Sixth Workshop "Solar influences on the magnetosphere, ionosphere and atmosphere"

Observations of substorms during different storms

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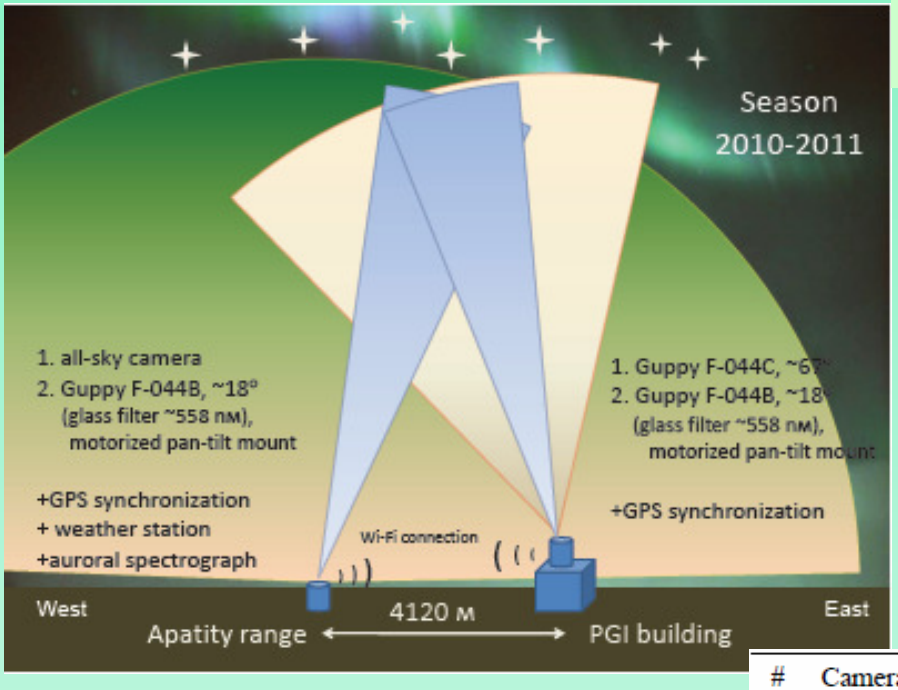
Instrumentation and data used

Goal: to study substorm development as seen from Apatity under different interplanetary and geomagnetic conditions.

- All-sky cameras data at Kola Peninsula from 2012/2013 winter season have been used.
- Solar wind and interplanetary magnetic field parameters were taken from CDAWeb (http://sdaweb.gsfc.nasa.gov/cdaweb/istp_public/).
- WIND satellite data revealed different solar wind streams: recurrent streams from coronal magnetic holes (RS) and magnetic clouds (MC) connected with non-stationary processes at the Sun or quiet conditions for the examined periods.
- Substorm onset time and further development were verified by ground-based data of IMAGE magnetometers network, Lovozero and Loparskaya magnetometers and by data of Apatity all-sky cameras.

Instrumentation and data used



Apatity coordinates

Code	Geographic		Corr. geomagnetic	
	Lat.	Long.	Lat.	Long.
APT	67.58N	33.31E	63.86N	112.9E

Characteristics of the auroral cameras:

#	Camera	Interface	Lens	Field of view	Position	Data resolution	Operation time
1	Watec WAT-902K	Analog video with frame grabber	Fujinon YV2.2 × 1.4A-SA2	180°	67°34′ N, 33°18′ E	232 × 232, 16 bits, 1 s, 24 integrated frames	28 Dec 2010–14 Apr 2011
2	AVT Guppy F-044B NIR	IEEE 1394a	Fujinon HF25HA-1B glass filter ~558 nm	15° × 10° 18° diagonal	67°34′ N 33°18′ E	376 × 288, 8 bits, 1 s	28 Dec 2010–14 Apr 2011
3	AVT Guppy F-044B NIR	IEEE 1394a	Fujinon HF25HA-1B glass filter ~558 nm	15° × 10° 18° diagonal	67°34′ N 33°24′ E	376 × 288, 8 bits, 1 s	20 Oct 2010–14 Apr 2011
4	AVT Guppy F-044C NIR	IEEE 1394a	Fujinon DF6HA-1B	56° × 44° 67° diagonal	67°34′ N 33°24′ E	376 × 290, 4 colors CMY+G, 8 bits, 1 s	20 Oct 2010–14 Apr 2011

Location of the cameras during 2010-2011 winter season

B.V.Kozelov et al., Geosci. Instrum. Method. Data Syst., v.1, pp.1-6, 2012

Instrumentation and data used

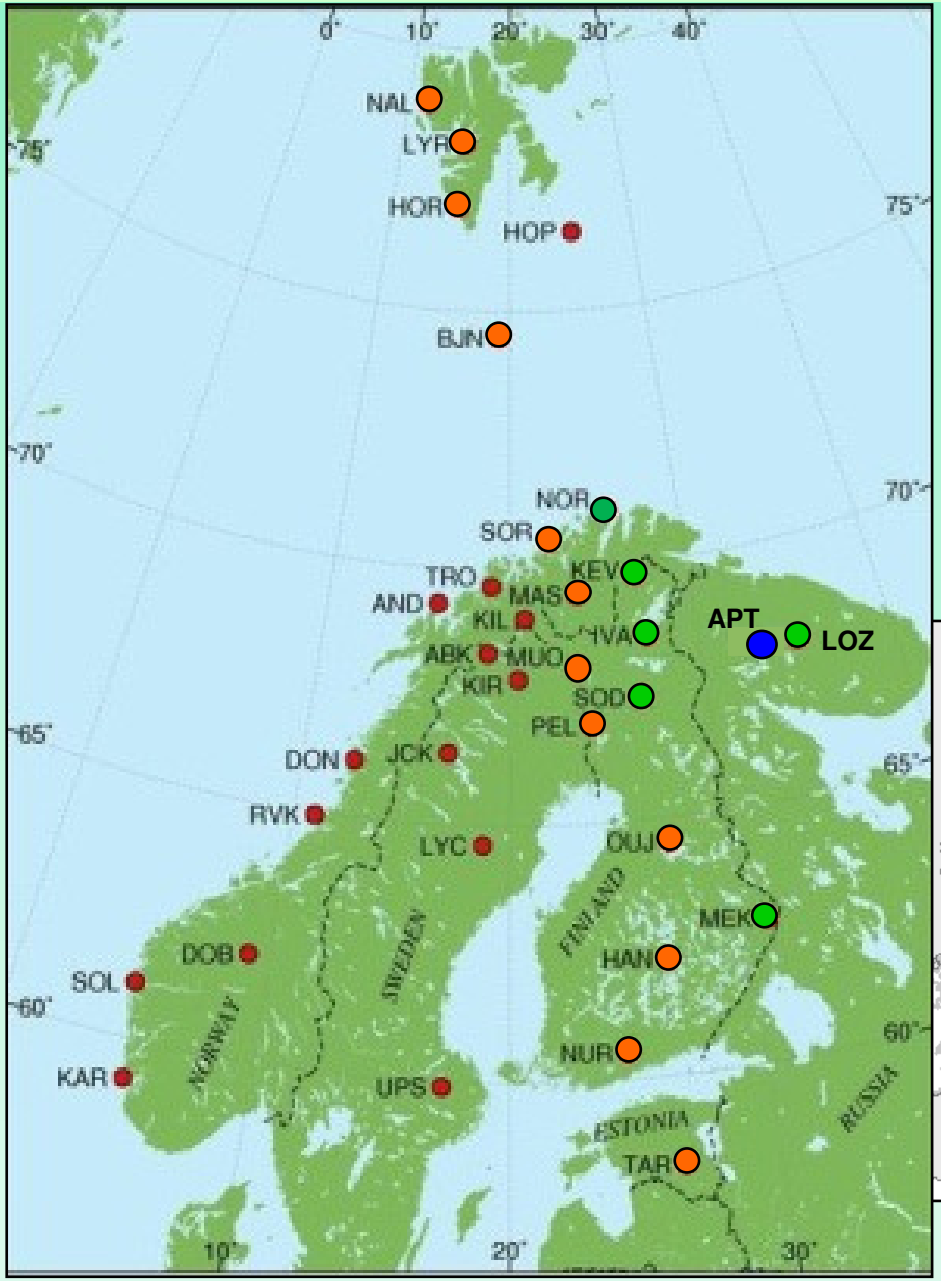
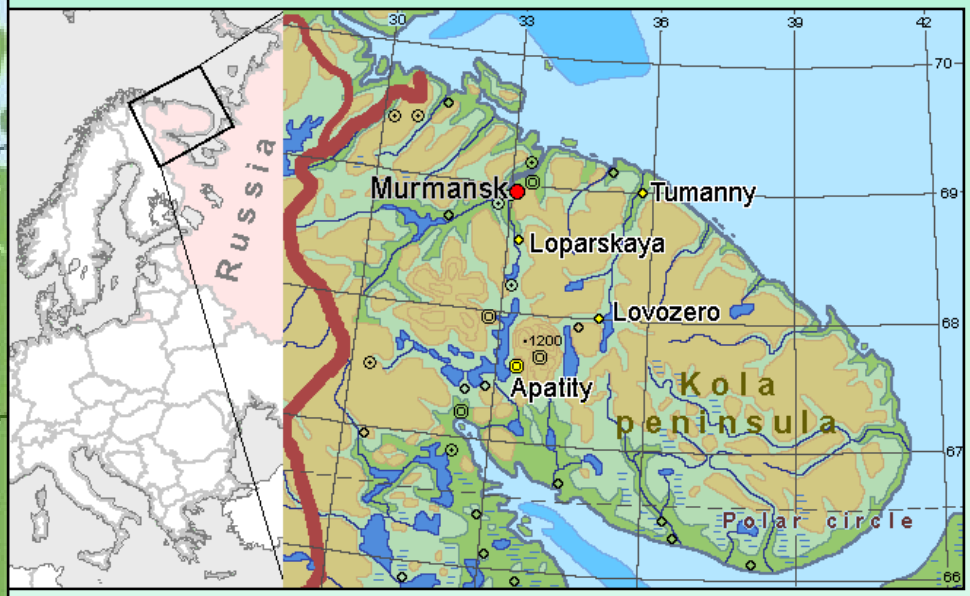


Image magnetometer set

- Apatity location
- Stations from the TAR-NAL chain
- Meridional stations nearer Apatity
- Other IMAGE stations

Apatity region map



Instrumentation and data used

The recurrent streams and magnetic clouds during 2012/2013 measurement season when measurements were taken by the Apatity all-sky cameras were detected. The substorms developed in the time of solar wind streams passage were identified. Three typical cases occurred during RS, MC and quiet conditions were chosen to present the variety of substorm developments over Apatity.

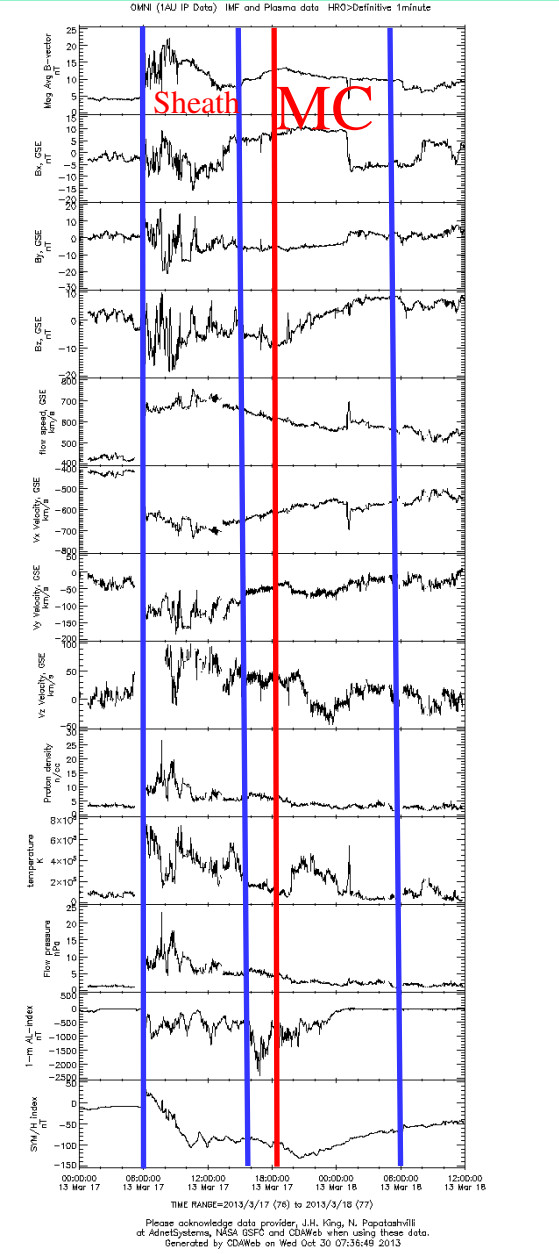
Presented cases:

Case 1: 17.03.2013
- Magnetic cloud (MC)
- Geomagnetic storm
- Highly disturbed conditions

Case 2: 29.03.2013, 30.03.2013
- Recurrent stream (RS)
- Geomagnetic storm
- Disturbed conditions

Case 3: 10.04.2013
- Quiet conditions

Case 1: interplanetary conditions, 17.03.2013



Magnetic cloud

Sheath: 06-15 UT, 17.03.2013

MC: 15 UT, 17.03.2013 – 06 UT, 18.03.2013

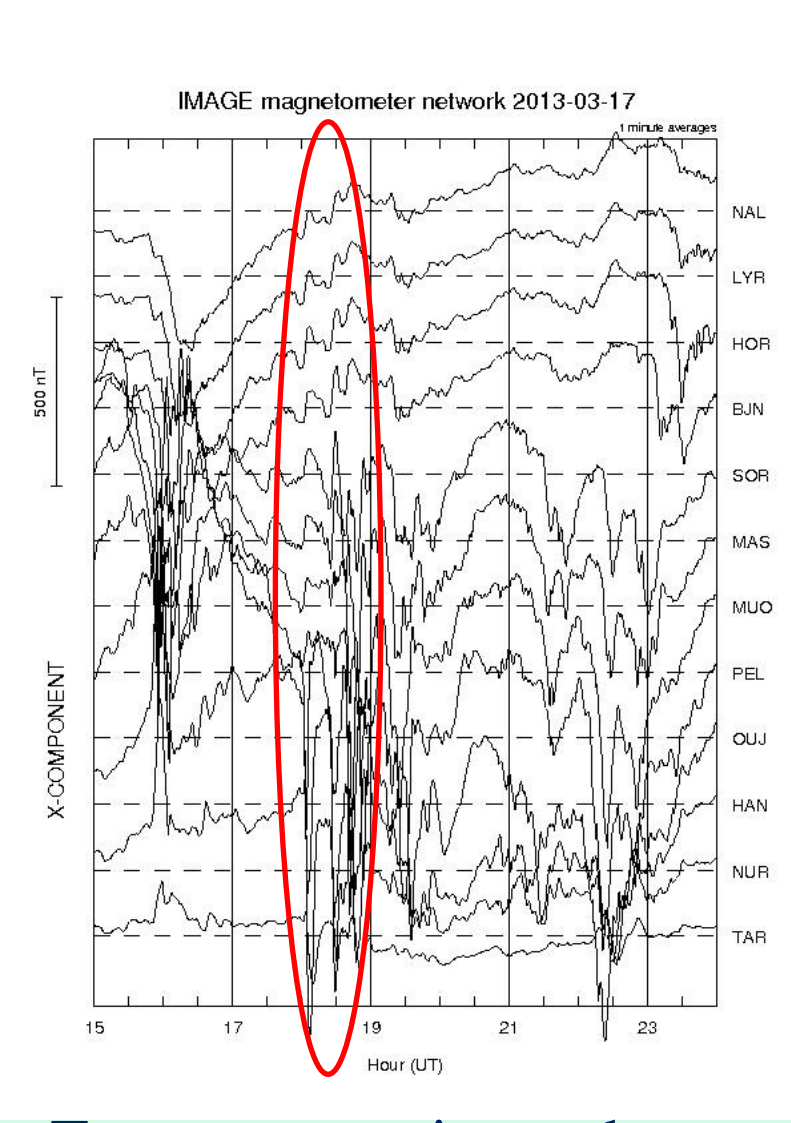
(blue vertical lines)

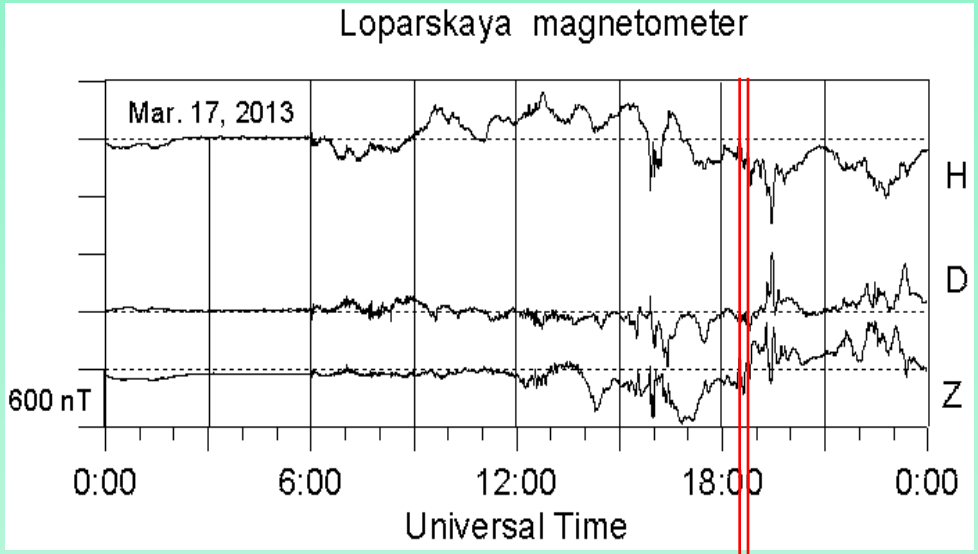
Geomagnetic storm (highly desturbed conditions) – Dst=-140 nT

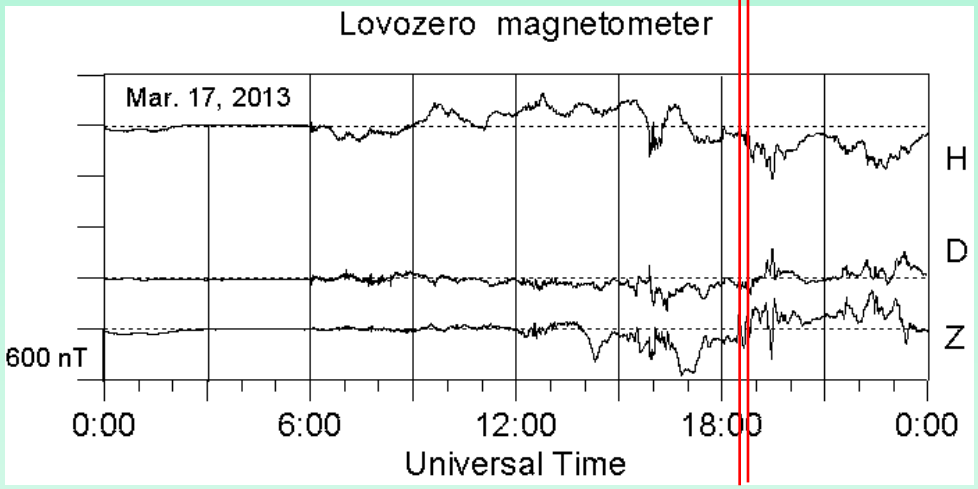
Substorms

Two consecutive substorms developed in 18:28 UT and 18:39 UT, 17.03.2013, during the magnetic cloud (red vertical line)

Case 1: magnetic field data



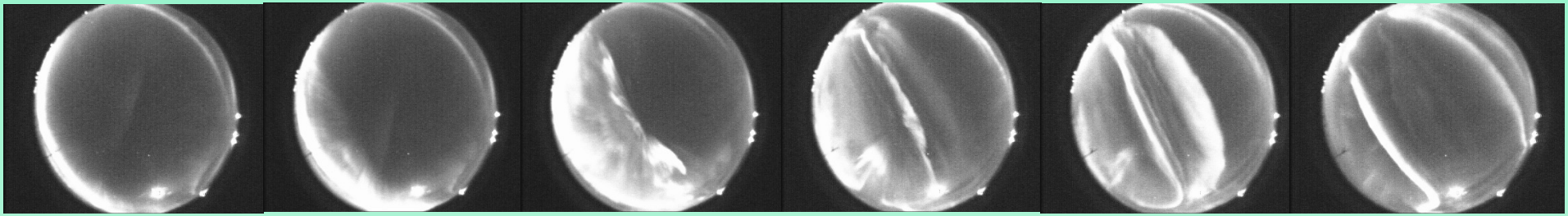




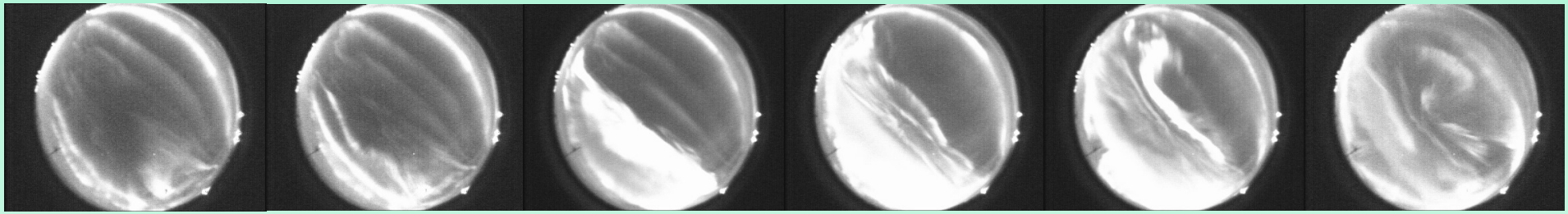
Two consecutive substorms during one of the most disturbed periods of the day were studied: in 18:28 UT and 18:39 UT.

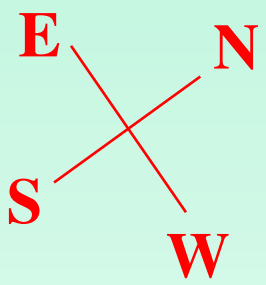
Case 1: all-sky camera data, 17.03.2013

UT: 18:26:40 18:27:20 18:29:00 18:32:00 18:33:40 18:36:30



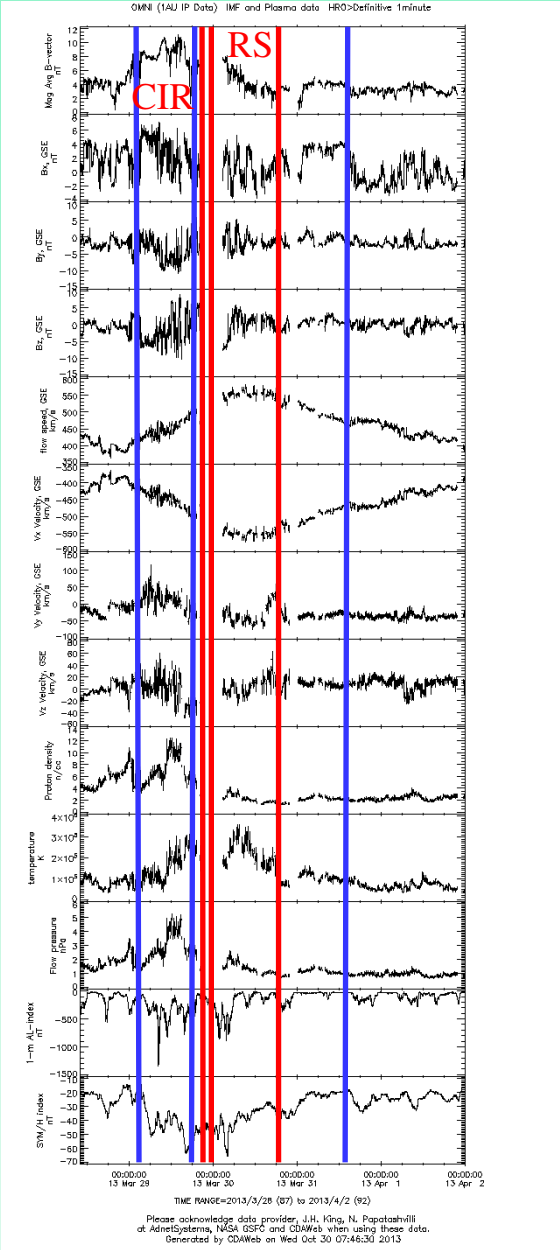
UT: 18:39:40 18:39:50 18:40:20 18:41:40 18:42:10 18:45:00





Chosen images of the substorms development: at these disturbed conditions, the auroral oval was to the South of Apatity. Substorm onset, polar edge movement to the North, surpassing station zenith (18:32 UT), the second intensification in 18:39:40 UT and its travel to North, the bulge expanding in the whole field of view are seen.

Case 2: interplanetary conditions, 29.03.2013, 30.03.2013



Recurrent stream

CIR: 03 – 18 UT, 29.03.2013

RS: 18 UT, 29.03.2013 – 14 UT, 31.03.2013

(vertical blue lines)

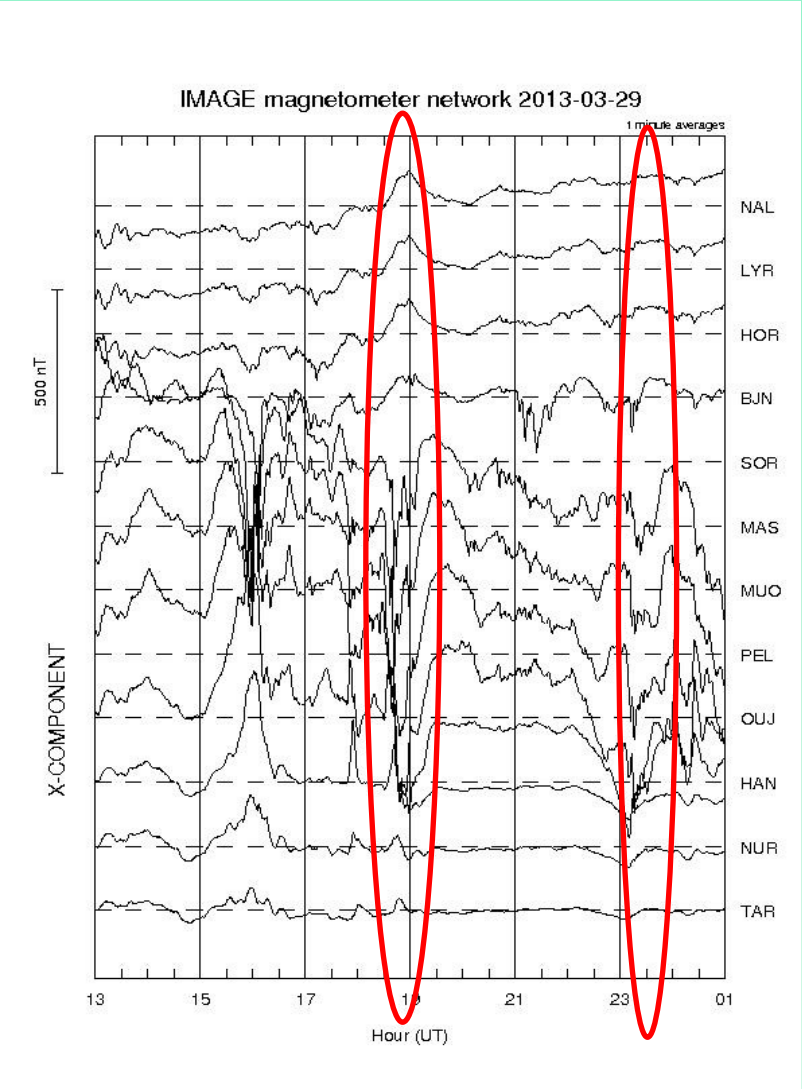
Geomagnetic storm, Dst=-65 nT, disturbed conditions

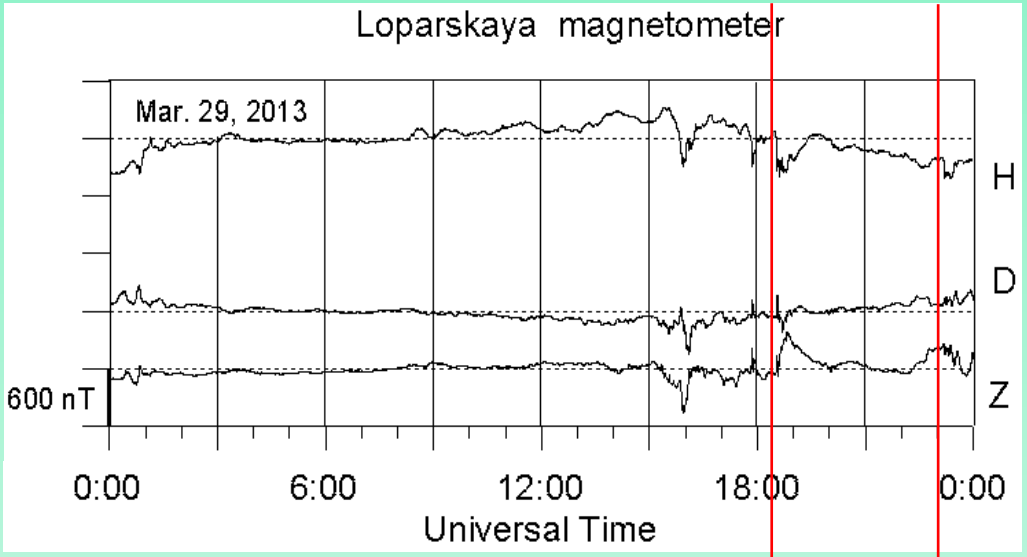
Substorms

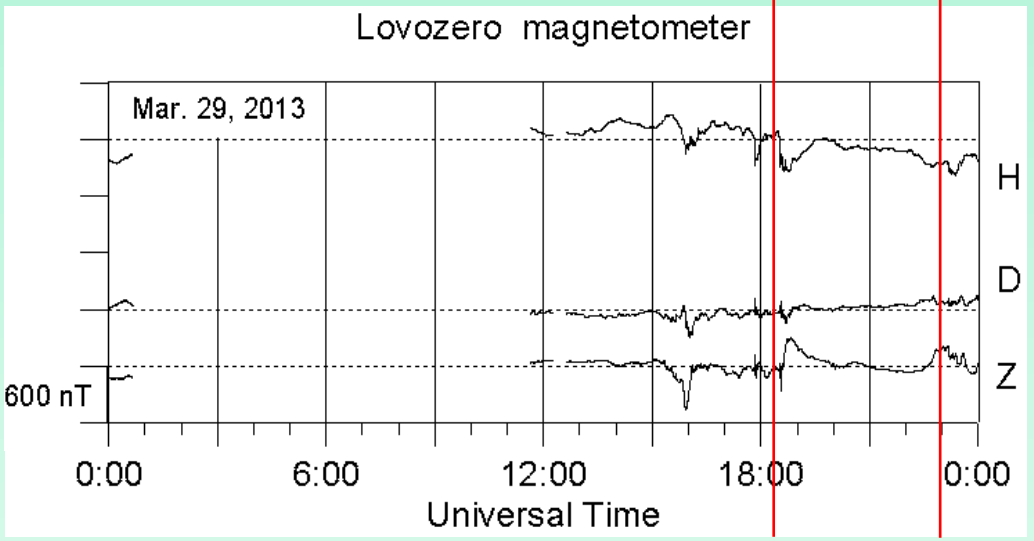
3 substorms developed during RS (vertical red lines):

2 substorms during the main phase of the storm (in 18:28 UT and 23:08 UT, 29.03.2013, Dst=-45÷-50 nT) and one – during the recovery phase (in 19:08 UT, 30.03.2013, Dst=-40 nT).

Case 2: magnetic field data, 29.03.2013



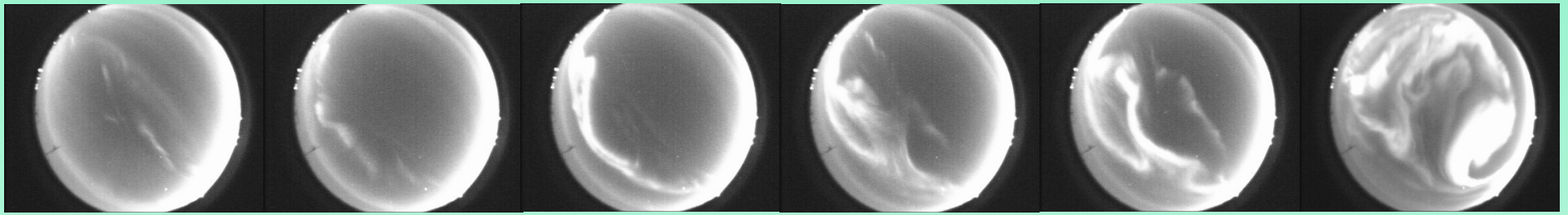


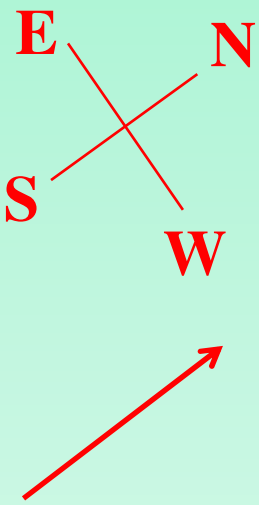


During RS two substorms were observed on 29.03 2013: in 18:28 UT and 23:08 UT.

Case 2: all-sky camera data, 29.03.2013

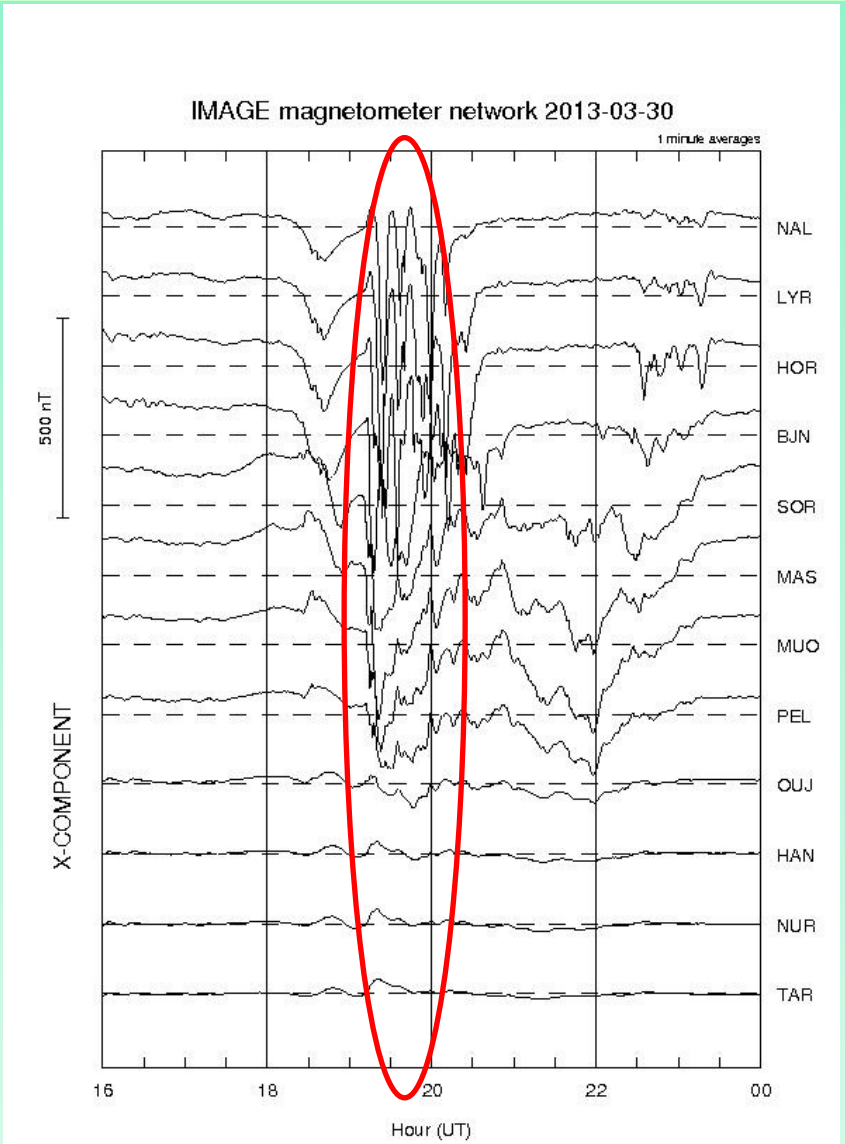
UT: 18:26:00 18:29:00 18:30:10 18:31:10 18:31:20 18:33:30

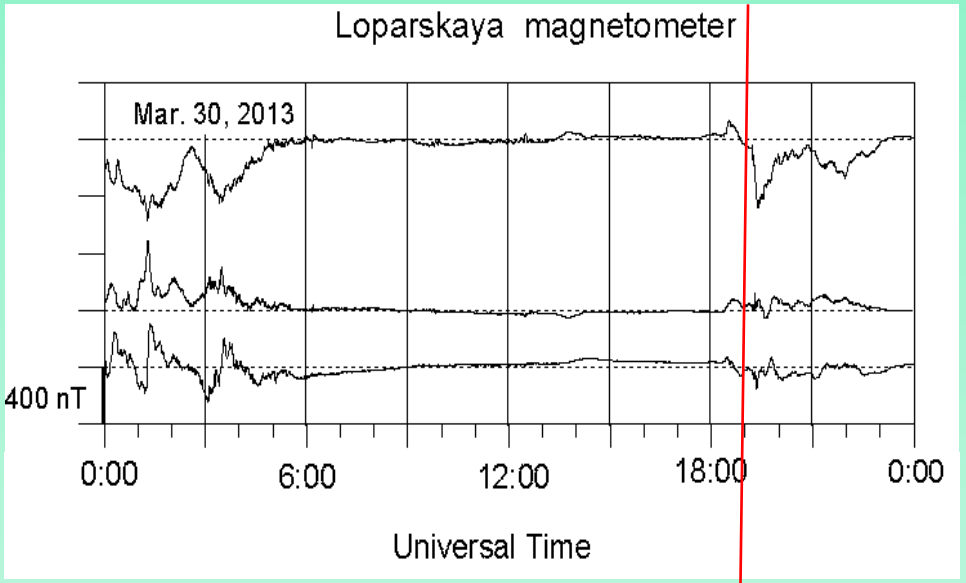


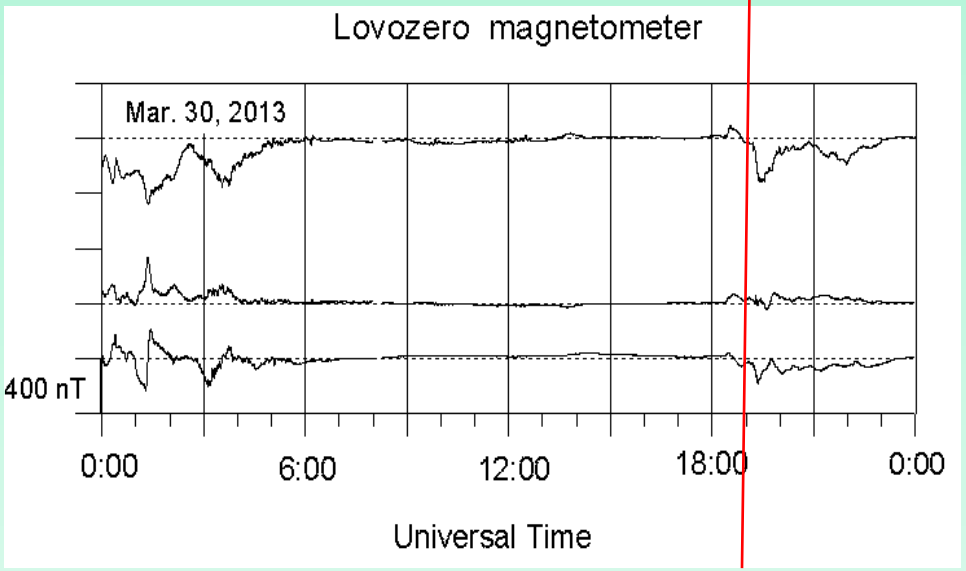


Selected images from one of the substorms development during the main phase of the geomagnetic storm. The auroral oval emissions are lying over Apatity latitudes. Before the substorm onset in 18:28 UT the arcs are moving to the South. During the bulge formation its polar edge moves in S-N direction, reaching zenith in 18:31:10 UT. In 18:31:20 UT the polar edge surpasses zenith location and after 18:32:40 UT the whole field of view is occupied by the auroral bulge forms.

Case 2: magnetic field data, 30.03.2013



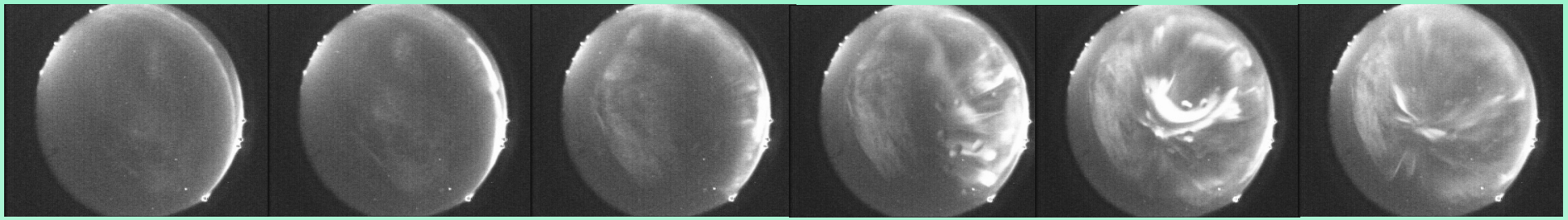


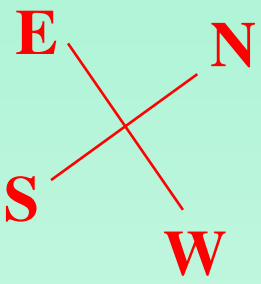


During RS on 30.03.2013 a substorm originated. The magnetic field disturbances began in in 19:08 UT.

Case 2: all-sky camera data, 30.03.2013

UT: 19:11:20 19:12:30 19:15:30 19:16:50 19:18:10 19:18:30

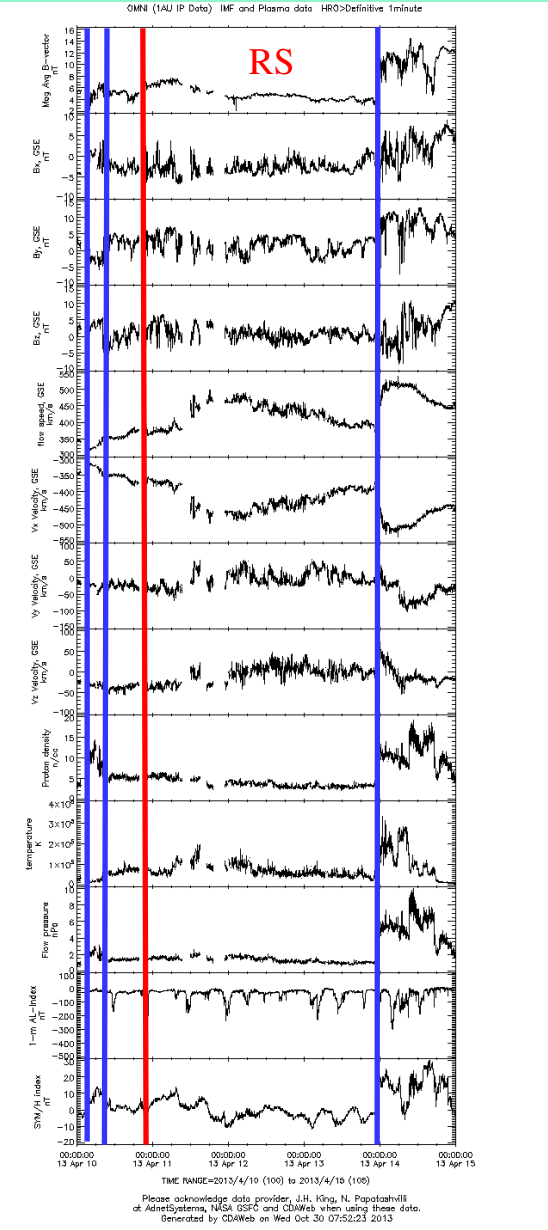




South edge of the auroral bulge movement direction

Chosen images of the substorm development in 19:11:20 UT on 30.03.2013 during the recovery phase of the geomagnetic storm associated with RS. The substorm onset is to the North of Apatity and the expansion of the South part of the substorm bulge is observed from the station.

Case 3: interplanetary conditions, 10.04.2013



Recurrent stream

CIR: 3 UT – 9 UT, 10.04.2013

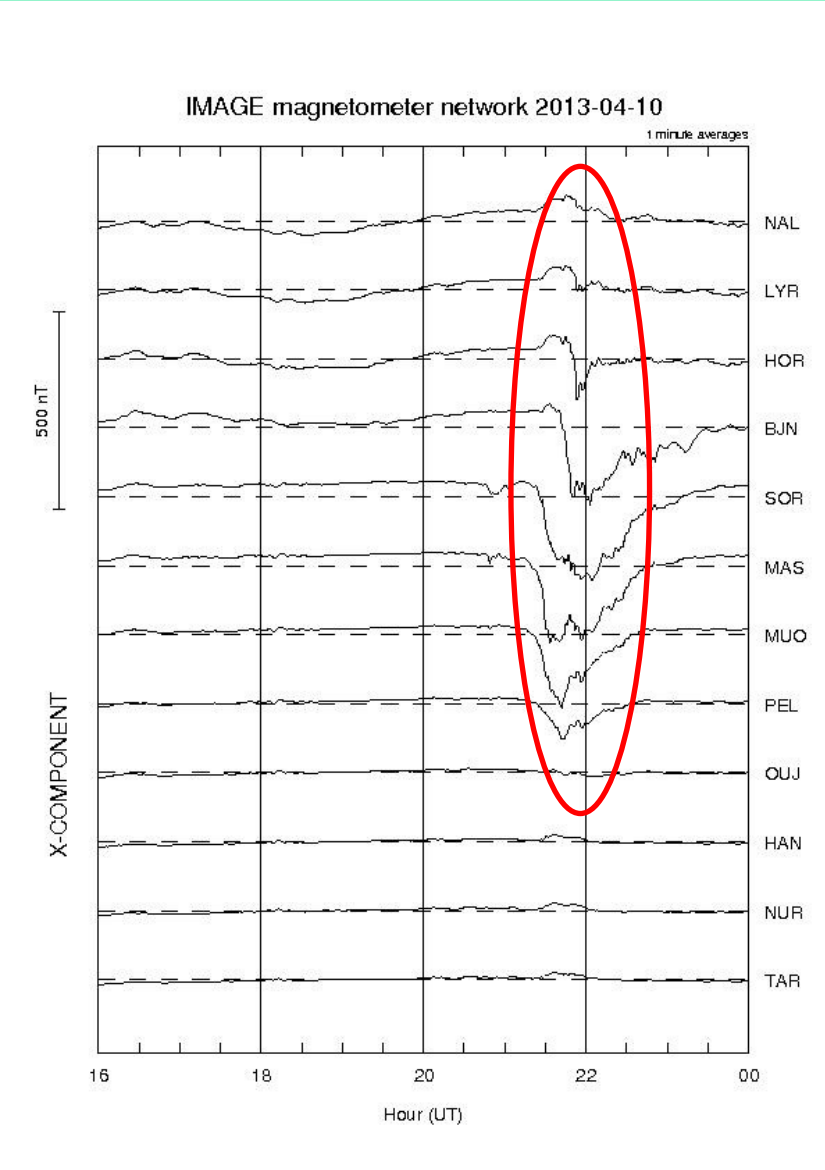
RS: 9 UT 10.04.2013 – 0 UT 14.04.2013

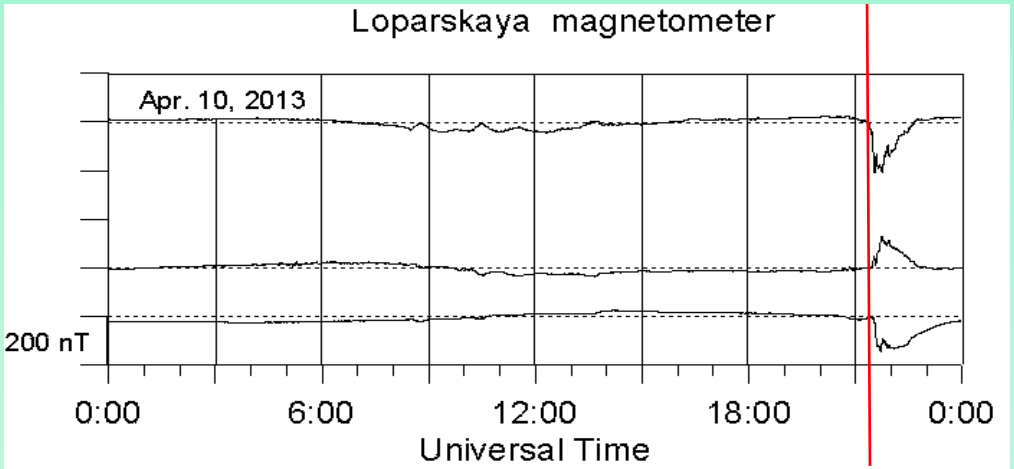
(blue vertical lines)

Quiet conditions (non-storm conditions)

The examined substorm developed in 21:28 UT, 10.04.2013 (red vertical line), during the beginning of the recurrent stream.

Case 3: magnetic field data, 10.04.2013

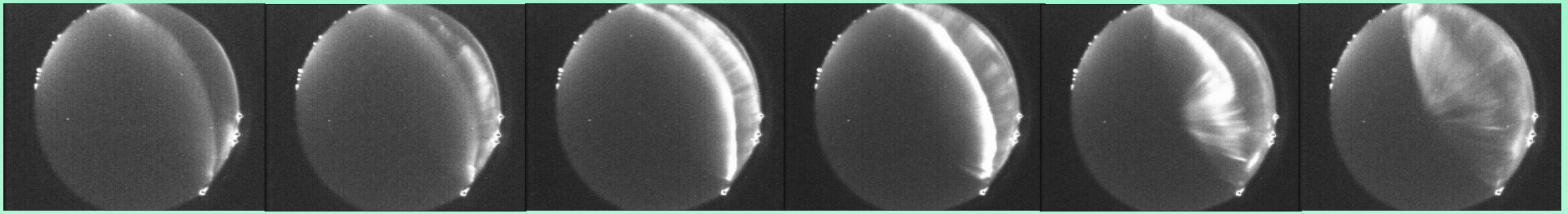


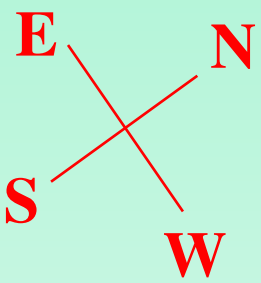


During RS on 10.04.2013 a substorm was observed in 21:28 UT.

Case 3: all-sky camera data, 10.04.2013

UT: 21:28:00 21:29:40 21:30:50 21:31:40 21:33:00 21:34:10





South edge of the auroral bulge movement direction

Images of the substorm development on 10.04.2013. Substorm onset in 21:28 UT at the South border of the auroral oval, **to the North** from Apatity.
From the expanding auroral bulge, the South edge is seen to travel to the South reaching Apatity zenith about 21:33:00 UT.

Conclusions

We investigated substorm development during storms caused by different sources in solar wind and during quiet conditions using observations of auroras in Apatity during 2011/2012 and 2012/2013 winter seasons.

It is shown that 2 types of substorm development occur over Apatity.

First type: substorm onset is to the South of Apatity, and the "usual" development of the substorm bulge is seen – from South to North; the polar edge of the bulge is observed to pass over zenith.

Second type: the auroral oval is situated at higher latitudes, substorm generates to the North from Apatity, and the movement of the auroral bulge to the South is seen from Apatity, i.e. the equatorial edge of the auroral bulge is observed.

It is shown that the first type of substorm development over Apatity happens during geomagnetic storms, associated with both magnetic clouds and high speed recurrent streams of the solar wind.

The second type of substorm development is observed quiet (non-storm) conditions or during the storm recovery phase.