**Proposals INSU**
**Solid Earth**

**Project Call 2016**

# Scientific & technical applications

**National Services of Observation (SNO)**

| Seismology | Magnetism | Volcanism | Slope instabilities | Geodesy & Gravimetry |
|---|---|---|---|---|
| | | | X | |

**SNO Tab title (if there is any) : OMIV**

**Main applicant** *(Family name, First name, position)*:
Grasso jean-robert, Physicien cEX ISterre, OSUG Grenoble

**Involved observatories** (please indicate the person in charge): EOST (Malet J-P)
Isterre (A. Helmstetter, G. Bievre, M. Radiguet), OCA-geoazur (T. Lebourg) OSU Theta-Besannçon (C. Bertrand),

**Other involved structures** (please indicate the person in charge):
UMR 1114 EMMAH, Avignon (V. Marc)

**Management committee if any** (please indicate the contact):
not yet

**Summary of the tab** (15 lines):

The Multidisciplinary Observations of Versant Instabilities, (SNO-OMIV) monitors four on-going landslides which are représentative of the mecanisms involved in the French Alps (hard/soft rock, slow/fast moving slope). On each sites, the SNO-OMIV provides continuous open access recording of the landslide kinematics, its seismic response, and the hydro-geochemistry characteristics of the slope. These data sets are unique example worldwide. The SNO-OMIV, SNO-INSU label for OMIV, since 2007, is labeled for

- 4 sites in the French Alps (Avignonet, La Clapiére, Séchilienne, Super-Sauze)
- 3 observables on each site : i) The displacement kinematics using tilt meters, extensometers ,GPS sensors, satellite imaging; ii) the landslide seismic patterns (endogenous seismic signals (micro-earthquakes rock falls, exotic signals) and landslide response to regional earthquakes) ; iii) The hydraulic response to weathering forcing (hydro-geochemistry measurements)

It corresponds to 13-GPS, 60 Tachometric benchmarks, 50_1C and 14-3C seismic sensors.
All data are open accessible through a single http://omiv.osug.fr/data.html portal

**Number of involved people (give the percentage in equiv.-researcher equiv.-engineer) for this tab**
**(you could provide an excel file for such update: please fill it carefully in close relation with the PI of the SNO; activity should be described in details through 2-3 explicit sentences)**

Physicist/Assistant Physicist:

Physicist/Assistant Physicist:

| Family Name | First Name | Activity | Percentage in full time equivalence |
|---|---|---|---|
| Grasso | jean-robert | Phys-Isterre / management and seismic data access | 30% |
| Radiguet | Mathilde | Phys- Adjt Isterre / seismic signals analysis | 30% |

Researcher or (Assistant) Professor:

| Family Name | First Name | Activity | Percentage in full time equivalence |
|---|---|---|---|
| Bertrand | C. | MC Chrono-Environnement, Besancon/Scientist in charge of Hydro-geochemistry (hard – rock slides) | 25% |
| Biévre | G. | MC Isterre /Scientist in charge of Avignonet site | 20% |
| Helmstetter | A. | CR Isterre / Scientist in charge of Séchilienne site | 50% |
| Lebourg | T. | MC GéoAzur / SNO-coresponsability | 15% |
| Malet | J.-P. | CR EOST / Scientist in charge of Super Sauze site | 30% |
| Marc | V. | MC EMMAH, avignon / Scientist in charge of Hydro-geochemistry (soft –rock slides) | 20% |
| Remaître | A. | MC Geogr. / Data analysis | 10% |
| Tric | E. | MC GéoAzur / Scientist in charge of La Clapiére site | 15% |
| | | | |

Engineer (Research structure/Universities):

| Family Name | First Name | Activity | Percentage in full time equivalence |
|---|---|---|---|
| Regent | B | IE Besançon/ E contribution to hydro- | 15% |

| | | | |
|---|---|---|---|
| | | geochm. analysis | |
| Ullrich | P | AI EOST / IPGS Engineer in charge of Super Sauze site and in charge of GPS data acquisition and validation for the 4 sites | 50% |
| Vial | B | AI isterre/ Engineer in charge of Avignonet and Séchilienne sites | 25% |
| Vidal | M | IE GeoAzur Engineer in charge of La Clapiere site | 50% |
| | | | |

Number of new necessary permanent human resources (related to this tab) needed in person.month while mentioning if this is a new position or a renewal as well as the time table for such hiring (to be high-lighted in the presentation):

| **Family Name** | **First Name** | **Activity and position (new or replacement)** | **Percentage in full time equivalence** |
|---|---|---|---|
| XX | x | IE, Geophyscist Engineer in charge of seismic data acquisition, validation and diffusion for the 4 sites | 100% |
| YY | y | IE, Engineer in charge of GPS data acquisition, validation and diffusion for the 4 sites | 50% |
| ZZ | z | IE, Engineer in charge of Hydro-geochemistry data acquisition, validation and diffusion for the 4 sites | 25% |
| | | | |

Number of necessary temporary human resources (related to this tab) needed in person.month while mentioning the financial source (to be high-lighted in the presentation):

| **Family Name** | **First Name** | **Activity** | **Percentage in full time equivalence** |
|---|---|---|---|
| Janex | G. | IE-CDD-insu/ Engineer in charge of seismic data acquisition and validation and diffusion for the 4 sites | 100% |
| | | | |

In case of new demands, please provide in annexes an overview of the activities of

people in place and the expected activities and milestones for the new person explaining why it should be permanent or temporary.

## Summary of the Global financial plan of the Project

Please provide the total amount of funds related to this project and requested to different sources (other national calls, specific equipment, and internal support of different organisms or laboratories …), European and international funds.

***Obtained and requested funds to ST-INSU as a SNO***

| | **2014 (obtained)** | **2015 (obtained)** | **2016 (requested)** | **2017 (anticipated)** |
|---|---|---|---|---|
| **Equipment** | 20 kE | 20 kE | 25 kE | 22 kE |
| **Consumables** | 17 kE | 17 kE | 15 kE | 18 kE |
| **Temporary human resources** | 43 kE | 43 kE | 41 kE | 41 kE |
| **Travels** | 5 kE | 5 kE | 4 kE | 4 kE |
| **Total** | 85 kE | 85 kE | 85 kE | 85 kE |

***Obtained and requested funds from instituion EOST***

| | **2014 (obtained)** | **2015 (obtained)** | **2016 (requested)** | **2017 (anticipated)** |
|---|---|---|---|---|
| **Equipment** | 4 kE | 4 kE | 4 kE | 4 kE |
| **Consumables** | 4 kE | 4 kE | 4 kE | 4 kE |
| **Temporary human resources** | | | | |
| **Travels** | | | | |
| **Total** | 8 kE | 8 kE | 8 kE | 8 kE |

***Obtained and requested funds from instituion OCA***

| | **2014 (obtained)** | **2015 (obtained)** | **2016 (requested)** | **2017 (anticipated)** |
|---|---|---|---|---|
| **Equipment** | 12 kE | 4 kE | 4 kE + **(12 kE obtained)** | 4 kE |
| **Consumables** | | | | |
| **Temporary human resources** | | | | |
| **Travels** | | | | |
| **Total** | 12 kE | 4 kE | 16 kE | 4 kE |

***Obtained and requested funds from instituion OSUG***

| | **2014 (obtained)** | **2015 (obtained)** | **2016 (requested)** | **2017 (anticipated)** |
|---|---|---|---|---|
| **Equipment** | 4 kE | 7 kE | 10 kE | 8 kE |

| | | | | |
|---|---|---|---|---|
| **Consumables** | 4 kE | 7 kE | 4 kE | 6 kE |
| **Temporary human resources** | | 14.5 kE (6mth AI) | | |
| **Travels** | | | | |
| **Total** | 8 kE | 28.5 kE | 14 kE | 14 kE |

***Obtained and requested funds from instituion OSU-THETA***

| | **2014 (obtained)** | **2015 (obtained)** | **2016 (requested)** | **2017 (anticipated)** |
|---|---|---|---|---|
| **Equipment** | | | | |
| **Consumables** | | | | |
| **Temporary human resources** | | | | |
| **Travels** | 0.8 kE | 0.8 kE | 0.8 kE | 0.8 kE |
| **Total** | 0.8 kE | 0.8 kE | 0.8 kE | 0.8 kE |

***Other financial supports (obtained and/or requested : please specify) in connection with this tab***

| | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|
| **(be short)** | | | | |
| **CNRS/INSU (outside SNO)** | | | | |
| **Ministry** | 10 kE EC/ANR-EOST | 12 kE EC/ANR-EOST | 10 kE EC/ANR-EOST | 8 kE EC/ANR EOST |
| **Specific funds** | 14.kE labexOSUG | 5 .kE labexOSUG | 10 kE labexOSUG | 8 kE labexOSUG |
| **County and territory fundings** | 4 kE cg 06 | 12 kE cg06 | 10 kE PACA | ? kE PACA-cg06 |
| **Other structure** | | | | |
| **Total** | 38 kE | 37 kE | 30 kE | 16 kE |

**Please, use bold characters for already obtained funds**

For equipment requests (including material renewals), give its maintenance cost and the saving in maintenance

**SCIENTIFIC AND TECHNICAL PROPOSAL**
***(three pages maximum, including figures, no extra pages allowed)***

**1. Scientific interest of observations made by the SNO and evolution with respect to new observables and new scientific challenges. Indicate short and long term strategy**

Landslides are a major threat to human life, property and constructed facilities, infrastructure and natural environment in most mountainous and hilly regions of the world (e.g. Petley, 2012). In the last century, Europe has experienced the second highest number of fatalities and the highest economic losses caused by landslides compared to other continents (*EM-DAT, 2003): at least* 16,000 people have lost their lives because of landslides and the material losses amounted to over € 1400 M in Europe during the 20th century, (including 200 for France). Apart from human casualties, most of landslides impact widespread disruption to roads and buildings. It corresponds to direct and indirect economic costs. Actual losses produced by landslides in France highlight the lack of a risk mitigation program including the short- term prediction of rapid landslides and integrated early-warning systems (as example see the 2015 and ongoing Chambon landslide in the Oisans massif) Furthermore as a consequence of climate change and increase in exposure, the risk associated with landslides is growing. In areas with high demographic density, protection works when possible to be built are not demonstrated to be efficient because of either economic or environmental constraints (e.g. gorges de la Bourne, Vercors Massif).

The mechanisms that drive the landslide triggering and their dynamics are numerous. Their couplings result in complex patterns that induced large uncertainty in the prediction of both the landslide size and their time of occurrence. Contrarily to other natural hazards (earthquake, river flood, volcano eruptions…) there are a few data sets worldwide, that relate the evolution toward collapse for landslides. Therefore the objectives of the OMIV observatory are to provide the scientific community the data sets that will allow (i) to identify the physical processes that control the slope instabilities, (ii) to be able to model them (iii) and to extract from the observables the patterns that may characterize a change in the land-sliding mode. There is now an important gap, both at the French level and worldwide, between the ability to simulate numerically or physically conceptual slope movements and to specifically reproduce data from past case studies or ongoing landslides. Moreover, when a given empirical law is a-posteriori adjusted on pre-instability observations, it is rarely validated by multi-parameter observations. Back in 2007's, both at the French national and at the worldwide level, there was no active slope sliding on which long lasting continuous records, for sensitive range of observables (displacement, seismology, hydro-geochemistry) were either recorded or available.

Within the context described above, the SNO-OMIV targets are defined as: (1) to stabilize and sustain over time the recording of 3 observable classes (kinematics, seismology, hydro-geochemistry of slope) on representative ongoing landslides ; (2) to homogenize measurements on the four landslides (parameter types and space and time sampling) ; (3) to archive the data and to provide free real time open access to the data for the wide scientific community (4) at a longer term target, to provide the users specific software and algorithms through a WEB base plateform. These software are tools to analyze and process OMIV data as well as numerical models to simulate the geomechanical processes and associated signals that are able to reproduce the observed signals.

These observations aims to contribute to (i) identify the key control parameters that allow to analyze different type of slope instabilities (i.e. soft/hard rock, cohesion/friction, slip/fracture, localized/diffuse damage,….).and (ii) to follow its evolutions through time and space (slowing down or accelerating up, sliding-flow transition,…) . Going beyond some existing case studies in Europe, the key aspect of the French OMIV observatory is embedded in the multi-parameters monitoring and the open access data for the worldwide community. The logic that builds up the OMIV observatory converges with the aims of recently national and EC funded projects to observe and to understand and to model slope instabilities. The funding EC and ANR project(including local French authorities) are recurrent necessary supports for the upgrade and stabilization of the monitoring tools of SNO-OMIV. The logic that builds up the OMIV observatory converges with the aims of recently national and EC funded projects to observe and to understand and to model slope instabilities. The funding EC and ANR project (including local French authorities) are recurrent necessary supports for the upgrade and stabilization of

the monitoring tools of SNO-OMIV.

**"Added value" of SNO-OMIV** –
The OMIV approach builds up momentum in bringing together 3 types of instrumental monitoring expertise with the scientific know-how of communities who did not used to interacts on landslide study, before SNO-OMIV started. Accordingly the SO-OMIV bring together geo-morphologists, geologists and hydro- geologists, geo-physicists and geo-chemists, rock, soil and fluid physicists working either at lab scale or in-situ or as modeling experiments. Such a multidisciplinary group is well fitted to understand the complex patterns of slope instabilities where soft and hard rocks interact with fluid within a wide range of fracture patterns.
From a broad scientific perspective, the knowledge derived from the complex coupling between fluid pressure – air and rock temperature – stress/strain within heterogeneous media with measurement close to the sliding surface and away from it may also be of major interest to understand the mechanics of rupture and sliding which is the key issues at all scale within the earth crust. As an example the shallow sliding surface can be a proxy for slow slip faulting as advertise on numerous deeper fault in the recent years.
As a more practical implication, groups in charge of alerts and risk assessment for landslides (RTM , Restauration des Terrains en Montagne (RTM), and regional IFSTAR-CEREMA, local representatives) appreciate new data type and tools (methodology and models) and that can be used to improve the decision process for risk management. For all these current techniques to quantify the uncertainties remains a very difficult task. One the major contributions of the SNO-OMIV are to transfer new technical and quantitative approaches to the person in charge of the risk mitigation. It is well illustrate by the "efficient" concept developed by the OSU-Theta with the Séchilienne data set and now in used by the CEREMA staff in charge of the alert (Valet et al. 2015a,b,c).
Further development in data analysis aims to maximize the potency of each measurements by adding to continuous validated raw data, upgraded post-processed data set (e.g. seismic velocity change through time using noise technique, PPP rather than DD technique for GPS deduced displacement)
Possible extension to other site including to monitor the peculiar case study of volcano slope, non available within inland France, or cliff rock falls will be discussed with the (SC) Scientific Council for OMIV as soon as the monitoring and data accesses for the 4 sites will be in a routine phase. One may note as possible, yet well monitored, site the cliff rock-falls at Piton de la Fournaise as monitored by OVPF, Réunion Island, networks and the response of volcano slope to strong earthquake at La
Guadeloupe, Island). The other aspect of the mid term strategy is to federate at world wide levels the landslide observatory in order to create and stimulate a world organization for landslide observatories, (WOLO) a similar organization to WOVO, the one existing for volcano observatories .

## 2. Main scientific and technical progress made during the last year

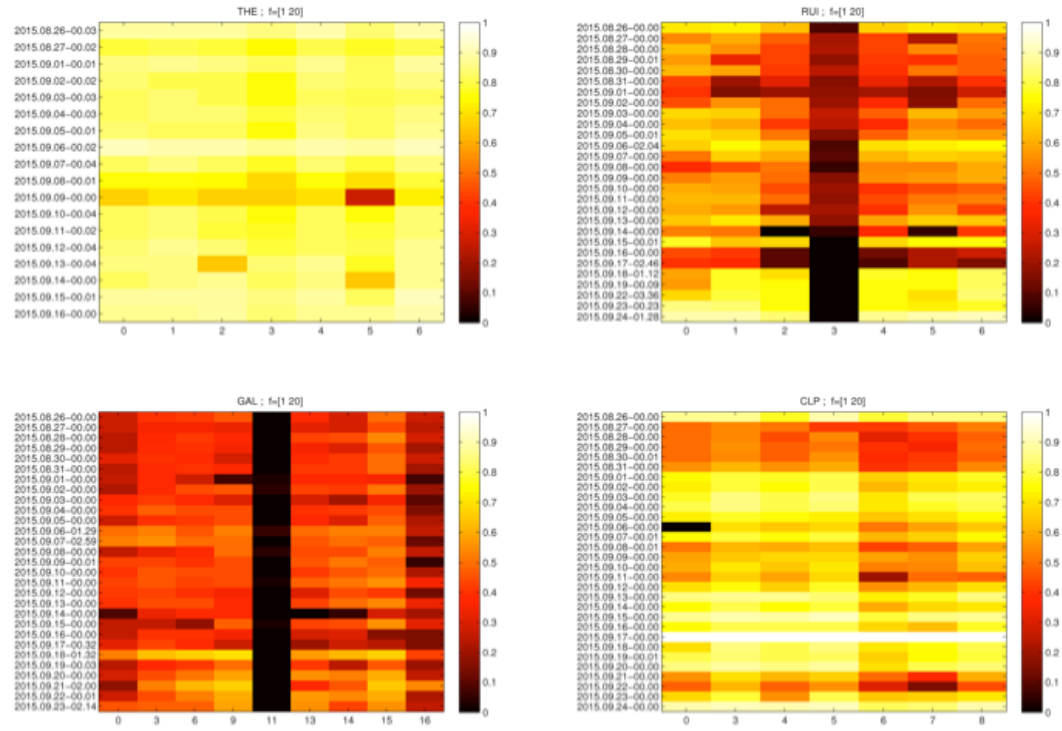
Seismic network: new antennae were installed on Super Sauze and La Clapiére sites starting mid-2015. 6 single vertical component sensors and 1 central 3C sensor on the La Clapiere site operate since 26/04/2015. The third antenna, as requested by the minima OMIV standard is planned to be installed in 2016, using regional funding by PACA administrative district. On Super Sauze the second antenna started to transmit signal in early May 2016. The installation of a third seismic station, including a bradband sensor, is planned for 2016.
For landslide kinematics, installation of 5 low-cost GEOMON GNSS sensors (InfraSurvey s.r.l.) was performed on Super sauze site with the Acquisition of stereo-pairs of Pleiades very-high resolution images.
On the Séchilienne and Avignonet site all structure ( transmission, energy, etc…) were retrofitted to be more robust and less time consuming in term of field maintenance. Problems with the protocol for hydro-geochemistry measurements postponed the 2015 spring water analysis for la Clapiére site.

## 3. Data quality assessment:

**- Measurement characterization (where, what, how) and quality control**

Data validation for quality control is made available on the OMIV web site for the three observables (seismic, GPS, Hydro-geochemistry) and the 4 sites. In the example below we highlight the 2014-15 achievement for seismic data. Automatic validation is now running on the OMIV web site .Daily validation is critical to quality-control of the acquisition chain and data continuity in the landslide context (instruments strongly exposed to disturbance such as mudflows, rock falls, ground movement that may either tilt a sensor or damage the connecting cables ). All of these likely affect data quality and completeness. Previously, only the state of health of the digitizer and recording continuity were monitored, which occasionally resulted in long periods (months) with unusable data.
Two data validation methods are currently in use for all OMIV seismic data;
Method 1 **Noise correlation plots** for the vertical channels of each seismological antenna (fig below as 24/09/15)
- Excludes horizontal channels and single-sensor stations.
- Runs on a short ambient noise window (1 minute in the example below), so can run at any time
- Uses low-pass filtered signal and nearby sensors (e.g., f<20 Hz and d<100 m) so that noise should be well
correlated
- Automatically runs daily, updated on *http://omiv.osug.fr/DATA_VALID/seismo.html*
A low correlation for many days likely indicates an instrument issue
**Method 2**: **Inspection of regional earthquake extractions**
- Includes all channels, all stations
- Focuses on an earthquake time window, so this is not necessarily run daily. However, there is typically 1 or 2
suitable earthquakes per week.
- now be automated and posted on *http://omiv.osug.fr/DATA_VALID/seismo.html*
Clearly shows significant recording issues (e.g. dead or noisy channel)

**Daily noise correlation within all antennas with near real-time transmission (La Clapière and Séchilienne sites)**




**- Data mining for new observables**
- Research contributions on seismic velocity changes as extracted from noise correlation on landslide were performed early on Avignonet landslide (Renalier et al. 2011,12). Following a test on Sechilienne landslide in 2014, these dV/V time series are planned to be implemented on all the four OMIV sites within a 2-year window (M. Radiguet contribution)
- New processing of the GPS times series have been tested using PPP rather than DD algorithms for the 3 OMIV sites where GPS are operated. The PPP solution renders nearly the same precision for the determination of the coordinates than the DD solution, and allows to obtain a frequency of 1 position /hrs rather than the current 1 position / day

**- Data modeling for improving reference models**

The relatively young SNO-OMIV is not yet explicitly involved on providing data modeling to users. At the current stage of the SNO-OMIV evolution, the objectives are to stabilize the observations and to improve the quality of the data we provide to the users. Nonetheless two types of advanced data set are provided to the users apart from the raw data. First a refined displacement data set of values (developed by EOST partner) is available online for the GPS measures that are operated on the 4 sites. Second, the SO-OMIV web site gives access to the
endogenous seismic signals (micro-earthquake, rock falls, and exotic source) and the corresponding catalogue (type, size, time, location). These later seismological catalogues are available on the 2 hard rock landslides sites (Séchilienne, La Clapiere) and in development on the Super Sauze soft rock site. These catalogues allow the non-seismologist users to compare and to correlate displacement data, seismicity rate, and hydro-geochemistry data. As a medium term target we expect to built up benchmark workshops during which the 3 observable data set will be provided to different groups to be able to extract robust change in landslide patterns through time. The other benchmarking, that started with IGN collaboration for the new geo-cube GPS sensors, is used to advertize the OMIV sites as platform to test new instruments in a context of dense and multi-parameters monitored landslides. The best test example for multidisciplinary test is currently the Super-sauze site, whereas for seismology data the Séchilienne test is the reference for benchmarking (e.g. Ineris-Cete groups tested seismic monitoring devices against the ongoing OMIV monitoring in the context of the ANR slams. An ongoing test with the university on Firenze aims to calibrate the ability of infra-sound array to record high frequency rock falls in the near field .

## NEEDED MEANS FOR THE ACHIEVEMENT OF THIS SNO TAB
***(two pages maximum, including figures, no extra pages allowed)***

Specify the means to be needed for reaching objectives of the next year: this has to be compatible with the table of the first page as well as with the final financial demand.

**1- instrumental effort for 2016**

+ Displacement:
- array of 8 low cost GEOMON GNSS sensors (InfraSurvey s.r.l.) (4 Sechilienne, 4 avignonet)
- Installation of new GPS and new seismic antenna CLP4 La Clapiere
+ Seismology:
- seismic digitizer (upgrading/jouvance of the old obsolete devices) Séchlienne - Avignonet
- Installation of a 3rd seismic antenna (possibly a broadband station):
- water proofing for all 1C sensors of seismic Antenna CLP2, (La Clapiere)
- Installation of new seismic antenna CLP4 , (La Clapiere)
+Hydro-geochemistry:
- 2 shallow boreholes and pore water pressure sensors (update of existing ones) super sauze
- Installation of a 4th ground-based camera: super sauze

**2 – Data integration, data validation and data diffusion 2016:**

Current status:
For each OMIV groups, all the technical aspects for each site instrumentation are in charge of AI-IE that are both CDD and CDI persons, as funded by each of the SO-OMIV partners.
For the 3 observables SO-OMIV is labeled for, there are three main steps in data processing
- measurement controls (transmission - validation)
- diffusion of raw data through web based data access
- diffusion of advanced data set and tools for data analyses

All of these three tasks are supported by non-stabilized man-powers for all the Seismic, GPS and Hydro-geochemistry observables.

For these 3 SO-OMIV observables the corresponding data complexity and data volume are as listed below.
- seismology: 1 TB of data per year (>80 chanels, 250-500hz sampling rate range)
- GPS : < 1GB of data per year (10 chanels, 30s- 1s sampling rate range)
- Hydro-gechemistry : < 10's MB of data per year (<10 chanels, 10'- few month sampling rate

range).

On this basis we synthesized the current status and the priority for SO-OMIV ITA engineer task force. The identification, the extraction, the validation of the seismic signals, the diffusion of signals and advanced data processing for seismic catalogues are performed by a CDD-IE position,. The corresponding charge is part of the SO-OMIV annual budget. Improvement toward Automatic processing is build up since 2010, and it allows us to reduce the initial 1.5 IE per year before 2010 to 1 IE since 2011.
The seismic data-base-oriented storage and the IE working site are located at ISterre, OSUG Grenoble, where the national database for earthquake signals is also located. OMIV seismological data are now part of Resif Node A and it is the task of the IE_CDD to recurrently achieve the data transfer to RESIF. The first priority for manpower for SO-OMIV remains since 2010 a recurrent stabilized IE position for identification, the extraction, the validation and diffusion of the seismic signals.

Similarly to the seismological data organization, the identification and the extraction and the validation of the GPS data sets are performed at IPGS. It corresponds to an ½ AI (P Ullrich) charge for the 4 OMIV sites. A specific scheme to resolved displacements within short aperture GPS network was developed by EOST team and is also on-line available through the OMIV web-site. This way the second priority for SO-OMIV ITA is the low cost transformation of AI to IE position (P Ullrich) as a partnership with the the SO-Renag (1/2 AI Renag, ½ AI OMIV).

The third priority is related to 1/4 AI position at Geoazur-OCA, for the identification, the extraction, the validation of the hydro-geochemistry measurements and database.

**2015 task force request:**

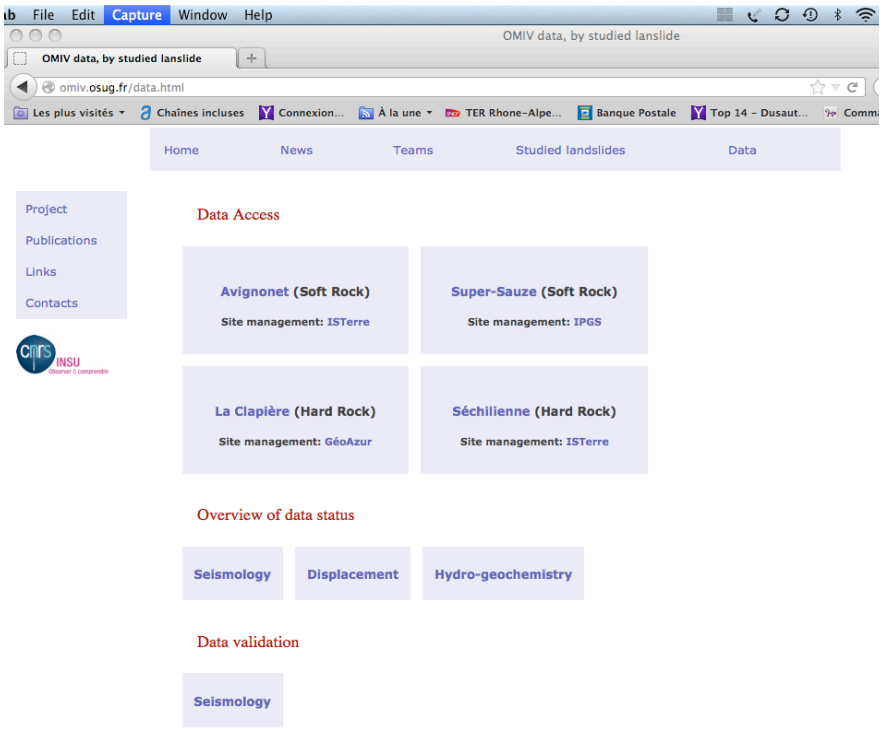
+Engineer and technical staff:
- 1 IE for the identification, the extraction, the validation, diffusion of the seismic signals, (OMIV-Isterre).
- AI ->IE transform, for the identification, the extraction, the validation and the diffusion of the GPS signals (1/2 RENAG- ½ OMIV, (IPGS)).

## DATA & MODELS DISTRIBUTION & DIFFUSION REALIZATION
***(four pages maximum, including figures, no extra pages allowed)***

The Commission is particularly concerned with the open-access and real-time distribution of the data acquired by SNO to the scientific community. Please, provide detailed information on the system for data dissemination: raw data (real-time), processed data and models of this SNO as well as workflows for these processing and modeling.

### 1. Description of data distributed by the SNO (type of raw data, processed data, models, software, metadata) and links of the open access distribution web sites.

The following page (http://omiv.osug.fr/data.html) corresponds to the organization of data per sites



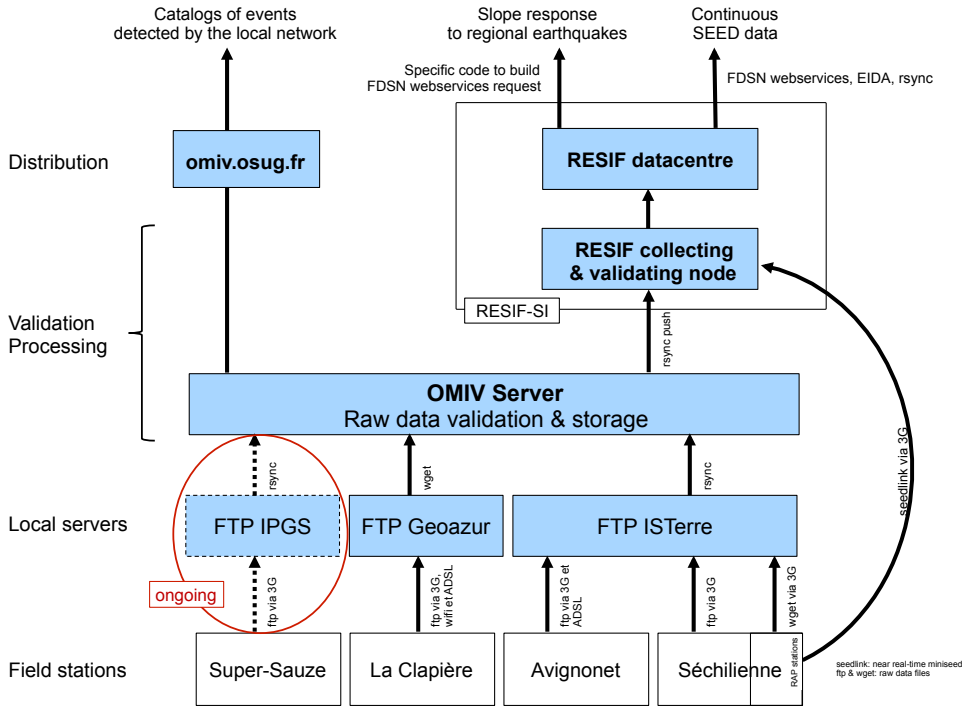

Then for each sites there are global and local time line specific to the history of available observables. Bullet points on the time lines explicit any events that impact the way data are qualified (change in geometry measurements, change in sensors, failure to record, etc…)
The comprehensive data set is available online for raw continuous records (GPS, seismic, weathering). For the GPS data the OMIV portal provides access (transparent to the users) to the EOST plate-form where all GPS data are archived and stored for real time open access. For the raw continuous seismic records the OMIV portal provides access (transparent to the users) to the RESIF plateform where all the national seismic data are archived and stored for real time open access.
Since 2014, OMIV seismology data are distributed through the RESIF infrastructure. Advanced processed data are available for both GPS and seismic data. Fast local displacements for small aperture GPS network are made available. (using PPP and DD technique during 2015 test period). For seismic signals the SNO-OMIV provide records of i) landslide responses to regional earthquake shaking, (RESIF database) ii) endogenous events (i.e. micro-earthquake within the landslide and rock falls); iii) catalogues for location, size and time of endogenous events. RESIF currently does not have a service for distributing event data such as our endogenous event catologs. They are therefore processed and provided through the OMIV websites, by the IE CDD in charge of seismology data. These catalogues are now fully available for the Séchilienne and La Clapiére landslides. One of the main technical achievements in data access was to recover event data (endogenous event catalogs and landslide response to regional earthquakes) directly from the resif plateform, avoiding data duplication. Ongoing work for data assimilation on Super-Sauze aims to deliver catalogues for this site. Due to weak anthropogenic seismic activity in the clay context of the avignonet site, the catalogue analysis was stopped late 2014.

As an example, the data flow for OMIV seismologyseismological data corresponds to 1Tb volume/yrs, i.e. close to the former RENASS French seismological service

| Data type | Currently available through… | Status as of October 2015 |
|---|---|---|
| **Continuous data (SEED format)** | - data/metadata web services<br>- arclink/EIDA requests | *D+3 updates (data available 3 days after acquisition)* |
| **Slope response to regional earthquakes** | *RESIF: Web service POST requests* | *Code available on omiv.osug.fr to allow users to build earthquake catalogs and produce FDSN web service POST requests. Submitted POST requests return required event data.* |
| **Catalogs of events detected by the local network (endogenous quakes and rockfalls, regional earthquakes)** | the omiv website *omiv.osug.fr* | Séchilienne: Fully available, real-time creation.<br>La Clapière: Fully available, real-time creation.<br>Super-Sauze: No catalog available yet<br>Avignonet: No catalog available, the seismic network does not allow the creation of a catalog. |

**Status of the 3 types of OMIV seismological data deliverables**

OMIV seismological data flow – October 2015




## 2. Statistics of accesses to distribution sites

Not all the database is available yet in term of statistics of access to distribution sites. Below is an overview of number of access and downloaded volume for the OMIV seismic data, 2013 – mid 2015

year | gigabytes ------+-----------------served_requests ------+----------------- -----
2013 | 9.8918838500976563 435
2014 | 15.1345300674438477 31644
2015 | 119.8643531799316406 299704
year | gigabytes ------+-----------------served_requests ------+----------------- -----

these proxies confirm the increasing impact of the SNO-OMIV database in a wide community . Implementation of these indexes is ongoing for the displacement and hydro-geochemistry database.

## 3. List of rank A publications and thesis where the usage of data and models distributed by the SNO are explicitly mentioned (restrict list to the 2014-2015 period).

Bernardie, S., Desramaut, N., Malet, J.-P., Gourlay, M., Grandjean, G. 2015. Prediction of changes in l andslide rates induced by rainfall. Landslides, 12: 481-495. doi:10.1007/s10346-014-0495-8

Bièvre, G.; Jongmans, D.; Goutaland, D.; Pathier, E. & Zumbo, V. 2015, Geophysical characterization of the lithological control on the kinematic pattern in a large clayey landslide (Avignonet, French Alps). *Landslides*. doi:10.1007/s10346-015-0579-0

Cappa, F., Y. Gugliemi, S. Viseur, and S. Garambois, Deep fluids can facilitate rupture of slow- moving giant landslides as a result of stress transfer and frictional weakening, Geophysical Research Letters, VOL. 41, 16, doi:10.1002/2013GL058566, 2013.

Gance, J., Malet, J.-P., Dewez, T., Travelletti, J. 2014. Target Detection and Tracking of moving objects for characterizing landslide displacements from time-lapse terrestrial optical images. *Engineering Geology*, 172: 26-40. doi:10.1016/j.enggeo.2014.01.003

Krzeminska, D.M., Bogaard, T.A., Debieche, T.-H., Cervi, F., Marc, V., Malet, J.-P. 2014. Field investigation of preferential fissure flow paths with hydrochemical analysis of small-scale sprinkling experiments, *Earth Surface Dynamics*, 2, 181-195. doi:10.5194/esurf-2-181-2014

Kurtz, C., Stumpf, A., Malet, J.-P., Gançarski, P., Puissant, A., Passat, N. 2014. Hierarchical extraction of landslides from multiresolution remotely sensed optical images. *International Journal of Photogrammetry and Remote Sensing*, 87: 122-136. doi:10.1016/j.isprsjprs.2013.11.003

Stumpf, A., Malet, J.-P., Allemand, P., Ulrich, P. 2014. Surface reconstruction and landslide displacement measurements with Pléiades satellite images. *Journal of Photogrammetry and Remote-Sensing*, 95: 1-12. doi:10.1016/j.isprsjprs.2014.05.008

Travelletti, J., Malet, J.-P., Delacourt, C. 2014. Image-based correlation of Laser scanning point cloud time series for landslide monitoring. *Journal of Applied Earth Observation and Geoinformation*, 32: 1-18. doi:10.1016/j.jag.2014.03.022

Vallet, A.; Bertrand, C.; Fabbri, O.; et al. (2015) An efficient workflow to accurately compute groundwater recharge for the study of rainfall-triggered deep-seated landslides, application to the Sechilienne unstable slope (western Alps), HYDROLOGY AND EARTH SYSTEM SCIENCES 19(1), 427-449

Vallet, A., J. B. Charlier, O. Fabbri, C. Bertrand, N. Carry, J. Mudry (2015), Functioning and precipitation-displacement modelling of rainfall-induced deep-seated landslides subject to creep deformation, Landslides, doi:10.1007/s10346-015-0592-3

Vallet, A., C Bertrand, J Mudry, T Bogaard, O Fabbri, C Baudement, B Régent (2015), Contribution of time-related environmental tracing combined with tracer tests for characterization of a groundwater conceptual model: a case study at the Séchilienne landslide, western Alps (France), Hydrogeology Journal, doi:10.1007/s10040-015-1298-2

**+ Thèses 2014-15 avec données OMIV:**

Niethammer, U. 2013. UAV-basierte Fernerkundungsmethoden der Aerogeophysik für die hochauflösende Beobachtung von alpinen Rutschhängen. PhD. Thesis, University of Stuttgart, 210p. (Nov. 2013)

Lien: http://elib.uni-stuttgart.de/opus/volltexte/2014/8921/pdf/DissertationNiethammerPub.pdf

Stumpf, A. 2013. Landslide recognition and monitoring with remotely sensed data from passive optical sensors. PhD Thesis, University of Strasbourg, 200p. & annex. (Dec. 2013)

Gance, J. 2014. Développements méthodologiques en géophysique haute résolution pour la caractérisation hydro-mécanique de glissements de terrain argileux. PhD Thesis, University of Strasbourg, 280p. (Juin 2014)

## OUTREACH OF COLLECTED DATA AND PREVIOUS ANALYSIS

### 1. List of signed contracts in the last three years on this SNO tab (outside financial support of SNO from INSU).

**Project title: KultuRISK (EC, 2012-2014) - http://www.kulturisk.eu/**
Funding : 700 k€ (total projet) – 25 k€ (for EOST, sub-contractor of Unesco-IHE)
Summary: Europe has recently suffered a number of natural disasters, such as the droughts and heat wave (summer 2003), devastating flooding in Central Europe (August 2002) and in England and Wales (summer 2007, autumn 2009), the dramatic Abruzzo earthquake (6 April 2009) and landslides in Messina (September 2009).
The extreme consequences of the recent catastrophic events have highlighted that risk prevention still needs to be improved to reduce human losses and economic damages. The main objectives of the KULTURisk project are:

- A critical and comprehensive review of static and dynamic measures to prevent water-related hazards with special focus on the importance of risk communication techniques.
- The development of a risk-based methodology for the evaluation and accounting of risk prevention measures.

The KULTURisk methodology was applied to diverse European case studies to evaluate the social and economic benefits of risk prevention, i.e. reduction of potential flood losses due to the implementation of prevention measures. Among many outcomes, it was demonstrated that:

- the implementation of early warning systems can significantly (between 30 and 40%, depending on various factors) reduce the potential flood damage in the Danube river basin countries indicating that investments in preparedness and early warning systems can be highly beneficial.
- In the Ubaye Valley (France), it was found out that a combination of structural and non-structural prevention measures can remarkably reduce the potential impact of flooding in Barcelonnette for different receptors (70% less for people, 84% for buildings, 77% for infrastructures, 91% for agriculture).
- In Zurich (Switzerland), prevention measures reduce the potential damage caused by extreme flood events in the Sihl River by 50%, while additional prevention options in Zurich (e.g. discharge tunnel) were found to potentially reduce flood losses near zero with benefits more than 10 times higher than the costs of prevention measures.

**Project title: CHANGES (EC, 2011-2014) - http://www.changes-itn.eu/**
Funding : 1.2 Mk€ (total projet) – 210 k€ (for EOST)
Summary: The CHANGES network will develop an advanced understanding of how global changes, related to environmental and climate change as well as socio-economical change, will affect the temporal and spatial patterns of hydro-meteorological hazards and associated risks in Europe; how these changes can be assessed, modeled, and incorporated in sustainable risk management strategies, focusing on spatial planning, emergency preparedness and risk communication.
**The main objectives are:**

(1) provide high-level training, teaching and research in the field of hazard and risk management in a changing environmental context to European young scientists.
(2) reduce the fragmentation of research on natural processes,
(3) to develop a methodological framework combined with modeling tools for probabilistic multi-hazard risk assessment taking into account changes in hazard scenarios (related to climate change) and exposed elements at risk.

**Project title: GTEP (ESA, 2015-2016)**
Funding : 600 k€ (total projet) – 85 k€ (for EOST)
Summary: Since more than 20 years, “Earth Observation” (EO) satellites developed or operated by ESA have provided a wealth of data. In the coming years, the Sentinel missions, along with the Copernicus Contributing Missions as well as Earth Explorers and other, Third Party missions will provide routine monitoring of our environment at the global scale, thereby delivering an unprecedented amount of data.
In this context, the GTEP (Geohazards Thematic Exploitation Platform) initiative aims to build an operative processing environment capitalizing on GS capabilities and ICT technologies to maximize the exploitation of EO data from past and future missions.
This presentation focuses on the "Optical Image Correlation" Pilot Project (funded by ESA within the GTEP platform) which objectives are to develop a easy-to-use, flexible and distributed processing chain for:1) the automated reconstruction of surface Digital Elevation Models from stereo (and tristereo) pairs of Spot 5/6/7 and Pléiades satellite imagery, 2) the creation of ortho-images (panchromatic and multi-spectral) of Landsat 8, Sentinel-2, Spot 6/7 and Pléiades scenes, 3) the calculation of horizontal (E-N)

displacement vectors based on sub-pixel image correlation.
The processing chains will be implemented on the GEP cloud-based environment and will be designed for analysis of co-seismic displacements at regional scale (100 $km^2$). The processing chain will be designed for both the analysis of archived data (Pléiades, Spot 5, Landsat 8) and optimized for the satellite missions Spot 6/7 and Sentinel 2. The possibility of rapid calculation in near-real time is an important aspect of the design of the processing chain.
Archived datasets will be processed for three 'demonstrator' test sites where significant earthquake occurred Mv> 5.8 and because large horizontal displacements have been observed. A prototype will also be developped for landslide monitoring, and the South French Alps is the targeted benchmark region because several active landslides are being surveyed (La Clapière, Super-Sauze, La Valette).

**Project title: ANR SAMCO (2013-2017)**
Funding : 800 k€ (total projet) – 210 k€ (for EOST)
Summary : The SAMCO project aims to develop a proactive resilience framework enhancing the overall resilience of societies on the impacts of mountain risks. The project aims to elaborate methodological tools to characterize and measure ecosystem and societal resilience from an operative perspective on three mountain representative case studies. To achieve this objective, the methodology is split in several points with:(1) the definition of the potential impacts of global environmental changes (climate system, ecosystem e.g. land use, socio-economic system) on landslide hazards,(2) the analysis of these consequences in terms of vulnerability (e.g. changes in the location and characteristics of the impacted areas and level of their perturbation) and (3) the implementation of a methodology for quantitatively investigating and mapping indicators of mountain slope vulnerability exposed to several hazard types, and the development of a GIS-based demonstration platform.

**Project title: ANR ASTERIX (2014-2016) - http://anr-asterix.irisa.fr**
Funding : 250 k€ (total projet) – 25 k€ (for EOST, sub-contractor of UBS/IRISA)
Summary : Suite à une profusion de données multi-sources de résolutions spatiales, spectrales et temporelles sans précédent, le problème de la reconnaissance dans les images complexes par télédétection de l'environnement est récemment devenu un défi à relever, avec la possibilité de considérer de nouvelles applications importantes. Cependant, il n'existe pas ou peu de cadre méthodologique pour traiter les données à des échelles spatiales et temporelles multiples : les méthodes de reconnaissance utilisées sont souvent des applications directes des méthodes classiques de classification et de modélisation.
Le but du projet ASTERIX (Analyse Spatio--temporelle pour la Télédétection de l'Environnement par Reconnaissance dans les Images compleXes), et son caractère novateur, est de fournir des méthodes, algorithmes et logiciels dans le domaine de l'analyse d'image et de l'apprentissage automatique afin d'aider à la reconnaissance dans les images complexes, en prenant explicitement en compte la spécificité des images de télédétection. Dans ce contexte, les principaux verrous scientifiques concernent la dimensionnalité, l'hétérogénéité, le volume, le caractère spatio-temporel, et l'évolution temporelle des données images.
Outre des développements méthodologiques permettant l'avancée de l'état de l'art dans les domaines du traitement des images et de l'apprentissage automatique dans un contexte de reconnaissance au sein d'images complexes, les résultats attendus lors du projet ASTERIX consistent en un ensemble de solutions concrètes à des problèmes cruciaux posés en télédétection de l'environnement, et plus précisément dans deux milieux privilégiés, littoral et montagnard, en considérant dans le premier cas la dynamique d'objets environnementaux indicateurs de l'évolution du littoral, et dans le second cas la dynamique de colonisation des prairies par le frêne dans les Hautes-Pyrénées et la dynamique de processus géologiques (glaciers et glissements de terrain).

**Project title:SLAM** Multidisciplinary and multi-temporal approaches of the huge Sechilienne iconic landslide
**Program/starting year/ Ending year: 2010-2014**
**Fund amount: 700 kE**
**Summary of main results** (twenty lines maximum) **:**
The multiparameter monitoring has shown a strong correlation between seismic activities, effective rainfall and surface deformation. It was shown an evolution of the reactivity of the movement to climate forcing, as well as the role of hydromechanical coupling on the destabilization and on the dynamics of the landslide. The 3D geometry affected by the movement and its hydrological and mechanical characteristics could be established, while a complex reconstruction of the kinematics of movement since the last glaciation has been proposed. It was also shown that the uncertainty at the heart of risk management requires an overhaul of the constitution and terms of expertise and strengthen the links between operational actors, policy and research.
**List of related publications of this project:**
- Cappa, F., Y. Gugliemi, S. Viseur, and S. Garambois, Deep fluids can facilitate rupture of slow- moving giant landslides as a result of stress transfer and frictional weakening, Geophysical Research Letters, VOL. 41, 16, doi:10.1002/2013GL058566, 2013.
- Helmstetter, A. and S. Garambois, 2010, Seismic monitoring of Séchilienne Rockslide (French Alps): analysis of seismic signals and their correlation with rainfalls, J. Geophys. Res., 115, F03016, doi:10.1029/2009JF001532.

- Lacroix, P. and A. Helmstetter (2011), Localisation of seismic signals associated with micro-earthquakes and rockfalls on the Séchilienne landslide, French Alps, Bull. Seism. Soc. Am. 101(1), 341-353, doi: 10.1785/0120100110.
- Vallet, A., C. Bertrand, et J. Mudry, (2013), Effective rainfall: a significant parameter to improve understanding of deep-seated rainfall triggering landslide - a simple computation temperature based method applied to Séchilienne unstable slope (French Alps), Hydrology and Earth System Sciences Discussions 10 (7) (juillet 10): 8945-8991. doi:10.5194/hessd-10-8945-2013.

**Project title:**Contrainte chronostratigraphique de la mise en place des argiles litées du Trièves (Alpes externes). Implications sur la dynamique des mouvements de terrain.
**Program/starting year/ Ending year:**
2013-2014
**Fund amount:**
Accès accélérateur ARTEMIS (plate-forme INSU) pour 10 datations
**Summary of main results** (twenty lines maximum) **:**
datations 14C de la séquence sédimentaire (milieu de séquence -> 40-45 ky cal. BP)
**List of related publications of this project:**
Not yet

**Project title:** Chronostratigraphie haute-résolution des argiles litées glacio-lacustres du Trièves (Alpes occidentales françaises)
**Program/starting year/ Ending year:**
2014-2015
**Fund amount:**
Accès accélérateur ARTEMIS (plate-forme INSU) pour 20 datations
**Summary of main results** (twenty lines maximum) **:**
datations 14C de la séquence sédimentaire (moraines intraséquence)
**List of related publications of this project:**
Not yet

**Project title:** BQR ISTerre (collaboration GRE-TRB-Géodynamo): Les argiles glacio-lacustres du Trièves (Alpes Occidentales Françaises) : un enregistrement haute résolution des variations du climat et du champ magnétique ?
**Program/starting year/ Ending year:**
2014-2015
**Fund amount:**
4500€
**Summary of main results** (twenty lines maximum) **:**
datations 14C et OSL de la séquence sédimentaire + mesures magnétiques sur carottes
**List of related publications of this project:**
Not yet

**Project title:** Labex-OSUG : complément d'instrumentation par capteurs hydrogéologiques
**Program/starting year/ Ending year:**
2014-2015
**Fund amount:**
4500€ (ou 5000€ ?)
**Summary of main results** (twenty lines maximum) **:**
Matériel qui vient d'être acquis et qui va d'abord être testé sur un petit glissement dans argiles équivalents (collaboration ISTerre-CEREMA)
**List of related publications of this project:**
Not yet

## 2. Other outreach initiatives.

- InfraSurvey s.rl : Développement des capteurs GNSS bas-cout Geomon (www.infrasurvey.ch)
- Kylia: Test des capteurs GNSS Geocube (http://kylia.com/)
- GeoTopo s.r.l : Test de solution de tachéométrie robotisé à Super-Sauze : http://www.geotopo.fr/
- ABEM : installation temporaire du GB-InSAR en Juillet 2015 à Super-Sauze : http://www.abemfrance.eu/index.php/fr/13-categories-en-francais/nouvelles/198-ibis-fl-demonstration-a-barcelonnette-surveillance-du-glissement-de-terrain-de-super-sauze
- Service Géologique Autrichien (GSA) : test du résistivimètre en continu Gelmon
- RTM 04 : echanges de données et co-financement d'acquisitions LiDAR

**BUDGET**

Please, detail financial information of the first page for a better understanding and analysis.

Give a priority level to the different items.

Aside from the funding asked to INSU as an SNO tab, provide the financial supports related to this SNO tab at the national level as well as European and international levels. Please note that any funding related to confidential data acquisition should not be considered here.

Super sauze site:
2 shallow boreholes and pore water pressure sensors (update of existing ones): 2 k€
- Installation of a 4th ground-based camera: 1 k€
- Installation of a 3rd seismic antenna (possibly a broadband station): 5 k€
- Hydrochemical analysis (collaboration Univ. Avignon): 1 k€
- Fieldwork expenses: 1 k€

Séchilienne site
- 4 low-cost GEOMON GNSS sensors (Contribution to) 3 k€
- seismic sensors (replacement) 2 k€
- Hydrochemical analysis (collaboration Univ. besançon): 2 k€
- data storage (RESIF) 2 k€
- Fieldwork expenses: 1 k€

Avignonet
- 4 low-cost GEOMON GNSS sensors (Contribution to) 3 k€
- seismic digitizer (replacement) 4 k€
- data storage (RESIF) 2 k€
- Fieldwork expenses: 1 k€

La Clapiére
Equipment and installation for the last coupled gps-seismic station
- GPS sensor (Contribution to) 4 k€
- new antenna (seismic digitizer and sensors, contribution to) 5 k€
- Fieldwork expenses: 1 k€

1. **Small equipment** (< 15kEuros HT)**:**

contribution to GPS and seismic instruments (see per site details above ):
25 kE

2.**Consumables:**

borehole , data storage , hydro-geochemistry analysis, replacement seismic sensors):
15 kE

3. **Travels:**
4 kE

4. **Temporary human resources (provide detailed job description)**

41 kE (see dialog file)