# Thematic Core Service Anthropogenic Hazards

## Step-change in Tackling Grand Challenges of Hazards Associated with Exploitation of Geo-resources

Institute of Geophysics Polish Academy of Sciences

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# Three Steps to better research into the Assessment and Mitigation of Anthropogenic Seismicity and other geophysical Hazards Induced by Exploitation of Georesources:

- **Cross-disciplinary approach** to the problem. Integration of research groups investigating the problem. Information exchange with other Earth sciences communities.

- Particular attention focused on studies of technology-nature couplings ↔ Deep synergy between **Science and Industry** based on mutual understanding of concerns and mutual respect of interests.

- **Integration of research infrastructures** both intra-disciplinary as well as interdisciplinary using the newest ICT.



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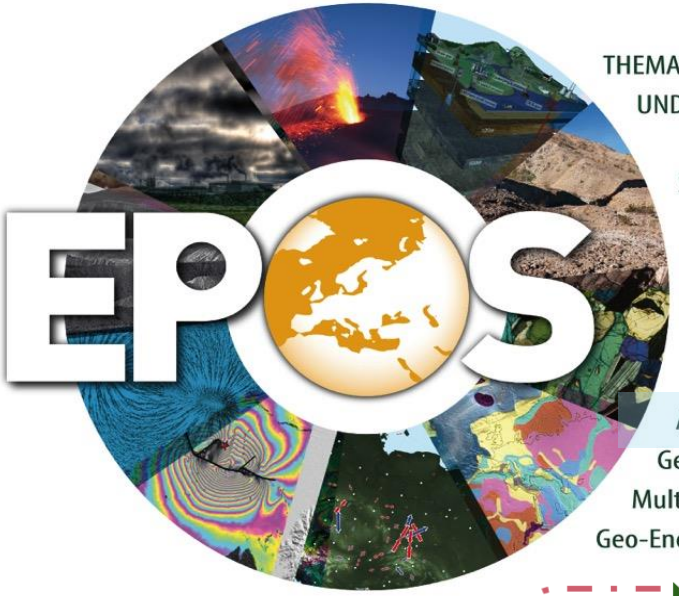
# EPOS A long term plan for integration of research infrastructures for solid Earth Science

> NERIES, NERA
> MEDSUV, FUTUREVOLC, MARSITE
> ORFEUS, EMSC, EUREF, EuroGeoSurvey, INTERMAGNET
> OneGeology Europe
> SHARE, SAFER, REAKT
> GEM, ICDP, IODP
> VERCE




THEMATIC CORE SERVICES UNDER IMPLEMENTATION

- Seismology
- Near-Fault Observatories
- GNSS Data & Products
- Volcano Observations
- Satellite Data
- Geomagnetic Observations
- Anthropogenic Hazards
- Geological Information and Modeling
- Multi-scale Laboratories
- Geo-Energy Test Beds for Low Carbon Energy

| *projects* | *national coordination* | *Working groups* | *TCS* | ERIC Operation |
|---|---|---|---|---|
| EPOS Conception | ESFRI Roadmap | EPOS Preparatory Phase | EPOS Implementation phase | |
| 1997-2007 | 2007-2008 | 2010-2014 | 2015-2019 | |

*From the presentation of M. Cocco „EPOS IP Starts up"*

EPOS EUROPEAN PLATE OBSERVING SYSTEM www.epos-ip.org

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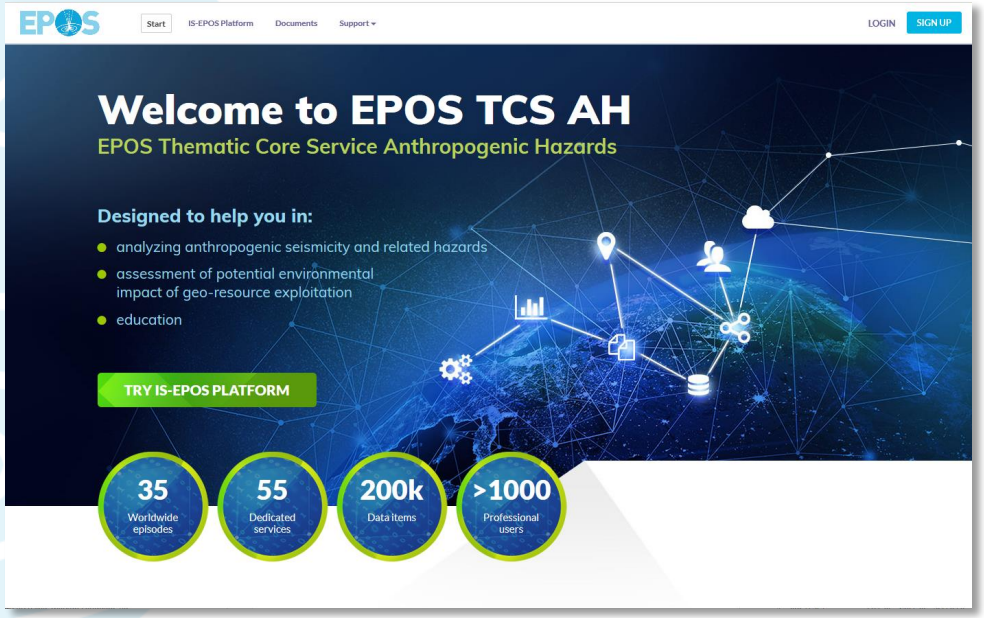
# TCS AH Consortium members:

- Institute of Geophysics Polish Academy of Sciences (IG PAS), Poland
- Instituto Nazionale di Geofisica e Vulcanologia (INGV), Italy
- Centre national de la recherche scientifique (CNRS), France
- Helmholtz Zentrum Potsdam Deutsches Geoforschungszentrum (GFZ), Germany
- L'Institut National de l'Environnement et des Risques (INERIS), France
- Geofyzikalni Ustav AV CR (IG ASCR), Czech Republic
- Oulun Yliopisto (OULU), Finland
- Lulea Tekniska Universitet (LTU), Sweden
- University of Keele (KU), UK
- University of Science and Technology – Academic Computer Centre Cyfronet (ACK UST), Poland
- Central Mining Institute (CMI), Poland
- Polish Mining Group (PMG), Poland



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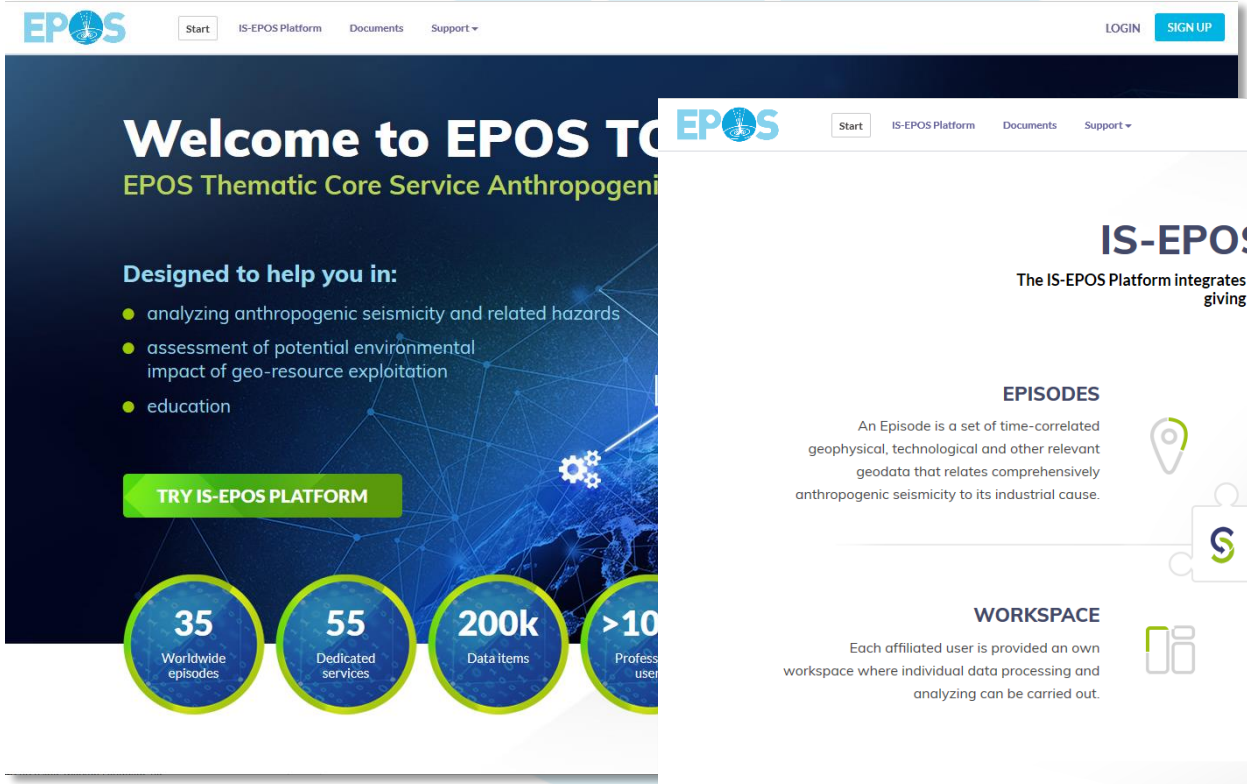
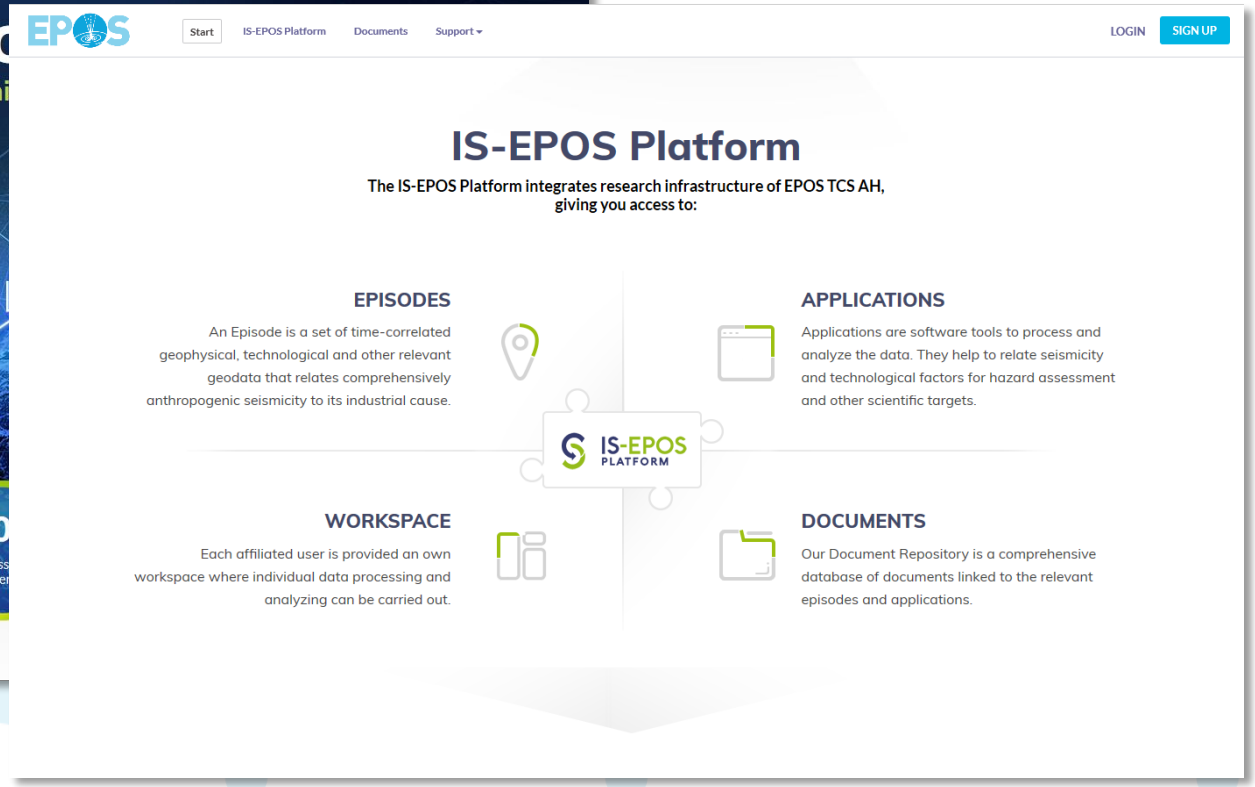
EPOS ANTHROPOGENIC HAZARDS

# IS-EPOS platform:

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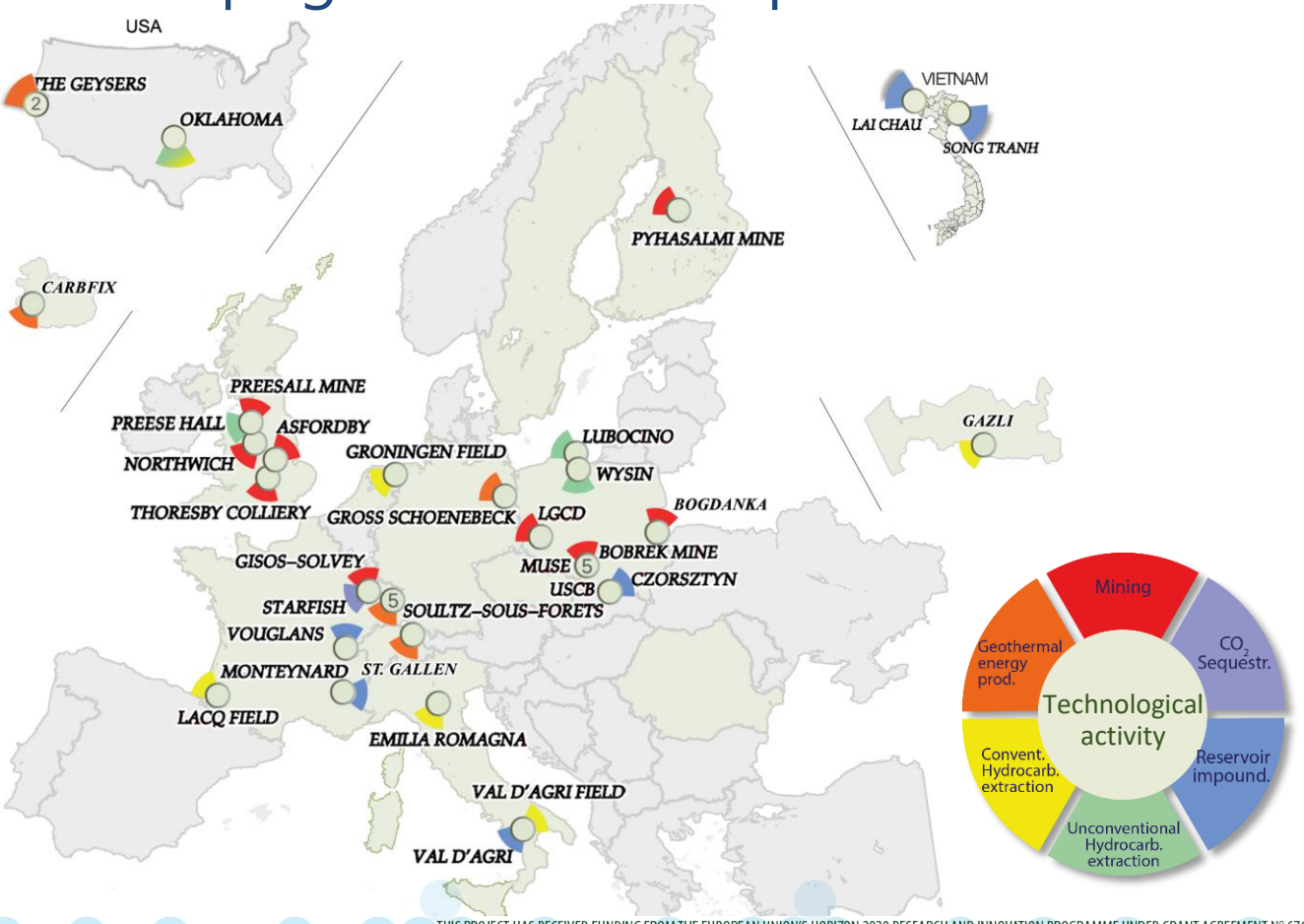
# Anthropogenic Hazards Episodes



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# IS-EPOS platform – episodes overview


## SONG TRANH: deep water reservoir

Seismic activity linked to Song Tranh 2 hydropower plant and the reservoir containing backed up water of Tranh river in central Vietnam. The reservoir volume is 740 million cubic meters and the water level varies between 140 and 175 m. Seismic activity in the reservoir region, previously known as aseismic, began in 2011, soon after filling of the reservoir.

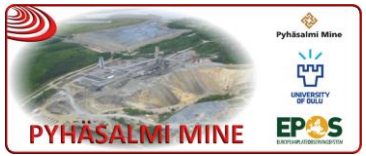
- Reservoir impoundment
- Vietnam, Quang Nam Province
- IS-EPOS, EPOS-IP


## PREESE HALL: Shale Gas

An exploration well for shale gas was drilled into the Bowland Shale formation to a depth of 2.7 km. Hydrofracture stimulations were carried out at five depths. Felt earthquakes occurred during the stage 2 treatment.

Episode integrated in the framework of:

- Unconventional hydrocarbon extraction
- United Kingdom, Lancashire
- EPOS-IP, SHEER

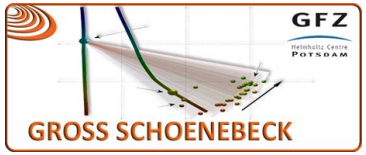



## PYHASALMI MINE: in situ underground laboratory

RESTRICTED DATA ACCESS

Pyhasalmi mine, Central Finland, is an underground mine which produces copper, zinc and pyrite. A seismic network was installed underground in 2002 to monitor and locate frequently occurring microseismic scale events. Main target in Pyhasalmi episode is to: 1. Compare microseismic networks detected events with observations with national permanent seismic stations observations. 2. Correlate mining related microseismic events with the production data of the Pyhasalmi mine. 3. Analyze regions, where events concentrate and compare the locations with known geology.

- Underground mining
- Finland, Pyhajarvi
- EPOS-IP




## GROSS SCHOENEBECK: geothermal energy production experiment

A deep injection well and a doublet of production wells were established in this area reaching the reservoir rocks like red bed sandstone and andesitic volcanic rock at the 4200m depth. Injection performed from 9th to 14th August 2007 was used for repeated stimulation treatments to investigate scenarios of enhancing productivity of thermal fluid recovery from the underground. A total amount of 13.000 m^3 of water was injected. The maximum injection well-head pressure reached 58.6 MPa.

- Geothermal energy production
- Germany, Gross Schoenebeck
- IS-EPOS, EPOS-IP, SHEER



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# EPISODE


## VAL D'AGRI FIELD: conventional hydrocarbon extraction

Seismic monitoring of the initial stage of wastewater injection into a disposal well of the Val d'Agri oil field. The monitoring unraveled a low magnitude swarm induced by disposal operations that initiated just a few hours after the beginning of injection. Main objective is to provide seismic data to be analyzed with advanced techniques for a better understanding of the mechanisms of injection-linked seismicity and of

Conventional hydrocarbon extraction, Wastewater injection

Italy, southern Apennines

EPOS-IP

### Description

Seismic monitoring of the initial stage of wastewater injection into a disposal well of the Val d'Agri oil field. The monitoring unraveled a low magnitude swarm induced by disposal operations that initiated just a few hours after the beginning of injection. Main objective is to provide seismic data to be analyzed with advanced techniques for a better understanding of the mechanisms of injection-linked seismicity and of physical properties of the reservoir.

Episode integrated in the framework of:
• EPOS IP project, European Plate Observing System Implementation Phase. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676564

How to cite:
IS EPOS (2017), Episode: VDF, https://tcs.ah-epos.eu/#episode:VDF, doi:10.25171/InstGeoph_PAS_ISEPOS-2017-017

### Data

*The data from this episode is embargoed till 2019/09/30*

**DATA RELEVANT FOR THE CONSIDERED HAZARDS**

SEISMIC

- Catalog 69 events from 02/06/2006 to 11/06/2006, magnitude ML range: 0.0 to 1.8
- Seismic Stations Locations and parameters of seismic stations at Val d'Agri oil field

**INDUSTRIAL**

- Injection Volume Injection volume in well at Val d'Agri oil field
- Wellhead Pressure Wellhead pressure in well at Val d'Agri oil field

**GEODATA**

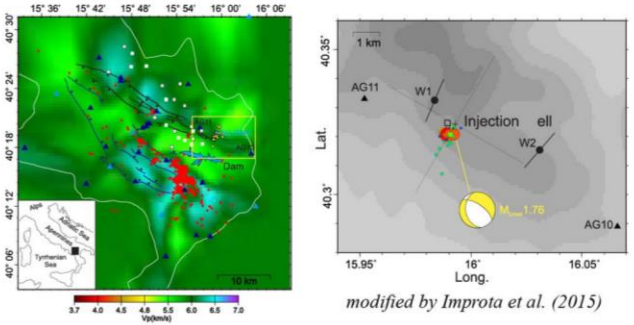
- Velocity Model Seismic velocity model of Val d'Agri oil field

ALL DATA RELATED TO THIS EPISODE | AVAILABLE VISUALIZATIONS

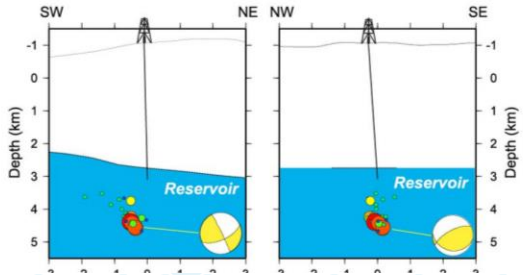
See more information in Document Repository

### Status details

| | |
|---|---|
| *Episode status:* | Closed |
| *Impacting factor:* | Conventional hydrocarbon extraction, Wastewater injection |
| *Region:* | Italy, southern Apennines |
| *Project association:* | EPOS-IP |




*modified by Improta et al. (2015)*



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# IS-EPOS platform – applications

**Stationary Hazard: Maximum Credible Magnitude**

This application uses the magnitude distribution and activity rate from calculated a seismic catalog to estimate the Maximum Credible Magnitude (MCM). The MCM for the time period of length T is the magnitude value whose mean return period is T. The MCM values are calculated for a series of periods of length values. Note: "Source size distribution functions/Stationary Hazard" application must be run before.

Probabilistic Seismic Hazard Analysis
Last updated: 2017 Jul 03

**Time dependent hazard in mining front surroundings**

To estimate time-dependent values of seismic hazard parameters: the activity rate, the Gutenberg-Richter b-value, the return period and the exceedance probability for a space window surrounding an advancing mining front. The parameter values for the time moment t are estimated optionally either from events that occurred in dt time units preceding t, where dt is kept constant, or from n last events before t, where n is kept constant, or from a time period during which the front

Probabilistic Seismic Hazard Analysis
Last updated: 2017 Jul 03

**FOCI**

This application makes use the P-wave first arrivals from the waveforms recorded by the seismic stations and resolves seismic moment tensors using various decomposition schemes. Three moment tensors are calculated: unconstrained (full) moment tensor solution, deviatoric moment tensor solution (no volumetric change in the source), and double-couple moment tensor solution (no volumetric change in the source, no linear dipole). In addition to the moment tensor

Source Parameter Estimation
Last updated: 2016 Jul 05

**Stress inversion**

This application evaluates stress axis orientation (σ1, σ2, σ3 axis orientation as well as P and T axes orientation) and relative stress magnitude (R value) by inverting earthquake focal mechanisms. Stress state can be defined for a point (0D case), profile or time change (1D case), map (2D). The framework of calculating the deviatoric stress tensor together with its uncertainties using bootstrap resampling method is also provided along with a variety of plots.

Stress Field Modeling
Last updated: 2018 Jul 23

**MERGER: Dynamic risk analysis using a bow-tie approach**

MERGER, a simulator for multi-hazard risk assessment in ExploRation/exploitation of GeoResources, is a tool for performing dynamic risk analyses using a bow-tie approach. The tool has been designed for solving fault trees (FT) and event trees (ET) linked in a bow-tie structure and using a Monte Carlo approach.

Probabilistic Seismic Hazard Analysis
Last updated: 2019 Aug 08



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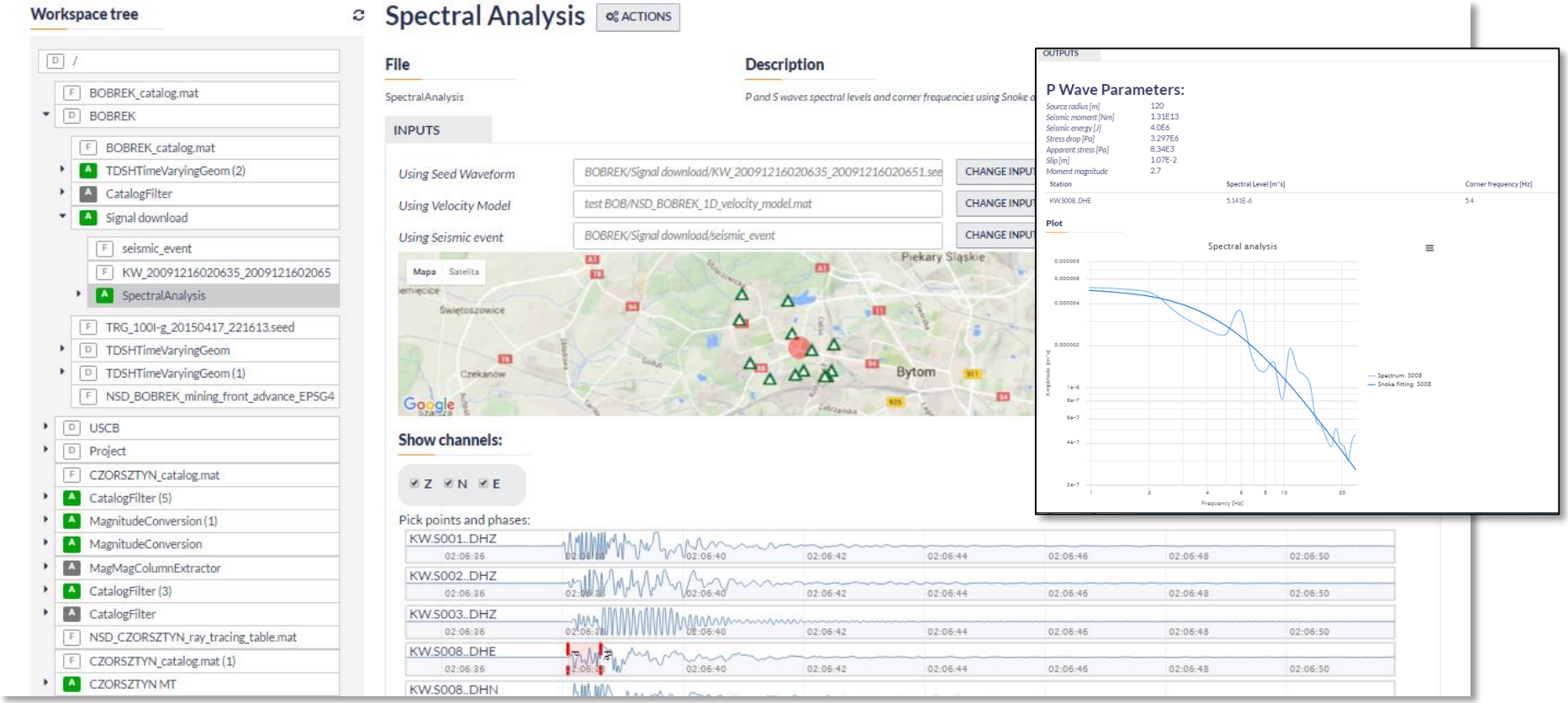
# IS-EPOS platform – user workspace



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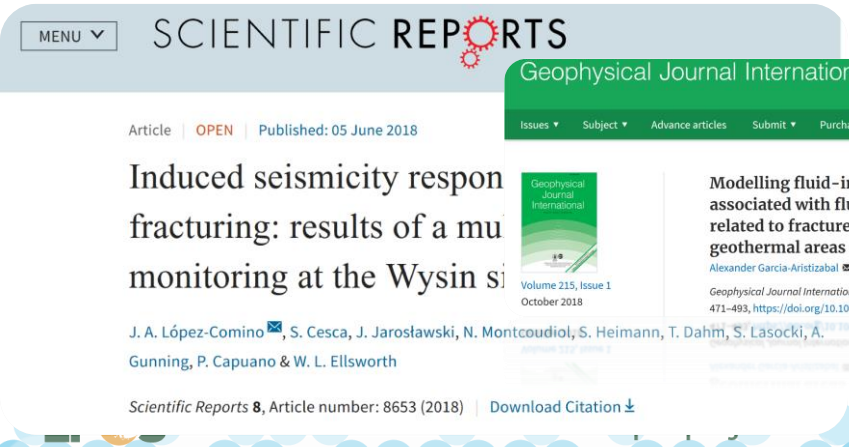
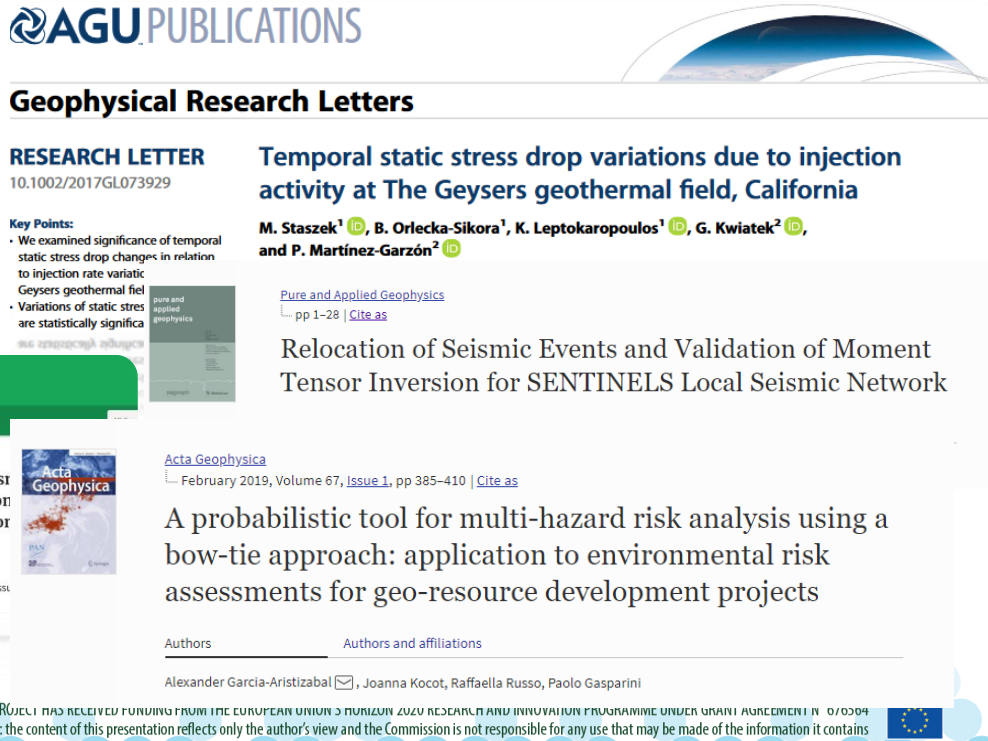
# IS-EPOS platform – RI in the scientific works

- **> 25 publications of JCR**;
- **Special Issue of Acta Geophysica: SHEER** "Environmental footprints induced by geo-energy exploitation: the shale gas case„;
- **4 papers in the peer-review proceedings**;
- Newsletters of SHEER, SERA and S4CE;
- Publications in the national journals;
- PhD theses, habilitations







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# IS-EPOS platform – easy and effective teaching tool

University of Oulu Finland, Luleå University of Technology Sweden, IGF PAS Poland, Master geo-risk, UGA, Grenoble France, GFZ Potsdam Germany, INERIS France, INGV Bolonia Italy, Keel University UK, Workshops of teachers of UE in the frameworks of ERIS and SCIENTIX (STEM Discovery week, March/April 2018), Summer School of S4CE in Salerno 09/2019.

eris

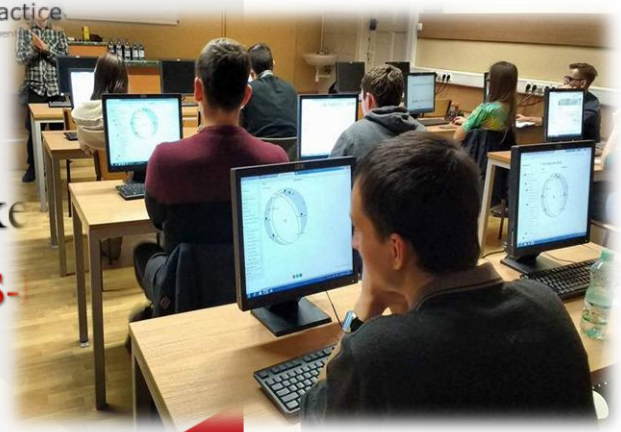
Erasmus+

Exploitation of Research results In School practice

The project has been funded with support from the European Commission within ERASMUS+ Programme (grant agreement

Physics of earthqueake

"Picking the seismograms on IS-



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# TCS Anthropogenic Hazards


Governance

Community Engagement

Strategic Partnership

IS-EPOS platform

eNodes

Services Integration

Promotion Dissemination

Episodes Intergration

*To capitalize on the benefits and opportunities offered by TCS AH and EPOS*



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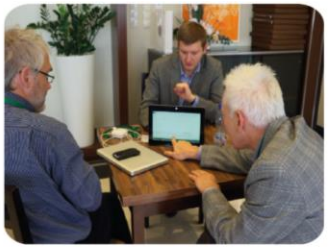
DIGITAL RESEARCH SPACE OF INDUCED SEISMICITY FOR EPOS PURPOSES



THEMATIC NODE FOR THE INDUCED SEISMICITY

INTER-SECTORAL KNOW-HOW TRANSFER

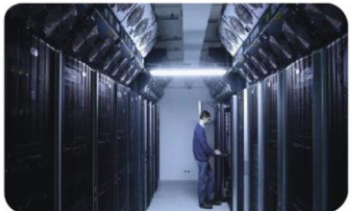
CONSOLIDATION OF SCIENTIFIC COMMUNITY

SYNERGY OF SCIENCE AND INDUSTRY

INTEGRATION OF DISPERSED RESEARCH INFRASTRUCTURE

CLOUD COMPUTING

ADVANCED IT INFRASTRUCTURE



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**55 Dedicated Services**

**200k Data Items 1000+ Professional Users**

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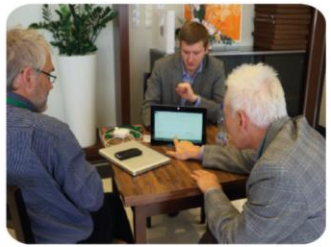

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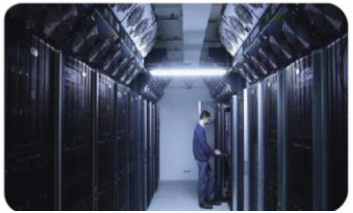

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