Global Collaborative Approaches to Anthropogenic Seismic Hazard Assessment

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THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 676564

Cross-cutting environmental hazards

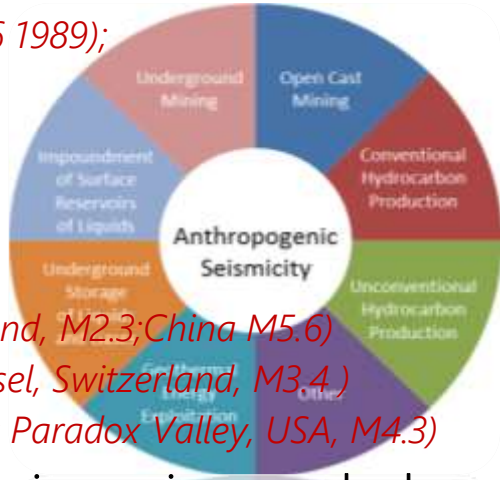
Anthropogenic seismicity	Air polutions	Fluid transport	Water Quality	Local Impact

Mining **I**nduced **S**eismicity (**MIS**): **underground mining** *(potash mine, Germany, M5.6 1989);* **open cast mining** *(brown coal mine, Belchatow, Poland, M4.6, 1980)*

Reservoir **I**nduced **S**eismicity (**RIS**): *(Koyna, India M6.5, 1967; Kremasta, Greece M6.3, 1966)*

Injection/**E**xtraction **I**nduced **S**eismicity (**IEIS**):

- conventional exploitation of oil and gas *(Kettleman North, USA, M6.1)*
- shale gas and other unconventional oil and gas exploitation *(Blackpool, England, M2.3;China M5.6)*
- geothermal energy production *(Geysers, USA M4.6; Berlin, El Salvador M4.4; Basel, Switzerland, M3.4.)*
- underground storage of liquids and gases, including CCS *(Denver, USA, M4.8; Paradox Valley, USA, M4.3)*



Cases **i**n **D**ebate (**CiD**): **The origin of earthquakes, whether natural or anthropogeneic, remains unresolved,** *(Gazli Uzbekistan sequence 1976-1984: M7.0, M7.0, M5.7, M7.0; Coalinga, USA, M6.7, 1983; Wenchuan, China, M7.9)*

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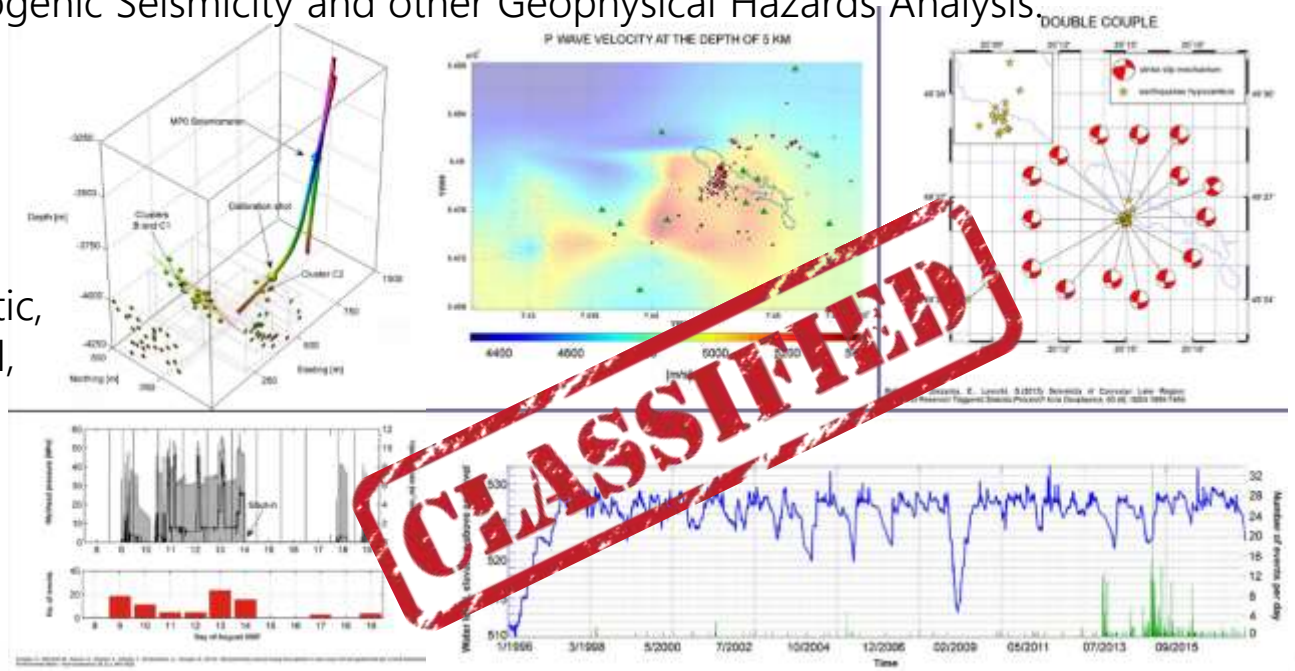
AH is related to the inducing technological process

- AH research requires multidisciplinary data collection with mandatory inclusion of relevant technological data

Data required for Anthropogenic Seismicity and other Geophysical Hazards Analysis:

- Seismic/Hazard Data
- Production Data
- Operational Parameters
- Technological Activity
- Other geo-data (geodetic, tectonic, geomechanical, geophysical etc)



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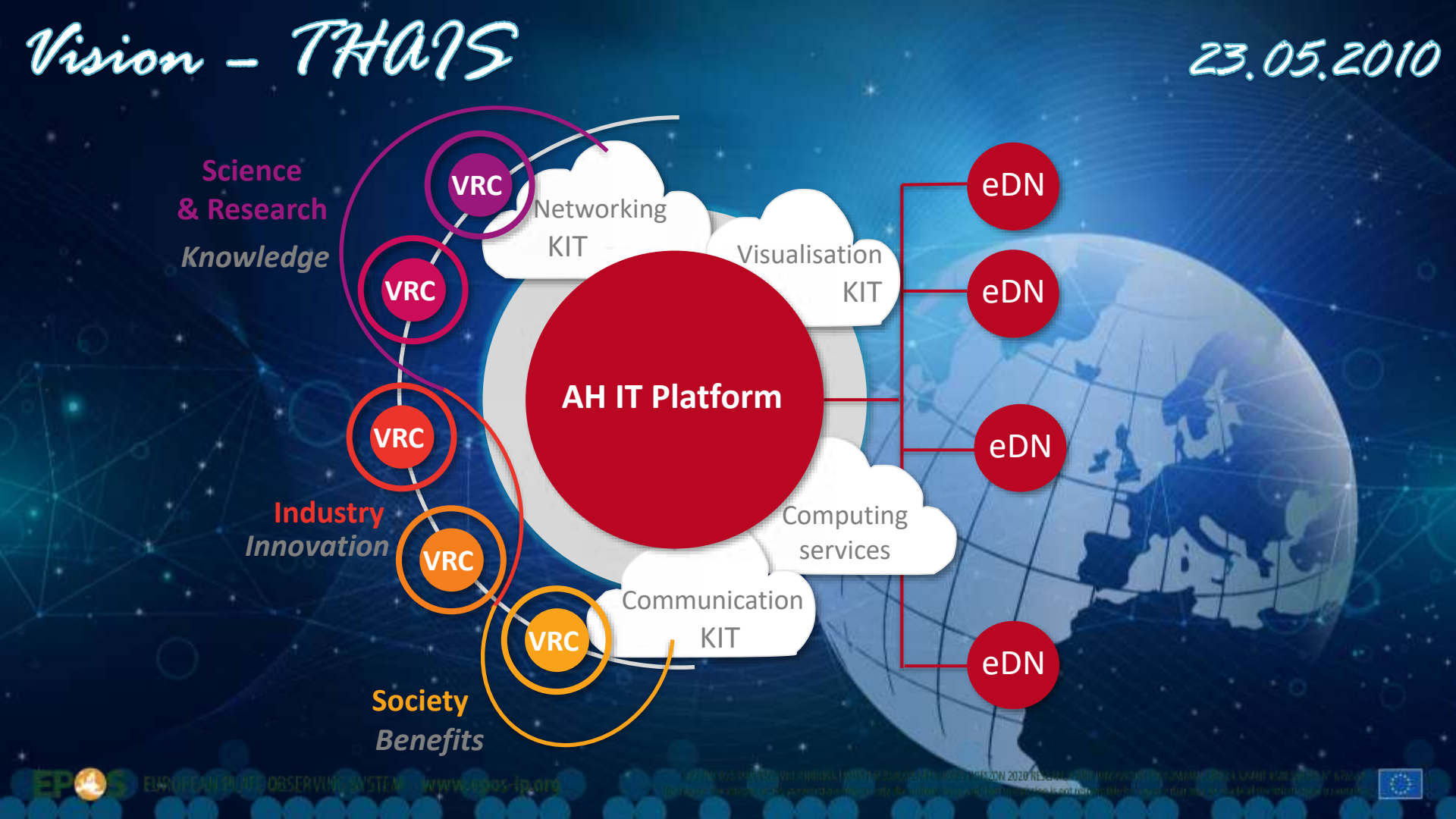
Vision – THAIS

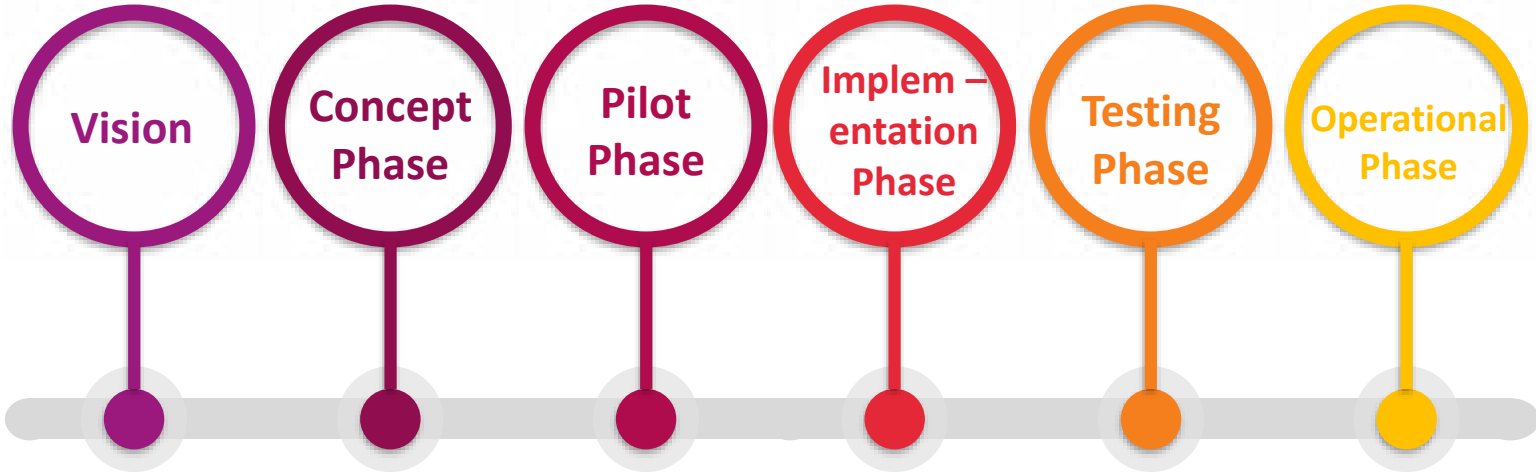
23.05.2010



Since 2011 to 2015 WP5b

RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 676564

Roadmap



2010

2013-2015

2015-2018

Legal & financial framework

2020

EPOS WG5b

EPOS WG10

EPOS TCS AH

TCS AH
Consortium CB, IAC, ED, GS

IS-EPOS C.

EPOS IP C.

EPOS SP C. + EPOS-ERIC

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TCS Anthropogenic Hazards

IS-EPOS	EPOS IP	MUSE-EPOS PL	SERA	EPOS PL+	EPOS SP
~ 4 mln EUR	~ 1.8 +1.2 mln EUR	~ 11 mln EUR	~ 1 mln EUR	~ 9 mln EUR	~ 400 tys. EUR

SHEER Consortium

S4CE *Consortium*

ERIS *Consortium*

LIDER13/0075/2022

Ver 1 NCN

Ver 2 NCN

Sonata Bis NCN

Preludium NCN

Preludium BIS NCN

RAFTIS FNP

UMO-2019/…/00515 NCN

UMO-2020/39/I/ST10/01318

DigiTwins4PEDs

TWIN-Waters

DT-GEO
~ 360 tys. EUR

GREAT
~ 120 tys. EUR

EPOS ON
~ 150 tys. EUR

MYCA 1-4
~600 tys. EUR

ARTIQ Excellence Center
~ 500 tys. EUR

TCS AH MEiN 1
~ 1 mnl EUR

TCS AH MEiN 2
~ 4 mln EUR

EGI & EOSChub *Consortia*

Σ > 35 mln EUR

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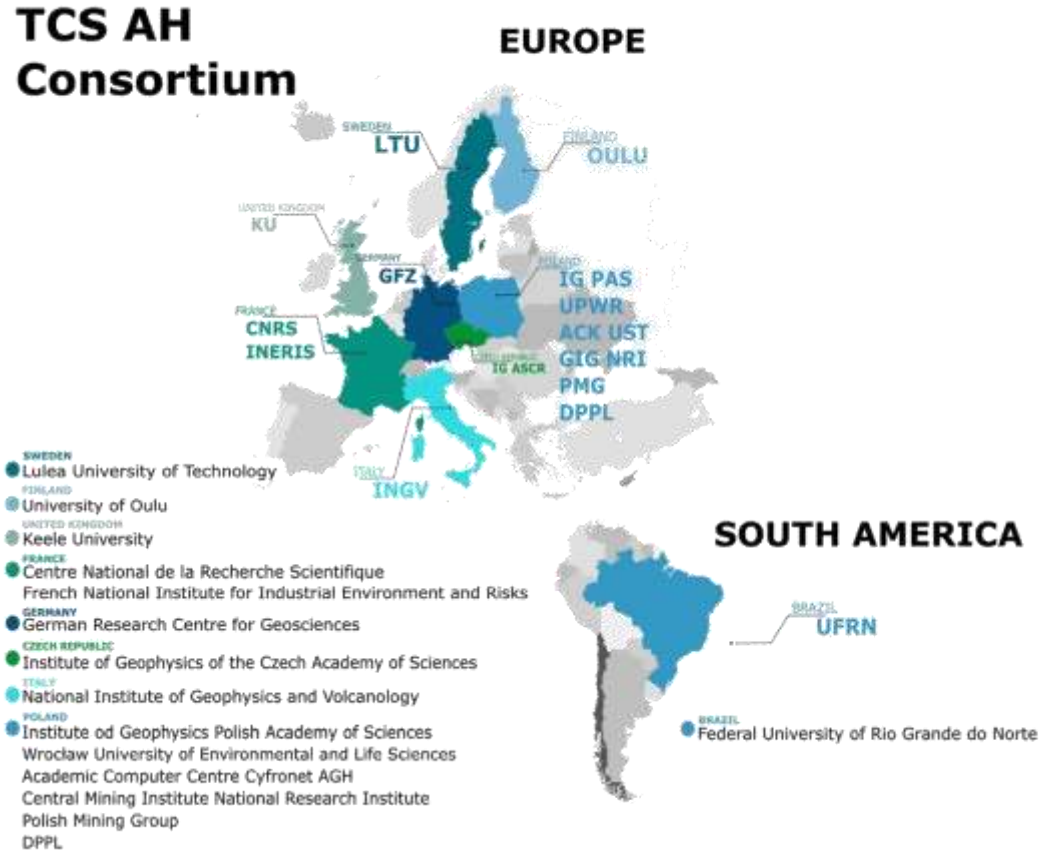
EPOS Thematic Core Service Anthropogenic Hazards (TCS AH) Consortium

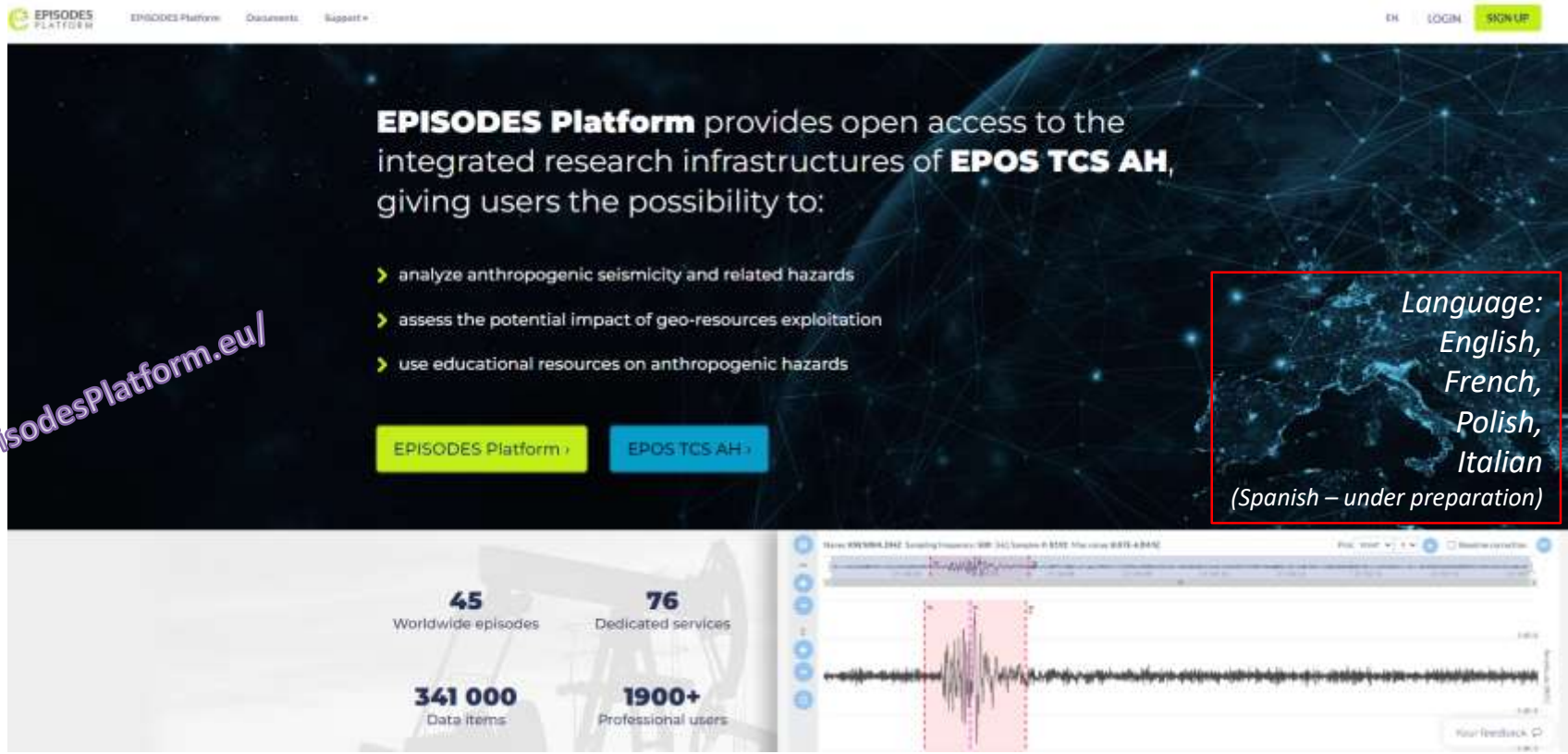
16 Institutions from 8 European and 1 Non-European Country

TCS AH mission: integrate the research infrastructures related to studies of geo-hazards of anthropogenic origin, in particular those caused by the exploration and



Access to the integrated research infrastructure of EPOS TCS AH:

episodes (datasets), applications (software), workspace, HPC, collaboration functionalities, document repository



https://EpisodesPlatform.eu/

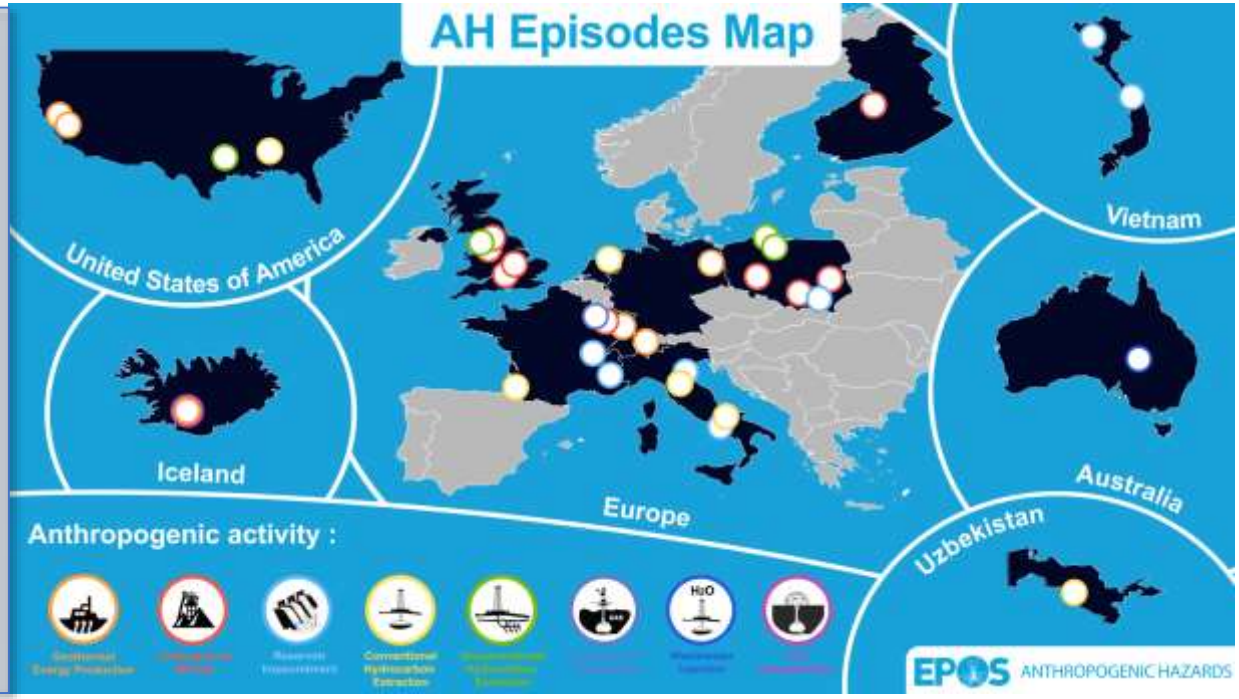
Language:
English,
French,
Polish,
Italian
(Spanish – under preparation)

ANTHROPOGENIC HAZARDS

Episodes: Sets of time-correlated seismic, technological, and other relevant geo-data that relate comprehensively anthropogenic seismic processes to their industrial causes

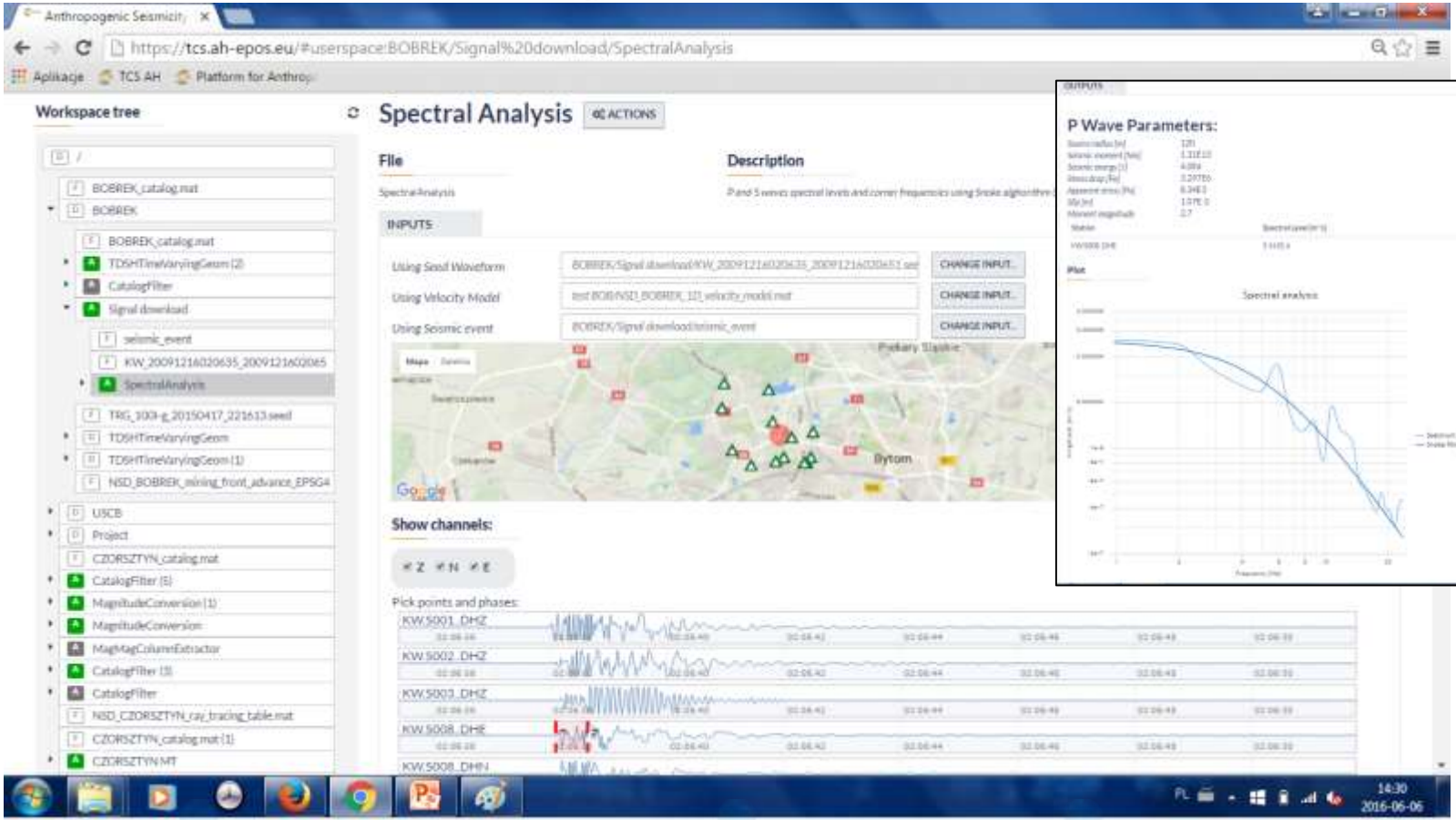
Inducing technologies:

CO2 sequestration	- 1
Conventional hydrocarbon extraction	- 6
Geothermal energy production	- 11
Reservoir impoundment	- 6
Underground gas storage	- 1
Unconventional hydrocarbon extraction	- 5
Underground mining	- 13
Wastewater injection	- 2



EPOS EUROPEAN PLATE OBSERVING SYSTEM

EPISODES platform – user workspace



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ANTHROPOGENIC HAZARDS

Report for: 2024-08-01 - 2024-08-31

EPISODES PLATFORM

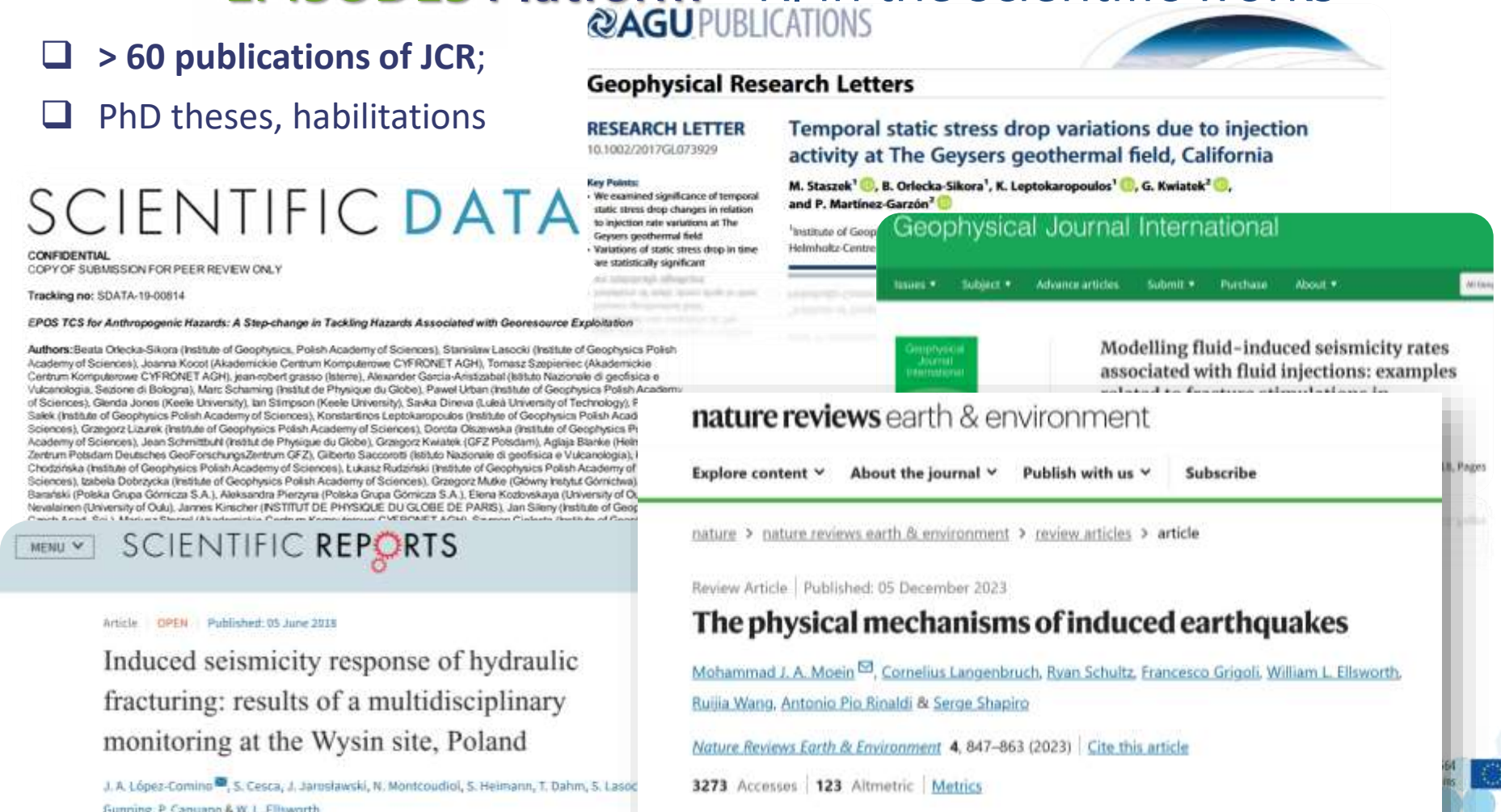
- **1920 users of the EPISODES Platform from 69 countries**
- **1323 users with institutional affiliation from 468 institutions**
- **97 new users registered in 2024**

- **485 file downloads from an external repository**
- **693 file downloads from workspace**
- **881 files added to workspace**
- **365 uploaded files**

EPOS

EPISODES Platform – RI in the scientific works

- **> 60 publications of JCR;**
- PhD theses, habilitations



AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER

10.1002/2017GL073929

Temporal static stress drop variations due to injection activity at The Geysers geothermal field, California

M. Staszek, B. Orlecka-Sikora, K. Leptokaropoulos, G. Kwiatek, and P. Martínez-Garzón

Key Points:
- We examined significance of temporal static stress drop changes in relation to injection rate variations at The Geysers geothermal field
- Variations of static stress drop in time are statistically significant

SCIENTIFIC DATA

CONFIDENTIAL
COPY OF SUBMISSION FOR PEER REVIEW ONLY

Tracking no: SDATA-19-00814

EPOS TCS for Anthropogenic Hazards: A Step-change in Tackling Hazards Associated with Georesource Exploitation

Authors: Beata Orlecka-Sikora (Institute of Geophysics, Polish Academy of Sciences), Stanisław Lasocki (Institute of Geophysics Polish Academy of Sciences), Joanna Kocot (Akademickie Centrum Komputerowe CYFRONET AGH), Tomasz Szepieniec (Akademickie Centrum Komputerowe CYFRONET AGH), Jean-robert grasso (Isterre), Alexander Garcia-Aristizabal (Istituto Nazionale di geofisica e Vulcanologia, Sezione di Bologna), Marc Schaming (Institut de Physique du Globe), Paweł Urban (Institute of Geophysics Polish Academy of Sciences), Glenda Jones (Keele University), Ian Stimpson (Keele University), Savka Dineva (Luleå University of Technology), Piotr Sałek (Institute of Geophysics Polish Academy of Sciences), Konstantinos Leptokaropoulos (Institute of Geophysics Polish Academy of Sciences), Grzegorz Lizurek (Institute of Geophysics Polish Academy of Sciences), Dorota Olszewska (Institute of Geophysics Polish Academy of Sciences), Jean Schmittbuhl (Institut de Physique du Globe), Grzegorz Kwiatek (GFZ Potsdam), Aglaja Blanke (Helmholtz Zentrum Potsdam Deutsches GeoForschungsZentrum GFZ), Gilberto Saccorotti (Istituto Nazionale di geofisica e Vulcanologia), Agnieszka Chodzińska (Institute of Geophysics Polish Academy of Sciences), Łukasz Rudziński (Institute of Geophysics Polish Academy of Sciences), Izabela Dobrzycka (Institute of Geophysics Polish Academy of Sciences), Grzegorz Mutke (Główny Instytut Górnictwa), Piotr Barański (Polska Grupa Górnicza S.A.), Aleksandra Pierzyna (Polska Grupa Górnicza S.A.), Elena Kozlovskaya (University of Oulu), Nevalainen (University of Oulu), Jannes Kinscher (INSTITUT DE PHYSIQUE DU GLOBE DE PARIS), Jan Silény (Institute of Geophysics Czech Acad. Sci.), Mariusz Sikora (Akademickie Centrum Komputerowe CYFRONET AGH), Szymon Cielesta (Institute of Geophysics

Geophysical Journal International

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Modelling fluid-induced seismicity rates associated with fluid injections: examples

MENU ▾ SCIENTIFIC REPORTS

Article OPEN Published: 05 June 2018

Induced seismicity response of hydraulic fracturing: results of a multidisciplinary monitoring at the Wysin site, Poland

J. A. López-Comino, S. Cesca, J. Jarosławski, N. Montcoudiol, S. Heimann, T. Dahm, S. Lasocki, P. Gunning, P. Canyago & W. L. Ellsworth

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Review Article | Published: 05 December 2023

The physical mechanisms of induced earthquakes

Mohammad J. A. Moein, Cornelius Langenbruch, Ryan Schultz, Francesco Grigoli, William L. Ellsworth, Ruijia Wang, Antonio Pio Rinaldi & Serge Shapiro

Nature Reviews Earth & Environment 4, 847–863 (2023) | Cite this article

3273 Accesses | 123 Altmetric | Metrics

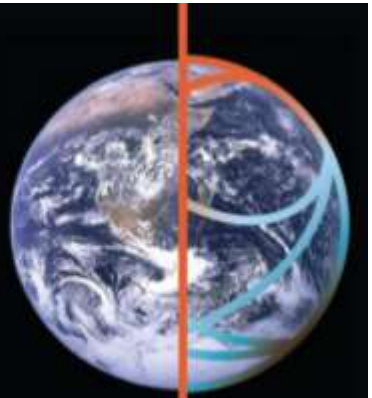
The Digital Europe Programme

Destine to sztandarowa inicjatywa Komisji Europejskiej mająca na celu opracowanie cyfrowego modelu Ziemi w skali globalnej. Model ten będzie podstawą do monitorowania, symulowania i przewidywania interakcji pomiędzy zjawiskami naturalnymi a działalnością człowieka. Przyczyni się do osiągnięcia celów transformacji zielonej i cyfrowej, w ramach Zielonego Ładu i strategii cyfrowej Komisji Europejskiej.

Partnerstwo: European Commission (EC), European Space Agency (ESA), European Centre for Medium-Range Weather Forecasts (ECMWF), European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)

Towards a European Digital future

DT-GEO



Project number: 101058129
Project name: **A Digital Twin for GEOphysical extremes**
Project acronym: DT-GEO
Call: HORIZON-INFRA-2021-TECH-01, Topic: HORIZON-INFRA-2021-TECH-01-01
Type of action: HORIZON Research and Innovation Actions
Granting authority: European Research Executive Agency
Project duration: 36 months, 1 September 2022 - 31 August 2025

ANTHROPOGENIC HAZARDS

WP8: Anthropogenic geophysical extremes

IGF PAN, CNRS, ACK CYFRONET, GFZ, INGV & TCS AH

Project funded by Horizon Europe under the grant agreement No 101058129

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DT - Anthropogenic Geophysical Extremes

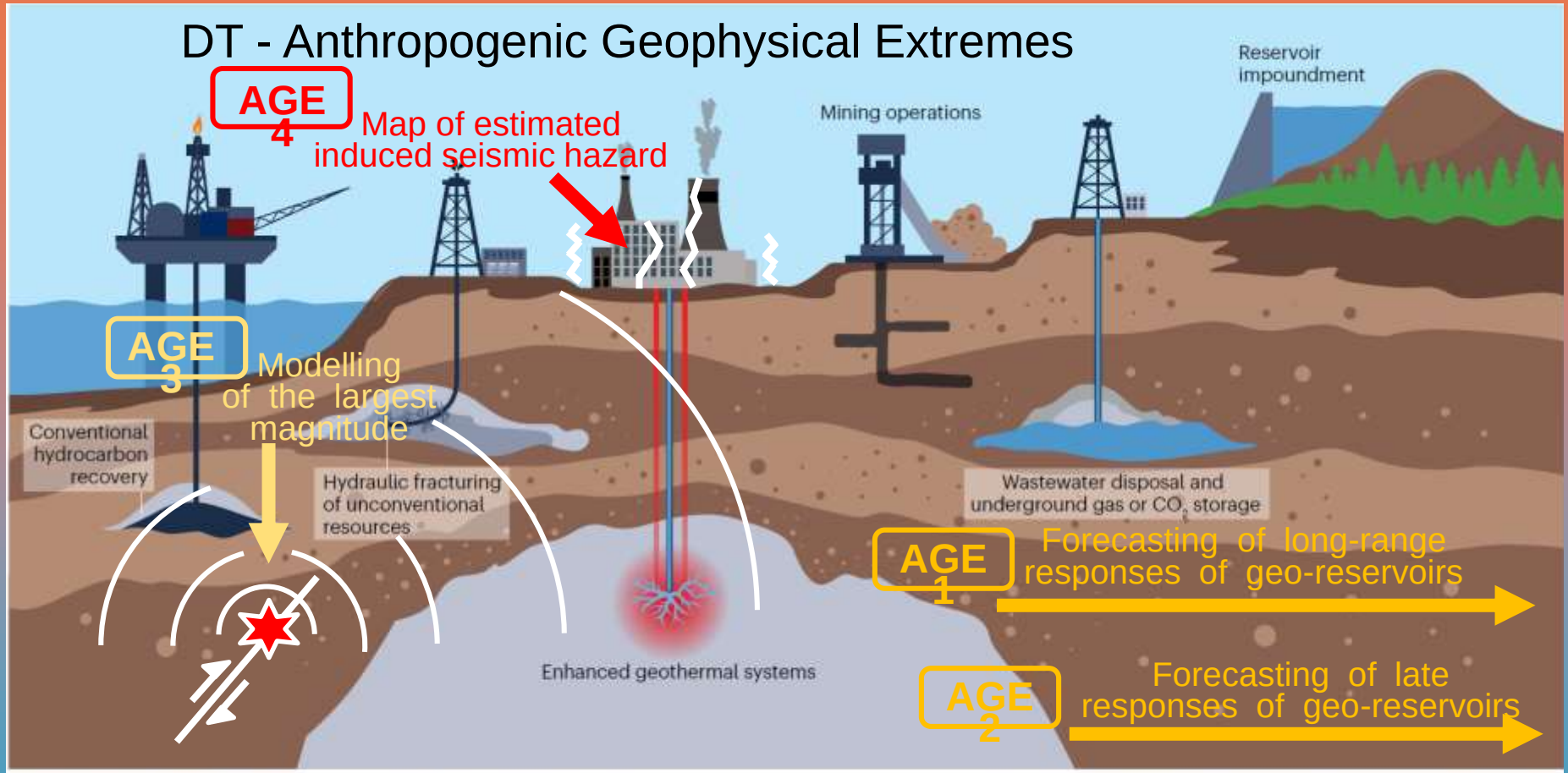
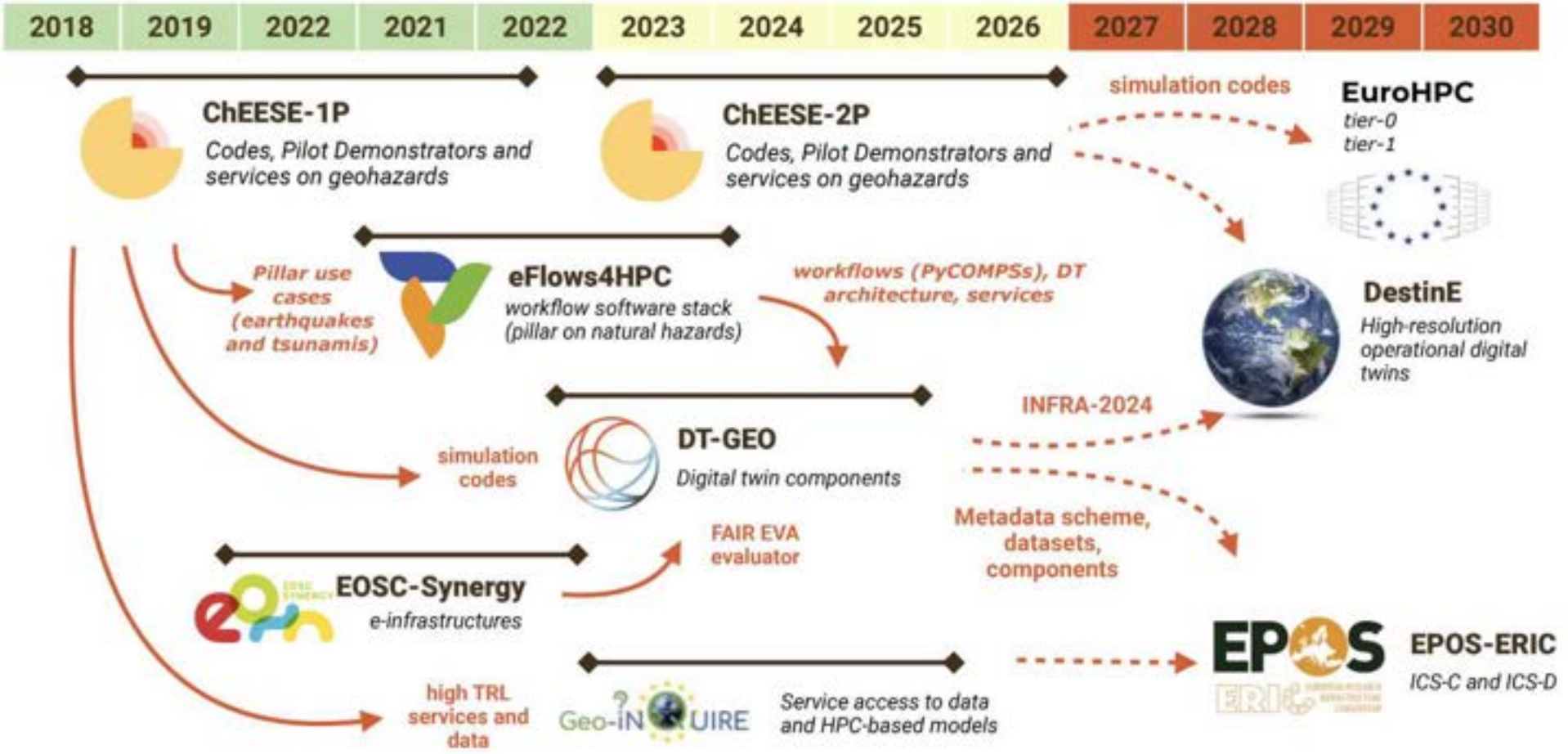


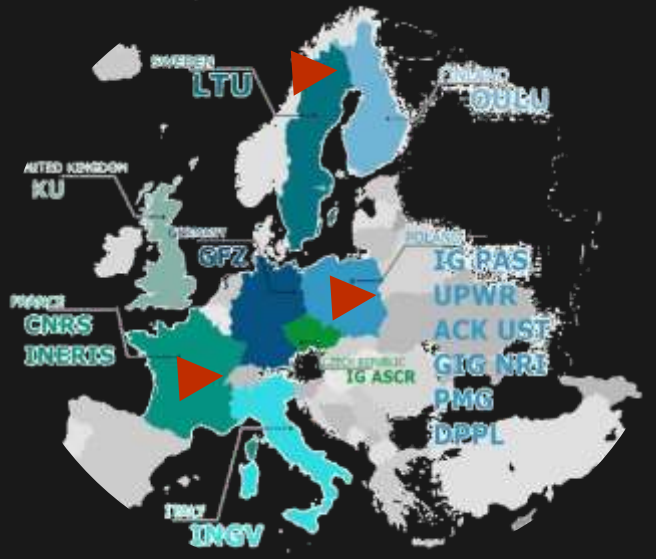
Fig. 1 | Industrial activities that can cause induced seismicity. Induced earthquakes can occur during conventional hydrocarbon recovery, hydraulic fracturing of unconventional resources, enhanced geothermal systems, mining operations, wastewater disposal, underground gas or CO_2 storage operations and reservoir impoundment. Figure adapted with permission from ref. 16, Wiley.

Figura from Moein et al., Nature Reviews Earth & Environment | Volume 4 | December 2023 | 847–863

Interakcje z innymi programami, inicjatywami i projektami



NOVA-Quake
Network for Observing of Versatility of Anthropogenic EarthQuake Predictability



DT-GEO

ANTHROPOGENIC HAZARDS

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