GlobSnow Workshop 1

- **SCAmod method for Fractional Snow Cover mapping**
- **Areal extension of Forest transmissivity map**

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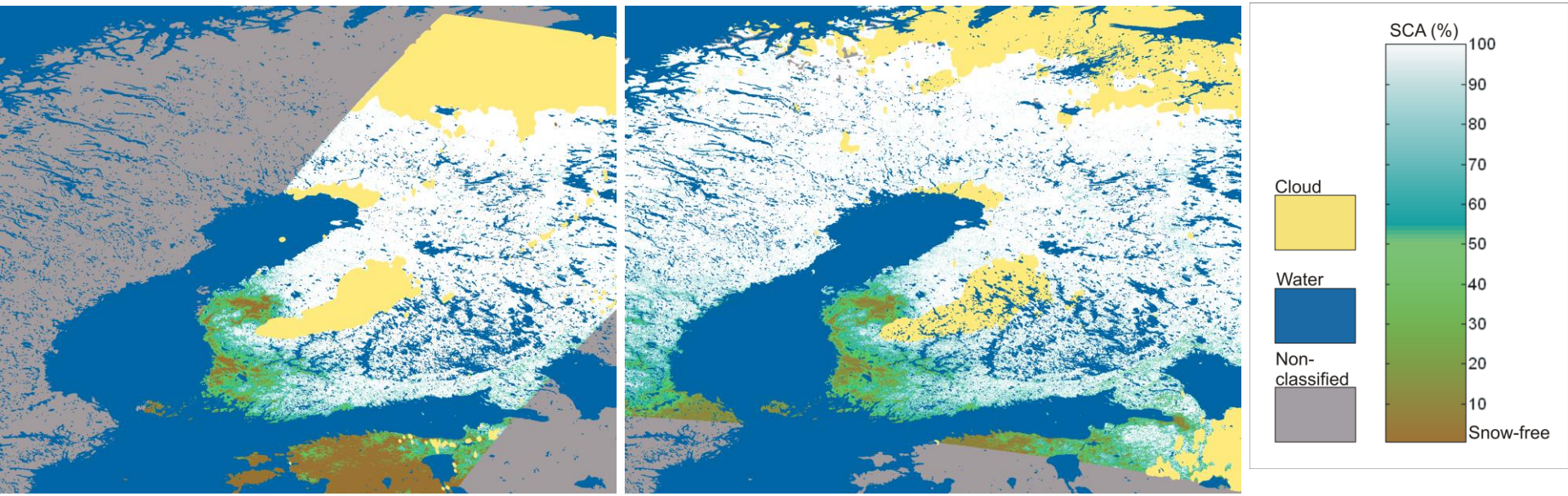
Fractional Snow Cover maps by *SCAmod*

- **SCAmod method for Fractional Snow Cover mapping**
  - Works for forested and non-forested areas -> provides the GlobSnow SE-product for most of the target area
  - Based on a reflectance model with three major reflectance contributors (snow, forest canopy, snow-free ground)
  - An average forest transmissivity must be known for each calculation unit area (estimated from EO-data using SYKE's model)
  - Method usable for a variety of optical instruments
  - No land cover data is needed (except water mask)

Fractional Snow Cover maps by *SCAmod*

Envisat/AATSR

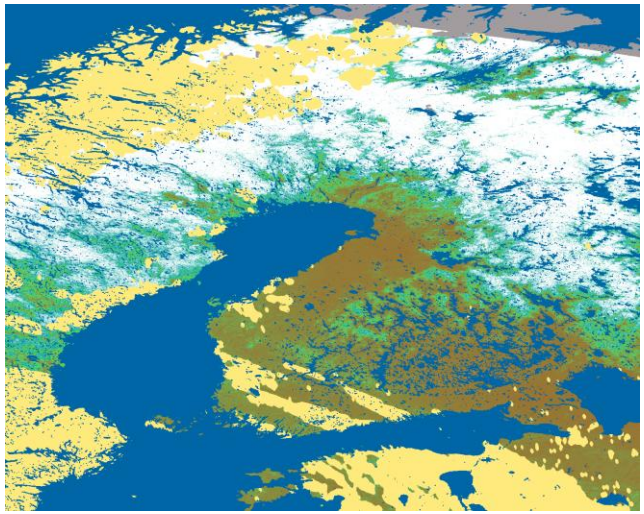
Terra/MODIS

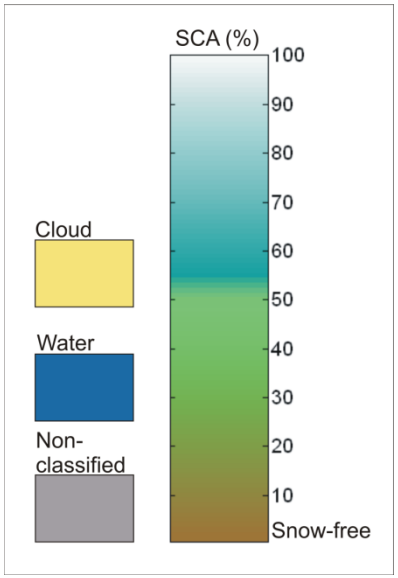


SYKE *SCAmod*-method: examples of Fractional snow cover maps on April 2, 2004

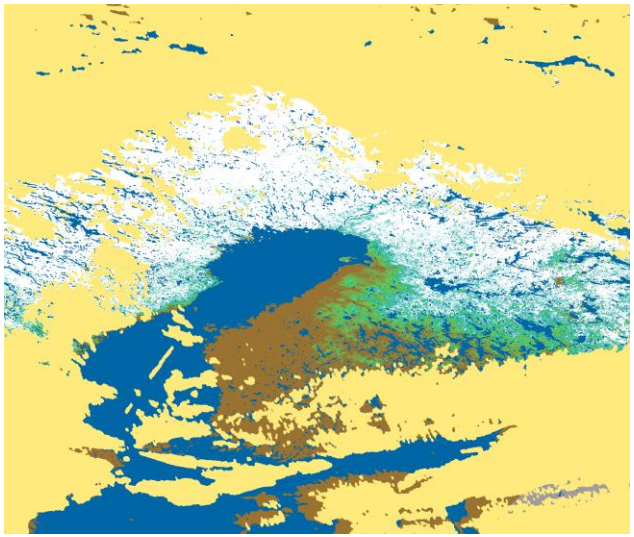
Fractional Snow Cover maps by *SCAmod*

Terra/MODIS





NOAA/AVHRR



Apr29, 2006

Apr19, 2008

SYKE *SCAmod*-method: example of Fractional snow cover maps

Reflectance model

$$\rho(SCA) = (1-t^2) * \rho_{forest} + t^2 \left[SCA * \rho_{snow} + (1-SCA) * \rho_{ground} \right]$$

$$SCA_i = \frac{\frac{1}{\hat{t}_i^{\,2}} * \rho(SCA) + (1-\frac{1}{\hat{t}_i^{\,2}}) * \rho_{forest} - \rho_{ground}}{\rho_{snow} - \rho_{ground}}$$

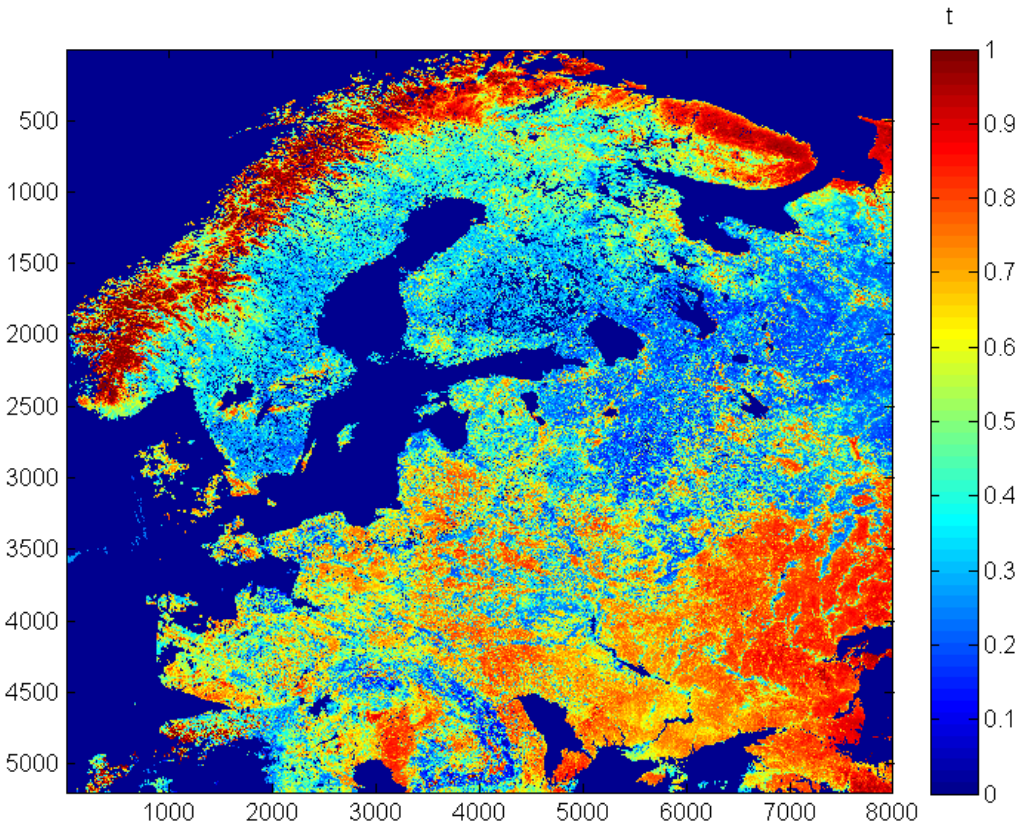
ρ(SCA)	observed reflectance from unit area
ρ_{snow}	reflectance for wet snow
ρ_{ground}	reflectance for snow-free ground
ρ_{forest}	reflectance for forest canopy
$\hat{t}$	forest canopy transmissivity for unit ar
SCA	fraction of snow covered area

Forest transmissivity

Forest transmissivity map for $0.01^o \times 0.01^o$ grid:

$$\hat{t}^2 = \frac{\rho(SCA = 100\%) - \rho_{forest}}{\rho_{snow} - \rho_{forest}}$$

- How much the canopy blocks the two-way radiation
- Calculated for each cell using optical data at full dry snow cover conditions
- Nodata for areas without seasonal snow coverage



Validation data for Fractional Snow cover method *SCAmod* over Finland (boreal forest and tundra)

•NASA snow product Mod10_l2_v005
-binary
-fractional

•SYKE SCAmod snow map with Envisat/AATSR
- Fractional

•SYKE SCAmod snow map with Terra/MODIS
-Fractional

FMI weather station observations
e-code describing the fraction of snow cover (classified data, 6 classes)

•NASA snow product Mod10_l2_v005
-fractional

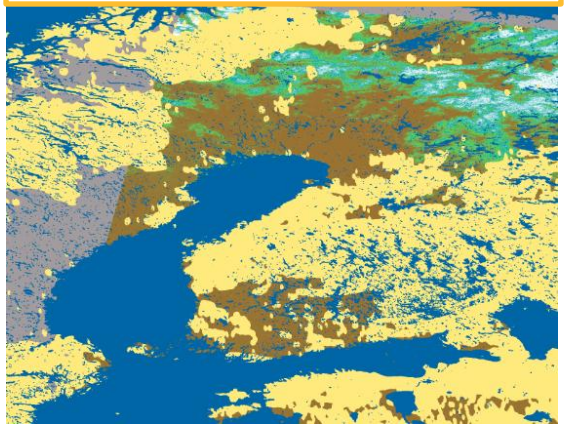
•SYKE SCAmod snow map with Envisat/AATSR
- Fractional

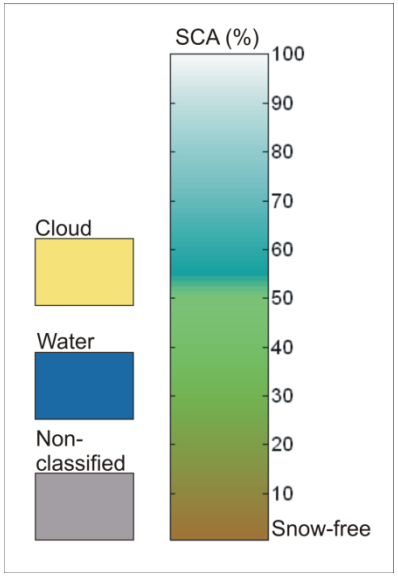
•SYKE SCAmod snow map with Terra/MODIS
- Fractional

SYKE snow course data
direct observations on fraction of snow cover
(continuous values, non-classified)

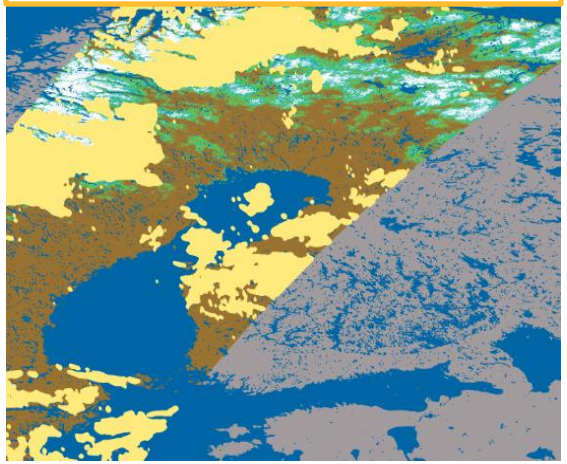
Three types of snowmaps to be validated

Terra/MODIS SCAmod frac.

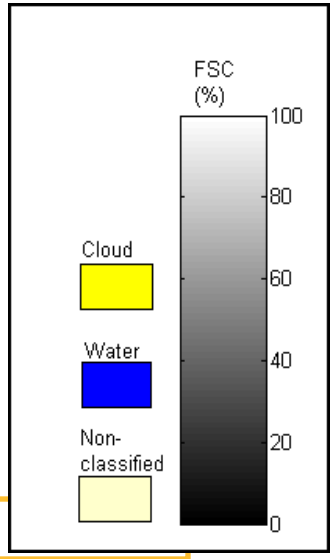


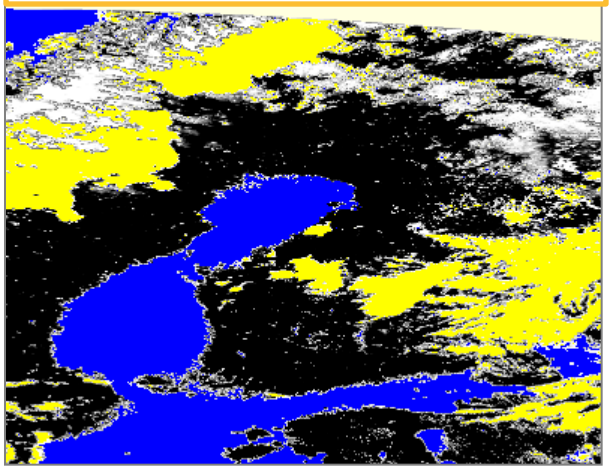


Envisat/AATSR SCAmod frac.



NASA Fractional





SYKE snow course network

•A snow course is a 2 to 4 km long trail through various terrains typical of the locality.

•Each course measured once a month

• Measurements on *snow depth* along the trail at 40-80 locations, with information on land cover type.

• For *density*, the snow is weighed at 8 points along the snow course.

• The *fraction of snow-free ground* (patchiness) is visually estimated at each snow depth measurement point

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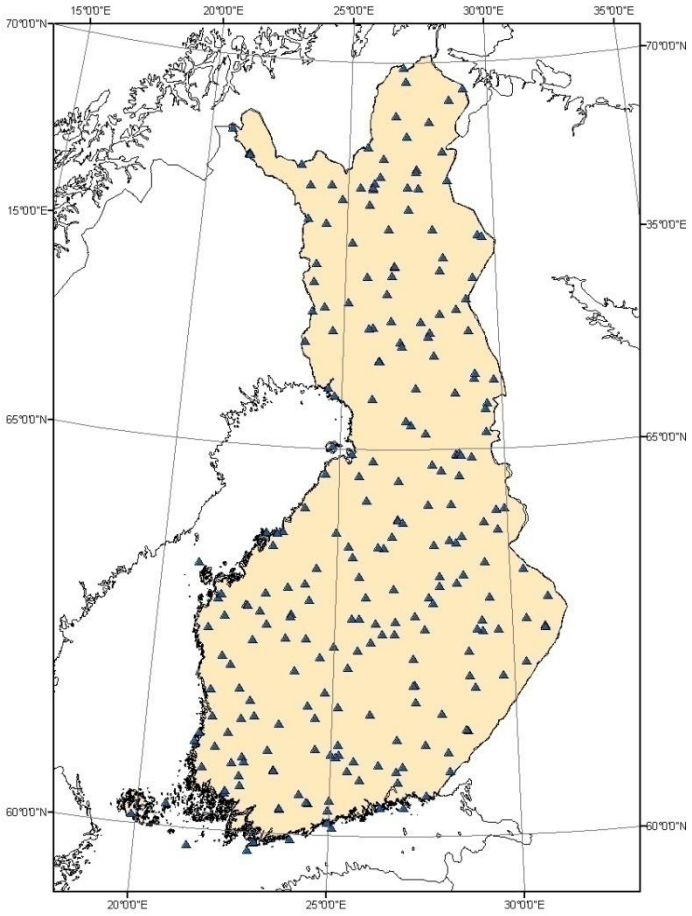
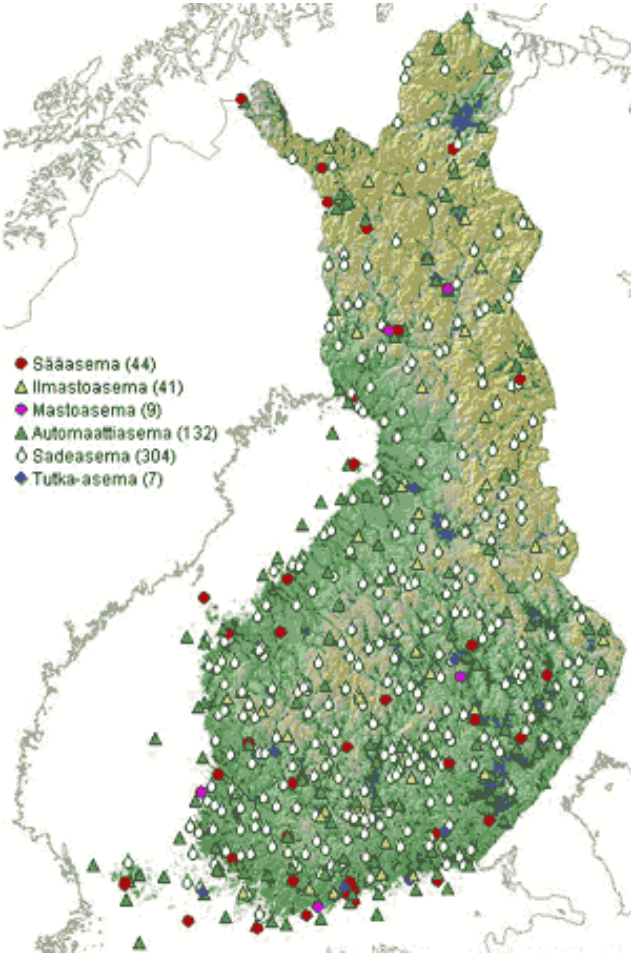


Land cover types used in snow course measurement recording

1 open area
2 forest opening
3 forest, pine dominating
4 forest, spruce dominating
5 forest, deciduous dominating
6 open bog

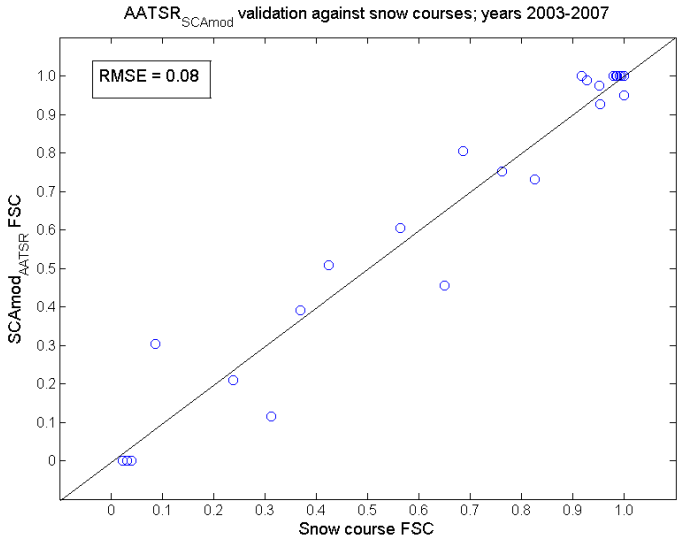
Weather station observations by FMI

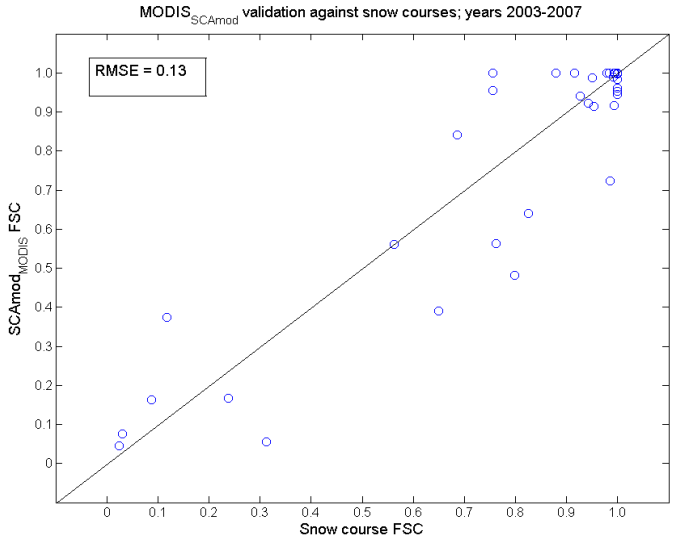
- **The Finnish Meteorological Institute regularly produces several kinds of observations nearly from 500 locations around the country.**
- **The SE related measured parameters:**
  state of ground (e-code) snow depth
- **Daily measurements over several decades**

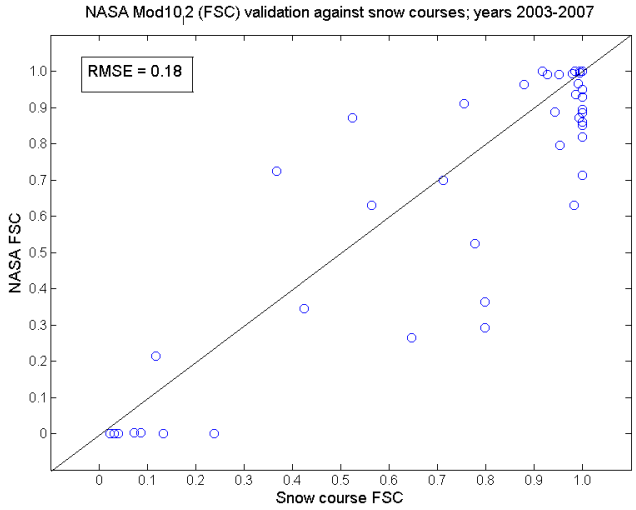


Snow e-code	Indication
9	dry snow full cover
7	wet snow full cover
6	snow cover more than 50% but less than 100%
5	snow cover less than 50% but more than 0%
4	Open areas snow free, snow exists in forests
3	0% snow cover

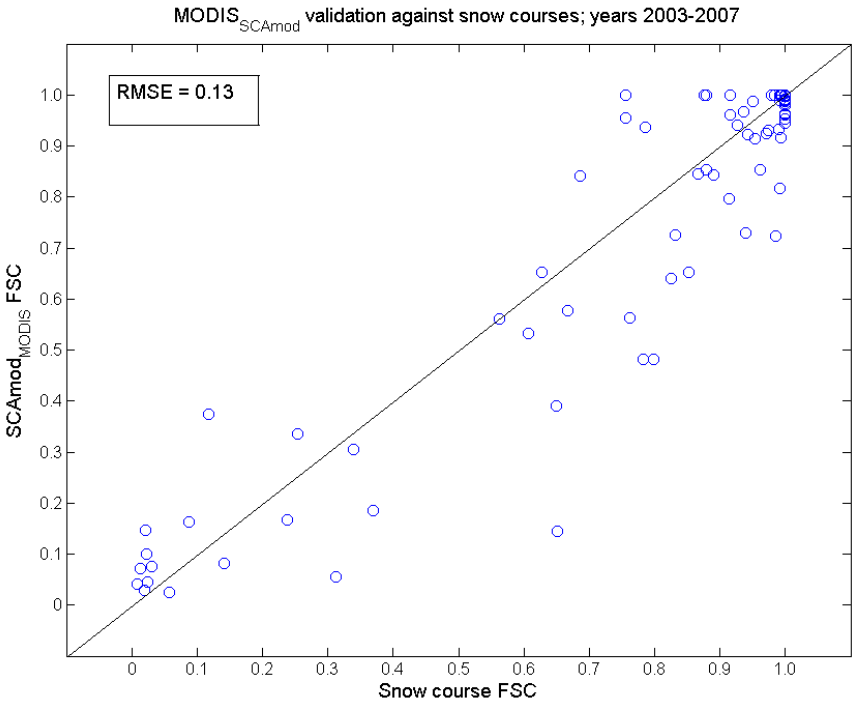
FSC validation against ground truth (snow courses)

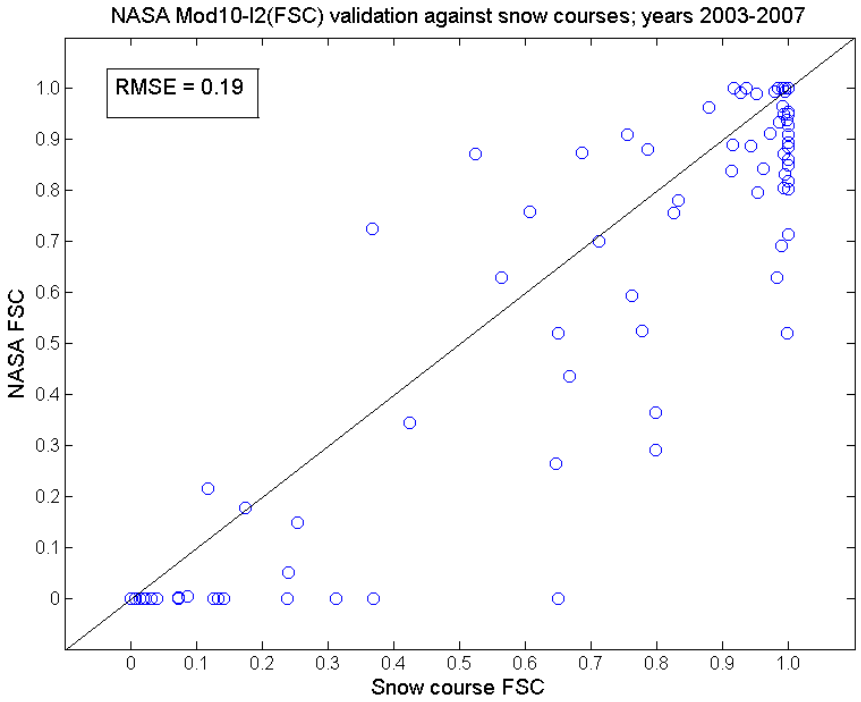






FSC validation against ground truth (snow courses)





Validation against weather station data:

Data set	Reference data: e-codes										
SCAmod AATSR	Classes	0%		0%<FSC<50%		50%≤FSC<100%		FSC=100%		Total#	Commission errors	
		%	#	%	#	%	#	%	#		%	#
	FSC = 0%	**97.2**	2423	45.6	1830	0.1	2	0.0	0	4255	43.1	1832
	0%<FSC<50%	2.4	61	**28.9**	1159	10.0	238	1.9	110	1568	26.1	409
	50%≤FSC<100%	0.3	8	16.3	653	**43.6**	1038	15.8	906	2605	60.2	1567
	FSC=100%	0.0	0	9.2	369	46.3	1103	**82.3**	4734	6206	23.7	1472
Total #			2492		4011		2381		5750	14634		
Omission		2.8	69	71.1	2852	56.4	1343	17.7	1016		**36.1**	

Total accuracy: 63.9%

Conclusions from validation

- *SCAmod* gives more accurate fsc-estimates than NASA product

- MODIS and AATSR give approximately same accuracy

Generation of transmissivity using GlobCover data

- **WHY?**
  - Transmissivity generation with MODIS-imagery is time consuming
    - Cloud-free images required (and good cloud screening method)
    - Full snow cover conditions required
    - Usually several obervations per pixel is recommended to provide information for accuracy assessments
  - Using GlobCover-data provides faster way, even though less accurate

Generation of transmissivity using GlobCover data

- **EO-derived transmissivity vs. GlobCover data over Baltic Sea Area**
  - Statistics (Mean and standard deviation) for each GlobCover class

$$transmissivity_{i,j} = \sum_{c=1}^{Nclasses} \frac{n_{c,i,j}}{n_{tot,i,j}} * \frac{(1 - sd(t_c))}{(1 - \max(sd(t_{c,i,j})))} * mean(t_c)$$

i,j are grid cell coordinates (cell size $0.01^O \times 0.01^O$)

$n_{c,i,j}$ is number of GlobCover pixels of class c in within grid cell

$n_{tot,i,j}$ is total number of GlobCover ($0.0025^O \times 0.0025^O$) pixels within grid cell (=16)

$sd(t_c)$ is standard deviation of transmissivity for class *c*

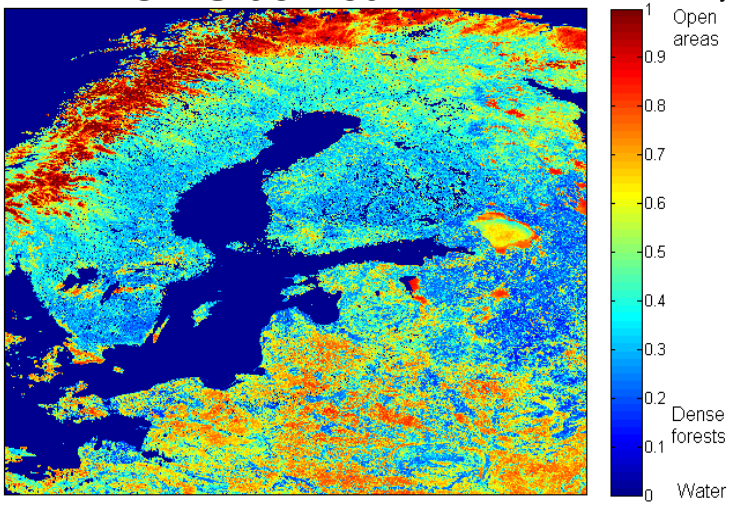
$max(sd(t_{c,i,j}))$ is local maximum of standard deviation of transmissivity within the grid cell *i,j*

$mean(t_c)$ is mean transmissivity for class *c*

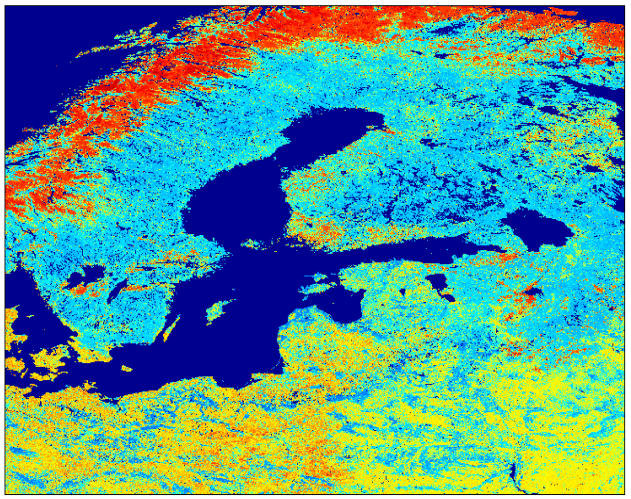
$N_{classes}$ is the number of GlobCover classes.

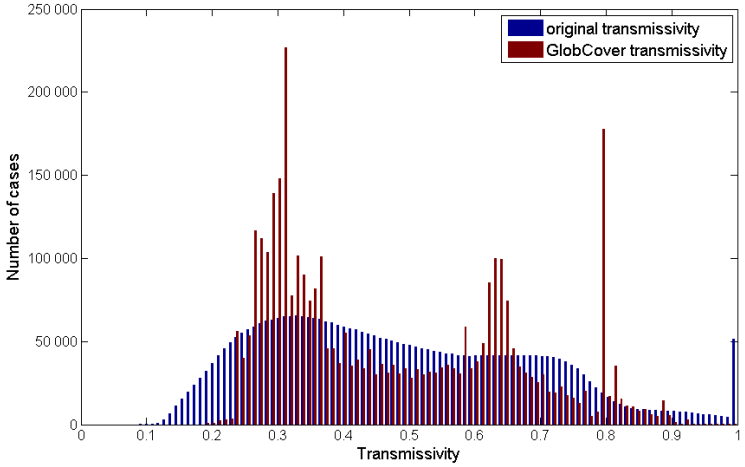
Comparison of the two transmissivities

MODIS-derived

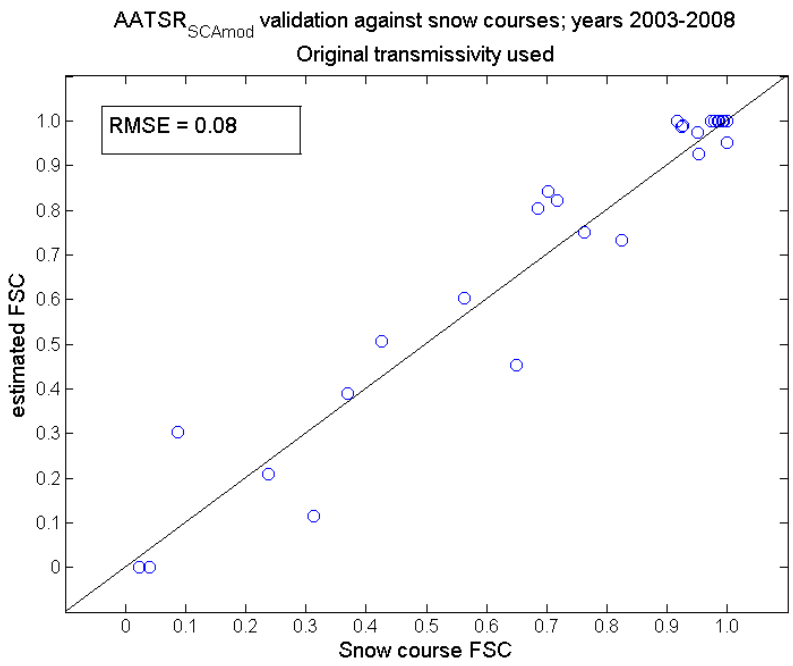


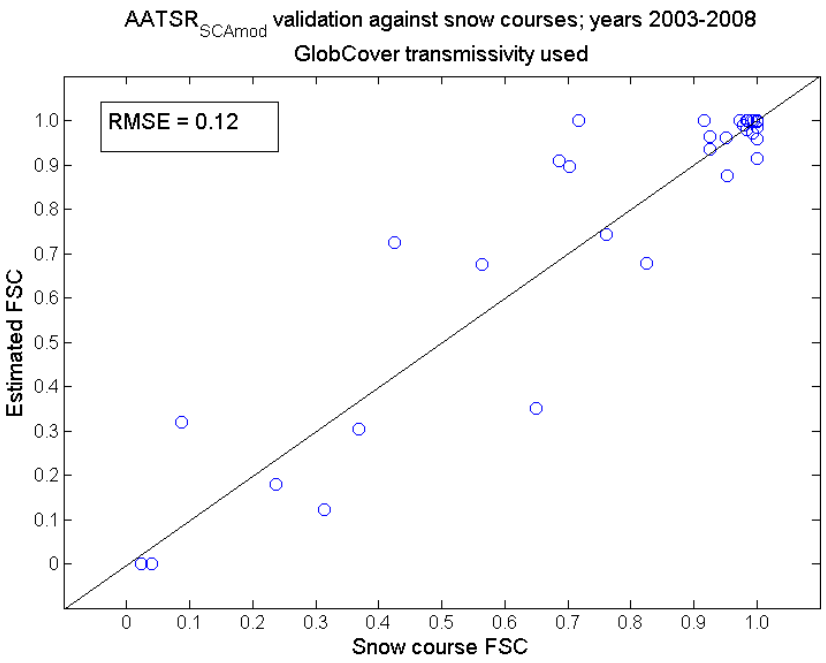
GlobCover-derived



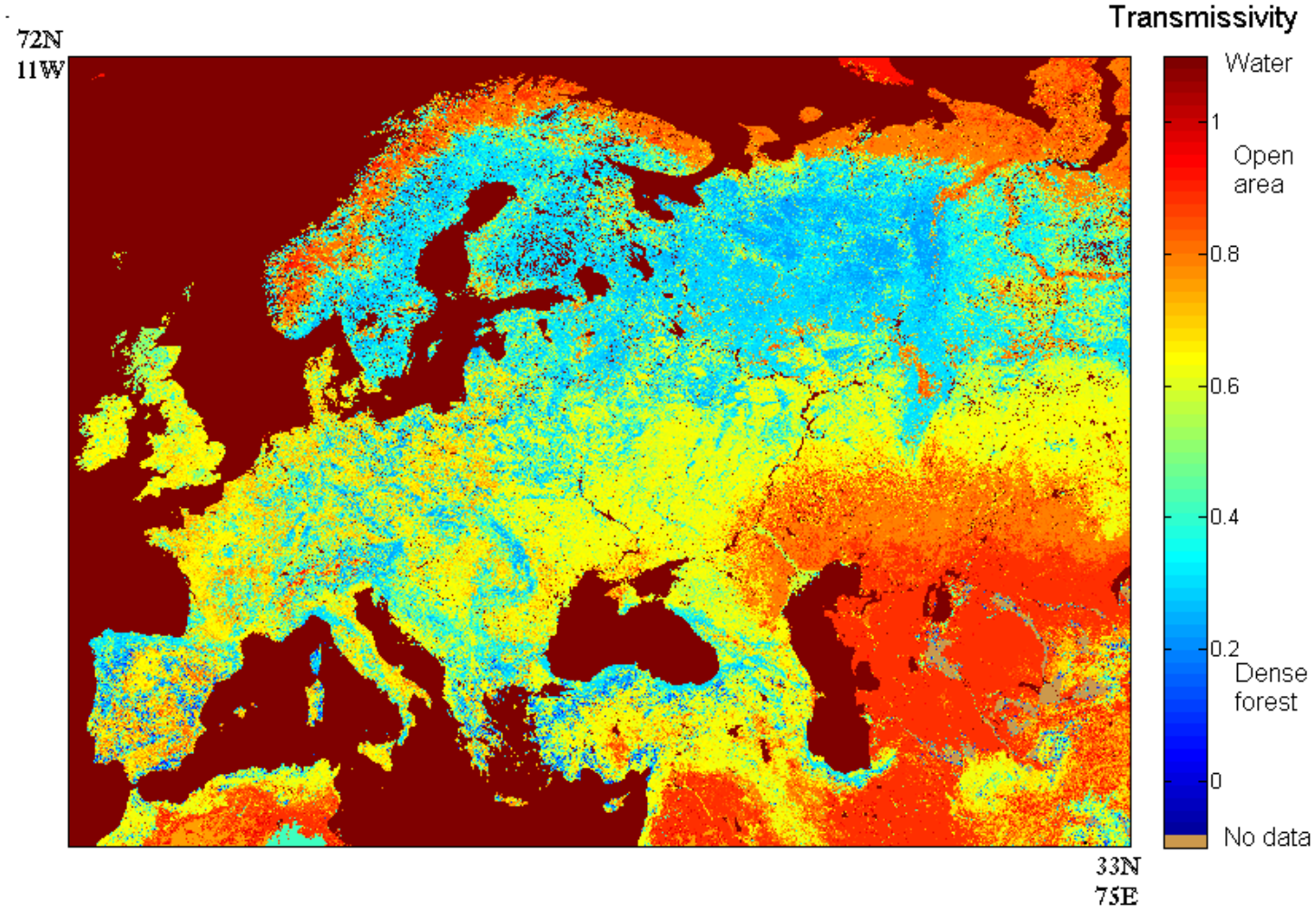


FSC validation against ground truth





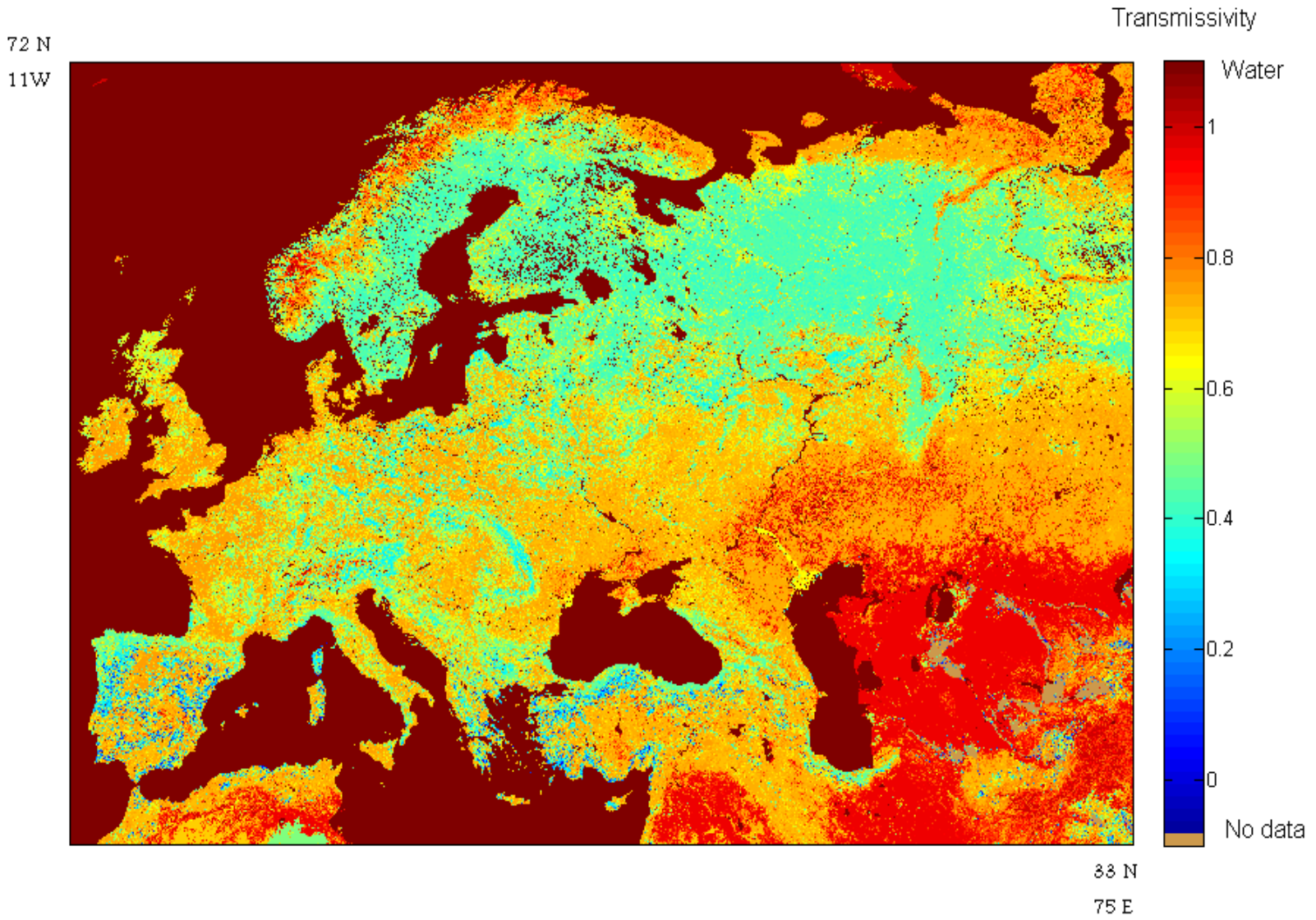
Pan-European transmissivity map
Based on GlobCover (ESA) data

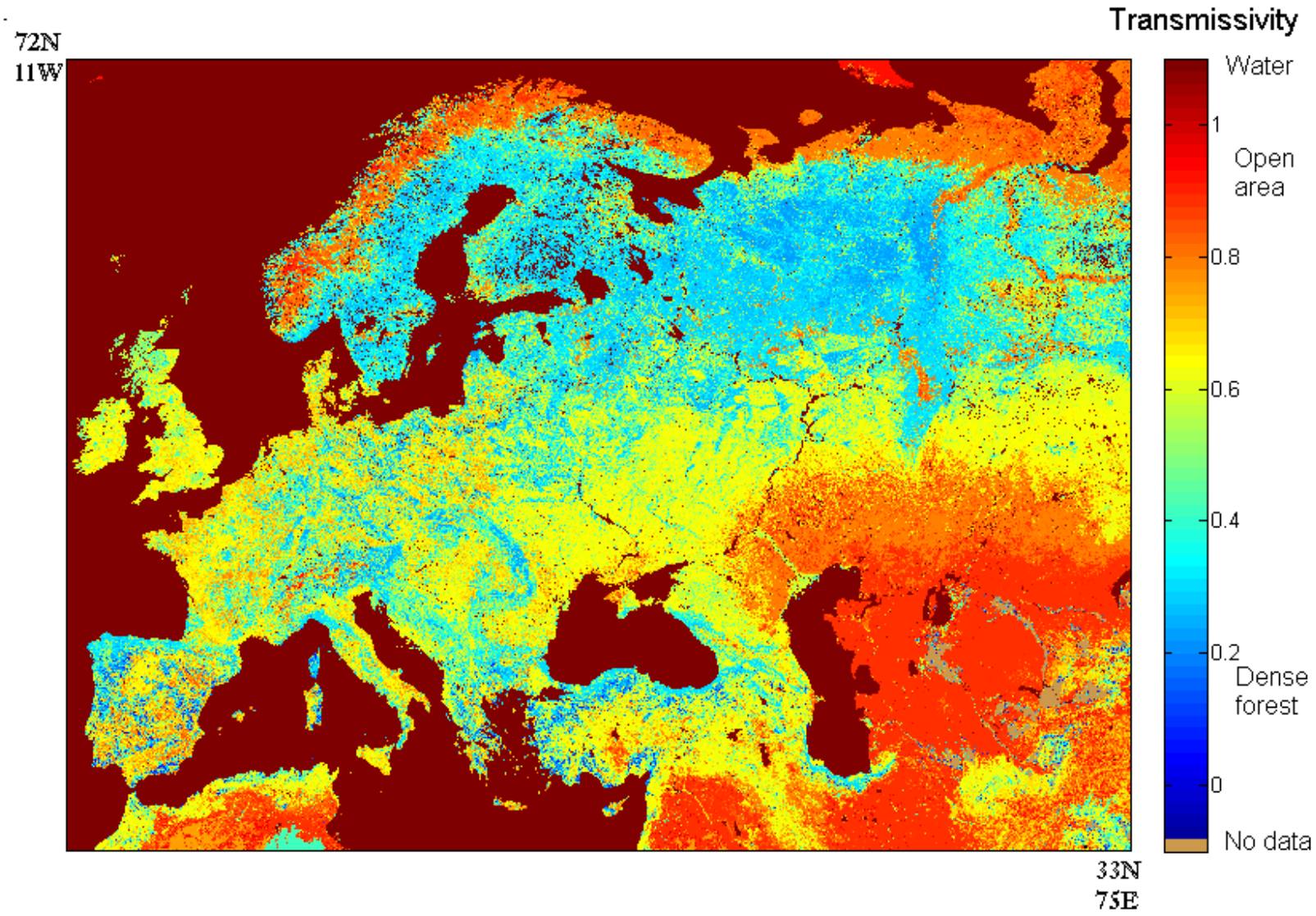


References

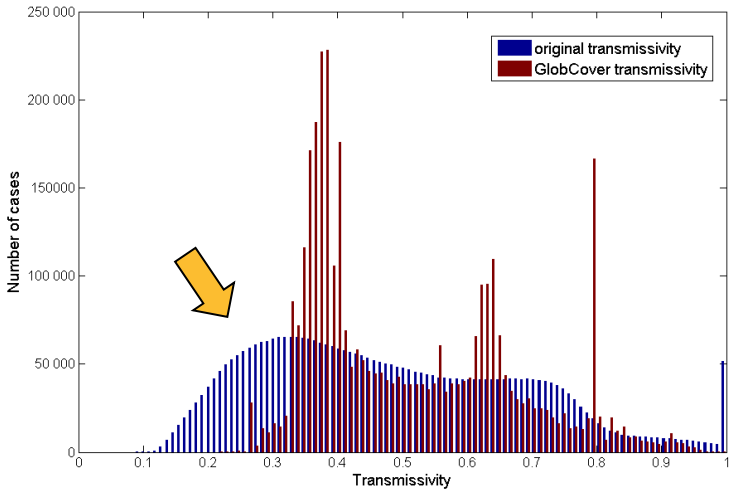
- **Bicheron, P., Huc, M., Henry, C., Bontemps, S., GLOBCOVER Product Description Manual, Issue 2, Rev. 2, 4/12/2008.**

- **Metsämäki, S., S. Anttila, M. Huttunen, J. Vepsäläinen, 2005. A feasible method for fractional snow cover mapping in boreal zone based on a reflectance model. *Remote Sensing of Environment,* Vol. 95 (1):77-95*.***

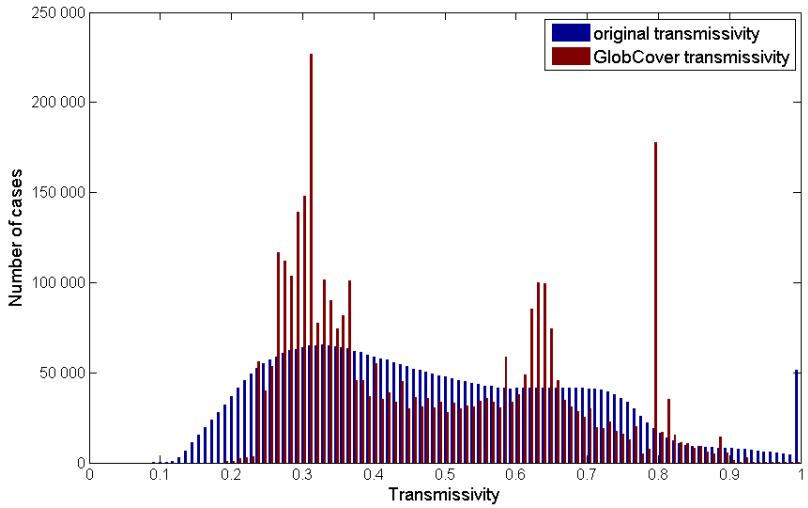

Transmissivity
72 N
11W
Water
1
0.8
0.6
0.4
0.2
0
No data
33 N
75 E


Transmissivity
72N
11W
33N
75E
Water
1
Open
area
0.8
0.6
0.4
0.2
Dense
forest
0
No data

- **The 1first version of GC-transmissivity map could not catch the very low transmissivities; the second version is improved (very dense Russian forests are now included in the statistical analysis)**



Old version



New version