NRAP Tools for Assessment of Carbon Storage Risk Performance: Supporting Decision Making Amidst Uncertainty

Tool Updates based on tester feedback

March 30, 2016; 4:00 PM EDT
Webinar Presentation

Technical Contributions from across the NRAP Working Groups
NRAP Phase I CO₂ Storage Risk Assessment Toolset

Available at: www.edx.netl.doe.gov/nrap

Integrated Assessment Model – Carbon Storage (NRAP-IAM-CS)
Reservoir Evaluation and Visualization (REV) Tool
Wellbore Leakage Analysis Tool (WLAT)
Natural Seal ROM (NSealR)
Aquifer Impact Model (AIM)
Design for Risk Evaluation and Monitoring (DREAM)
Short Term Seismic Forecasting (STSF)
Reservoir ROM Generator (RROMGEN)
Atmospheric Impact ROM (AIR)*
Ground Motion Prediction for Induced Seismicity (GMPIS)*

* Tools in development as of 3/29/2016
NRAP Phase I CO₂ Storage Risk Assessment Toolset

- Atmospheric Impact ROM*
- Design for Risk Evaluation and Monitoring
- Wellbore Leakage Analysis Tool
- Natural Seal ROM
- Reservoir Evaluation and Visualization
- Reservoir ROM Generator

NRAP-IAM-CS
- Aquifer Impact Model
- Short Term Seismic Forecasting
- Ground Motion Prediction for Induced Seismicity*

* Tool in development as of 3/25/2016

www.edx.netl.doe.gov/nrap → TOOL BETA TESTING link
NRAP Tool Webinar Series – Fall, 2015

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<td>October 13, 2015 Time: 1:00 - 3:30 PM EDT</td>
<td>Integrated Assessment Model Carbon Storage (NRAP-IAM-CS)</td>
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<td>Josh White, Corinne Bachman</td>
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Presentation video and slides available for download: [wwwedx.netl.doe.gov/nrap](http://wwwedx.netl.doe.gov/nrap)
NRAP Integrated Assessment Model for Carbon Storage (NRAP-IAM-CS) Tool Updates

- Tested reservoir lookup table approach for simulations performed with STOMP: Need defined by EPA.
- Implemented atmospheric dispersion module, developed dashboards and tested performance.
- Fixed error in assignment of wellbore cement permeability for single wells: Error initially reported by ITRI, previously wellbore cement permeability was assigned a fixed value irrespective of user input.
- Fixed the error in calculations resulting in negative brine leak rates: Error reported by ITRI and NETL.
- Updated reservoir reduced order model for simple reservoir to fix issues related to computation of CO$_2$ saturations, the error was noted for a problem developed by BP.
NRAP-IAM-CS – Tool Updates (cont.)

- Updated plots for cumulative brine and CO$_2$ leakage to ensure correct reporting on cumulative leakage. Error first reported by ITRI.
- Fixed JAVA viewer problems associated with viewing single realizations and results of simple reservoir with injector well placed at an off-center location.
- Updated input dashboard for shallow aquifer and intermediate aquifer physical characteristics.
Well Leakage Analysis Tool (WLAT)

Tool Updates

- No Substantive Change to Code From Prior Release
- Updated Version Number and Date on Initial Dashboard to Correspond with Tools Manual
- Minor changes to GUI
  - Switched order of components to match User’s Manual
- Reviews Did Not Indicate Any Operational Concern
- Reviews Suggested Several New Options or Example Use Cases (Not Implemented):
  - Comparison between ROMs and full-physics models
  - Ability to save/print the plots in different formations
  - Expand leakage models to match more types of geometries (e.g. multiple thief zones with different properties)
  - Clean up folder space to make navigating the input and output easier
NRAP Seal ROM (NSealR)
Tool Updates

- No Substantive Change to Code From Prior Release
- Updated Version Numbers and Date on Initial Dashboard to Correspond with Tools Manual
- Review Did Not Indicate Any Operational Concern
- Review Suggested Several New Options (Not Implemented):
  - Seal Permeability to include Geo-Statistical Approaches for Spatial heterogeneity (e.g., Variogram Models)
  - Vertical Variability In Hydraulic Parameters
  - Additional Probability Functions Such as Logarithmic Permeability
  - Time-Variant Permeability
  - Additional Cases Studies
NSealR User Guide Updates

- No Substantive Change to Tools Manual From Prior Release
- Changes to the Tools Manual Text to Clarify the Options for the Upper Boundary in Appendix A
- Updated Technical Leadership Team Membership Listings
- Minor Number of Typographical Errors Corrected
Reservoir Evaluation and Visualization (REV) tool Updates

Generates risk metrics from reservoir simulation results

- Fixed XY- inversion issue in Tough 2 style inputs
- Fixed hard coded reservoir size in FEHM style inputs
- Cleaned up user’s manual and clarified several points
- Included sample files folder in the REV tool distribution

Size of CO₂ Plume
Size of Pressure Plume
Pressure at a Location
Reservoir Reduced Order Model Generation (RROM-Gen) Tool Updates

Generates Reservoir ROM look-up tables for use in the NRAP-IAM-CS

- Fixed XY- inversion issue in Tough 2 style inputs
- Fixed hard coded reservoir size in FEHM style inputs
- Cleaned up user’s manual and clarified several points
- Included sample files folder in the REV tool distribution
Aquifer Impact Model (AIM) Updates

- Expanded functionality to include sensitivity analysis for the confined alluvium ROM
- Improved error trapping and reporting
- Cosmetic improvements to auto-generated plots
  - larger fonts*
  - more clear axis labels, titles, and legends*
  - multiple pages of plots, to better visualize large number of water quality metrics
  - log-scale quartile plots added*
- User interface improvements
  - user can now easily see which ROM has been selected, on all screens*
  - dx, dy outputs have been removed from confined alluvium option list
  - expanded list of acknowledgements, list of contacts
AIM User Guide Updates

- User guide placed in main folder of download package to help with installation*
- Installation instructions were updated*
- Noted that for Carbonate Aquifer, concentrations of trace metals and organics in the brine are automatically scaled according to chloride concentration*
- Added description of Monte Carlo and Sensitivity analysis methods and related references
- Example problem was simplified so that just one input parameter needs to be modified by user
Design for Risk Evaluation and Monitoring (DREAM) Tool Updates

- Yonkofski et al. (2016) is referenced in the manual and on the tool welcome screen for background on the simulated annealing theory.
- Clickable information buttons are now available on windows.
- A “Cancel” button was added to the Leakage Criteria page.
  - Because of the way that the memory is distributed while in use, it is currently not recommended to cancel the iterative procedure or go back through the DREAM windows mid-process.
- The TECPLOT input option was added because it is a common post-processing tool for subsurface simulators.
  - We suspect that most flow simulators will be able to use parsers to convert output data to TECPLOT format relatively easily.
DREAM User Guide Updates

- Reorganized the user manual to present the example problem along with the UI walkthrough.
- A workflow chart has been added as Figure 2.
- The easiest way to prepare DREAM input files is to format simulation output into one of the acceptable HDF5 conversion formats: NUFT, STOMP, TECPLOT. This is more thoroughly discussed in Section 3.2.
Short Term Seismic Forecasting (STSF) Tool Updates

- Running the application with one click is enabled
  - File named ‘application’ starts tool with double click

- Error messages during the run were updated
  - No more ‘ATTENTION…’ error messages which could have been confusing to average users

- “Run finished” message added

- Example files were updated
  - Starting values were updated

- Visual output options and spatial variation within tool will be part of Phase II
STSF User Manual Updates

- Update to clarify file structure within tool and location of relevant files
- Added example of input files to manual to explain the structures of those files
- Emphasis in manual on files that should not be deleted as that will lead to a segmentation fault during a run
- Higher emphasis in manual on Bachmann et al, 2011 as different options of runs are explained there
Thank you!

www.edx.netl.doe.gov/nrap
NRAP@netl.doe.gov

Become an NRAP Tool Beta Tester!

NRAP leverages DOE's capabilities to help quantify uncertainties and risks necessary to remove barriers to full-scale CO₂ storage deployment.

NETL's Office of Research and Development (ORD) is leading a multi-laboratory effort that leverages broad technical capabilities across the DOE complex into a mission-focused platform that will develop the integrated science base that can be applied to risk assessment for long-term storage of CO₂; the National Risk Assessment Partnership (NRAP). NRAP involves five DOE national laboratories: NETL, Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, and Pacific Northwest National Laboratory.

The motivating goal of NRAP is to develop science-based methodologies and tools for calculating risks at any CO₂ storage site while providing necessary scientific and technological advances to support that methodology. Fiscal Year 2016 will span a period of transition for the NRAP research program, with Phase I of this multi-year research effort expected to come to completion by June 2016, and Phase II research beginning concurrently. Phase I is focused on assessment of risk associated with large-scale CO₂ storage, and with quantifying uncertainties associated with those assessments; Phase II will focus on management of risk associated with large-scale CO₂ storage, and with reducing associated uncertainties.

CONTACTS

Cynthia Powell
Director
Office of Research and Development
National Energy Technology Laboratory
cynthia.powell@netl.doe.gov

Grant Bromhal
Technical Director, NRAP
grant.bromhal@netl.doe.gov

Tom Richard
Deputy Technical Director, NRAP
trichard@psu.edu

Robert Dilmore
NETL Technical Portfolio Lead
robert.dilmore@netl.doe.gov

George Guthrie
Chair, Executive Committee
gut@guthrie.com

Traci Rodosta
Technology Manager, Carbon Storage
traci.rodosta@netl.doe.gov

Mark Acknowledges
Director
Division of Carbon Capture and Storage
mark.acknowledges@hq.doe.gov