

Schweizerischer Erdbebendienst  
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**ETH** zürich



# Geomechanical Modelling of spent fluid reinjection in the Hengill Geothermal Field

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# Hengill geothermal field

Hellisheiði    Nesjavellir

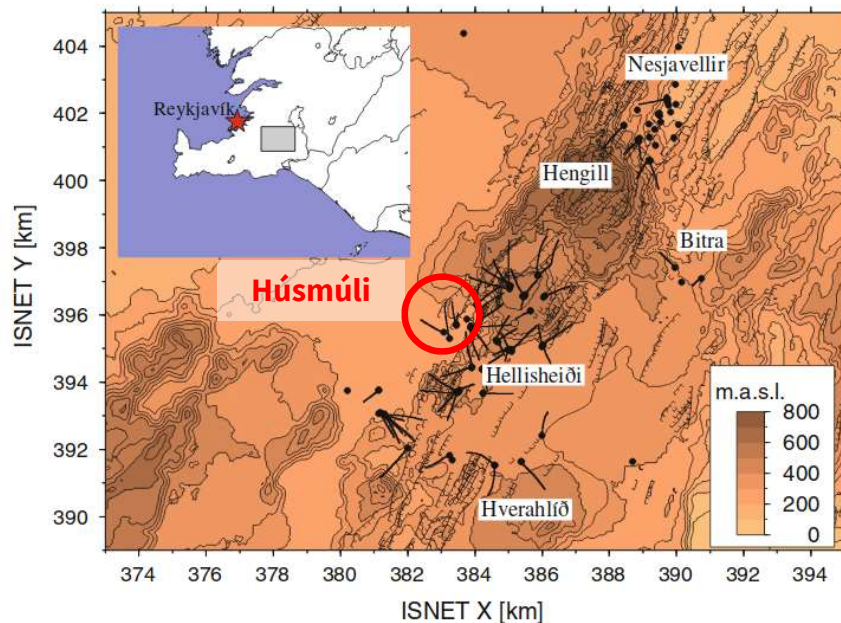
Intalled capacity

thermal    133 MW<sub>th</sub>    300 MW<sub>th</sub>

electric    303 MW<sub>e</sub>    120 MW<sub>e</sub>

production wells    63    30

injection wells    17    7



Gunnarsson et al. 2011

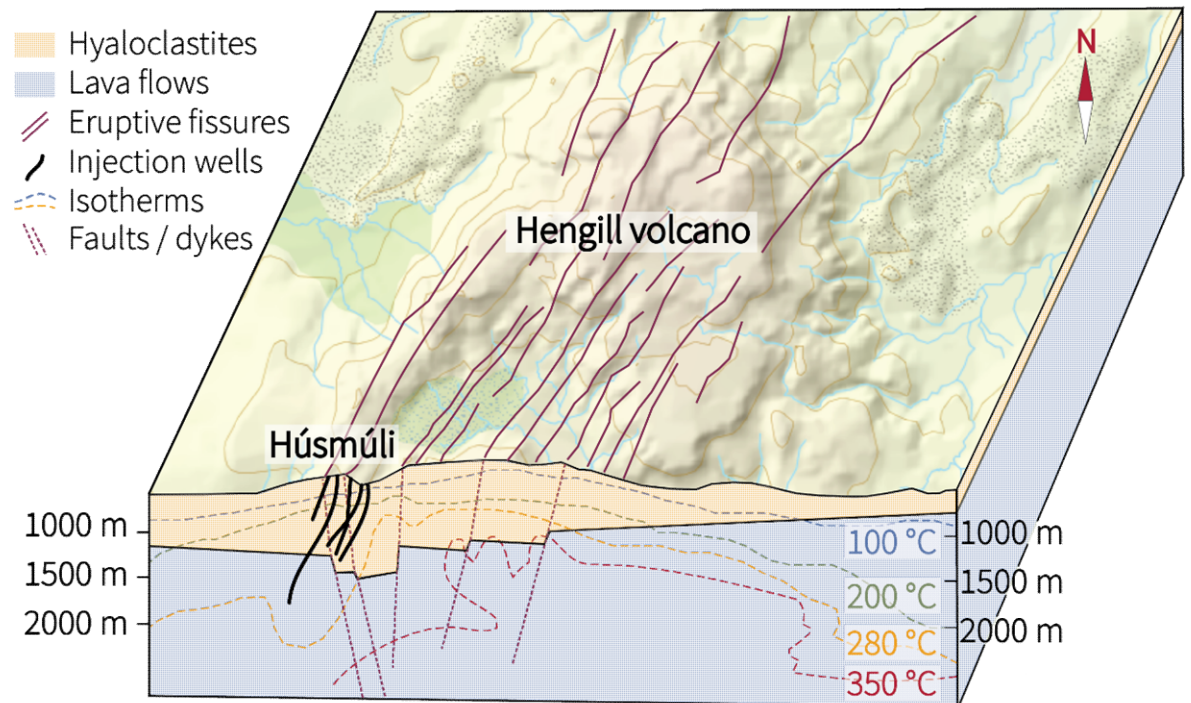
# Hús múli reinjection zone

Conventional injection with H<sub>2</sub>S and CO<sub>2</sub> dissolved

5 active injection wells since 2011

One well reaching the consolidated lava flow

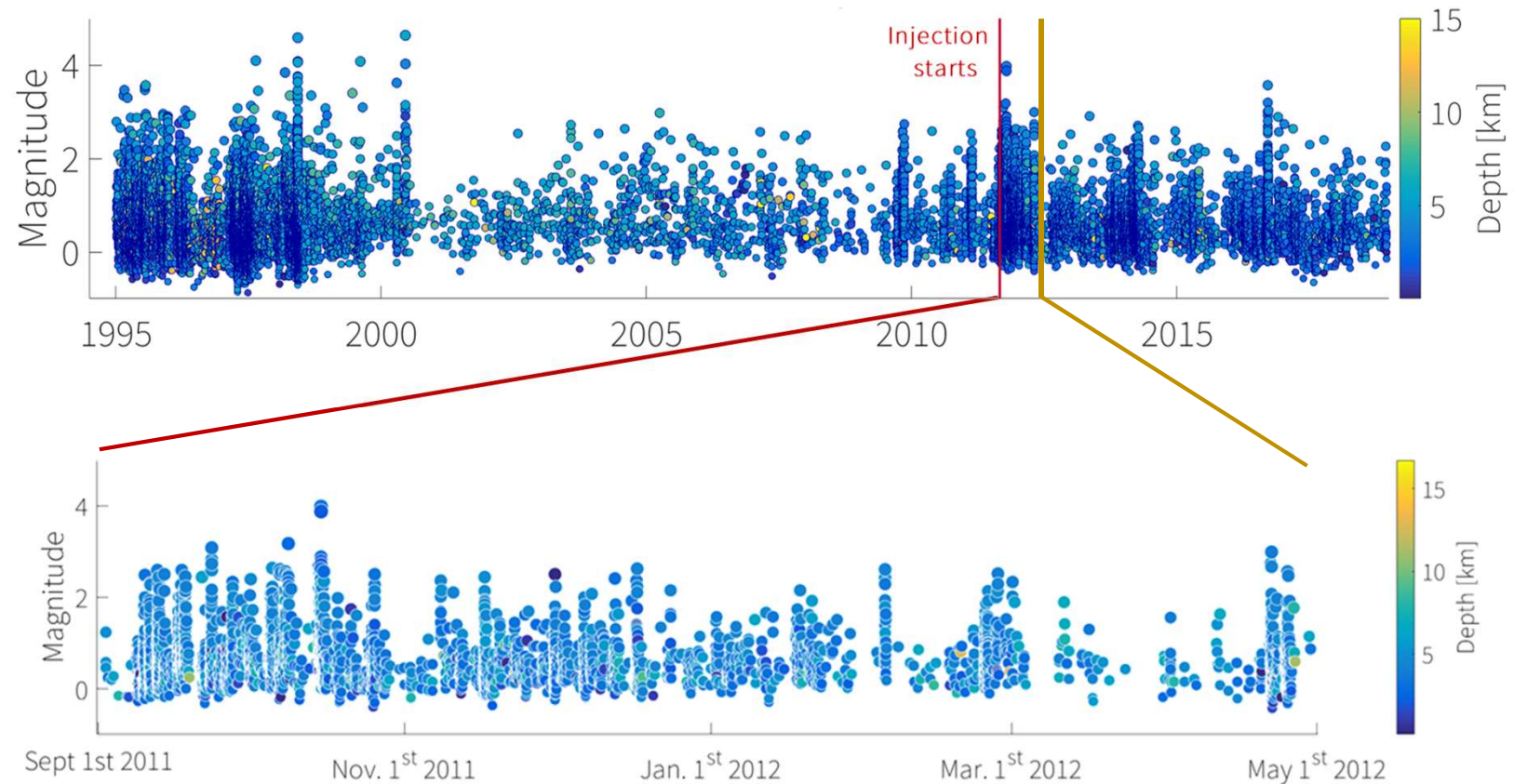
~300 to 400 L/s injected after May 2012



Conceptual model (adapted from geological models from ISOR)

# Observed seismicity in Húsmúli

- Large amount of recorded earthquake in the Húsmúli reinjection area
- 1993-1998 volcanic uplift (SIL network from 1995)
- Drilling of 8 wells between 2007 and 2011
- Start of injection in 5 wells in September 2011
- Intense period of seismic activity for 8 months (September 2011 to April 2012) until reduction of injection rates

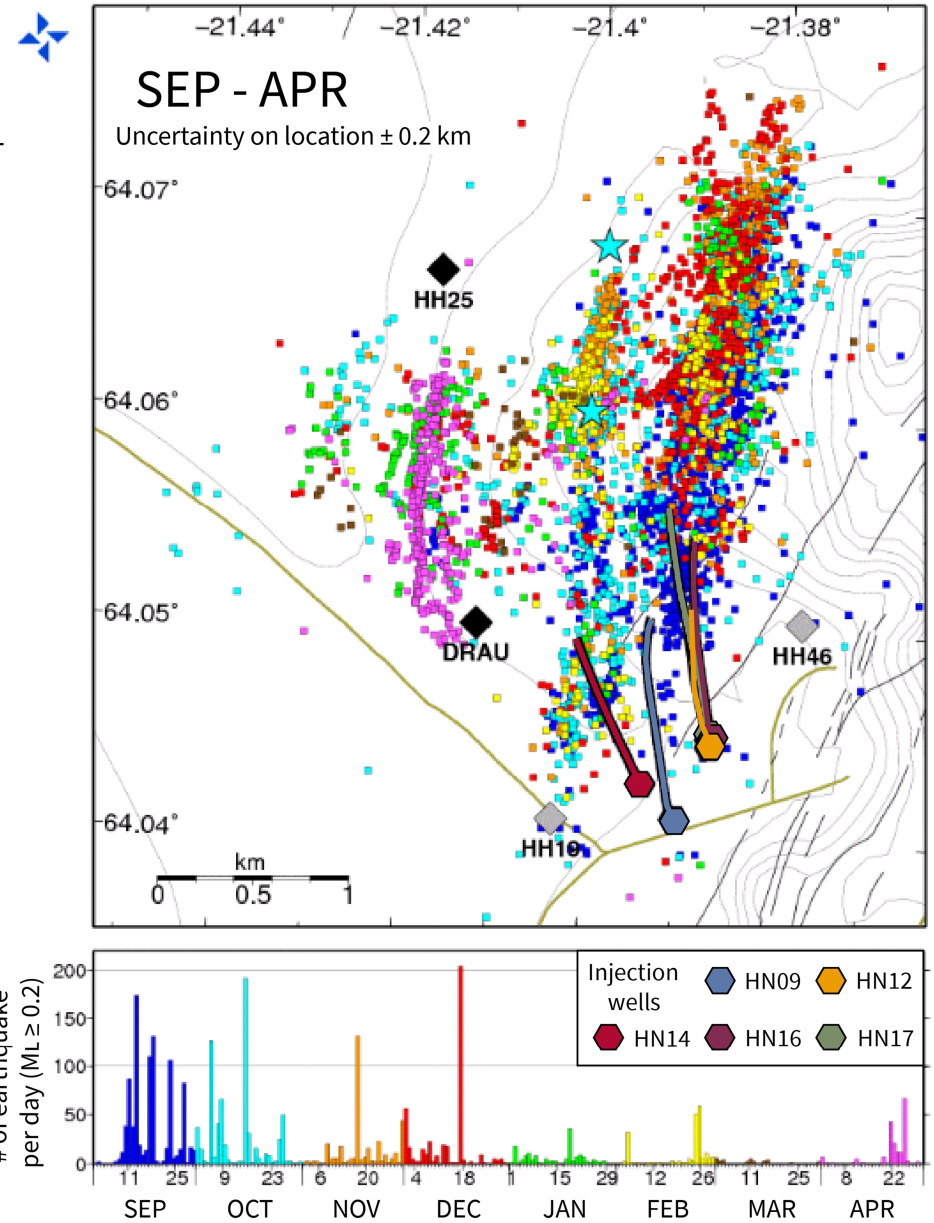
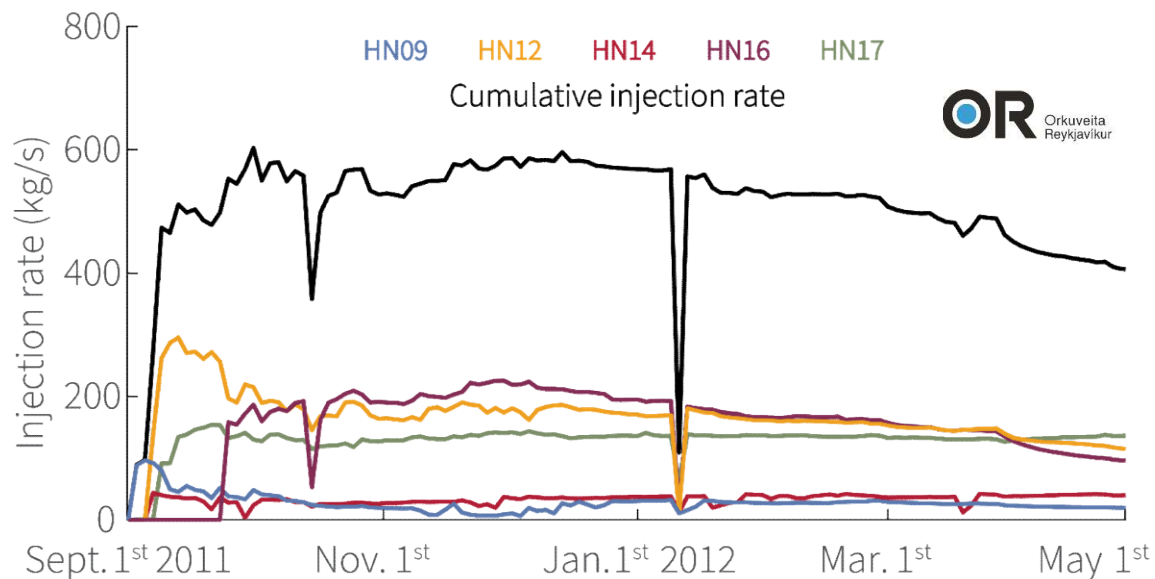


*SIL catalogue (IMO)*



# Reinjection of spent fluid in Húsmúli

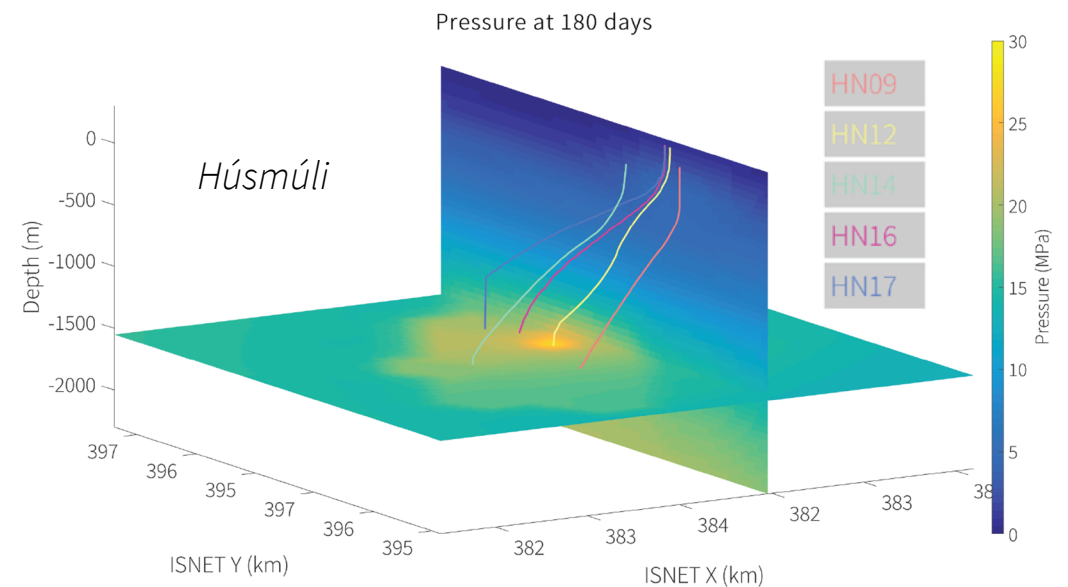
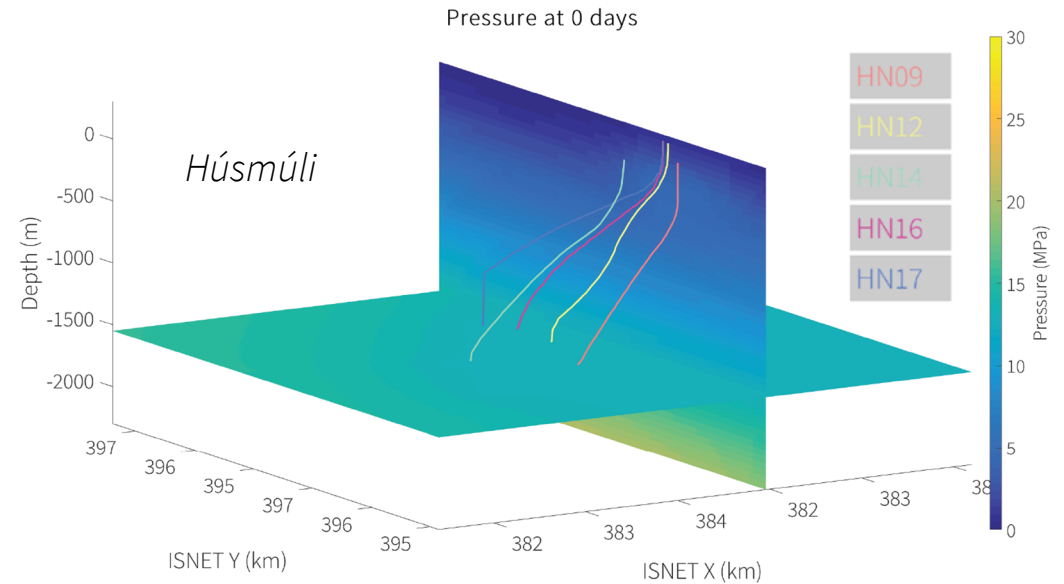
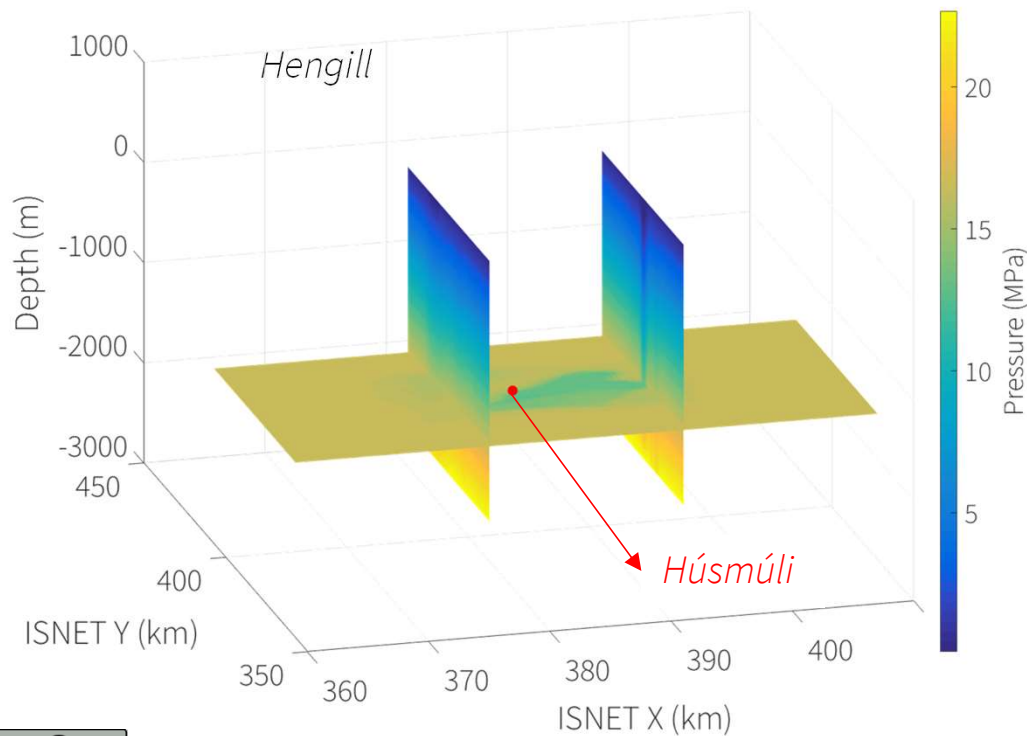
- Intense period of seismic activity for 8 months (September 2011 to April 2012) until reduction of injection rates
- 5 active injection wells for a combined injection rate ~500 L/s
- 4600 recorded earthquakes (minimum magnitude  $M_L -0.4$ )  
150 earthquakes of  $M_L \geq 2$   
8 earthquake with  $3.0 \leq M_L \leq 4.0$



Adapted from Bessason et al. 2012

# Regional TOUGH2 model

- 50x50 km, 3km depth
- ~43 000 elements
- Mesh centred around production area
- 129 production time series
- 31 injection time series



# TOUGH2-SEED

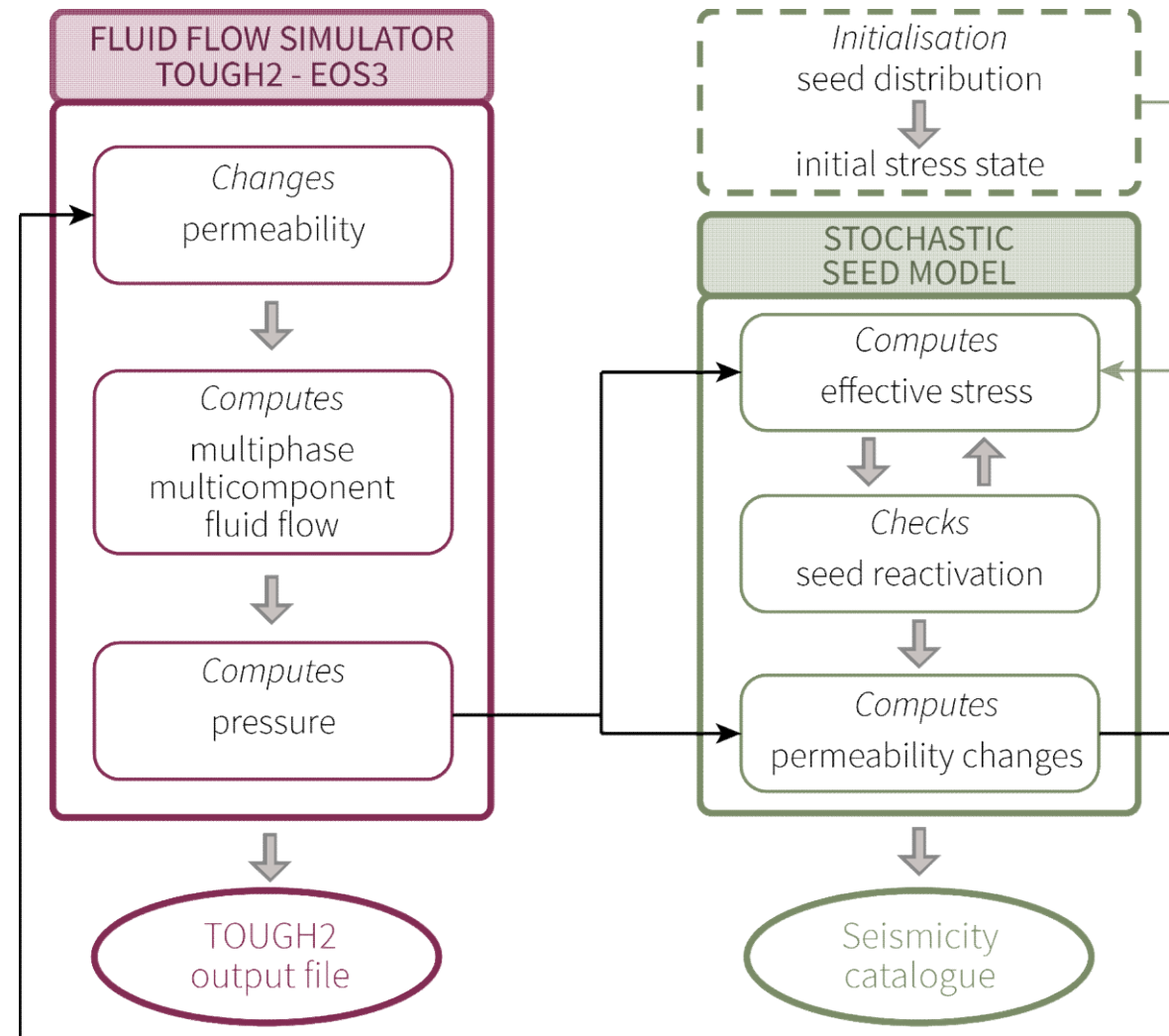
A coupled hybrid hydro-geomechanical model

## TOUGH2/EOS3

- Simulation of multiphase (gas/liquid) multi-component (air/water) fluid flow in porous medium
- Applied to a wide range of geo-engineering applications

## SEED MODEL

- Seeds = potential hypocentres distributed in space reactivating for critical pressure (Mohr-Coulomb)
- Each seed with given stress state, orientation, and local b-value from differential stress.
- At each failure a stress drop and a new stress state associated (also with CFS) and possible retriggering



*Adapted from Rinaldi and Nespoli, 2017*

# Modelling results

Model without permeability changes (only pore-pressure diffusion)

Pressure signal dominated by cluster of shallow wells HN12, and HN16

Agreement of the timely evolution of modelled seismicity with recorded seismicity, but spatial extent of modelled seismicity limited

