International Modeling Updates from IEAGHG Modeling Network

US DOE Carbon Storage R&D Project Review Meeting

12th – 14th August 2014

Pittsburgh

Panel for International Modeling Updates

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Monitoring Network and Modeling 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

IEA Greenhouse Gas R&D Programme (IEAGHG)

- A collaborative international research programme founded in 1991
- Aim: To provide information on the role that technology can play in reducing greenhouse gas emissions from use of fossil fuels.
- Focus is on Carbon Dioxide Capture and Storage (CCS)
- Producing information that is:
  - Objective, trustworthy, independent
  - Policy relevant but NOT policy prescriptive
  - Reviewed by external Expert Reviewers

Partner Organisations:

JCOAL Japan Coal Energy Center

ptrc Petroleum Technology Research Centre

CO2 GeoNet

carbon sequestration leadership forum

IEAGHG

- Flagship activities:
- Technical Studies >250 reports published on all aspects of CCS
- International Research Networks
  - Risk Assessment
  - Monitoring
  - Modeling
  - Environmental Impacts
  - Environmental Impacts
  - *Wellbore Integrity (PTRC)*
  - Social Research
  - Oxy-combustion
  - Post-combustion Capture
  - Solid Looping
- GHGT conferences - GHGT-12 Austin, TX, USA, 5-9 Oct 2014

IEAGHG Research Networks

- Bring together international key groups of experts to share knowledge and experience
- Identify and address knowledge gaps
- Act as informed bodies, eg for regulators
- CO_2 geological storage – assessing and managing risks
- Started in 2004/5
  - *Risk Assessment Research Network*
  - *Monitoring Research Network*
  - *Wellbore Integrity Research Network (now PTRC)*
  - *Modeling Network (2009)*
  - *Environmental Research Workshops/Network (2008)*
- Benefit experts and wider stakeholders
- Depend on experts' time and inputs – valuable and widely appreciated
- **Joint Networks Meeting, Santa Fe, LANL, June 2012**

Networks' Objectives –

- **Modeling 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 programs.

- 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

Meeting Agenda

Theme: Reducing uncertainty – the application and effectiveness of Monitoring and Modeling

1. Monitoring topics day
2. Modeling topics day
3. Combined Monitoring and Modeling topics day

Modeling Themes

- Long-term predictability
- Heterogeneity & up-scaling capacity models
- Leakage pathways & fault transmissivity
- CO_2-EOR and long-term storage

➢ Defining model complexity – Rajesh

➢ Application of modeling & monitoring for CO_2 storage: Snøhvit, In Salah, Sleipner - Andrew

➢ Modeling leakage pathways - Grant

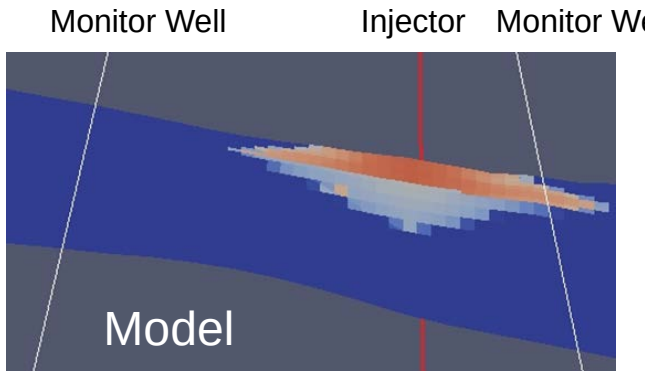
Model Complexities, Heterogeneity and Up-scaling

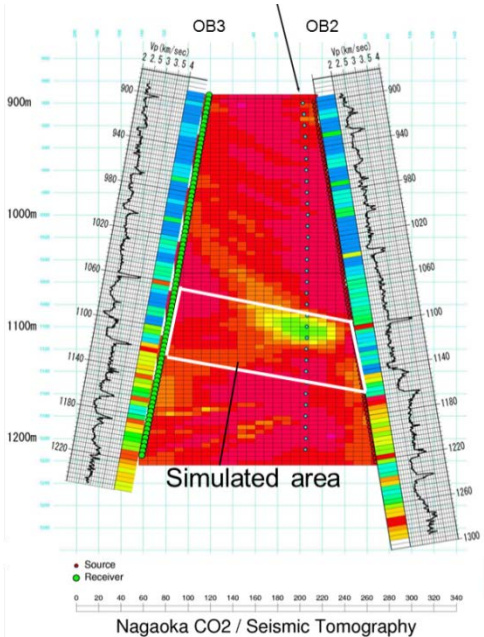
- Presentations on approaches to handle model complexities, heterogeneities
- Topics covered:
  - NRAP's approach to quantify site-specific risks using system-level modeling
  - Limitations of current approaches to upscale heterogeneities for gravity-dominant processes in presence of capillary effects
  - Numerical modeling of international field tests, including, Nagaoka (Japan), Sleipner (Norway), Ketzin (Germany)
  - Integration of site-specific monitoring with modeling and risk assessment

Model Complexities, Heterogeneity and Up-scaling

- General conclusions:
  - Are the current numerical models limited in their ability to capture some fundamental physics? Need for additional observations?
  - Site-specific models show good match with observed data but how do you assess their broader applicability?
  - How do you link reduced order models with monitoring data?
  - How many modeling realizations are needed to capture site-specific heterogeneities/uncertainties?

Nagaoka simulation results (CO_2 saturation)





Cross-well seismic tomography

Long-term Issues

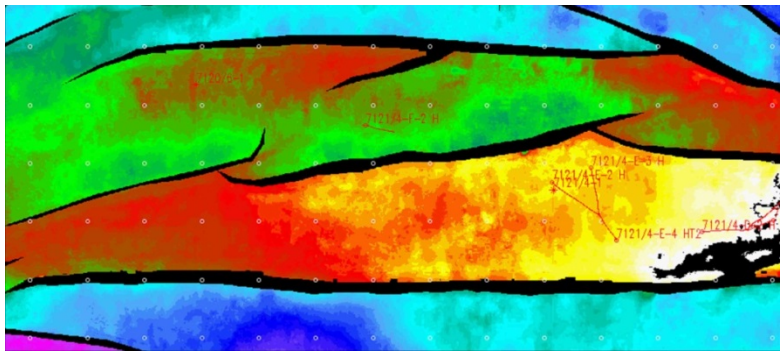
- More similarities than differences amongst countries in regulatory requirements
  - modeling essentially required in all
  - in most, attempts to be prescriptive about what info is needed from models and NOT what models to use
  - still much uncertainty/variability about long-term issues (e.g., liability transfer)
- Glaciation should be accounted for in some environments

Fault leakage

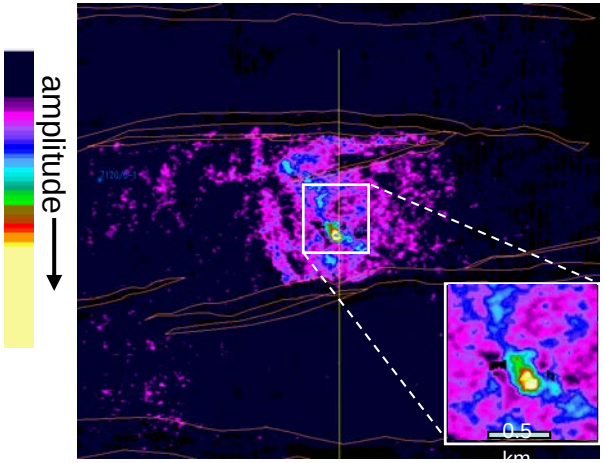
- Lots of discussion about fault permeability (uncertain)
- Database of fault properties in literature, and pulled together by operators
- Other industries (rad. waste, dam construction)
- Slip event often not large enough to impact entire fault permeability
- Some experiments show fault slip in clay rich shale lowers fault permeability (range of applicability?)

Modeling & Monitoring

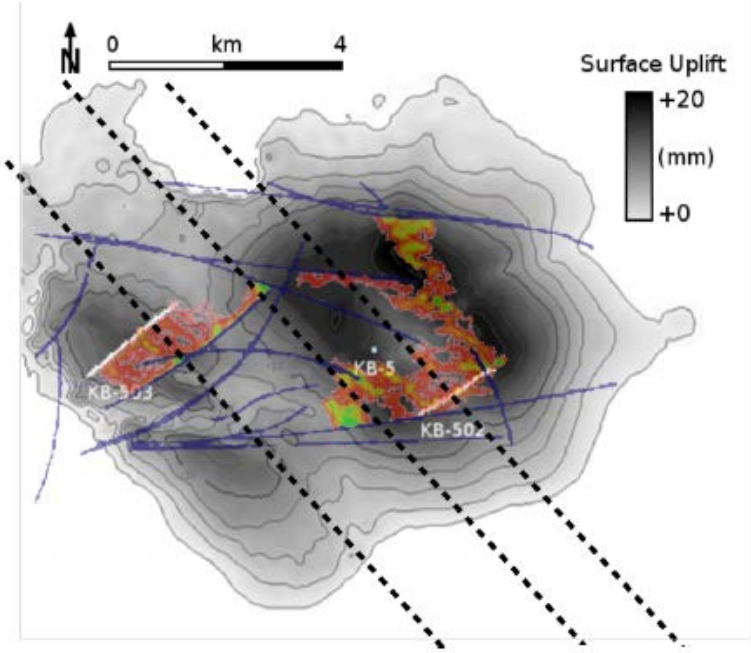
- Snøhvit



4D seismic and pressure monitoring



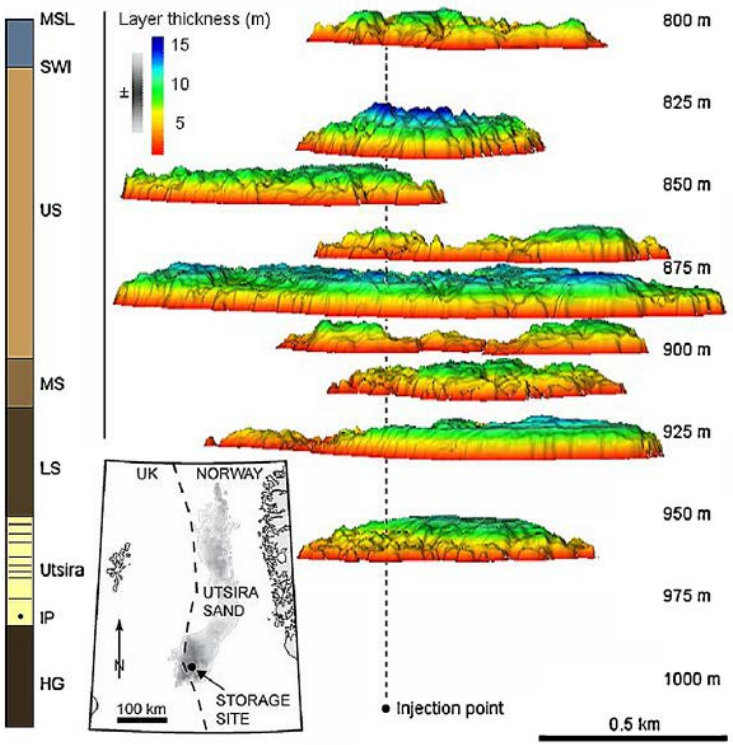
- In Salah



Satellite (InSAR) and geophones

Modeling & Monitoring

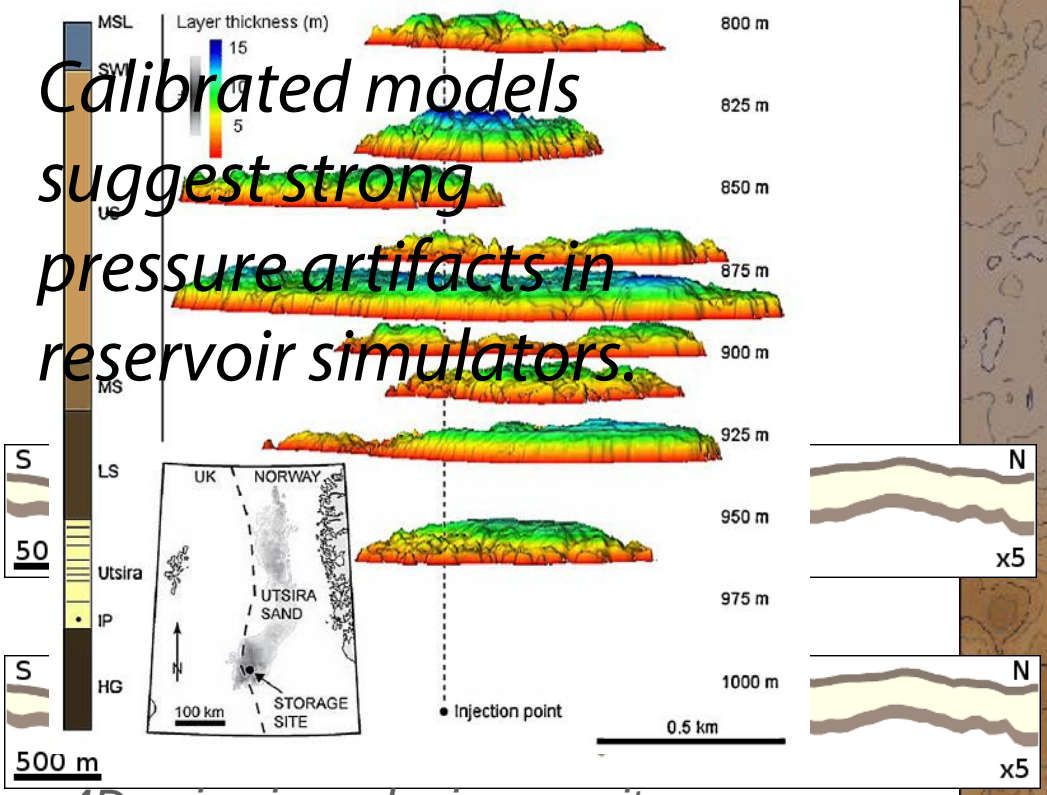
- Sleipner



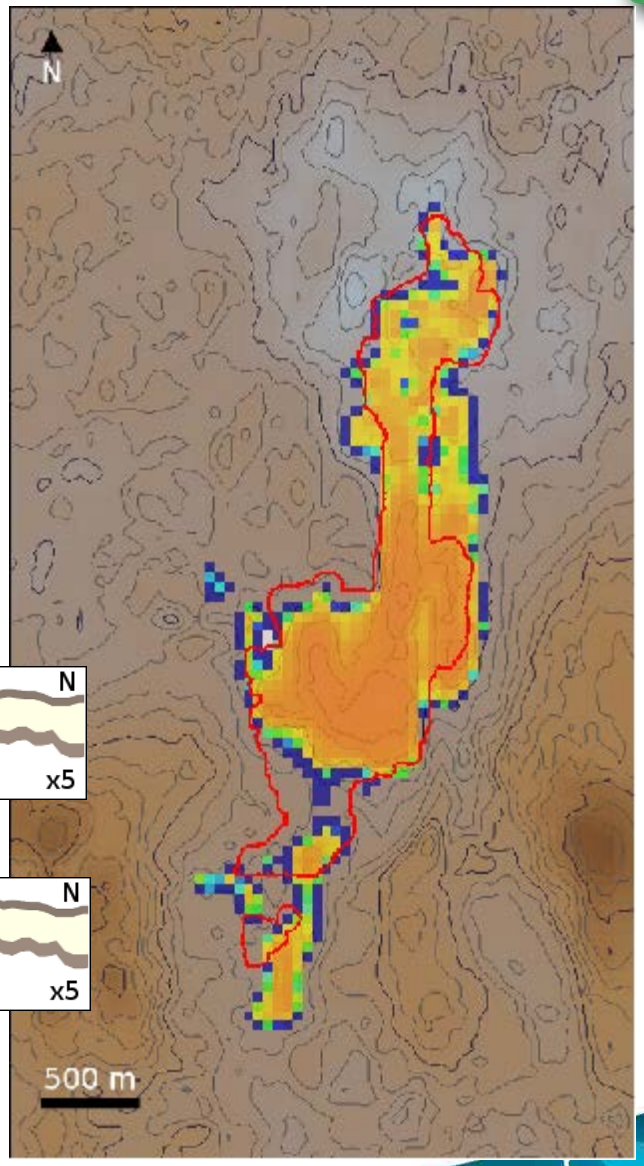
4D seismic and microgravity

Modeling & Monitoring

- Sleipner



Calibrated models suggest strong pressure artifacts in reservoir simulators.



4D seismic and microgravity

Cavanagh, EP 2013

Cavanagh & Haszeldine, IJGGC 2014