# Highlights from two years of geoelectric monitoring of permafrost at the Magnetköpfl / Kitzsteinhorn

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## Introduction/Background

Changes of climate parameters due to global warming generate increased permafrost warming and deglaciation in alpine regions. The area of interest is the Magnetköpfl, a peak below the Kitzsteinhorn (3203 m) (location see Fig. 1), where scientists observe increasing rock instability due to the probable degradation of permafrost as well as the decrease of glacier height followed by a lack of counter pressure at the flanks of the slope. Geoelectric measurements are an adequate method to measure permafrost, since the underground electric resistivity is highly dependent on temperature and the amount of unfrozen pore water. In October 2011 a geoelectric monitoring profile was installed on the north facing ridge of the Magnetköpfl (see Fig. 2). Measurements of soil temperature on the profile support the interpretation of geoelectric data.

## Geoelectric Monitoring

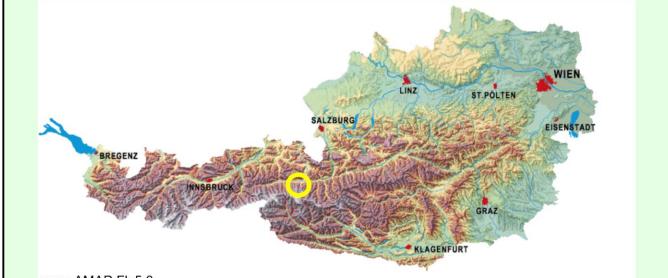


Fig.1: Location of the investigation area in Austria

The geoelectric monitoring is carried out with the GEOMON4D system. The monitoring profile, which is measured once a day, consists of 81 electrodes at a



Fig.2: The investigation area (overview and position of the monitoring profile)

spacing of 1 m. A single measurement contains 2590 data points distributed in a gradient array.

Power is provided by a fuel cell (SFC Efoy Pro© 600).

#### Monitoring of rock temperature

To improve the interpretation of the geoelectric monitoring data four temperature sensors were installed at two locations directly on the profile (Fig. 3). The sensors were placed at two different depths (10 and 80 cm bgl.) with a measuring interval of 3 hours. These measurements are carried out in the framework of the MOREXPERT project (University of Salzburg and alpS).





Fig.3: View of the monitoring profile (left, midle) and measuring point - rock temperature (right)

## Occured problems





Fig.4: Due to the exposed position snow was blown into the instruments and power supply -> Box-in-Box solution

Extreme weather conditions – incomplete dataset

Very high subsurface resistivities – limited range of the system/method

## Acknowledgment

The geoelectric monitoring is supported by the project "TEMPEL", funded by the Federal Ministry for Transport, Innovation & Technology (BMVIT) and the Austrian Science Fund (FWF): TRP 175-N21 and internal funds of the Geological Survey of Austria.

We thank the Gletscherbahnen Kaprun for assisting this project.

#### Outlook

Due to the importance of additional soil parameters, soil humidity sensors and a camera to interpret the influence of snow along the profile on the resistivity will be installed in the near future to enhance the interpretation of the geoelectric monitoring data.

Although the monitoring time has already exceeded 2 years there are still seasonal periods where the amount of high quality data has to be enlarged for an improved interpretation of ongoing processes.

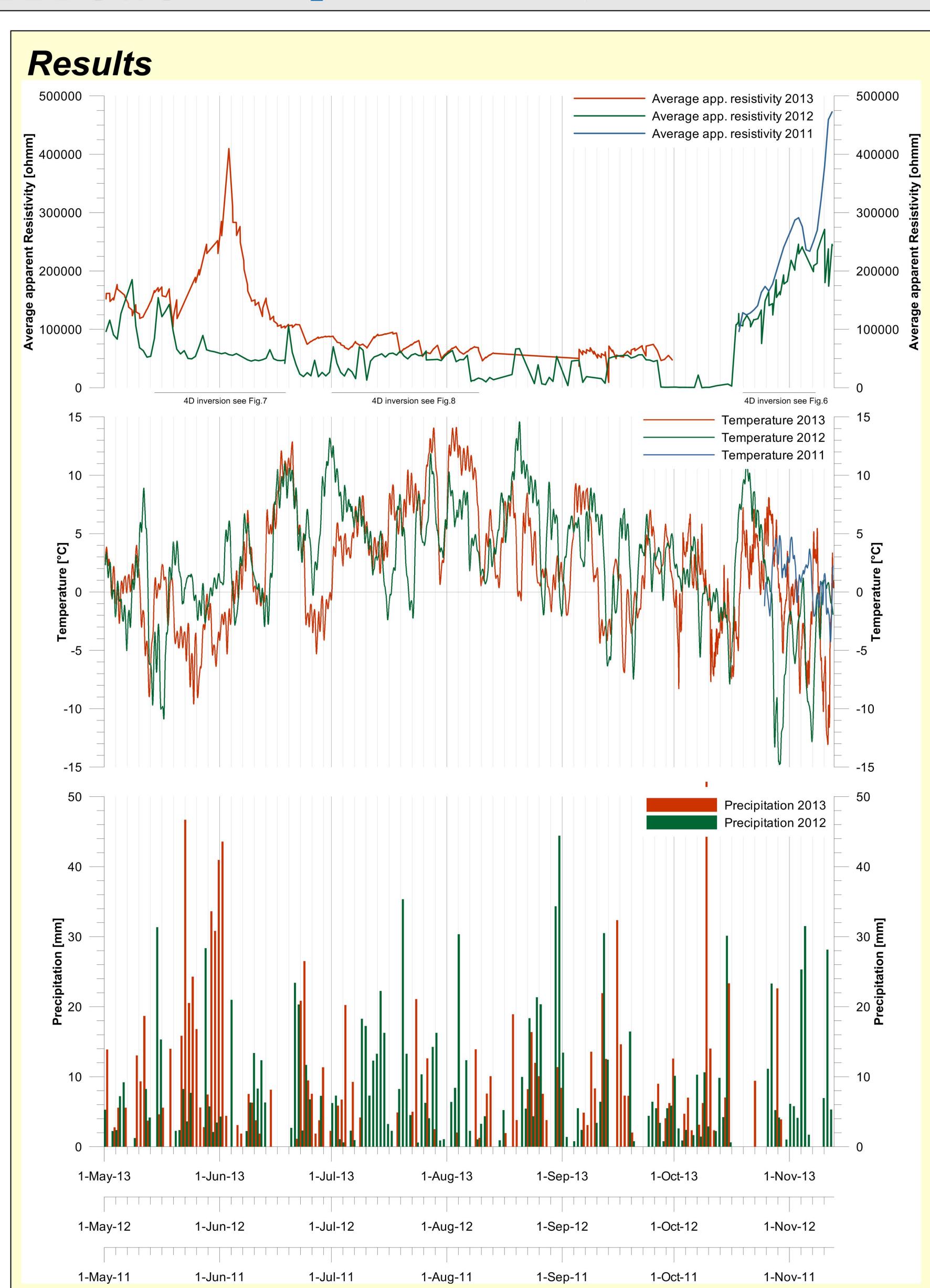
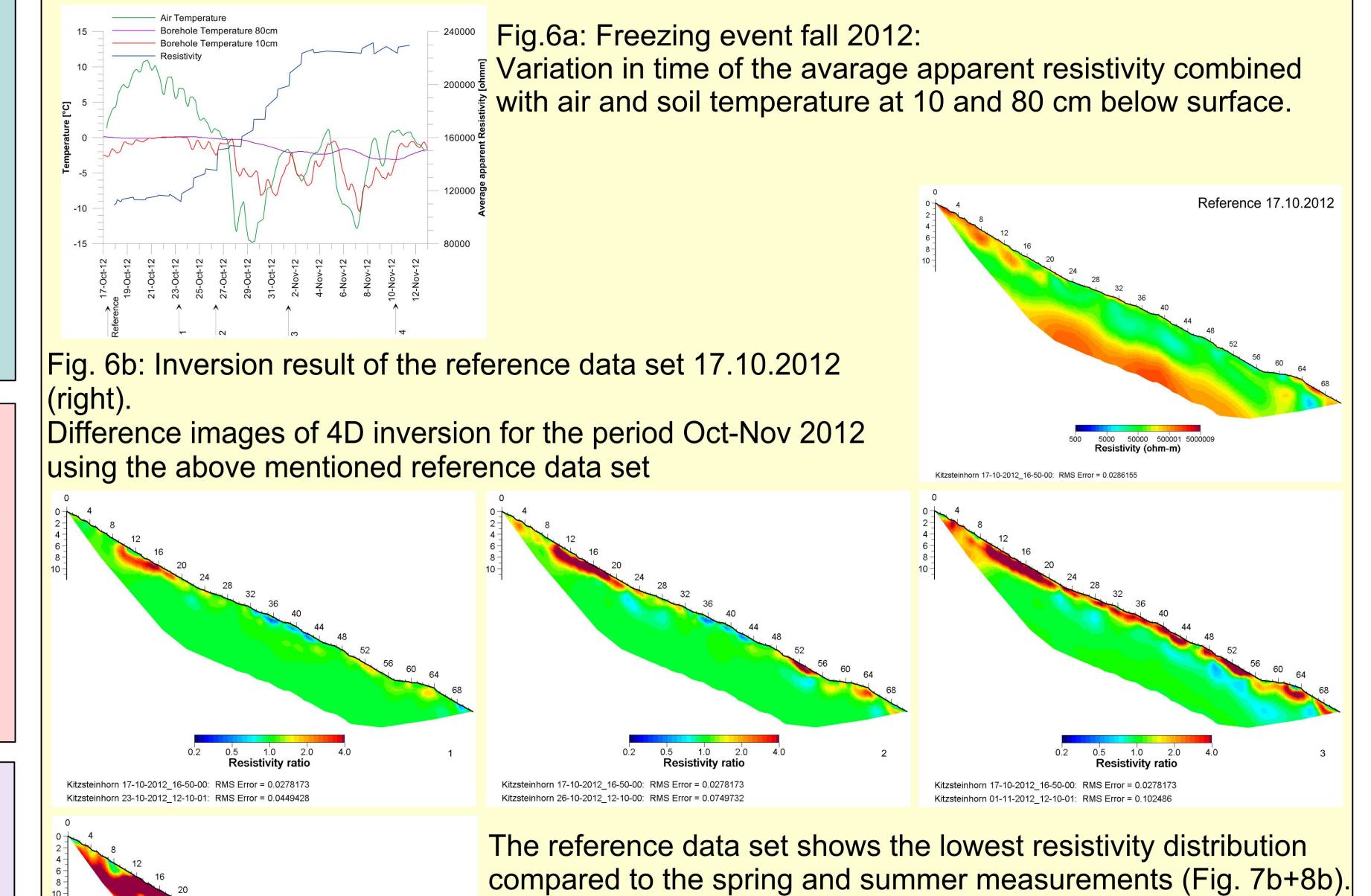


Fig.5: Variation in time of the avarage apparent resistivity (calculated by using all resistivity values of one data set) of 2011, 2012, 2013 (above) combined with air temperatures (middle), precipitation (below).

Fig. 5 shows that different temperature periods have a direct correlation to average apparent resistivity. Due to the connection with temperature, the strongest variations in average apparent resistivity are observed in spring and fall. Especially in spring 2013 (May/June) a long low temperature period led to a distinct resistivity anomaly which indicates the refreezing of the topmost layer (see also Fig. 7a+b). A very similar characteristic of the average apparent resistivity during the freezing periods in fall 2011 and 2012 is observed. In contrary to geoelectrical monitoring in non permafrost regions precipitation shows no distinct influence on resistivity.

The permafrost at Magnetköpfl starts at a depth of approx. 3m below surface and seasonal temperature varations below 0°C can be observed down to 8-10 m below surface. This helps us to interpret the selected inversions of the geoelectric monitoring results, derived from an innovative 4D resistivity inversion approach (Kim et al 2013). (Fig. 6-8)



In 7-8 m b.s. the resistivity is less than 50.000 Ohmm.

top 2.5 m due to temperatures falling below 0°C.

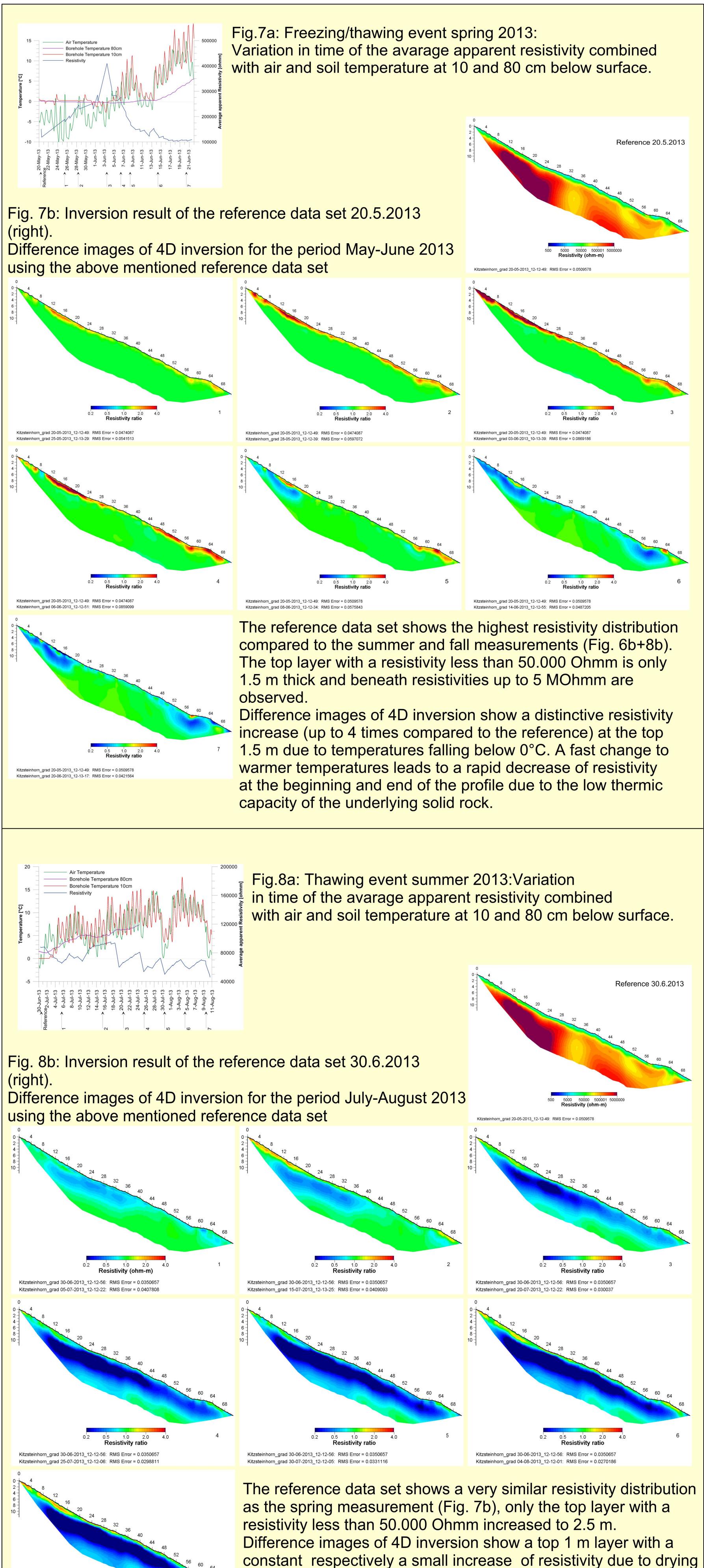
Difference images of 4D inversion show a distinctive resistivity

increase (more than 4 times compared to the reference) at the

beginning and end of the profile these areas freeze faster and

Due to the low thermic capacity of the underlying solid rock at the

deeper than the loose and water filled material of the middle part.



#### References

Kim J.-H., Supper R., Tsourlos P. and Yi M.-J. 2013. Four-dimensional inversion of resistivity monitoring data through Lp norm minimizations. Geophysical Journal International, 2013-11-21

up the top soil (August).

A distinctive resistivity decrease (less than a quarter compared to

seasonal temperature wave reaching this part of the subsurface.

the reference) is observed at the underlying 6 m due to the

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