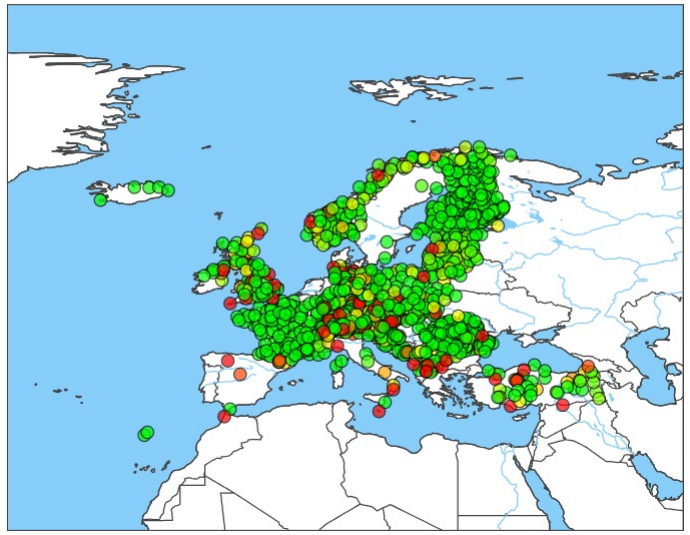
CLMS 20m FSC, binary vs multiclass

Satellite prod. threshold (%): 50

Insitu data threshold (cm): 2

Hit	Miss	Fal. Alarm	Corr. Neg.	#Points	ACC	FAR	POD	POFD
8360	1643	627	27781	38411	0.94	0.07	0.84	0.02

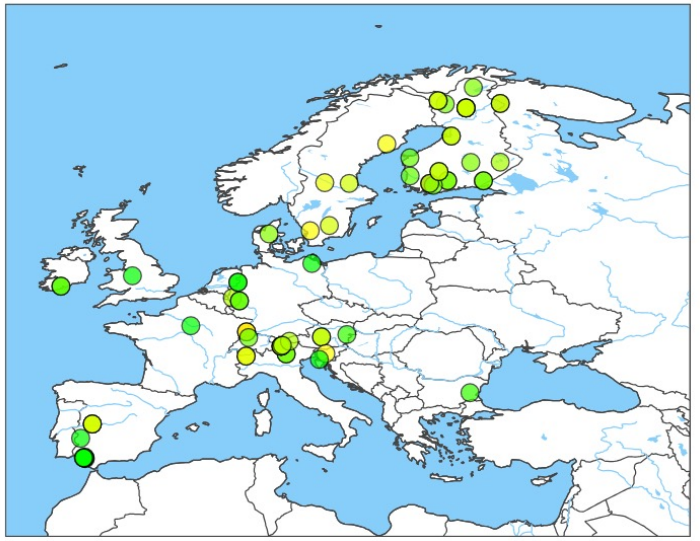
Accuracy Map



/////Webcam ///// Satellite/////	Category 1	Category 2	Category 3	Category 4	Category 5	Total	Commission errors
Category 1	3260	186	637	12	207	4302	0.24
Category 2	4	1	3	0	7	15	0.93
Category 3	14	5	31	0	29	79	0.61
Category 4	2	1	14	1	27	45	0.98
Category 5	140	56	307	15	481	999	0.52
Total	3420	249	992	28	751	5440	0.31
Accuracy	**0.95**	**0.00**	**0.03**	**0.04**	**0.64**	**0.69**	

RMSE	#Points
34.47	5440

RMSE Map



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Start date: 2021-01-01

End date: 2024-06-12

Comparison / Visualization options

Satellite product
- CLMS SE 500m
- CLMS SE 1km
- CLMS HRSI FSC
- CLMS HRSI GFSC
- HSAF H34
- HSAF H35
- HSAF H85, H43?

Reference data
- In-situ SD
  - WMO In-situ
  - FMI In-situ
  - ALPS Stations
- In-situ FSC
  - FMI Snow Course
- Webcam derived
  - FSC
    - MONIMET
    - Phenocam Alps
    - Phenocam North America
    - Europhen Pan-European
  - 3Class Snow Cover (ML)
    - MONIMET
    - Phenocam (All)
    - Finnish airports

Resampling
- Nearest neighbour
- Average
- Median
- Majority (classified)
- Max distance: XX

Thresholds
- FSC: XX
- SD: XX

DONE
PLANNED

Algorithm selection (Webcam)

Metrics
- Accuracy
- FAR
- POD
- POFD
- Kappa
- RMSE
- Multiclass contingency matrix

Plots
- Time series
- Scatter
- Trend lines
- Error bars
- Metrics maps
- …

Outreach

- Tanis, C.M.; Lindgren, E.; Frey, A.; Latva, L.; Arslan, A.N.; Luojus, K. Use of Webcams in Support of Operational Snow Monitoring. Geosciences 2023, 13, 92. https://doi.org/10.3390/geosciences13030092

- Day-1, near real-time validation portal for EUMETSAT H-SAF and Copernicus snow products using in-situ and webcam derived data by Tanis et al.
  - EUMETSAT 2024 - Meteorological Satellite Conference
  - Session 7-B Copernicus data and products (Oct 2, 2024)

Future work

- Optimization for vast data
  - FMIPROT Portal webcam data API
  - ARKSATQA portal processing chains
- Improved ML method for high quality reference data
  - Training coverage
  - More than 3 classes
- ESA Snowpex & ESA Snow CCI, Copernicus Land Monitoring Services, EUMETSAT HSAF

Ground-based validation of satellite snow products

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[for contact: name.surname@fmi.fi]

WP-2170
IDEAS-QA4EO Workshop, 01.03.2023.

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