New findings regarding the ground air circulation by chimney effect in low-altitude permafrost susceptible porous screes (Detunata Goală, Romanian Carpathians)

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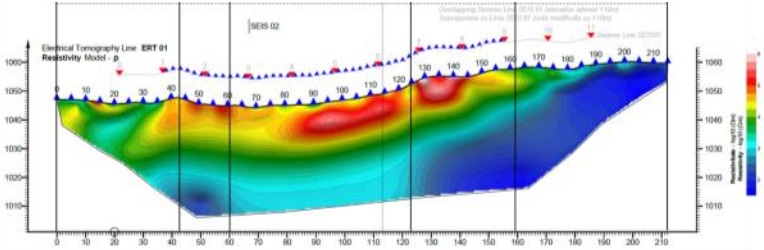
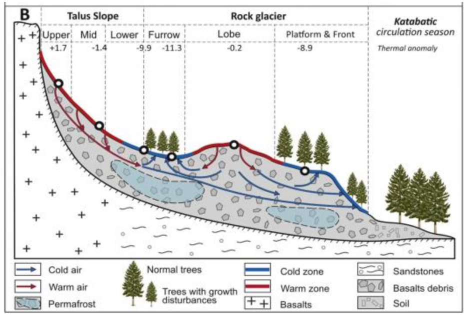
Objectives:

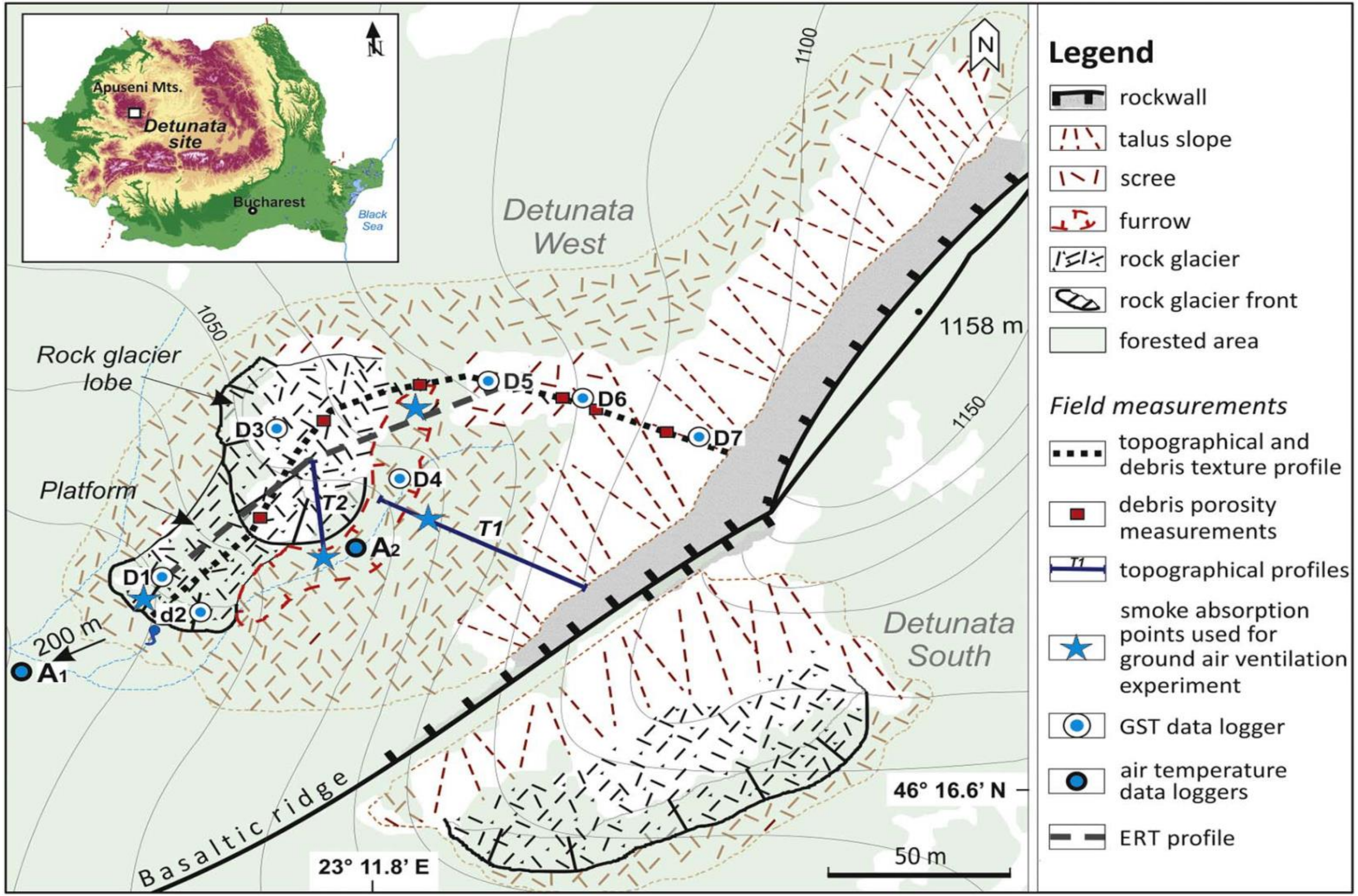
- To analyze the relation between the morphometry of the deposit and the early winter warm air evacuation areas;

- To discuss new geophysical investigations results (electrical resistivity tomography and seismic refraction tomography) performed in October 2020 in the coldest area of the scree;



- To characterize the thermal and ground air circulation regime during February-April.





Study site

- Basaltic andesite ridge with talus slope and probably rock glacier at the base;
- Mean annual air temperature of 6-8°C;
- Mean annual ground temperature is < 0 °C in the furrow caused by proven chimney effect;

Popescu et al., (2017). *Geomorphology*

Aerial photographs (November-April) of rock glacier lobe (horizontal area) acting as a warm air evacuation area during winter

29.11.2020, 16:25

30.11.2020, 11:53

30.11.2020, 16:54

13.03.2021, 12:22

14.03.2021, 10:04

- Melting areas (29th) and lines (30th) at the end of November 2020. Light snowfall during the night between 29 and 30;

- Melting zones in March (light snowfall during previous night) or April (unknown date of the most recent previus snowfall) are related mostly to solar radiation.

Aerial photographs (November-April) of talus slope (steep area)

29.11.2020, 16:39

30.11.2020, 11:57

30.11.2021, 16:58

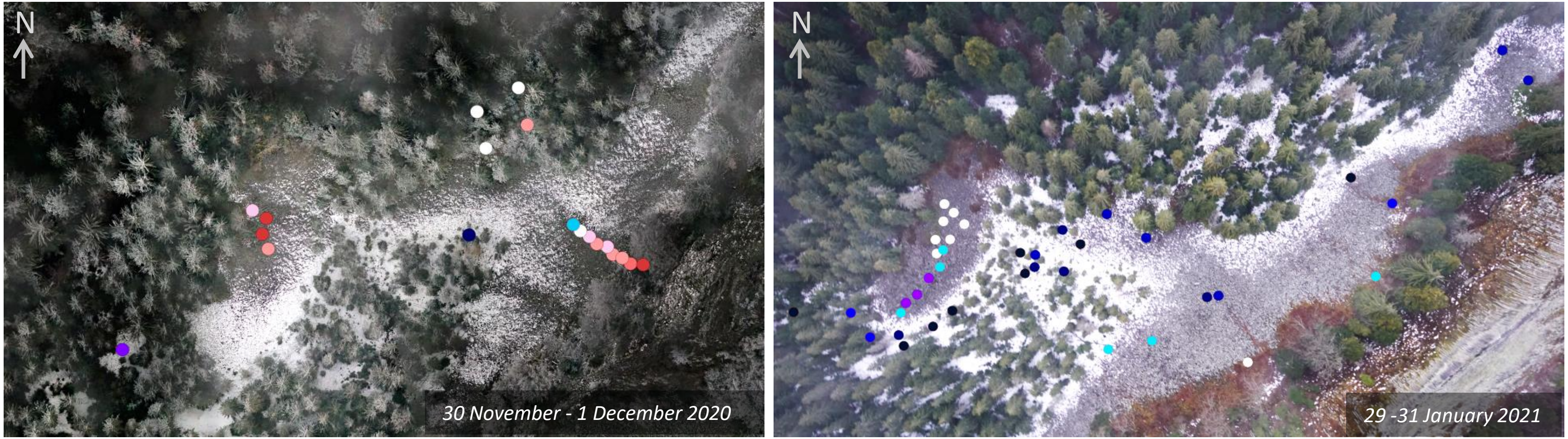
14.03.2021, 10:06

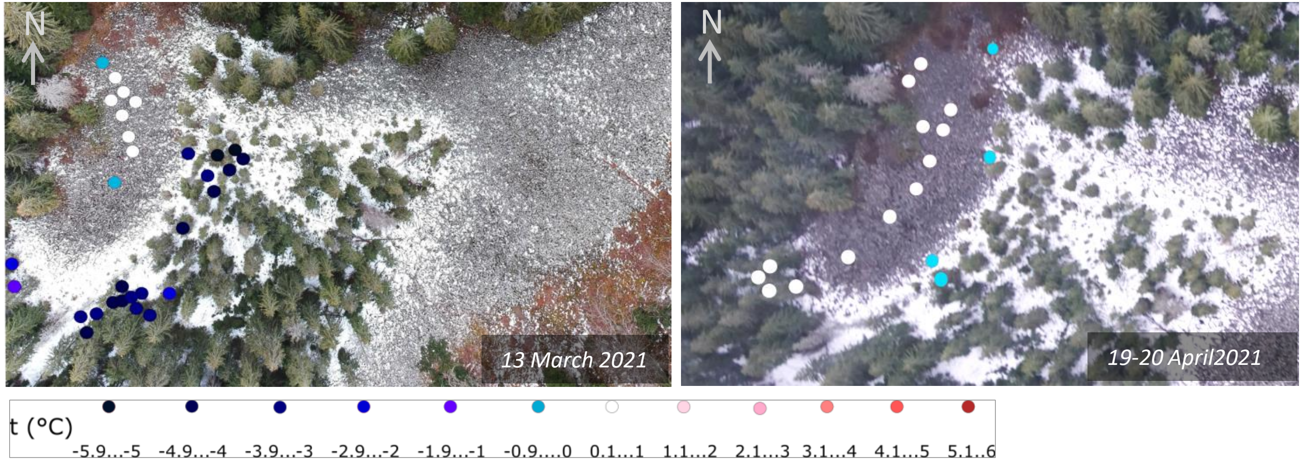
19.04.2021,19:59

- Melting areas (lines or triangles with base oriented uphill) form in november 2020 after light snowfall during previous night;

- Melting zones in March (light snowfall during previous night) or April (unknown date of the most recent previus snowfall) are related mostly to solar radiation. That is in part because “warm” air is not that warm any more.

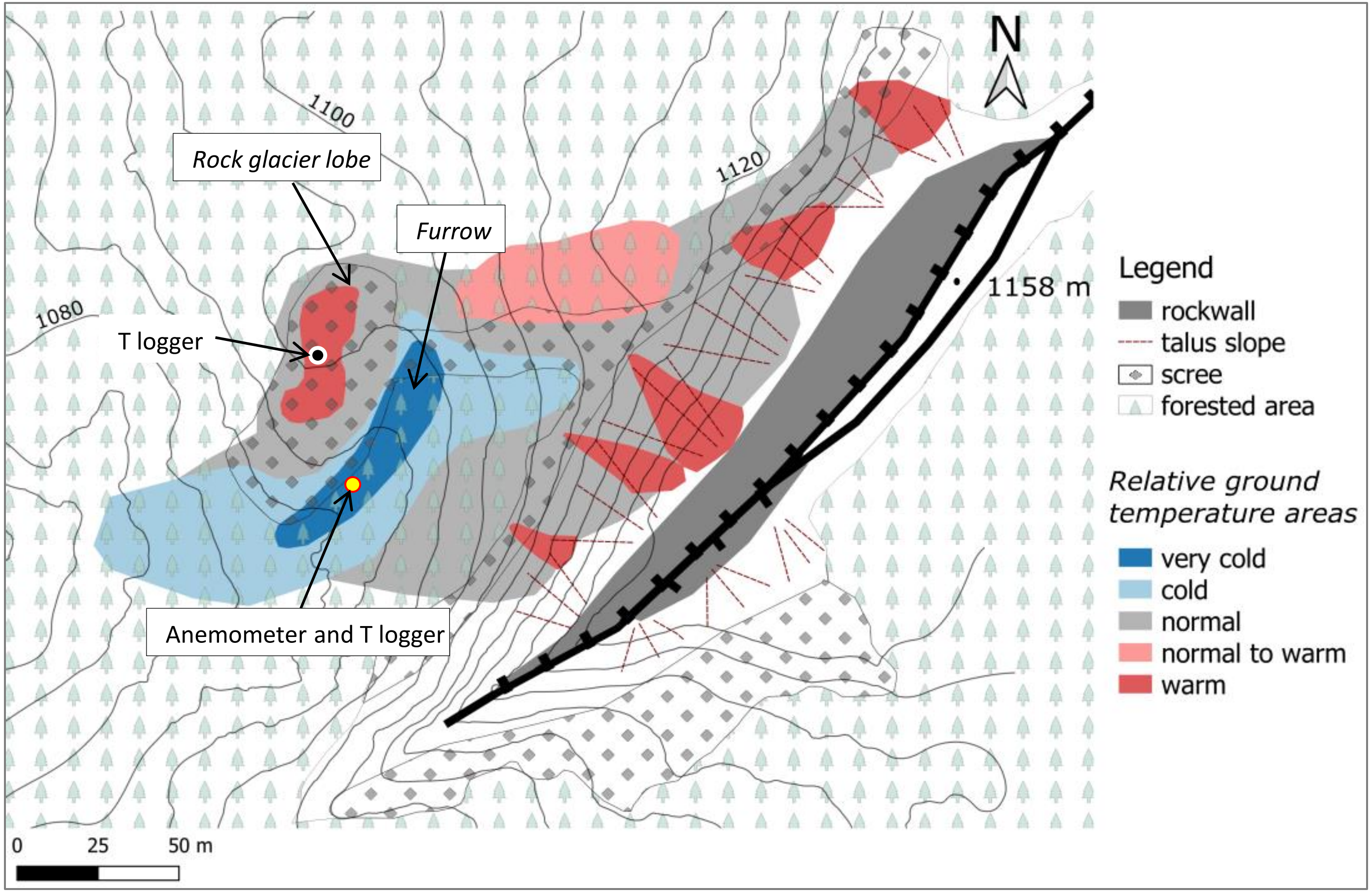
Itinerant measurements of ground temperature between gelifracts



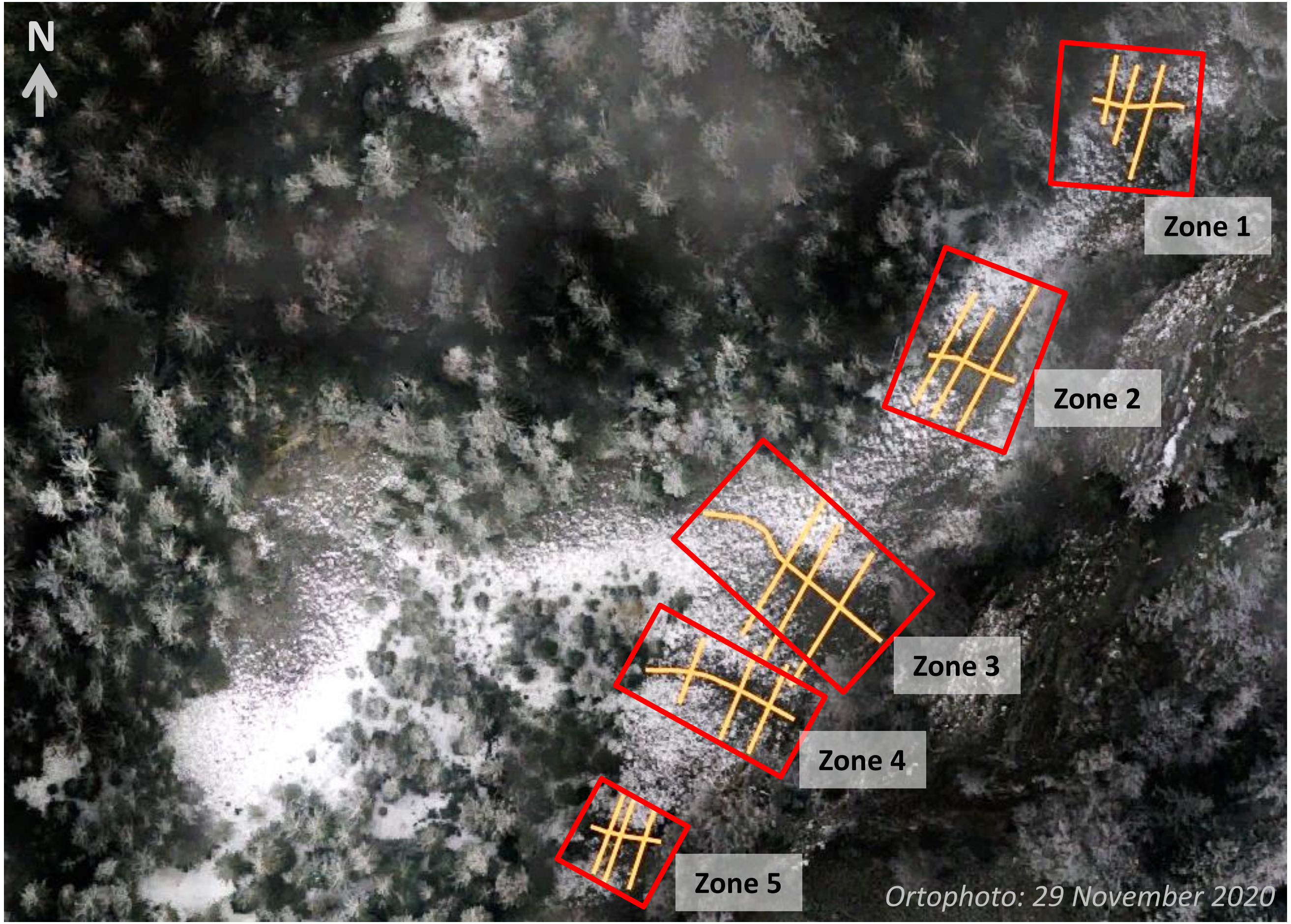


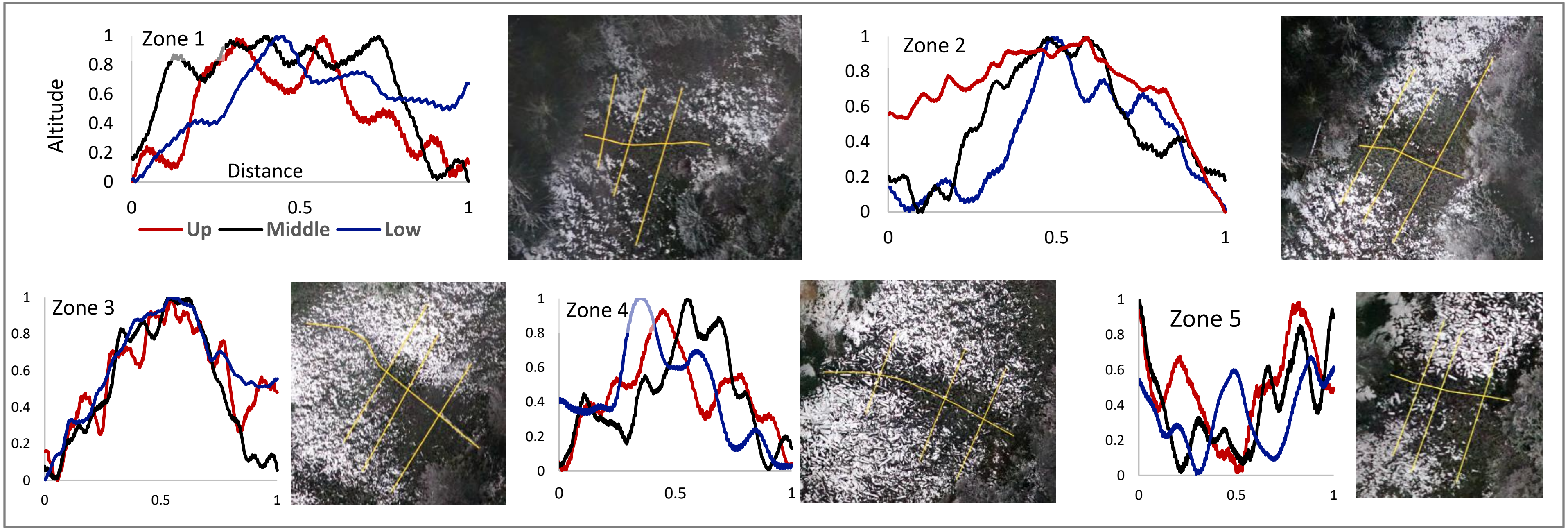
- Thermal contrast between cold and warm zones is pronounced in early winter and fades towards spring;
- Their thermal regime is highly dependent on air flow regime and daily atmospheric temperatures.
- The early winter melting zones from talus slope have an upwards thermal gradient.

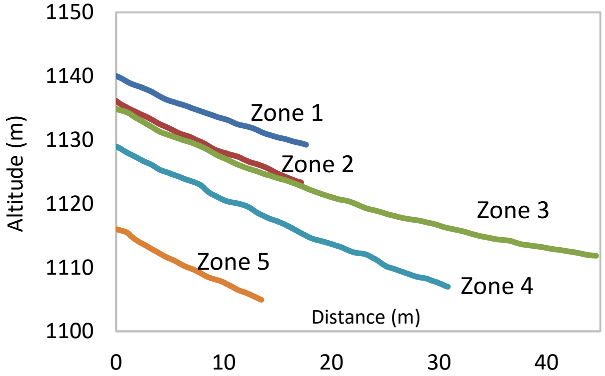
Distribution of thermal areas on the talus slope-rock glacier system during early winter using aerial survey and field thermal data



Numbering of early winter melting zones and the position of the transverse profiles for plan curvature evaluation.



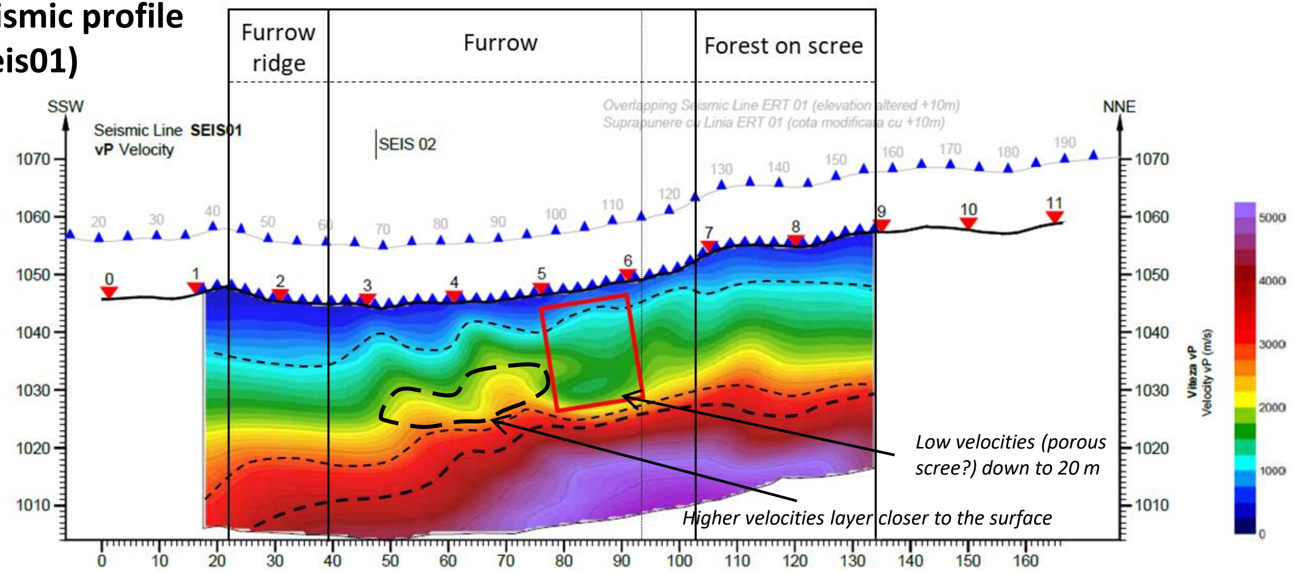


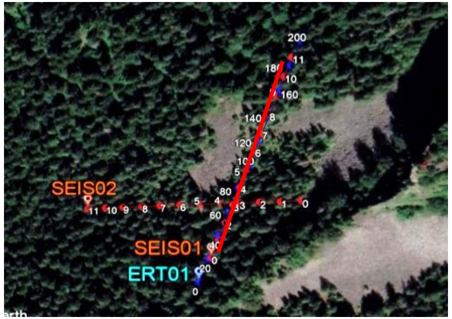


Zone	Mean slope of longitudinal profile (°)
1	30.9
2	35.9
3	27.6
4	35.0
5	38.5

- All transverse profiles exept zone 5 are convex and act as chymneys of warm air;
- Profile 5 is concave but has the largest slope value and the shortest length.

Seismic profile (Seis01)





Scree stratigraphy in furrow (the maximum interest area)

SEIS-1	Depths range (m)	Thickness range (m)	P wave velocity (m/s)	Interpretation
Layer 1	0 - 2.5 (9)	2.5-9	0-900	Openwork scree layer
Layer 2	2.5 (9) – 20 (30)	16.5-24	900-2000 (3000)	Lower porosity talus?
Layer 3	20 (30) – 25 (36)	1-10	3000-4000	Transition to bedrock?
Layer 4	25 (36) – max depth		>4000	Bedrock?

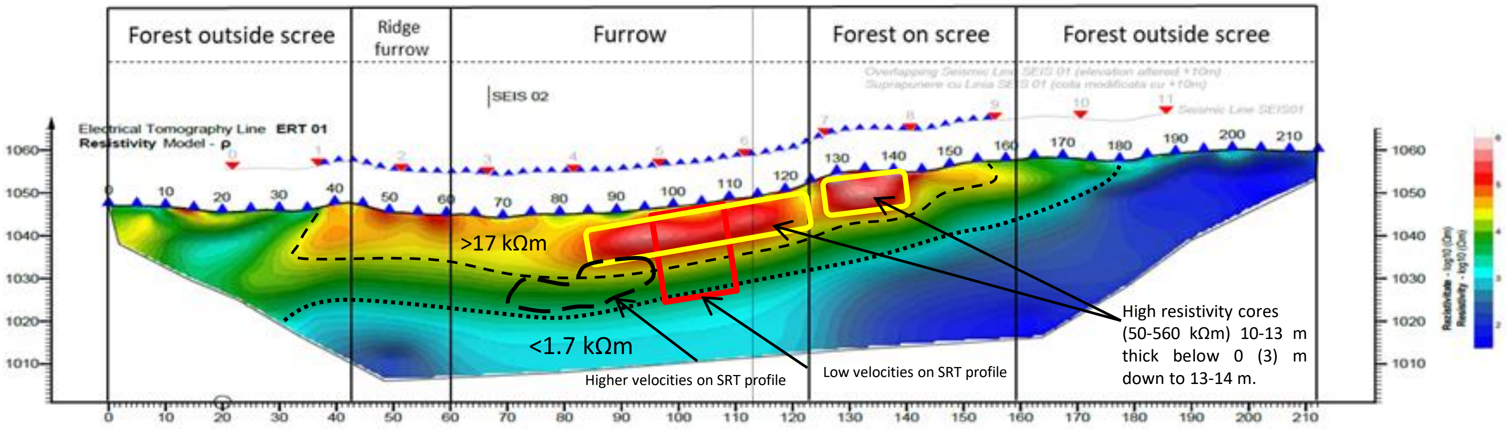
Profile performed in 15 October. Data below 20 m depth are less reliable

P wave velocity in refraction seismic according to Draebing (2016):

- Active layer: 500-900 m/s close to air (300 m/s);
- Rock glaciers permafrost: 3140 m/s;
- Talus slope permafrost: 2700 m/s;
- Ice core moraines: 3150 m/s;
- Bedrock: >4000 m/s.

Stiegler et al., (2014) found 1700 m/s velocities at a low altitude permafrost site but suggested that SRT is not very suitable for sounding such locations.

Electrical resitivity tomography (ERT)

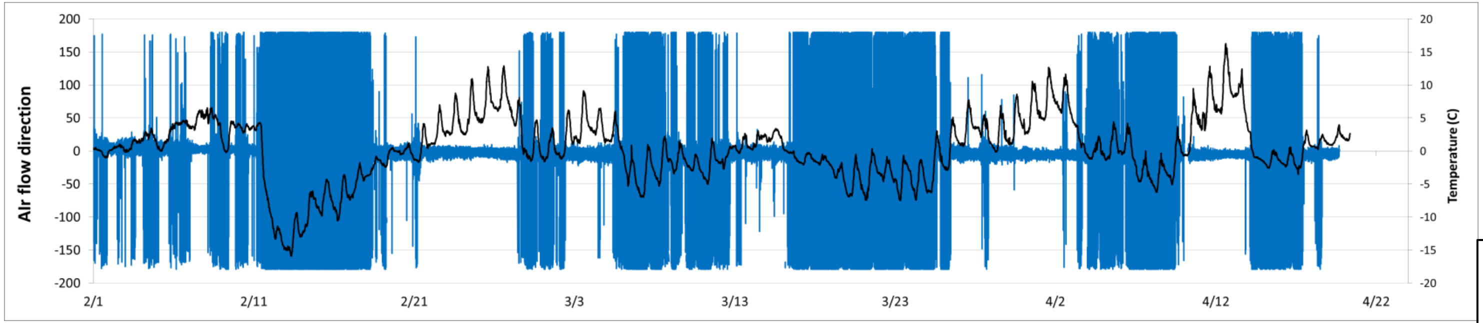


Profile performed in 16 October 2020. RMS error: 10.6

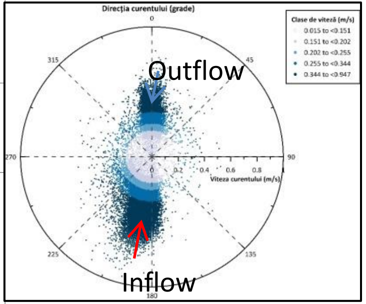
- The upper layer (0-14 m) has high to very high resistivity values (17-560 kΩm) in the furrow. However, 560 kΩm is rather an artifact and some 100 kΩm or 56 kΩm could be the value characterizing the cores.
- A low resistivity layer (<1.7 kΩm) occurs below the furrow (>20-25 m) and at the surface in the forest area (northern part);
- An intermediate layer with values of 5-10 kΩm between the two.

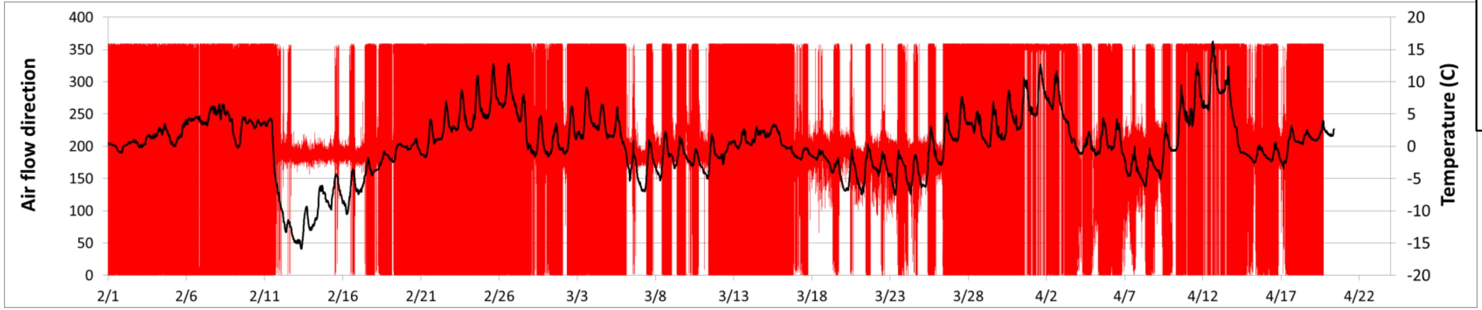
The resistive layer on ERT (0-14 m depth range) does not overlap the high velocity layer on SRT which is below 20 m. ERT and SRT do not validate each other and offer different/contradictory results regarding most probable locations of frozen ground.
- According to ERT, permafrost (if present) should be close to surface even in autumn between 3 and 14 m depths (yellow rectangles);
- According to SRT, permafrost (probable only if velocities lower than 2000 m/s are considered) should be located deeper in the underground between 10-17 m and slightly more to the south (thick dashed black contour) than the high resistivity cores.

Ground air circulation regime in February-April 2021



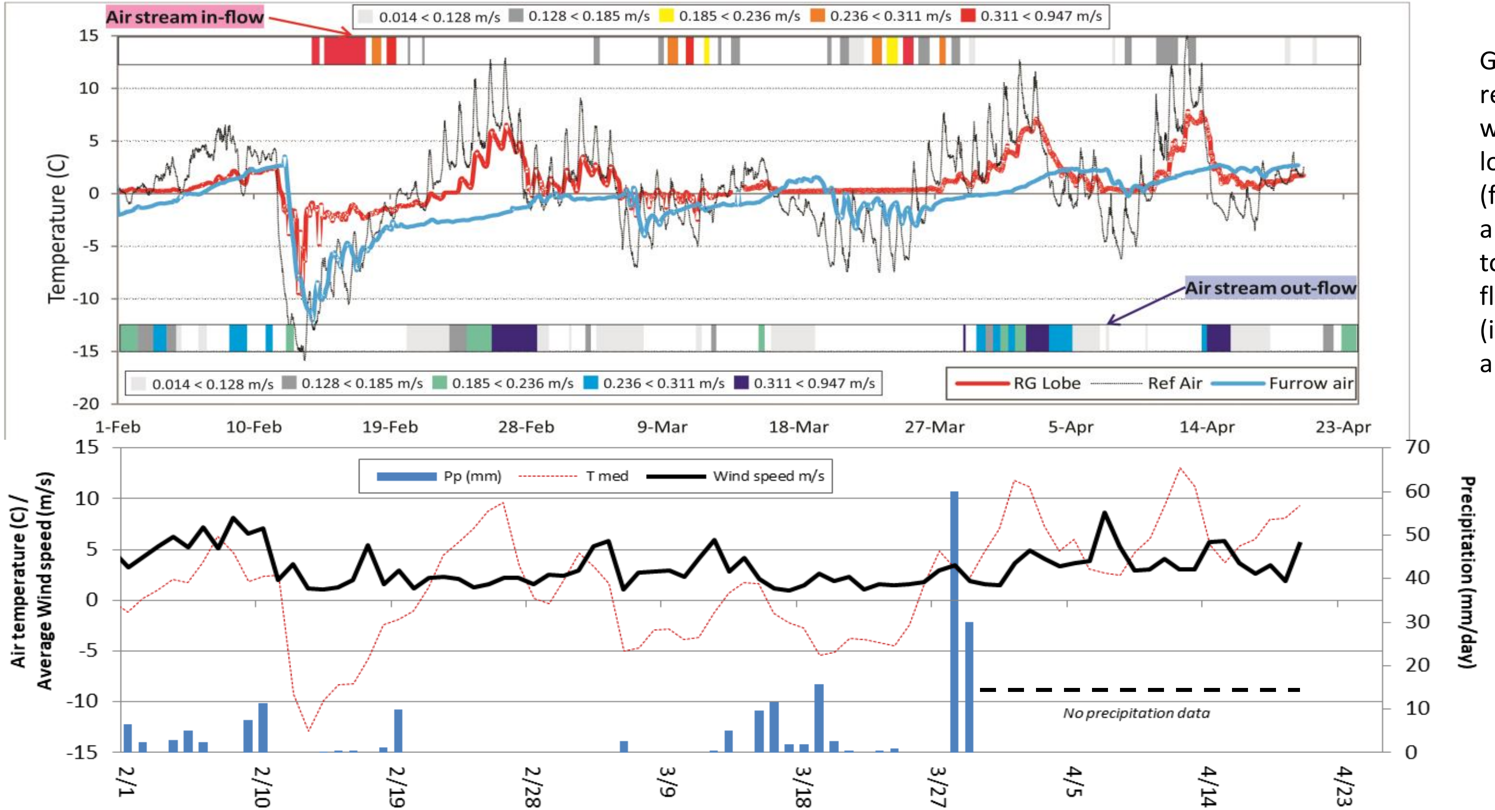
Direction of air flow grouped around 0° (180-360 ° directions represented as -180...0 °) for **outflow detection**.





Direction of air flow grouped around 180 ° for **inflow detection**.

Measured every 5 seconds and averaged and stored every 30 seconds with ultrasonic anemometer (1405-PK-100 Gill instruments)



Ground thermal regimes in the warm (rock glacier lobe) and cold (furrow) areas along reference air together with air flow regime (inflow-outflow and speed)

- Air outflow (occurring during warming atmospheric events) is more frequent than air inflow (during cold atmospheric events);
- Air flow cessation/initiation thermal thresholds varies relative to the temperatures recorded in the previus days;
- For inflow, all threshold are represented by negative temperatures, no outflow occurs in negative temperatures.

Thank you!

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