Committee on Earth Observation Satellites

Landslide Pilot to Demonstrator Working Group Presentation

March 9th, 2021

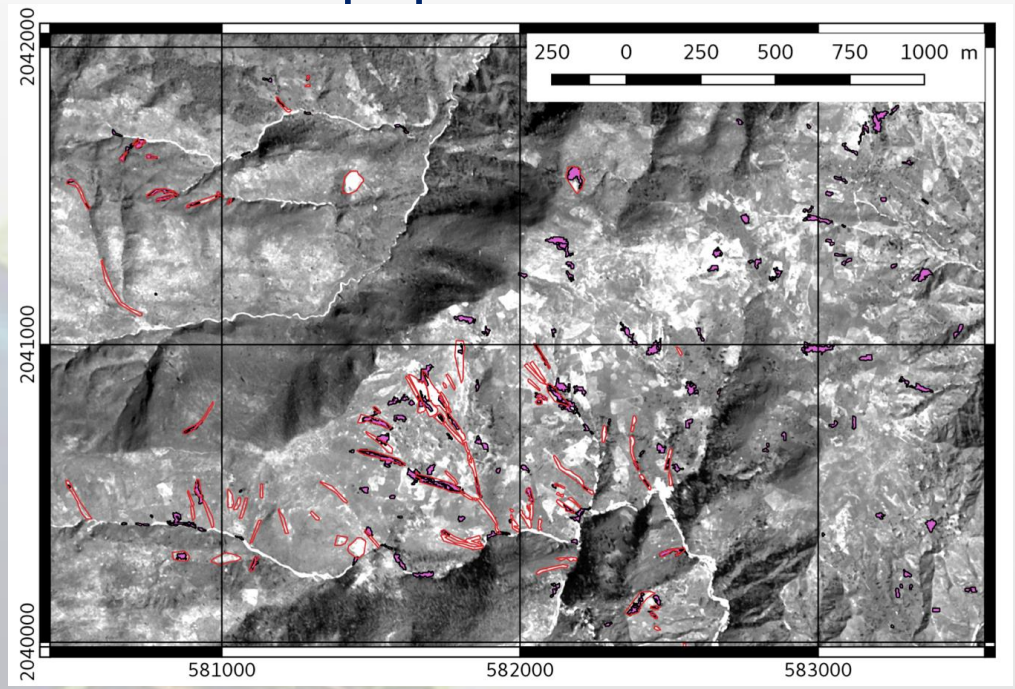
Overview

- Lessons learned and achievements from the Landslide Pilot
- Presentation by CSA
- Plans and current activities for the Landslide Demonstrator

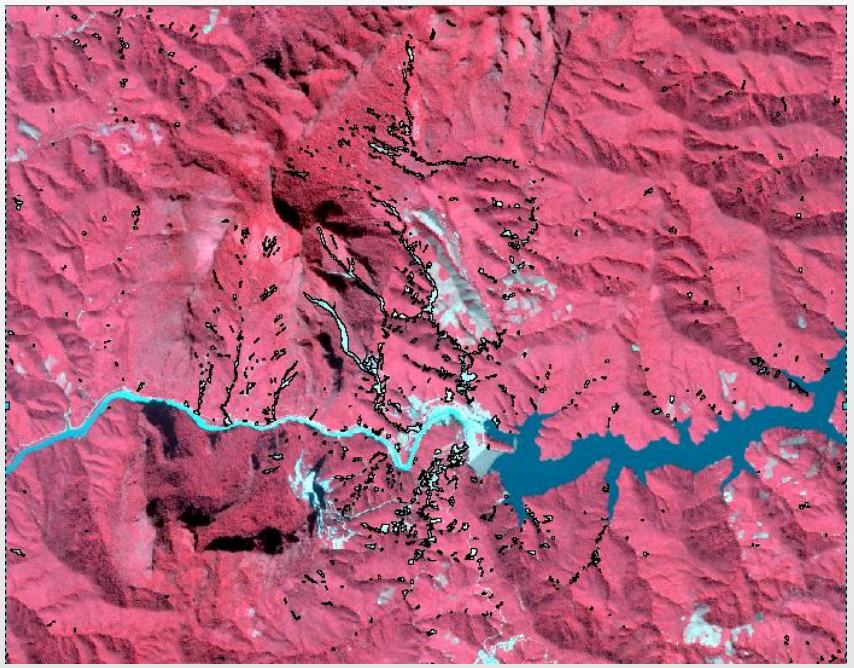
Achievements of Landslide Pilot

- Advancements in Landslide Mapping:
  - ALADIM (Strabourg) and SALaD (NASA) algorithms were developed for VHR optical (Pleiades and Planet) to advance modeling capabilities. Methodologies and results were compared and used during disasters to inform local populations about landslide hazard

ALADIM mapped landslides in La Reunion Island from Hurricane Matthew



Aline Déprez & Jean-Philippe Malet (CNRS/EOST)

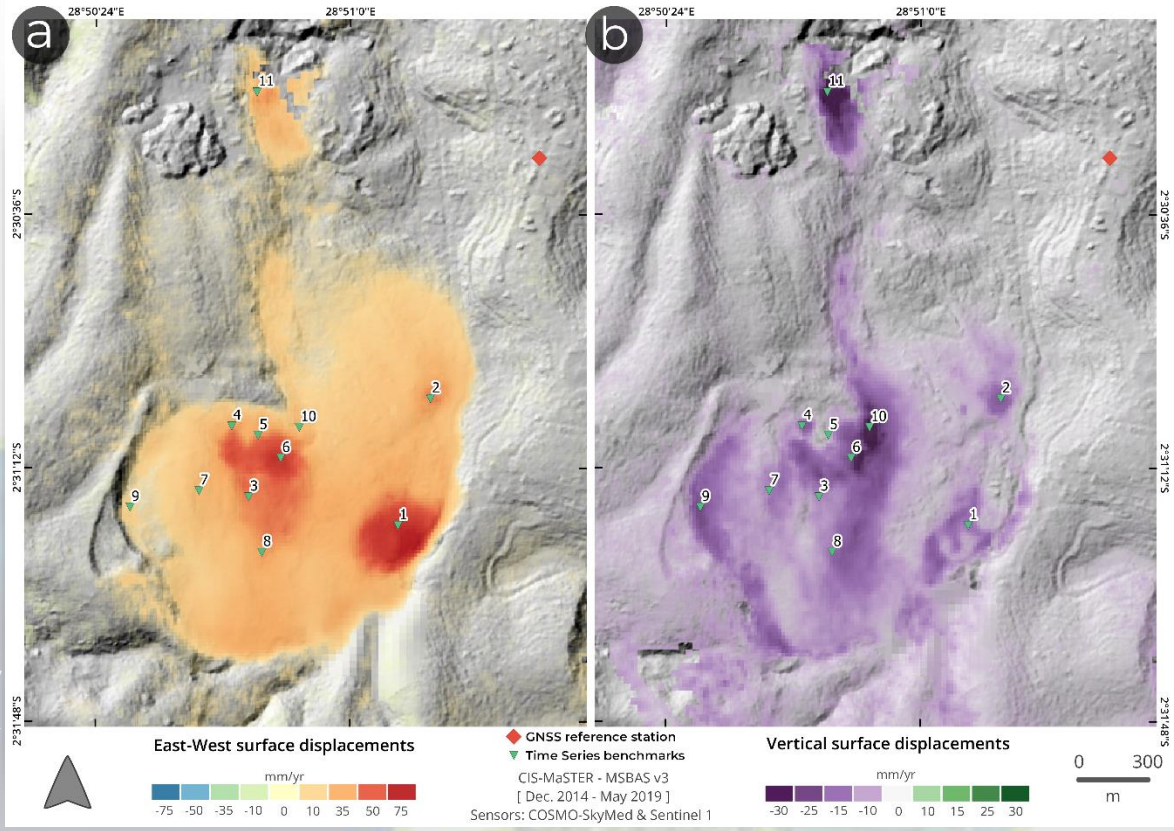


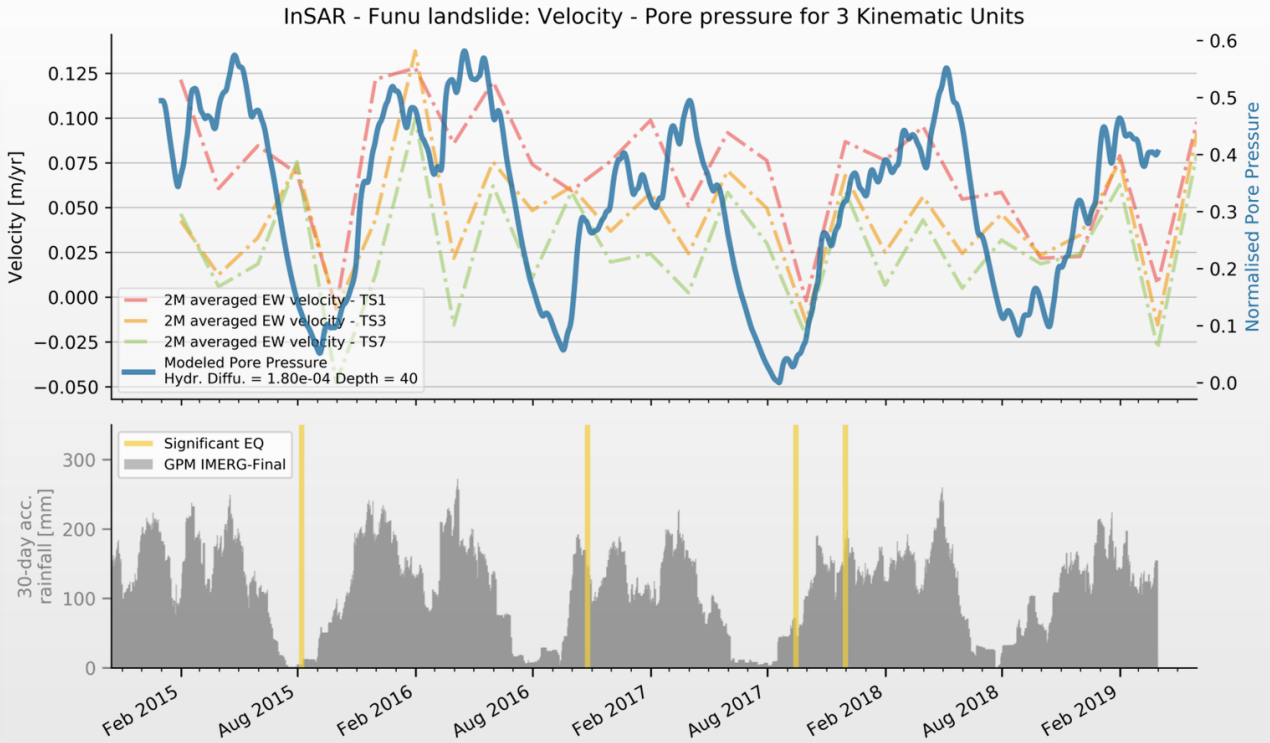
SALaD-based inventory using Planet in Vietnam

Pukar Amatya (NASA/USRA)

Achievements of Landslide Pilot

- Demonstration of SAR for slow moving events



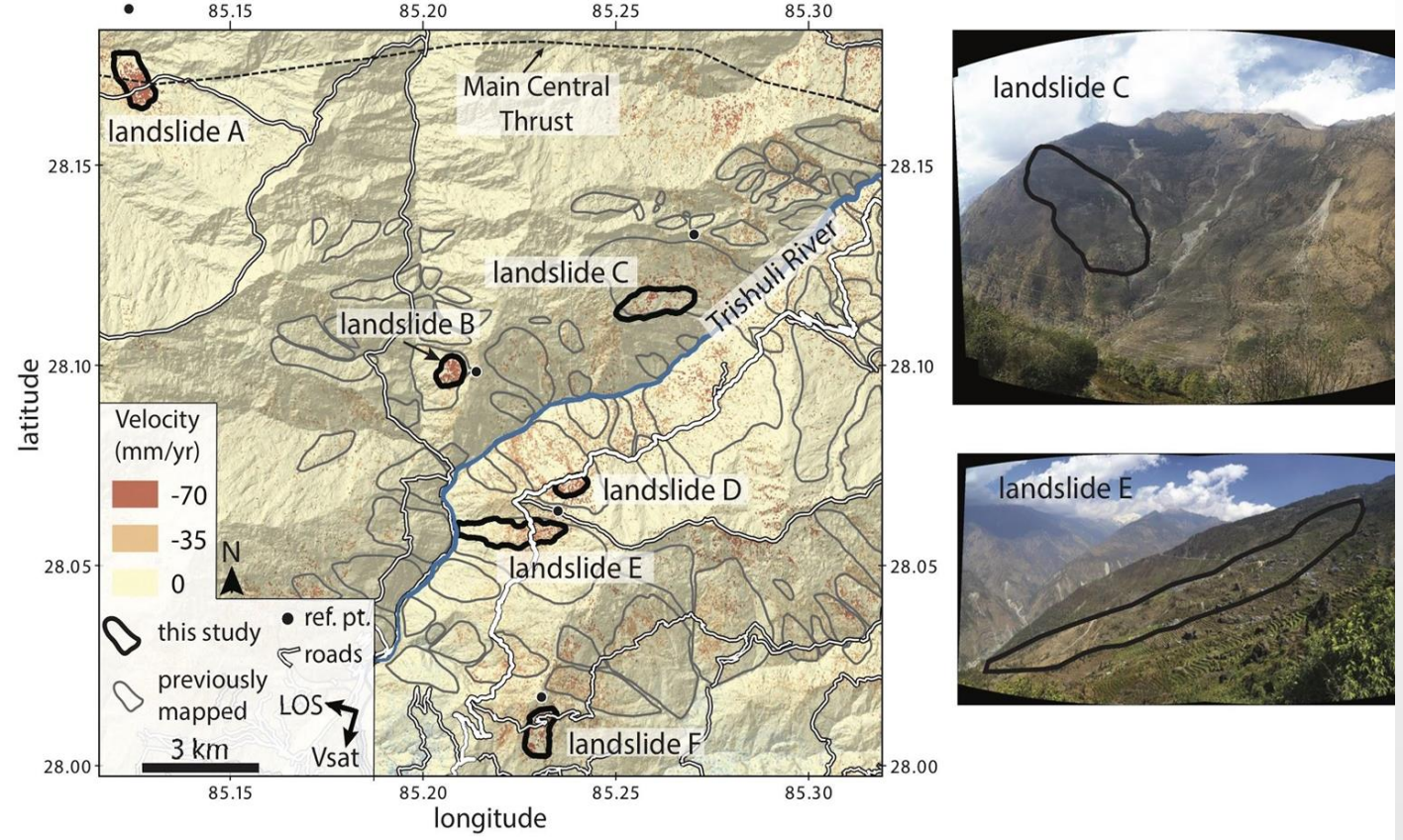


Processing of **>500 CSK and S1 images through MSBAS processing chain**

- **3.5 year time series**

Achievements of Landslide Pilot

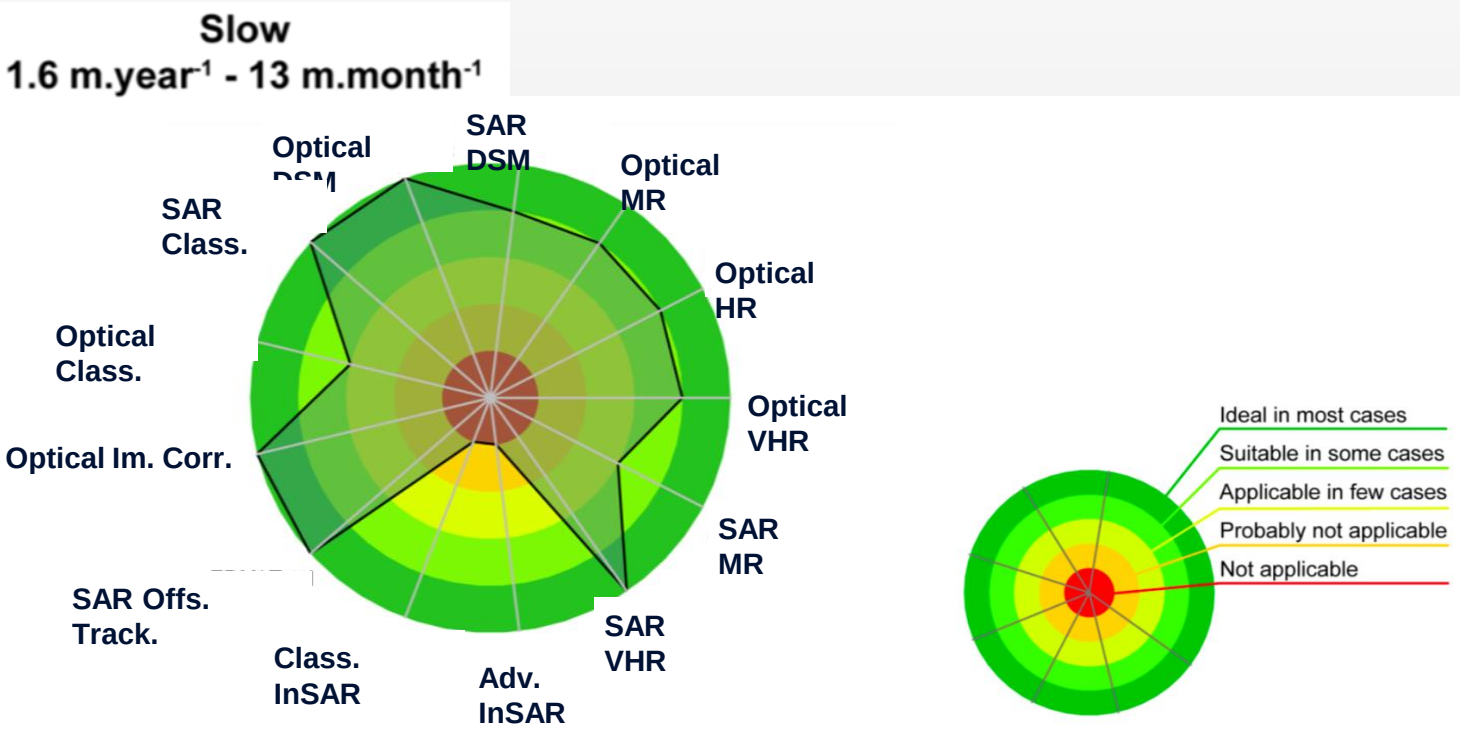
- Demonstration of SAR for slow moving landslides



Bekaert et al. 2020, Nepal-based slow moving landslides using InSAR time series from Sentinel-1B. Field validated by other Pilot participants (N. Rosser)

Achievements of Landslide Pilot

- Establishment of guidelines and relevant criteria for the operational use of EO (satellite) data for landslide detection, mapping and monitoring at several spatial scales

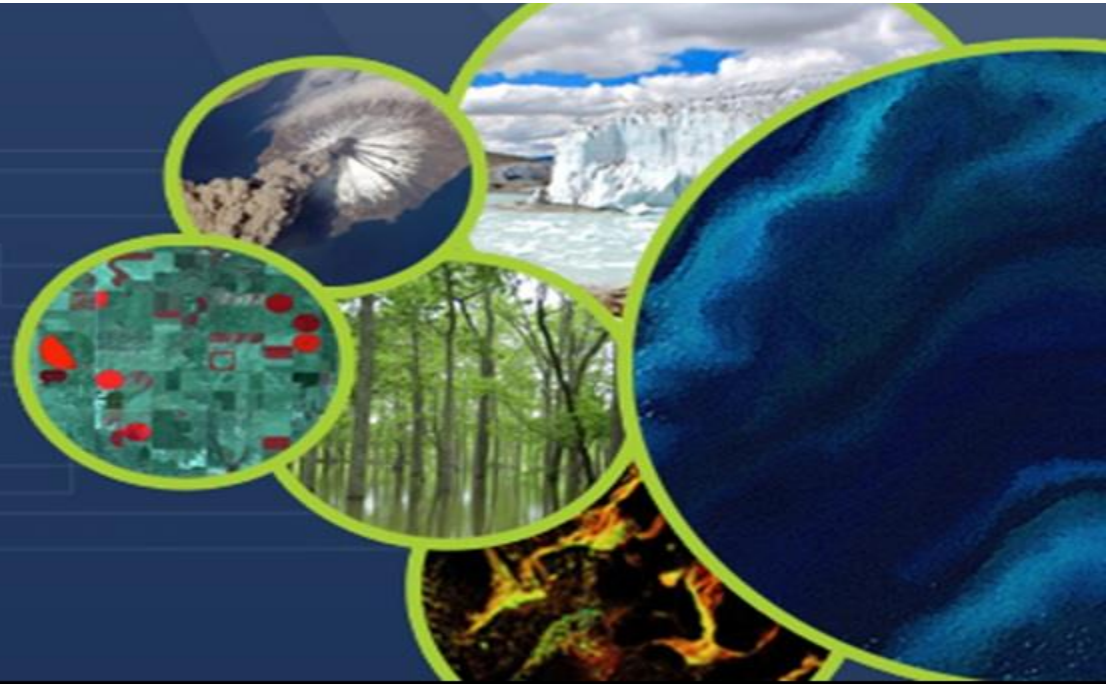


Technological criteria

Criteria	Scale range	Explanation
Spatial coverage	Local (e.g. slope) Regional	Typical scales at which the measurements are carried out.
Information type	Landslide location	Geographical position of the landslide
	Landslide size	Geographical position and extent of the landslide
	Landslide volume	Volume of the landslide
	Landslide displacement fields	1D (one component of the displacement or change along a spatial axis or along the Line-Of-Sight -LoS- of the sensor), 2D (horizontal displacement field), 3D (3D displacement field)
	Landslide surface features	Time and space evolution of typical landslide surface features (cracks , boulders)
Spatial resolution	10^{-1} to 10^{2} m	Typical spacing of individual measurements
Temporal resolution	Days to months	Typical time lag between individual measurements
Measurement accuracy	10^{-1} to 10^{2} m for size 10^{1} to 10^{3} m^3 for volumes 10^{-1} to 10^{2} $m.day^{-1}$ for displacement rates	Accuracy of the measured quantities such as displacement rates, volumes and the location of surface features
Operation mode	Continuous – data flow type processing	Automatic calculation can be carried out without human intervention for long time periods and for each new sensor images
	Campaigns – on-demand processing	Measurements require regular human intervention and are thus typically carried at intervals of several days, weeks or months.
Approximate elaboration time	minutes to days	Approximate time lag between the measurement of the system and the production of the output results.
Approximate costs	XXXX $	Typical costs including sensor data acquisition and processing
Technological maturity	Concept	Technical design and potential applications have been proposed.
	Prototype	Working prototypes have been tested in a limited number of experiments.
	Case-studies	Operating systems have been tested for landslide applications for short time periods.
	Commercial	Working systems and processing softwares are

Landslide Demonstrator

“EO-based Landslide services: Paving the Way for Landslide Risk Management Products”



Plan for Landslide Demonstrator

Landslide demonstrator builds on the outcomes of the Landslide Pilot and identifies three key areas in which landslide hazard and risk modeling and characterization may be advanced to support different end user communities.

- **Application 1**: Use satellite data for landslide disaster assessment and mitigation along **transportation and pipeline corridors**, with goal of establishing local monitoring of areas of possible danger with regularity and consistency of observation, and of facilitating the assessment of the future evolution of these slopes

- **Application 2:** Use of satellite data for establishing **landslide risk financing products** (country or region risk profiles, hazard and risk maps) in full complementarity with the World Bank Disaster Risk Financing and Insurance Program (DRFIP).

- **Application 3:** Coordinate and expand the availability of landslide inventories and supporting data to advance **landslide science** at global scale, with the systematic documentation of large landslide disasters triggered by intense rainfall and/or high magnitude earthquakes in terms of standardized inventories of different complexity.

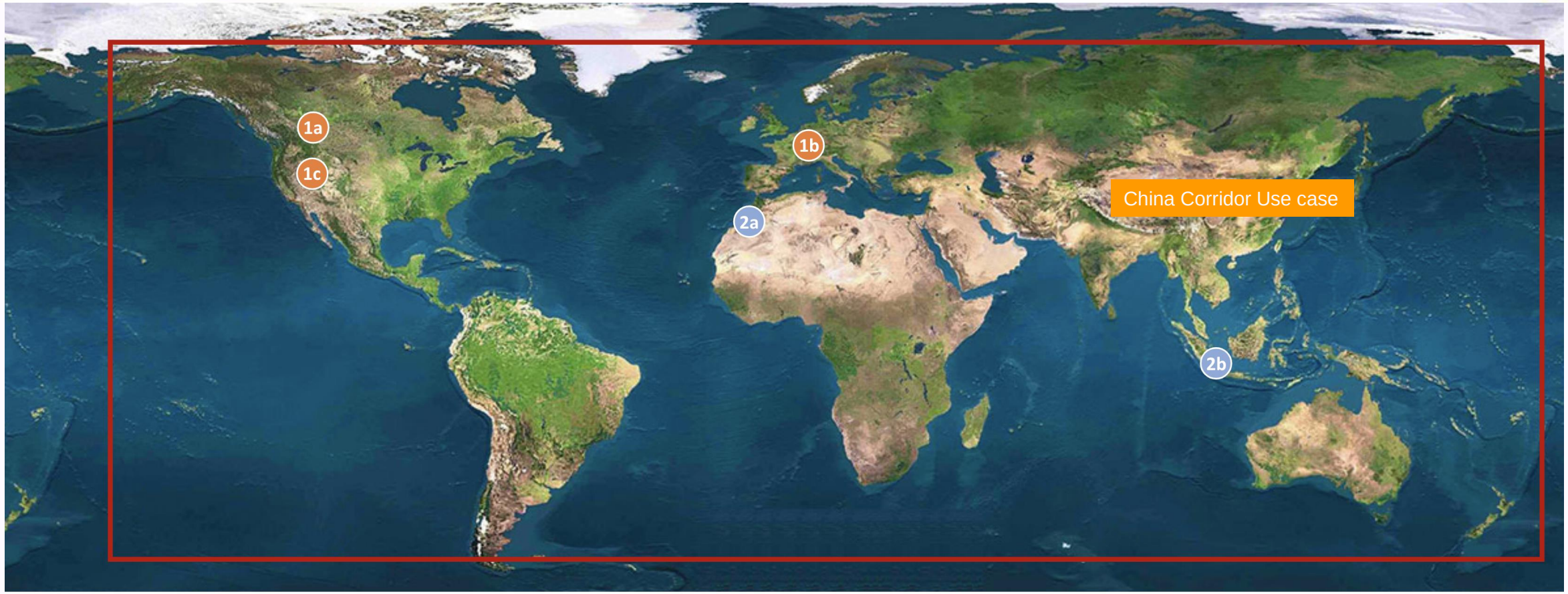
Landslide Demonstrator Objectives

Demonstrator Leads

Jean-Philippe Malet (University of Strasbourg)
Dalia Kirschbaum (NASA)
Corey Froese (BGC Engineering)
Clément Michoud (Terranum)

- Showcase satellite tailored services and products for the 3 thematic applications over relevant areas of interest for the 2021-2023 period;
- Document the data and services with the creation of on-line demonstration/dissemination materials in order to extend the use of the data and services to a larger partnership of *landslide DRM stakeholders* for regular use of satellite imagery, on-line processing services and derived products;
- Engage and expand multi-sectorial partnership by providing timely support (in best effort mode) to the 3 thematic applications and facilitating the provision of satellite-derived products, access, and support for use of services.

Use cases



CEOS Landslide Demonstrator

- Application 1 / Corridor (1a: Canada/Alberta – Swan Hills, 1b: France-Italy-Swiss - Aosta/Wallis/Arve , 1c: US – Midwest)
- Application 2 / DRF (2a: Morocco / Rif-Tetouan-Tanger, 2b: Indonesia)
- Application 3 / Inventories

Application 1: Transportation Corridors

Application 1: A demonstrator for the operational landslide monitoring of traffic and pipeline corridors (China, European Alps, US, Canada)

Demonstrator Leads: Jean-Philippe Malet (CNRS/EOST) and Corey Froese (BGC)

Industry Participants: Highway/Train companies, Pipelines companies, Engineering Geology Bureaux, State offices

Pipelines to be protected

Methodologies

- Use of InSAR-PSI techniques to monitor slow-moving deformation patterns
- Use of optical derived techniques to monitor fast-moving deformation patterns
- Definition of procedures to propose permanent monitoring services over the uses cases as demonstrator

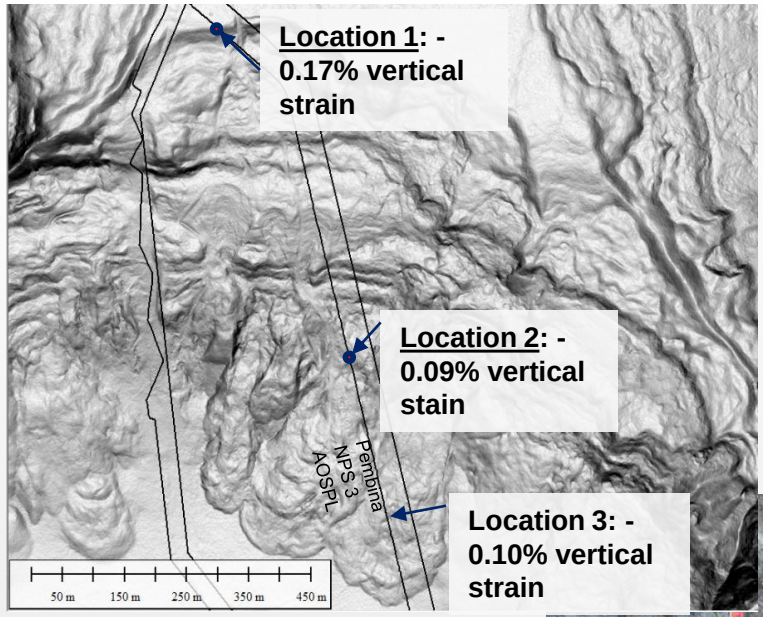
East France – March 2020 – landslide on high speed train TGV

Elkhorn city (Kentucky, US) – February 2020 – shallow landslide / mudflow

Application 1: Transportation Corridors

EO to be applied across **several phases of risk management**:

- **Identification:** Where are landslides and how fast are they moving?
- **Hazard/Risk Analysis:** What are the relations between landslide movement and climate?
- **Monitoring and Warning:** Can we utilize EO, coupled with landslide models, to provide operational early warning



Application 2: Landslide Risk Financing

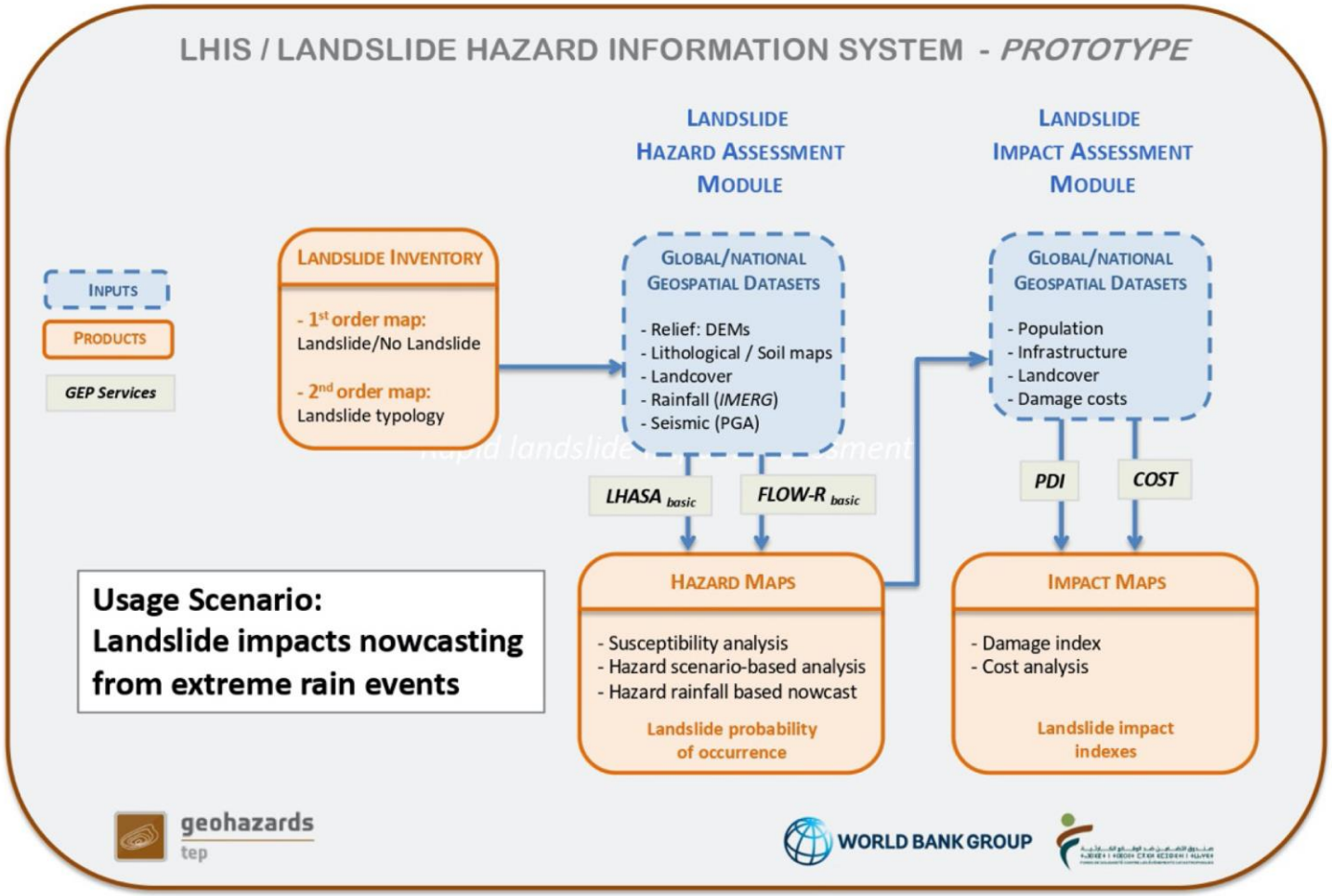
Application 2: Operational Landslide EO Products for Disaster Risk Financing and Insurance Program (World Bank)

Demonstrator Leads: Clément Michoud (Teranum) and Jean-Philippe Malet

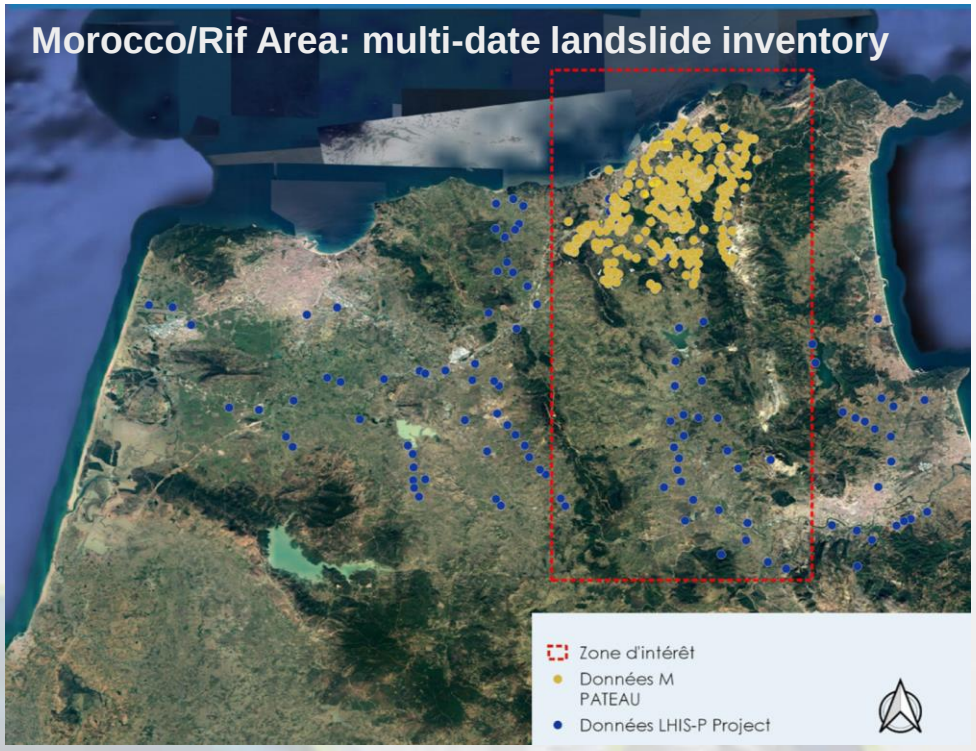
Industry Participant: World Bank

Goal: implement a processing platform prototype to respond to likely landslide events (in Near-Real Time, NRT) in order to provide estimates of parameters suitable to inform parametric insurance calculations.

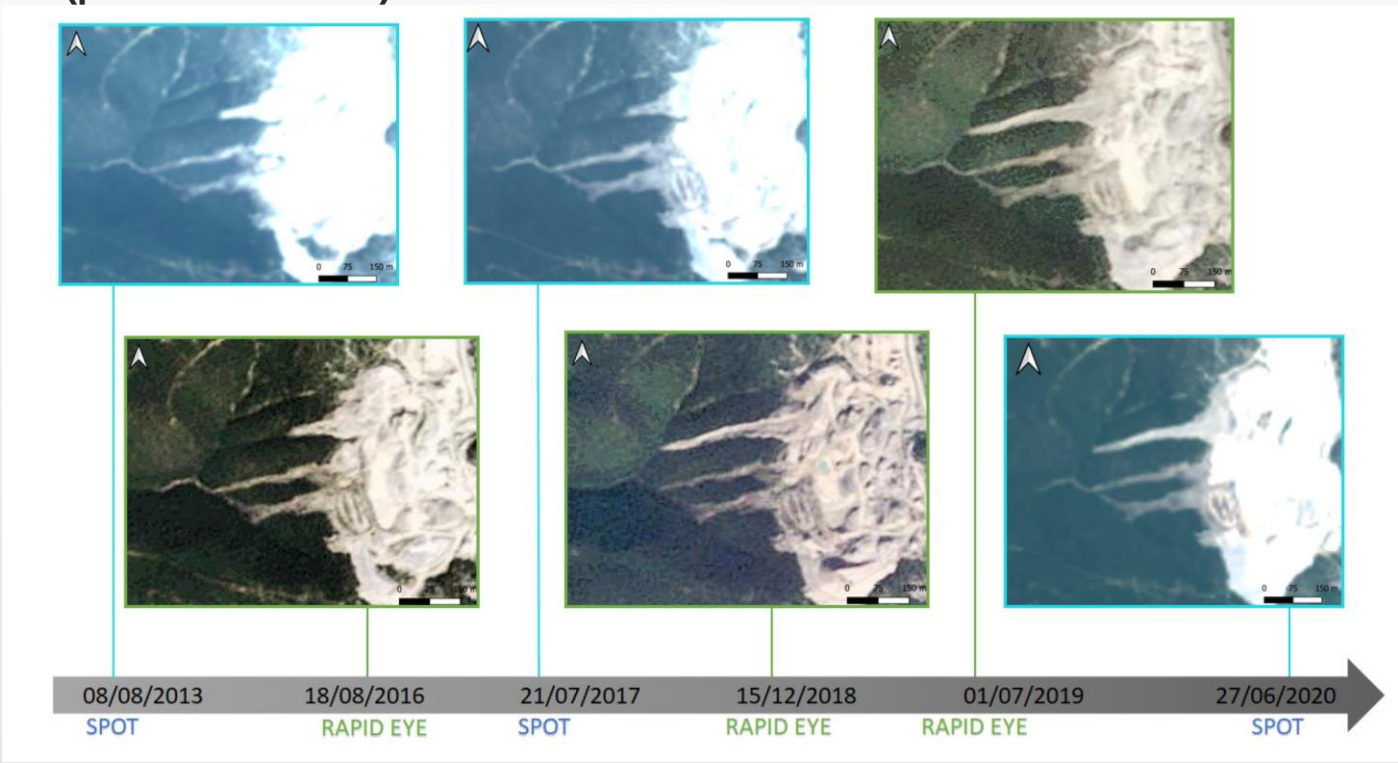
Development and stress-tests of services and products over Morocco, but all the development will be generic to be easily transferred to other countries and risk situations (especially in SE Asia).



Application 2: Landslide Risk Financing

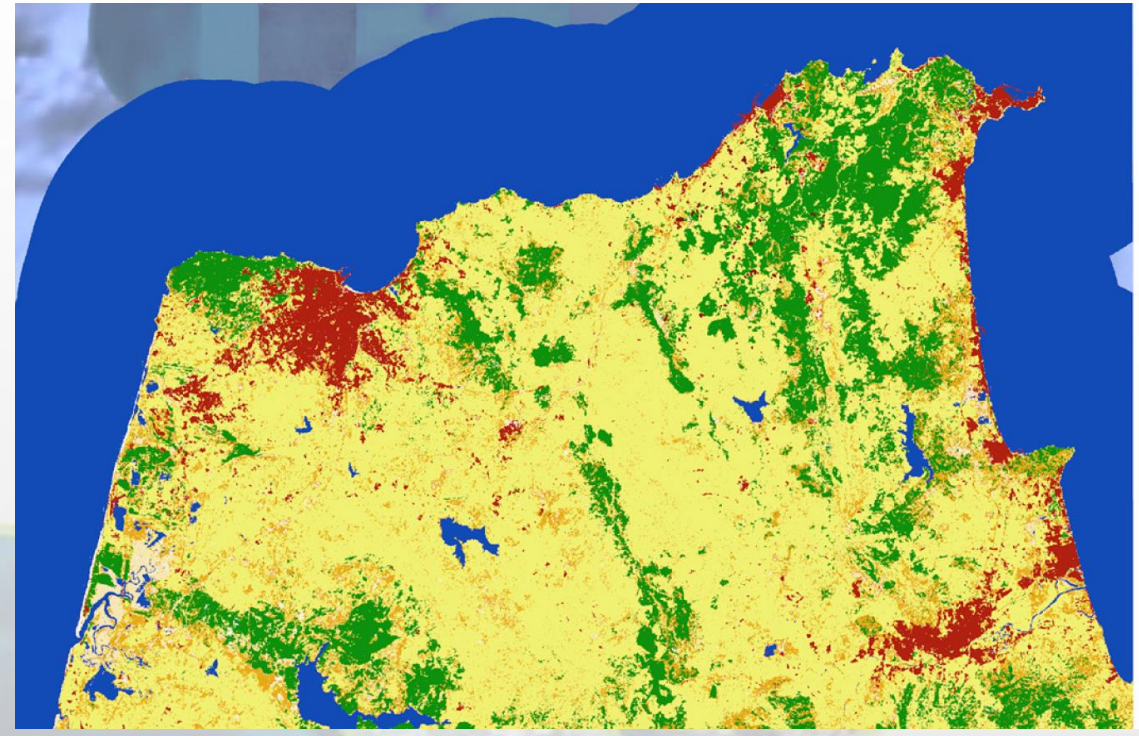


Use of a combination of visual/expert interpretation and ALADIM service (period 2013-2020)

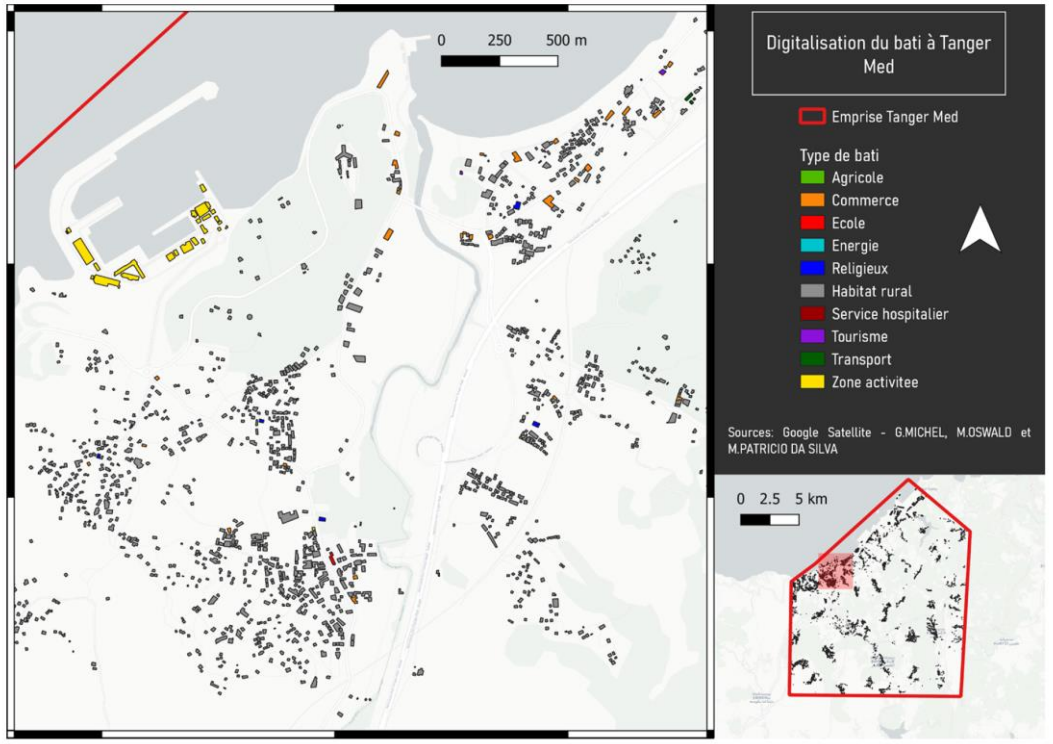


Application 2: Landslide Risk Financing

Morocco/Rif Area: global landuse at 20 m from Sentinel-2



➔ Hazard and risk modelling on-going (LHASA – Flow-R – PDI/Cost)



Morocco/Rif Area: local landuse at 1 m from VHR imagery (Tanger Med harbour)

Application 3: Global Landslide Data

Application 3: Advancing EO-based landslide inventories for extreme forcing events (heavy rains, high-magnitude earthquakes)

The goal of this application is to coordinate and share methodologies for the establishment of landslide inventories accross different geologic and morphologic zones. In this activity we will proose standard for creating and publishing EO-based landslides inventories, with the goal of develoing an online open system to share algorithms and inventories using SAR and optical methodologies. This work will be done in coordination with the newly formed LandAware consortium's Data Working Group, with EGS (EuroGeoSurveys) and with JRC

Methodologies

Inventories

- New, open methods for SAR and optically-derived inventories. Definition of quality criteria for validating EO-based inventory and store the information, data standards
- System to store and disseminate inventories on-line

Models

- Comparison and sharing of models that provide automatic mapping capabilities and calculation of advanced statistics from the EO database.
- Establish correlation with triggers (thresholds, scaling laws) for benchmark inventories.

Demonstrator Leads: Dalia Kirschbaum, Jean-Philippe Malet (CNRS/EOST) and Olivier Dewitte (RMCA).

Industry Participants: LandAware Consortium, World Landslide Forum, USGS, EuroGeoSurveys, JRC and other geological mapping agencies

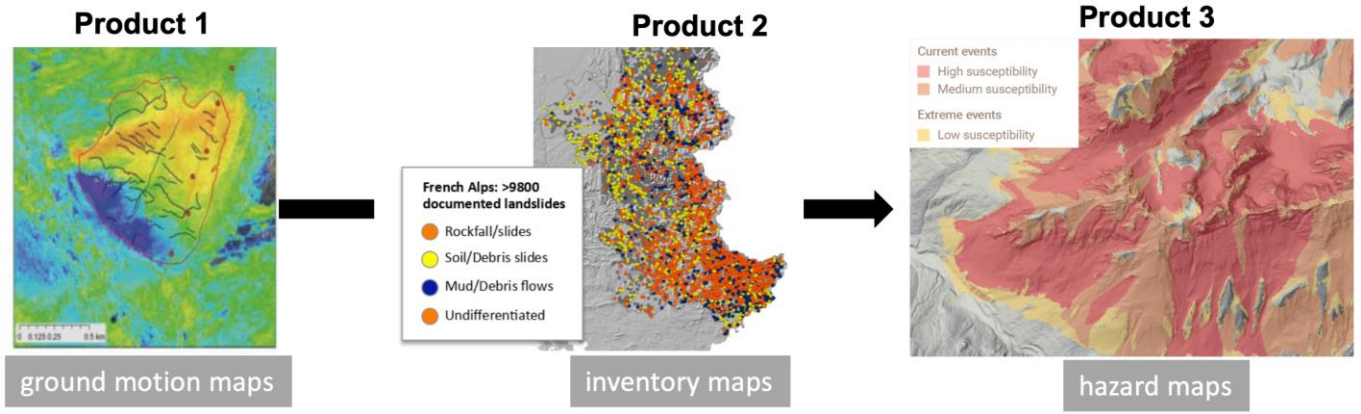
Application 3: Global Landslide Data

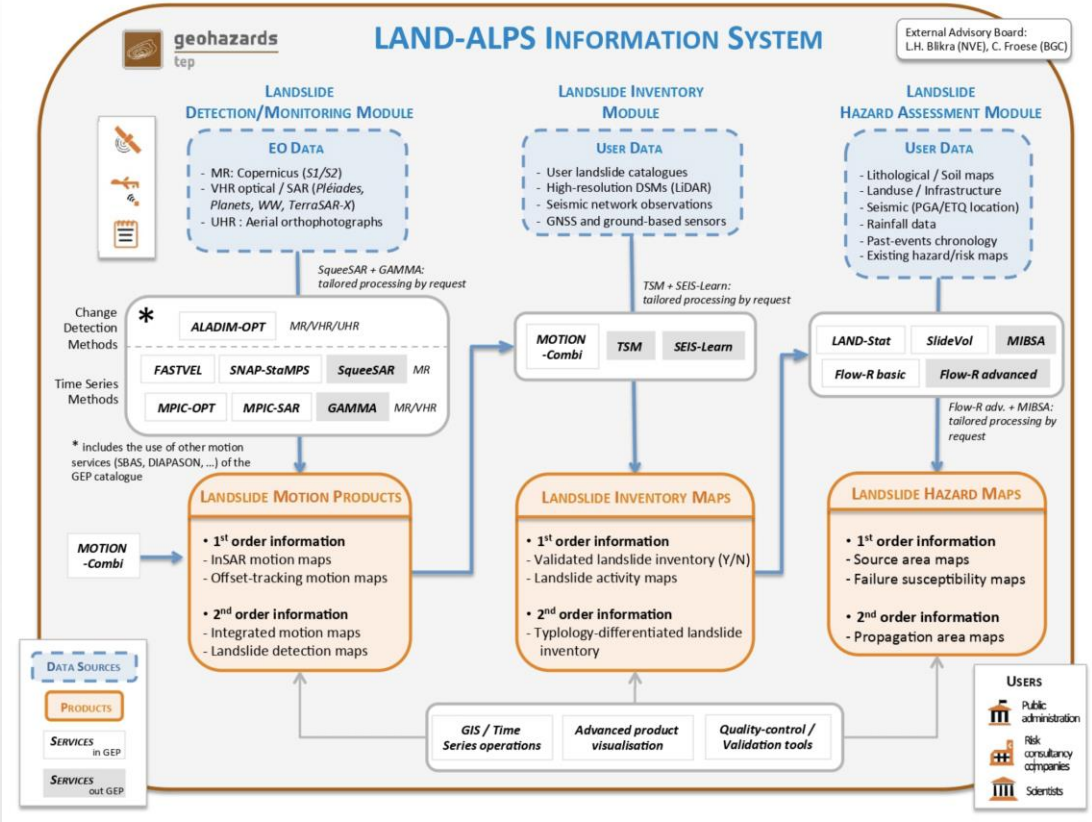
- Kirschbaum (NASA) and Mirus (USGS) co-leading a Landslide Early Warning System Data Working Group
- LandAware Kickoff Meeting, December
- LEWS Data WG Kickoff: January 2021
- **Topics:**
  - LEWS Data Review – White Paper and Journal Article
  - Collection of Benchmark Datasets
  - Repository and Metadata for inventories and other products

Application 3: Global Landslide Data

ESA is financing the development of an operational App for systematic landslide inventory from multisource data

eo4Alps-landslide - Geo-information Services for Landslides in the Alps: implementing systematic regional products for landslide hazard in the Euopean Alps. Set the basis for the creation of harmonized and advanced landslide inventories and susceptibility/hazard maps based on EO ground motion services linked to advanced modelling capabilities. Strong engagement of end-users.





→ **An ecosystem to be later implemented for other mountain ranges / countries**

Demonstrator Timeline

Demonstrator Implementation Plan transferred to CEOS WGD leads in March 2021

- **Year 1 (June 2021 – June 2022):**
  - Definition of landslide services and products requirements for the three applications.
  - EO-satellite database creation for the geographical use cases.
  - Consolidation of resources (persons, data, IT processing).

- **Year 2 (June 2022 – June 2022):**
  - Demonstration of the landslide services for some use cases and reporting;
  - Concept of the prototype demonstration App on GEP for the three applications.

- **Year 3 (June 2023 – June 2024):**
  - Implementation of the prototype demonstration App on GEP for the three applications;
  - Training and dissemination on-line user-oriented material for the three applications.
  - Final Demonstrator reporting

Demonstrator EO Data Requests

Requests

- [Application 1] and [Application 2]: **archive and new regular acquisitions over relevant AOIs, time intervals and time period in Morocco** [Application 1], and **France, Canada, USA and China** (??) for [Application 2]
  - Key Data Types/Coverage: High Resolution Optical and SAR data for landslide detection, C-band and L-Band SAR Data for mapping of landslide activity, X-band data for Very-High Resolution information (TSX). New C-Band acquisitions (RCM) have been committed by the Canadian Space Agency for the Canadian test site
  - Key point: L-Band data will be key to support assessments in vegetated terrain. Specific requests highlighted for ALOS-2 and/or SAOCOM L-Band SAR Data can an action be engaged through CEOS?

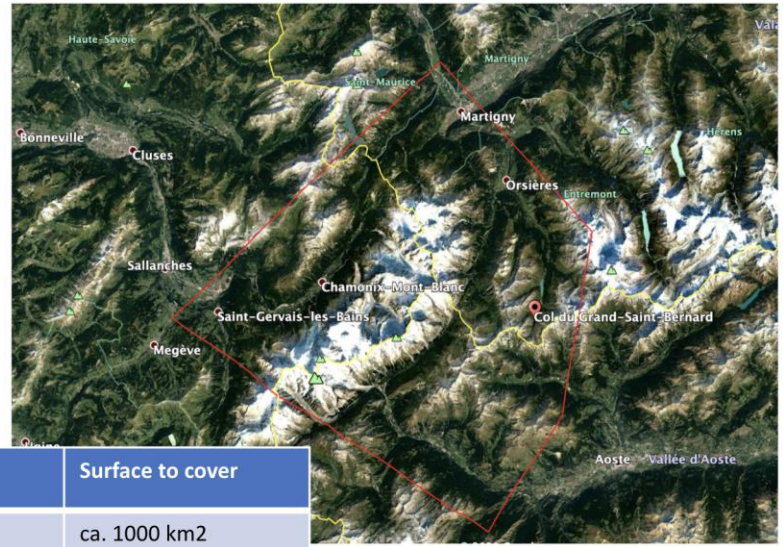
- [Application 3]: **archive and new acquisitions of pre/post disaster imagery at global scales for relevant landslide disasters**. The team will define criteria to select landslide disaster to analyze for this application. If possible, the disaster might be similar to those used for response by the International Disaster Charter, the Copernicus EMS Rapid Mapping, the CNES CIEST2 Activation program, or any other relevant initiatives.

→ Landslide Demonstrator Leads will now engage (Sept. 2020) with space agencies to discuss their interest

Demonstrator EO Data Requests

Application 1 – Site 1b – Swiss-France-Italy / Aosta-Wallis-Arve – Great St-Bernard Pass

Great Bernard Pass corridors accross 3 countries



→ Most of the agencies have been contacted and confimed their interest
→ Detail data requests to setup …. Ex. of provision plan for Application 1/European Alps below

Agency	Satellite/Sensor	Acquisition period	Frequency	Surface to cover
CNES	Pléiades	June-Aug-Oct 2021 March-June-Aug-Oct 2022 March-June-Aug-Oct 2023	3 to 4 dates/year (stereo)	ca. 1000 km2
DLR	TSX/StripMap	June-Aug-Nov 2021 March-June-Aug-Nov 2022 March-June-Aug-Nov 2023	36 image (2 images/month x 3 ½ years)	ca. 1000 km2
ASI	CSK/StripMap Himage (5 m)	June-Nov 2021 March-Nov 2022 March-Nov 2023	8 months / year	40x40 km (1600 km2)
CSA	/	/	/	/
CNSA	/	/	/	/
JAXA	ALOS-2			

Data provision plan

Wrap-up

- Achievements in the Pilot
  - Case studies that demonstrate the following:
    - EO satellite data can effectively support the estimation of relevant landslide parameters (location, size, velocity, triggers) over large spatial domains;
    - the combination of Synthetic Aperture Radar (SAR), multispectral and microwave satellite data can improve classical landslide modelling approaches;
    - EO satellite data can provide first order estimates of landslide hazard where local ground-based observation capacity is limited, making it highly suitable for applications in developing countries.
- Goals for the Demonstrator
  - Demonstrate the usefulness of satellite data for *operational applications of landslide disaster risk management (DRM)* with the ultimate goal to increase resilience against landslide disasters.
    - Use EO data to engage the railway, transportation and pipeline sector on monitoring of hazards that may affect their operations and planning
    - Develop an operational platform to conduct and evaluate landslide risk financing products
    - Coordinate and expand the use of EO data for landslide inventory generation, particularly after major triggering events, create a repository for data and code sharing on this topic.