Finnish pulsation magnetometer chain:

mapping of the arrival direction of the Pc1 pulsations

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Instrumentation

Sodankylä Geophysical Observatory has carried continuous pulsation magnetometer recordings since 1963. The present network implies the third generation of pulsation magnetometers. Coils used since start of the digital recordings were build for ground-based support of the Swedish Satellite VIKING in 1984-85. New instruments were built at SGO (electronics) and Department of Physical Sciences (ferrite core coil sensors) in 2000-2003. The three component pulsation magnetometers have 16 bit A/D converters, 40 Hz sampling rate with GPS timing. Frequency band cover from tens of mHz up to 10 Hz. The chain was extended to Barentsburg in 2005.

Stations

Station	Code	Lat	Lon	L-value ⋆
Barentsburg	BAR	78.05°N	14.15°E	15.8
Kilpisjärvi	KIL	69.02°N	20.86°E	6.1
Ivalo	IVA	67.84°N	20.41°E	5.6
Sodankylä	SOD	67.42°N	26.39°E	5.3
Rovaniemi	ROV	66.78°N	25.94°E	5.1
Oulu	OUL	65.08°N	25.90°E	4.5
Nurmijärvi	NUR	60.51°N	24.65°E	3.4

⋆) calculated to year 2005 at altitude 100km (DGRF/IGRF)

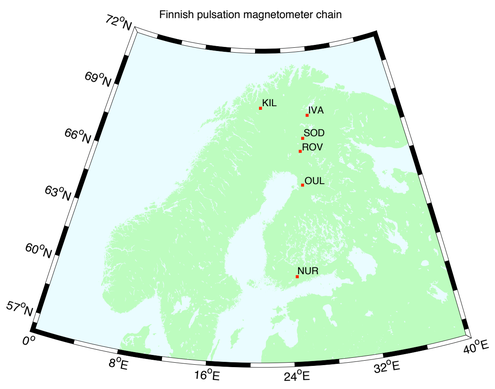

Figure 1. Location of the Finnish pulsation magnetometer stations. The present chain on the territory of Finland constitutes from 6 observation points.

Data availability

- data is available for the scientific use by on request in Matlab 4.0 format
- quick-look plots and raw data are available online in delay of one night

Station	Sampling rate	Digitally available
BAR	40 Hz	Jul 2005 -
KIL	20 / 40 Hz	Jun 1999 / Jun 2000 -
IVA	20 / 40 Hz	Sep 1999 / Oct 2000 -
SOD	20 / 40 Hz	Jun 1995 / Dec 2000 -
ROV	20 / 40 Hz	Jun 1999 / Sep 2000 -
OUL	40 Hz	Jul 2000 -
NUR	40 Hz	Aug 2000 -

Future development

SGO has run test measurements of high resolution pulsation magnetometer since 2006. Present ferrite core coils are used, but the pre-amplifiers are redesigned to get best signal-noise ratio. Also the sampling frequency is rised up to 200Hz. These changes make possible to monitor the ULF/ELF band up to 30 Hz. SGO plans to upgrade the whole chain to use this type of instrumentation in future.

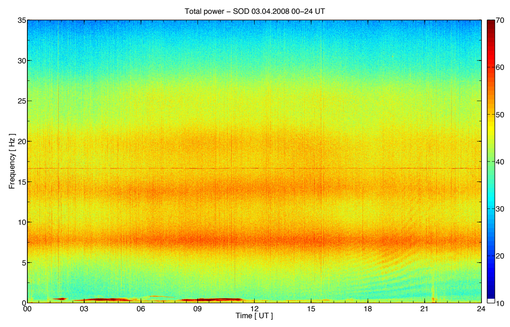

Figure 2. Sodankylä 03 Apr 2008. Total power spectrum of the test measurement (XY) shows Pc1 pulsations (01-12UT), Alfvén resonators (starting around 18UT) and three lowest Schumann resonances. Also strong signal at 16.6Hz from Swedish railway system can be seen.

Mapping of the arrival direction of the Pc1 pulsations

Finnish geomagnetic community has long tradition of studies of geomagnetic pulsations. One of the first Pc1 pulsation observations were made by Eyvind Sucksdorff in 1932-1935. They were recorded by Danish La Cour quick-run magnetometers. Nevertheless, the advances of the computer power and new instrumentation has not really been used earlier to pulsation data. One unknown field is the behavior of the source regions of the Pc1. Multi-station array gives possibilities to map the arrival directions of the events.

Analysis

- selected sensor pair (XY,XZ,YZ) is handled as a complex data
- time-frequency-intensity analysis, orientation, axis ratio and sense of rotation of the polarization ellipse is computed
- several filtering possibilities exist (power levels, eccentricity, sense of rotation and orientation in numerous combinations)

Difficulties

- only the strongest one is seen in the results during overlapping events
- 180 degrees ambiguity, several stations give solution
- the angle of arrival is just near the 0-180 degrees boundary, the estimate formation leads sometimes to erroneous results

First results

The event selected for testing the method occurred on 23.01.2008 on 14.15 UT and it lasted more than one hour. The stations Ivalo, Sodankylä and Rovaniemi were used in this test. Figure 3. shows the event in time-frequency-intensity plot from Sodankylä station.

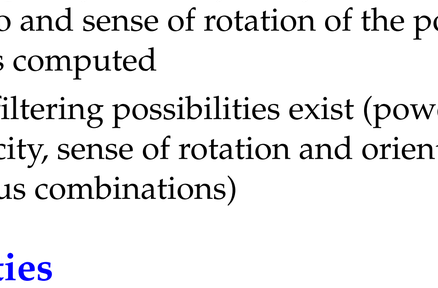

Figure 3. Sodankylä 23 Jan 2008. Total power spectrum of the event for testing the arrival direction. Several Pc1 events at slightly differing frequencies and pearl periods.

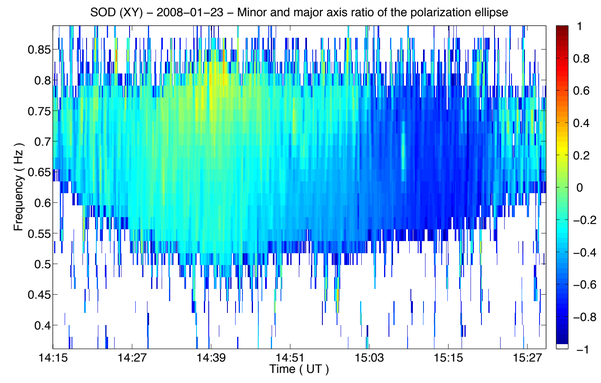

Figure 4. The polarization of the event as minor and major axis ratio with sign indicating the sense of rotation (+1 is right handed circular). The event is most of the time left handed polarized. Around 15:15UT it is nearly left-hand circular polarized.

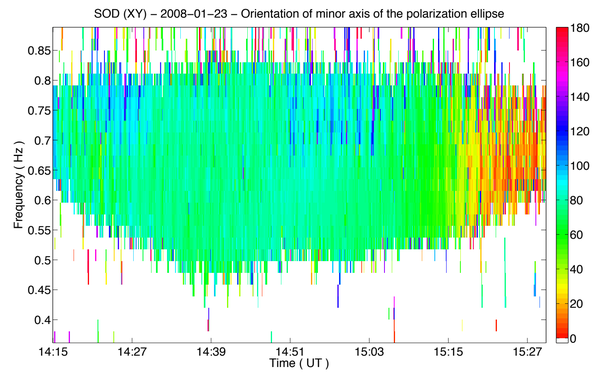

Figure 5. The angle of arrival calculated from SOD.

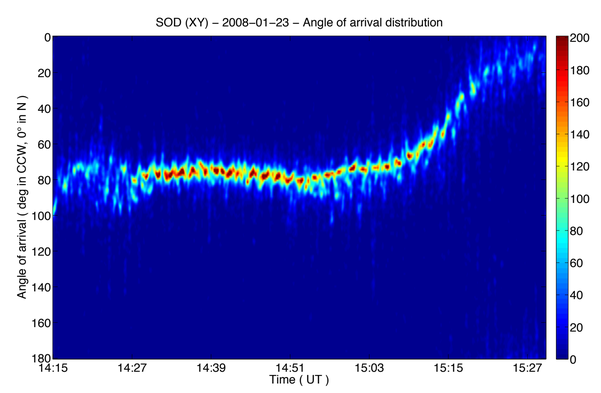

Figure 6. The distribution of arrival angles in the event as a function of time. Frequency band 0.51 - 0.8 Hz.

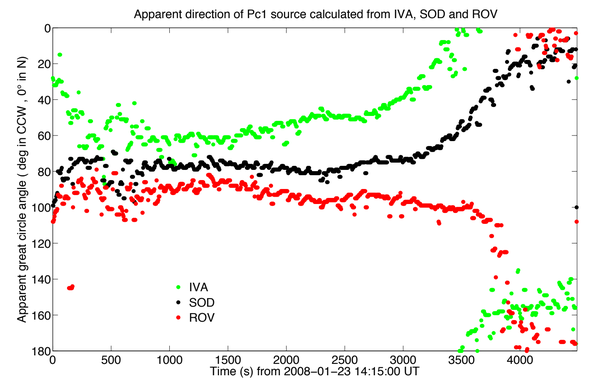

Figure 7. Apparent direction of the source region calculated from recordings of SOD, ROV and IVA. The direction is CCW from north.

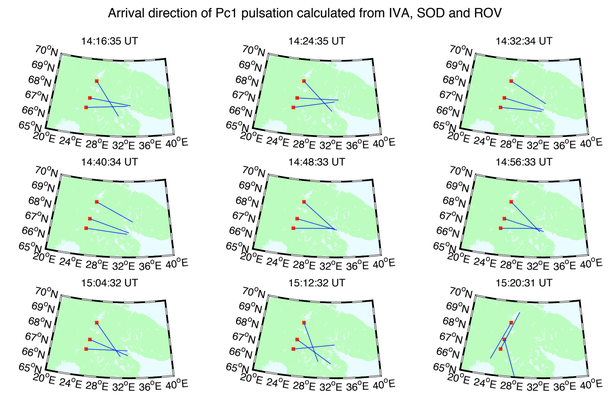

Figure 8. Arrival direction of the Pc1 seen from different stations. The source moves few hundred kilometers to west from Kola peninsula over SOD.

Finnish pulsation magnetometer chain: http://www.sgo.fi → Data Archive