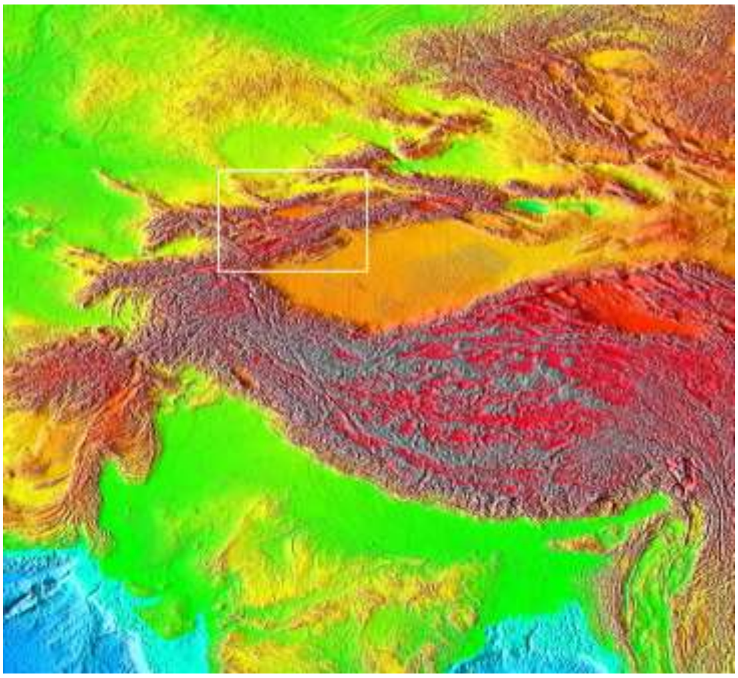
Central Asian Institute for Applied Geosciences

CAIAG

Research & Development Programme for the Years 2008/2009



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Introduction

Central Asia with its extreme surface topography constitutes the world's outstanding natural laboratory for studying the processes of intra-continental mountain building. With the highly active water cycling over its most elevated parts this region has in addition a profound influence on the atmospheric heating process, the weather, climate and water cycle in entire Asia and on a global scale.

As a consequence of these extreme dynamics in the regional geologic and atmospheric regime natural hazards, such as earthquakes, floods, landslides, glacial lake outbursts, avalanches and droughts, occur frequently in Central Asia, partly also coupled with phenomena of the global change and partly connected with and enlarged by human-induced events and technogenic activities. Such natural and natural- technogenic disasters cause loss of life and property and have a strong negative impact on the sustainable development and well- being of the societies in Central Asia.

A growing number of scientists and organisations from all over the world are starting to set up in international co-operation new multi- disciplinary observing programs with most advanced technology and are intensifying scientific research projects in order to improve the data base for relevant observations and data products and to enhance understanding and modelling of the underlying natural and human-induced processes in the region.

The Central Asian Institute for Applied Geosciences (CAIAG), http://www.caiag.kg, established in 2004 by the Government of the Kyrgyz Republic and the GeoForschungsZentrum Potsdam (GFZ), Germany, has been created with the intention to become in the medium term a competent component in this cluster of international efforts in the region, with a distinct orientation towards application aspects of the problems to be investigated.

The first CAIAG Research and Development Programme for the period 2008-2009 (R&D PROG 08/09), developed by the not yet complete staff of the institute and presented in the sequel, is focussed on three priority themes, which are fundamental for the Central Asian region:

- **I. Geodynamics and geo-hazards;**
- **II. Climate and water;**
- **III. Information and monitoring systems.**

The seven projects under these three priority themes, proposed to be carried out during the first 2 years, are primarily concerned with the acquisition of basic observational data and the performance of scientific research activities in three key areas on the Kyrgyz territory, which also will have direct or indirect implications on the environmental and socio-economic development in the neighbouring states . These are:

- the region of the Talas-Fergana and Chichkan fault system with the close-by Toktogul water reservoir, an important water supplier for irrigation of Fergana valley and Aral Sea
- the region of the Sary-Dshaz river basin and the adjacent Inylchek glacier, constituting one of the largest fresh water and hydropower resource in the area and
- the vicinity of the Issyk-Kul lake and the Bishkek city, constituting sensitive areas for earthquake hazard mitigation efforts.

All three areas are of critical importance for investigations on the probability of the occurrence of both natural and natural-technogenic disasters and are also of crucial importance for the adequate water supply of Kyrgyzstan and of adjacent regions in Uzbekistan, Kazakhstan and the Xinjiang province , for the planning of large scale geotechnical projects in the region, such as hydroelectric power station cascades, high voltage power lines, water storage reservoirs and intrastate railway and road systems, project plans with great impact on the socio-economic development of the Central Asian countries and on the living conditions and physical well-being of their population.

The CAIAG R&D Programme 08/09, as presented in this document, is considered to complement a number of project plans being formulated in the 'Global Change Observatory - Central Asia' initiative, launched recently by GFZ Potsdam and a number of German and international partner groups. A close coordination and joint execution of similar research and observation plans in both programs is indispensable and presently a subject of joint discussions.

In addition external co-operations with specialized institutions are envisaged on all three main directions of CAIAG activity during the implementation of the seven projects described in the following sections: Tomsk University, Institute of Geology and Mineralogy of Siberian RAS (Russia), National Nuclear Center (Kazakhstan); Institutes of the National Academy of Science of Kyrgyzstan and Central Asian countries, Ministries of Emergency Situations and geological institutions of Kyrgyzstan and Central Asian countries and other interested institutions in Europe and worldwide.

Bishkek, December 2007

Dr. Bolot Moldobekov

Prof. Dr. Christoph Reigber

1 Theme 1: Geodynamics and Geohazards

Theme Supervisor: A. Mikolaichuk

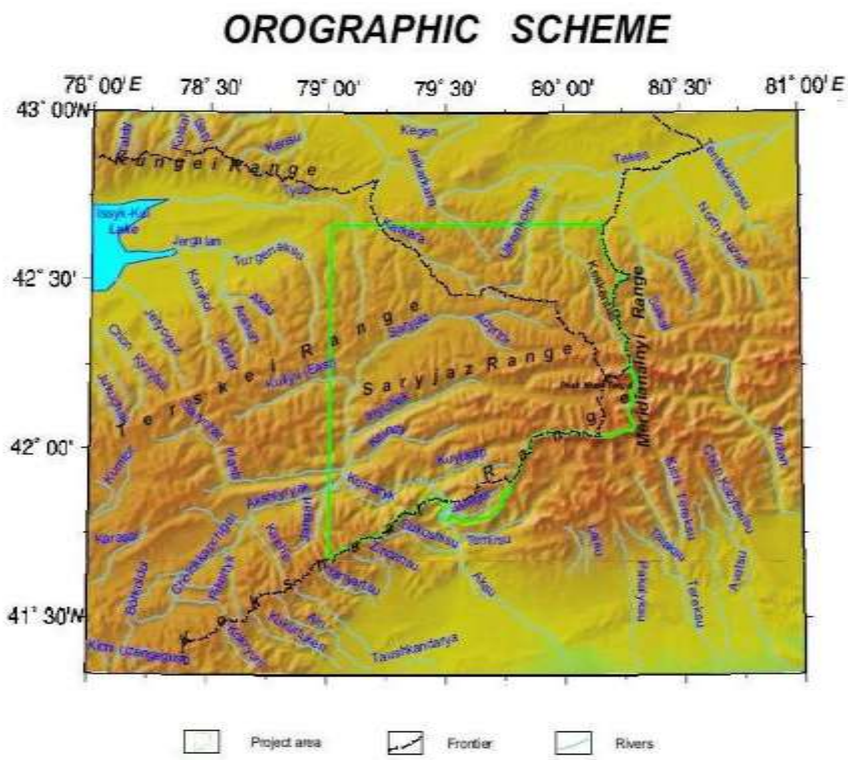
1.1 Project 1: Preparatory geological and geophysical research of the Sarydjaz river basin as the region for future construction of a hydroelectric power system

Project Leader: Z.Kalmetieva

1.1.1 Project short title

Preliminary geological and geophysical research of Sarydjaz river basin

1.1.2 Project outline



The Sarydjaz river basin has always been recognized as a very promising region for construction of hydroelectric power stations. The opportunity of co-operation with Xingjiang-Uygur Autonomous Region in developing this territory has been lately discussed in the government of the Kyrgyz Republic and mass media. At the same time the region is the least studied one in terms of geological and especially geophysical aspects, because the region is the most difficult to access in the Tien-Shan mountainous system.

Geological data in Sarydjaz river basin can be considered as rather satisfactory. At the beginning of the 60th of the last century there were discovered ore deposits. That is why geological investigations have been carried out quite regularly. But since neotectonics have not been the purpose of research, there is a significant gap in the seismo-geological description of the region. Geophysical data of the region are also not reliable enough because of insufficient density of the stationary observation network.

Within the framework of the project we plan to improve the monitoring of seismic activity and surface deformations by means of installation of new stationary observation points (3 seismic stations, 5 GNSS stations) and modernization of existing analogue seismic stations of the Kyrgyz Institute of Seismology (IS) The effectiveness of the network will significantly increase due to the appointed data interchange with the Institute of Seismology NAS KR, the Kazakh National Nuclear Centre and the Xingjiang-Uygur Seismological Bureau. China operates observation stations to the south, to the west and to the north of the research area. To characterize the geodynamic situation in the Sarydjaz region we plan to carry out joint analyses of geological and seismological data, as well as the inclusion of space geodetic and remote sensing data products.

1.1.3 Project objectives and methods

Long-term objectives:

The geographical location of the research area between Kazakhstan and China makes the installation of an effective seismic, GNSS and meteorological observation station network highly attractive. With the anticipated data exchange the newly created network will serve as a basic element for an integrated observation network covering the whole territory of Central Asia. The experimental data obtained will be used for research work on the region's geodynamics and for investigations on processes linking the region´s interior dynamics to the hazard potentials at the surface. Synthesis of geophysical and geological data will especially serve for the assessment of the regional seismic and engineering-geological hazards of the planned hydropower station construction.

Short-term objectives:

The short term goal of the project is the preliminary geological-geophysical characterisation of the Sarydjaz river watershed and the formulation of further research tasks for the region's geodynamics. For achieving this purpose it is necessary to create a geophysical observation system, to carry out additional field geological research work and to collect bibliography and archived data.

For creating a geophysical observation system it is necessary to take into account the long-term objectives of CAIAG. Digital seismic stations must be equipped with broadband sensors. This will allow investigating earthquakes of the whole region in future. Sites of seismic stations should also be equipped with high rate GNSS receivers which will allow first studies on the linkage of the regional internal dynamics to the hazard potential at the surface.

Methods:

- Geological methods (neotectonics, paleoseismology and fission-track analysis);
- Seismological methods (seismostatistics, spatio-temporal distribution, earthquake sources mechanisms, seismotectonic deformations);
- Satellite geodesy (GNSS station positioning);
- Satellite remote sensing techniques (radar, multispectral).

1.1.4 Current status and special requirements

Until the beginning of the 70th of last century the precision of earthquake epicenter definition in this area was about 50-100 km. The regional network of seismic stations of Kyrgyzstan, established after this time, is located in a narrow range of azimuths in relation to this area. Though the epicenters definition spread has decreased to 10-20 km, the configuration of the network remained still unsatisfactory. Even temporary stations, established additionally in the eastern part of Kyrgyzstan (Akshiryak, Sarydjaz and Kensu) in 1981-1985 for carrying out detailed surveillance work, did not allow to investigate such important characteristics as hypocenters depth, earthquake source mechanisms, attenuation models etc. [1]. In China, to the south of this area, seismic stations of the Xingjiang-Uygur Seismological Bureau are in operation. This network has considerably been expanded in the last years by installing new digital stations. In the past, when data exchange existed between seismologists of Kyrgyzstan and China, the earthquake epicenters were defined quite precisely [2, 3, 4]. In the last decade the data exchange was stopped, and despite the fact that the representativeness of the catalogue published by Kyrgyzstan's seismologists remains at the same level (M=2,2), the accuracy of definition of main earthquake parameters and earthquake source mechanisms in this area remains low [2,5].

The accuracy requirement of seismological data considerably increases when comparing it with other geophysical data precision, representing earth crust deformation processes. To mention here is at first the high point positioning accuracy achievable by space geodetic techniques.

GPS - measurements in the Tien-Shan region began in 1992 [6-8]. The very first results of measurements showed a high velocity gradient on the East Issyk-Kul side. In 1997-2001, the number of GPS points was considerably increased there [6]. However the most southern sub-meridian profile stretches along the Terskey ridge, covering only the northern part of the planned research area.

It is evident from the aforesaid that there is a need for expansion of the observation networks for monitoring of seismic activity and surface deformations. It is planned to establish at least three new high resolution seismic stations equipped with modern broadband digital seismographs, and to modernize two IS (Institute of Seismology) analogue seismic stations (Karakol and Kensu) by installing modern digital registrars. It is supposed to establish also 5 permanent GNSS stations, three of which will be jointly operated with the mentioned BB-seismic stations.

Remote sensing research activities in the project area have not been carried out earlier. Multi-spectral sensor data (e.g. Landsat) exist for the region and radar TerraSAR-X data products will become available early in 2008. Both data types are supposed to be used intensively in the project.

As a matter of fact studies on neotectonics of the area are narrowed down to the work of S.S.Schultz's [9] and the preliminary geological-geophysical research activities which were carried out in 1981-85 for the purpose of seismic zoning of the eastern part of Kyrgyzstan [1]. It is abundantly clear, that these studies could only outline the general tectonic zonality. At that time no techniques existed for active faults studying and isotope dating of Cenozoic complexes. Due to lack of available studies of the region and the short duration of the present project, the main emphasis will be given on the application of remote sensing methods, i.e. aero- and satellite images interpretation, and likely on the application of various radar remote sensing techniques. As the relief of the research area is strongly jagged field research work will be carried out only along authenticated routes along the sparse network. In case of need to get detailed field data helicopter transport will be needed.

1.1.5 Internal and external cooperation

The project will be carried out by employees of departments 1 and 4 of CAIAG. Close cooperation is foreseen with corresponding profile organizations in Kyrgyzstan (Institute of Seismology of National Academy of Sciences, Kyrgyz Republic), Kazakhstan (National NuclearCenter, Kazselzaschita), China (Xingjiang-Uygur Seismological Bureau) and Germany (University of Potsdam/ Institute for Geosciences, University of Jena/ Geological Institute).

Coordination with the GCO- CA Initiative

The planned project in its content has close links to the objectives of theme 3 (Earth's Surface Dynamics) of the GCO project. First of all a close coordination for installation of new monitoring stations of observations, the organisation of data acquisition, transfer and processing of data is envisaged. A first reconnaissance field trip for sites (seismic and GNSS stations) selection was already carried out with participants from GFZ´s department 1. For regional structures interpretation, and also for the creation of a three-dimensional model of the area, joint remote sensing data product analyses and interpretations are planned, as well as an exchange of data and analysis results obtained from seismic and space geodetic observations in the region.

Responsible scientists of GFZ: Dr. U. Wetzel (RS techniques)

Dr. A. Helm (GNSS technology)

Dr. W. Hanka (Seismology)

1.1.6 Working plans and necessary resources

Duration of the project - 2008-2009

2008:

- Geological field work;
- Field surveys in support of establishing a network of seismic and GNSS stations in the Sarydjaz area;
- Installation of seismic data processing and archiving software and test of operation environment;
- Pilot processing phase of seismological data (own and external ones) for creation of a catalogue of earthquake epicenters and source mechanisms;
- Support of geo- database development by defining seismic data formats and metadata content;
- Collection and introduction of existing geological and historical seismic event information into the geo- database Central Asia.

2009:

- Extended geological field work;
- Routine processing of seismic network data and analysis of regional results;
- Studying of GNSS station position time series in the region for horizontal and vertical component changes;

- Analysis of surface deformation patterns in the region as obtained from D-InSAR and Permanent Scatterer technique analyses of Envisat and TerraSAR- X radar data;
- Generalization of material on neotectonics (as obtained by field survey and remote sensing techniques);
- Characterizing of geodynamic conditions of the Sarydjaz area on the basis of the geological and geophysical joint data analysis.

Required manpower:

- department 1- 39 man-months;
- department 4 - 60 man-months.

Required observations/data and tools:

- Seismic monitoring: high resolution digital broadband station data, software for seismometric data processing, archival of data on seismicity of the Kyrgyzstan territory;
- Measurement of surface displacemens:
  - time series of GPS/GLONASS receiver 3D position information;
  - Optical and radar satellites images of the region and interpretation software;
- Field geological research, material from geological archives, field geological equipment.

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1.2 Project 2: Preparation of infrastructure for landslide phenomena research using remote sensing and ground observation methods (in a pilot area of mountain ridge of the Fergana basin, inner Tian-Shan)

Project Leaders: A. Mandychev, A.Checheibaev

1.2.1 Project short title

Landslides in the Fergana basin region and inner Tian-Shan

1.2.2 Project outline

Landslide processes are widespread in Kyrgyzstan and the adjoining Central Asian countries because of the predominance of alpine landform. Causative factors of landslides are of highly complex nature and include geomorphological, geological (including tectonic and lithologic), seismic, climatic, hydrological, hydro-geological, and engineering-geological characteristics. There are both natural and anthropogenic components in this system of factors.

Landslide processes cause severe economic damage and life losses. The study of landslides, the elaboration of landslide danger forecasts and measures of landslide hazard risk reduction have, therefore, a great importance.

Project 2 is an integrated project to be realized by departments 1, 2 and 4 of CAIAG, as well as in cooperation with GFZ Potsdam (Department 1) and the German Aerospace Center DLR (DFD). It consists of four parts:

1. Retrospective analysis and monitoring of landslide activities using methods of remote and ground-based sensing.
2. Seismologic and geophysical research.
3. Modelling landslide processes, thereby taking neotectonics, seismic activity and meteorological/climate changes into account.
4. Application of complex risk assessment techniques.

For the retrospective and current analysis of landslide activities, remote sensing data on a regional scale, i.e., satellite images from Landsat, Aster, Spot and others, using algorithms of displacement determination will be used. Additionally, it is planned to use differential radar interferometry (D-InSAR) for observing the early formation of cracks and joints and for assessing the shearing load of the Earth's crust. On a local scale, it is planned to use different methods of ground exploration (geological, geophysical, geodetic, seismic and geotechnical) and methods of landslide monitoring with GPS-sensors and extensometers. In field trips data received by remote sensing observations shall by verified on-site.

For modelling the seismic impact, the different types of focal mechanisms of seismic events will be taken into account. The base material are catalogues of earthquake epicentres, catalogues of source mechanisms, and seismograms.

Seismic observation data received from analogue stations will be analyzed and compared to the results of monitoring landslide activities. Besides, data from the newly installed digital seismic stations shall enlarge the data pool and enhance the monitoring quality.

The main goal of landslide modelling is to study the multi-factor mechanisms of landslide formation and to develop qualitative and quantitative models of functioning. It is essential to identify the key parameters determining the character of landslide development and to detect regularities of their spatial and temporal evolution.

Within the project, at least three major landslides in the region of the towns of Minkush, Gulcha and Mailisu will be investigated in detail. The field work comprises the following procedures: electrical exploration, determination of ground filtration properties, selection of ground samples for defining humidity, granulometric and mineral content and other physical and mechanical parameters, penetration radar sensing.

An innovative mathematical model of landslide development on the basis of a "large-particles method" will be worked out. Available landslide modeling programs will be utilized for this model. The elaborated mathematical landslides model will allow prognoses of their evolution, thereby differentiating between natural and anthropogenic influencing factors.

The final stage of research is the elaboration of a forecast algorithm of landslide processes development. As an output of the project, recommendations for landslide risk assessment and measures for risk reduction shall be prepared. A long-term goal is the creation of a landslide early warning system and scientific substantiation of measures on engineering - geological melioration of sliding grounds.

1.2.3 Project objectives and methods

Long-term objectives:

The main objective of this project is the preparation of an infrastructure for effective monitoring and early warning system of landslide phenomena. The prepared infrastructure shall allow to determine also the parameters of main factors, on the basis of which a modeling and prognosis of landslide developments shall be accomplished, as well as a complex appraisal of landslide process risks be initiated.

Development of regional understanding of landslide processes is supposed in it's connection with tectonic structure, geomorphologic and lithosphere structure, as well as with seismic activity, change of climatic, hydrological, hydro geological and engineering-geological conditions in landslide prone areas along the eastern ridge of the Fergana basin and inner Tian-Shan; This understanding will be based on the development of system of detailed factor appraisal of landslide risk and danger in space and time scale and monitoring of landslide phenomena and trigger factors, making the start of slope destruction (atmospheric precipitation, seismicity, deformation of surface).

A special mathematical model of landslide processes and prediction algorithm for their evolution will be worked out on its basis a justification of prognosis of a landslide process development for concrete areas will be elaborated and recommendations on reduction of landslide danger will be made. A longer term prospect is the anticipated creation of an early warning system for landslide phenomena in the Central Asian region.

Short-term objectives:

In the frame of this project systematic research activities on typical landslides, selected in the course of analyses of existing geological, engineering-geological, hydro-geological, hydrological, climatic, satellite remote sensing data and field research in the area of Minkush, Mailisu and Gulcha towns, will be started. For this research an infrastructure will be created composed of automatic stations, which will conduct measures of seismic, meteorological and geodetic quantities (e.g. GPS derived displacements) in the area of landslide risk. At the same time the formation of a landslide data base component will be started as part of the Geo Data Base GDB (project 7), containing characteristic parameters of landslides and data received from the network of automatic stations and from field measurements on landslides. On the basis of this data a preliminary prediction model of landslide functioning in connection with climatic changes, seismic activity, geological conditions and man-caused activity will be worked out. An initial scheme for an early warning on catastrophic landslide motions shall be established, as well as justification measures for the prediction of landslide process development for special areas and recommendations on landslide danger reduction be worked out.

Methods:

- Satellite and airborne remote sensing techniques (multispectral, hyperspectral, radar);
- Ground-based geodetic/geophysical/hydro-meteorological monitoring (GPS positioning, levelling, Total Station ranging, seismic broadband stations, hydro-meteorological gauging stations, meteo-stations);
- Geomorphological, geological, hydrological, hydrogeological and engineering-geological field research;
- Study of filtration capacities, granulometric and mineralogical content, physical-mechanical features of landslide soil;
- Geophysical landslide research (ground-based georadar sensing, electrical exploring, recording electromagnetic impulses);
- Modeling of spatio-temporal landslide process development, hazard and risk assessment.

1.2.4 Current status and special requirements

The today available material on landslide processes on the territory of Kyrgyzstan and the Fergana basin comprises data and analysis results collected in special reports, maps and publications. Important contributions on landslide investigations for the Kyrgyzstan area are provided in publications by Lutaeva N.G., Timofeeva T.A., Rivman A.I., Turzin V.A., Troicky A.N. (1980), Salahov I.N. (1981), Bidenko Z.S., Kojogulov D., Nikolskaya O.D., Usupaev Sh. E. (1997), Moldobekov B.D. (2000), Kleymenov V.N., Sernogoev A.K. (2000), Meleshko A.V. (2000), Ibatulin H.V., Torgoev I.A. (2003) and Erohin S.A. (2006).

These authors describe the geological landslide formation conditions including tectonic, lithologic, geomorphologic, hydro-geological, hydrologic and engineering-geological characteristics. Some of the larger landslides are described in terms of their structure, lithologic condition, physical-mechanical and mineralogical parameters and evolution history.

Some recent landslides have been monitored using advanced technology (cf. Roessner et al. 2005). Databases of landslide processes exist in the Ministry of Emergency Situations (MES) KR, the State Geological Agency, Institute of Geology NAS KR, and the GFZ Potsdam. The Institute of Physics and Rock Mechanics, the Institute of Geology NAS KR, the Agency on Geodesy and Cartography and other institutions have collected remote sensing data.

The data necessary for the initial evaluation stage (catalogues, analogue seismograms) is available in the EMSE (Experimental - methodical seismological expedition) NAS KR.

Recently the collection of facts on landslides (geological and tectonic structure, hydrological and hydro-geological conditions, climatic parameters), in the South of Kyrgyzstan and in the vicinity of the Mailisu and Gulcha towns has started. This first fact collection will allow to choose the most important objects for investigation and to make an appropriate planning for the field work. This material will already be included into data base, and in the future it will be included into the analysis of landslides process mechanism. Local GPS monitoring networks were investigated and some reconnaissance field inspections of some landslides in the Chui area realized. These preparatory activities will allow to select an optimal composition of landslide investigation methods to be used during the realization phase of the project.

Data required for a successful implementation of the project include satellite images and other data received with remote sensing techniques.

In order to conduct more detailed seismic investigations which demand the use of spectral methods, it is necessary to purchase and install at least three digital seismic stations.

For complex, automatic monitoring systems at some chosen sites it is necessary to purchase and install equipment such as extensometers, GPS-sensors, accelerometers, electromagnetic field recorders.

It is necessary to use automatic meteo-stations to investigate climatic impact factors. Penetration geo-radar is required for the study of a landslide under field conditions: its geological structure and lithological composition and the proportion of dry and water-saturated parts.

A field hydro-chemical laboratory and ion meter shall be used to define the general chemical content of the surface layers and ground waters.

Finally, financial means are necessary to carry out laboratory analysis regarding physical-mechanical parameters of ground and mineralogical ground content.

1.2.5 Internal and external co-operation

The project will be carried out in team-work by departments 1, 2 and 4 of CAIAG. Close co-operation is foreseen with the GFZ Potsdam, the Institute of Geology and the Institute of Physics and Rock Mechanics of the National Academy of Sciences of the Kyrgyz Republic (NAS KR), EMSE NAS KR, MES KR, the State Geological Agency and Osh State Institute of Engineering Research. Furthermore, collaboration is planned with the University of Liege, Belgium and scientists of the neighbouring Central Asian states of Kazakhstan, Uzbekistan and Tajikistan.

Coordination with the GCO- CA Initiative

The proposed project has links to the Global Change Observatory Central Asia (GCOCA) project sub-task 2.1.2 “Hydrological cycle and aridization: Problem of water management and soil, vegetation, land tenure, poverty reduction strategy”, and here in particular with its subsection: “Surface instability”, where it is supposed to conduct investigations of exogenous processes in the form of landslides, landslips, soil erosion, flood, mudflows. Beginning in 2008, joint activities of CAIAG-, GFZ- and DLR- researchers with participation of research groups from other Central Asian countries on landslide monitoring are being planned. Preparatory and routine work will be based on most recent satellite remote sensing data products, in-situ data of different type and historical data from various sources.

Responsible scientists of GFZ Potsdam : Dr. U. Wetzel (RS techniques)
Dr. S. Roessner (Landslide processes)

1.2.6 Work plan and required resources

Duration of the project - 2008-2009

2008:

- Collection and analysis of actual data, beginning of forming of geo-data base part on landslides;
- Reconnoitering field investigation and selection of representative areas for detailed field studies, additionally including investigations on availability of appropriate remote sensing data products;
- Creation of station network for landslide process monitoring by establishing a local network of automatic stations, which will deliver seismic, meteorological and geodetic observables (GPS);
- Development and implementation of landslide process analysis.software.

2009:

- Upgrading of monitoring network establishment and implementation of field investigations of landslides;
- Continuation of forming the geo-data base part on landslides;
- Analysis of remote sensing, seismic, seismological, climatic, geological, hydro geological data and of physical-mechanical parameters of landslides;
- Generalization of main multifactor regularity of mechanism of forming of studied landslides;
- Elaboration of a preliminary mathematical model of landslide processes;
- Justification of algorithm of landslide development, actions on risk mitigation and schemes of early warning systems.

Required manpower:

- Department 1 - 63 man-months;
- Department 2 –70 man-months;
- Department 4 –24 man-months.

Required observations/data and tools:

- Movements/displacements with high precision and frequency:
    - space geodesy: GPS/GLONASS receiver network and point positioning software package;
    - geodetic/geophysical surveying: leveling, laser distance, inclinometer, extensometer measurements;
    - satellite remote sensing: satellite SAR data at various wavelengths and data processing software(ENVI, Erdas Imagine, RockWorks etc);
- Topography/slope mapping:
    - satellite remote sensing: DEM from high resolution optical and radar satellite data (SPOT, IKONOS, ASTER, TerraSAR etc.) and processing software;
- Geology/ erosion mapping:
    - field geology: geologic structures by field surveys, radiometer of radon for detection of activity of newest faults;
    - satellite remote sensing: geomorphology and cover from high resolution optical and radar data processing;
- Soil physical and chemical properties:
    - geophysical measurements: pore water pressure by piezo-meters, geo-technical observations by geo-radar and electromagnetic field recorder;
    - geo-chemical properties. Ion meter and field laboratory, isotope external laboratory analyses;
- Seismic accelerations monitoring:
    - seismic monitoring: magnitude, intensity, peak acceleration with digital BB network stations and analysis software;
- Weather/climate impact quantities:
    - satellite geodesy: water vapor through GPS/GLONASS data analyses;
    - ground meteorology: temperature and precipitation from automatic meteo-station network.

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1.3 Project 3: Seismic micro-zonation of Bishkek city territory

Project Leader: J. Tokmulin

1.3.1 Project short title

Seismic micro-zonation of Bishkek city territory

1.3.2 Project outline

Fig. 1: An example of construction practice used in the territory of Bishkek city

In view of the fast rate of construction activity in Bishkek and rather disputable construction practice used for that (Fig. 1) the need for seismic microzonation on a modern quantitative basis exists. Kyrgyzstan is located in a high seismic activity area of Central Asia. According to the latest map of seismic zonation of Kyrgyzstan the zone with intensity number 7 takes 8 %, the zone with intensity number 8 takes 49 % and the zone with intensity number 9 takes 43 % of its territory (intensity in MSK scale). The majority of population lives in regions, cities and settlements with seismicity rate number 8-9, where human lives and physical construtions are under high level of danger connected with consequences of destructive earthquakes. Confirmation of this fact can be found in tens of destructive earthquakes which occurred in Central Asia, among them the strongest event is Keminskoe, 3.01.1911 with intensity 10-11 and the most destructive events, namely Vernenskoe, 8.06.1887 with intensity 9-10 and Tashkentskoe, 1966 with intensity 8.

Precise and objective seismic microzonation maps of city territories and big industrial centers are of high economical and social importance, because they support saver positioning of constructions and reduction of construction costs. Scientifically justified quantitative data about nature of ground shaking during the strongest earthquakes in a given area allow application of anti-seismic measures which guarantee stability of buildings and, constructions and, of course, it gives possibility to save human lives.

In modern practice of seismic microzonation of city territories, important industrial objects and hydrotechnical constructions two approaches were established.

The first approach is of an engineering-geological type which is based on qualitative, empirically established dependence of seismic intensity increment and engineering-geological attributes of different soil types. This approach is fast but it doesn´t take into account velocity characteristics of seismic cross-sections and interferometric processes. Because of these facts this approach does not provide qualitatively complete information about the nature of soil motions during the strongest possible earthquakes in a target area. It means that this approach does not give full information about maximal amplitudes of displacement, velocity, acceleration, their periods and duration of motion.

The second approach is of instrumental type which includes a method of seismic rigidity and a method of amplitude-frequency characteristics.

The method of seismic rigidity is based on empirically established dependence between intensity of the seismic impact on a building or construction, and the seismic rigidity of soil, ground water level and thickness of loose sediments. This approach being basically of an engineering-geological type is limited what concerns cross-section thickness (tens of meters) and does not allow to get full information about seismic movement of ground during a strong earthquake.

The method of amplitude-frequency type is based on the experimental study of motion of different soil types during an earthquake event. Significantly advantageous of this approach in comparison to other methods is the fact that it provides real ground motion but not a calculated one. The long recurrence period of catastrophic earthquakes (several hundreds up to thousand of years) decreases probability to get records of soil acceleration under different engineering-geological conditions during a seismic catastrophe.

For the proposed project it is planned to make use of the approach of experimentally studying of amplitude-frequency characteristics of soil oscillations, caused by strong earthquakes. For this purpose it is necessary to carry out continuous recordings of seismic motions (earthquake recordings) simultaneously at several (up to tbd) points with different soil conditions within the territory of Bishkek. The data obtained is supposed to be used for the estimation of influence of various soils types on the basic characteristics of seismic waves caused by strong earthquakes. The preliminary characteristic of soil conditions will be derived on the basis of archival material (prospecting seismology, borehole drilling, hydro-geology, etc.). A detailed study on soil types is planned to be carried out by field work using digital acquisition systems and seismometers (Nakamura method, microseisms). All this information will end up in a seismic microzonation map, where quantitative parameters of seismic influence will be shown.

New map is intended to be used as a normative document of Gosstroy KR for modelling of destructive seismic events and design of aseismic buildings and constructions.

1.3.3 Project objectives and methods

Long-term objectives:

Modern type seismic micro-zonation mapping for those cities and settlements of Kyrgyzstan and Central Asia where great need exists – for example, Almaty city [1].

Short-term objectives:

A network of seismic stations will be established for a limited time period at points in Bishkek city and surroundings. Acquisition, processing and analysis of the seismic data will be performed. Soils frequency characteristics will be studied using the method of single station measurements of noise. Parameters of possible strong earthquakes in the proximity of Bishkek will be determined. A map of soil conditions will be worked out.

Methods:

- Engineering - seismological method of estimation of quantitative parameters of soil motions, caused by strong earthquakes;
- Nakamura method for estimating the fundamental resonance frequency of a site and, if possible – where constraints on the sedimentary cover thickness exists – the S-wave velocity profile [2].

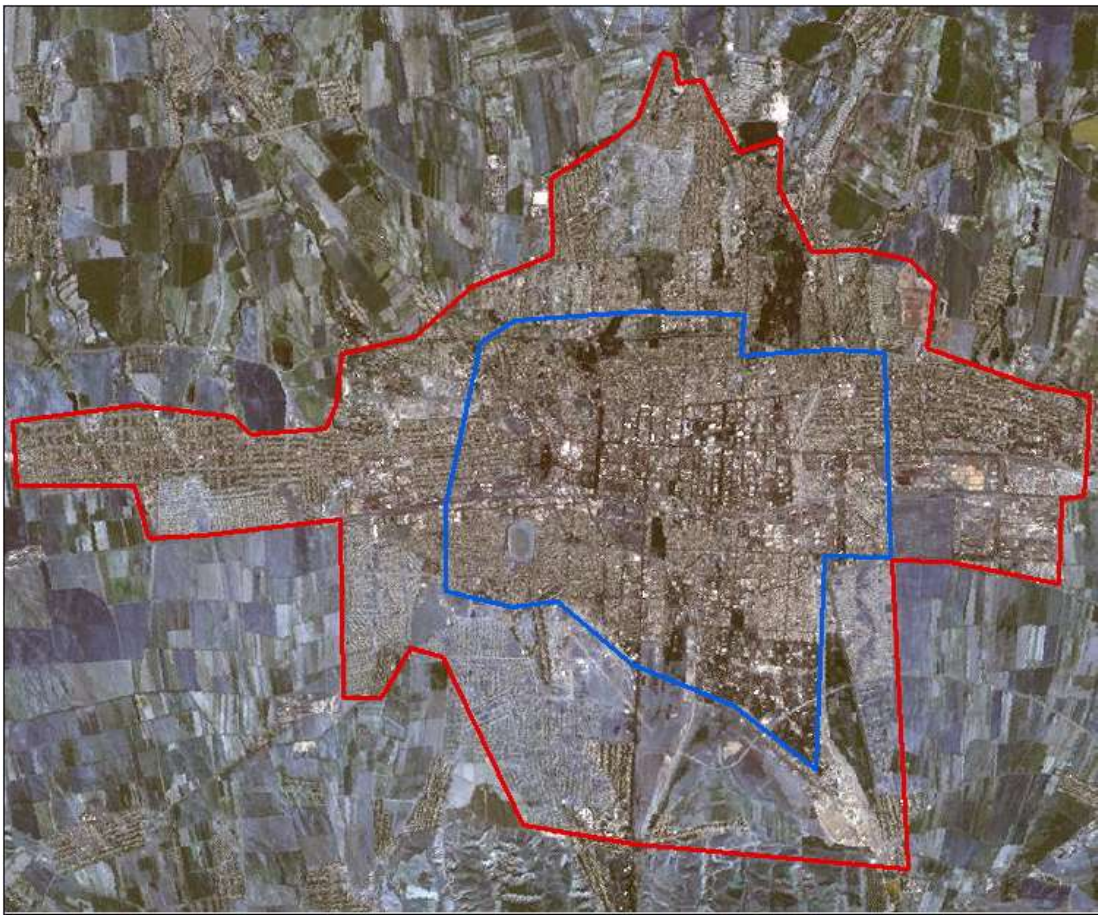

Fig.2 Satellite image of Bishkek city territory with former (blue color) and new (red color) city borders.

1.3.4 Current status and special requirements

There exists rich archival material in Kyrgyzstan, which are under the authority of the State Geo-Agency Gosstroy, the Institute of Seismology NAS KR, etc. It allows to create the basis for a good quality preliminary engineering - geological and geotechnical characterization of the target territory. Qualitative seismic microzonation of the terrirory of Bishkek city was made in 1975 and 1995 [3]. Since that time the city territory has expanded considerably (Fig.2) and the demand for quantitative estimation of seismic hazard has grown up. New hardware and software possibilities to execute microzonation on a modern level have appeared. Existing microzonation maps, which have been used for aseismic construction in Kyrghyzstan till now, aimed at dividing the territory under consideration into districts of different intensity (MSK scale). Now quantitative seismic impact parameters (amplitude-frequency characteristic, maximal acceleration) for the design and construction of buildings are used. Non- availability of digital seismic stations in Kyrgyzstan did not allow to carry out this kind of research in the past. The installation of an accelerograph and seismometer network is required for the implementation of this project.

1.3.5 Internal and external co-operation

The project will be implemented and carried out as a bilateral collaborative activity of CAIAG (departments 1& 4) and the GFZ Potsdam (department 2), for the latter as an activity within the Global Change Observatory- Central Asia program. The collection of archival material will require intensive co-operation with the following organizations in Kyrgyzstan: KyrgyzGIIZ, Gosstroy, Institute of Seismology NAS KR.and others. It is also planned to cooperate with other foreign organizations, specialized in such kind of research, such as the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy.

Coordination with the GCO- CA Initiative

As mentioned already, the proposed project of micro-zonation of the Bishkek city area will be carried out as a joint undertaking of the CAIAG Bishkek and the GFZ Potsdam within its GCO-CA program sub-task 2.2.2, entitled “Surface processes as integrative response to geodynamics” The proposed cooperative joint activity will be a major contribution to the CAIAG theme 1 and to the GCO sub-task 2.2.2 milestone “Seismic micro-zonation of urban areas”.
The intention of the project is to set-up a temporary seismic network for micro-zonation at an urban scale. Stations of this network will be used for temporary micro-array recording of noise as well as of earthquakes. Planning of the network layout, field observations, noise data analyses and the use of earthquake recordings for estimating the site responses will be done in close coordination.

Responsible scientists of GFZ Potsdam: Prof. Dr. J. Zschau (Project Supervisor)
Dr. A. Parolai (Project Leader)

1.3.6 Work plan and required resources

Duration of the project - 2008-2009

2008:

- Design of urban station network and coordination work with city authorities;
- Organizational-preparatory work for training with, assembly, transport and installation of equipment;
- Field work (few weeks) with about 15-20 stations with the purpose of seismic noise measurements, data processing;
- Temporarily (few months) installation of stations for recording earthquakes, data processing and analyses.

2009:

- Continuation earthquake recordings, data processing and analyses;
- Quantitative assessment of seismic influence and creation of map of seismic micro-zonation of Bishkek;

- Final report preparation, scientific publications.

Required manpower:

- Department 1 - 138 man-months.

Planned observations/data and tools:

- Digital seismic stations EDL equipped with Mark 1Hz sensors (15-20 units) for deriving S-velocity profiles at characteristic sites;
- Portable system of Guralp type (1 unit) for seismic noise measurements;
- Strong motion sensors;
- Digital broadband seismic stations of STS-2 type (3 units) for earthquake recording;
- Software for earthquake records spectral analysis;
- Engineering – geological and geotechnical data.

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2 Theme 2: Climate and Water

Theme Supervisor: A. Mandychev

2.1 Project 4: Studying and monitoring of the Inylchek glacier with the goal of defining the glacier balance, its morphological and dynamic characteristics and its climatologic and hydrological conditions

Project leader: R. Usubaliev

2.1.1 Project short title

Study of the Inylchek glacier

2.1.2 Project outline

The Tien Shan mountains of Kyrgyzstan are situated in a unique, anthropogenic non-influenced large glacial region which represents the main water supply reservoir of Central Asia. The glaciation regression of this area during the last decades is due to changes in the glaciers' dynamics. It leads to the activation of mudflows, floods and outbursts of glacial lakes in the high-mountain regions of Kyrgyzstan. The Merzbacher Lake, the largest glacial lake of Central Asia, is remarkable for its most regular, annually reoccurring glacier outburst floods of known glacier-dammed lakes. At this exemplary key area, the global to regional hydrological, climatologic and atmospheric circulation change impact can be studied. In the project, momentary climatologic, hydrological and essentially glaciological characteristics of the Inylchek glacier will be investigated.

An Inylchek glacier deep ice-coring project, planned for 2009 by Japanese, US and possibly German scientists and supported by CAIAG, will further enhance understanding of the present and past (about 1,000 years) global and regional climatic regime and related physical processes influencing the variability of glacier-water resources and the environment in the region.

In the process of glaciological exploration it is planned to study glacier mass changes in representational areas and the movement rate of the glacier's upper part on the basis of satellite remote radar sensing, GPS measurements and direct geodetic surveying. In the process of research it is planned to reveal climate changes influencing the glacier balance, the Inylchek river flow and outburst flow regime of the Merzbacher Lake. This information is of high importance for the shaping of the Sarydjaz river basin.

Automatic weather stations will provide information on temperature, humidity, atmosphere pressure, wind and total solar radiation, data required for the glacier balance survey

A number of permanent GPS/GLONASS stations are planned to be established for studying the outburst mechanism of the Merzbacher Lake. It is also planned to investigate the summer glacial flow of the Northern and Southern glaciers separately with the help of tracer agents such as salt or paint.

To get more liable information on the Northern Inylchek glacier, a dense local GPS station network will be re-observed a few times.

Fluctuations of the Merzbacher lake level and the lake's glacial surface displacement shall be registered by operating a GFZ developed Open-GPS receiver and using laser scanning technology and a high-resolution web-camera for monitoring permanent surface changes. Thus the mechanism of the dam outburst shall be disclosed. In the long run, an automatic system based on Open GPS technology for monitoring dangerous outbursts at high mountain lakes shall be developed.

All results obtained will be included into the GIS "Inylchek", being part of the Geodata Base Central Asia (c.f. project 6), and thus be available for modeling the dynamics regime of the Merzbacher Lake, the river Inylchek, and the Inylchek glacier.

A significant part of the project will consist of data acquisition and analysis of climatologic, hydrological and glaciological information using weather and hydro station data in the vicinity of the Inylchek glacier. This information will help to extrapolate climate and flow formation regularities in this region.

Other research activities will include snow cover surveys, observations of ice movement and its ablation. The glacier structure, its capacity, physical and mechanical characteristics will be measured using shallow-focus broadband seismic sounding or by using penetration georadar observations.

The obtained results will be an important contribution for a safe economic development of the Sarydjaz river basin, particularly in the context of the design process for the hydroelectric power system in this region and its exploitation. Moreover, the results will serve as supplementary information for the assessment and forecasting of climatic and ecological changes in the Central-Asian region.

2.1.3 Project objectives and methods

Long –term objectives:

The main objective of this project is the generation of long time series of key climatic, hydrological and glaciological parameters for the Southern and Northern Inylchek glaciers, the Inylchek river and the Merzbacher lake. For the realization of this goal monitoring of long term and short term dynamics of the Inylchek glacier system is foreseen by establishing and using a combination of remote- sensing and ground- based observing systems. Measurement time series from these regional observing systems and data products derived from analyses will become integral part of the Geo Data Base Central Asia.
On a long-term this continuous monitoring of glaciers status quantities will make it necessary to build up a small glacier observatory station in high altitude, which would allow housing of special equipment, maintenance material and people.

As a longer-term perspective the project team aims at studying and enhancing the understanding of the Inylchek glaciers regression and the changes in their dynamics in connection with the global climatic change and its influence on water resources balance in Central Asia. Special emphasis will be placed on the exposure of factors and processes, which are causing the annually repeating break of the glacial dyke of the Merzbacher lake and on the development of an integrated remote sensing and in- situ measurement system for monitoring glacier lake outbursts and associated hazards in general. In this context it is anticipated to study also the influence of short- term movements of huge water masses, as occurring during a sudden glacial lake outbursts, on the regional seismicity and tectonics

It is envisaged to extend the continuous GNSS stations data analysis to integrated water vapor (IWV) monitoring over the project area and to apply all aforementioned developed remote monitoring techniques to other high mountain regions of Central Asia.

Short-term objectives:

The most urgent short term task for achieving significant advances in the understanding of the dynamics of the Inylshek glacier system and their coupling with the regional geologic, hydrologic and atmospheric subsystems is the consequent routine acquisition of reliable long period time series of quantities needed for the glacier-, water-, atmosphere- subsystem modeling, interpretation and prediction, particularly with respect to possible geo-hazard risks and water resources development. This comprises the systematic collection of already existing and newly acquired data, that means e.g. data on ice ablation, ice movement speed, hydrological, hydro chemical and meteorologic status parameters, as obtainable from satellite remote sensing snapshot observations, repeated field measurement campaigns and observations from continuously recording and transmitting ground sensor stations in the region.

Thus, on the short term the collection and archiving of historical data and the establishment of a few automatic meteorologic, hydrologic and geodetic sensor stations and a satellite based communication system in the harsh environment of the Inytshek glacier will have first priority.

Secondly, the transmitted remote sensor data will allow to gain experience with reliability of the continuous data flow, the quality of the individual sensor data and the routine processing, archiving and dissemination of the data to external users. And thirdly, as a result of the analysis of received data a preliminary assessment of the glacial- water balance of Inylchek glacier will be initiated and a preliminary multifactor model for the coupling of the main natural factors, determining the functioning and evolution of the Inylchek glacier system will be worked out.

Methods:

- Satellite remote sensing techniques (optical multi-spectral, hyper-spectral and radar DInSAR and permanent scatterer techniques);
- Space geodetic monitoring (GNSS precise point positioning, GPS reflectometry, GPS atmospheric sounding, meteorological stations);
- Field measurements of hydrological, glaciological parameters (measurement of water discharges, snow survey, scale and thermistor setting);
- Observation of lake level changes by employing continuous radar water gauges;
- Observation of distance changes using automatic geodetic Total Station laser ranging outputs;
- Determination of ice structure, its capacity, physical and mechanical characteristics employing portable digital shallow-focus broadband, 48-channel seismic stations or penetration geo-radar;
- GIS technology for modeling processes on various spatial-temporal scales.

2.1.4 Current status and special requirements

Significant contributions to glaciers research on the territory of Kyrgyzstan have been provided by: Avsyuk G.A. (1956), Bondarev L.G. (1975), Sydykov J. (1976), Zabirov R.J. et al.(1981), Bakov E.K. (1985), Koshoev M.K. (1986), Ermolov A.A. (1990), Maksimov E.V. (1995), Osmonov A.O. (1995), Dikih A.N. et al. (2005), Kuzmichenok V.A. (2006), Usubaliev et al.(2006), Ajzen V.V. et al. (2007). Basic recent information on glaciers in Kyrgyzstan and adjacent countries can be found in the glacier catalogue of the USSR (1968-1982 years) and on the map “Modern glaciation” of scale 1:500,000, published within the series of Natural Resources of the Kyrgyz Republic, which was compiled on the basis of space photographs of the time period 1977-1980. This information has hardly, only for single glaciers, been updated.

There is sparse hydrological, glaciological and climatic information for the region of the Inylchek glacier and the Inylchek, Sarydjaz rivers. In 2005, however, this situation was improved by the expedition carried out in close co-operation between GFZ (Michajljow W., Wetzel H. & others), when new data on the Inylchek glacier balance, glacial flow, ice movement rate, character of the level fluctuations of the Merzbacher lake, and satellite maps on area of glacier with scale 1:25,000, 1:50,000 of the glacier topography were obtained. These investigations are only the beginning of an intensified research process and need to be continued over a longer time period.

Presently, a systematic collection and study of historical and actual material (climatic, hydrological, glaciological parameters, remote sensing data) for the Inylchek glacier, the Inylchek river and the Sarydjaz river is under way.. This information will allow to conduct an accurate planning of field research activities in terms of amount as well as of content. This material will be included into database and it will be further used for the analysis of the Inylchek glacier system and the Saryjaz river basin. It has been explored techniques of the GPS – indicators which will be used for the measurements of the movement rate of glacier surface.

Special requirements for the execution of this project are:

- availability of at least 3 permanently monitoring GNSS stations, equipped with meteorological sensors;
- data communication by a combination of terrestrial (radio transmission) and satellite (VSat) communication equipment;
- operation of a GFZ developed open loop GNSS receiver for scatterometry and 1 year maintenance of the system;
- At least 10 hours of helicopter flight time.

2.1.5 Internal and external co-operation

The project shall be realized by scientist and technicians of departments 2 and 4 of CAIAG in close co.-operation with scientists of department 'Geodesy and remote sensing' of the GFZ Potsdam. Researchers of the Main Directorate on Hydrometeorology within the Ministry of Emergency of the Kyrgyz Republic, of the Kyrgyz-Slavic University, of the Institute of Water Problems and scientists of the Institute of Geology NAS KR and from other Central-Asian countries will be involved in the project.

Additional foreign partners of the project will be:

- German Aerospace Centre, DFD, Oberpfaffenhofen;
- Technical University Berlin, Computer Vision and Remote Sensing, Berlin;
- Commission on Glaciology, Bavarian Academy of Sciences, Munich;
- Alfred Wegener Institute for Polar and Marine Research, Bremenhaven
- Versuchsanstalt fuer Wasserbau, Hydrologie und Glaziologie, Swiss Federal Institute of Technology, Zurich;
- University of Idaho, College of Mines and Earth Resources, Moscow USA;
- Universities of Nagoya and Kyoto, Japan.

Coordination with the GCO- CA Initiative

The proposed project has obvious connections with the Global Change Observatory Central Asia (GCOCA) project sub-task 2.1.2 "Hydrological cycle and aridization: Problem of water management and soil, vegetation, land tenure, poverty reduction strategy", and here in particular with its subsection: "Water Cycle", where the intentions for observing and modeling of different aspects of the water cycle (including glaciers) and related hazards (including GLOFs) are being described. On the short term close coordination of the CAIAG activities with the GCO-CA plans for establishing an operational hydrology monitoring system (glaciology, climatology, hydrology) in the vicinity of the Inylchek glacier system is foreseen. In addition to these infrastructure development activities, preparatory joint work for establishing mirrored data bases for the development of regional hydrological and climate models has already been started on both sides. These data bases will be filled with most recent satellite remote sensing data products, in-situ data of different type and historical data from aforementioned data sources.

Responsible scientists of GFZ Potsdam : Dr. A. Helm (Monitoring system)
Dr. U. Wetzel (RS techniques)
Dr. W. Michajljow (Glaciology)
Dr. A. Güntner (Hydrology)

2.1.6 Work plan and required resources

Duration of the project - 2008-2009

2008:

- Preparatory collection and analysis of remote sensing data, actual material on climatic, hydrological conditions and parameters of Northern and Southern Inylchek glaciers, Merzbacher Lake , Inylchek and Sarydjaz Rivers for field campaign planning purposes;

- 2008 Inylshek field campaign for (1) Installation of continuous monitoring GPS/GLONASS receiver(s), automatic meteostation(s), hydropoints and VSat communication antenna , (2) execution of a small hydrological, glaciological and GPS measurement campaign, (3) support of the geophysical exploration work in preparation of the 2009 ice core drilling project of the collaborating US, Japanese and Gernan groups;
- Support of establishment of the glacier component of the Geo-Data Base Central Asia by defining glaciologic and hydrologic data formats and metadata content;
- Introduction of existing glaciologic, hydrologic, geodetic and meteorologic information into the Geo- Data Base Central Asia.

2009:

- Continuation of collecting and analysis of satellite remote sensing, meteorological, hydrological, glaciological/geodetic data received from automatic stations and during the first field measurement campaign;
- Analysis of received data and developing a multi-factor model of interaction of climatic, hydrologic and glaciologic elements of the Inylchek glacier system;
- Complementation of the Geo-Data Base CA with climatic, hydrologic and glaciologic data, data products and modeling products of the CA region;
- Working out of GIS models for the Merzbacher lake regime and on the dynamics of the Inylchek glacier system, determining water balance of its parts;
- Elaboration on the justification and design of a preliminary early warning system for the Merzbacher lake outbursts.

Required manpower:

- Department 2 - 34 man-months;
- Department 4 – 10 man-months.

Required observations/data and tools:

- Motion detection with high precision and frequency:
  - space geodesy: GPS/GLONASS receiver network and point positioning software package, GPS reflectometry signal analysis software;
  - geodetic ground surveying: angular and distance measurements with total station and surveying equipment;
  - satellite remote sensing: satellite SAR data at various wavelengths and data processing software, DInSAR and polarimetric SAR;
- Topography/large-scale deformation mapping:
  - satellite remote sensing: DEM from high resolution optical and radar satellite data, and large- scale deformation mapping by means of DInSAR and optical imaging, processing software for different applications;
- Geology mapping:
  - field geology: geologic structures by field surveys, radiometer of radon for detection of activity of newest faults;
- Glacier body physical and chemical properties:

- observation thickness, structure, density: with penetration geo-radar system;
- chemistry of river and glacial waters : Ion meter and field laboratory;

- Hydrologic parameter measurements:
  - flow velocities in rivers by current meter measurements;
  - river discharge measurements by Q-liner system;
- Weather/climate impact quantities:
  - satellite geodesy: water vapor through GPS/GLONASS data analyses;
  - ground meteorology: temperature and precipitation from automatic meteostation network.

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2.2 Project 5: Study of runoff regularities in southern Kyrgyzstan in connection with climate change for assessing the intensity of erosive processes and precipitation transfer into the basin of the Toktogul reservoir

Project Leader: A. Shabunin

2.2.1 Project short title

Runoff in the Toktogul reservoir basin

2.2.2 Project outline

With the change of global climate the water runoff changes in the Central Asian region have achieved a particular significance. They are closely connected with the water resources supply issue and with land degradation as a result of erosion.

Within the project, all data gathered so far by meteorological stations and hydro-posts in southern Kyrgyzstan on precipitation amount, temperature, runoff and non-permanent flows shall be collected and analyzed. Detailed research is planned in the Toktogul reservoir basin, in particular field surveys on the intensity of erosive processes and the quantity of sediment runoff on the inlet of the reservoir.

For this end, an automatic meteorological station has to be set up. Satellite remote sensing data will be widely used for the project. Data from different satellites (for example, high-resolution Landsat, ASTER, CHRIST-PROBA, ALOS data or low- and high-resolution radiometric SeaWiFS, MODIS, MERIS data) will be used in order to detect the surface inflow of sediments into the Toktogul reservoir and to determine the concentration of suspended material in the top layer of the reservoir. Part of the surface inlet flow will be observed by means of spectro-radiometry. Remote sensing data will provide necessary information for modeling, such as information on snow covers, changes in the tendency of land use, sediment entries due to landslides or land surface expansion owing to glacier recession. To determine the quantity of sediment runoff flowing into the reservoir, it is planned, in addition to hydrometric investigations, to examine the tributaries and to select samples and define the transferred terrigene material. The

data of the field surveys will be used as input to modeling calculations using the following programs: DYRESM for modeling the reservoir composition, WaterGap for a hydrological model, and AGNPS for the erosion model.

To analyze temporal correlations between climatic and hydrological parameters, different methods will be used: traditional mathematical methods of periodicity determination on the one hand and more recent ones on the other hand which are based on the notion of atmosphere and hydrosphere being stochastic systems.

The intensity of erosive processes and their spatial development will be determined with the help of satellite images and air photos, including GIS. Theoretically, the principles of erosion assessment and terrigene material transfer elaboration can be applied for basins in other regions as well.

Patterns of surface flow changes related to climate change shall be rendered more precisely. This will enable to formulate guidelines for predicting and assessing erosive land degradation and measures to effectively reduce the silting of reservoirs.

2.2.3 Project objectives and methods

Long-term objectives:

The main long term objective of this project is the study of functional relationships between climatic changes, surface flow changes and intensity of erosion processes and the scale of solid flow in the Toktogul reservoir and its surroundings. This study will be based on the collection and analysis of existing material and observation derived parameters resulting from above mentioned activities.

As a result it is planned to create unified hydrological and erosive models for the Toktogul reservoir. The successful execution of the project will allow to work out recommendations for actions to be implemented in case of warning of soil erosion and siltation of the reservoir. Methodical experience on other similar objects in Kyrgyzstan and neighboring countries of the Central-Asian region will be taken into account.

Short-term objectives:

On the short term the accomplishment of climatic and hydrological investigations in the Toktogul reservoir basin is being planned, based on existing data including those from remote sensing sensors and data obtained from sporadic field observation campaigns.

The establishment of a Geo-Data Base component containing climate parameters, hydrological parameters of rivers and parameters of erosive processes. will be started

On the basis of the received data the correlations between climatic, hydrological and erosion factors will be highlighted and an assessment of the water balance of the reservoir and the balance of solid flow will be made. This will allow to work out preliminary hydrological and erosion models.

Methods:

- Satellite remote sensing SAR and radiometric systems regional data products and analysis of precipitation, temperature and river flow time series;
- Ground-based monitoring of precipitation, temperature, runoff;
- Field work and laboratory analyses (meteorological, hydro-meteorological observing, estimation of erosive processes and speed of sediment development);
- Modelling of the terrestrial water balance and balance of sediment.

2.2.4 Current status and special requirements

Climatic and hydrological investigations on the territory of Kyrgyzstan have a rather long history. Now, in the Department of Hydro-Meteorology there exist data on climatic parameters and values for the runoff of rivers for a number of decades, as obtained by hydro- and meteorology- stations on the KR territory. Particularly, there exist series of observations on climatic parameters, beginning from 1881 (Karakol, Osh), from 1885 (Naryn), acquired by meteorological stations of the KR Governmental Hydro-Meteorological Service. Over the last ten years , the network of meteorological stations has considerably been reduced, nevertheless, hydro-meteorological observations are still continued. For the territory of the Kyrgyz Republic a great part of the work being realized in the past years is outlined in: “The climate of Kyrgyz SSR”, edited by Razanceva Z.A., 1965, “Atmospheric precipitation of Kyrgyzstan”, Ponomarenko P.N., 1976, “Science applied reference book on climate of USSR”. Series 3. Edition 32. Parts I-VI., 1989, in which the vertical zoning of climate and feature of its changing by territory depending on relief, directions of atmospheric impacts are considered. In the past years contributions of Podrezov O.A. (2006) are devoted to investigations on climate.
The river flow on the territory of Kyrgyzstan was quite well studied during Soviet time (c.f. “The resources of surface water of USSR”, volume 14, 1967-1987, “Water resources of rivers of Soviet Tien Shan and methods of its calculation”, Bolshakov M.N., 1974) and in the following period with the hydro-stations of the Governmental Hydro-Meteorological Service. This Service has a data base containing the within- a-year distribution of flow and average annual flow till present time. In the past years, investigations on river flows were published by Pozmogov V.A. (1972), Alamanov S.K. (1977), Karamoldoev D. (1990), Ergeshov A.A. (1991), Sumarokova V.V. (1973) and Bajanova L.V. (2005). Less investigated are the variable seasononal flow and erosive processes. The dissertation of Choduraev T.M. was dedicated to investigations on sediment runoff for the territory of Kyrgyzstan.
Investigations on the of hydrology of the Toktogul reservoir basin in various years, were carried out by Shabunin G.D., Romanovsky V.V., Dosaev R.A. (1981), Matychenkov V.E. (2001) and by specialists of the Toktogul HES (2006), Department of Hydro-Meteorological Service (1977-2006). Results of these investigations are presented in special reports and articles.
Presently a collection and study of actual material for the Toktogul reservoir area and adjacent territories has been started by CAIAG. This material consists of climatic, hydrological, hydro chemical and erosive parameters and also data of remote sensing sensors. This preparatory study will allow a reliable planning of field measurement campaigns, in particular what concerns as the content as well as the extent of such campaigns.

The following data products and equipment are needed:

- satellite images of different spatial and temporal resolution to analyze the intensity of erosive processes;
- automatic meteorological stations and equipment for hydrometric measurements to define the amount of the sediment runoff in the Toktogul reservoir basin;
- Echo-sounder for investigations of structure and capacity of sediments of the reservoir;
- Boats for field work on the reservoir.

2.2.5 Internal and external co-operation

The project shall be realized by joint activities of departments 2, 3 and 4 and in co-operation with the Institute of Water Issues and Hydroenergetics, the Institute of Geology of the NAS KR, the Institute of Irrigation, the Main Department of Hydrometeorology of MES KR and with scientists from other Central Asian republics as well. Close working relations are planned with the GFZ Potsdam sections: section 5.4 - engineering hydrology, section 1.4 - remote sensing and section 3.3 - climate dynamics and sediments.

Coordination with the GCO- CA Initiative

The proposed project has connections with the Global Change Observatory Central Asia (GCOCA) project sub-task 2.1.2 “Hydrological cycle and aridization: Problem of water management and soil, vegetation, land-use, poverty reduction strategy”, and here in particular with its sub-theme “Water Cycle”, under which the implementation of an operational monitoring system, investigations on the dynamics of surface waters as well as the build-up of regional hydrologic and climate simulation models are being planned.

On the short term coordination of the CAIAG activities with the GCO-CA plans for establishing an operational hydrology monitoring system (climatology, hydrology) as well as an exchange of acquired field campaign observations could be envisaged.

Responsible scientists of GFZ Potsdam : Dr. U. Wetzel (RS techniques)
Dr. A. Güntner (Hydrology)
N.N. (Soil erosion)

2.2.6 Work plan and required resources

Duration of the project - 2008-2009

2008:

- First-time collection and analysis of remote sensing data and of material on climate, hydrological and erosive processes in the Toktogul reservoir basin and on adjacent territory;
- Establishment of automatic weather and GNSS station(s), acquisition of field measurements on erosive process characteristics and on intensity of transfer of sediment material during field campaign;
- Support in the creation of the Geo-Data Base through the part on meteorological, hydrological, erosive parameters;
- Analysis of acquired data and derivation of a multi-factoral model on the coupling of climatic, hydrological and erosive processes.

2009:

- Continuation of collection and analysis of remote sensing data and of meteorological, hydrological and erosive data sets;

- Repeated field campaign(s), gathering of new hydrology, erosion, GPS positioning related observations, decoding of remote sensing data under in-situ conditions;
- Routine filling of the Geo-Data Base CA with meteorological, hydrological, erosive process data and data products as well as with the related metadata;
- Working out of preliminary hydrological and erosive models, assessment of the water and sediment balance of the Toktogul reservoir.

Required manpower:

- Department 2 - 50 man-months;
- Department 3 - tbd man-months;
- Department 4 – 10 man-months.

Required observations/data and tools:

- Hydrologic observation parameters:
  - Terrain characteristics: land use, topography, drainage pattern, erosive forms and their area;
  - satellite remote sensing: high-resolution satellite optical and radar sensor data and data processing software;
  - space geodesy: GPS regional network campaign observations, reservoir surface level observations by GPS reflectometry, signal analysis software;
  - geodetic ground surveying: survey results with total station and classical surveying equipment;
  - hydrologic observations: LOG_aDSLP-System for echo-location of bottom of reservoir;
- Areal extent of and flow of water:
  - satellite remote sensing: high resolution optical and radar satellite data products, processing software for different applications;
  - current meter measurements: determination of velocities in rivers;
  - discharge measurements: Qliner - river discharge measurement system;
- Reservoir and river chemical properties:
  - Ion meter measurements : Ion meter and field laboratory;
- Weather/climate status parameters:
  - ground meteorology: temperature and precipitation from automatic meteo-station network;
  - satellite geodesy: water vapor distribution in low atmosphere by GPS data analyses.

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3 Theme 3: Information and Monitoring Systems

Theme Supervisor: A. Zubovich

3.1 Project 6: Geo- Data Base of Central Asia

Project Leader: M. Jantaev

3.1.1 Project short title

Geo-data base of Central Asia

3.1.2 Project outline

The Geo -Data Base (GDB) of Central Asia shall become the basic data and information system of CAIAG.. The main purpose of GDB is to store data in the form of bit-mapped and digitized topographic and thematic maps, satellite images and aero-photos, radar scenes and different geophysical and geodetic data (e.g. topographic, gravimetric, electro- magnetic, seismic, meteorological, remote sensing data and derived data products) in the form of binary records or tables.

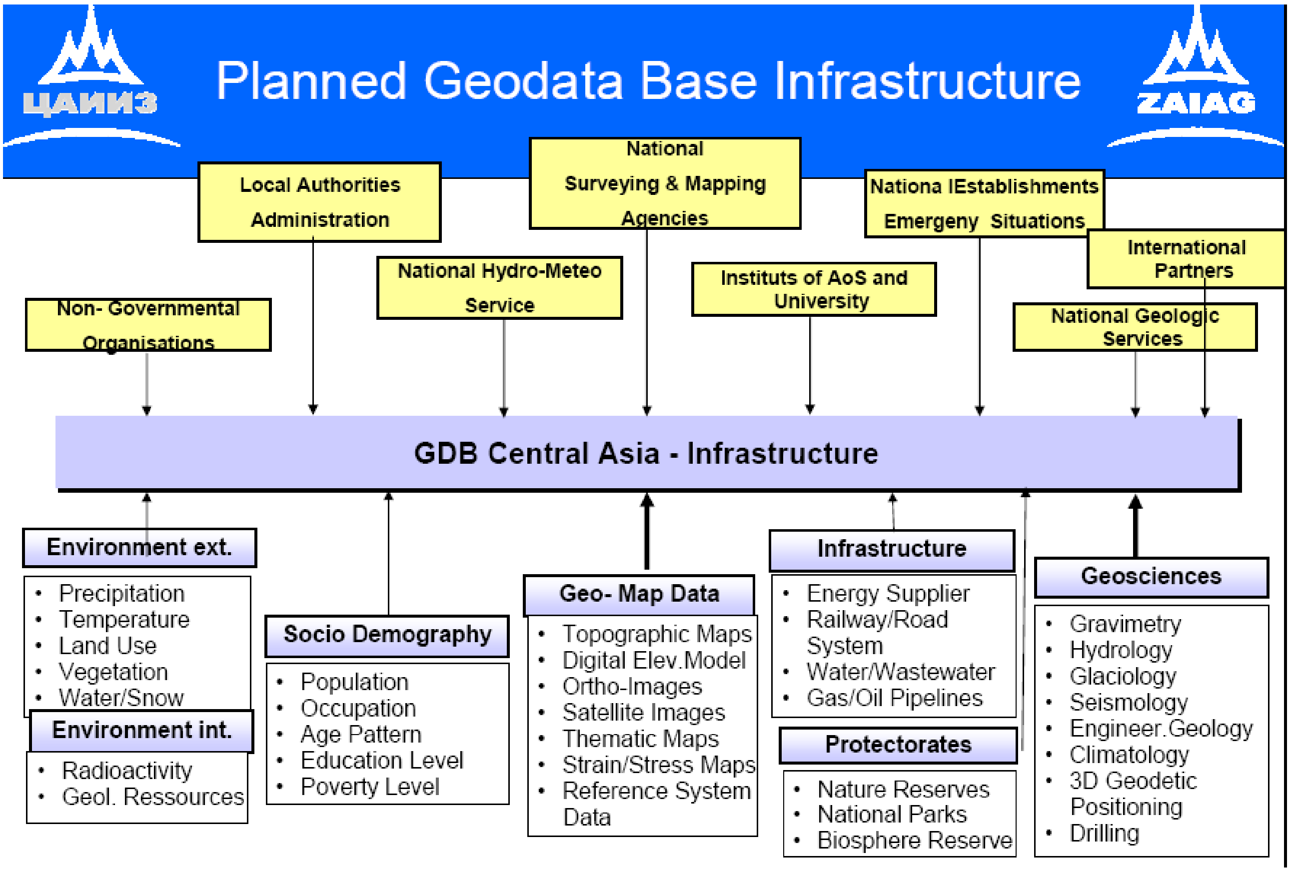
First step is to define the structure of the data base creation. For this experience of other institutions working in the same area will be acquired and analyzed. Input data for the GDB may come from different sources: data archives, external Internet sources, automatic monitoring systems of CAIAG and other institutes of Central Asia. Input and management of this data will be supported with a data base manager system (DBMS). A major requirement for it is the multi-user-oriented handling of vast amounts of data in a wide data type variety. Authorized access to the data base, information search and visualization, partly operating in real-time mode, will be performed using advanced web technologies. Besides attributive information, the GDB will contain metadata describing this information. Altogether, the GDB will become a basis for analysing and interpreting of information about endogenous and exogenous processes in the Earth system, with special emphasis on natural hazards and early warning in the Central Asia region.

3.1.3 Project objectives and methods

Long-term objectives:

One of the basic objectives of this project is the establishment of a geodata base for Central Asia, with emphasis on natural hazards. GDB will involve regional as well as detailed local data for specific areas, which are accumulated from the different sources (fig.1) while the data base is being developed. The topographic basis will be determined for different spatial scales. This will allow to enter data of all spatial levels. At first a detailed spatial data base (for regions and communities) will be created for serving the projects already being implemented in the CAIAG programme. Besides spatial data, the GDB will contain geophysical and geodetic observational products for various levels of processing (from level 0 - raw data up to level 4 - hierarchy top processing), acquired from monitoring network stations or external data sources, such as global data centres.

The GDB Central Asia should become the focal point for the data flow from ground monitoring systems, external data archives and CAIAG co-laborating partners. On the other hand the data base should be the only interface for access to CAIAG data and data products for the scientific user community. The outer components of the GDB CA will be the data product upload directory (for the data product upload), the Clearing House (web-based product retrieval) and the Data Warehouse (ftp-based product download). The tasks of the GDB CA are data archiving and long-term storage (data centre functions),running a catalogue system for product retrieval and download, monitoring and reporting about status of input/output products and the user management according to a predefined data policy (information system functions).



For storage of information in different formats, a relational data base system with dispersed data support will be used. During the establishment of the GDB it is planned to create in parallel the metadata for the different types of information (for identification and search), the Web interface (for navigation, searching and loading of necessary data), and special programs allowing input of initial data and preliminary processing in automatic mode, and also its transformation into the formats of processing applications.

Short-term objectives:

In **2008** we plan to define and install the data base manager system, necessary for the project tasks. Under this DBMS the architecture of the Geo-Data Base Central Asia will be designed. The data base will be adjusted and tested for the required configuration. In this first year we are going to organize access to the GDB for local use from CAIAG network. Some spatial data sets which are available at the institute at the moment will be uploaded to the system.

In **2009** the development of GDB will be continued. We are going to carry out a client-server and multi-user organization of GDB and will start to install an external user access. The local geodata base should be migrated into a client-server GDB and new data will replenish it. Also the access to geodata via Internet server should be organized.

Methods:

- Relational data base with spatial data support;
- Building of data base structure on the basis of conceptual objects, class objects and relations between them;
- Unique identification of data units and search organizations on the basis of hierarchical structured metadata;
- Spatial and network analysis of geodata objects;
- Spatial and object geocoding.

3.1.4 Current status and special requirements

Currently, there exists no geo-data base in Central Asia which would comply with the aforementioned objectives. There exist only some isolated attempts, which are related to separate elements of a GDB type system and these experiences will be used during the establishment of the GDB CA. Experiences on data base creation of different European organizations, including GFZ, DLR (Germany) will be used also. There is a significant amount of archive information available at agencies and organizations of Central Asia and it should be used as input to the GDB after systematization and digitalization.

The basic requirements for the GDB development are:

- Data support in different formats (dispersive and non-dispersive) providing the integrity of interrelated data;
- High safety of data and efficient service for users;
- Scalability (with stable operating quality under conditions of increasing data amount);
- Quick switchover to other hardware and software platforms;
-
- Multi-user access to geodata according to the rights which allow competent operations with GDB;
-
- Comfortable interface to access data, providing means of navigation in GDB CA catalogues, quick search using key words or spatio-temporal inquiries.

Basic parts of GDB:

Hardware:

- GDB Server for geo data storage and management;
- Communication channels for information transmission from monitoring networks into GDB;
- Internet Server for external users of GDB;

- Network Infrastructure, to which GDB Server and Internet Server are connected;
- Client computers

Software:

- Relational data base manager system with spatial data support;
- Devices to create and support Internet portal for external access to data of GDB;
- Tools to elaborate the structure of GDB, input, support of the actuality and unity of dispersive data connection;
- Different programs and utilities

Data:

- Maps in raster and vector forms
- Remote sensing data
- Geodetic and geophysical data (climatic, seismic and other measurements)
- Publications (articles, reports, methods etc.)
- Metadata for unique identification of data units and search.

3.1.5 Internal and external cooperation

The project will be realized by staff of department 4 in co-operation with specialists from departments 1, 2, and 3 of CAIAG and consulting support of specialists of GFZ and other organizations. It is planned to include into the GDB step by step the data received from the Ministry of Emergency Situations of KR, the State Cartography Service, different institutes and organizations of Central Asia. After installation of the stations of the CAIAG monitoring system and filling the GDB the data exchange with other Central Asian and international institutes will become possible.

3.1.6 Work plan and required resources

Duration of the project - 2008-2009

2008:

- Design of the Central Asian Geo-Data Base architecture.
- Acquisition, installation and debugging of the data base manager system.
- Adjustment and testing of data base for required configuration.
- Development of the local GDB available from CAIAG network for the spatial data, existing at the institute (topographic and thematic maps, remote sensing data).

2009:

- Organization of the client-server multi-user GDB, installation of external user access.
- Migration of local geodata base into the new GDB, replenishment by new data.
- Organization of data input from monitoring networks.
- Extension of the functional opportunities of GDB, in particular, access to geodata via Internet server.

Required Manpower:

- Department 4 - 80 man-months;
- Department 1, 2 and students– 40 man-months.

Required observations/data and tools:

- Software:
  - Data Base Management System DBMS – Oracle 10g, MySQL, or PostgreSQL;
  - Internet server – ArcIMS or UMN MapServer;
  - Designer tool – Developer Kit, ArcObject;
  - Other applications and utilities.
- Movements/displacements:
  - Space geodesy: GNSS network data and point positioning software for GPS and GLONASS;
  - Remote sensing and SAR data at various wavelengths as well as processing software (ENVI, Imagine, RockWorks and etc);
- Topography and remote sensing:
  - Optical and radar DEM data of high resolution (SPOT, IKONOS, ASTER, TerraSAR etc.) and processing software;
  - Topographic and thematic maps of different scale;
- Geophysical and geochemical data:
  - geochemical soil property;
  - seismic monitoring: magnitude, intensity, peak acceleration with digital BB network stations and analysis software;
- Weather/climate impact quantities:
  - meteorological status parameters: temperature, pressure, humidity and precipitation from stations and services.

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3.2 Project 7: Assembly of a monitoring system for dangerous phenomena in a quasi-real-time mode

Project Leader: A. Shakirov

3.2.1 Project short title

Construction of quasi-real-time monitoring system

3.2.2 Project outline

The Tien Shan, one of the world´s largest intracontinental mountain belts, is known for its high tectonic activity. Earthquakes, landslides, avalanches and mudflows are inherent phenomena of this tectonic activity and high mountain relief leading quite often to catastrophic events with severe consequences for regional infrastructure and the living conditions of people. Therefore, creating monitoring networks tracing these dangerous phenomena is most vital for the countries located in the region.

The primary objective of this project is the creation of a prototype monitoring system, through which the implemented technology, the interaction of its different elements, requirements for uninterrupted operation and requirements for the development of a subsequent operational monitoring and early warning system could be studied. The prototype system is planned to be established and tested under normal field conditions as they exist in Central Asia. Of course, the mountainous relief and the absence of advanced communication systems in this part of the world considerably complicate the implementation and operation of such a system

Complexity, but also value of the information is significantly increased, if collection at and transfer of data from the observation sites to a central location is performed in real (or close to real) time mode. Under these conditions the only chance is communication satellite channel use. Nowadays, information transfer via satellites becomes more and more available and can

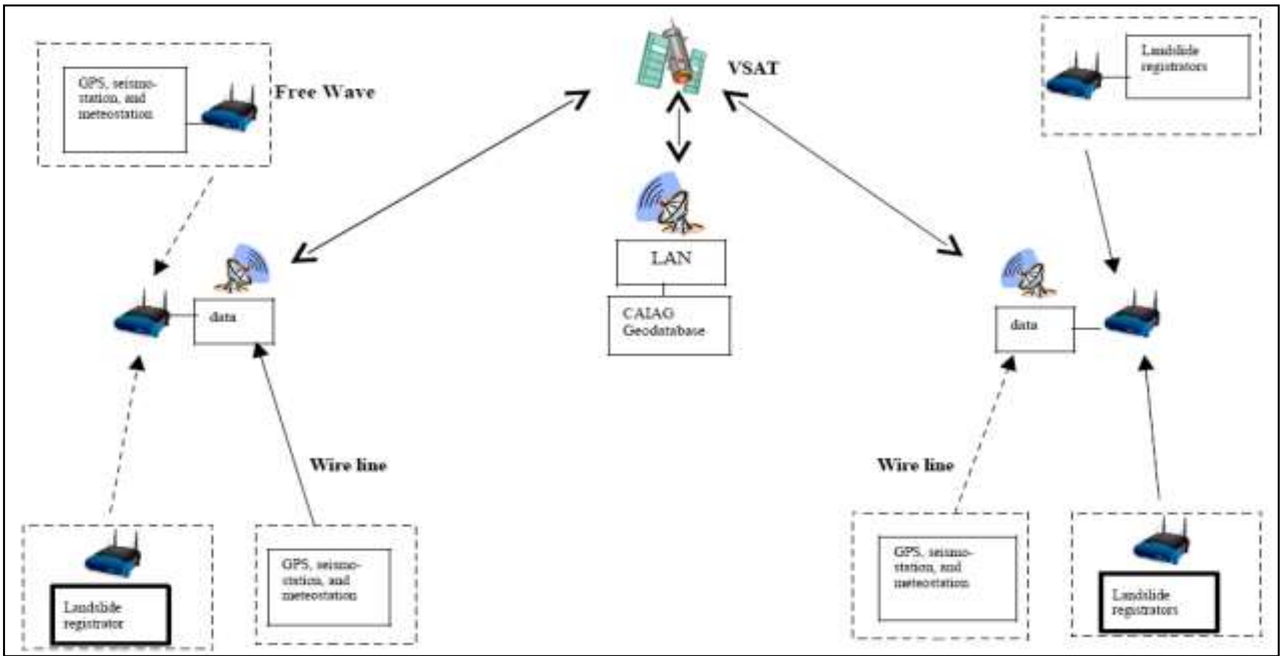

Fig.1. Possible scheme of communication for quasi-real time monitoring system.

compete with other communication means. Most attractive for our project is the installation of complex monitoring stations, which have connection with a central data collection center via VSAT terminals (fig.1). Such stations can consist of GNSS receivers, seismic, meteo-sensors, equipment for landslide condition tracking, chemical analysis devices and combinations thereof. For the connection of recording devices to a VSAT terminal, wire connections or radio links can be used depending on their remoteness.

During the implementation phase of the project it will be necessary to choose the most economic scheme of data transfer from the VSAT terminals to the data collection center at the CAIAG. One possible solution for solving the task is installation of a basic VSAT- hub station directly connected to the CAIAG local information network and database. The other option is usage of the VSAT hub of one of the commercial providers of satellite connection. In this case data will be transferred to CAIAG via Internet, or through a supplementary VSAT terminal set up at the institute´s observation platform.

3.2.3 Project objectives and methods

Long-term objective:

Central Asia is one of the most active regions on Earth. Because tectonic processes happen here faster than in other regions, Central Asia, in particular Tien-Shan can serve as a natural laboratory for checking different theories of modern orogeny and testing methods of disaster events prevention. It can be assumed that a regional monitoring system, operating in a quasi-real-time mode for the observation of natural hazards, will be built-up in this region in the next future. The creation of such a system will need efforts in the following two directions. First, the inter-connection of separate local monitoring systems already operating at some time from now in Central Asian countries will need to be realized. This task, despite large organizational work will demand availability of high speed communication links, required for information exchange between local data collection centers. The second task is the development of a CAIAG continuous monitoring network. The existing observation networks usually cover the central parts of the countries. Due to absence of modern communications means, the remote areas are being uncovered. This project initiates the creation of a modern monitoring system with regard to natural hazards relevant to the Central Asian region. The information about endogenous and exogenous processes collected in the database will be combined with remote sensing data, processed and visualized on the basis of GIS tools and should finally form the basis for an early warning system supporting for decision-making agencies.

Short-term objective:

In **2008** the necessary equipment has to be specified and purchased, the necessary licenses for import of radio devices and use of radio frequencies have to be obtained. It is planned to first install and test the individual devices and combined smart station sets on the CAIAG premises under laboratory conditions. Also data communication via a VSAT station will first be tested locally at CAIAG and places for installation of a smart station will be prepared. It is planned to install 1-2 smart stations in the field in 2008.

In **2009** site preparations and station installation in bunkers will be continued. The data-acquisition equipment should be connected to VSAT terminal station, and satellite channel and data transfer to collecting center have to be tested under real operational conditions. For devices remote from VSAT terminal radio-modem links will be established and checked. And as a final result the data flow from the monitoring system into the Central Asia Geo-Data Base need to be checked out.

3.2.4 Current status and special requirements

Currently, there are no modern systems for real-time monitoring in the Central Asian countries existing for recording high rate non-uniformly scaled geophysical and geodetic information. There exists some experience in establishing separate seismological networks in some of these countries.

For the initial development of the described prototype monitoring system, it is necessary to set up 3 sets of smart stations, including GNSS receiver, seismic and meteorological sensors and power plus data management equipment , VSAT terminals, two radio-modems of FreeWave type including antennas.

Separate VSAT-terminal (or Hub) for installation on the CAIAG roof platform and satellite channel rent is required. One of the major requirements of the project is protection of the equipment against vandalism.

3.2.5 Internal and external cooperation

The project will be carried out by staff of department 4 of CAIAG, in close co-operation with department 1 and with GFZ Potsdam, Germany. In addition work is planned to be done in cooperation with the organizations in the Kyrghyz Republic (Experimentally - methodical seismological expedition, Scientific station of the Russian Academy of Science), in Kazakhstan (Institute of Seismology and Seismological Experimental-Methodical Expedition, the data center of the National Nuclear Center), Tajikistan (Institute of Seismic Building and Seismology), China (the Seismological Bureau of Xinjiang-Uigur autonomous region). Joint agreements with commercial enterprises are not excluded.

3.2.6 Work plan and required resources

Duration of the project - 2008-2009

2008:

- Specification and acquisition of necessary equipment;
- Obtainment of necessary licenses for import of radio devices and use of radio frequencies, execution of documents for stations lots, etc.;
- Assembly and testing of devices and smart station as a whole under laboratory conditions (on the CAIAG premises);
- Testing of satellite channel for data transfer with VSAT station;
- Site preparation and bunker making in order to install the smart stations;
- Installation of at least 1-2 smart stations under field conditions.

2009:

- Continue of the site preparation and installation of stations in bunkers;
- Connection of data-acquisition equipment to VSAT terminals;
- The testing of satellite channel and data transfer to collecting center in real conditions;

- Installation and checking of radio-modem links for devices remote from VSAT terminal;
- Data input into the Geo-Data Base of Central Asia.

Required manpower:

- Department 4 - 48 man-months;
- Department 1 - 4 man-months.

Required observations/data and tools:

- Positional monitoring network:
  - Space geodesy and GNSS meteorology: GPS/GLONASS receiver network stations, data management system;
- Seismic monitoring network:
  - Ground seismology: system of broad-band seismo-stations, data management system;
- Hydro-meteorologic monitoring network:
  - meteorology: meteo stations system and data management system;
- Communications:
  - VSAT terminals for smart stations;
  - VSAT central or terminal station for installation in CAIAG;
  - Radio-modems with antennas;
- Power supply, energy management system;
- Lease of a hauler for delivery of equipment, bunker construction and other shipment, lease of an excavator for preparation of bunker pit;
- Providing the safety of stations.

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