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DATA PROCESSING OF GNSS OBSERVATIONS OF THE GEONAS NETWORK - EFFECTS OF EXTREME METEOROLOGICAL CONDITIONS

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ABSTRACT

The Institute of the Rock Structure and Mechanics AS CR operates the GEONAS network that now consists of 17 permanent GPS observatories. The outliers and inconsistencies occur within the time series observed in the winter season 2005/2006 for the position of the GNSS antennas of the observatories SNEC and BISK located high in the mountains, at the Sněžka Mt. (1602 m, the Giant Mts.) and the Biskupská kupa Mt. (890 m, the Jeseníky Mts.) respectively. Therefore web cameras and meteorological sensors were installed at GEONAS observatories located in the mountain regions. The snow coverage and other meteorological influences affecting the antennas monitoring GPS signals at these observatories were estimated. The individual photos were analyzed and compared to variations in the time series to obtain the time series for winter seasons reducing the snow coverage effects.

KEYWORDS: GPS permanent observatories, time series, meteorological effects

1. INTRODUCTION

GEOdynamic Network of the Academy of Sciences (GEONAS) of the Czech Republic was established to make regular geophysical and geodetic observations for geodynamic studies of the Bohemian Massif and the adjacent areas.

The GEONAS network consists at present of the five EPN stations operated by the IRSM – BISK, MARJ, POUS, SNEC and VACO – and twelve more non-EPN permanent GPS observatories – BEZD, CHOT, KYNS, LITO, LUBY, PRAG, SECZ, SLUK, STAM, TEME, UPIC and VIDN (Fig. 1; Schenk et al., 2002, 2004a, 2004b, 2005; Mantlík et al., 2007). Table 1 gives for the individual observatories their geographic coordinates, types of receiver and antenna and date of the beginning their operation.

The observatories BISK, LITO, MARJ and VACO are equipped with the Ashtech Z-18 receivers and the others with Topcon GB-1000 receivers. All stations have corresponding choke-ring antenna with snow domes and receive both GPS and GLONASS signals. Selected mountain observatories are equipped with web camera and meteorological sensors to monitor snow coverage at the antenna.

The meteorological data are monitored at the BISK, SNEC MARJ, STAM and PRAG observatories. The positions of individual permanent GPS observatories were selected with respect to the geological structures and assumed active tectonic zones. Remote control of GPS observatories and transmission of data to IRSM central unit are described in papers (Kottnauer et al., 2003; Mantlík et al., 2005).

2. DATA PROCESSING

Registered data in the sampling rate 30 s with the elevation mask 5° are processed by the BERNESE GPS Software version 5.0 (Beutler at al., 2007). The positions of GNSS antennas and their RMS are evaluated for each GPS day by the standard procedure RNX2SNX. Since the European regional centre CODE offers products for both satellite systems NAVSTAR and GLONASS, the input parameters like the Earth orientation parameters (EOP), the precise orbits, the clock corrections, the global ionosphere model, etc. were taken over from this centre.

3. EFFECTS OF EXTREME METEOROLOGICAL CONDITIONS

The permanent GPS observatories located at relatively high altitudes present disturbances in the time series during winter seasons. Those outliers are caused with high probability by frosty snow coverage of GPS antennas. In this paper the attention is given to the mountain observatories (Fig. 2) SNEC (the Sněžka Mt., 1602 m, the Giant Mts.) and BISK (the Biskupská kupa Mt., 890 m, the Jeseníky Mts.) There are two GPS antennas at the Sněžka Mt.; one antenna is permanently placed on the top of the reinforced chimney of the small building "Poštovna" and the second one seasonally on the top of 8 m high geodetic pillar (Schenk et al., 2002; Cacoń et al., 2004). The

Table 1 Permanent observatories of the GEONAS network and their characteristics

Station	Place	Date	Latitude	Longitude	El. height	Receiver	Antenna	Obtions
BEZD	Bezděkov nad Metují	Dec 16,2005	50.50870277	16.22926031	537.728	TPS GB-1000	TPSCR3_GGD CONE	
BISK	Biskupská Kupa	Sep 6,2001	50.25672330	17.42859875	950.867	ASHTECH Z18	ASH701946.2 SNOW	meteo+webcam
CHOT	Chotěboř	Aug 10,2006	49.71170820	15.67264081	607.445	TPS GB-1000	TPSCR3_GGD CONE	
KYNS	Kynšperk-Kolová	Dec 19,2005	50.11282809	12.55601142	569.958	TPS GB-1000	TPSCR3_GGD CONE	
LITO	Litoměřice	Sep 1,2006	50.54215782	14.14480306	244.695	ASHTECH Z18	ASH701946.2 SNOW	
LUBY	Luby	Dec 21,2005	50.24813459	12.40771465	587.868	TPS GB-1000	TPSCR3_GGD CONE	
MARJ	Mariánská	May 15,2003	50.35688985	12.89347340	904.730	ASHTECH Z18	ASH701946.2 SNOW	meteo+webcam
POUS	Poustka	Nov 12,2003	50.13843445	12.29785666	572.177	TPS GB-1000	TPSCR3_GGD CONE	
PRAG	Praha-Holešovice	May 15,2006	50.11810136	14.46361902	293.731	TPS GB-1000	TPSCR3_GGD CONE	meteo+webcam
SECZ	Seč	Aug 11,2006	49.84293455	15.64941357	581.978	TPS GB-1000	TPSCR3_GGD CONE	
SLUK	Šluknov	Aug 17,2006	50.99988785	14.46024839	424.157	TPS GB-1000	TPSCR3_GGD CONE	
SNEC	Sněžka	Oct 21,2001	50.73587968	15.73974170	1651.582	TPS GB-1000	TPSCR3_GGD CONE	meteo+webcam
STAM	Staré Město	Aug 23,2006	50.16232012	16.94776447	598.976	TPS GB-1000	TPSCR3_GGD CONE	meteo+webcam
TEME	Temelín	Aug 17,2006	49.17396461	14.37993066	562.789	TPS GB-1000	TPSCR3_GGD CONE	
UPIC	Úpice	Dec 21,2005	50.50713162	16.01093213	468.089	TPS GB-1000	TPSCR3_GGD CONE	
VACO	Vacov	Oct 20,2004	49.13378401	13.72417612	799.401	ASHTECH Z18	ASH701946.2 SNOW	
VIDN	Vidnava	Aug 22,2006	50.37293401	17.18544542	287.546	TPS GB-1000	TPSCR3_GGD CONE	

Fig. 2 The mountain observatories – SNEC and BISK.

antenna at the Biskupská kupa is situated on a stone 19.3 m high watchtower (Schenk at al., 2002).

The position time series reveal non-linear motions and jumps for the observatories located high in the mountains (Figs.3 and 4). Site disturbance effects caused by snow coverage of GPS antennas were observed e.g. by Bruyninx (2006). For the Hafelekar (HFLK) observatory it was reported that the north and vertical position determinations are moved significantly in winter time, the north component by 15 mm and the vertical component by 22 mm (Angermann et al., 2003).

4. METEOROLOGICAL DATA REGISTRATION AND WEB CAMERAS AT GEONAS OBSERVATORIES

Long-term monitoring of observatories BISK and SNEC since 2001 has shown deviations in the time series in winter (Figs. 3 and 4) and thus in March 2006 the selected GEONAS observatories were equipped with web cameras and the standard meteorological sensors - temperature, relative humidity and air pressure – to be possible to correlate the frosty snow effects with the inconsistencies in the time series. The cameras shoot the GPS antennas

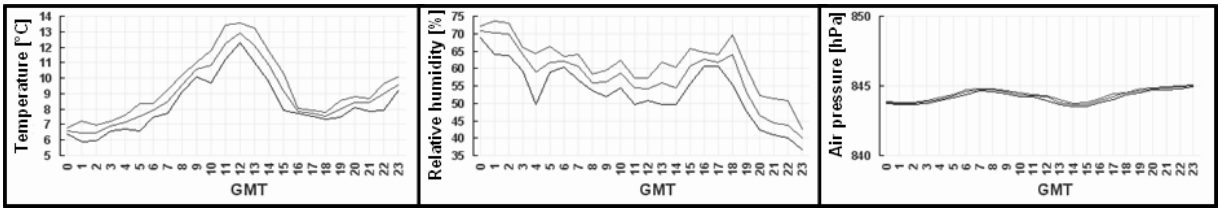

Fig. 6 Records of meteorological quantities – temperature, relative humidity and air pressure in hour-intervals for the observatory SNEC and one day March 16, 2006. The individual curves correspond to minimum, average and maximum hourly values, respectively.

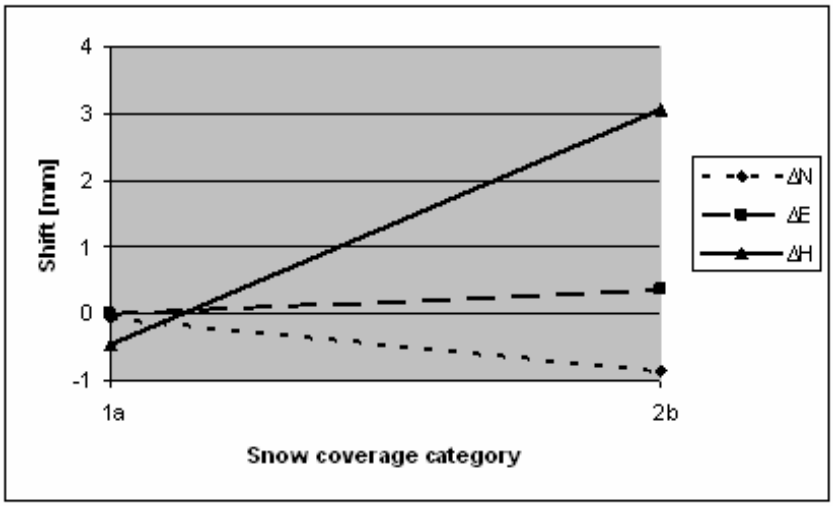

Fig. 8 Shifts in position of the observatory BISK for three components.

in 5-minute intervals. The examples of the camera snaps for March 19 and 20, 2006, are given in Figure 5. The records of the temperature, relative humidity and air pressure in time for the observatory SNEC are show in Figure 6. The snaps allow the snow coverage (its thickness, form and snow consistency) on the GPS antenna dome to be evaluated.

Web cameras installed on a few GEONAS observatories prove the correlation between time series outliers and frosty snow coverage of the antenna.

The photos (Fig. 7) are used for a classification of the snow cover amount. This image processing is completed and controlled by direct evaluation of the snow cover at the antennas. The following categories of the snow coverage were defined:

0 – no snow cover

1 – low snow cover

2 – moderate snow cover

3 – high snow cover

4 – very high snow cover

And, if possible, categories 0-4 were specified further as:

a - homogenous coverage

b - inhomogeneous coverage

The observation periods with the snow cover at the antenna were removed from the GPS data processing. The cleared position time series does not reveal non-linear motions and jumps any more.

The dependences of the shifts in the observatory positions determined by the GPS processing on the category of the snow cover are in Figures 8 and 9. The shift is larger in the vertical component than in the horizontal ones. The shifts in the north component at the observatory BISK and in the east component at the observatory SNEC are significant due to inhomogeneous shape of the snow cover on corresponding sides of the antennas.

5. CONCLUSIONS

It is visible in the presented plots (Figs. 8, 9) that mountain observatories of the GEONAS network BISK and SNEC suffer from the snow cover at the antenna domes. Strongly dependent systematic position shift was observed mainly at the SNEC observatory.

The possibility to remove the periods with the snow covered antennas makes the winter time series usable even for geodynamic studies.

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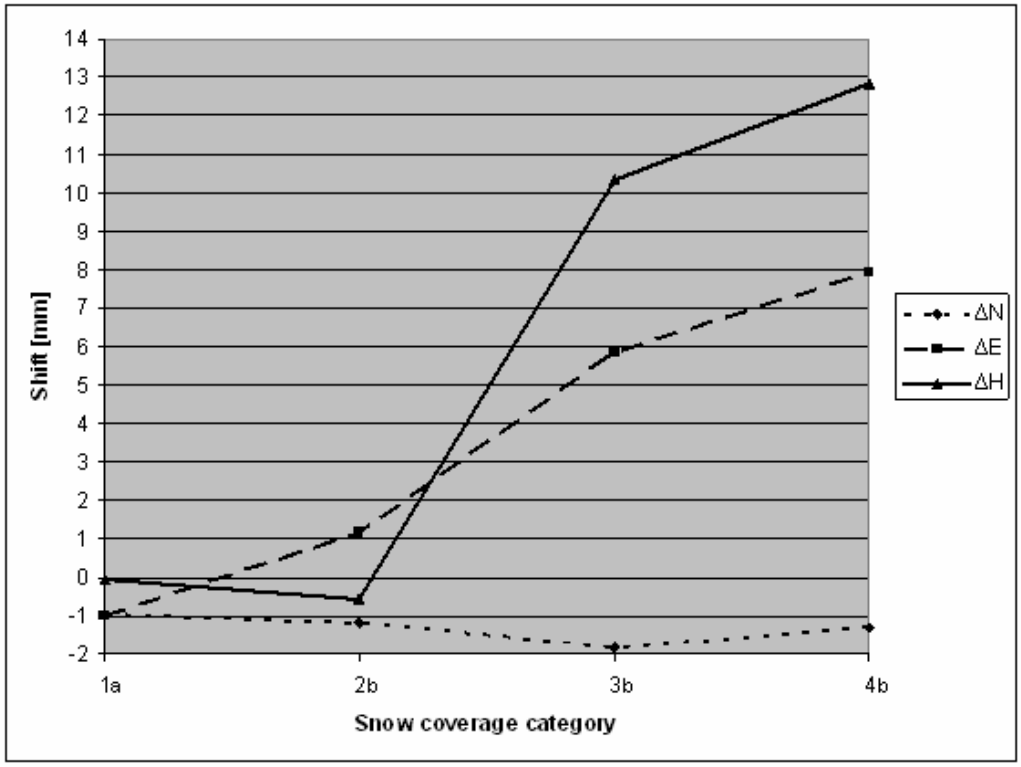

Fig. 9 Shifts in position of the observatory SNEC for three components.

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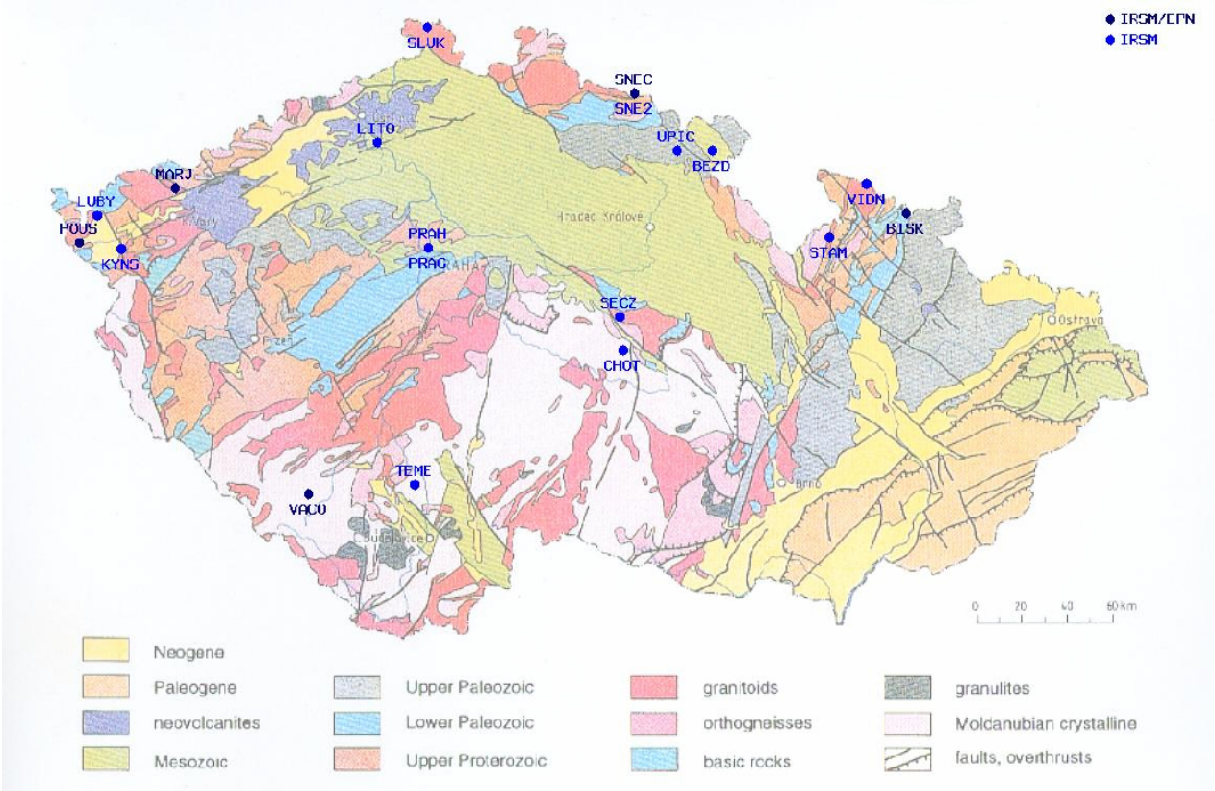


Fig. 1 Schematic map of the GEONAS observatories.

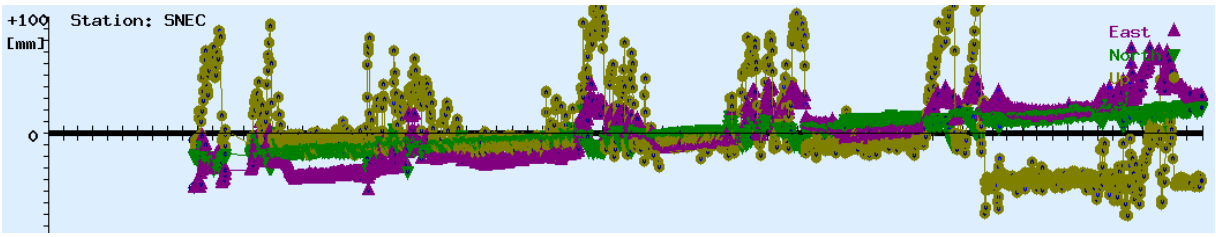


Fig. 3 Six-year time series for the observatory SNEC.

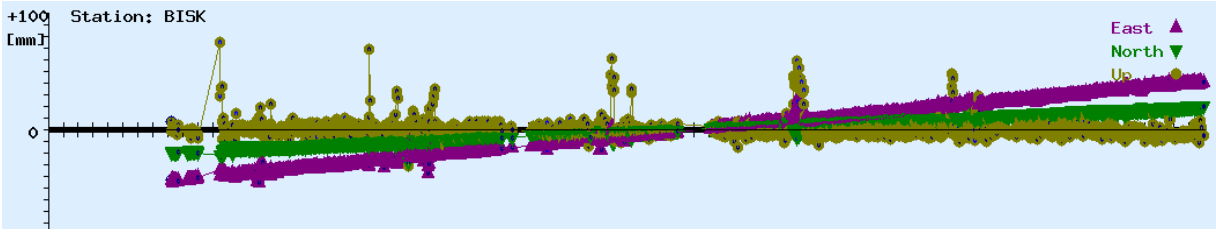


Fig. 4 Six-year time series for the observatory BISK.

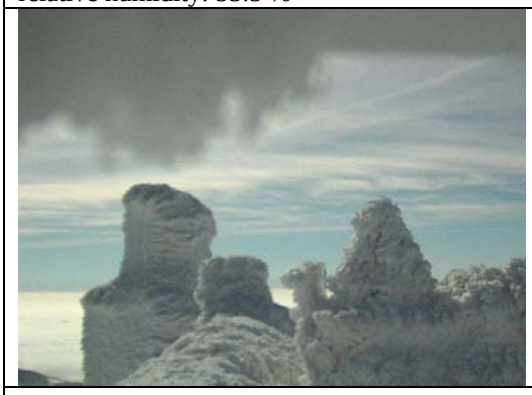
time: 9a.m. air pressure: 829.2 hPa temperature: -6.2 °C relative humidity: 74.3 %	time: 11a.m. air pressure: 829.1 hPa temperature: -4.1 °C relative humidity: 67.9 %
	
time: 1p.m. air pressure: 828.4 hPa temperature: -3.4 °C relative humidity: 53.5 %	time: 3p.m. air pressure: 827.5 hPa temperature: -3.1 °C relative humidity: 46.7 %
	
time: 5p.m. air pressure: 827.4 hPa temperature: -2.5 °C relative humidity: 41.8 %	time: 5 a.m. next day air pressure: 827.2 hPa temperature: -4.6 °C relative humidity: 80.8 %
	

Fig. 5 Photos of the antenna at the observatory SNEC on March 19, 2006 including monitored meteorological values.

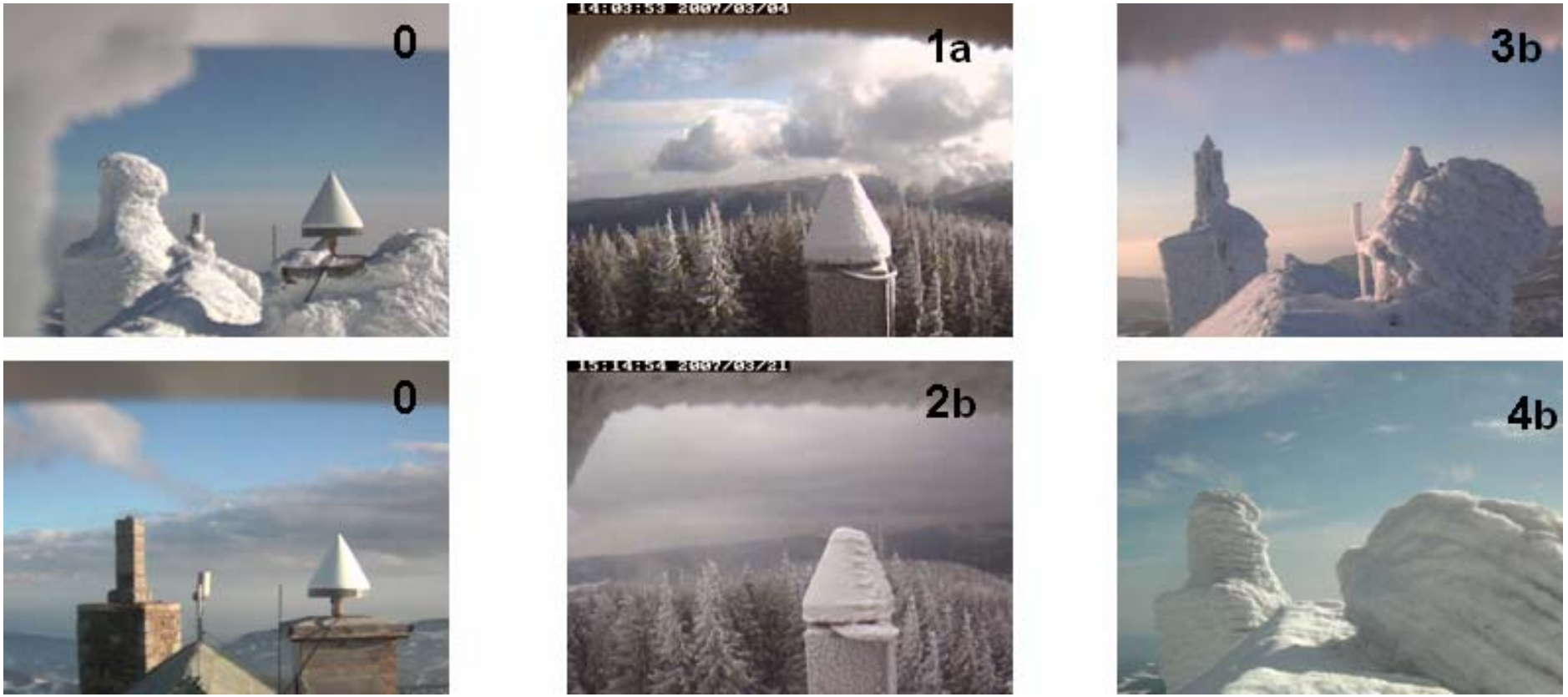


Fig. 7 Examples of the snow coverage categories: 0-no snow, 1a-low snow homogenous, 2b-moderate snow inhomogeneous, 3b-high snow inhomogeneous and 4b-very high snow inhomogeneous.