4th ACT Knowledge Sharing Workshop, 6-7 November 2019, Athens, Greece

Assuring Integrity of CO2 storage sites through ground surface monitoring (SENSE)

Bahman Bohloli[1], Joonsang Park[1], Tore I. Bjørnarå[1], Per M. Sparrevik[1], Malte Vöge[1], Christian Berndt[2], Ceri Vincent[3], Luke Bateson[3], Antoine Soulat[4], Audrey Estublier[4], Ola Eiken[5], Nazmul H. Mondol[6], Yann Le Gallo[7], Joshua White[8], Timothy Meckel[9], Amirali Soroush[10], Iñaki Álvarez Gutiérrez[11], Ziqiu Xue[12], Roberto Martínez Orio[13]

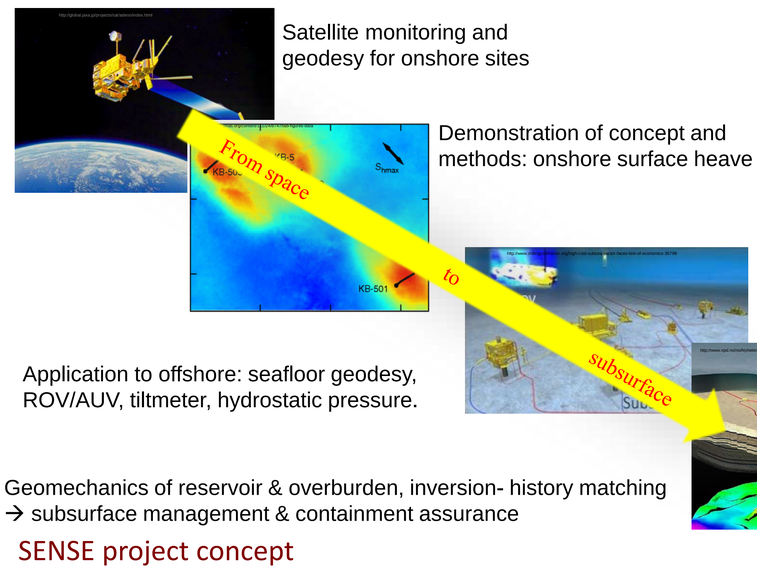
[1]Norwegian Geotechnical Institute, [2] GEOMAR, [3] British Geological Survey, [4] IFP Energies Nouvelles, [5] Quad Geometrics, [6] University of Oslo, [7] GEOGREEN, [8] Lawrence Livermore National Laboratory, [9] University of Texas Austin, [10] CSIRO, [11] Fundación Ciudad de la Energía, [12] Research Institute of Innovative Technology for the Earth, [13] Spanish Geological Survey

Contact: bahman.bohloli@ngi.no

Introduction and objective

Monitoring of geological CO_2 storage is crucial for large-scale injection to gain acceptance as a reliable method for globally reducing CO_2 emissions. Monitoring plans for large-scale operations need to include both the injection and post-injection phases to assure CO_2 is stored over geological time-scales. SENSE Project has ambitions to develop reliable, continuous and cost-efficient monitoring based on ground movement detection combined with geomechanical modeling and inversion, utilizing new technology developments, data processing optimization, and interpretation algorithms. The proposed research activities include:

1. demonstration of continuous monitoring of surface deformation and subsurface pressure distribution using satellite data, water pressure sensors, fiber optics and seafloor geodesy;
2. quantitative characterization of critical geomechanical and hydraulic parameters and automatization routine for data processing and interpretation;
3. optimization of sampling arrays and offering storage site operators a cost-effective monitoring option, forming part of an effective site assurance program and feeding into existing workflows for an early alert system.



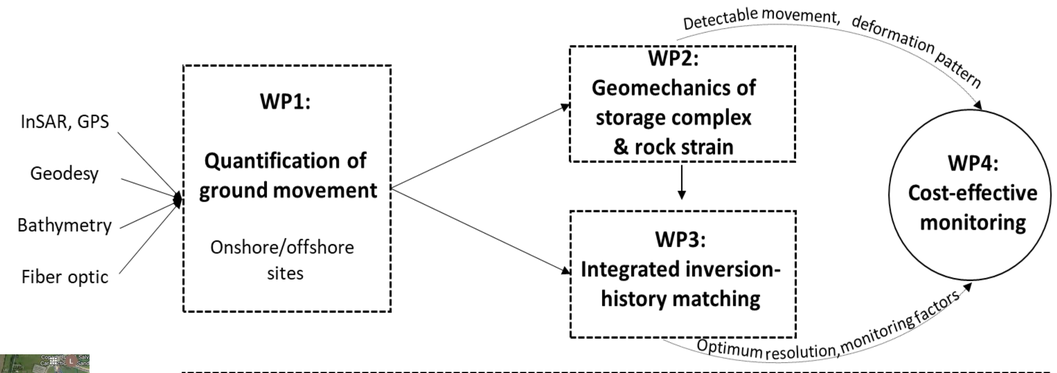
Satellite monitoring and geodesy for onshore sites

Demonstration of concept and methods: onshore surface heave

Application to offshore: seafloor geodesy, ROV/AUV, tiltmeter, hydrostatic pressure.

Geomechanics of reservoir & overburden, inversion- history matching
→ subsurface management & containment assurance

SENSE project concept



SENSE project structure and workflow

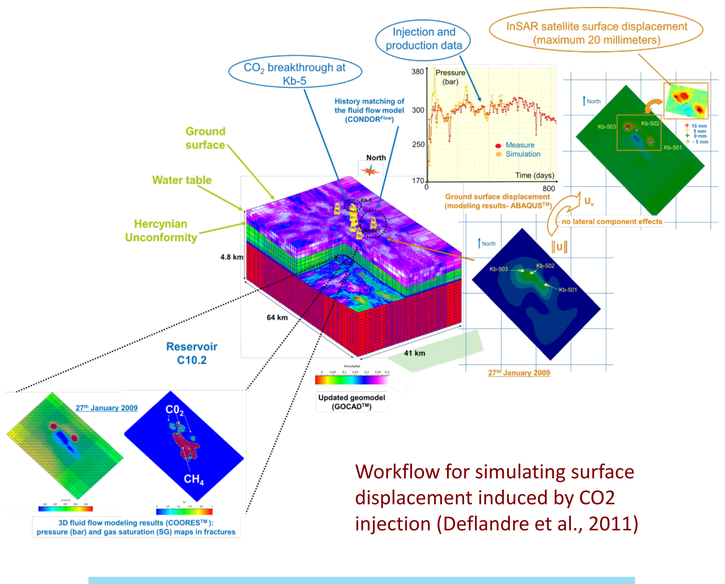
WP1: Quantification of ground movement

- Improvement of accuracy of acquired ground movement data;
- Automation of InSAR data processing to accelerate availability of ground movement to site operators;
- Demonstration of a new ocean bottom lander for cost-effective seafloor data acquisition;
- Demonstration of fiber optic strain cable for measuring ground uplift offshore.

Proposed study sites

Site #1: Hatfield Moors, UK onshore gas storage site

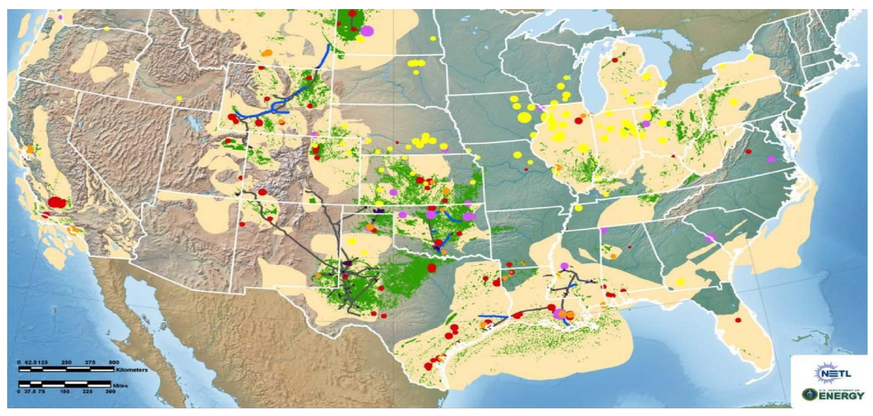
Site #2: Hontomin, Spain, pilot CO2 injection site



Workflow for simulating surface displacement induced by CO2 injection (Deflandre et al., 2011)

- First campaign completed Oct. 2019
- Coring was performed; samples to be tested
- New injection experiment (air in sand) applied for Nov 2020

Site #3: Mecklenburg Bay, Germany. Ideal geological conditions for injection



Site #4: Gulf-of-Mexico: evaluating ground deformation in GoM geologic setting

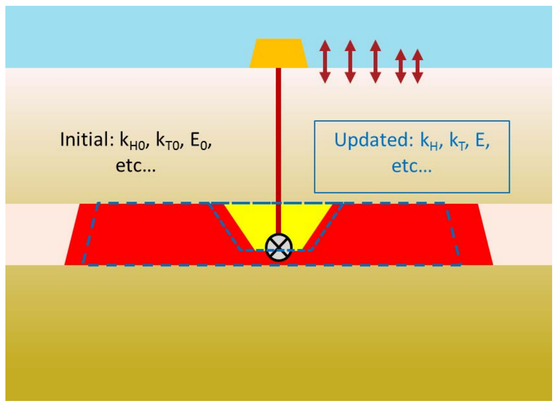
WP2: Geomechanics modelling and rock strain

Big-data-driven theoretical and conceptual SMART models based on the newly acquired and available data in SENSE;

- Advanced coupled flow-geomechanics simulations of the candidate sites including non-linearity and inelasticity;
- Coupling of geomechanical behavior of the candidate sites with changes in pressure and saturation in the subsurface.

WP3: History matching inversion; coupled flow-mechanics

- History matching (inversion) of surface deformation with subsurface pressure distribution, based on conceptual models;
- Development of inversion algorithms;
- Application of inversion technique to onshore and offshore data acquired in SENSE.



History matching inversion concept

WP4: Integration of results for cost effective monitoring

- Assessment of the effectiveness of SENSE ground deformation monitoring techniques;
- Evaluation of the ground-monitoring approach for real-time monitoring and early warning;
- Recommendation to integrate continuously-acquired ground data with monitored information such as bottom hole pressure, seismic and micro-seismic.

Acknowledgement

SENSE (Assuring integrity of CO2 storage sites through ground surface monitoring) project No. 299664, has been subsidized through ACT (EC Project no. 691712) by Gassnova, Norway, United Kingdom Department for Business, Energy and Industrial Strategy, Forschungszentrum Jülich GMBH, Projektträger Jülich, Germany, The French Agency for the Environment and Energy Management, The United States Department of Energy, Ministry of Economy, Industry and Competitiveness-State Research Agency, Spain, with additional support from Equinor, Quad Geometrics and Geogreen.