

Status and plans for Offshore Monitoring

UTCCS-5 Meeting, January, 2020

Austin, Texas

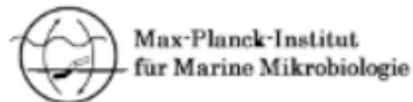


TOPICS

- **STEMM-CCS**
- **GoM-CARB MVA Task**
- **ACT-SENSE**
- **Field Example: Tomakomai, Japan**
 - **Overburden monitoring with HR3D Seismic.**

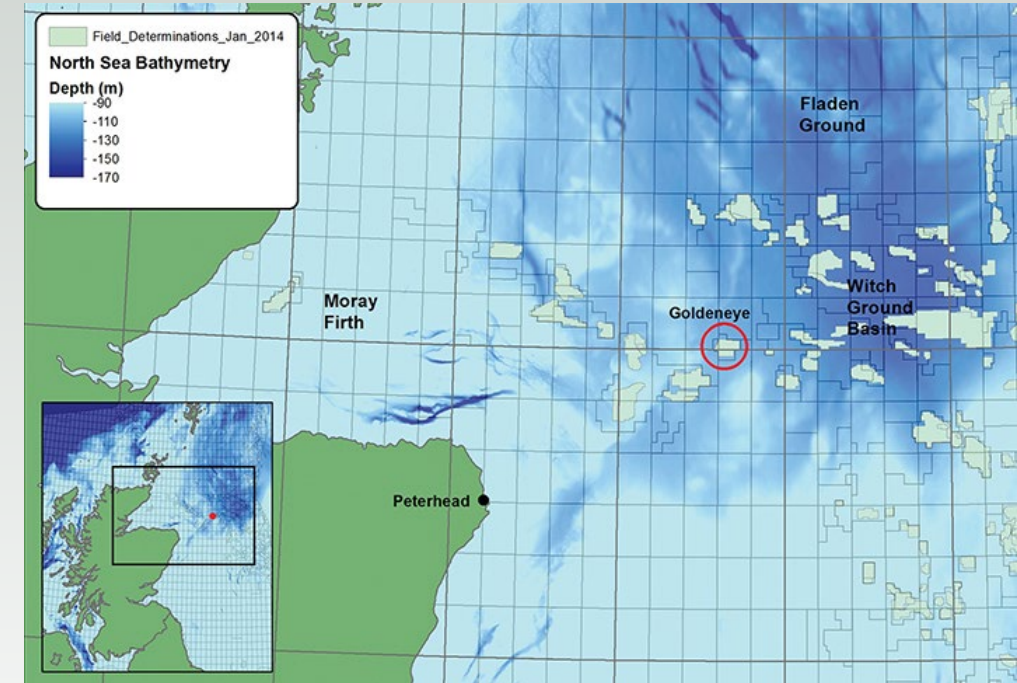
STEMM-CCS

- Produce new tools and techniques for environmental monitoring as well as CO₂ emission monitoring, quantification and assessment;
- Generate new knowledge of the reservoir overburden by direct investigation of natural geological and manmade features;
- Deliver the first CCS demonstration project level implementation of an ecological baseline, incorporating geochemical and biological variability;
- Promote knowledge transfer to industrial and regulatory stakeholders and local and international communities.



Strategy: conduct a leakage field experiment

- The keystone of STEMM-CCS is a novel **experiment to simulate a sub-seafloor CO₂ escape** under real-life conditions in the North Sea.
- Over a period of three weeks in spring 2019, CO₂ gas – augmented with inert chemical tracers – was injected into seafloor sediments at a carefully chosen experimental site near the **Goldeneye complex**, just over 100 km offshore Peterhead in NE Scotland.
- The consequences of this CO₂ release were carefully **monitored by a sophisticated array of chemical sensors, acoustic devices, visual observations and seismic surveys** operated by scientists aboard research vessels RRS James Cook and RV Poseidon.



Registration now open for the STEMM-CCS Open Science Meeting and 4th International Workshop on Offshore Geologic CO₂ Storage. Join us in Bergen, 11-12th Feb 2020.

GoMCARB Task 4: Monitoring, Verification, and Assessment

- **Subtask 4.1: MVA Technologies and Methodologies**
- This subtask will identify a **suite of MVA technologies and methodologies for large-scale storage projects** and evaluate suitability for the unique characteristics of the environments expected to be encountered in the region. Adaptations of existing, and novel-technologies will all be considered.
- **Subtask 4.1.1 Geochemical Monitoring of Seabed Sediments** The Recipient will investigate geochemical monitoring of seabed sediments
- **Subtask 4.1.2 UHR3D Seismic** The Recipient will refine concepts related to utilization of novel UHR3D (ultra-high resolution 3D) seismic for characterization and monitoring of injection reservoirs and overburden.
- **Subtask 4.1.3 Distributed Acoustic Sensors** The Recipient will investigate Distributed Acoustic Sensors (DAS) via fiber for targeted MVA.
- **Subtask 4.1.4 Pipeline MVA** The Recipient will investigate MVA applicable to pipeline transport in the offshore.
- **Subtask 4.2: Plans for Testing of MVA Technologies**
- This subtask will incorporate the knowledge and lessons learned from previous and current offshore storage efforts (including international collaboration) to develop plans for testing of MVA technologies to support the most likely offshore geologic storage scenarios. Based on the lessons learned from this subtask, a summary of MVA lessons learned will be developed in collaboration with the other awarded project from FOA1734 to ensure safe, long-term, economically viable carbon storage in offshore environments.
- **Subtask 4.2.1** A priority list for MVA technologies and their testing methods will be developed.

D4.1a Table of MVA technologies and methodologies

Organization	Methodology	Technology
	Geochemical	
Texas A&M GERG	Physical dynamics of seawater column-temperature, currents, salinity for understanding geochemical variability and mixing	TABS buoys with sensors - additional sensors can be added to fill in gaps.
Texas Water Development Board	Freshwater inflows to Texas bays and estuaries.	Datasonde collects water temperature, conductivity, water level, and salinity data of freshwater inputs
Plymouth Marine Labs	Marine system modelling for characterizing pH baseline as well as trace gases, nutrients and carbonate chemistry variables	Using large databases and marine models to discern chemical changes from a release from natural variability
National Oceanographic Centre Southampton/University of Bergen	Seawater column process-based or stoichiometric geochemical assessment "C-SEEP"	biogeochemical sensor technology- pH, nitrate, phosphate new optodes for Oxygen and pH; mounted on benthic landers and water column moorings
National Oceanographic Centre Southampton	Eddy Co-variance	novel estimation of benthic dissolved inorganic carbon fluxes using eddy covariance and fast O2 and pH sensors
Japan CCS/METI	Ecological survey	Benthic faunal species direct observation
Japan CCS/METI	Bubble plume detection	Side scan sonar
University of Southampton	Bubble plume detection	Passive acoustic monitoring with optical techniques
Italian Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS),	multibeam seafloor echosounder survey	Detailed map of the seabed and images of bubbles in the water column.
IEAGHG Monitoring selection tool	bubble stream chemistry/tracers	
TDI-Brooks, Int.	Shallow sediment pore water/dissolved gas geochemistry	Shallow sediment coring and geochemical assessment

	Geophysical	
GCCC	Acquisition of High-frequency, medium-depth investigation 3D seismic	High-Resolution 3D Seismic
	Acoustic	
LBNL / Rice University	Relies on light, which is Rayleigh backscattered from small variations in the refractive index of the fiber	Distributed Acoustic Sensing (DAS) fiber
Fugro	Seabed mapping and water column gas detection	Acoustic sonar
Fugro and potential 3rd-party-provided sensors	multibeam echo sounder	Acoustic sensor
	single beam echo sounder	Acoustic sensor
	synthetic aperture sonar	Acoustic sensor
	subbottom profiler	Acoustic sensor
	pCO2	chemical sensor
	pH	chemical sensor
	conductivity	chemical sensor
	Redox potential (ORP)	chemical sensor
	major elements	chemical sensor
	trace elements	chemical sensor
	nutrients	chemical-biological sensor
	hydrocarbons	chemical-biological sensor
	mass spectrometer	chemical sensor
	OsmoSampler	sampling system

ACT-SENSE

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



Meckel will attend SENSE meetings and provide earth models and recommendations for evaluating prospective storage sites in the U.S. offshore region of the Gulf of Mexico.



The objective of this project is to:

1. Demonstrate tools and technology for measuring ground movement accurately,
2. Develop innovative techniques and workflows for coupling ground movement to the variable reservoir parameters such as pressure, rate, temperature and
3. Provide continuous, cost-effective monitoring methods for CO₂ storage sites and reassure operators and regulators about safety and long-term site closure.

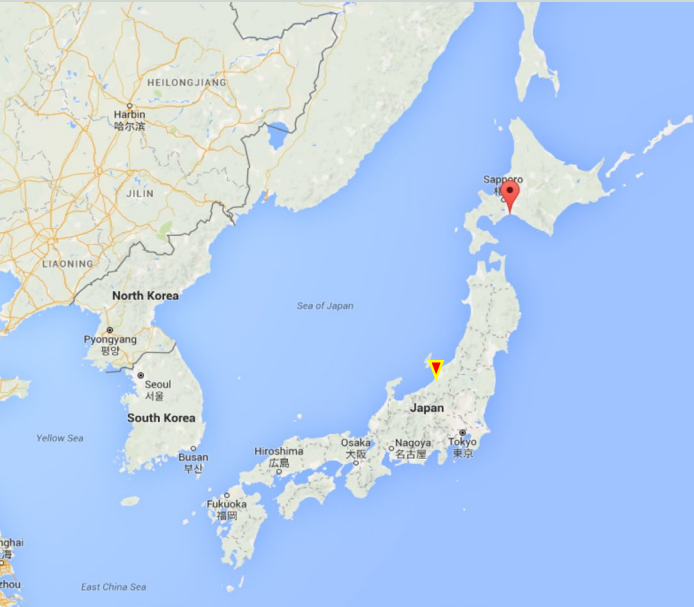
Approach

- Monitoring of ground surface above reservoirs on land through satellite/GPS data, and **at seabed** through integrated technical solutions such as water pressure sensors, inclinometers, fiber optics and seafloor geodesy.
- The field data will then be utilized for **inversion and history matching** to understand the response of the subsurface (including the overburden) to pressure disturbance in the reservoir.
- **Numerical simulation** of the sites will be carried out to quantify and understand the geomechanical behavior of the sites, the physical processes behind ground movement, and develop concepts to link ground uplift/subsidence to hydro-mechanical events in the subsurface.

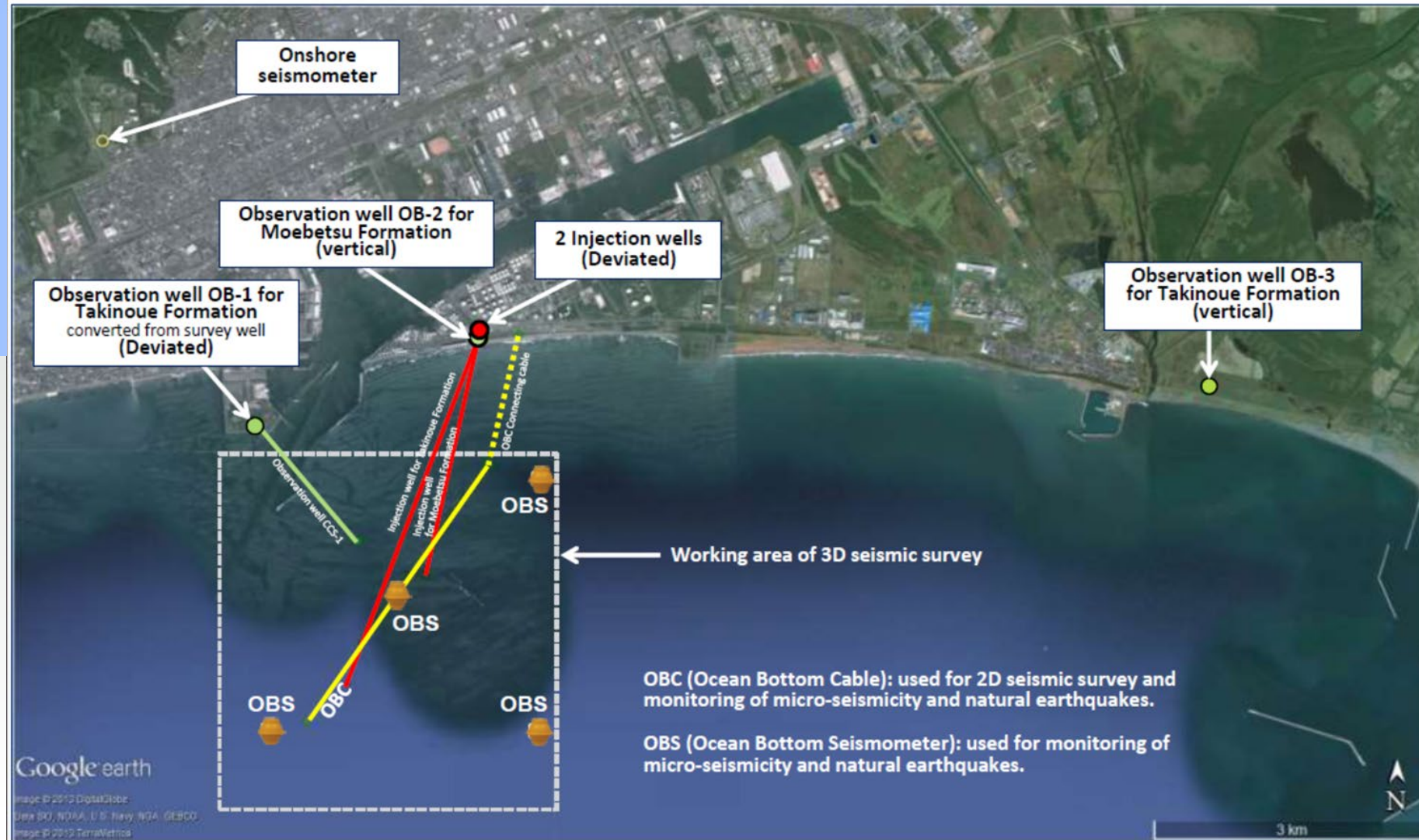
A number of technical tools and measures will be utilized

- Demonstration of a new ocean bottom lander for cost-effective seafloor data acquisition,
- Demonstration of fiber optic strain cable for measuring and monitoring the uplift lobe above a pressurized reservoir,
- Development of innovative inversion algorithms and workflows for coupling ground deformation to state variable reservoir parameters and to pressure distribution in space and time.

Layout of Monitoring Facilities

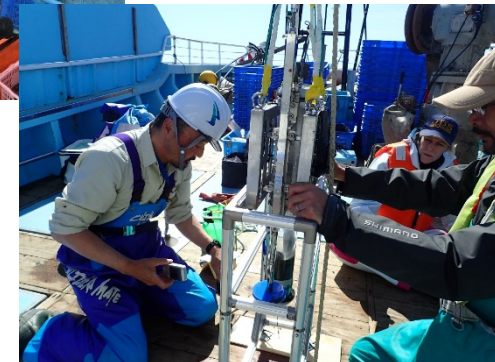


Tomakomai Project Japan

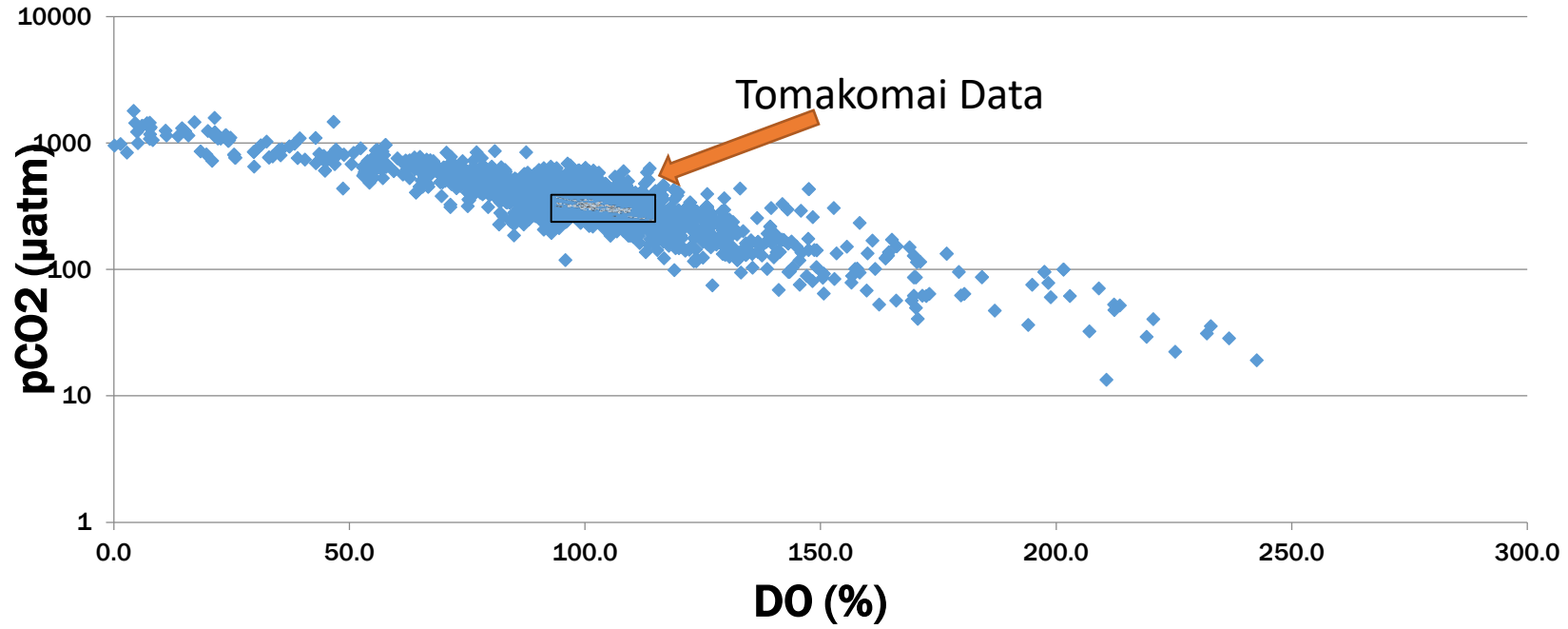


Sediment and Water Sampling

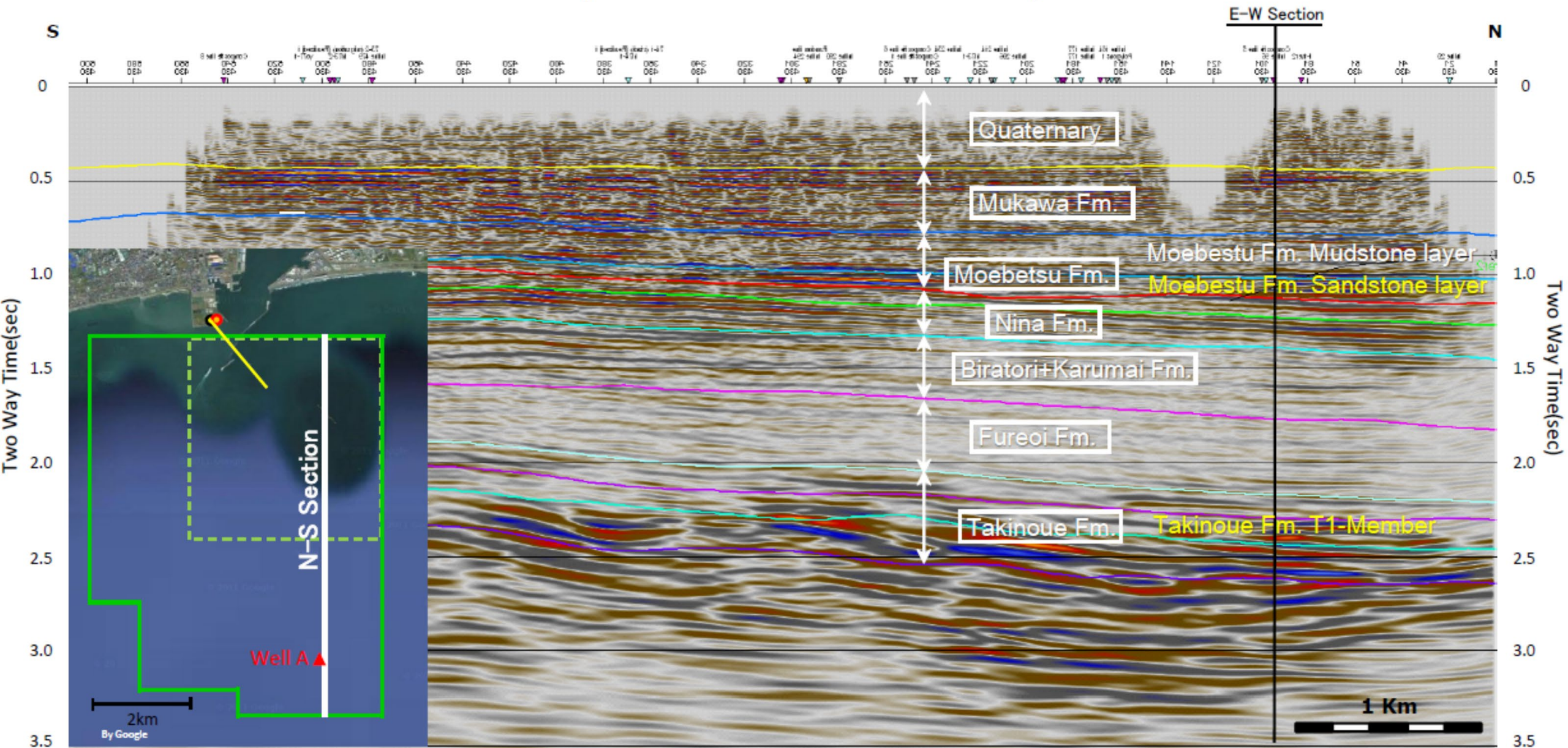
- Accompany environmental sampling team on a routine monitoring trip
- Add sediment pore water analysis
- Add ^{14}C and hydrocarbons to analytical suite
- Collaborate to integrate analyses with current monitoring parameters and methods



10 Years of Osaka Bay Data 1 year Tomakomai Data

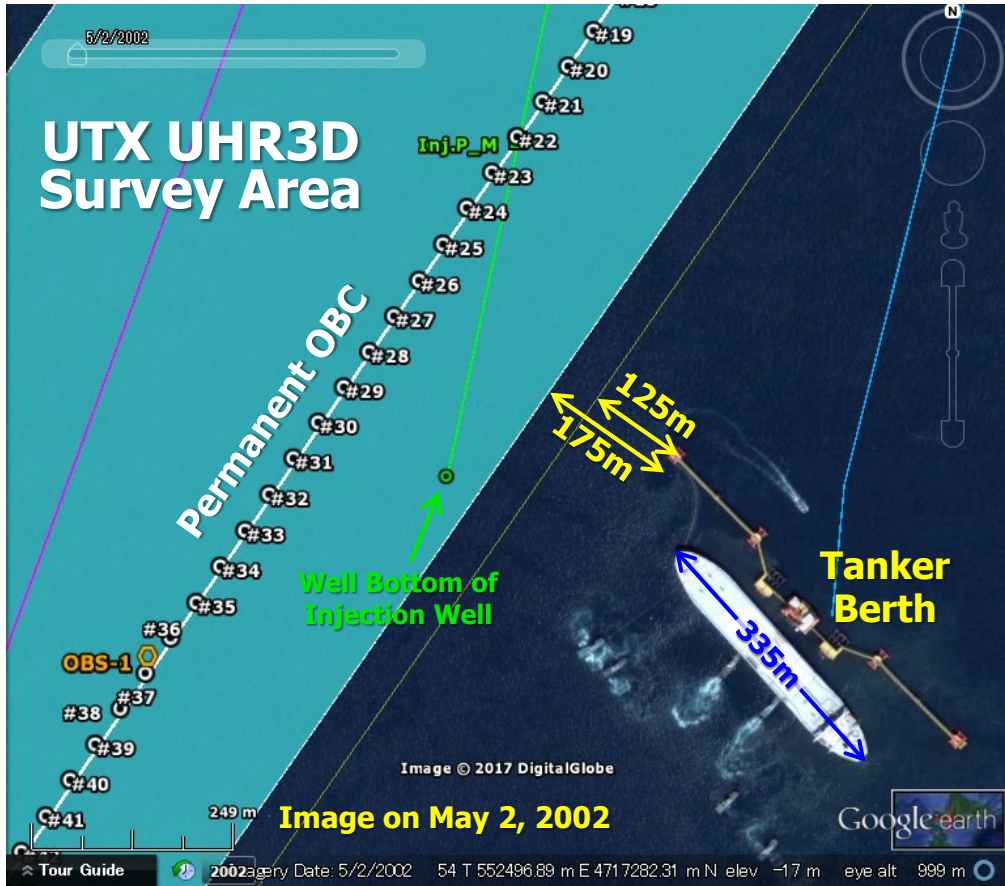
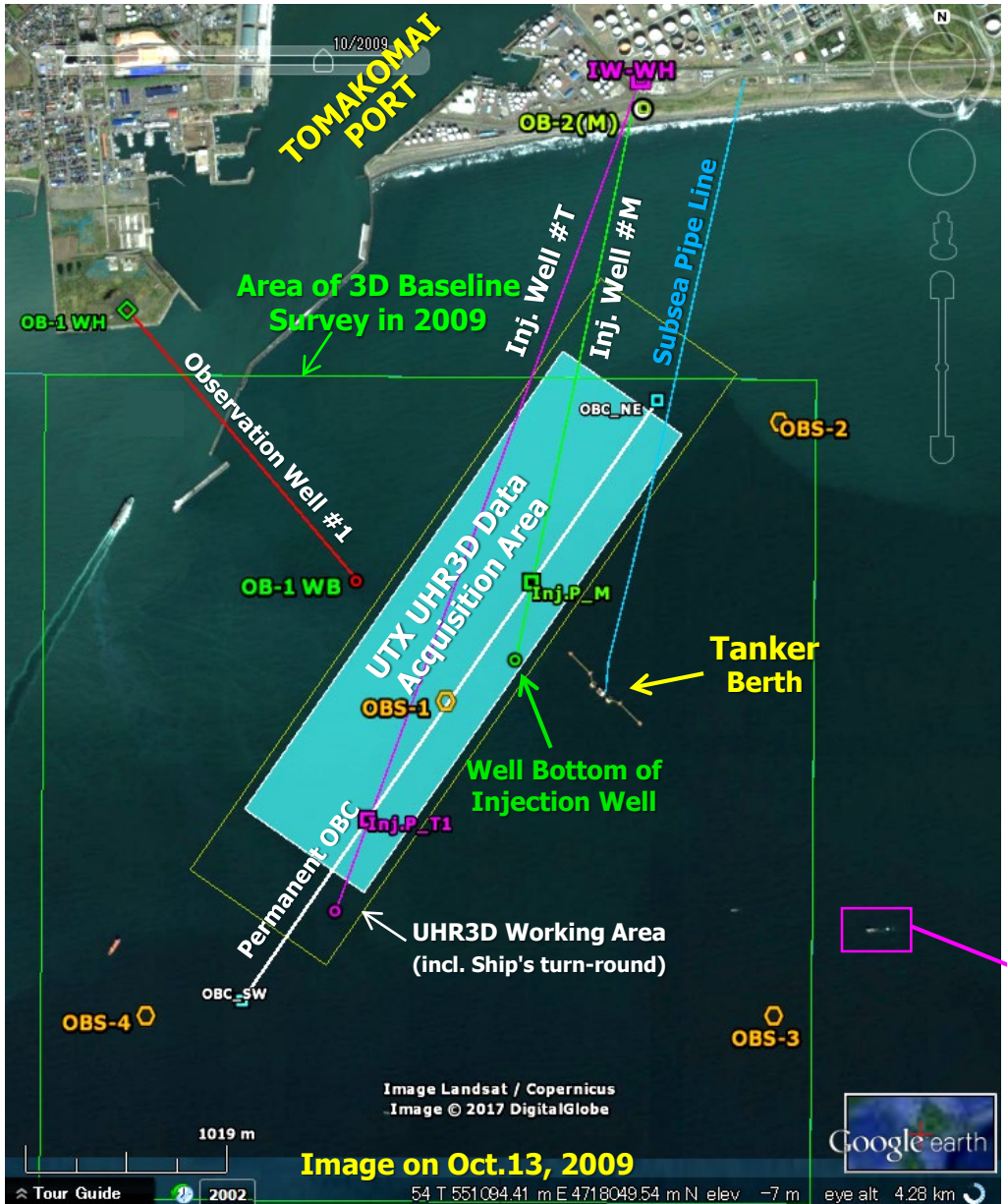


Geological Structure: North-South Section by 3 D Seismic Survey



Survey Area of UTX UHR3D off Tomakomai (Final Plan)

Rev. 2017.07.21



Google Earth Image on Oct.13, 2009 (1st 3D Survey in 2009)

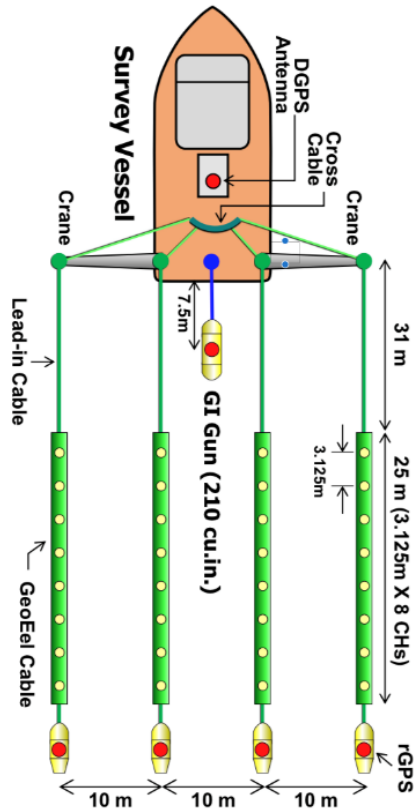
HR3D acquisition August 2017 – Tomakomai, Japan



CO₂ Injection

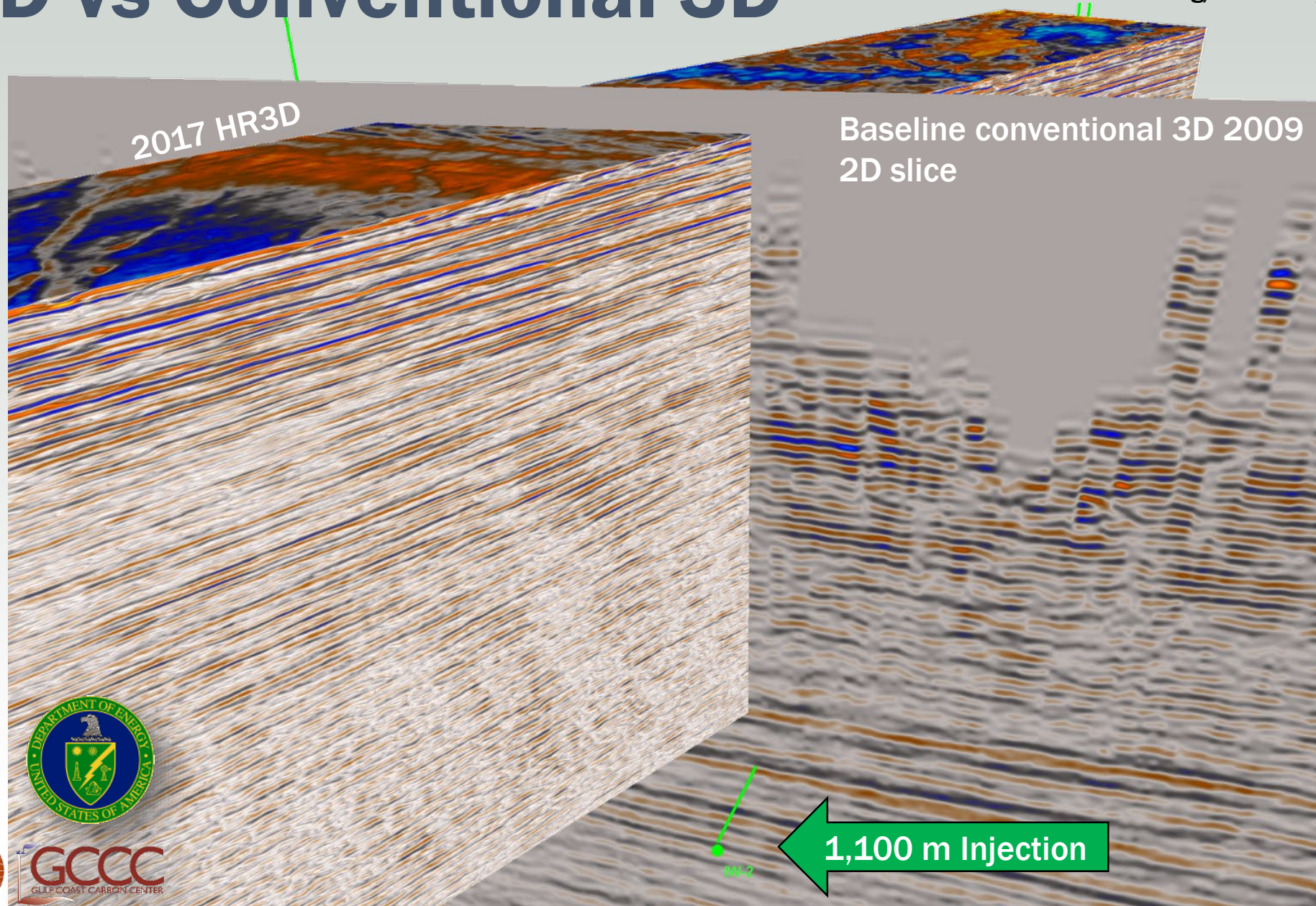


Gas Separation



HR3D vs Conventional 3D

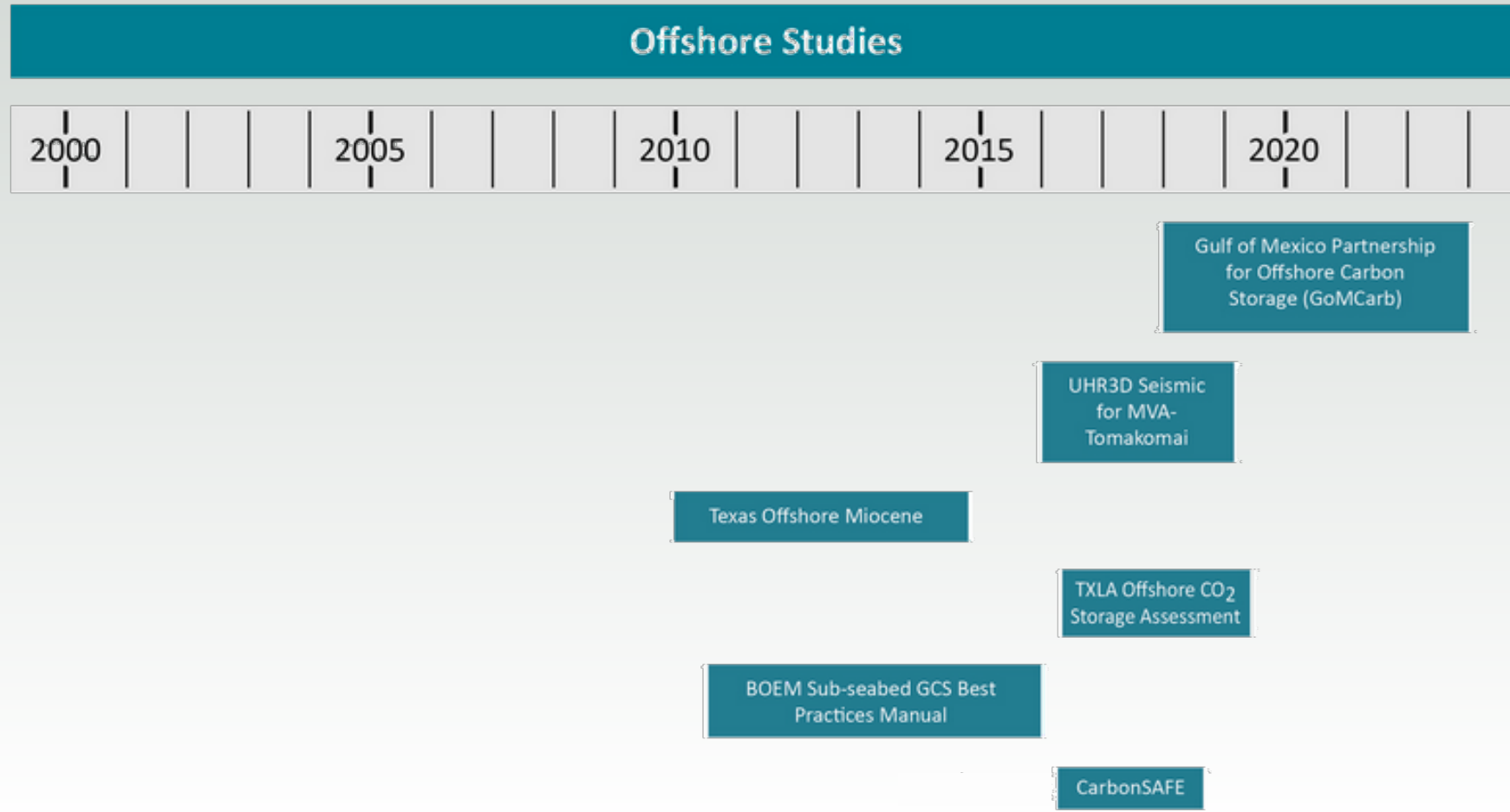
Meckel & Feng , 2019, IJGGC
doi.org/10.1016/j.ijggc.2019.05.034





Extra slides

Offshore GoM (Gulf of Mexico) Studies



ACT – Accelerating Carbon Technologies

Q3 2019 - Q2 2022



SENSE – Assuring integrity of CO₂ storage sites through ground surface monitoring

Demonstrate reliable, cost efficient CO₂ storage monitoring using ground surface deformation detection combined with geomechanical modelling and inversion to provide information on pressure distribution and hydraulic behaviour of storage sites.

Meckel will attend SENSE meetings and provide earth models and recommendations for evaluating prospective storage sites in the U.S. offshore region of the Gulf of Mexico.

Country	National Coordinator	Participating partner
Australia	CSIRO - Commonwealth Scientific and Industrial Research Organisation	
France	IFP Energies Nouvelle	GEOGREEN
Germany	GEOMAR Helmholtz Centre for Ocean Research Kiel	
Japan	Research Institute of Innovative Technology for the Earth (RITE)	
Norway	Norwegian Geotechnical Institute	University of Oslo, EQUINOR ENERGY AS, QUAD GEOMETRICS NORWAY AS
Spain	Fundación Ciudad de la Energía (CIUDEN)	Spanish Geological Survey (IGME)
Switzerland	Swiss Federal Institute of Technology, EPFL	
UK	British Geological Survey (BGS)	
USA	Lawrence Livermore National Laboratory	The University of Texas at Austin

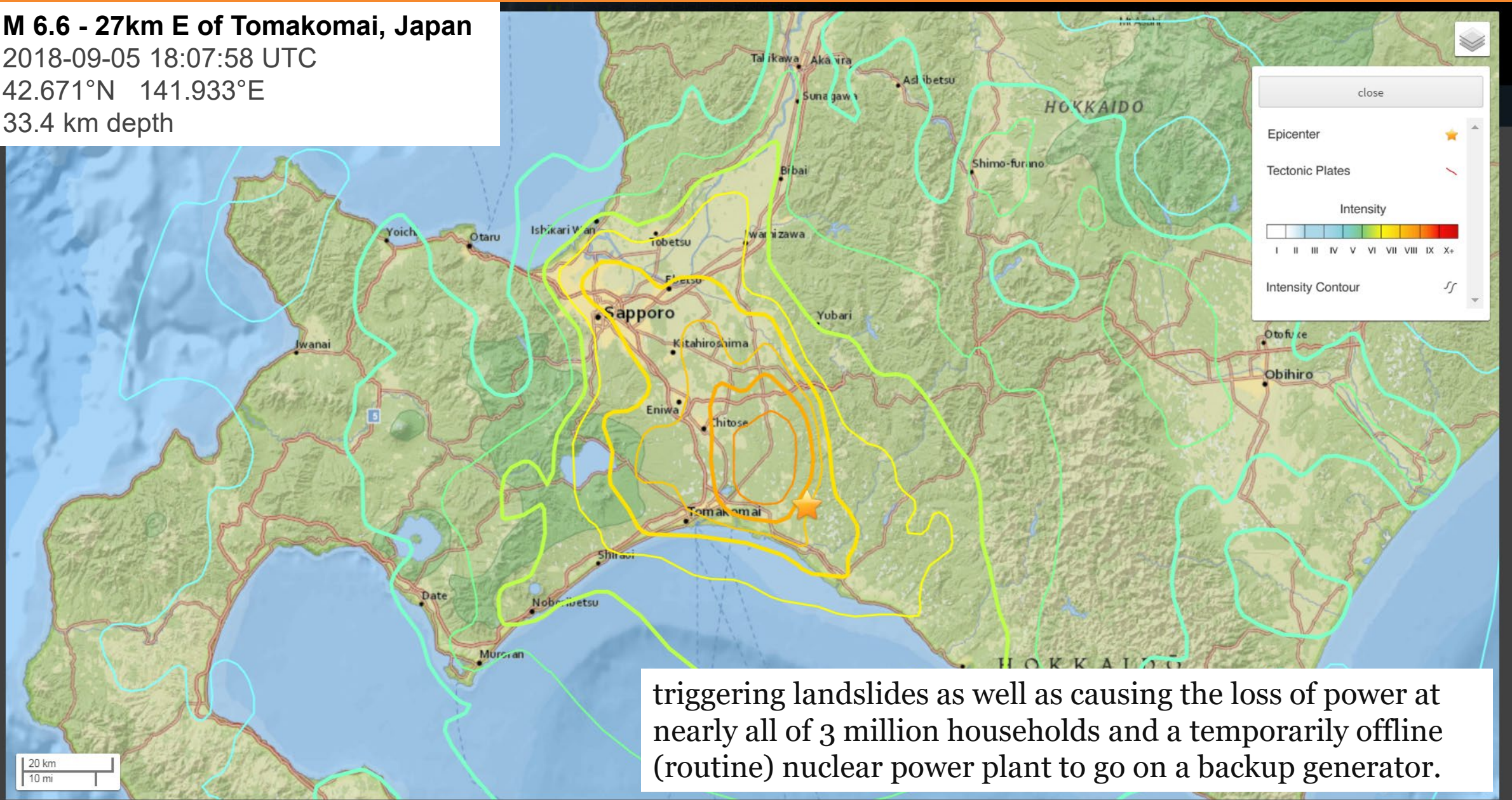
Last meeting October 2019
Next meeting June 2020

M 6.6 - 27km E of Tomakomai, Japan

2018-09-05 18:07:58 UTC

42.671°N 141.933°E

33.4 km depth



triggering landslides as well as causing the loss of power at nearly all of 3 million households and a temporarily offline (routine) nuclear power plant to go on a backup generator.