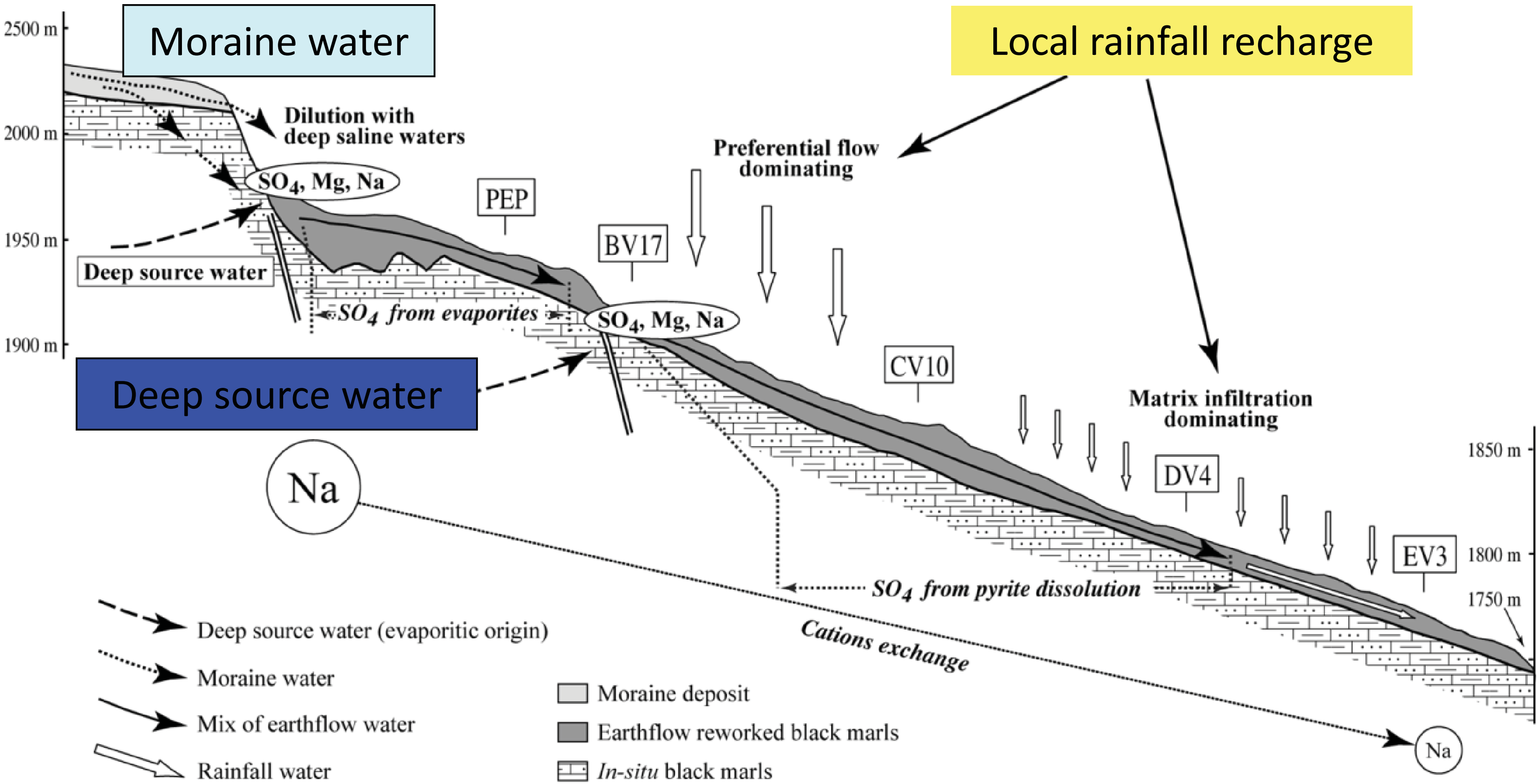
Monitoring landslide hydro-meteorology

Hydrogeochemistry – Surface and sub-surface water quality

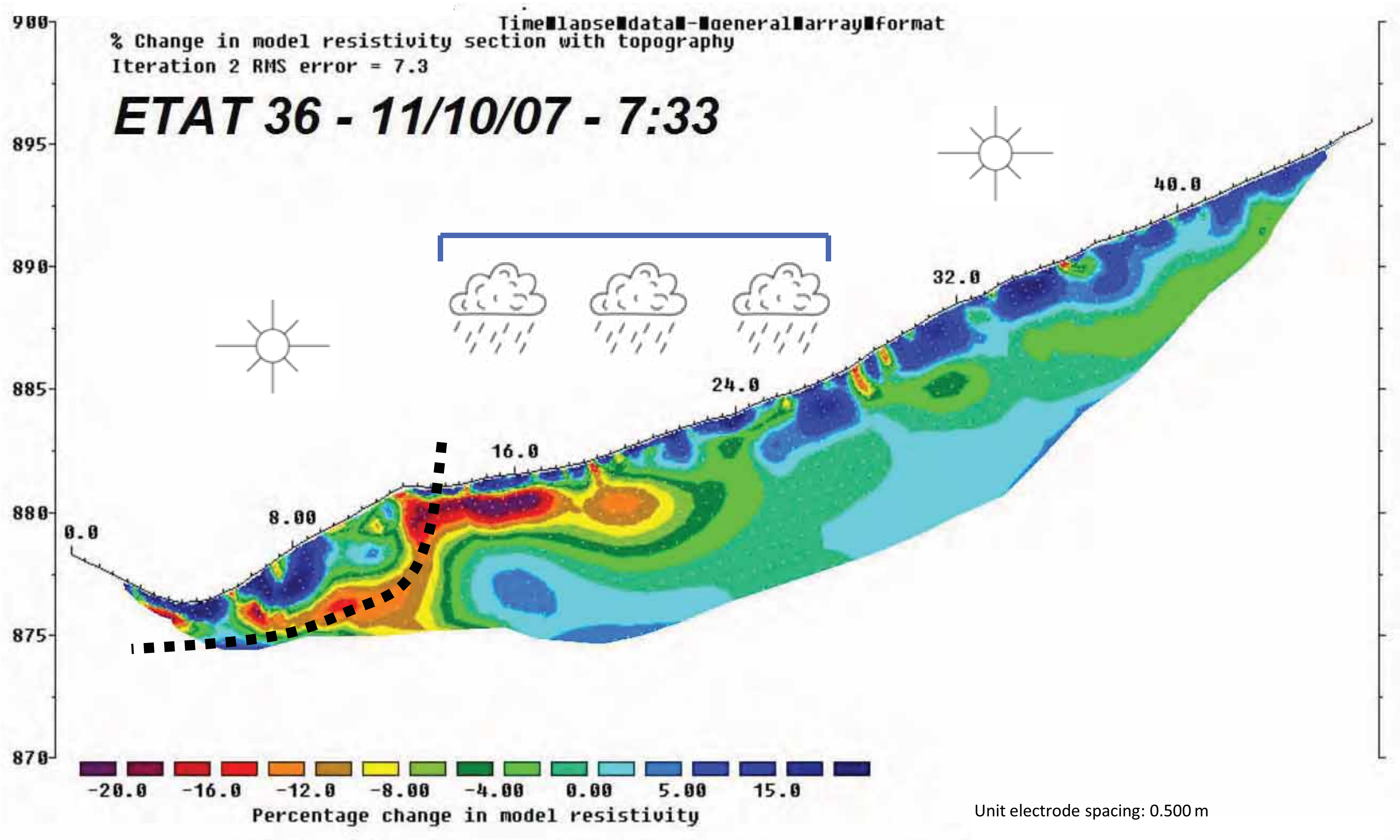


De Montety et al. (2007)

Monitoring landslide hydro-meteorology

Time-lapse hydrogeophysics (e.g. ERT)

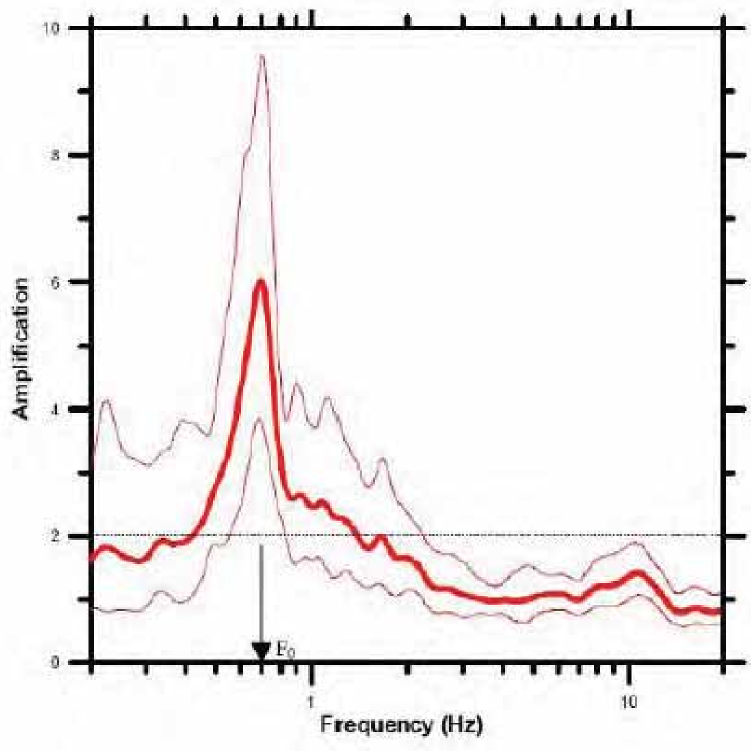
Travelletti et al. (2012)

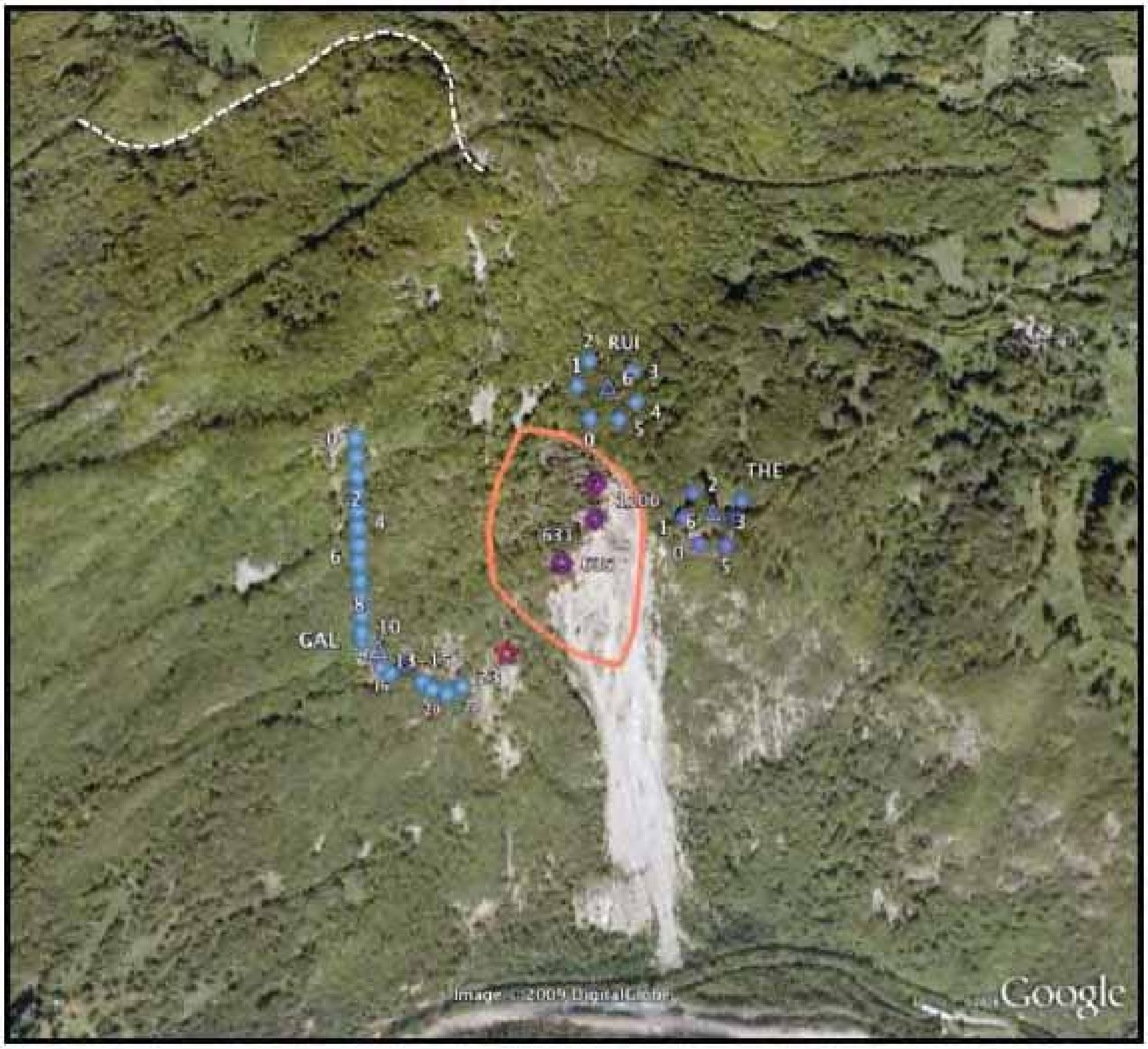


Monitoring landslide seismology (micro-seismicity)

Seismic noise tomography

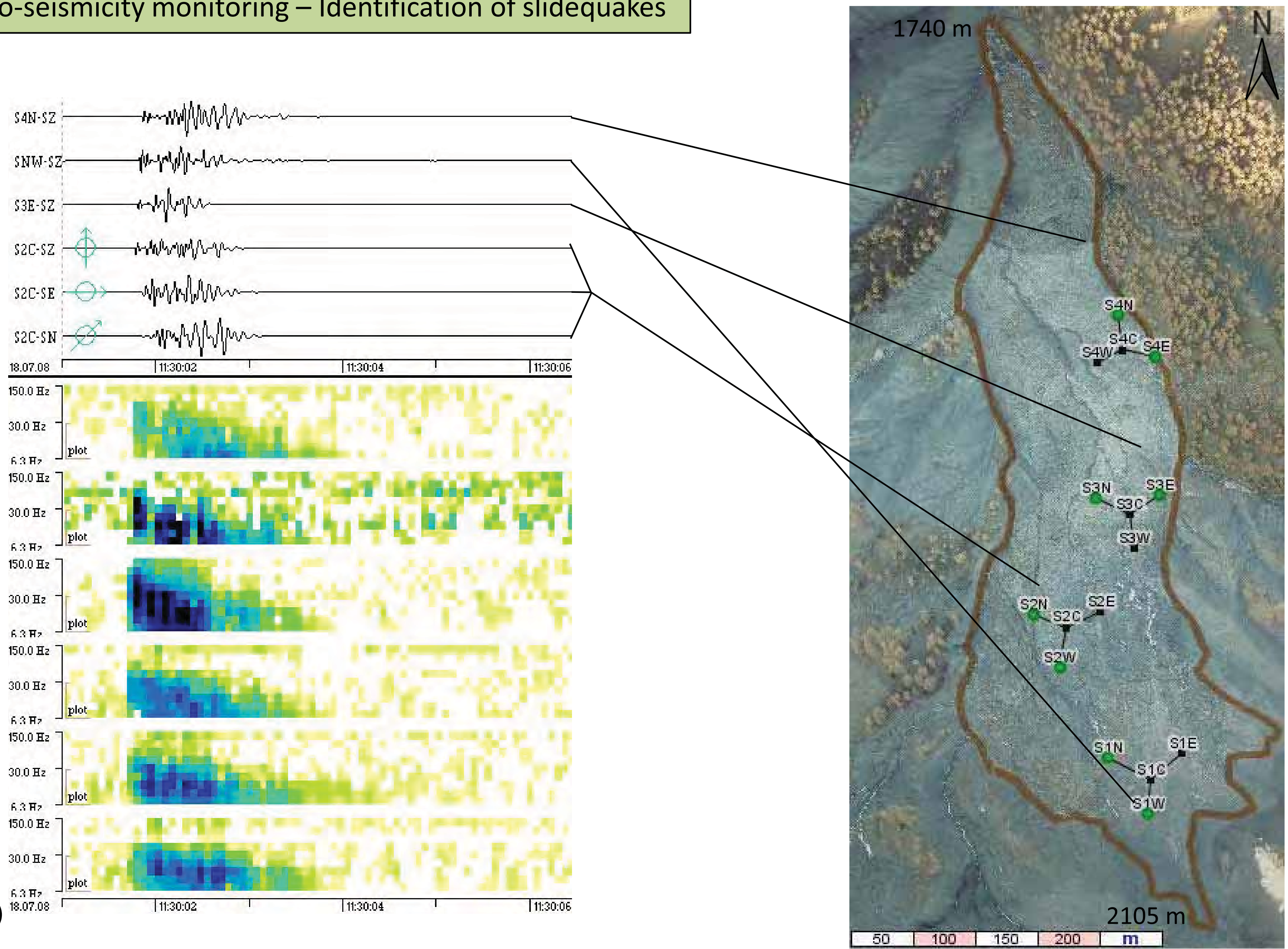
H/V ration and fundamental frequancy (0.7 Hz) at Séchilienne





Monitoring landslide seismology (micro-seismicity)

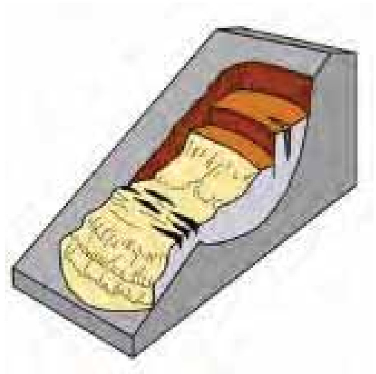
Micro-seismicity monitoring – Identification of slidequakes



Walter et al. (2012)

Criteria for the selection of the appropriate techniques

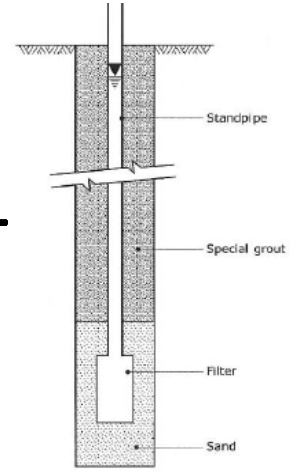
- Is the landslide type a sufficient condition for the selection of the optimal technique?



Rotational landslide

?
=

+



- More criteria need to be considered!

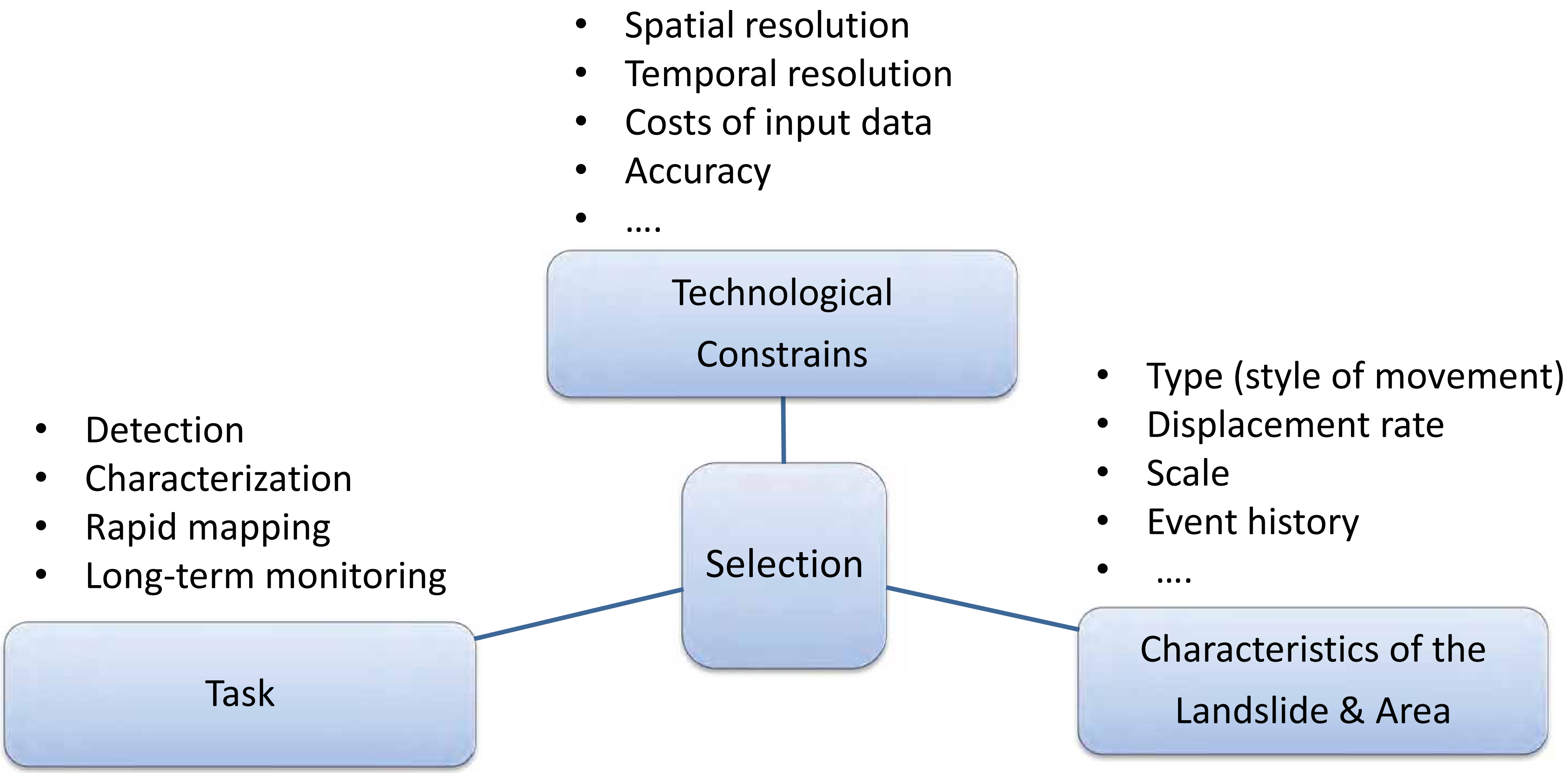
- Guidelines have been proposed in the SafeLand EC Project
➔Deliverable D4.4, Leaders: CNRS & ITC


SafeLand

SafeLand

Deliverable D4.4

Criteria for the selection of the appropriate techniques



Criteria for the selection of the appropriate techniques

- Spatial resolution
- Temporal resolution
- Costs of input data
- Accuracy
- ....

Technological Constrains

- Type (style of movement)
- Displacement rate
- Scale
- Event history
- ....

- Detection
- Characterization
- Rapid mapping
- Long-term monitoring

Selection

Task

Characteristics of the Landslide & Area

Criteria for the selection of the appropriate techniques

- What are the technological constrains? More details

Ground-based sensors

- Spatial resolution
- Temporal resolution
- Accuracy
- Costs of input data
- Additional costs for processing
- Additional costs for EW
- Development status
- Elaboration time

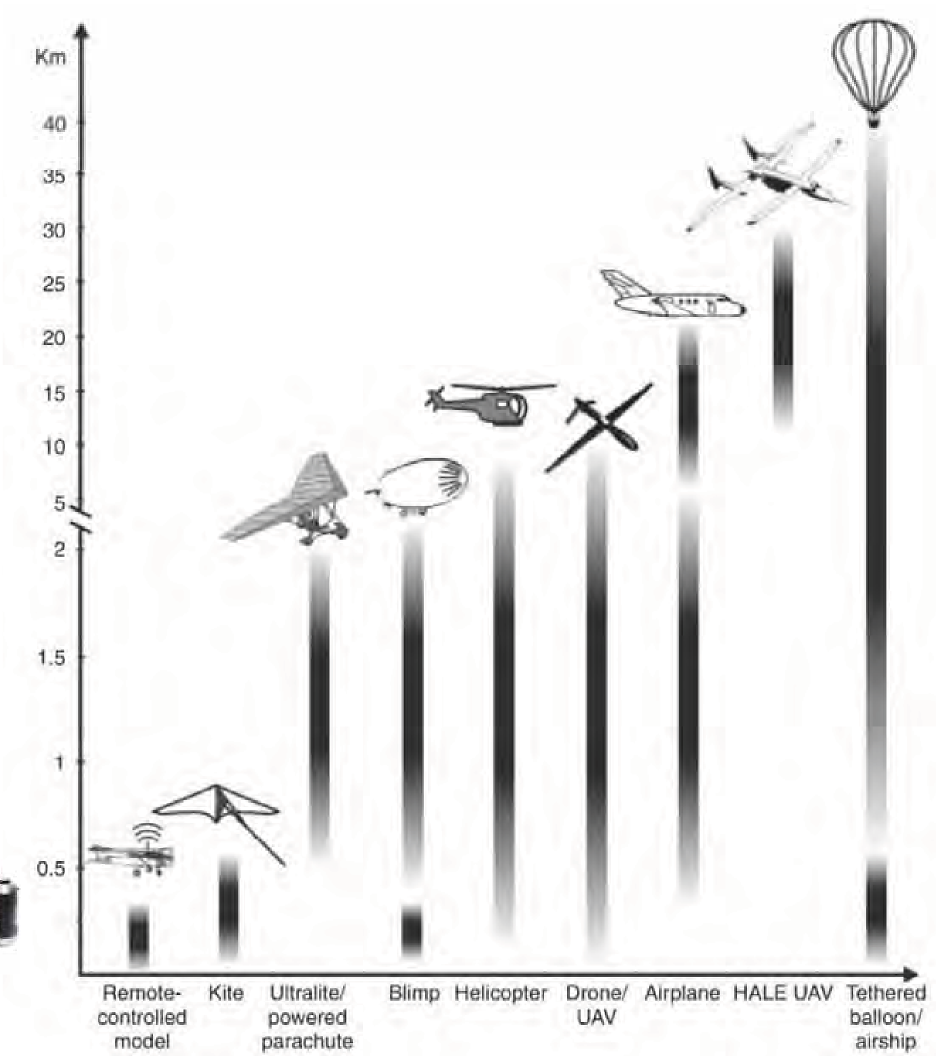
Remote-based sensors

- Data product
- Spatial resolution
- Temporal resolution
- Accuracy level
- Costs of input data
- Availability of alternatives
- Spatial Coverage
- Sensor type
- Platform

Criteria for the selection of the appropriate techniques

- Availability of different ground-based, airborne and satellite platforms and approximate operating altitudes

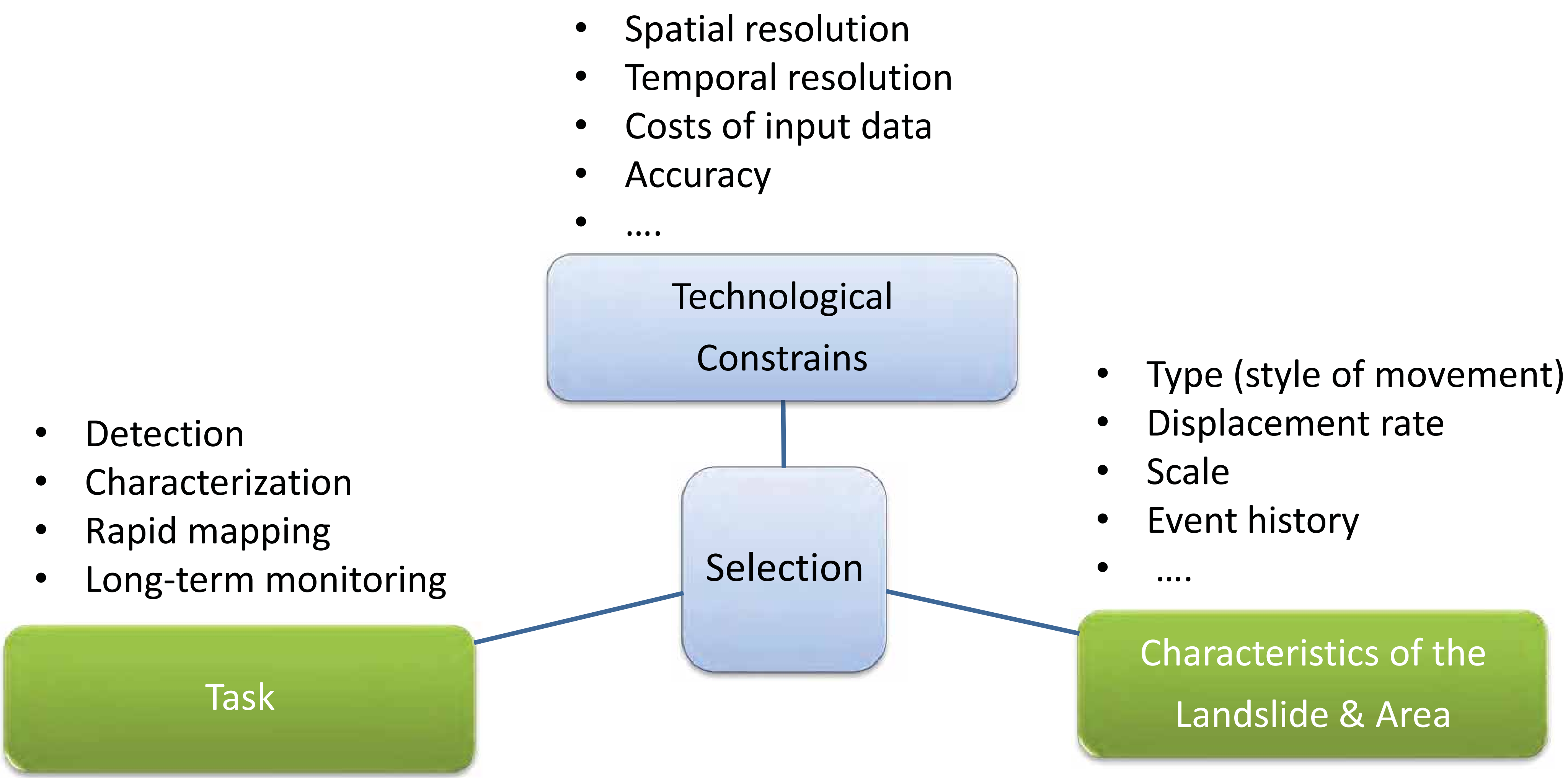
satellite



ground-based

[Kerle et al., 2008]

Criteria for the selection of the appropriate techniques



Criteria for the selection of the appropriate techniques

- Landslide type

Landslide types	Detection			Fast Characterization			Rapid mapping			Long-term monitoring		
	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases
Fall												
Topple												
Rotational slide												

- Displacement rates

	Typical velocity	Detection			Fast Characterization			Rapid mapping			Long-term monitoring		
		suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases
none													
Extremely slow	16 mm /year												
Very slow	1.6 m /year												
Slow	13 m /month												
Moderate	1.8 m /hour												

- Observation scale

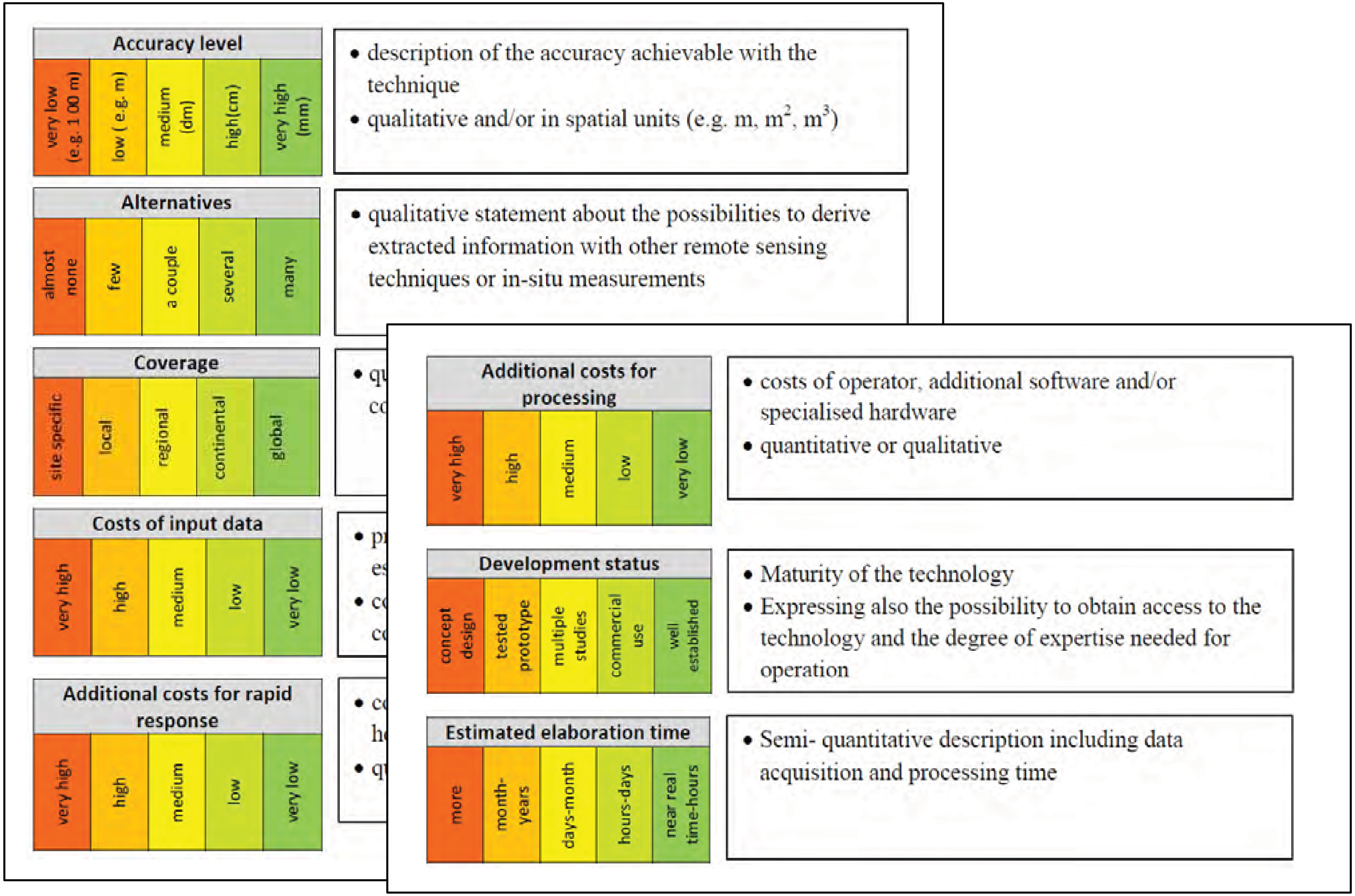
Scale	Detection			Fast Characterization			Rapid mapping			Long-term monitoring		
	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases	suitable in few cases	suitable in some cases	suitable in many cases
1:1000 (and larger)												
1:5000												
1:10000												

Methodology for the setup of the guidelines

- Collaborative online tables fulfilled by scientists for different:
  - *techniques*
    - Passive optical
    - Active optical
    - Microwave
    - Other (airborne geophysics, offshore methods)
  - *platforms*
    - Ground-based
    - Airborne
    - Satellite

- Tables fulfilled according to:
  - *the expertise of the scientist*
  - *the necessity of providing as much quantitative information as possible*
  - *the necessity of providing at least relative qualitative approximations*

Examples of tables used for each technique



Accuracy level				
very low (e.g. 1 00 m)	low (e.g. m)	medium (dm)	high(cm)	very high (mm)

- description of the accuracy achievable with the technique
- qualitative and/or in spatial units (e.g. m, m^2, m^3)

Alternatives				
almost none	few	a couple	several	many

- qualitative statement about the possibilities to derive extracted information with other remote sensing techniques or in-situ measurements

Coverage				
site specific	local	regional	continental	global

Costs of input data				
very high	high	medium	low	very low

Additional costs for rapid response				
very high	high	medium	low	very low

Additional costs for processing				
very high	high	medium	low	very low

- costs of operator, additional software and/or specialised hardware
- quantitative or qualitative

Development status				
concept design	tested prototype	multiple studies	commercial use	well established

- Maturity of the technology
- Expressing also the possibility to obtain access to the technology and the degree of expertise needed for operation

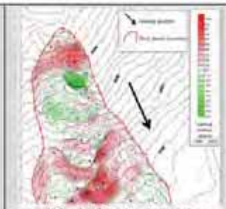
Estimated elaboration time				
more	month-years	days-month	hours-days	near real time-hours

- Semi- quantitative description including data acquisition and processing time

Organisation of the guidelines

- Example of tables for passive observation techniques

Surface reconstruction with close range photogrammetry — A1



modified after Ladstaedter and Kaufmann 2004

Sensor type	Platform	Recording system	System names	Contributing institution	Applicable analysis methods	Method Nr.	Data product
Passive optical sensors	Ground – based, Low-altitude aerial	Metric cameras		ITC	Close range photogrammetric DSM generation (D4.1 Part A:2-3)	A1 (see also A7)	Historical volume budgets, vertical deformation, surface displacement

Accuracy level	Alternatives	Coverage
dm historic; cm with recent systems	Terrestrial LIDAR	Close range, up to 1km distance; Site specific

Spatial resolution	Temporal resolution	Costs of input data
10-50 cm	Historical images usually only recorded every few years	Nil as historical imagery is used

Additional costs for rapid response	Additional costs for processing	Development status
Not assessed	Scanning; Camera calibration	

Estimated elaboration time	Advantages	Limitations
	• Exploitation of already historical imagery • One of the few sources for quantitative historic information on displacement and volumes • Relatively low costs	• Constrains on viewing geometry and gaps in occluded areas • Historic reconstruction only possible where regular surveys had been carried out • Increasingly difficult with low view angles • Inhomogeneous accuracies dependent on the image depth

Visual image interpretation — A7

Sensor type	Platform	Recording system	System names)	Contributing institution	Applicable analysis methods	Method Nr.	Data product
Passive optical sensors	Airborne	Metric cameras - multispectral		ITC	Visual interpretation (high resolution and at least colour information is desirable, D4.1, Part A: 2.2, 3.4, 4.2)	A7 (see also A1-14)	Landslide area, number of landslides, landslide types

Accuracy level	Alternatives	Coverage
Dependent on the interpreter; m; Sometimes dm	VHR satellite imagery	5-25 km^2; Local; Regional

Spatial resolution	Temporal resolution	Costs of input data
25-50 cm	More frequently available since 1990s	More recent 5-10 €/km^2; Low costs for historical imagery, <100 € per scene

Additional costs for rapid response	Additional costs for processing	Development status
Flight crew, airplane…	Work hours of expert	

Estimated elaboration time	Advantages	Limitations
Month-years	• Established method for the creation of landslide inventories • No advanced image processing techniques needed for the analysis	• Subjective, time-consuming

Organisation of the guidelines

- Example of tables for <u>active</u> observation techniques

Airborne LiDAR scanning		B3
	 modified after Van Den Eeckhaut et al. 2011	

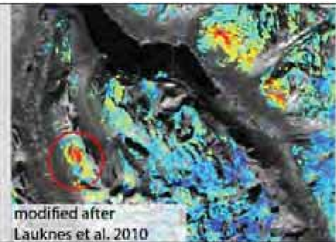
Sensor type	Platform	Recording system	System names	Contributing institution	Applicable analysis methods	Method Nr.	Data product
Active optical sensor	Airborne	LiDAR	e.g. Optech ALTM	JRC	Visual interpretation, morphostructural analysis (D4.1 Part B: 4), Object-oriented analysis (D4.3: 3.3 and 3.4)	B3	x, y and z coordinates of million points, areas, volumes, displacement

Accuracy level					Alternatives					Coverage					
		dm	cm							Max. range up to 6 km (typically from 1 up to 3 km)		Local	Regional scale		

Spatial resolution	Temporal resolution	Costs of input data				
0.1- >30 points/m²	(month) typically years	Higher for higher point densities	0.5 points/ m² over large areas, around 100- 300 €/ m²			

Additional costs for rapid response					Additional costs for processing					Development status				
	Plane	Crew				Large datasets	Highly specialised software					Analysis	Data acquisition	

Estimated elaboration time					Advantages	Limitations
	Expert interpretation		Point-cloud processing	Hours for scanning	• High accuracy • Near nadir viewing • Software tools for post-processing widely available • Useful in vegetated areas (LiDAR pulses may penetrate through canopy) • Major teething problems have been solved by now	• Rather expensive • Data collection can occur beneath clouds and in some haze, but because water absorbs most near infrared light, it will not operate correctly during fog, rain, or snow. • Bad coverage in steep terrain (e.g. cliffs)

Small baseline spaceborne SAR (C-band)		C9
	 modified after Lauknes et al. 2010	

Sensor type	Platform	Recording system	System names	Contributing institution	Applicable analysis methods	Method Nr.	Data product
Active micro-wave sensors	Satellite	InSAR (C-band)	ERS-1/2, ENVISAT SAR	UNISA	SBAS - Small baseline subset (D4.1: 4.3.1 and Case study 11)	C9	3D reconstruction of landslide displacements

Accuracy level					Alternatives					Coverage					
				mm						Swath width:50-100 km					

Spatial resolution	Temporal resolution	Costs of input data					
80 x 80 m² for full-resolution data; 10 x 10 m² for high-resolution data	35 days						Min. 15 scenes, 0.6 €/km² (ERS, archive)

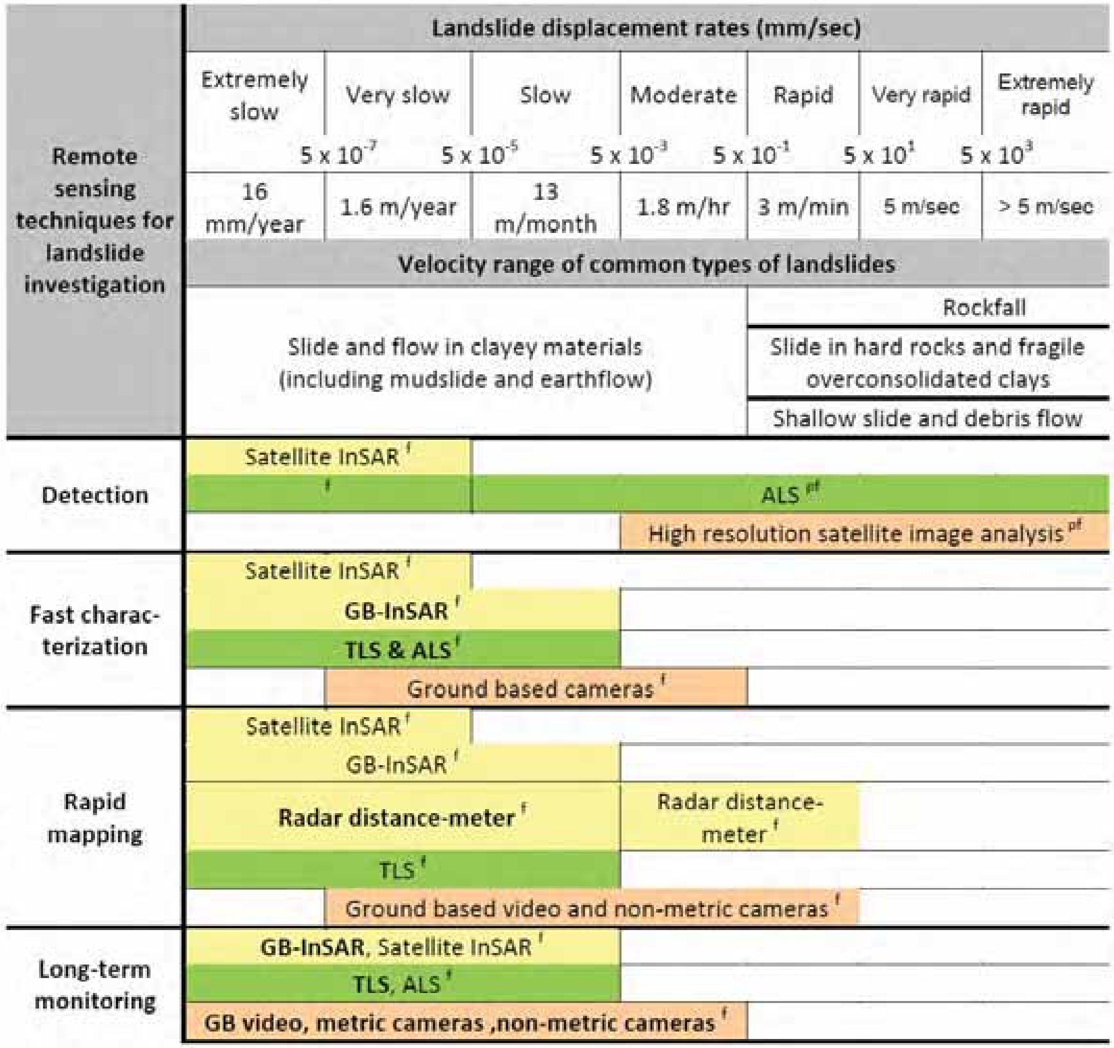
Additional costs for rapid response				Additional costs for processing				Development status				
		2 €/ km²	0.2 €/ km²									

Estimated elaboration time				Advantages	Limitations
			3 weeks for a 30 image data-set	• Fast data processing / low user interaction • High point density in urban areas • High accuracy • Cost-effective, regular updates over large areas • Easy data-integration in standard GIS	• Not applicable in densely vegetated and forested areas • costly for specific local analysis • Low-reflectivity areas (e.g. smooth surfaces and certain materials). • Temporal sampling limited by satellite repeat-cycles • Only "slow" deformation can be measured (<10 cm/yr in LOS) • difficult anticipation of PS distribution in an area • SAR data must be acquired by the same satellite

Organisation of the guidelines

➔ Synthetic tables for the selection of suitable methods

- *for different landslide types*
- *according to their expected velocity and their activity state* (pre-failure, failure, post-failure)
- *the tasks in risk management*



Conclusion

SafeLand

Grant Agreement No.: 226479

SafeLand

Living with landslide risk in Europe: Assessment, effects of global change, and risk management strategies

7th Framework Programme
Cooperation Theme 6 Environment (including climate change)
Sub-Activity 6.1.3 Natural Hazards

Deliverable D4.4

Guidelines for the selection of appropriate remote sensing technologies for monitoring different types of landslides

Work Package 4.2 – Remote Sensing technologies for landslide detection, monitoring and rapid mapping

- Comprehensive base for the comparison of relevant monitoring techniques

- Guidelines and checklist for scientists and stakeholders to select among the most relevant / suitable techniques according to criteria

- A guidepost to experts and relevant websites for specific services (e.g. Safer, Doris, GMES, Pléaides, Sentinel, etc) and processing softwares (commercial, open source)

Conclusion

- Guidelines presented and discussed at ESA Forum in May 2012, Santorini


SEVENTH FRAMEWORK PROGRAMME

SafeLand

Grant Agreement No.: 226479

SafeLand

Living with landslide risk in Europe: Assessment, effects of global change, and risk management strategies

7th Framework Programme
Cooperation Theme 6 Environment (including climate change)
Sub-Activity 6.1.3 Natural Hazards

Deliverable D4.4

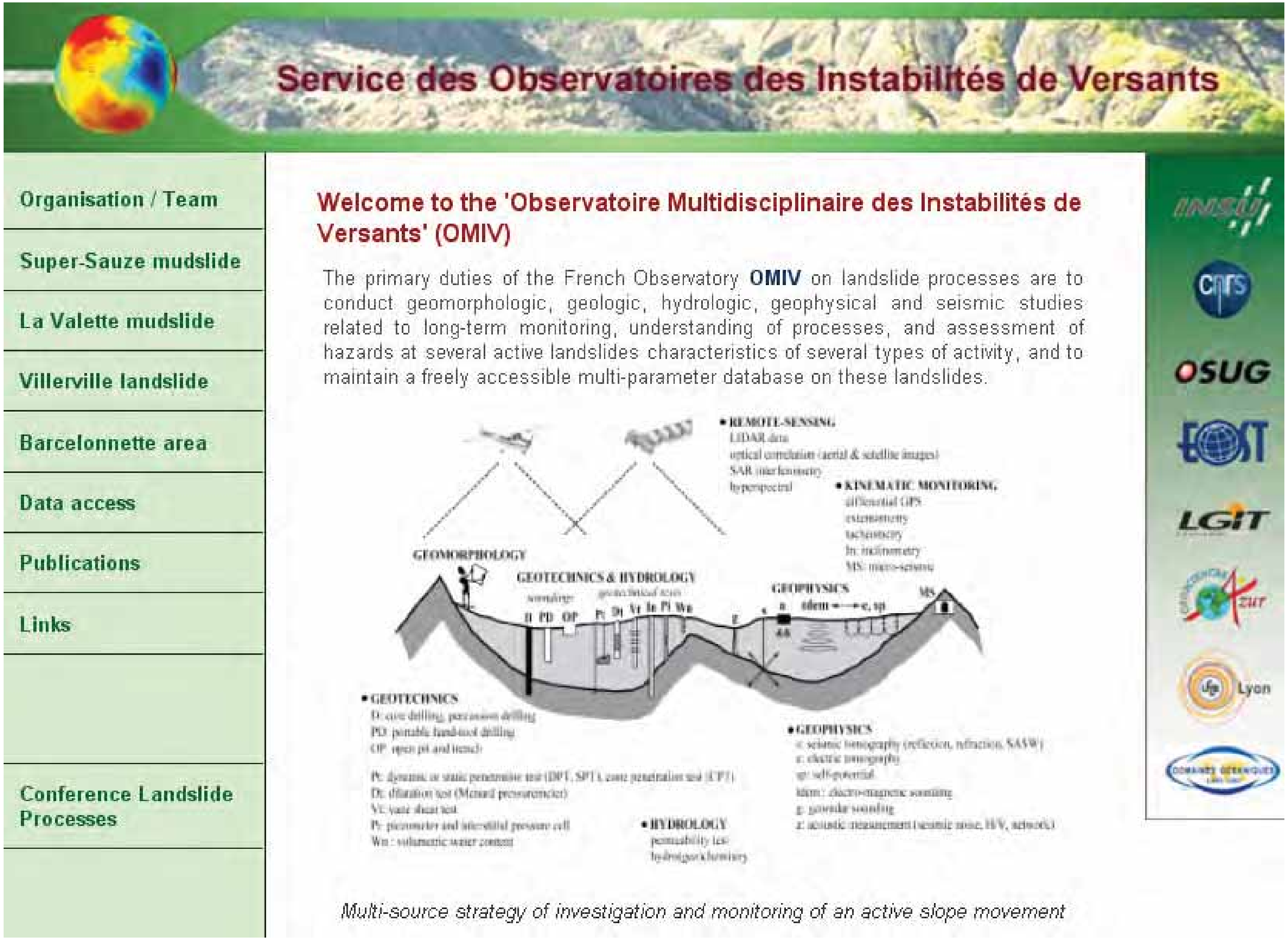
Guidelines for the selection of appropriate remote sensing technologies for monitoring different types of landslides

Work Package 4.2 – Remote Sensing technologies for landslide detection, monitoring and rapid mapping

- Guidelines presented in a manuscript submitted to *ESR – Earth Science Reviews* (Stumpf, Malet, Kerle, Michoud, Jaboyedoff & Casagli)

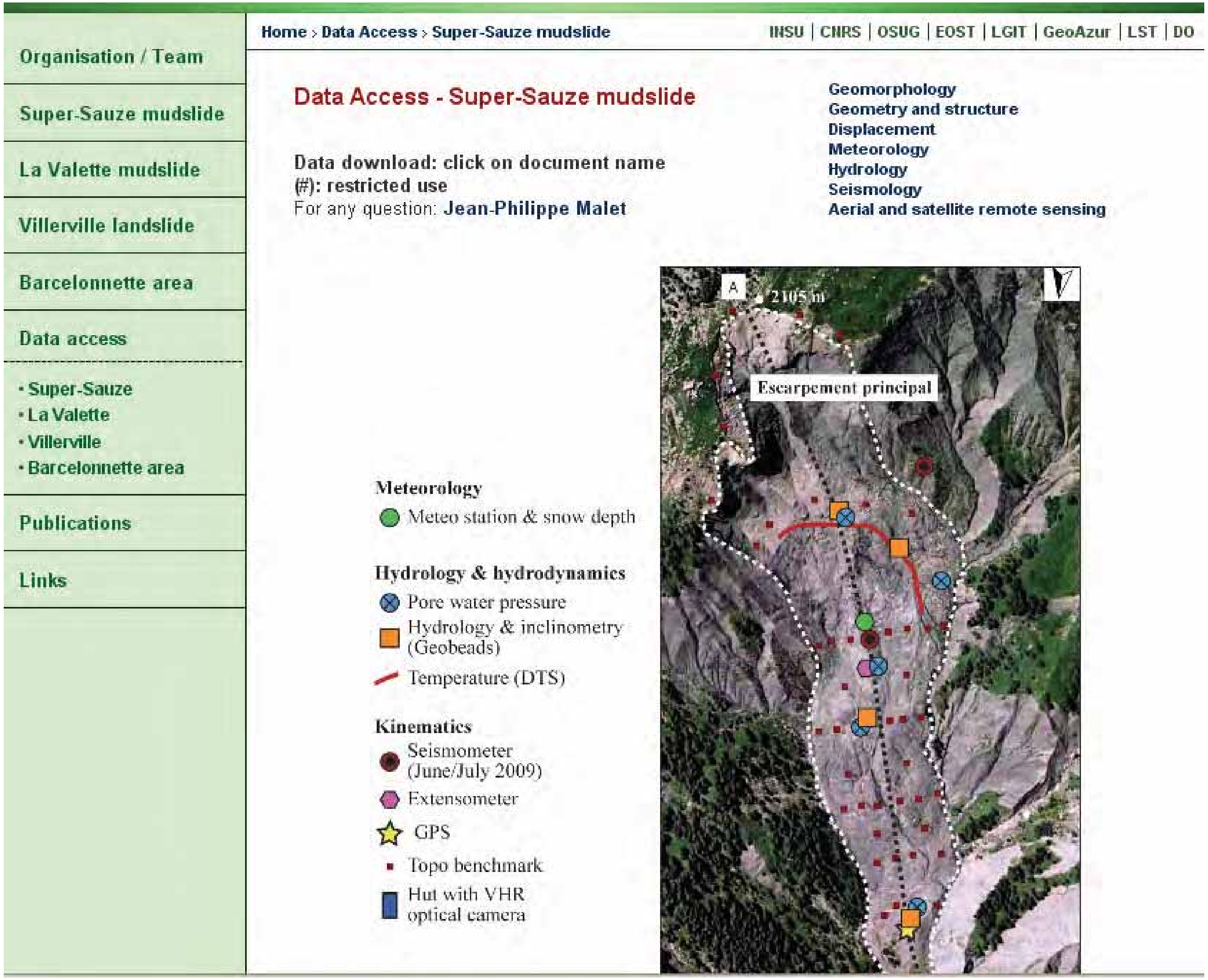
Conclusion: towards “Landslide Observatories”

omiv.osug.fr

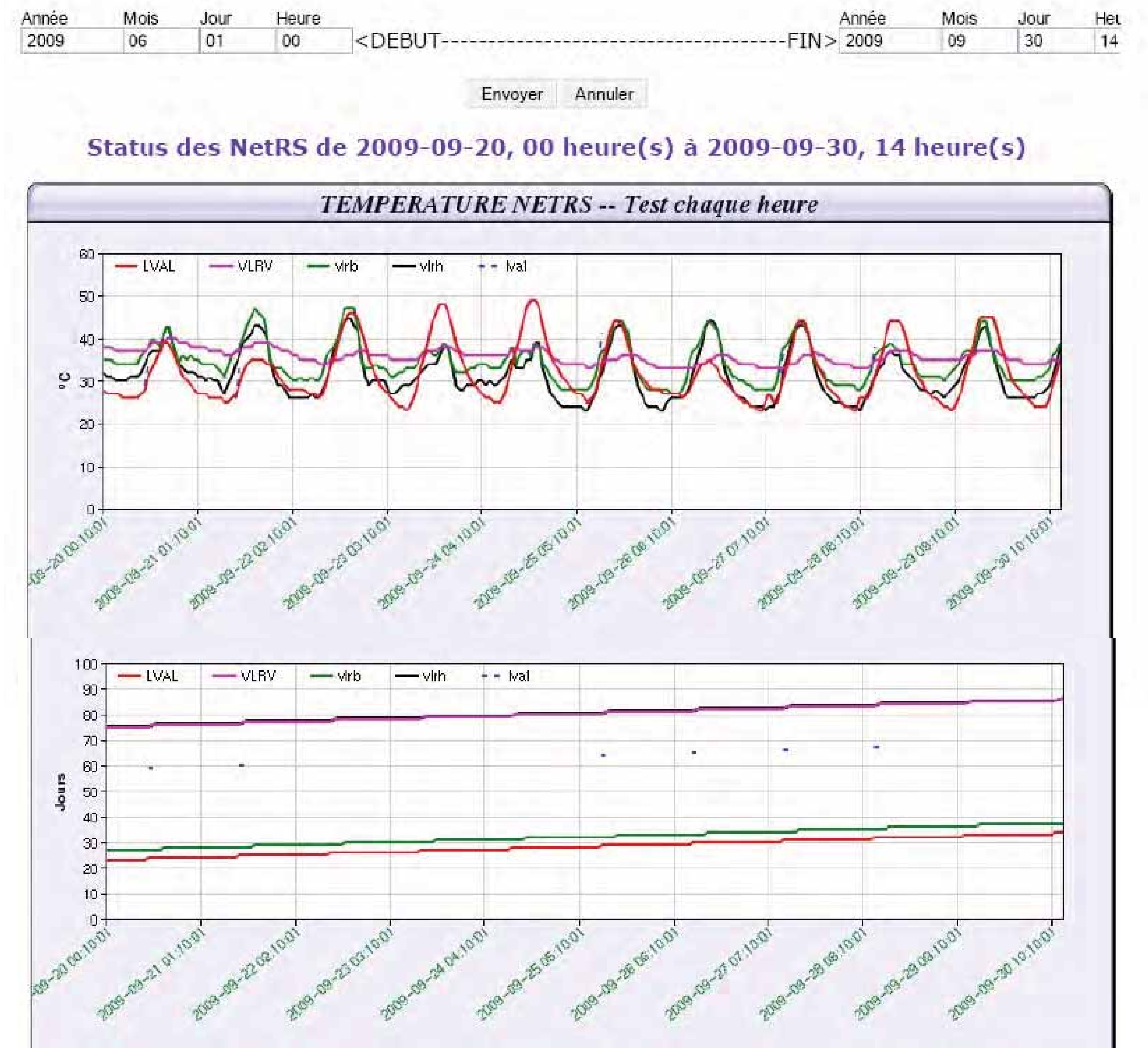


Conclusion: towards “Landslide Observatories”

Sharing ‘long-term’ landslide data for research



Sharing 'long-term' landslide data for research



Continuous monitoring by dGPS and baseline processing at Day+1

Questions, suggestions, remarks?