
Evaluation and validation of GlobSnow SE product

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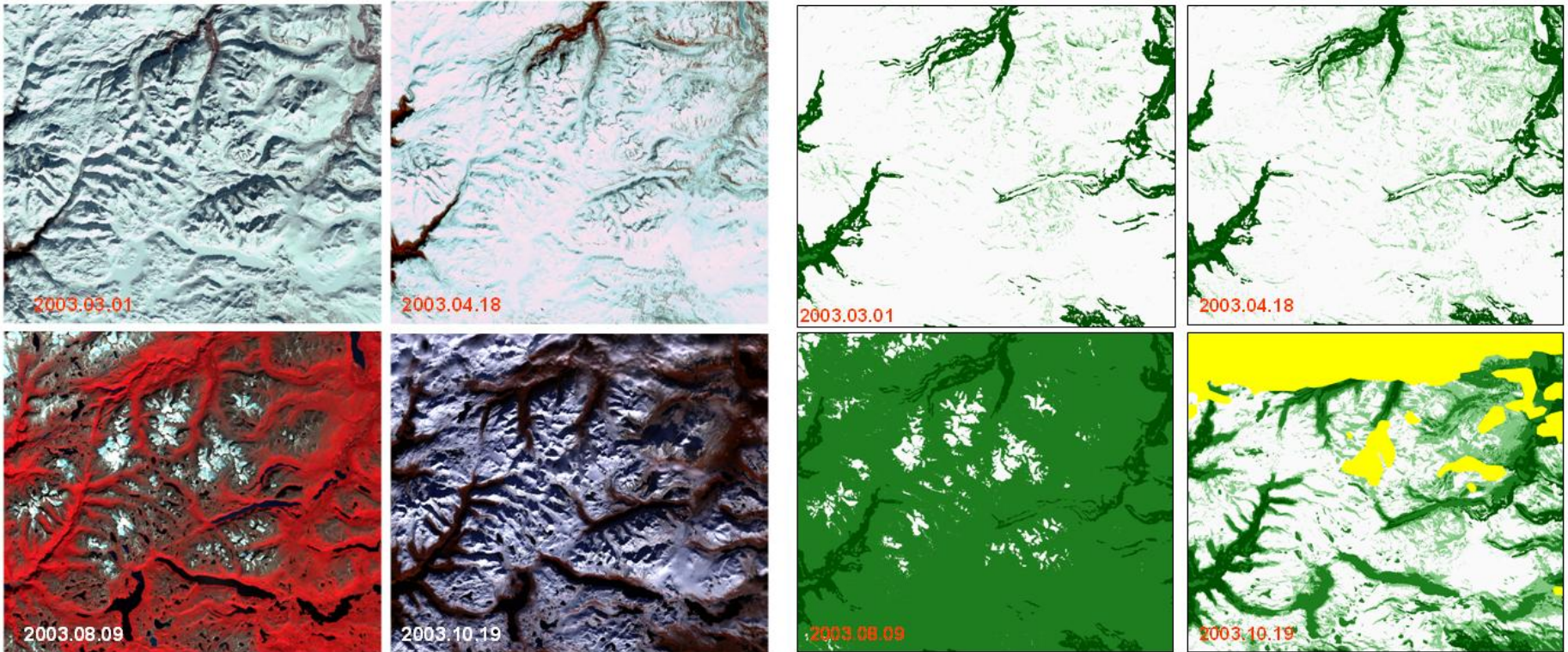
Outline

- **Evaluation/validation approach**
- **Results Norway (NLR)**
- **Results Alps (NLR)**
- **SYNOP study**
- **Mountain forest test (all algorithms)**

Approach

- **For mountainous areas above tree line:** Determine snow extent in high-resolution imagery and compare with GlobSnow SE maps
- **For forested areas:** Use point and profile measurements and compare with GlobSnow SE maps
- **Inter-comparison:** Comparison with other products
- **Measures of error:**
 - For FSC (continuous variable): Root mean square deviation
 - For classification results (categorical variable): Confusion matrix
- **Other issues:**
 - Cloud detection accuracy
 - Geolocation accuracy
- **Sites:**
 - The Alps (Austria)
 - South Norway (Jotunheimen)
 - Finland (whole country)
 - SYNOP stations in Europe and Russia

Example Landsat TM images, Norway



Unsupervised
clustering + editing

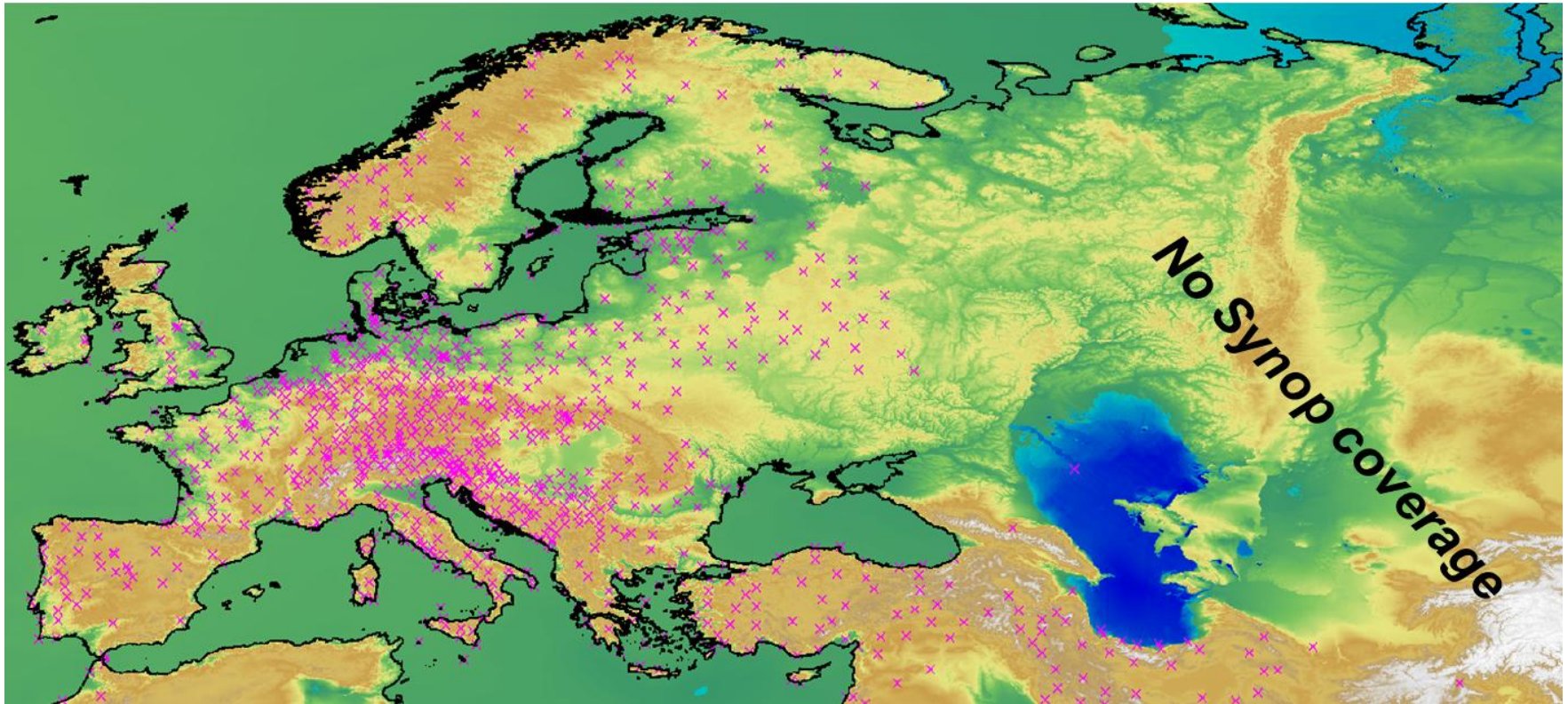
Results Norway

Date of reference data	Date of product	Number of samples compared	Number of samples masked out as clouds	Total snow covered area (grid cell equiv.)	RMSD (% FSC)	Bias (% FSC)	Un-biased RMSD (% FSC)	Corr. coeff.
2003.03.01	2003.02.27	5372	743	4213	26.66	19.34	18.35	0.31
2003.04.18	2003.04.16	5855	152	5502	9.02	0.88	8.98	0.58
2003.08.09	2003.08.08	5040	980	299	10.47	-2.23	10.22	0.68
2003.10.19	2003.10.17	4697	107	2441	34.53	21.88	26.71	0.52
2004.05.30	2004.05.27	5009	993	2364	21.69	11.50	18.39	0.86

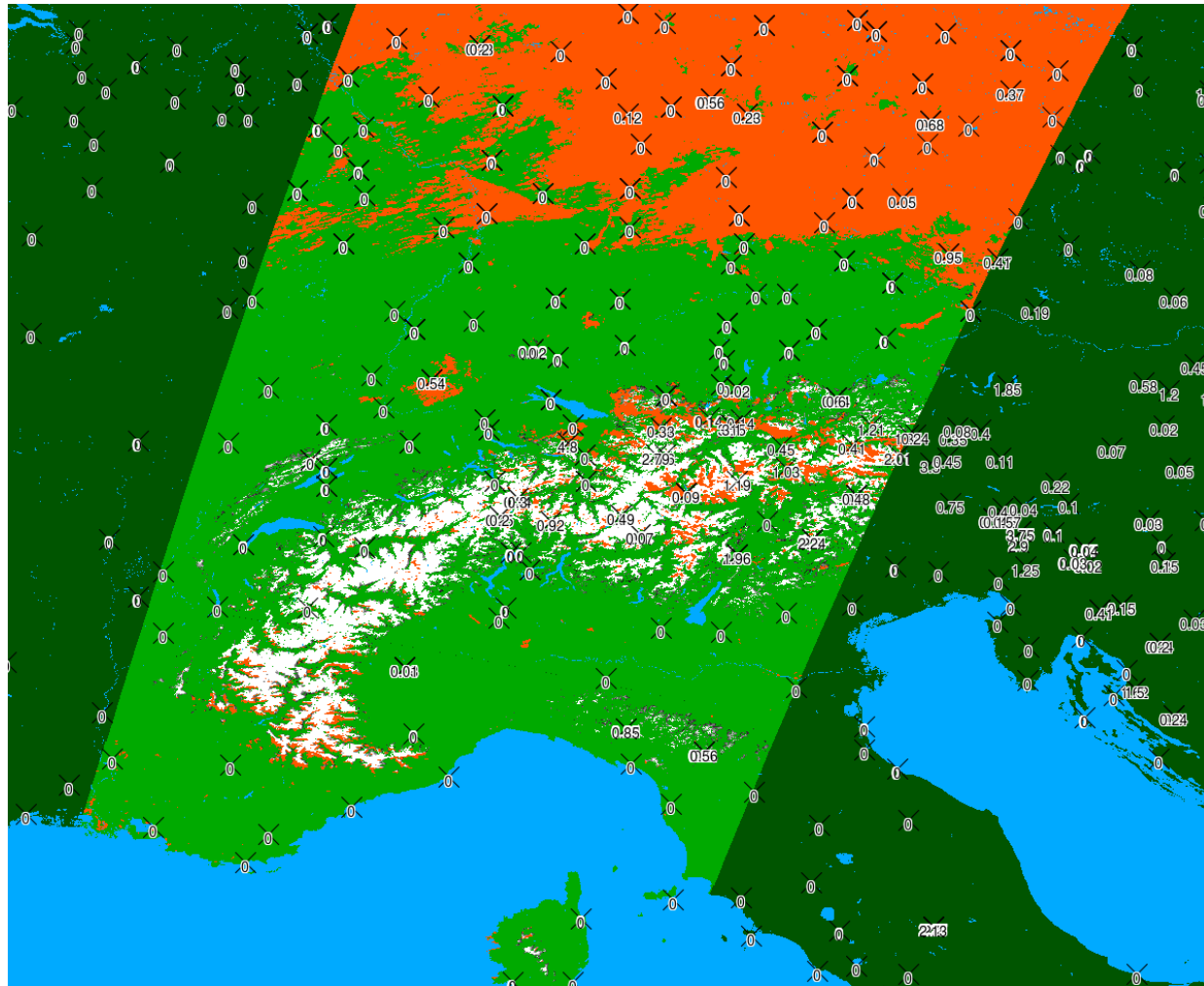
Results Alps

Reference data	Date of product	Number of samples compared	Number of samples masked out as clouds	Total snow covered area (grid cell equiv.)	RMSD (% FSC)	Bias (% FSC)	Un-biased RMSD (% FSC)	Corr. coeff.
ASTER	2004-03-16	8649	0	2724	22.67	13.4	18.28	0.91
Landsat 5	2006-06-11	40988	0	8281	10.97	-0.06	10.97	0.86
Landsat 5	2006-06-13	41431	0	5280	14.25	1.91	14.12	0.91

Comparison with SYNOP stations

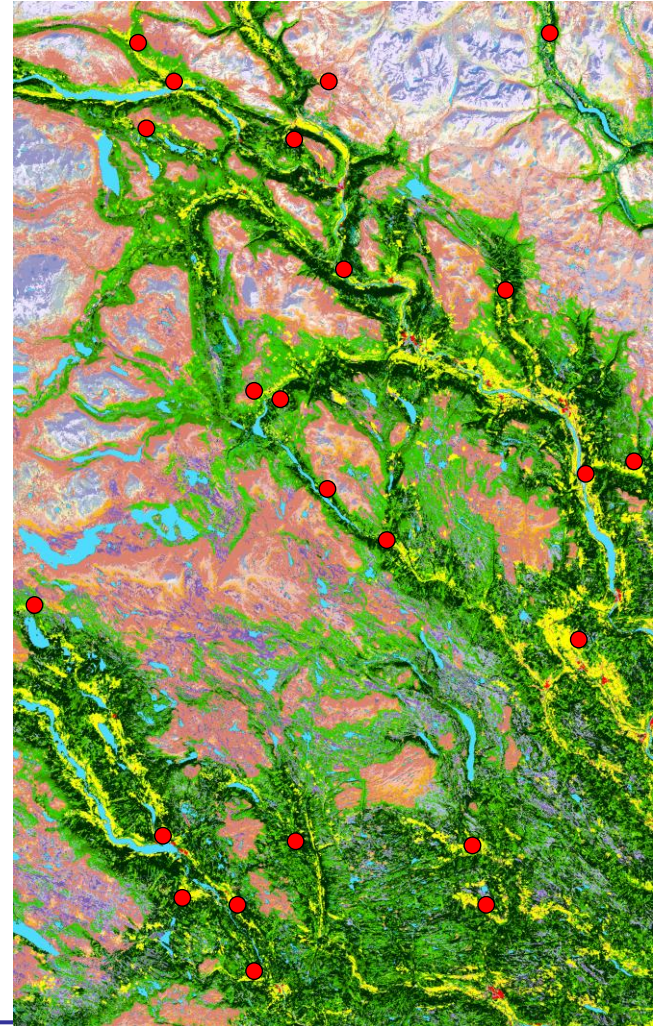


From the manual comparison



Mountain forest test data set (Norway)

- **Dates of Landsat TM data:**
 - 24 February 2003: FSC = 100%
 - 30 May 2004: FSC = 0%
- **Algorithms:**
 - NLR
 - Shi/ENVEO
 - SCAMod



SCAmod accuracy for 100% FSC

Forest type	10-50 %	50-90 %	90-100 %	Errors
All types	3	25	72	28
Dense coniferous	4	29	67	33
Open coniferous	3	25	71	29
Coniferous	4	27	69	31
Deciduous	2	23	76	24

- **Vs. forest type:**

Slope angle	10-50 %	50-90 %	90-100 %	Errors
< 10	2	24	75	26
10-30	5	29	67	33
>= 30	9	28	63	37

- **Vs. terrain slope angle:**

Slope direction	10-50 %	50-90 %	90-100 %	Errors
North	6	37	57	43
East	2	25	72	28
South	1	18	81	19
West	1	20	78	22
Flat	0	21	79	21

- **Vs. terrain slope direction:**

NLR and Shi/ENVEO for 100% FSC (binary)

Algorithm	0 %	100 %	Errors
NLR	0.5	99.5	0.5
Shi/ENVEO	17	83	17

SCAmod accuracy for 100% FSC

Forest class /mask	Number of samples compared	Total snow covered area (grid cell equiv.)	RMSD (% FSC)	Bias (% FSC)	Un-biased RMSD (% FSC)	Mean % FSC
All forest	8293	7533	18.00	9.16	15.49	90.84
Coniferous	5145	4621	19.30	10.19	16.40	89.81
Deciduous	3148	2912	15.62	7.49	13.71	92.51
Dense coniferous	2704	2407	20.27	11.00	17.02	89.00
Open coniferous	2441	2214	18.18	9.29	15.63	90.71
All forest, aspect flat	58	55	11.29	5.16	10.04	94.84
All forest, aspect north	2123	1802	24.26	15.13	18.97	84.87
All forest, aspect east	2093	1907	17.36	8.88	14.92	91.12
All forest, Aspect south	2057	1934	13.98	6.00	12.63	94.00
All forest, Aspect west	1962	1835	14.20	6.45	12.65	93.55
All forest, slope < 10deg	5673	5221	16.14	7.96	14.03	92.04
All forest, 10<=deg<30	2470	2183	21.30	11.62	17.85	88.38
All forest, deg>=30	150	129	24.24	14.07	19.74	85.93

All algorithms for 0% FSC

Algorithm	0%	100%	Errors
SCAmod	100	0	0
NLR	97	3	3
ENVEO	100	0	0

Overall conclusions

- **Typical RMSD values for the NLR algorithm:**
 - Summer months ('bright period'): 10-15%
 - Winter months ('dark period'): 15-25%
- **Typical RMSD values for the SCAMod algorithm in forested areas: ~25%**