International Monitoring Updates from IEAGHG Monitoring Network

US DOE Carbon Storage R&D Project Review Meeting

12th – 14th August 2014

Pittsburgh

Panel

- Don White, Geological Survey of Canada, NRCAN
- Katherine Romanak, BEG University of Texas at Austin
- Ian Wright, Director Science and Technology, National Oceanography Centre, Southampton UK
- Tim Dixon, IEAGHG

Monitoring Network and Modelling Network - Combined Meeting

Hosts: West Virginia University

Sponsors: West Virginia University National Research Center for Coal and Energy, West Virginia Division of Energy, Battelle, Southern States Energy Board

4th – 8th August 2014

Morgantown

Networks' Objectives –

- **Modelling Network**: To provide an international forum for technical experts to share knowledge and ideas, promoting collaborative projects and contributing to the development of storage performance assessment.

- **Monitoring Network :** Overall aim: To facilitate the exchange of ideas and experiences between experts in the monitoring of CO_2 storage, and to promote the improved design and implementation of monitoring programmes.

- Specific aims and objectives:
  - Assess new technologies and techniques
  - Determine the limitations, accuracy and applicability of techniques
  - Disseminate information from research and pilot storage projects
  - Develop extensive monitoring guidelines
  - Engage with relevant regulatory bodies
    - Monitoring Selection Tool http://www.ieaghg.org/index.php?/ccs-resources.html

Technical Sessions relating to Monitoring

- Detection and Monitoring of Migration and Leakage
- Detection and Quantification of Leakage
- Offshore
- Microseismicity
- How can Modelling Improve Monitoring
- Cost-effectiveness

Some Specific Key Messages

- Tracers - most useful for residual saturation (containment) - Australia
- Marine water column - improved approach based on process-based method - Japan
- Complexity at shallow depth at CO2Fieldlab - Norway
- New data on marine shallow subsurface and water column from QICS - UK
- P-cable providing high resolution data on shallow overburden - USA
- FutureGen2 and ADM first permits – precedent - USA

Some General Key Messages and Conclusions

- Pressure monitoring likely to be early indicator of leakage; we are getting more out of pressure gauge data
- Seismic monitoring applied offshore and onshore – example of cheaper offshore per unit area
- Storage monitoring of CO2 EOR is different from saline storage
- Microseismic - benefits; data from current projects is reducing uncertainty - and identifying uncertainty
- Monitoring to modelling iteration is essential and proving effective

Some Gaps

- Surface monitoring for leak detection – large area with high sensitivity
- Will introduced tracers make it to the surface?
- Monitoring fracture zones and migration mechanism/process
- Secondary accumulations at shallower depths
- Baseline for CO2 EOR projects – difficult to define
- Need (shallow) monitoring techniques which are continuous, real time, accurate, and cost effective – problems with accuracy of available sensors – benchmarking of available sensors
- Monitoring for commercial-scale deployment: what will be the right balance between cost and sensitivity to meet regulatory requirements

Geophysical Monitoring: Deep CO_2 – In or Near the Storage Complex

- Pressure measurements
  - Reservoir performance & overburden monitoring
  - Great value and relatively inexpensive
- Time-lapse surface seismic
  - Best demonstrated for large-scale injection (Snohvit, Sleipner, Ketzin Weyburn)
  - But, expensive & has some "blind" spots (small volumes or thin zones)
  - New developments:
    - dedicated surface arrays (Aquistore, Australia)
    - continuously operating low-impact sources (Spain, Japan/Aquistore)
    - improved sensitivity & reduced cost
- Time-lapse vertical seismic profiles
  - Suited for "near wellbore" environment (Decatur, Citronelle, Bell Creek, Aquistore, Weyburn); repeatability and deployment issues persist
  - New developments: Distributed Acoustic Sensing (Citronelle, Otway, Quest, Aquistore)

Geophysical Monitoring- Deep CO_2

- Passive seismic monitoring (widespread)
  - microseismicity (local processes associated with pressure transients)
  - potential induced seismicity (fault reactivation)
- InSAR (In Salah, Quest, Decatur, Aquistore)
  - pressure plume monitoring
  - covers large area at reasonable cost
  - but, needs good geomechanical model
- Other geophysics (surface and downhole):
  - gravity (Sleipner, Aquistore, FutureGen, MRCSP)
  - electrical (sensitive to dissolved CO_2! Ketzin, Nagaoka, Aquistore)
  - Electromagnetic (CCP3-Aquistore)
- Quantification
  - requires integration of monitoring data and modelling

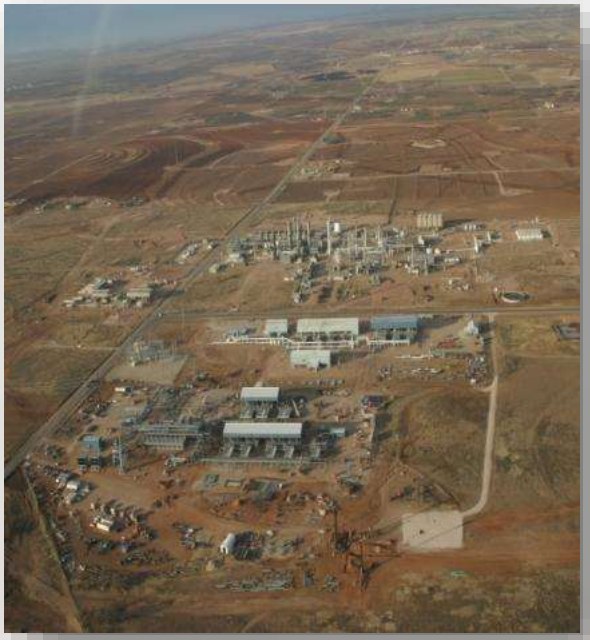
Near-Surface Monitoring

- New field observations (Norway and Brazil) show little predictability in where CO_2 will emerge at the surface
- Integrating data collection over an appropriate area is a remaining challenge
- Understanding transport and chemical evolution of fluids through the overburden
  - Role of faults in vertical transmission
  - Reactivity – Under what fluxes and time spans will CO_2 reach the surface?
  - Secondary accumulations?
  - Effectiveness of tracers to track vertical migration

***Deep Reservoir to Near-surface**:*

Transition to Cost-Effective Industrial Monitoring

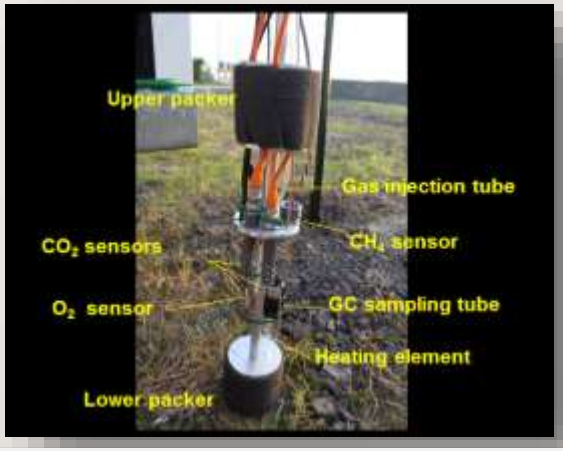
- Minimalistic approach relative to research-oriented
- Not all tools and approaches will be used
- Balance between regulatory and technical goals
- Balance between cost effective and accurate data collection



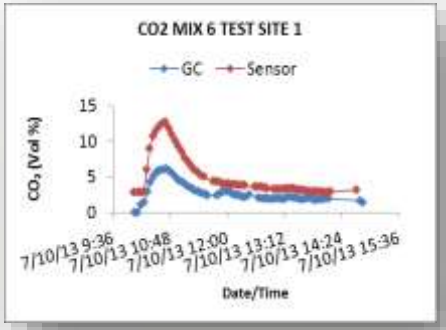
User-Friendly Data Collection

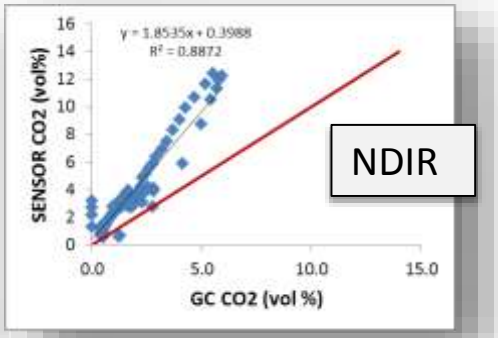
- Accurate
- Continuous
- Real-time
- Smart

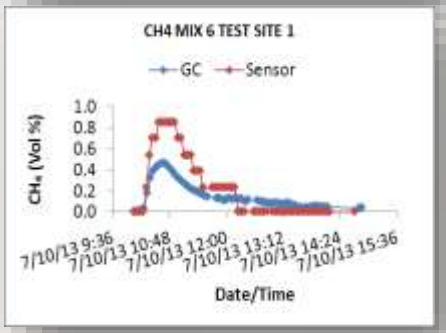
Current technologies require improvement for field deployment

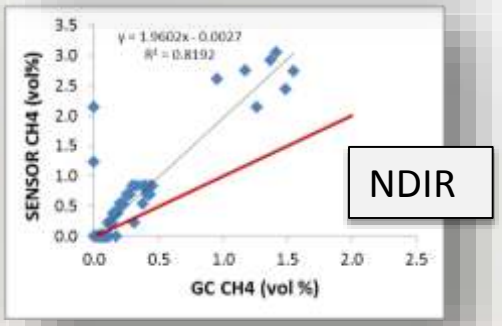


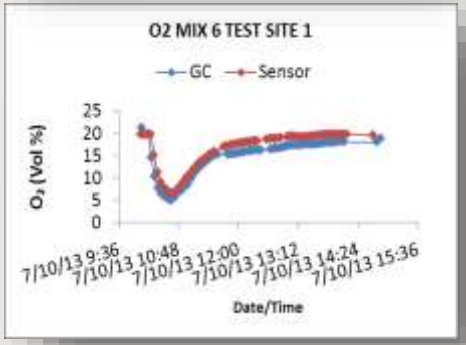
Commercial sensors being tested downhole

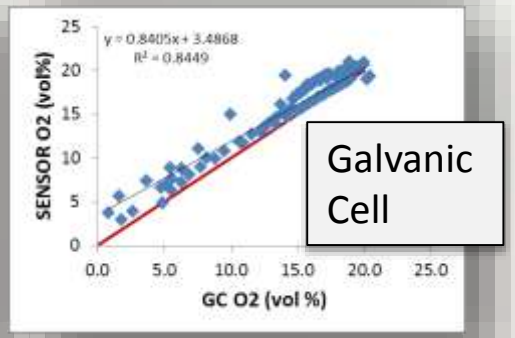












Katherine Romanak

QICS
Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbon Storage

QICS: UK – Japan; controlled sub-seafloor CO_2 release experiment

ECO2
Sub-seabed CO_2 Storage: Impact on Marine Ecosystems

ECO2: EU project; analogue and existing site study, including work at Sleipner and Snøhvit; Statoil project partner

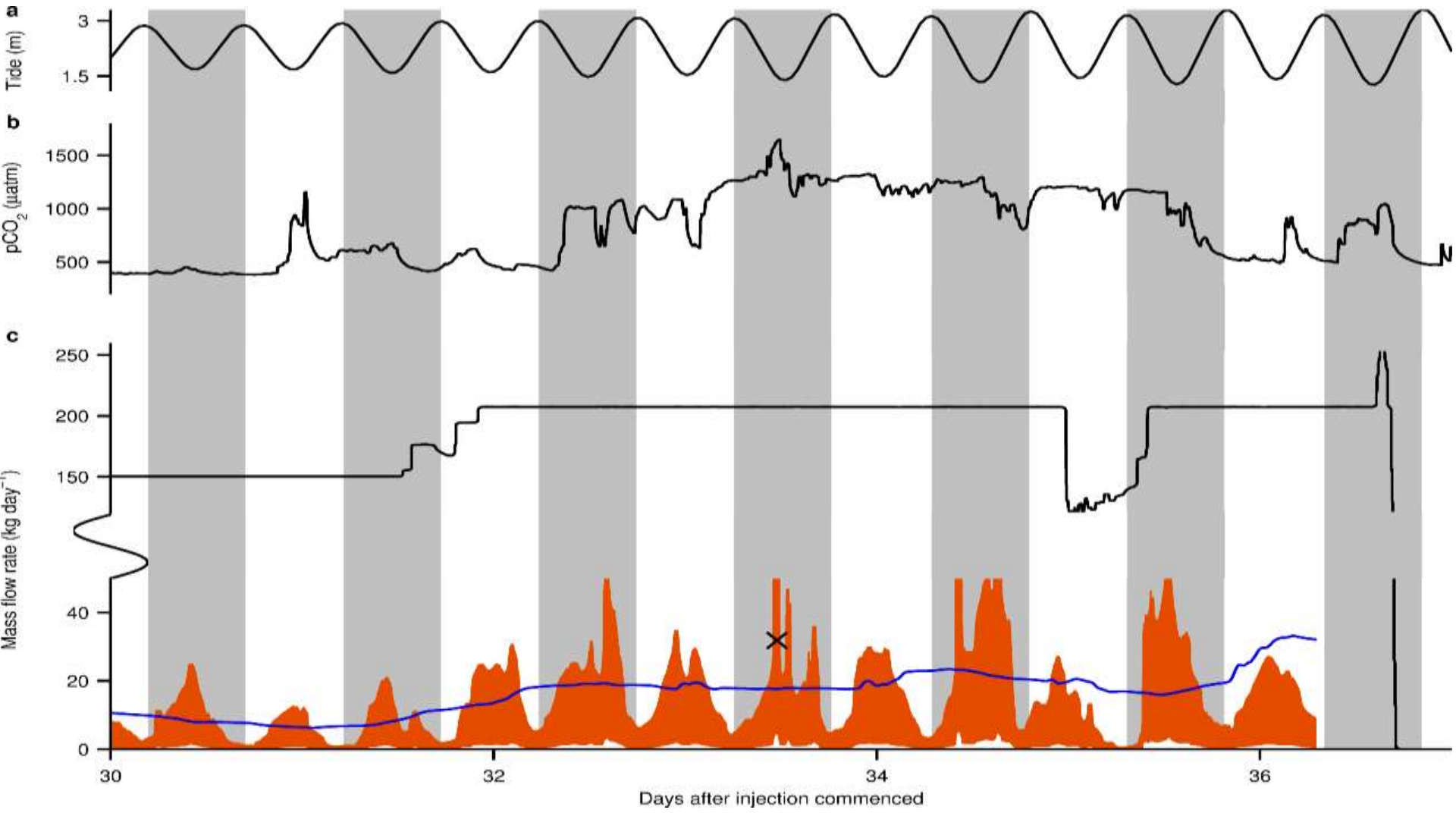
Ian Wright,
Director, Science and Technology
National Oceanography Centre, Southampton, UK

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

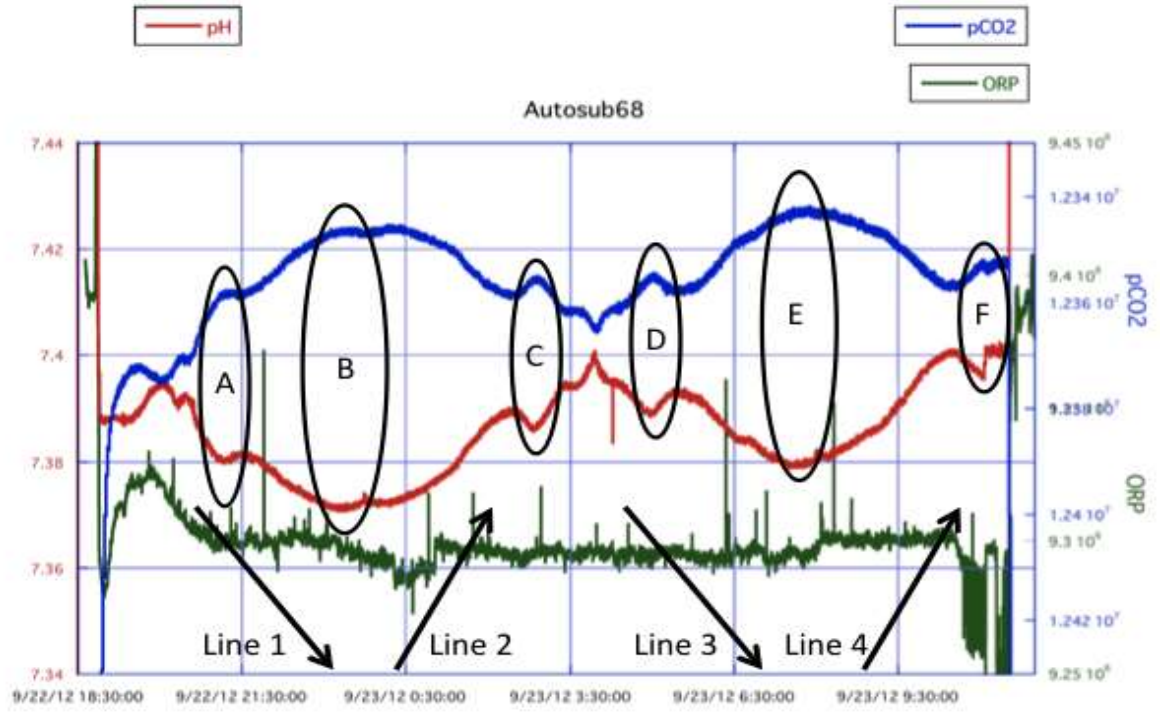
QICS

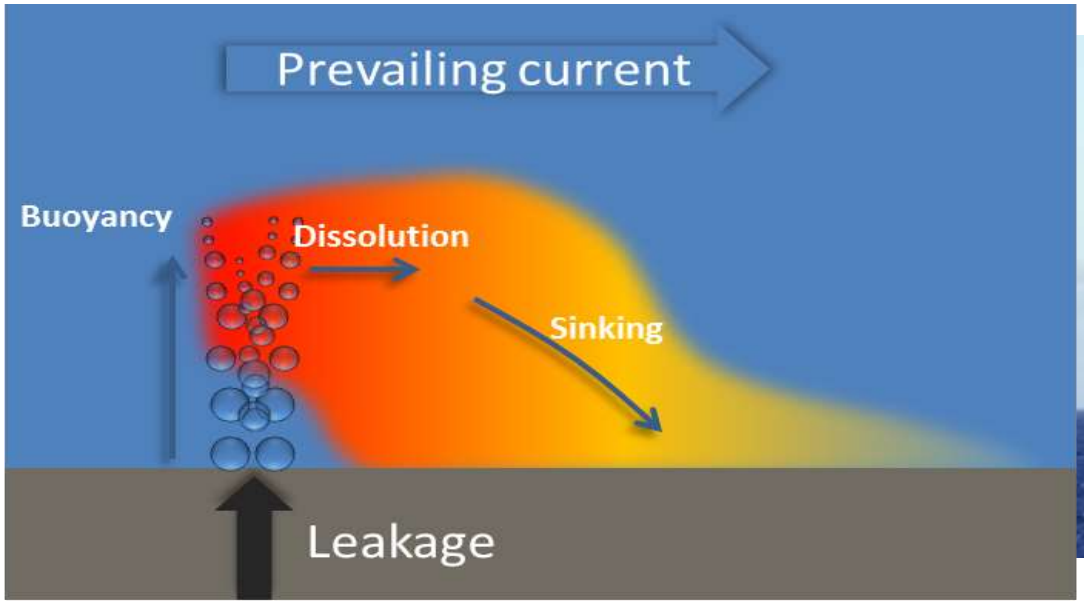
Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbon Storage



ECO2

Sub-seabed CO_2 Storage:
Impact on Marine Ecosystems





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