ÚSTAV HYDROLÓGIE SAV
INSTITUTE OF HYDROLOGY SAS

SPATIAL VARIABILITY OF SNOW IN AN ALPINE CATCHMENT

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Introduction

The main effect on snow cover creation:

- **accumulated in the mountains**
- **great impact of the wind**
- **spatial distribution of the snow cover**

The main effect on snowmelt:

- **spatial distribution of the snow cover**
- **orientation**

- **For a more detailed examination of these phenomena, we have built a measuring network in the Sokolny creek catchment in the Western Tatras**

J. Hydrol. Hydromech., 64, 2016, 4, 316–328
DOI: 10.1515/johh-2016-0038

Experimental measurements for improved understanding and simulation of snowmelt events in the Western Tatra Mountains

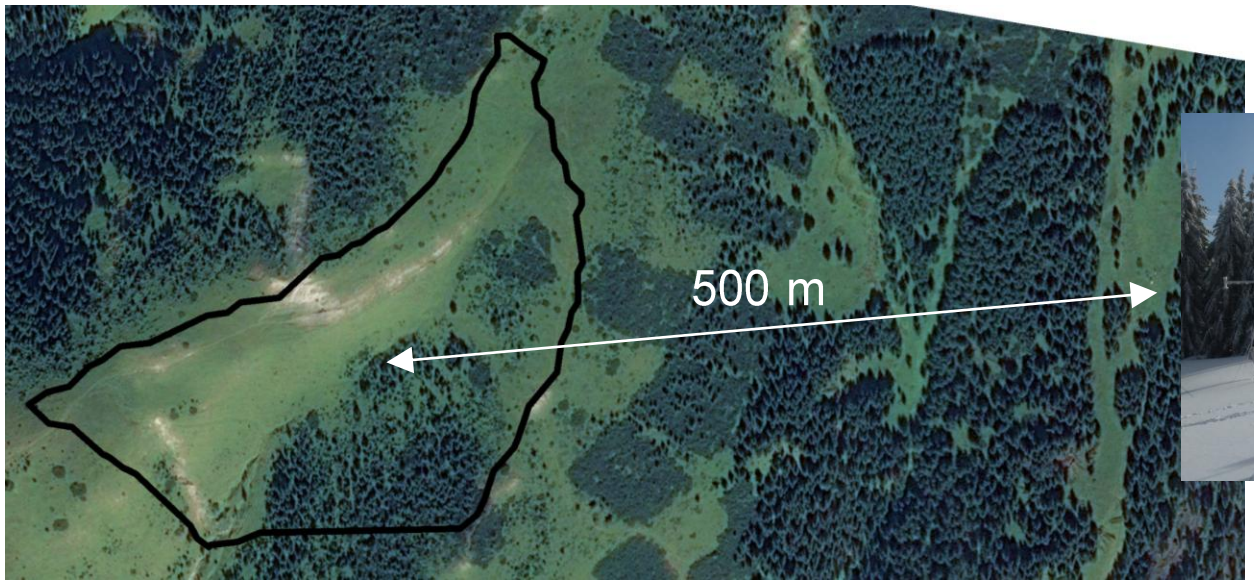
Pavel Krajčí*, Michal Danko, Jozef Hlavčo, Zdeněk Kostka, Ladislav Holko

Thesis

1. **Spatial and temporal variability of the snow cover**
- **Winter 2015, 2016, 2017**
- **Duration of stable snow cover**
- **Differences between open area and forested part in the catchment**

2. **Modeling the spatial and temporal distribution of the snow by model Mike SHE**
- **Map of spatial distribution of the snow cover**
- **Compare simulations and measurements**
- **Snowmelt**

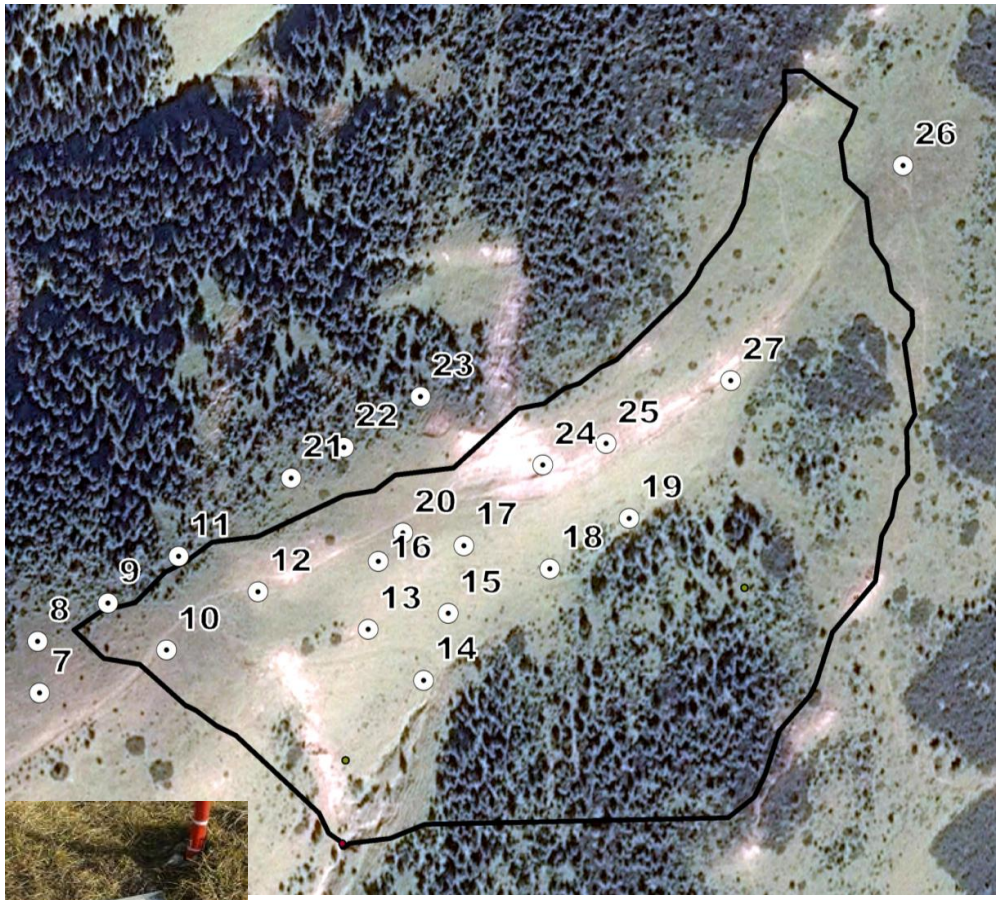
Sokolný creek catchment



- since 2014
- area 0,056 km^2
- Min. altitude 1440 m asl.
- Max. altitude 1566 m asl.
- Forested part 39%
- Geology: Limestone and dolomite
- Grassland and young forest

- Data for Sokolný creek catchment
- Automatic Meteorological Station
- 500 meters nearby catchment
- Air temperature
- Precipitation (only 2015)
- Wind
- Snowscale
- Global radiation

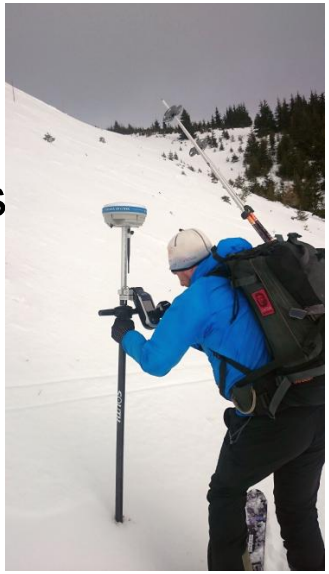
Winter 2015



- 13 Snow stakes at open area for maesurements of the snow
- 7 surface thermometers in open area and two in forested part in the catchment (*duration of stable snow cover*)

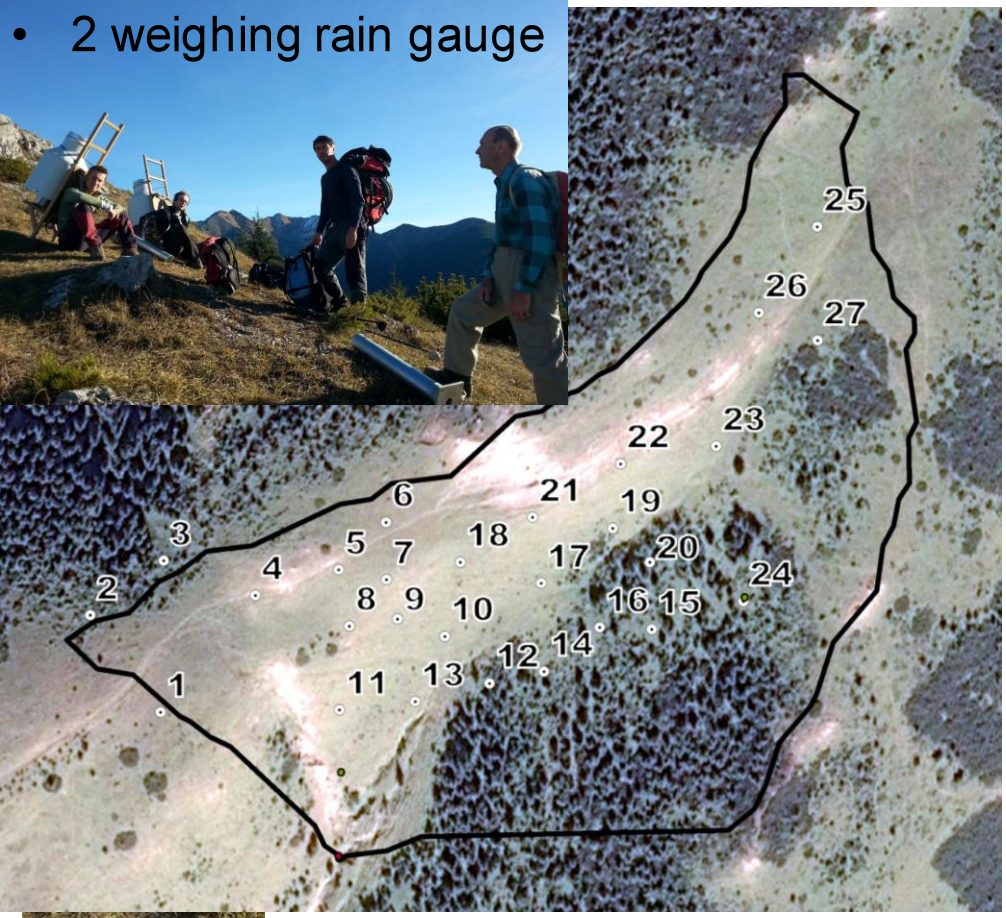
- 3 lysimeters

- GPS measurements
- Soil moisture measurements



Winter 2016, 2017

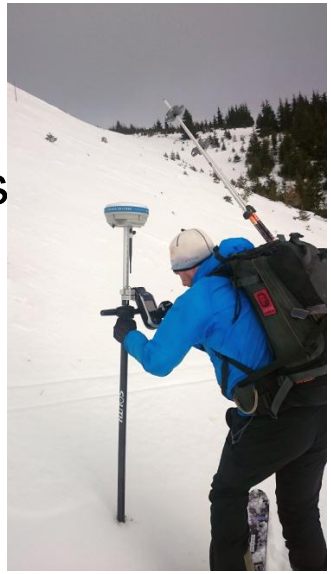
- 2 weighing rain gauge



- 19 Snow stakes at open area
- 6 Snow stakes in forest

- 19 surface thermometers in open area and 6 in forested part in the catchment (*duration of stable snow cover*)

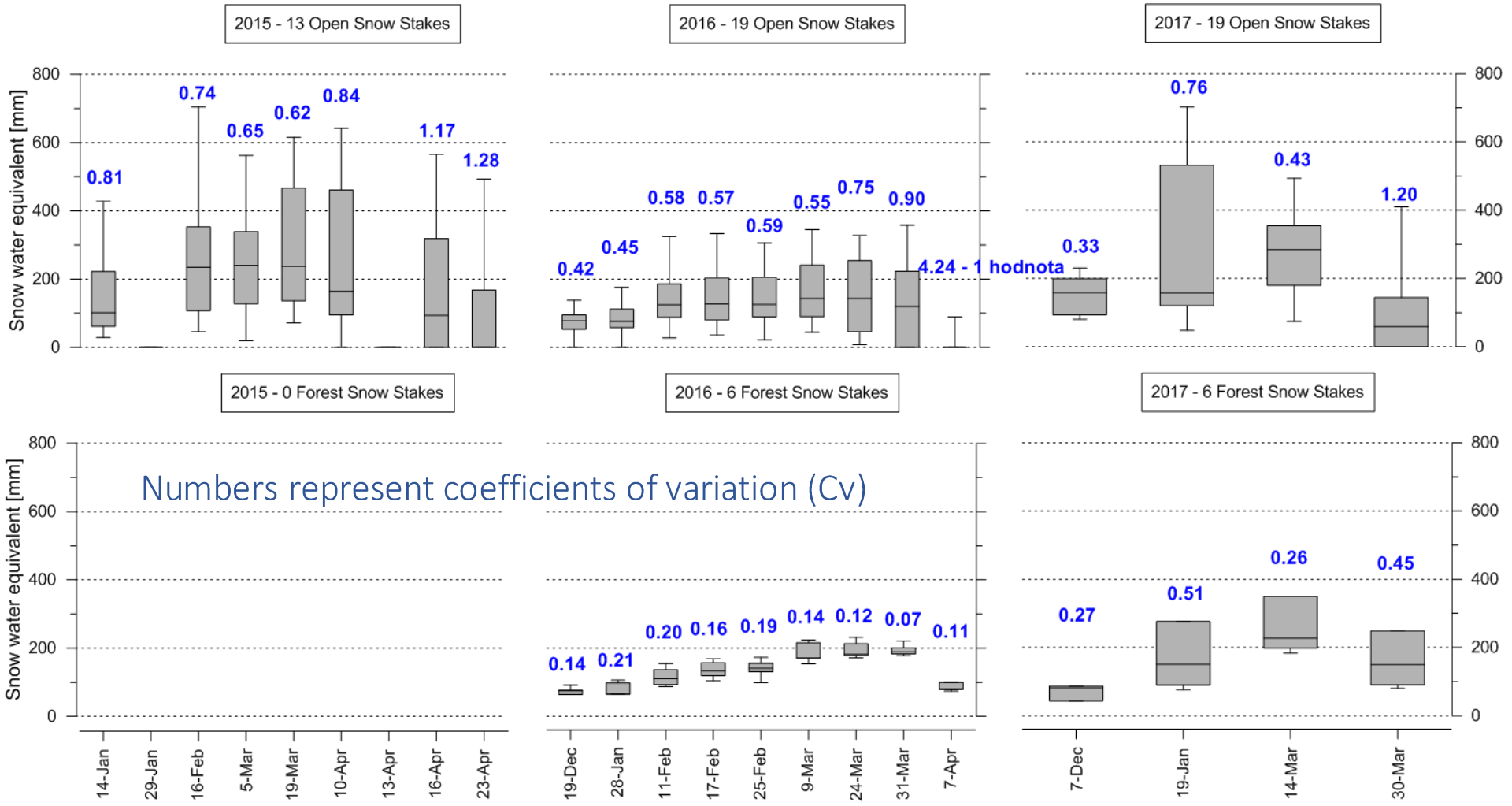
- GPS measurements



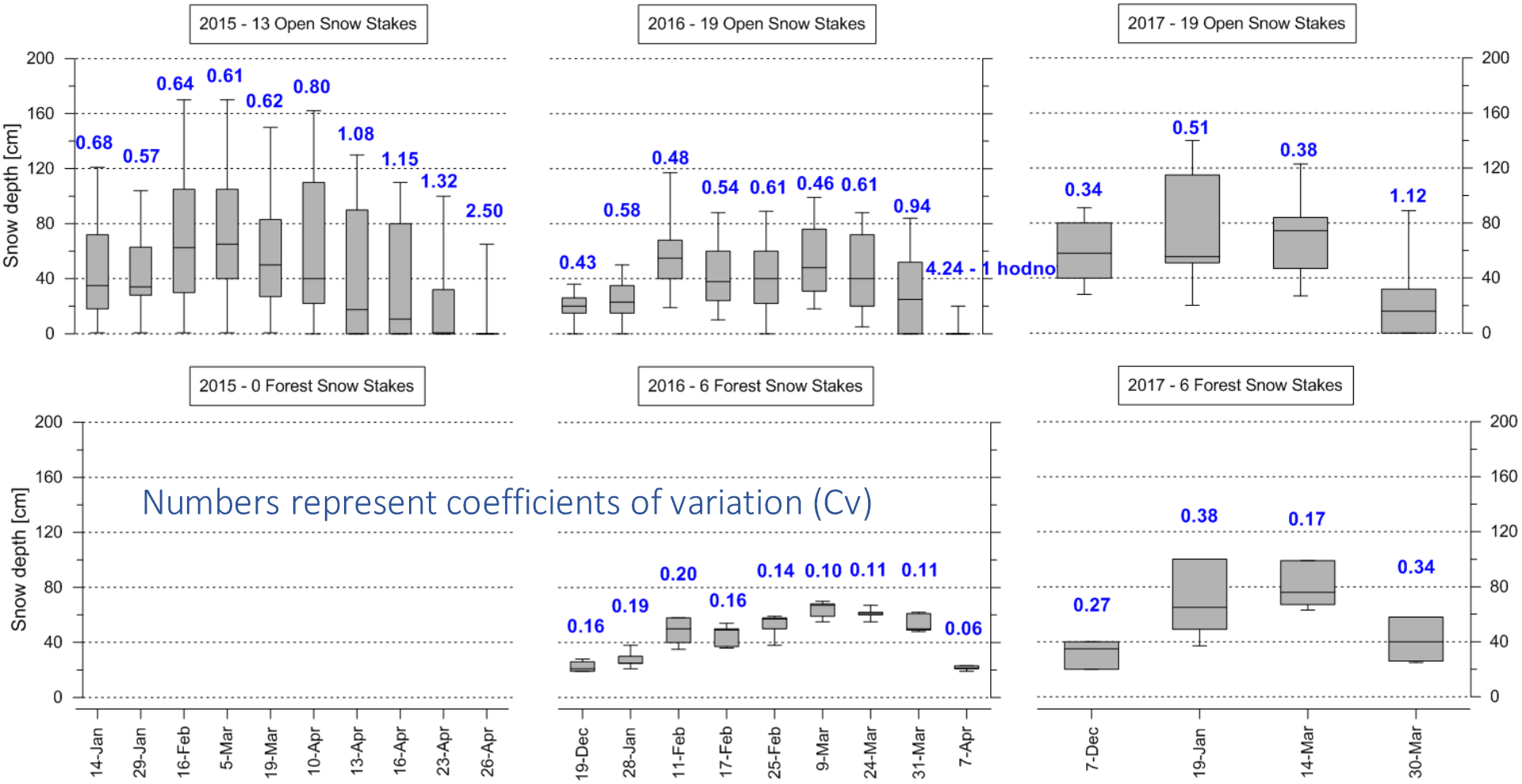
- 9 lysimeters

- Soil moisture measurements

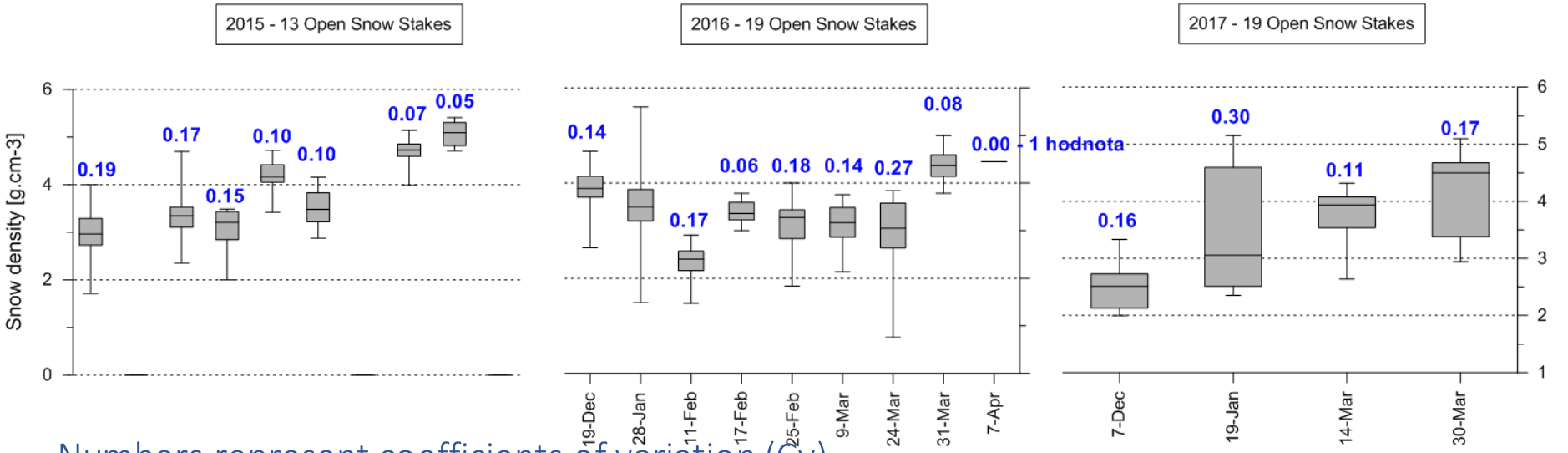
Spatial and temporal variability of snow water equivalent (SWE) in Winter 2015 -2016 - 2017



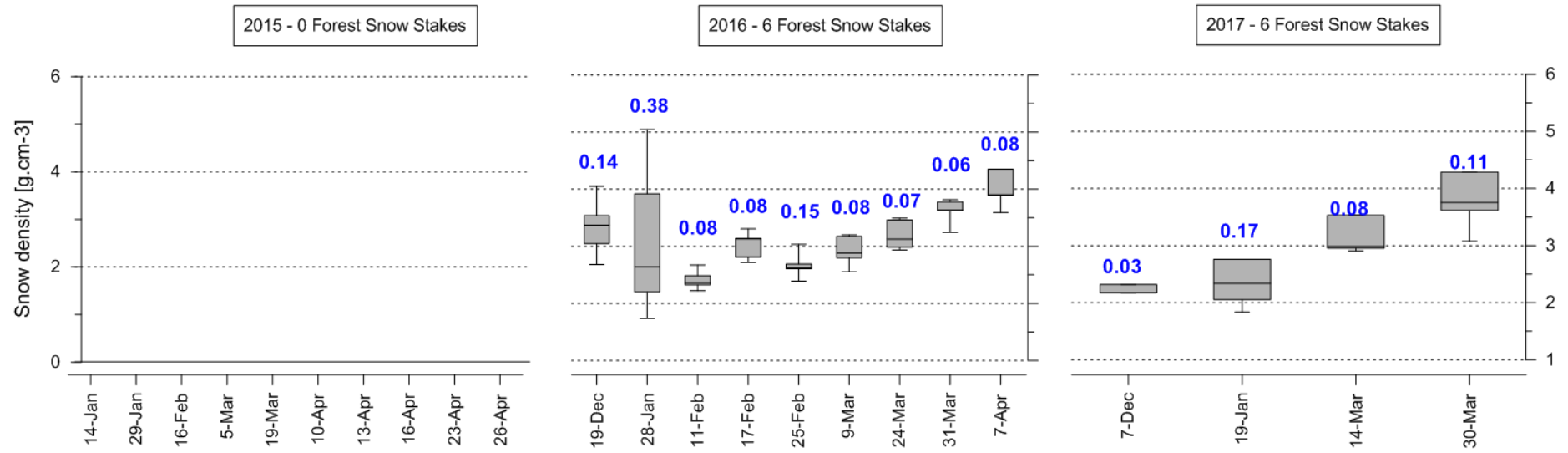
Spatial and temporal variability of snow depth 2015 – 2016 - 2017



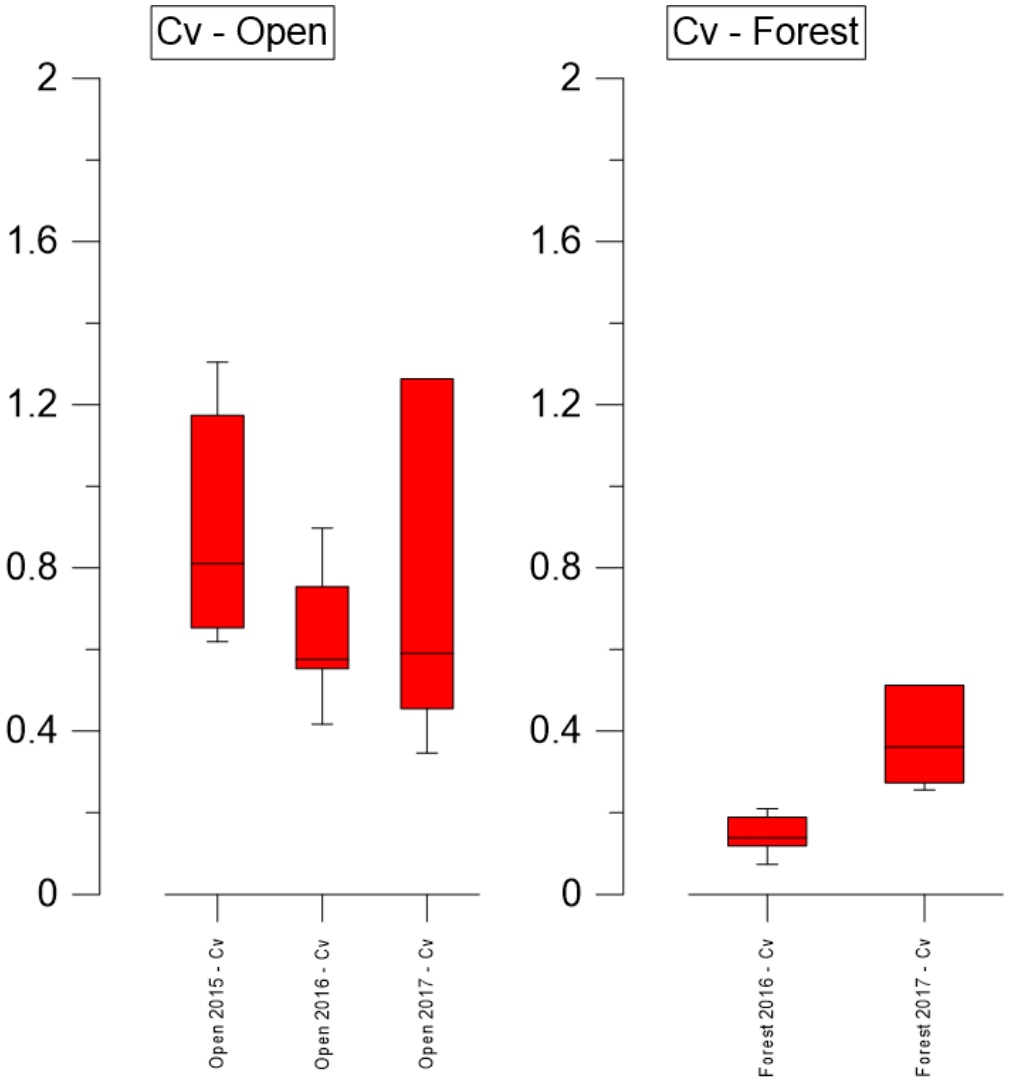
Spatial and temporal variability of snow density 2015 – 2016 - 2017



Numbers represent coefficients of variation (Cv)

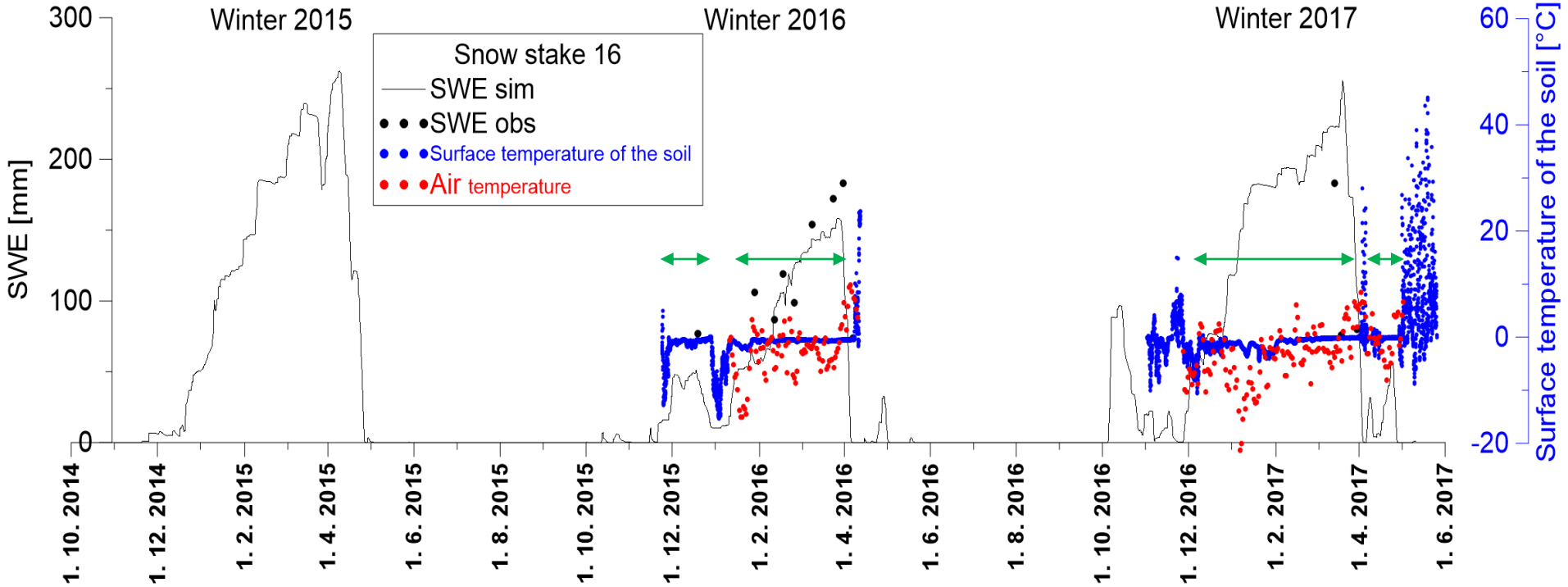


Coefficients of variation in open area and the forest (SWE)

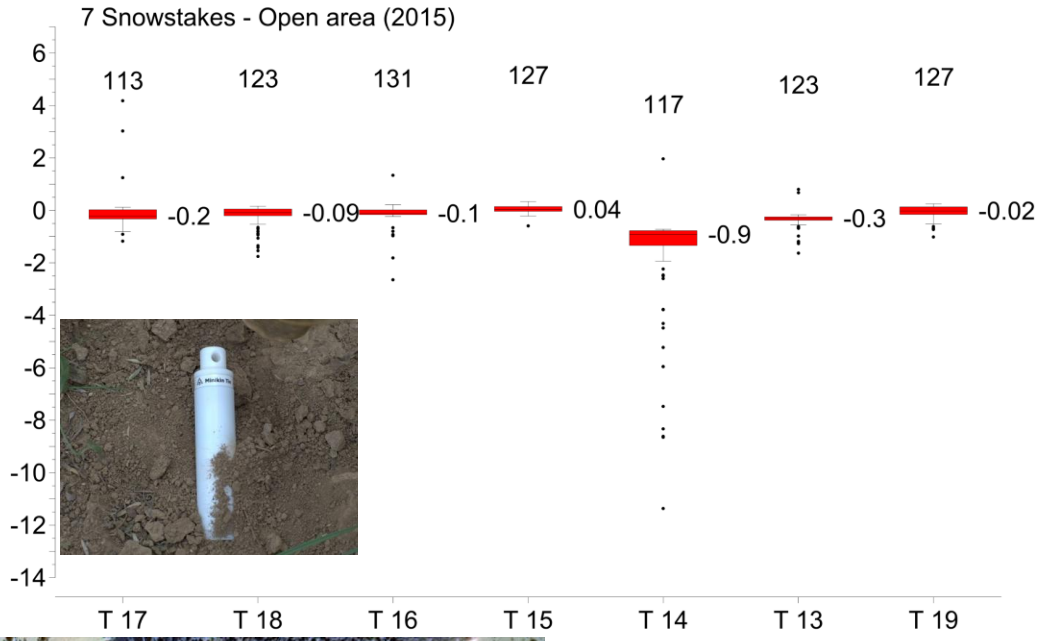


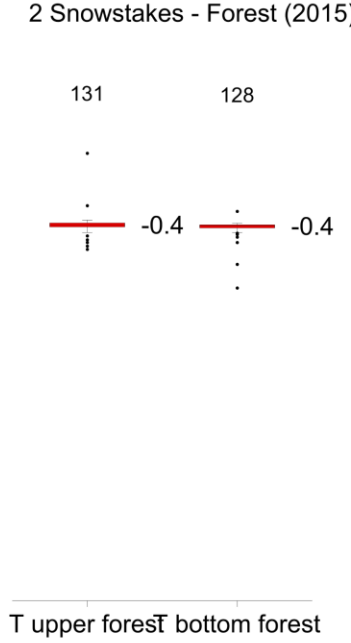
Duration of stable snow cover

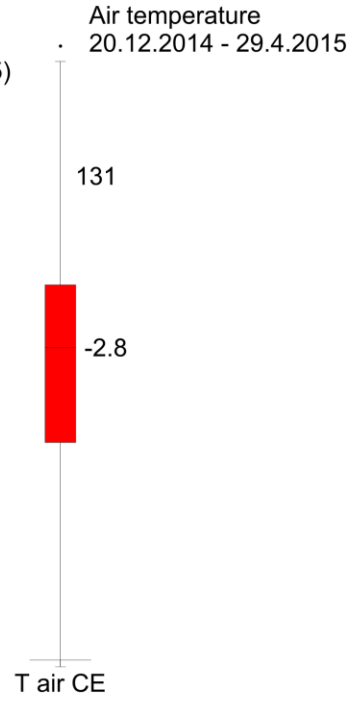
For example:
surface temperature of the soil at snow stakes under permanent snow cover at snow stake no. 16

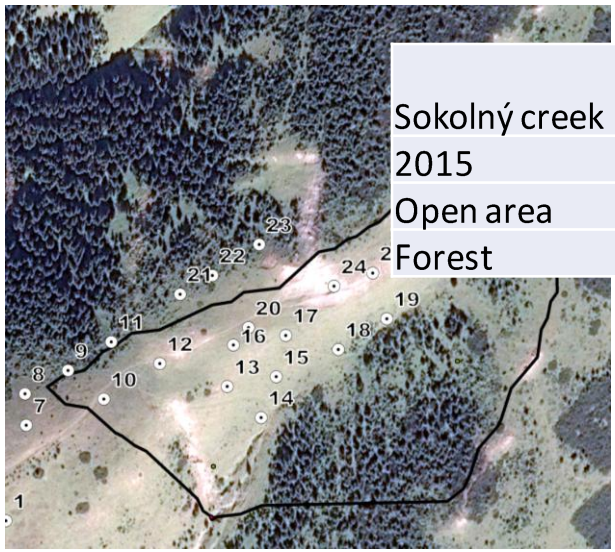


Duration of stable snow cover in winter 2015

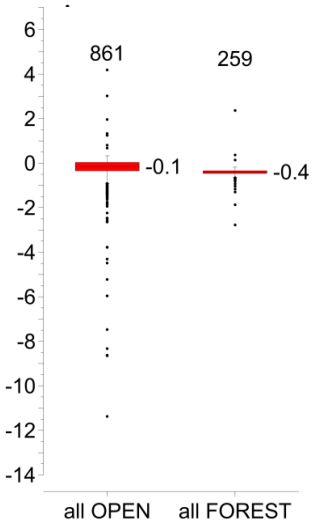




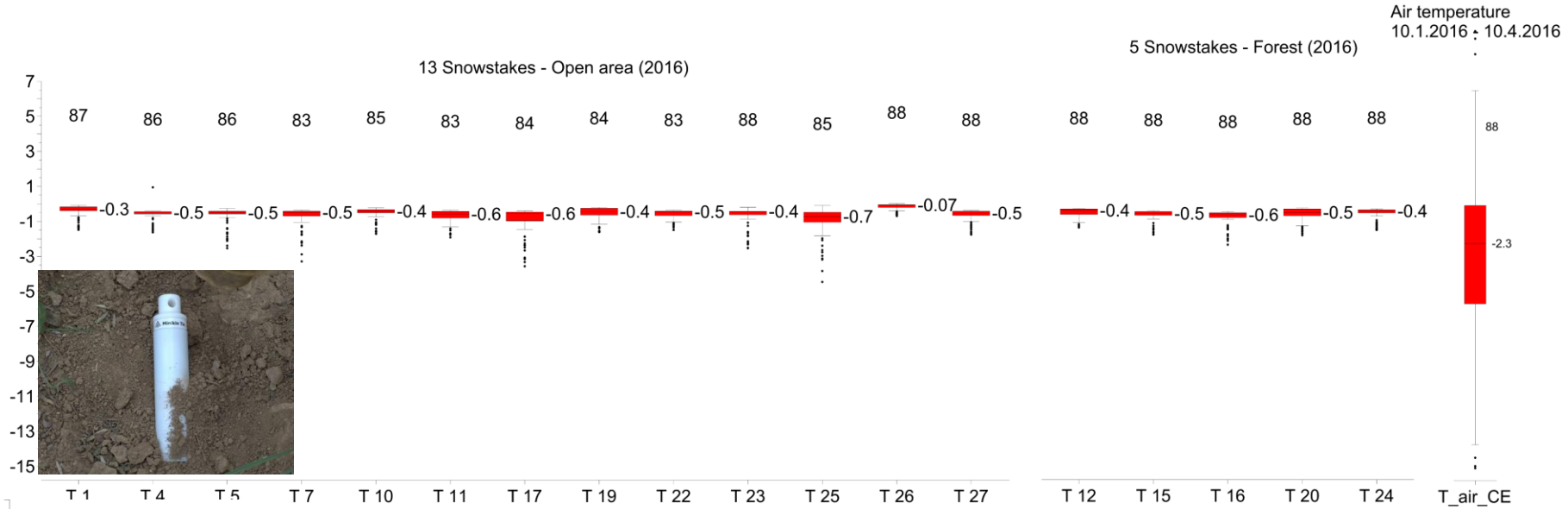


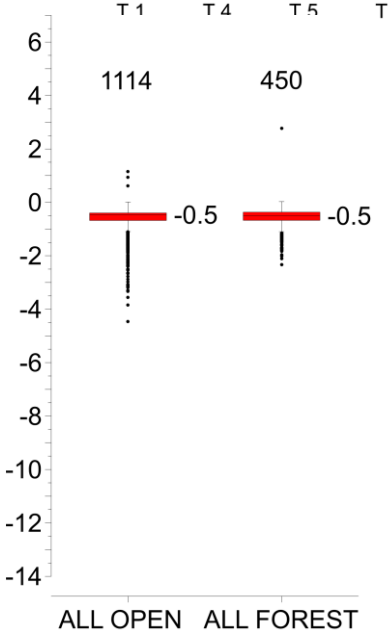


Sokolný creek	Duration of stable snow cover [days]	Median temperature under permanent snow cover [°C]
2015		
Open area	123	-0.1
Forest	130	-0.4

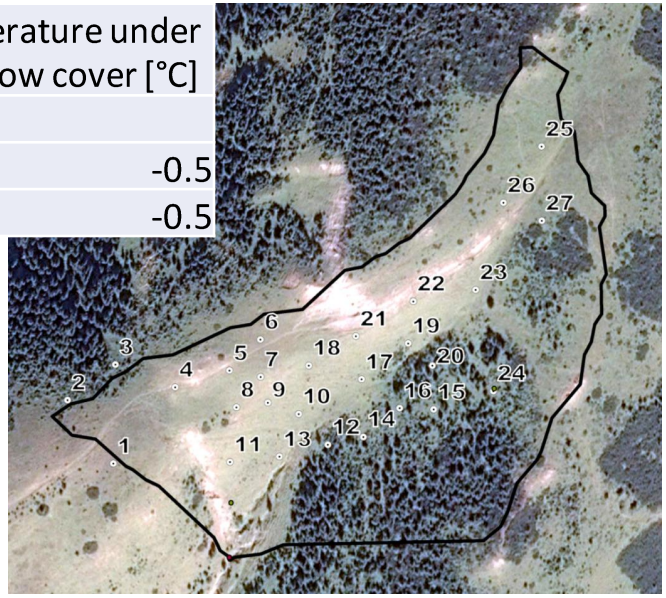


Duration of stable snow cover 2016

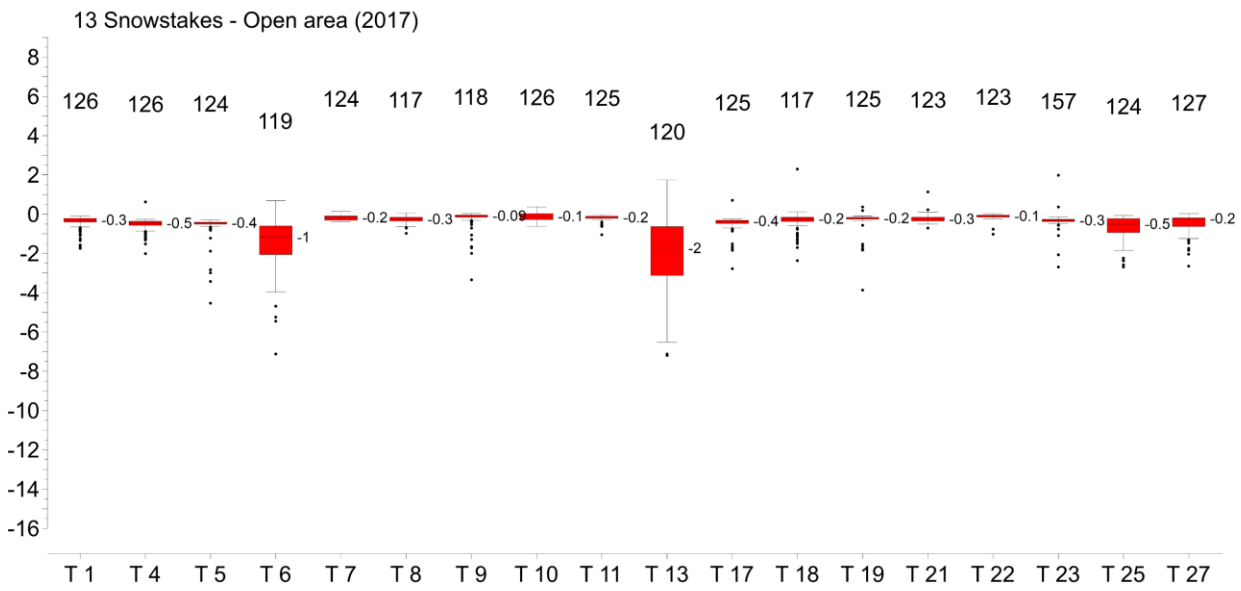


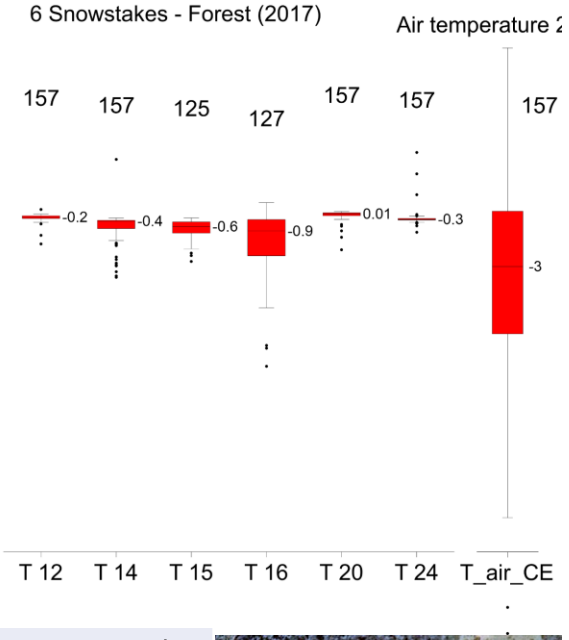


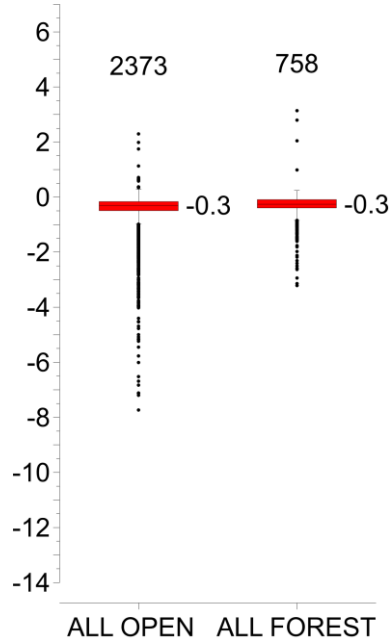
Sokolný creek	Duration of stable snow cover [days]	Median temperature under permanent snow cover [°C]
2015		
Open area	85	-0.5
Forest	88	-0.5



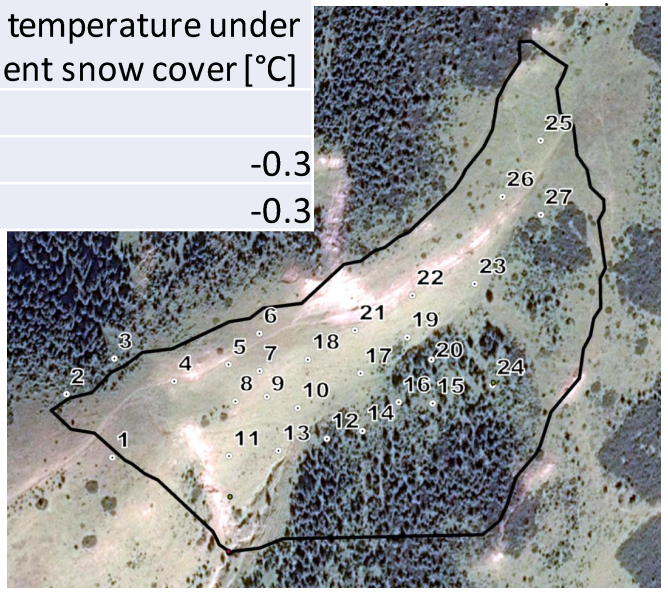
Duration of stable snow cover 2017



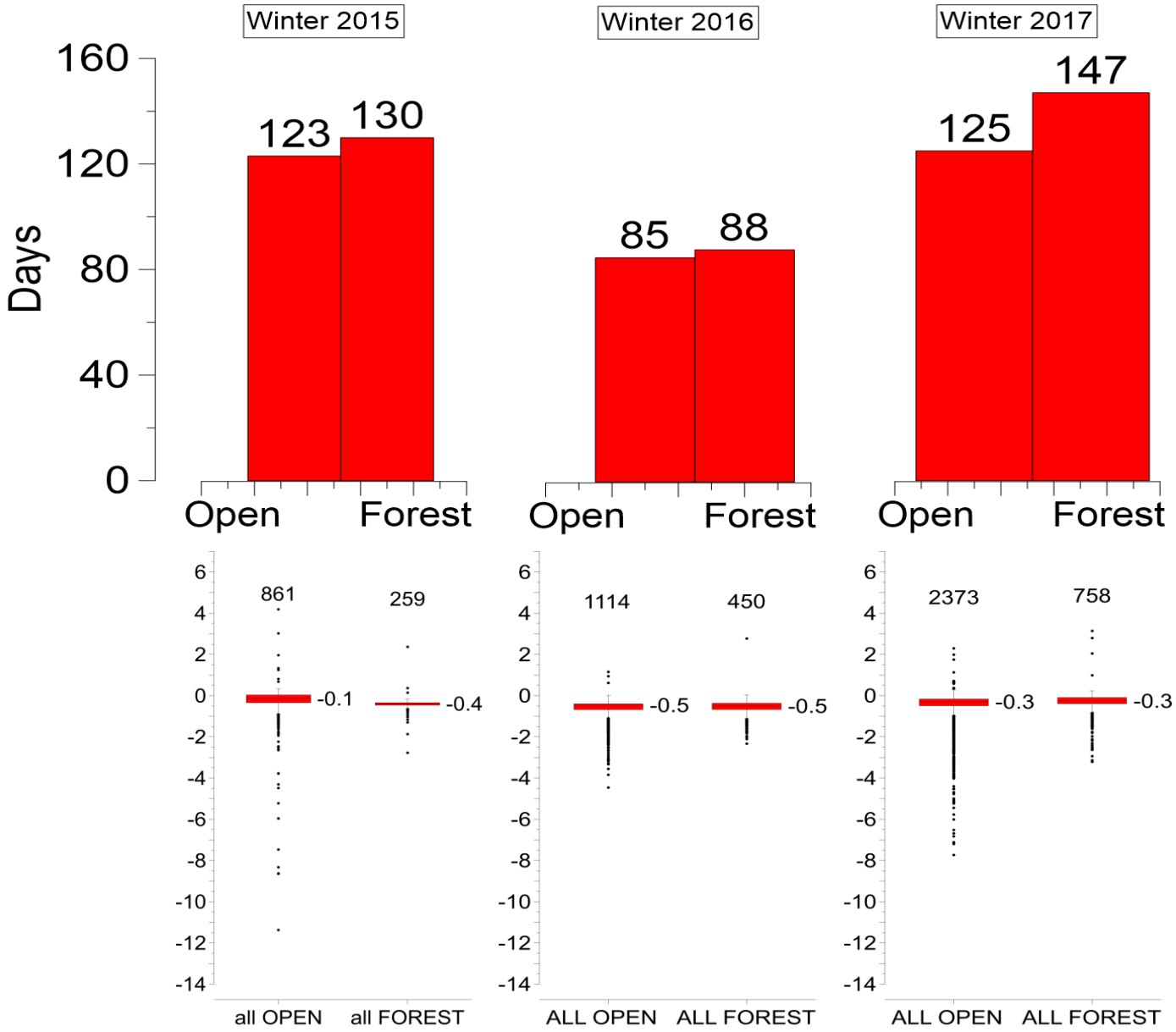




Sokolný creek	Duration of stable snow cover [days]	Median temperature under permanent snow cover [°C]
2015		
Open area	125	-0.3
Forest	147	-0.3



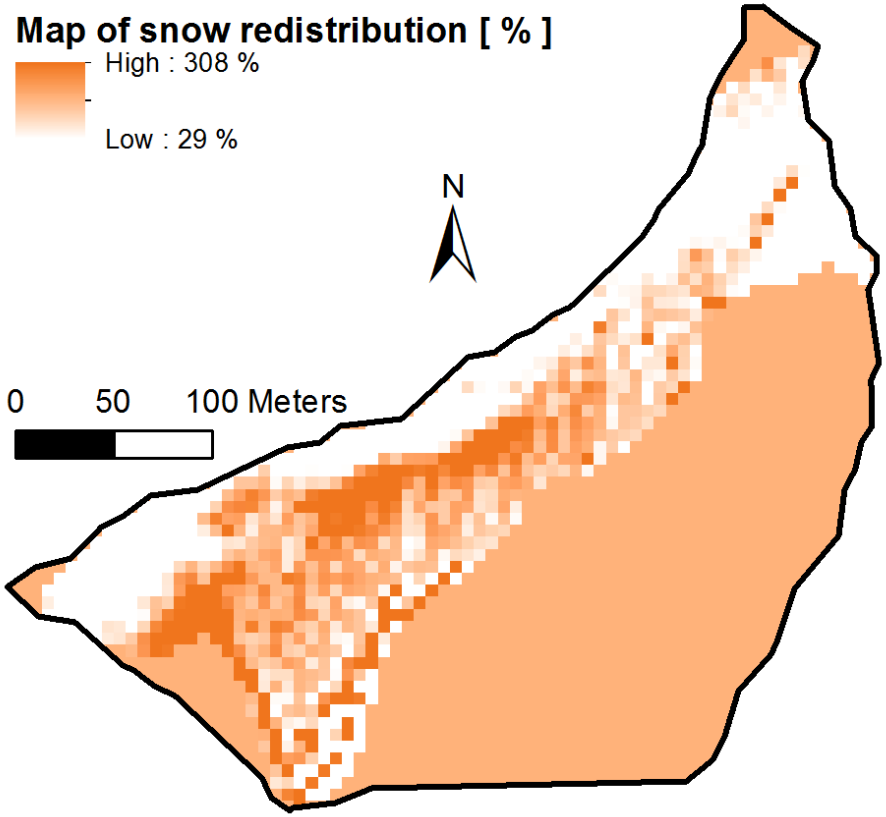
Duration of stable snow cover 2015 – 2016 - 2017

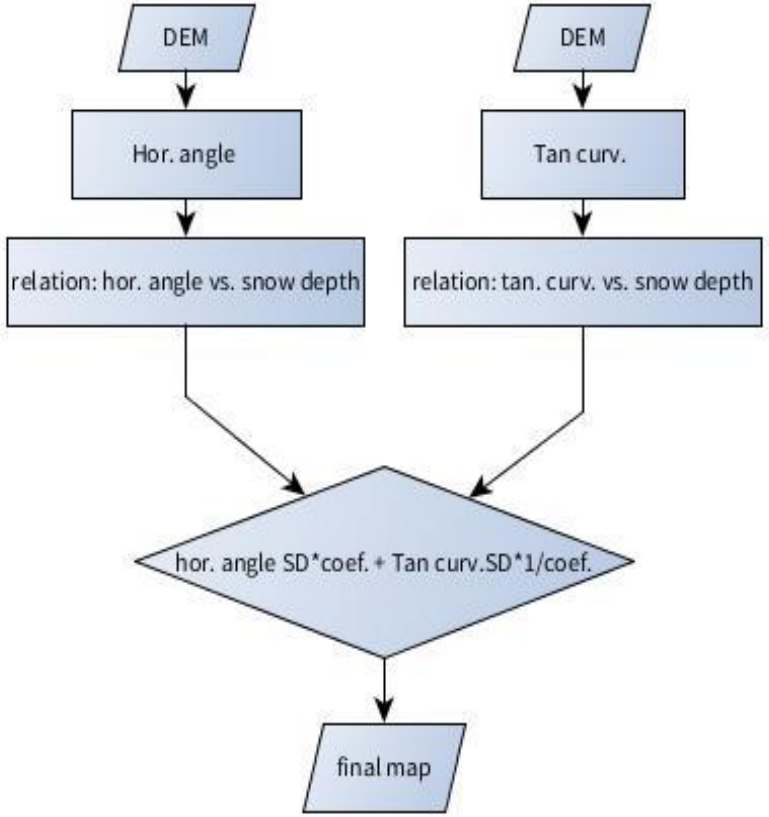


Hydrological model Mike SHE – Spatially distributed snow accumulation and melt

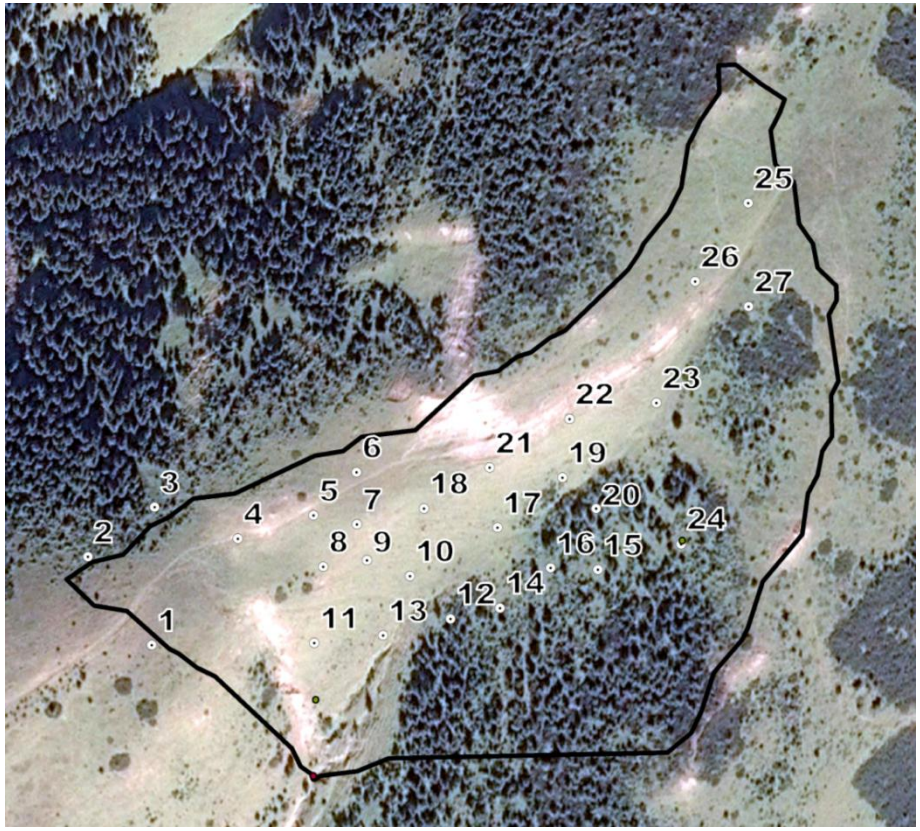
Snow redistribution by the wind

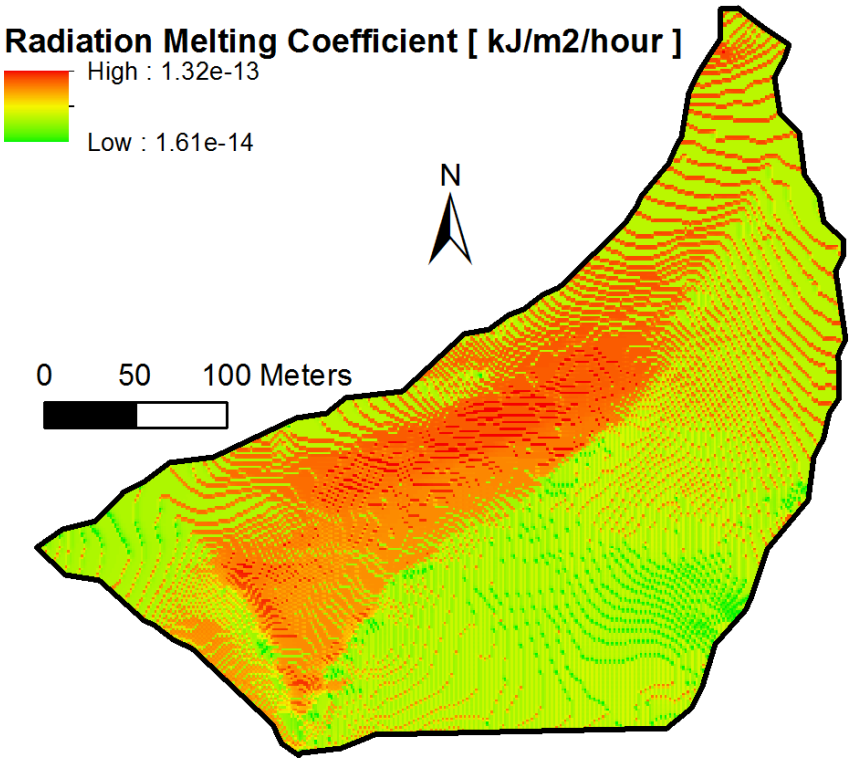
Construction of the precipitation redistribution map based on snow depth (2016) and terrain morphometric data



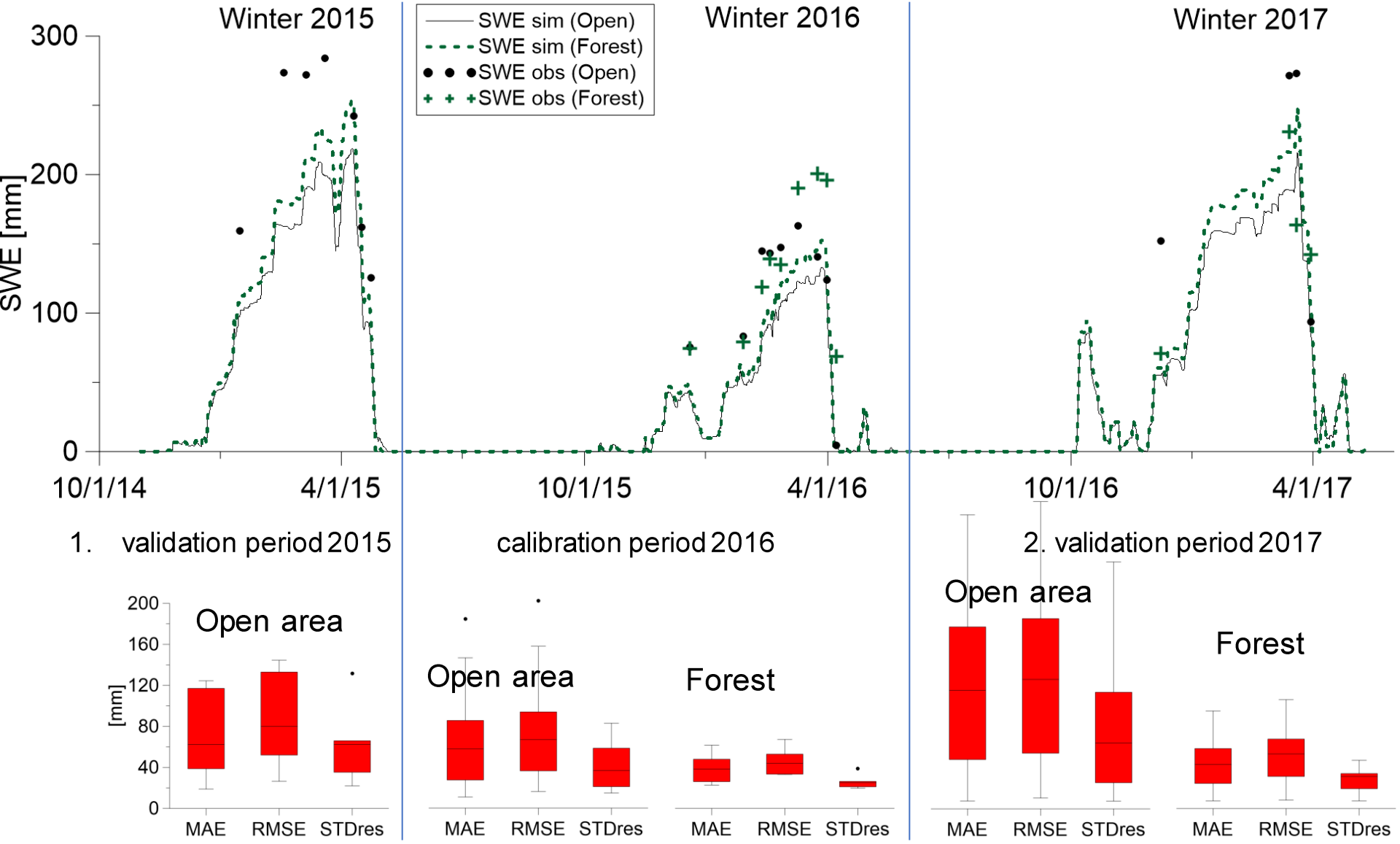


Construction of the radiation melting coefficient map (software Solei32 - Meszároš, 1998)

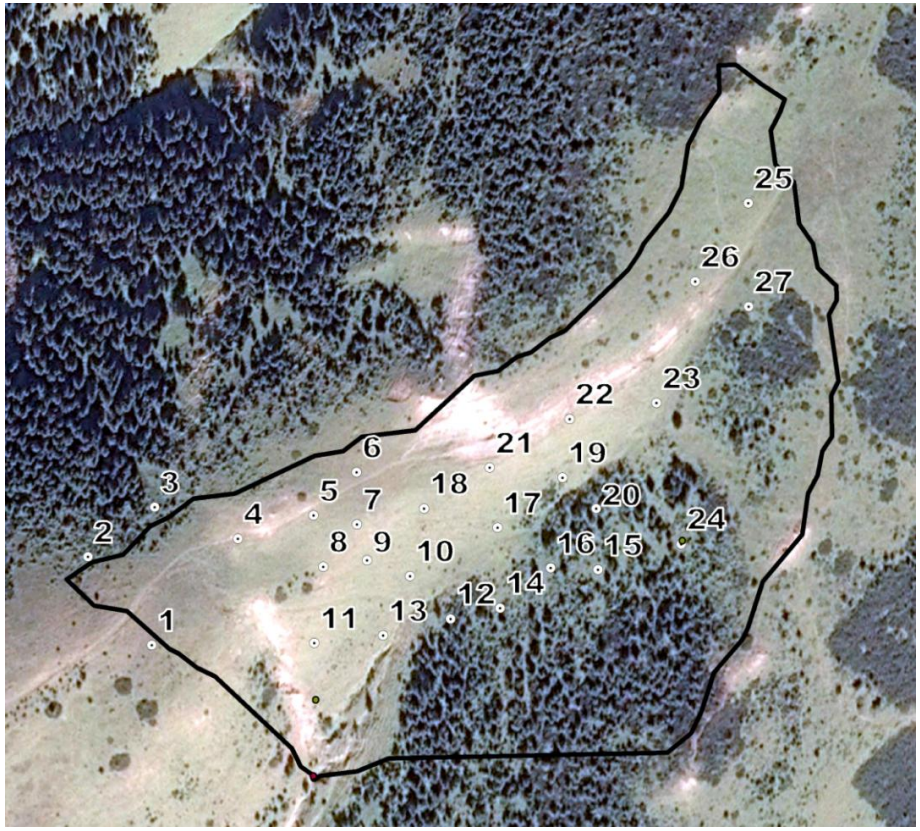




Results


Winter 2015
Winter 2016
Winter 2017
SWE sim (Open)
SWE sim (Forest)
SWE obs (Open)
SWE obs (Forest)
SWE [mm]
300
200
100
0
10/1/14
4/1/15
10/1/15
4/1/16
10/1/16
4/1/17
1. validation period 2015
calibration period 2016
2. validation period 2017
Open area
[mm]
200
160
120
80
40
0
MAE
RMSE
STDres
Open area
Forest
Open area
Forest

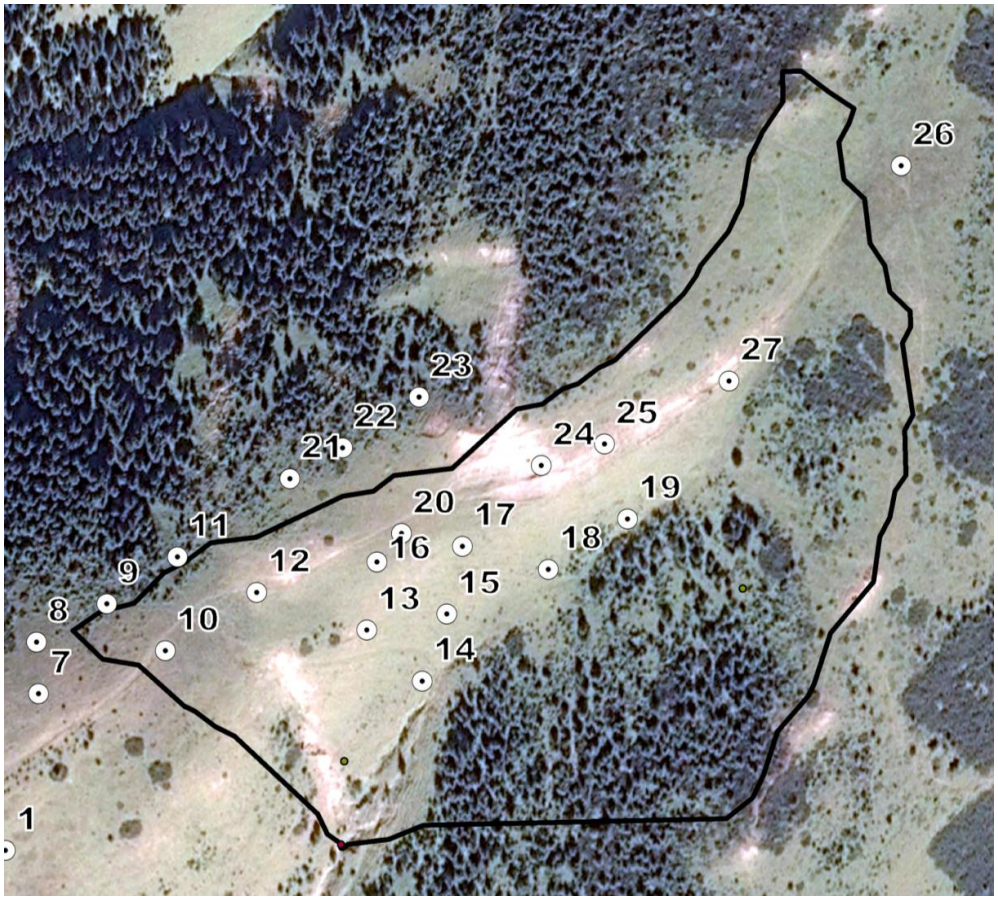
Calibration period – Winter 2016



19 Snow stakes (Open area)	
Nash-Sutcliffe > 0.35	**OK / wrong**
	6 / 13
RMSE < 70	
	12 / 7
R(corr) > 0.5	
	14 / 5

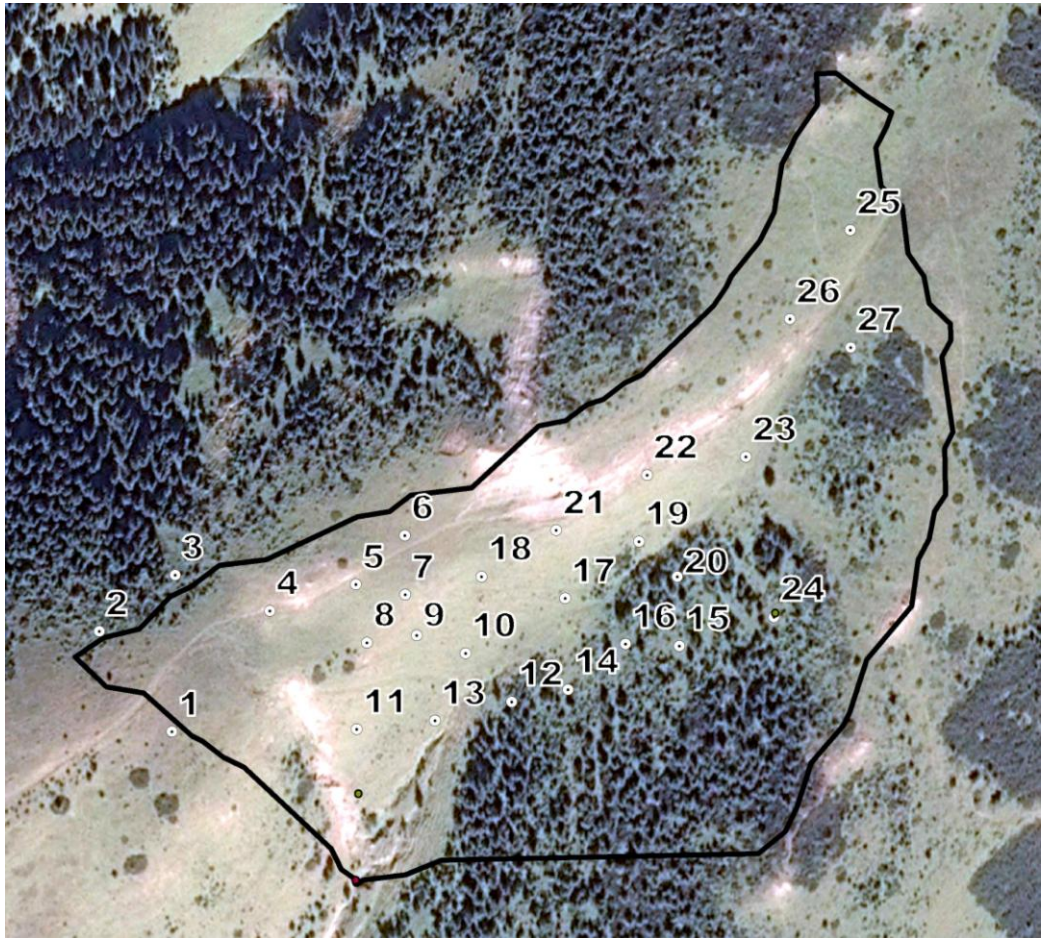
6 Snow stakes (Forest)	
Nash-Sutcliffe > 0.35	**OK / wrong**
	3 / 3
RMSE < 70	
	6 / 0
R(corr) > 0.5	
	6 / 0

1. Validation period – Winter 2015



13 Snow stakes	
Nash-Sutcliffe > 0.35	**OK / wrong**
	9 / 4
RMSE < 70	
	7 / 6
R(corr) > 0.5	
	13 / 0

2. Validation period – Winter 2017

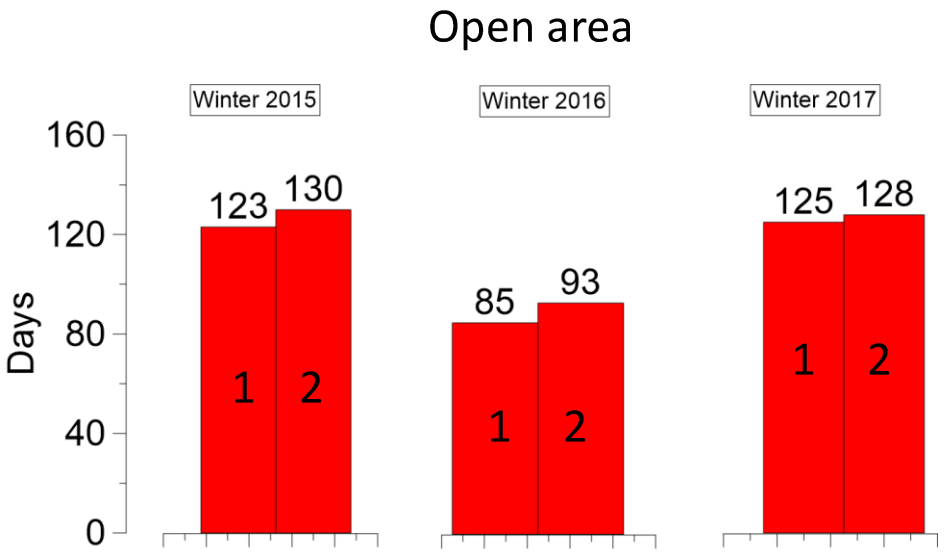


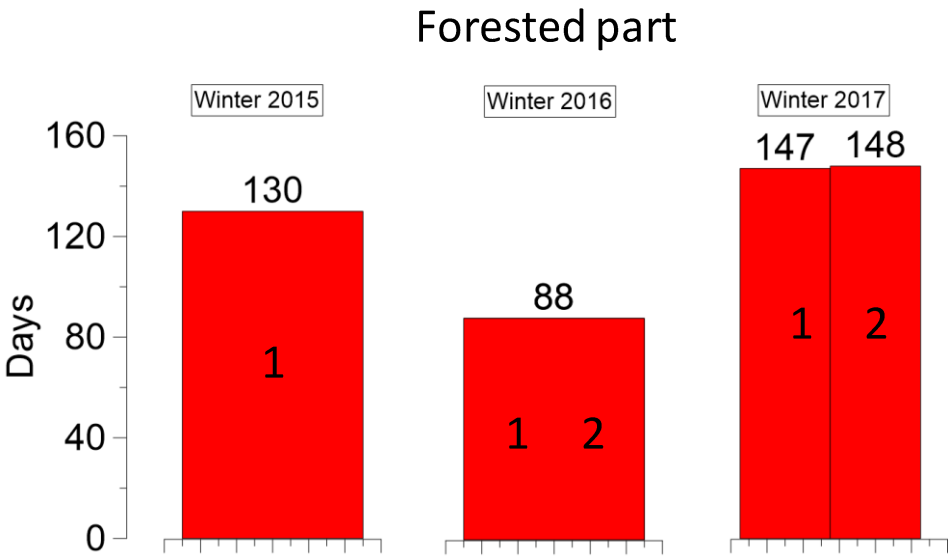
19 Snow stakes (Open area)	
Nash-Sutcliffe > 0.35	**OK / wrong**
	3 / 16
RMSE < 70	
	5 / 14
R(corr) > 0.5	
	17 / 2

6 Snow stakes (Forest)	
Nash-Sutcliffe > 0.35	**OK / wrong**
	1 / 5
RMSE < 70	
	5 / 1
R(corr) > 0.5	
	6 / 0

Comparison duration of stable snow cover 2015 – 2017 in days between:

1. Soil surface thermometers (Open area and forest)
2. Mike SHE model (Open area and forest)

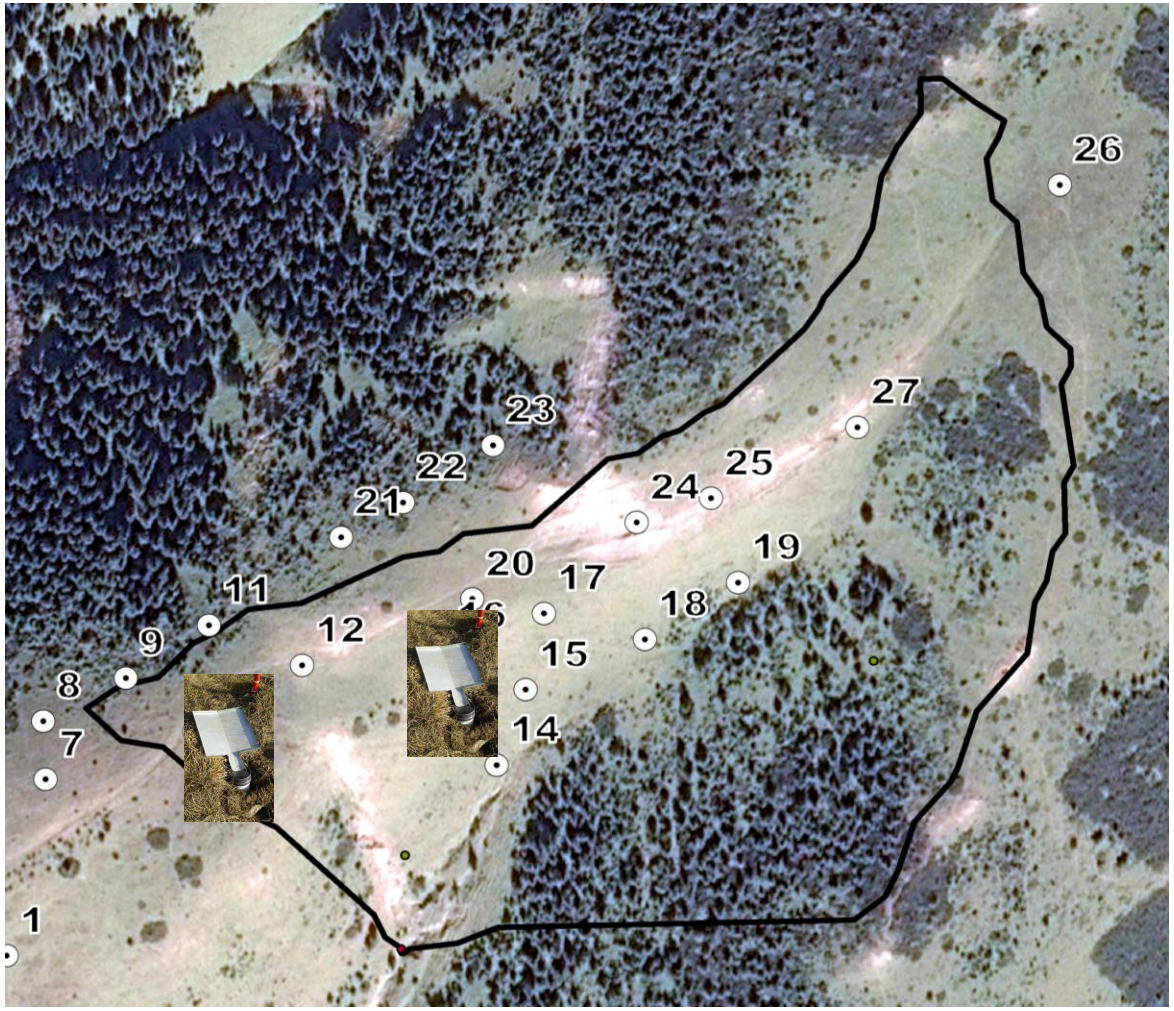




Comparison of snowmelt from lysimeters

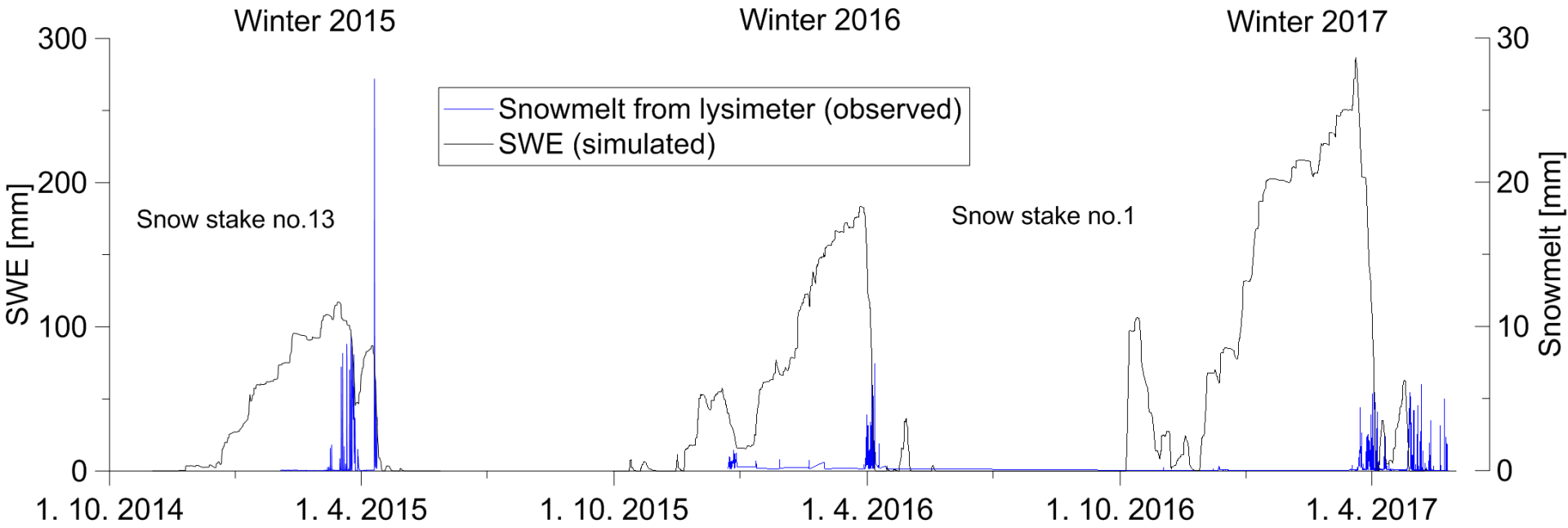
1. Lysimeters at snow stake no. 13 in Winter 2015

2. Lysimeters at snow stake no. 1 in Winter 2016-2017



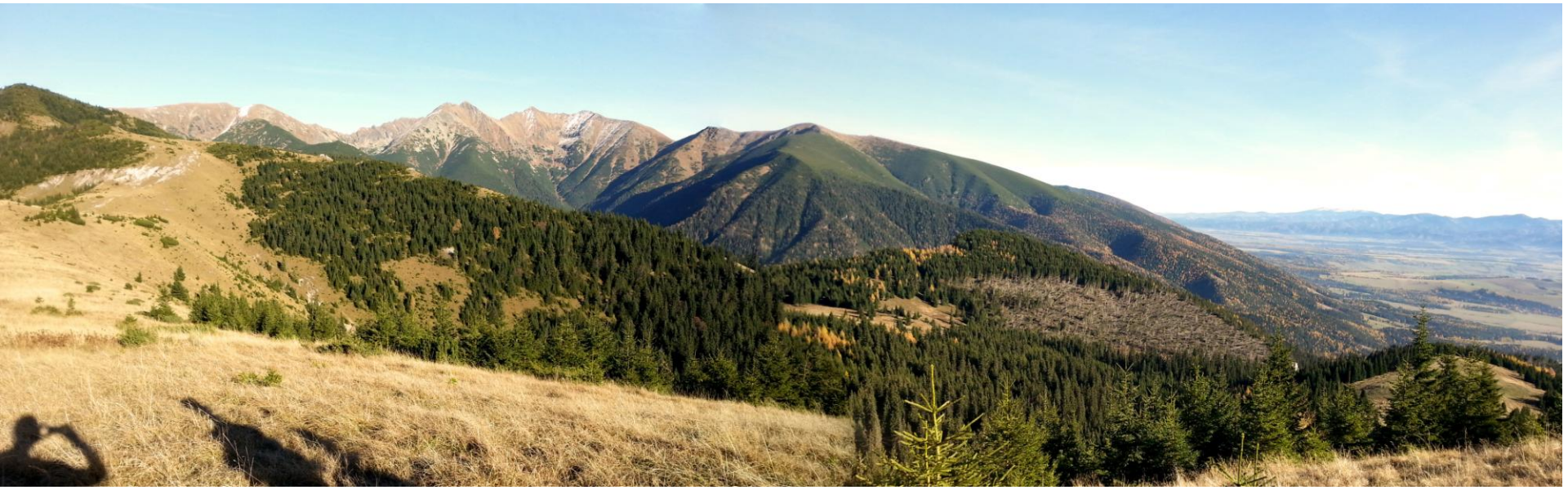
Comparison of snowmelt from lysimeters

1. Lysimeters at snow stake no. 13 in Winter 2015
2. Lysimeters at snow stake no. 1 in Winter 2016-2017



Conclusions

1. Snow variability in the mountain basin is large in the open area and minimal in the forest
2. The low variability of snow density was confirmed
3. Surface thermometers are useful for determining the duration of stable snow cover
4. Duration of stable snow cover in the forest was longer than on the open area
5. The precipitation redistribution map is applicable
6. Simulated snowmelt are comparable to measured by lysimeters



Thanks you for your attention

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