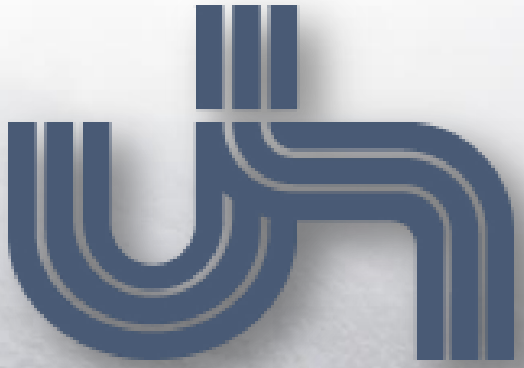

INSTITUTE OF HYDROLOGY
SAS

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SNOW LINE ESTIMATION FROM MODIS IMAGES FOR SEASONALLY-SNOW COVERED MOUNTAIN BASINS

INTRODUCTION

- **Snow line in general**
  - the outer boundary of a snow covered area (Fierz et al, 2009)
- **Climatic snowline in glacier studies**
  - characterizes the point above which snow and ice are present throughout the year.
- **Our case**
  - daily snow line is an elevation that most precisely dividing given area to snow covered and snow free part.

WHY IS IT IMPORTANT?

- Availability of water – important issue in the changing world
- Input and validation for snow melt models
- Climate characteristic of alpine region
- Cloud reduction for remote sensing snow cover data
- Field measurements -

  limited in mountain areas

OBJECTIVES

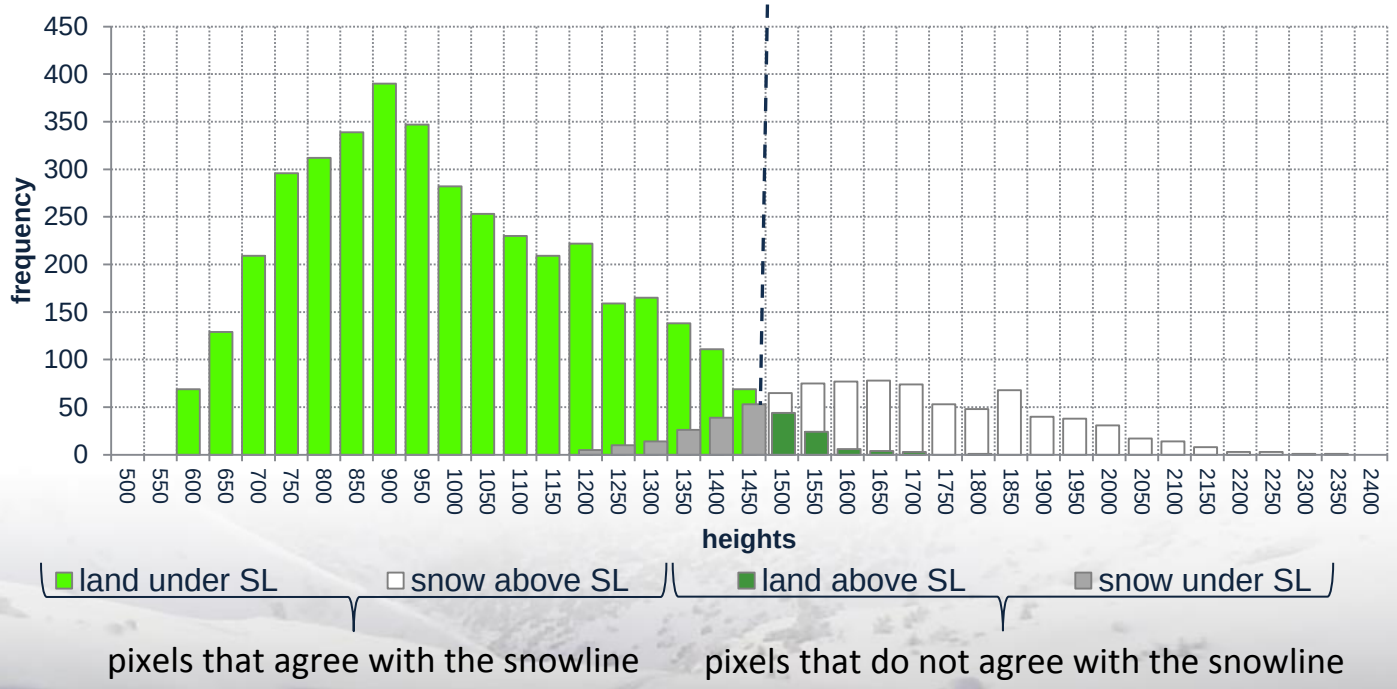
- Develope and validate a method for estimation of regional snow line (SL) elevation in seasonally snow-covered basin
- Evaluate spatial and temporal variability of SL elevation in upper Váh catchment (Slovakia)

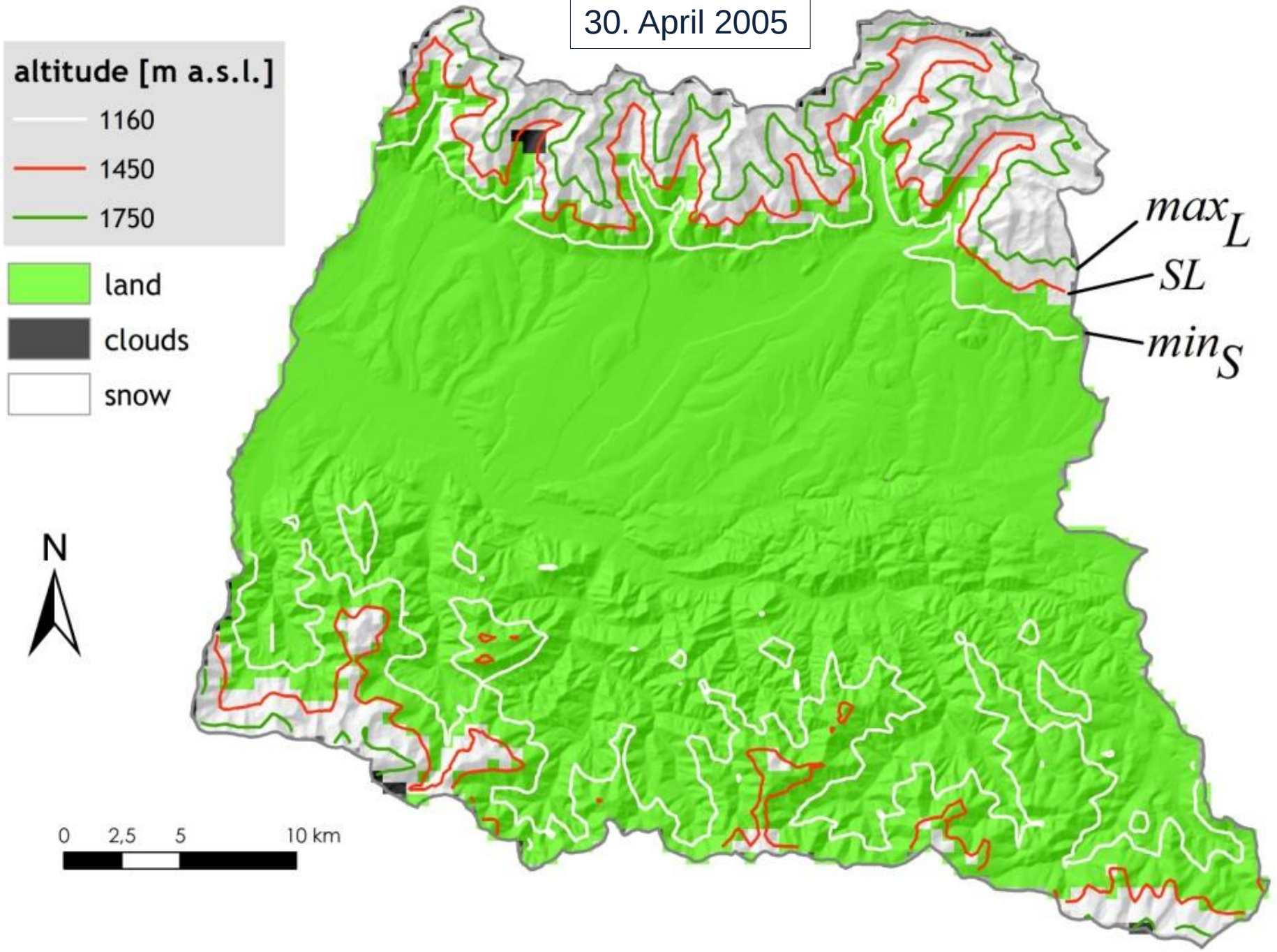
SL ESTIMATION METHOD

- comparing count of snow and no snow pixels under and above different elevations (virtual snow lines)

30. April 2005

SL = 1453 asl.



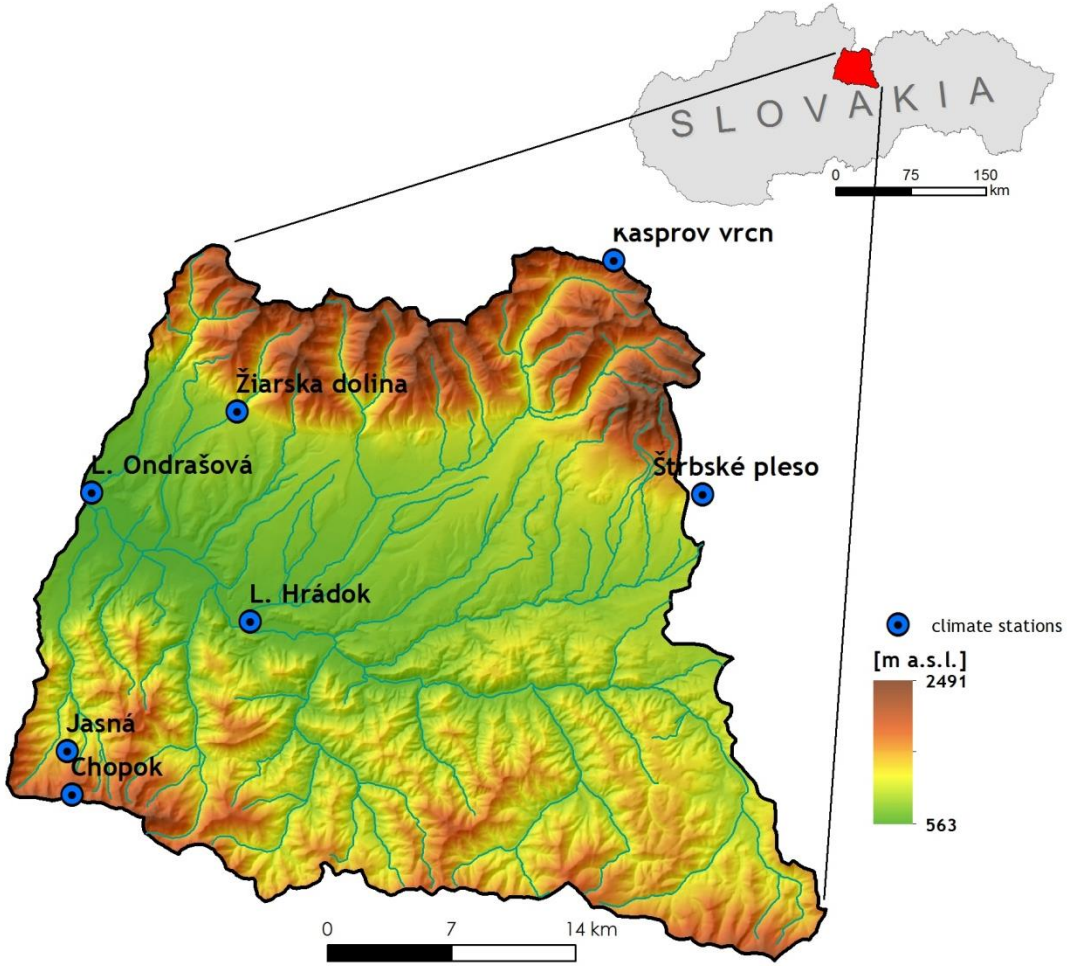

30. April 2005
altitude [m a.s.l.]
1160
1450
1750
land
clouds
snow
N
0
2,5
5
10 km
max_L
SL
min_S

DATA

- Remote sensing data
  - Satellite images MODIS daily snow cover product (satellites Terra & Aqua)
  - February 2000 – June 2013
  - Winter period (November to May) – 2840 days
- In-situ observations
  - 7 stations
  - Daily snow depth measurement

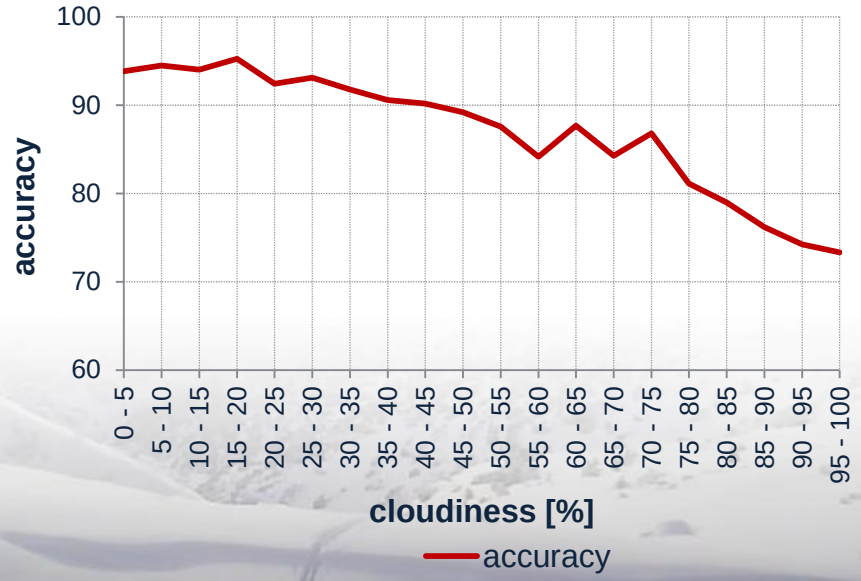
STUDY AREA

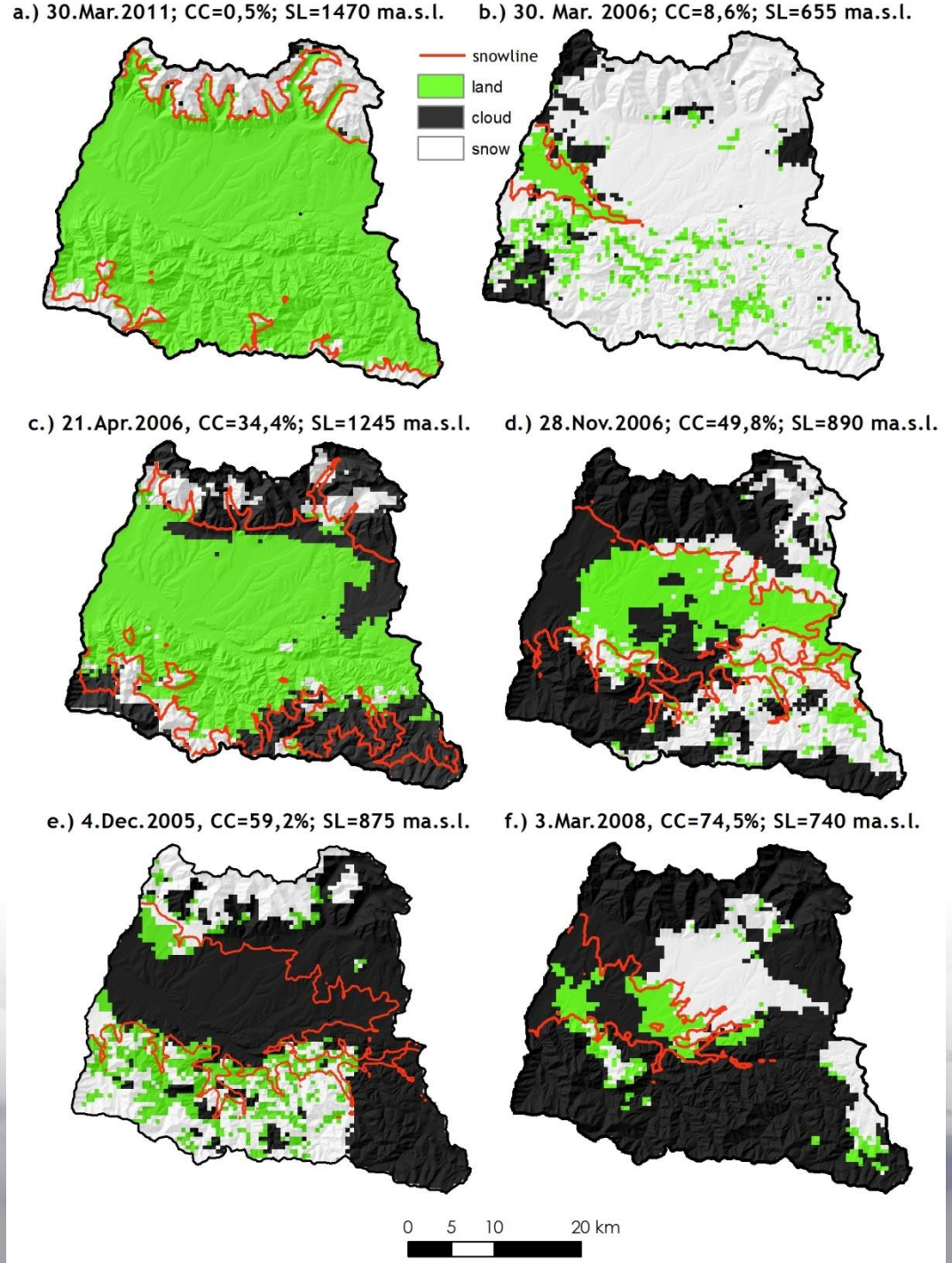
- Basin area is 1216 km^2
- elevations range 564 m a.s.l. to 2494 m a.s.l.



CLOUDINESS THRESHOLD

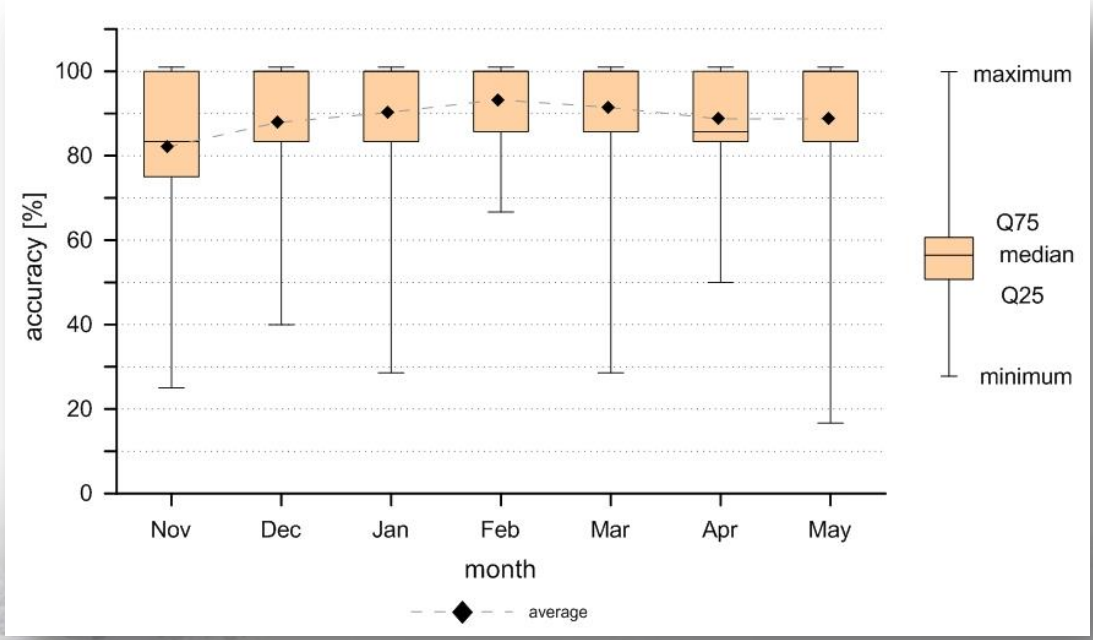
- Accuracy decreases with increase of cloud cover percentage.
- In our case significant decrease is at 75%
- Further analysis - just days with less cloud cover than 75%




a.) 30.Mar.2011; CC=0,5%; SL=1470 ma.s.l.
b.) 30. Mar. 2006; CC=8,6%; SL=655 ma.s.l.
snowline
land
cloud
snow
c.) 21.Apr.2006, CC=34,4%; SL=1245 ma.s.l.
d.) 28.Nov.2006; CC=49,8%; SL=890 ma.s.l.
e.) 4.Dec.2005, CC=59,2%; SL=875 ma.s.l.
f.) 3.Mar.2008, CC=74,5%; SL=740 ma.s.l.
0 5 10 20 km

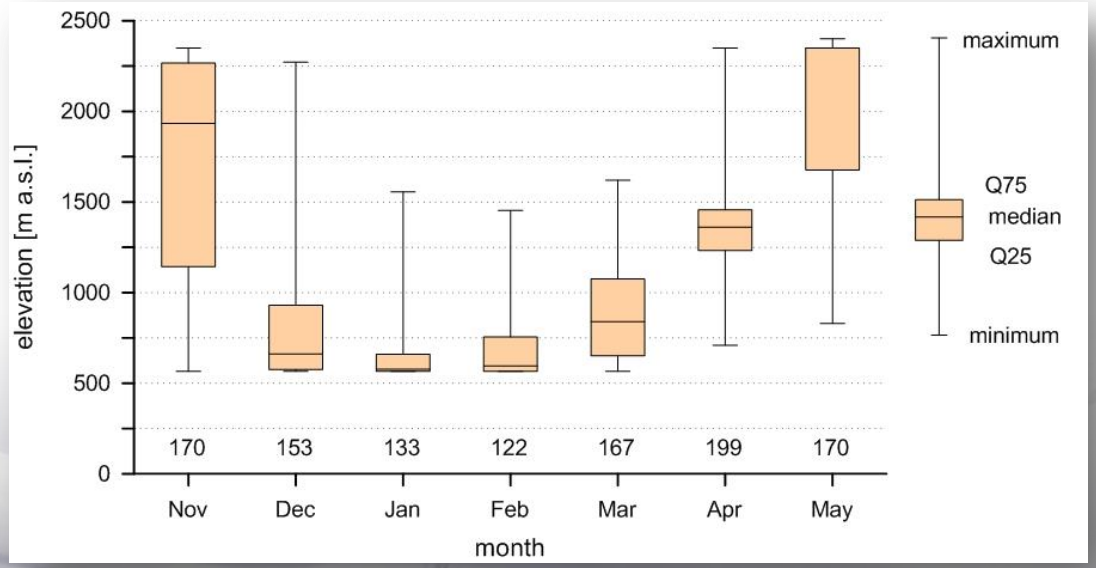
RESULTS

- Overall accuracy (NOV. – MAY): 90,1% .
- highest mean value in February when the whole basin is usually covered with snow
- The lowest accuracy is in the beginning of the winter when the SL is the most variable

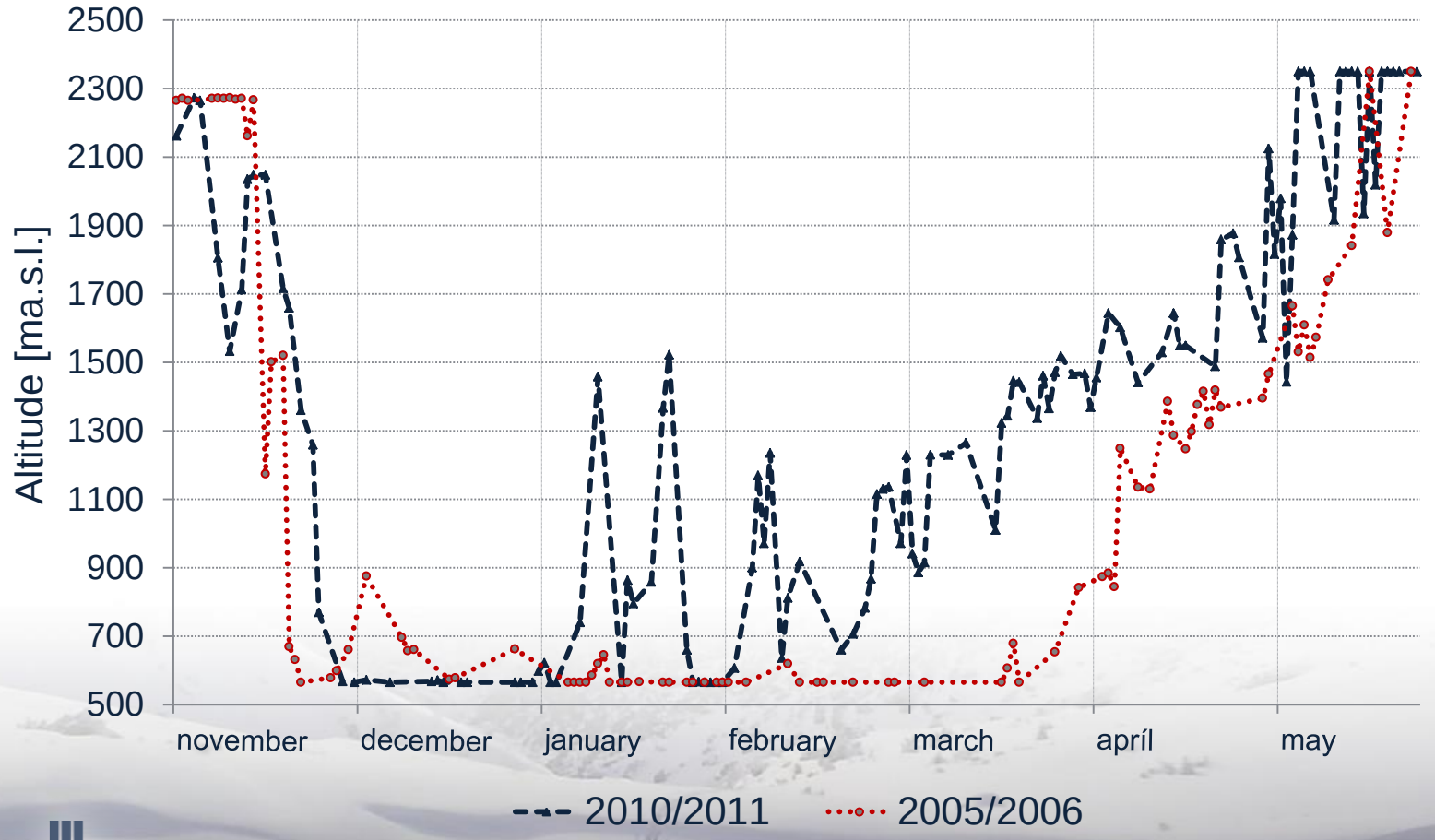


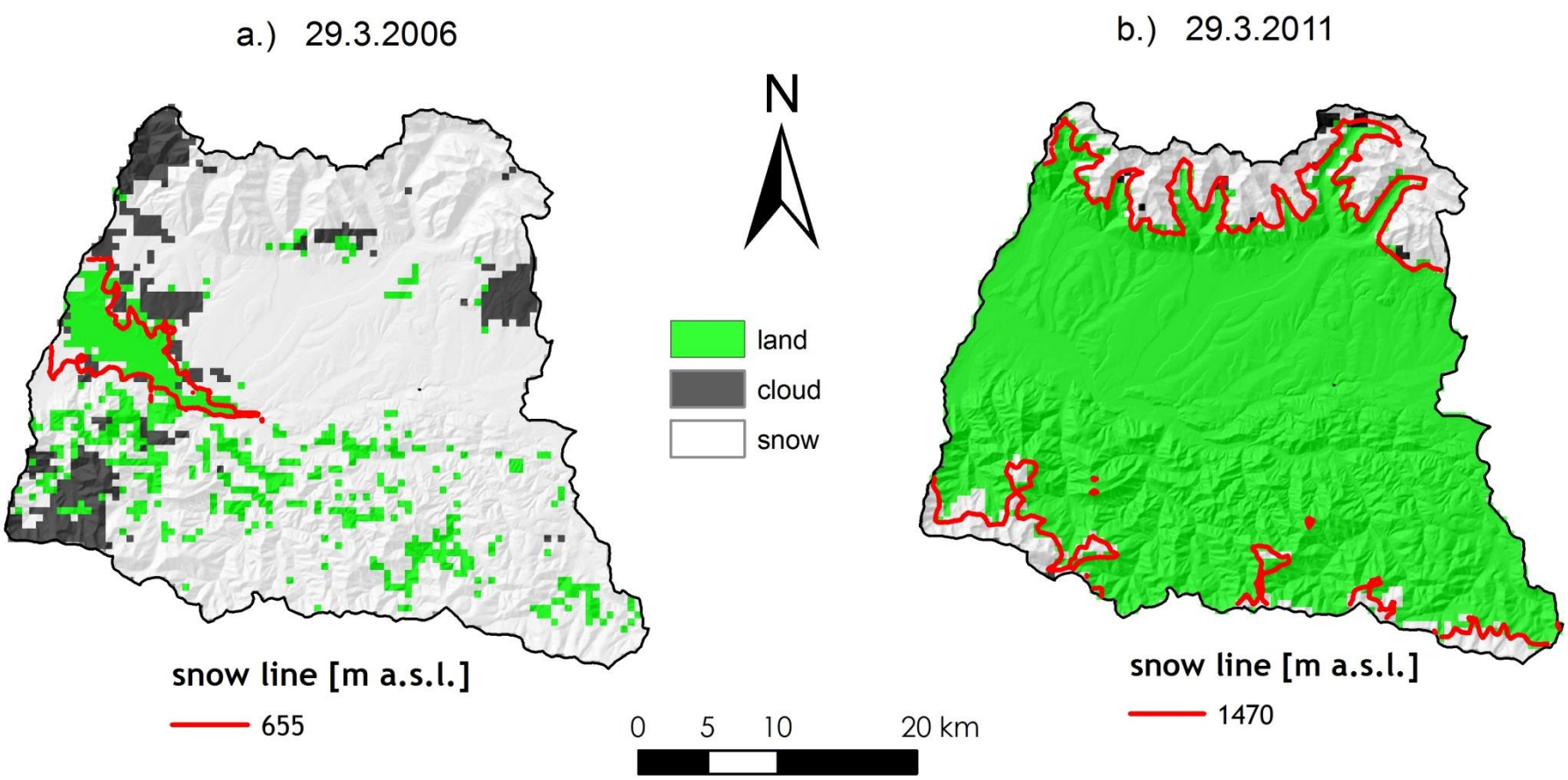
RESULTS

- Jan., Feb. - snow mostly covers the whole basin
- in May it often happens that the whole basin is without snow
- differences between snow line elevation among winters may exceed 1000m



CHOSEN WINTERS (2005/2006, 2010/2011)

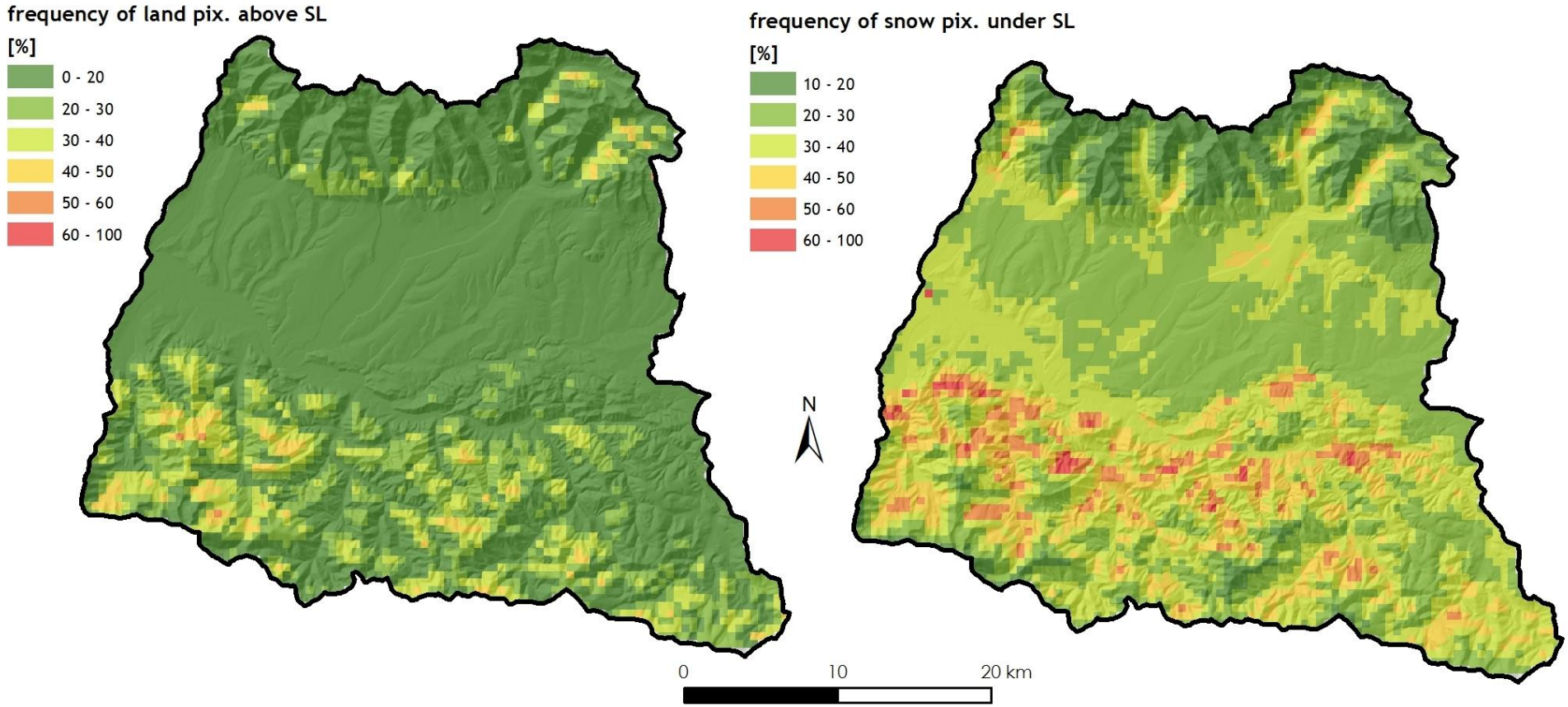


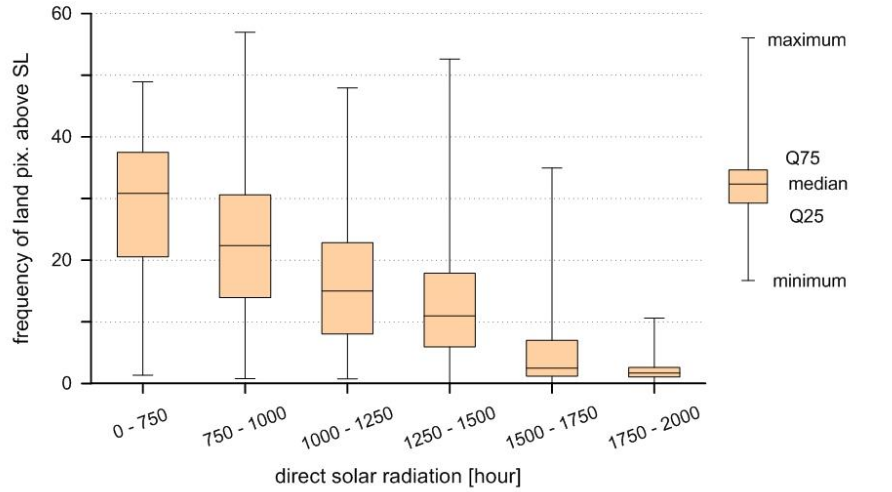

a.) 29.3.2006
b.) 29.3.2011
N
land
cloud
snow
snow line [m a.s.l.]
655
snow line [m a.s.l.]
1470
0 5 10 20 km

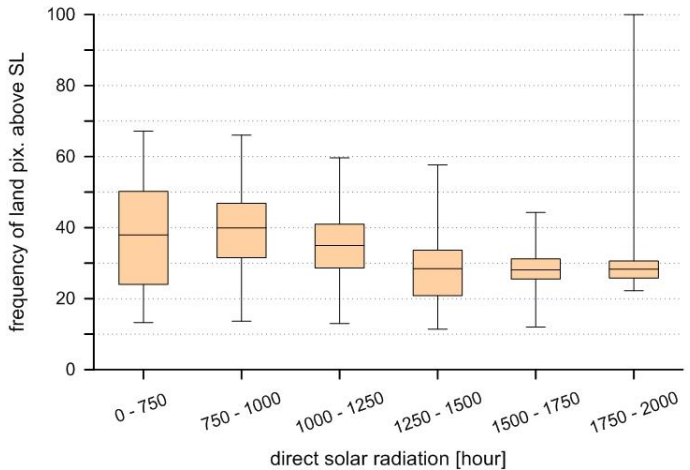
CONCLUSION

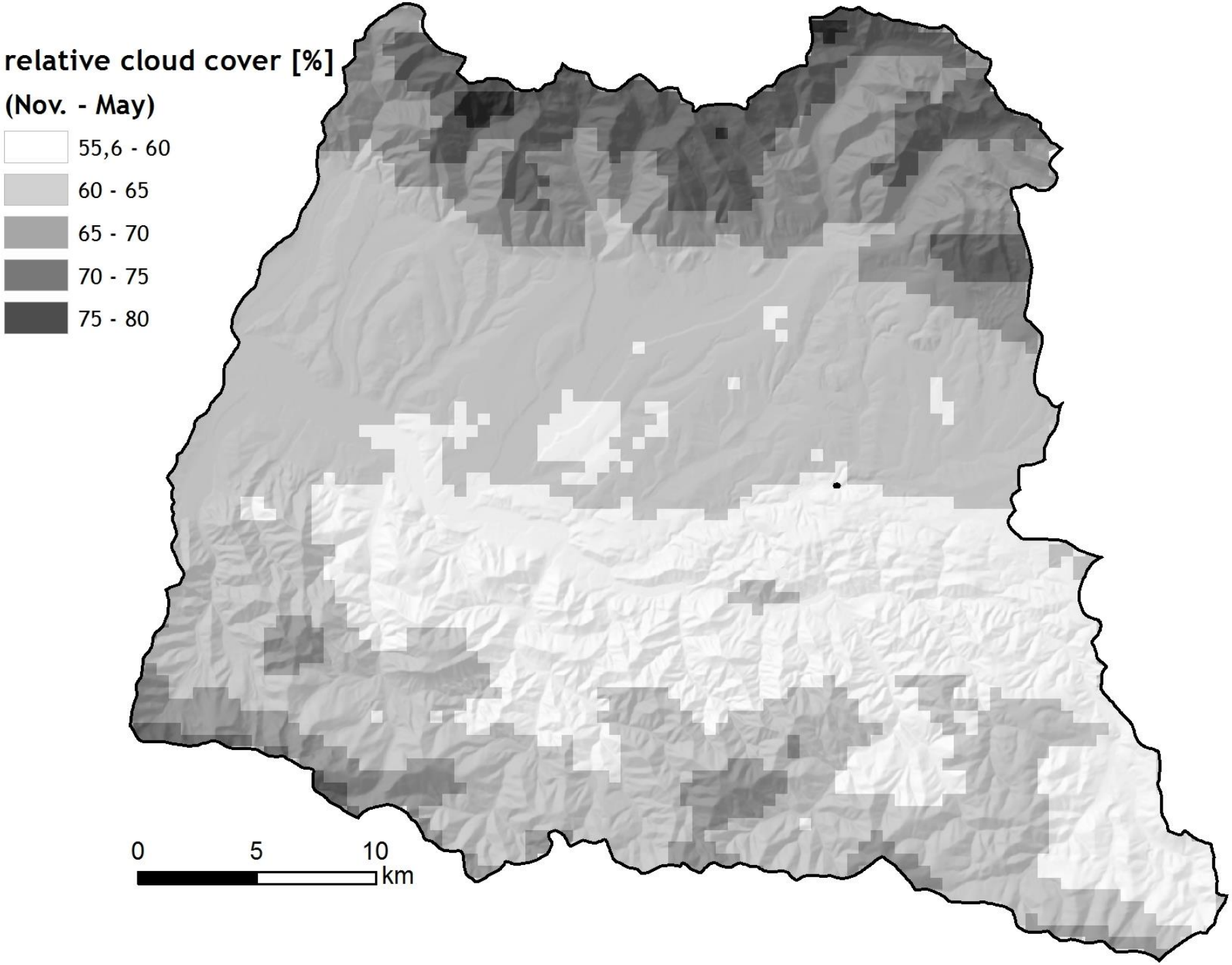
- SL determination is usable in seasonally snow-covered basin
- Overall accuracy of the presented method was 90,1%
- Difference between snow line altitude among the snow rich and poor winters may achieve even 1000 m

THANK YOU
FOR YOUR ATTENTION


frequency of land pix. above SL
[%]
0 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 100
frequency of snow pix. under SL
[%]
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 100
N
0
10
20 km


frequency of land pix. above SL
60
40
20
0
0 - 750
750 - 1000
1000 - 1250
1250 - 1500
1500 - 1750
1750 - 2000
direct solar radiation [hour]
maximum
Q75
median
Q25
minimum


frequency of land pix. above SL
100
80
60
40
20
0
0 - 750
750 - 1000
1000 - 1250
1250 - 1500
1500 - 1750
1750 - 2000
direct solar radiation [hour]


relative cloud cover [%]
(Nov. - May)
55,6 - 60
60 - 65
65 - 70
70 - 75
75 - 80
0
5
10
km

	accuracy [%]							
	L. Ondrašová	L. Hrádok	Žiarska dolina	Jasná	Štrbské pleso	Červenec	Kasprov vrch	Chopok
Nov.	94,0	96,5	93,3	87,4	77,3	88,2	83,8	71,7
Dec.	83,6	81,8	85,6	91,9	84,5	100,0	96,6	95,2
Jan.	71,1	79,7	87,2	93,8	95,3	100,0	100,0	100,0
Feb.	80,0	95,8	83,3	96,6	99,2	100,0	100,0	100,0
Mar.	85,7	90,0	76,5	89,4	96,8	98,8	100,0	100,0
Apr.	100,0	99,5	84,8	68,9	79,3	85,3	99,5	99,5
May	100,0	100,0	99,1	97,6	96,4	89,3	71,5	74,0
winter season	88,8	92,4	87,4	88,4	89,3	93,8	93,5	92,0