

EMSEV - Bishkek Russian Academy of Science Cooperation

<http://www.emsev-iugg.org/emsev/> and <http://www.gdirc.ru/en/>



Workshop on



Fundamental problems on the earthquake generation processes and the way to monitor them for hazard mitigation March 25 - 29, 2014, Toulouse (France)

Report: March 31, 2014

Background

In 2011, IUGG Inter-Association EMSEV and Research Station RAS in Bishkek began a cooperative research program in Kyrgyzstan where some outstanding research on the relations between EM phenomena and electrical resistivity changes with earthquakes has been conducted during the last 30 years. In November 2011, teams from Japan, France and Greece visited Bishkek Research station. A meeting was held during which a synthesis of the past results was made and a four-year agreement of cooperation was signed (<http://www.emsev-iugg.org/emsev/page016.html>, and <http://www.gdirc.ru/en/index.php?limitstart=8>). In addition to the kick-off meeting, two continuous passive EM recorders were installed in order to carry out new detailed studies (see below).

Scope of the March 2014 EMSEV-RS RAS Workshop (Toulouse, France)

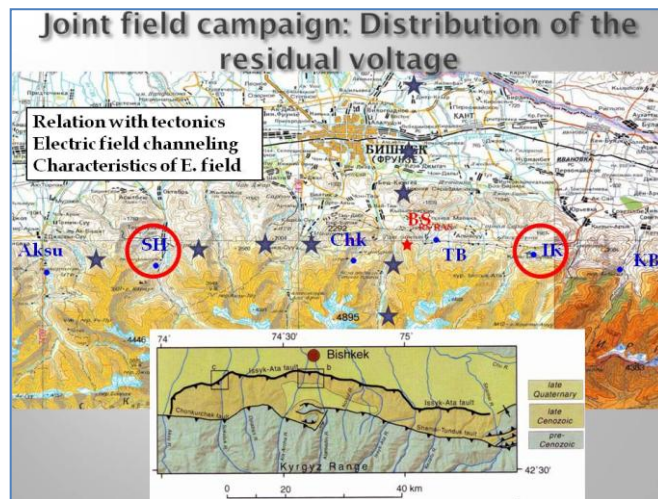
The main objectives of the workshop were:

- To cross-correlate the observations made during the period November 2011-March 2014,
- To highlight signals possibly related to tectonic activity,
- To check if VAN'S SES and /or underground electric conductivity changes are observed before earthquakes,
- To evaluate the triggering effects of electric current injection and magnetic storms,
- To discuss about future cooperation on theoretical study and field experiments.

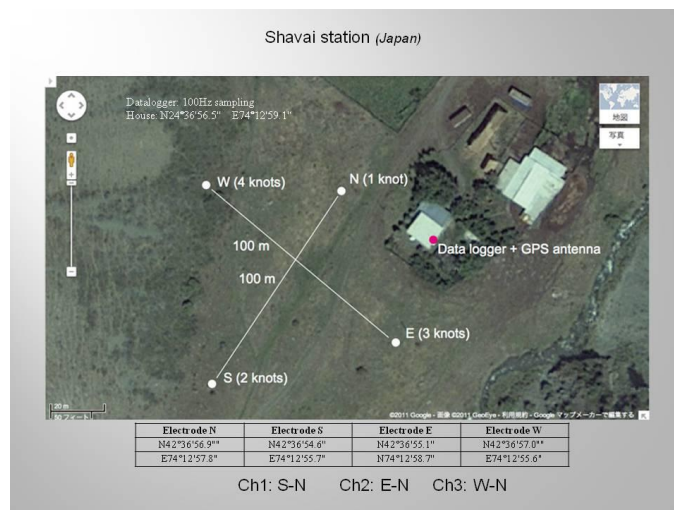
Opening presentation

An introducing talk was done by J. Zlotnicki and T. Nagao, in which past and present status of the cooperation was recalled.

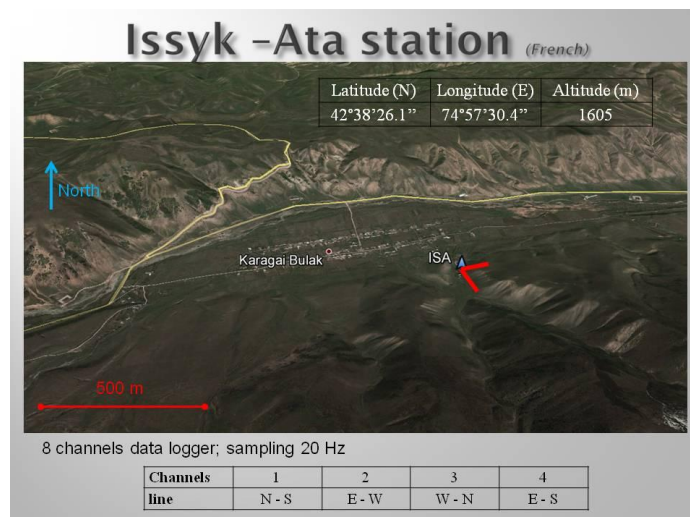
Between November 2011 and March 2014, the two autonomous Japanese (Shavai, 'SHA') and French (Issyk-Ata, 'ISA') stations were in operation along the Kyrgyz ridge. Both stations were included in the RS RAS network in Bishkek in which an alternating square shaped 600A DC current with period of 10 seconds peak to peak was injected during about 10 minutes every working day at 2, 3, 4, 5, 7, 8 UT time (LT=UT+6). Current system was oriented along a 4 km North-South long dipole.



- Shavai station (SHA, Jp) was located at about 40 km away to the West of the current system. It was composed of three electric channels sampled at 100 Hz, and synchronized by a GPS receiver.



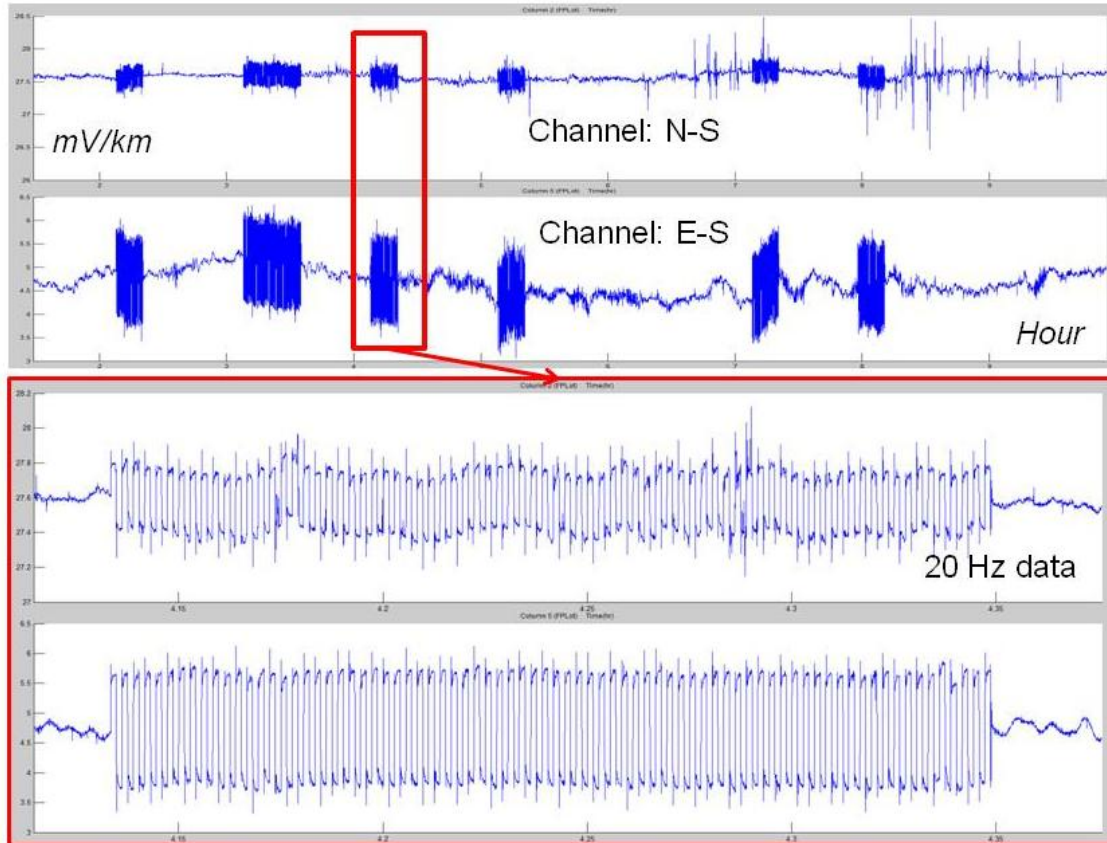
- Issyk-Ata station (ISA, Fr) was located at about 30 km away to the East of the current system. It was composed of four electric channels and data were sampled at 40 Hz. The temporal drift of the internal clock was less than 0.5 second/month.



- Both stations have been operating well during the 2.5 years, due to efforts of Bishkek scientists.

- Both SHA and ISA stations have a resolution of a few $\mu\text{V}/\text{km}$. During the operation of the current system during working days, stations are recording square shaped residuals voltages with amplitude of several mV/km .

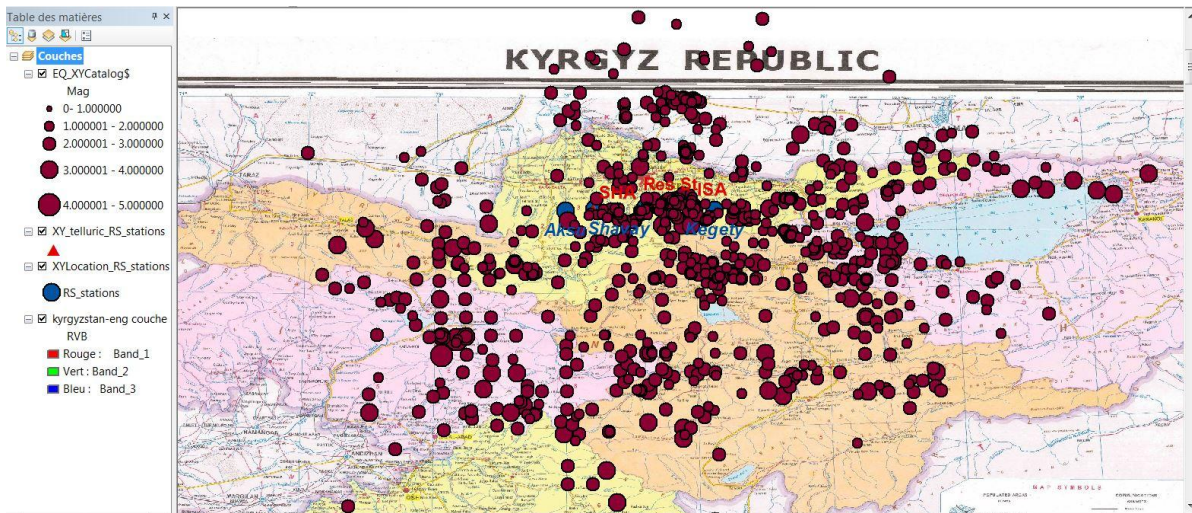
ISA station (day 320, 2011)



High signals versus noise also allow the analyzing of weak natural or anthropogenic electric variations. Some of these variations might be considered as linked to the tectonic activity.

- Seismicity has remained at a low level during the 2.5 years of observation, and few - far away - earthquakes of magnitude above 4 were recorded.

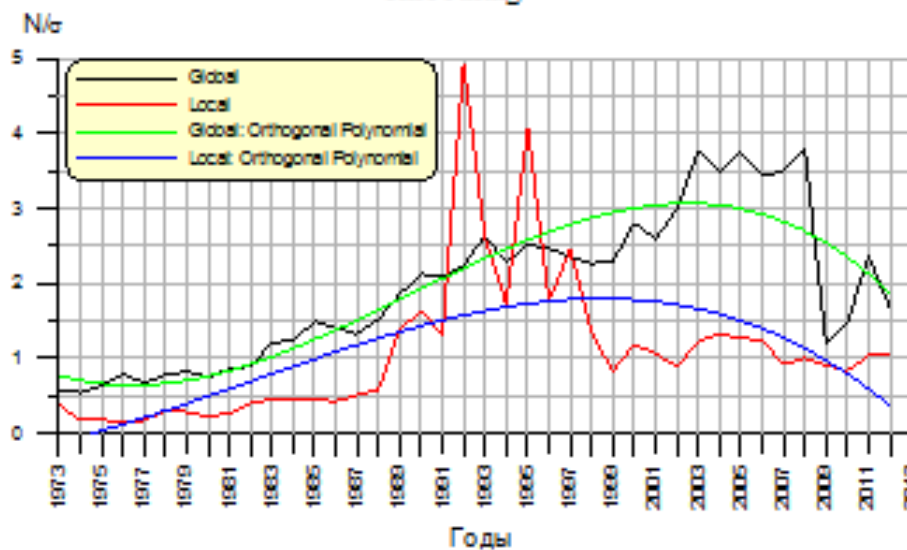
Only 1 large earthquake of magnitude 5.2 (Mb) occurred on February 5, 2012 at 07h10mn20sec UTC (lat: 41.59°N, long:74.76°E, distance to stations ~ 140 km).



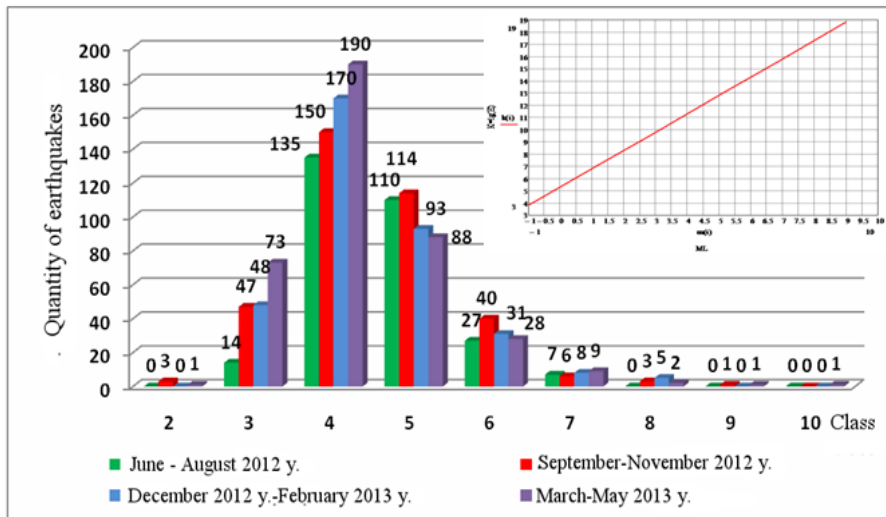
Presentation on the current seismic monitoring network (by V. Bragin)

- In his talk V. Bragin mentioned that the number of low magnitude earthquakes has simultaneously increased with the operation of their current monitoring network in 1991 and after, while the number of larger magnitude earthquakes has decreased (red curve on the following graph).

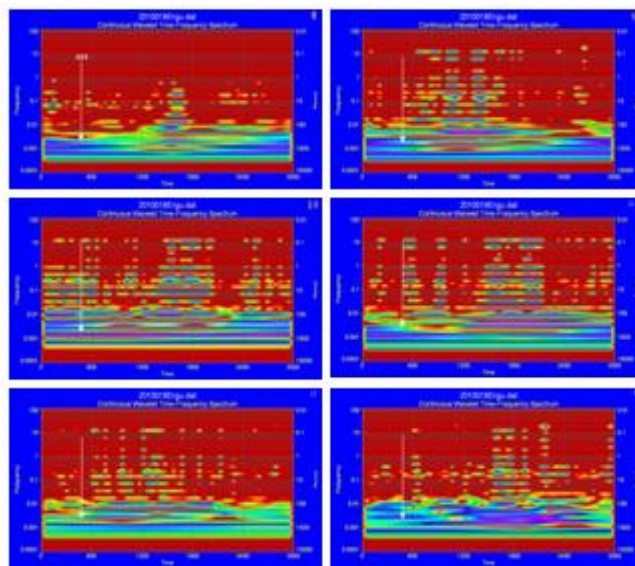
Standardized distribution graphs of the number of seismic events for the eastern hemisphere territory and Bishkek geodynamic test ground and the results of their smoothing



- In 1992 one large earthquake of magnitude 7.2 was recorded.
- At present, the distribution of earthquakes is concentrated below magnitude 1.5 (Class= $1.8 \times M + 4$). Therefore, it seems that the continuous operation of the injection current system could have reduced the magnitude of large earthquakes with time, resulting in the generation of many small earthquakes (see following graph).



- After the beginning of each injection of the 600A DC current into the ground induced low seismicity is observed. The next figure represents 1 hour spectrograms of the seismicity during 1 hour periods after the beginning injections at 2, 3, 4, 5, 7, 8 UT time.



Examples of wavelet diagrams (Morlet) of seismic responses to sessions of electromagnetic sounding (energetic influence). White arrow marked the beginning of sessions electromagnetic sounding. Index in the upper right corner corresponds to the local time the session of began electromagnetic sounding

- Computed apparent resistivity over the last two years does not show any long term variations. Only transient decreases of a few weeks duration and of a few % in amplitude are observed. V. Bragin interprets these transient decays as a result of seismic activity.

Results obtained during the workshop

Quality of the data recorded at SHA and ISA

Signals versus noise high ratios allow the analyzing of weak electric variations in spite of local noises recorded at some dipoles nearby the observation houses.

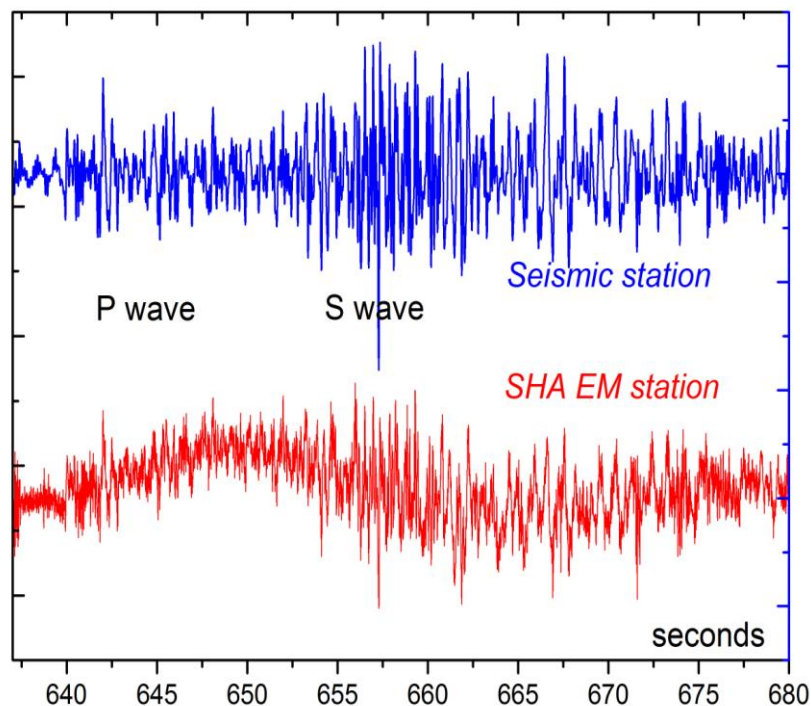
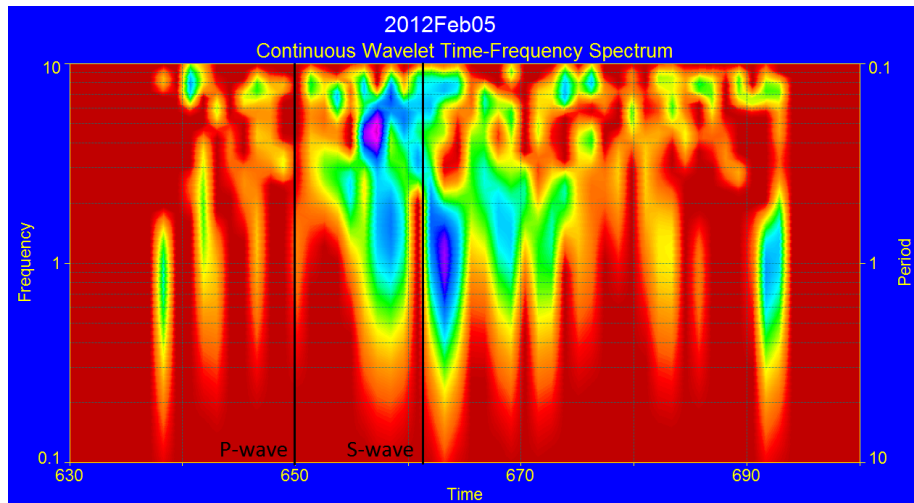
A requirement is that electric lines will be moved farther away from the houses.

A vertical 2 Hz seismometer should be added at both SHA and ISA stations in order to facilitate cross correlation between data.

Co-seismic electric signals and seismicity

As expressed before, during the observation period (Nov. 2011 to March 2014), the seismicity has remained weak with magnitude generally less than 2, except on Feb. 5, 2012 when a M 5.2 earthquake occurred at 07h10mn20sec UTC (lat: 41.59°N, long:74.76°E, Mb= 5.2 , distance to stations ~ 140 km).

For this event, co-seismic electric signal was clearly recorded at SHA station and was highlighted on the associated spectrogram



Some other signals, apparently associated with small and nearby earthquakes were also observed.

Pre-seismic electric signals and seismicity

In order to access easily to a first level data analysis, data have been averaged to 1 second and analysis has been operated manually.

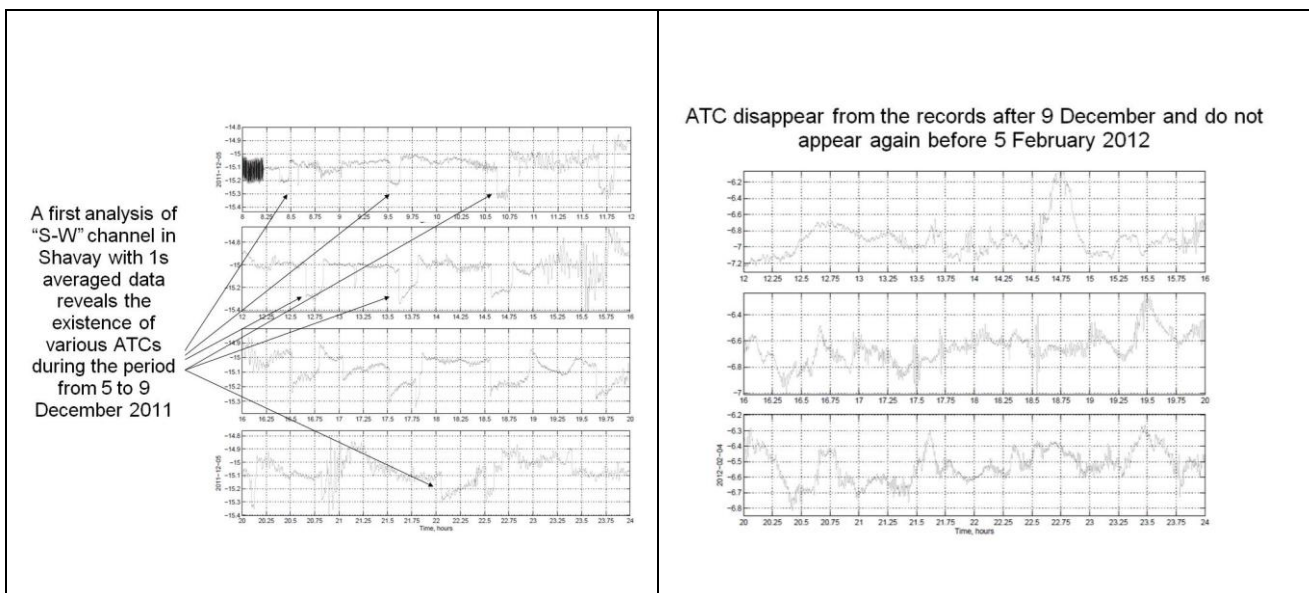
Analysis was done over three months of data based on SHA station (Nov. 13, 2011 to Feb. 5, 2012) on the best operating measuring dipole (channel 3). Some Anomalous Telluric Changes (ATC), with periods from 7 mn to half an hour were recognized.

At present, correspondences with the 5.2 earthquake (Feb. 5, 2012) as well as inter-correlation with ISA records remain for further detailed studies.

The first results obtained are encouraging, for example, the RS RAS in Bishkek current source is measurable at 40 km away with a shape compatible with that is observed for SES by VAN group.

Comparison of the ATCs identified in the single "free of local noise" operating channel at SHA station with the records of ISA station should be made taking into account the time lag between the two stations.

Operation of a multitude of measuring dipoles would be necessary for securing the identification of SES. At least two electrodes have to be redeployed at SHA and possibly at ISA for reducing the local noise due to the proximity of farms. It is also suggested to add an additional 200 m dipole at ISA.



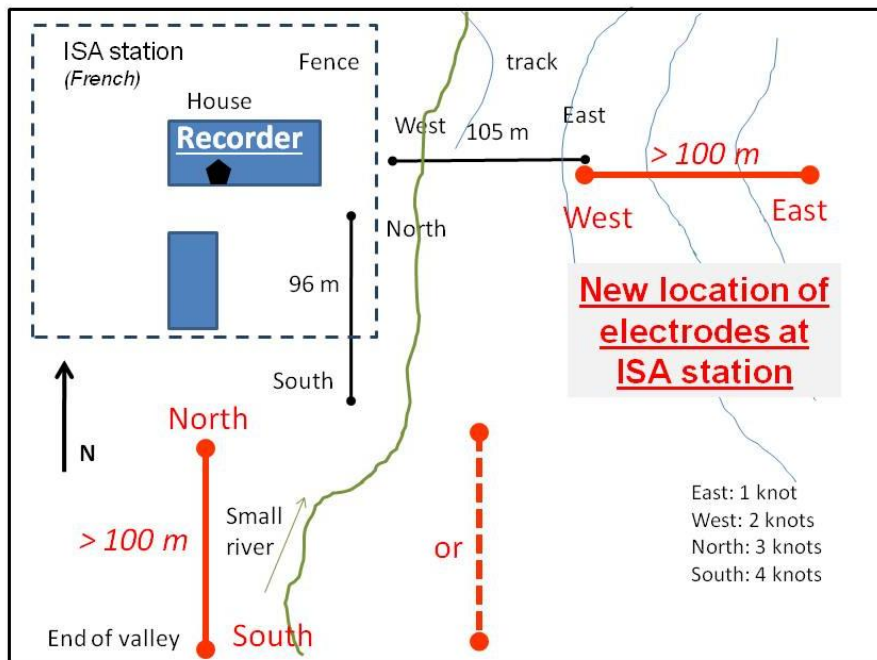
Future Tasks for upgrading EM autonomous network

Both stations could record electric variations with a larger signal versus noise ratio if the nearest electrodes buried nearby the farms are moved away. It will be the priority of the next joint EMSEV- RS RAS station in Bishkek

Updating ISA station

- *Remove West and North electrodes,*
- *Install new electrodes far away from the farm along the same directions,*
- *East electrode could be kept, South electrode could be kept,*
- *If lines have to be installed in the soil, protected cables need to be buried at 30 cm depth at least,*
- *Lines should be at least 100 m long (distance between electrodes),*

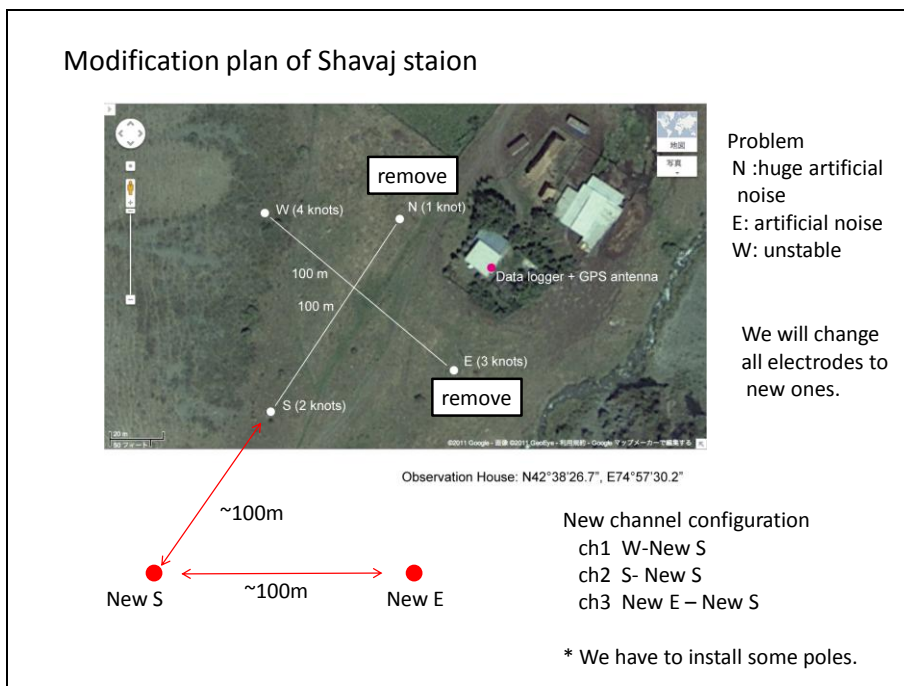
- Installation of a long dipole of between 200 m to 1 km length (ATC signals),
- Install a vertical 2 Hz seismometer on 1 channel
- Upgrading in 40 Hz?
- New electrodes should be brought from France



Line should not cross the river

Updating SHA station

- A second data logger would be imported to Bishkek
- Adding a vertical 2 Hz seismometer
- New electrodes should be brought from France



2014 Research Tasks

Different tasks have been defined for processing and analysing the first data set:

- > *Correlation between variations of electric field and of resistivity (Kr)*
- > *Seismic catalog (M>4) since 1977 ... (Gr)*
- > *Pre-seismic EM signals (Gr)*
- > *Co-seismic signals (Gr)*
- > *Identification of possible SES (Gr)*
- > *Information on tectonics, geology, etc.*
- > *(creep fault and values): historical data*
- > *GIS (Fr)*
- > *Detection of abnormal signals (Fr)*
- > *FTP site*

Timetable

June 23-29, 2014 "Geodynamic meeting", Bishkek

The SIXTH INTERNATIONAL SYMPOSIUM on "PROBLEMS OF GEODYNAMICS AND GEOECOLOGY OF INTRACONTINENTAL OROGENS" will be held in Bishkek (Kyrgyzstan) between June 23 and 29, 2014 (<http://www.gdirc.ru/en/>).

T. Nagao and J. Zlotnicki will participate to a special session on electromagnetism. Preliminary results will be presented by Kyrgyz colleagues.

During this meeting, 3 days will be devoted to joint field work with RS RAS station in Bishkek. The field campaign objectives will be to upgrade stations.

2014 EMSEV meeting in Poland

The international 2014 EMSEV meeting will be held between September 22 and 26, 2014 at Konstancin-Jeziorna 30 km south of Warsaw (Poland, <http://emsev2014.cbk.waw.pl/>).

Three presentations related to EMSEV activity with RS RAS station in Bishkek (GDIRC) are envisioned.

2015

A new meeting should be organized for a complete synthesis of observations, processing, and analyzing. Location will be defined during the next months.

More completed results should be presented at IUGG General Assembly in Prague (Czech Republic, June 22-July 2; <http://www.iugg2015prague.com/>).