Profile

Dr. Richard Middleton is CEO and co-founder of Carbon Solutions LLC, a mission-driven, fast-growing business focusing on low-carbon energy Research & Development and Software & Services. Energy applications include CO_2 capture and storage (CCS), direct air capture (DAC), hydrogen, energy equity, and renewable energy (geothermal, wind, and solar). Previously, he was a manager and senior scientist at Los Alamo National Laboratory (LANL) for more than a decade. Dr. Middleton's research has focused on two major areas: (1) energy & infrastructure modeling, including CCS, unconventional fossil fuels (such as shale gas and CO_2-enhanced fracturing & hydrocarbon recovery), geothermal exploration, wind energy optimization, and bioenergy planning and landscape design; and (2) climate impacts on natural & engineered systems including climate extremes, hydrology, ecosystem dynamics, and the energy-water nexus. He has been ranked as the US' third-most productive CCS researcher (1997–2017) as well as LANL's most-published Earth science first-author from 2010–2018. He is the lead developer of *SimCCS*, a research- and industry-leading decision support framework for understanding how, where, and when CCS infrastructure could and should be deployed.

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Richard Middleton

Chief Executive Officer | **Carbon Solutions LLC**

Education & Training

Ph.D. | **Geography/Operations Research** | **University of California Santa Barbara**
2001–2006 | GPA: 4.0

M.Sc. | **Geographical Information Science (GIScience)** | **University of Leicester**
1998–1999 | *Distinction*

B.Sc. | **Geography** | **Lancaster University**
1993–1996 | *2:1*

Professional Experience

Chief Executive Officer | **Carbon Solutions LLC** | **2021–Present**
Develop & manage multi-million dollar annual portfolio | Principal analyst | Strategic development | Long-term operational management

Manager | **Los Alamos National Laboratory** | **2016–2020**
Manage, guide, & mentor 50 researchers, postdoctoral fellows, & students | Mange $15M/yr group budget | Oversee multi-million-dollar projects

Senior Scientist | **Los Alamos National Laboratory** | **2016–2021**
Major project development | Strategic planning | Energy-water nexus lab lead

Research Scientist | **Los Alamos National Laboratory** | **2009–2016**
CO_2 capture & storage | Climate/disturbances | Energy-water nexus | Geothermal exploration | Shale gas/fracturing | Water resource management

Senior Infrastructure Modeler | **Oak Ridge National Laboratory** | **2007–2009**
Biofuels | Geospatial modeling | Transportation | Supply chain

Postdoctoral Researcher | **Los Alamos National Laboratory** | **2006–2007**
CO_2 capture & storage | Water resources management | Geospatial optimization

Awards

- Double R&D 100 Award winner | *Quic-Fire* | **2020**
- Highest-impact Earth science pub., Los Alamos (2017–2020) | **2020**
- POWER Magazine Award, Finalist | *SimCCS* | **2020**
- Double R&D 100 Award winner | *SimCCS* | **2019**
- World "Top 10 most-cited" CCS researcher (1997–2017) | **2019**
- #1 First-author for Earth Science, Los Alamos (2011–2018) | **2018**
- Distinguished Mentor Award, Los Alamos | **2017**

Media & Interviews

Scientific American | Carbon Capture: Solved by Software? | **2020**
Albuquerque Journal | AI pinpoints renewable energy resources | **2020**
Reuters | Startups strive to recycle emissions for 'new carbon economy | **2019**
Le Monde | Au Texas, on exploite le gaz de schiste en pleine ville | **2018**
Albuquerque Journal | New approach to extracting fossil fuels | **2018**
Physics Today | Refracturing may not be all it's cracked up to be | **2017**

Publications

1. Bennett, J.A., Ellett, K.M., **Middleton, R.S.**, Winter, S., Blumer, E. (**2023**). Preliminary life cycle assessment of a net-zero power plant co-fired with waste coal and biomass, *Procedia CIRP*, *doi.org/10.1016/j.procir.2023.02.004*.
2. Bennett, J.A., Ogland-Hand, J.D., Middleton, E.J., Eidbo, J.B., Prorok, M., Ross, B., Yaw, S.P., **Middleton, R.S.** (**2023**). The transmission ramifications of social and environmental siting considerations on wind energy deployment, *Frontiers in Energy Research*, *doi.org/10.3389/fenrg.2022.1040957*.
3. Miranda, M.W., Ogland-Hand, J.D., Bielicki, J.M., Moghanloo, R.G., Danesh-Far, J., **Middleton, R.S.** (**2023**). Developing a roadmap for carbon capture, and storage in Oklahoma by assessing the viability of stacked storage, *Greenhouse Gases: Science and Technology*, *doi.org/0.1002/ghg.2244*.
4. Vesselinov, V.V., Ahmmed, B., Mudunuru, M.K., Pepin, J.D., Burns, E.R., Siler, D.J., Karra, S., **Middleton, R.S.** (**2022**). Discovering hidden geothermal signatures using unsupervised machine learning, *Geothermics*, *doi.org/10.1016/j.geothermics.2022.102576*.
5. Jones, E.C., Yaw, S.P., Bennett, J.A., Ogland-Hand, J.D., Strahan, C., **Middleton, R.S.** (**2022**). Designing Multi-Phased CO_2 Capture and Storage Infrastructure Deployments, *Renewable and Sustainable Energy Transition*, *doi.org/10.1016/j.rset.2022.100023*.
6. Moodie, N. Jia, W., **Middleton, R.S.**, Yaw, S., Lee, S., Xiao, T., Wheatly, D., Steele, P., Esser, R., McPherson, B. (**2022**). Geologic carbon storage of anthropogenic CO_2 under the Colorado Plateau in Emery County, Utah, *Minerals*, *doi.org/10.3390/min12040398*.
7. Ogland-Hand, J.D., Adams, B.M., Bennett, J.A., **Middleton, R.S.** (**2022**). A geospatial cost comparison of CO_2 plume geothermal (CPG) power and geologic CO_2 storage, *Frontiers in Energy Research*, *doi.org/10.3389/fenrg.2022.855120*.
8. Ogland-Hand, J.D., Cohen, S.M., Kammer, R.M., Ellett, K.M., Saar, M.O., Bennett, J.A., **Middleton, R.S.** (**2022**). The importance of modeling carbon dioxide transportation and geologic storage in energy system planning tools, *Frontiers in Energy Research*, *doi.org/10.3389/fenrg.2022.855105*.
9. Ogland-Hand, J.D., Kammer, R.M., Bennett, J.A., Ellett, K.M., **Middleton, R.S.** (**2022**). Screening for geologic sequestration of CO_2: A comparison between SCO_2T^{PRO} and the FE/NETL CO_2 saline storage cost model, *International Journal of Greenhouse Gas Control* 114, 103557, *doi.org/10.1016/j.ijggc.2021.103557*.
10. Atchley, A.L., Linn, R.R., Jonko, A., Hoffman, C., Hyman, J.D., Pimont, F., Sieg, C., **Middleton, R.S.** (**2021**). Spatial fuel distribution effect on wind profiles and resulting wildland fire behavior, *International Journal of Wildland Fire* 30, 179–189, *doi.org/10.1071/WF20096*.
11. Lyu, Q., Tan, J., Li, L., Ju, Y., Busch, A., Wood, D.A., Ranjith, P.G., **Middleton, R.S.**, Shu, B., Hu, C. Wang, Z., Hu, R. (**2021**). The role of supercritical carbon dioxide for recovery of shale gas and sequestration in gas shale reservoirs, *Energy & Environmental Science* 14, 4203–4227, *doi.org/10.1039/D0EE03648J*.
12. Mehana, M., Guiltinan, E., Vesselinov, V.V., **Middleton, R.S.**, Hyman, J., Kang, Q., Viswanathan, H.S. (**2021**). Machine-learning predictions of the shale wells' performance, *Journal of Natural Gas Science and Engineering* 88, 103819, *doi.org/10.1016/j.jngse.2021.103819*.
13. Wei, N. Jiao, J., Ellett, K.M., Ku, A.Y., Liu, S., **Middleton, R.S.**, Li, X. (**2021**). Decarbonizing the Coal-Fired Power Sector in China via Carbon Capture, Geological Utilization, and Storage Technology, *Environmental Science & Technology*, *doi.org/10.1021/acs.est.1c01144*.
14. Wei, N., Li, X., Jiao, J., Stauffer, P.H., Ellett, K.M., **Middleton, R.S.** (**2021**). A hierarchical framework for CO_2 storage capacity in deep saline aquifer formations, *Frontiers*, *doi.org/10.3389/feart.2021.777323*.
15. Whitman, C., Yaw, S.P., Hoover, B.A., **Middleton, R.S.** (**2021**). Scalable solutions to the carbon capture infrastructure design problem, *Optimization and Engineering*, *doi.org/10.1007/s11081-021-09621-3*.
16. **Middleton, R.S.**, Ogland-Hand, J.D., Chen, B., Bielicki, J.M., Ellett, K.M., Harp, D.R., Kammer, R.M. (**2020**). Identifying geologic characteristics and operational decisions to meet global carbon sequestration goals, *Energy & Environmental Science* 13, 5000–5016, *doi.org/10.1039/D0EE02488K*.
17. **Middleton, R.S.**, Bielicki, J.M., Chen, B., Clarens, A.F., Currier, R., Ellett, K.M., Harp, D.R., Hoover, B.A., Kammer, R.M., McFarlane, D., Ogland-Hand, J., Pawar, R.J., Stauffer, P.H., Viswanathan, H.S., Yaw, S.P. (**2020**). Great SCO_2T! Rapid carbon sequestration science and screening, *Applied Computing and Geosciences* 7, 100035 *doi.org/10.1016/j.acags.2020.100035*.
18. **Middleton, R.S.**, Yaw, S., Hoover, B.A., Ellett, K.M. (**2020**). An open-source tool for optimizing CO_2 capture, transport, and storage infrastructure, *Environmental Modelling and Software* 124, 1045–1060, *doi.org/10.1016/j.envsoft.2019.104560*.
19. Bennett, K.E., Miller, G.A., Talsma, C.J., Jonko, A., Bruggeman, A.M., Atchley, A.L., Lavadie-Bulnes, A., Kwicklis, E.M., **Middleton, R.S.** (**2020**). Future water resource shifts in the high desert Southwest of Northern New Mexico, USA, *Journal of Hydrology: Regional Studies* 28, 100678. *doi.org/10.1016/j.ejrh.2020.100678*.

20. Chen, B., Harp, D.R., Pawar, R.J., Stauffer, P.H., Viswanathan, H.S., **Middleton, R.S.** (**2020**). Frankenstein's ROMster: Avoiding pitfalls of reduced-order model development, *International Journal of Greenhouse Gas Control* 93, 102892, *doi.org/10.1016/j.ijggc.2019.102892*.
21. Hoover, B.A., Yaw, S.P., **Middleton, R.S.** (**2020**). *CostMAP*: An open-source software package for developing cost surfaces, *International Journal of Geographical Information Science* 34, 520–538, *doi.org/10.1080/13658816.2019.1675885*.
22. Linn, R.R., Goodrick, S., Brambilla, S., Brown, M.J., **Middleton, R.S.**, O'Brien, J.J., Hiers, J.K. (**2020**). QUIC-Fire: A fast-running simulation tool for prescribed fire planning, *Environmental Modelling and Software* 125, 104616, *doi.org/10.1016/j.envsoft.2019.104616*.
23. White, S., Carroll, S., Chu, S., Bacon, D., Pawar, R., Cumming, L., Hawkins, J., Kelley, M., Demirkanli, I., **Middleton, R.S.**, Sminchak, J., Pasumarti, A. (**2020**). A risk-based approach to evaluating the area of review and leakage risks at CO_2 storage sites, *International Journal of Greenhouse Gas Control* 93, 102884, *doi.org/10.1016/j.ijggc.2019.102884*.
24. An, J., **Middleton, R.S.**, Li, Y. (**2019**). Environmental Performance analysis of cement production with CO_2 capture and storage technology in a life-cycle perspective, *Sustainability* 11, 2626–2628, *doi.org/10.3390/su11092626*.
25. Atchley, A.S., Birdsell, K.H., Crowell, K., **Middleton, R.S.**, Stauffer, P.H. (**2019**). Simulating 10,000 years of erosion to assess nuclear waste repository performance, *Geosciences* 9, 120–140, *doi.org/10.3390/geosciences9030120*.
26. Bennett, K.E., Tidwell, V.C., Llewellyn, D., Behery, S., Barrett, L., Stansbury, M., **Middleton, R.S.** (**2019**). Threats to a Colorado River provisioning basin under coupled future climate and societal scenarios, *Environmental Research Communications* 1, 1–15, *doi.org/10.1088/2515-7620/ab4028*.
27. Kwicklis, E.M., Lu, Z., **Middleton, R.S.**, Miller, T.A., Bourret, S.M., Birdsell, K.H. (**2019**). Numerical evaluation of unsaturated-zone flow and transport pathways at Rainier Mesa, Nevada, *Vadose Zone Journal* 18, 1–22, *doi.org/10.2136/vzj2019.01.0005*.
28. Solander, K.C., Bennett, K.E., Fleming, S.W., **Middleton, R.S.** (**2019**). Estimating hydrologic vulnerabilities to climate change using historical simulated data: A proof-of-concept for a rapid assessment algorithm, *Journal of Hydrology: Regional Studies* 26, 100642, *doi.org/10.1016/j.ejrh.2019.100642*.
29. Wei, L., Xu, C., Jansen, S., Zhou, H., Christoffersen, B.O., Pockman, W.T., **Middleton, R.S.**, Marshall, J.D., McDowell, N.G. (**2019**). A heuristic classification of woody plants based on contrasting shade and drought strategies, *Tree Physiology* 39, 767–781, *doi.org/10.1093/treephys/tpy146*.
30. Xu, C., McDowell, N.G., Fisher, R.A., Wei, L., Sevanto, S., Christoffersen, B.O., Weng, E., **Middleton, R.S.** (**2019**). Increasing impacts of extreme droughts on vegetation production under future climate change, *Nature Climate Change* 9, 948–953, *doi.org/10.1038/s41558-019-0630-6*.
31. Yaw, S.P., **Middleton, R.S.**, Hoover, B.A. (**2019**). Graph simplification for infrastructure network design, *COCOA 2019: Conference on Combinatorial Optimization and Applications*, 576–589, *doi.org/10.1007/978-3-030-36412-0_47*.
32. **Middleton, R.S.**, Yaw, S. (**2018**). The cost of getting CCS wrong: Uncertainty, infrastructure design, and stranded CO_2, *International Journal of Greenhouse Gas Control* 70, 1–11, *doi.org/10.1016/j.ijggc.2017.12.011*.
33. An, J., Li, Y., **Middleton, R.S.** (**2018**). Reducing energy consumption and carbon emissions of magnesia refractory products: A life-cycle perspective, *Journal of Cleaner Production* 182, 363–371, *doi.org/10.1016/j.jclepro.2018.01.266*.
34. Atchley, A.L., Kinoshita, A.M., Lopez, S.R., Trader, L., **Middleton, R.S.** (**2018**). Simulating surface and subsurface water balance changes due to burn severity, *Vadose Zone Journal* 17, 1–13, *doi.org/10.2136/vzj2018.05.0099*.
35. Bennett, K.E., Bohn, T.J., Solander, K., McDowell, N.G., Xu, C., Vivoni, E., **Middleton, R.S.** (**2018**). Climate-driven disturbances in the San Juan River sub-basin of the Colorado River, *Hydrology and Earth System Sciences* 22, 709–725, *doi.org/10.5194/hess-22-709-2018*.
36. Bennett, K.E., Urrego Blanco, J.R., Jonko, A., Bohn, T.J., Atchley, A., Urban, N.M., **Middleton, R.S.** (**2018**). Global sensitivity of simulated water balance indicators under future climate change in the Colorado Basin, *Water Resources Research* 54, 132–149, *doi.org/10.1002/2017WR020471*.
37. Bielicki, J.M., Langenfeld, J.K., Tao, Z., **Middleton, R.S.**, Menefee, A.H., Clarens, A.C. (**2018**). The geospatial and economic viability of CO_2 storage in hydrocarbon depleted fractured shale formations, *International Journal of Greenhouse Gas Control* 75, 8–23, *doi.org/10.1016/j.ijggc.2018.05.015*.
38. Dai, Z., Zhang, Y., Bielicki, J.M., Amooie, M.A., Zhang, M., Yang, C., Zou, Y., Ampomah, W., Xiao, T., Jia, W., **Middleton, R.S.**, Zhang, W., Sun, Y., Moortgat, J., Soltanian, M.R., Stauffer, P.H. (**2018**). Heterogeneity-assisted carbon dioxide storage in marine sediments, *Applied Energy* 225, 876–883, *doi.org/10.1016/j.apenergy.2018.05.038*.
39. Goodsman, D.W., Aukema, B.H., McDowell, N.G., **Middleton, R.S.**, Xu, C. (**2018**). Incorporating variability in simulations of seasonally forced phenology using

integral projection models, *Ecology and Evolution* 8, 162–175, *doi.org/10.1002/ece3.3590*.

40. Goodsman, D.W., Grosklos, G., Aukema, B.H., Whitehouse, C., Bleiker, K.P., McDowell, N.G., **Middleton, R.S.**, Xu, C. (**2018**). The effect of warmer winters on the demography of an outbreak insect is hidden by intraspecific competition, *Global Change Biology* 24, 3620–3628, *doi.org/10.1111/gcb.14284*.
41. McDowell, N.G., Michaletz, S., Bennett, K.E., Solander, K.C., Xu, C., Maxwell, R., Allen, C., **Middleton, R.S.** (**2018**). Predicting chronic climate-driven disturbances and their mitigation, *Trends in Ecology and Evolution* 33, 15–27, *doi.org/10.1016/j.tree.2017. 10.002*.
42. Solander, K.C., Bennett, K.E., Fleming, S.W., Gutzler, D.S., Hopkins, E.M., **Middleton, R.S.** (**2018**). Interactions between climate change and complex topography drive observed streamflow changes in the Colorado River Basin, *Journal of Hydrometeorology* 19, 1637–1650, *doi.org/10.1175/JHM-D-18-0012.1*.
43. **Middleton, R.S.**, Gupta, R., Hyman, J.D., Viswanathan, H.S. (**2017**). The shale gas revolution: Barriers, sustainability, and emerging opportunities, *Applied Energy* 199, 88–95, *doi.org/10.1016/j.apenergy.2017.04.034*.
44. **Middleton, R.S.**, Levine, J.S., Bielicki, J.M, Stauffer, P.H. (**2017**). Industrial CO_2 and carbon capture: near-term benefit, long-term necessity, *Energy Procedia* 114, 7601–7605, *doi.org/10.1016/j.egypro.2017.03.1892*.
45. Dai, Z., Zhang, Y., Stauffer, P.H., Tiao, T., Zhang, M., Ampomah, W., Yang, C., Zhou, Y., Ding, M., **Middleton, R.S.**, Reza Soltanian, M., Bielicki, J.M. (**2017**). Injectivity evaluation for offshore CO_2 sequestration in marine sediments, *Energy Procedia* 114, 2921–2932, *doi.org/10.1016/j.egypro.2017.03.1420*.
46. Ellett, K.M., **Middleton, R.S.**, Stauffer, P.H., Rupp, J.A. (**2017**). Facilitating CCS business planning by extending the functionality of the *SimCCS* integrated system model, *Energy Procedia* 114, 6526–6535, *doi.org/10.1016/j.egypro.2017.03.1788*.
47. Harp, D.R., Stauffer, P.H., O'Malley, D., Jiao, Z., Egenolf, E.P., Miler, T.A., Martinez, D., Hunter, K.A., **Middleton, R.S.**, Bielicki, J.M, Pawar. P. (**2017**). Development of robust pressure management strategies for geologic CO_2 sequestration, *International Journal of Greenhouse Gas Control* 64, 43–59, *doi.org/10.1016/j.ijggc.2017.06.012*.
48. Hunter, K., Bielicki, J.M., **Middleton, R.S.**, Stauffer, P.H., Pawar, R., Harp, D., Martinez, D. (**2017**). Integrated CO_2 storage and brine extraction, *Energy Procedia* 114, 6331–6336, *doi.org/10.1016/j.egypro.2017.03.1769*.
49. Langenfeld, J.K., Bielicki, J.M., Tao, Z., **Middleton, R.S.**, Menefee, A.H., Clarens, A.F. (**2017**). Response of integrated CO_2 capture and storage systems in saline aquifers and fractured shale formations to changes in CO_2 capture costs, *Energy Procedia* 114, 4099–4105, *doi.org/10.1016/j.egypro.2017.03.1550*.
50. Solander, K.C., Bennett, K.E., **Middleton, R.S.** (**2017**). Shifts in historical streamflow extremes in the Colorado River Basin, *Journal of Hydrology: Regional Studies* 12, 363–377, *doi.org/10.1016/j.ejrh. 2017.05.004*.
51. Solander, K.C., Reager, J.T., Wada, Y., Famiglietti, J.S., **Middleton, R.S.** (**2017**). GRACE satellite observations reveal the severity of recent water over-consumption in the United States, *Scientific Reports* 7, 1–8, *doi.org/10.1038/s41598-017-07450-y*.
52. Dai, Z., Viswanathan, H., **Middleton, R.S.**, Pan, F., Ampomah, W., Yang, C., Jia, W., Xiao, T., Lee, S., McPherson, B., Balch, R., Grigg, R., White, M. (**2016**). CO_2 Accounting and risk analysis for CO_2 sequestration at enhanced oil recovery sites, *Environmental Science & Technology* 50, 7546–7554, *doi.org/10.1021/acs.est.6b01744*.
53. Skurikhin, A.N., McDowell, N.G., **Middleton, R.S.** (**2016**). Unsupervised individual tree crown detection in high–resolution satellite imagery, *Journal of Applied Remote Sensing* 10, 1–7, *doi.org/10.1117/1.JRS.10.010501*.
54. **Middleton, R.S.**, Carey, J.W., Currier, R.P., Hyman, J.D., Kang, Q., Karra, S., Jiménez-Martínez, J., Porter, M.L., Viswanathan, H.S. (**2015**). Shale gas and non-aqueous fracturing fluids: Opportunities and challenges for supercritical CO_2, *Applied Energy* 147, 500–509, *doi.org/10.1016/j.apenergy.2015.03.023*.
55. **Middleton, R.S.**, Levine, J.S., Bielicki, J.M., Viswanathan, H.S., Carey, J.W., Stauffer, P.H. (**2015**). Jumpstarting commercial-scale CO_2 capture and storage with ethylene production and enhanced oil recovery in the US Gulf, *Greenhouse Gases: Science and Technology* 5, 241–253, *doi.org/10.1002/ghg.1490*.
56. Person, M.A., Kelley, S.A., Kelley, R.E., Karra, S., Harp, D.R., Witcher, J., Bielicki, J.M., Sutula, G., Pepin, J.D., **Middleton, R.S.** (**2015**). Hydrogeologic windows: Detection of blind and traditional geothermal play fairways in southwestern New Mexico using conservative element concentrations and advective-diffusive solute transport, *GRC Transactions* 39, 751–759, *publications.mygeoenergynow.org/grc/1032216.pdf*.
57. **Middleton, R.S.**, Clarens, A.F., Liu, X., Bielicki, J.M, Levine, J.S. (**2014**). CO_2 deserts: Implications of existing CO_2 supply limitations for carbon management, *Environmental Science & Technology* 48, 11713–11720, *doi.org/10.1021/es5022685*.
58. **Middleton, R.S.**, Viswanathan, H.S., Currier, R.P., Gupta, R. (**2014**). CO_2 as a fracturing fluid: Potential for commercial-scale shale gas production and CO_2 sequestration, *Energy Procedia* 63, 7780–7784, *doi.org/10.1016/j.egypro.2014.11.812*.

59. Bielicki, J.M., Callas, G., **Middleton, R.S.**, Ha-Duong, M. (**2014**). National corridors for climate change mitigation: Managing industrial CO_2 emissions in France, *Greenhouse Gases: Science and Technology* 4, 262–277, *doi.org/10.1002/ghg.1395*.
60. Bielicki, J.M., **Middleton, R.S.**, Levine, J.S., Stauffer, P.H. (**2014**). An alternative pathway for stimulating regional deployment of carbon dioxide capture and storage, *Energy Procedia* 63, 7215–7224, *doi.org/10.1016/j.egypro.2014.11.757*.
61. Bielicki, J.M., Clarens, A.F., **Middleton, R.S.**, Liu, X., Levine, J.S., Barbosa de Carvalho, M., Giovanini Junior, N. (**2014**). Shifting sands in a CO_2 desert: Replacing extracted CO_2 with byproduct CO_2 for use in enhanced oil recovery, *Energy Procedia* 63, 6557–6564, *doi.org/10.1016/j.egypro.2014.11.692*.
62. Dai, Z., **Middleton, R.S.**, Viswanathan, H., Fessenden-Rahn, J., Bauman, J., Pawar, R., Lee, S.-Y., McPherson, B. (**2014**). An integrated framework for optimizing CO_2 sequestration and enhanced oil recovery, *Environmental Sciences and Technology Letters* 1, 49–54, *doi.org/10.1021/ez4001033*.
63. Dai, Z., Stauffer, P.H., Carey, J.W., **Middleton, R.S.**, Lu, Z., Jacobs, J.F., Hnottavange-Telleen, K., Spangler, L.H. (**2014**). Pre-site characterization risk analysis for commercial-scale carbon sequestration, *Environmental Science & Technology* 48, 3908–3915, *doi.org/10.1021/es405468p*.
64. Dai, Z., Viswanathan, H.S, Fessenden-Rahn, J., **Middleton, R.S.**, Pan, F., Jia, W., Lee, S., McPherson, B., Ampomah, W., Grigg, R. (**2014**). Uncertainty quantification for CO_2 sequestration and enhanced oil recovery, *Energy Procedia* 63, 7685–7693, *doi.org/10.1016/j.egypro.2014.11.802*.
65. Stauffer, P.H., **Middleton, R.S.**, Bing, B., Ellett, K.M., Rupp, J., Xiaochun, L. (**2014**). System integration linking CO_2 sources, sinks, and infrastructure for the Ordos Basin, China, *Energy Procedia* 63, 2702–2709, *doi.org/10.1016/j.egypro.2014.11.292*.
66. **Middleton, R.S.** (**2013**). A new optimization approach to energy network modeling: anthropogenic CO_2 capture coupled with enhanced oil recovery, *International Journal of Energy Research* 37, 1794–1810, *doi.org/10.1002/er.2993*.
67. **Middleton, R.S.** and Brandt, A.R. (**2013**). Using infrastructure optimization to reduce greenhouse gas emissions from oil sands extraction and processing, *Environmental Science & Technology* 47, 1735–1744, *doi.org/10.1021/es3035895*.
68. **Middleton, R.S.** and Eccles, J.K. (**2013**). Fracking, renewables, and natural gas power: the complex future of carbon capture and storage, *Applied Energy* 108, 66–73, *doi.org/10.1016/j.apenergy.2013.02.065*.
69. Sullivan, E.J., Chu, S., Stauffer, P.H., **Middleton, R.S.**, Pawar, R.J. (**2013**). A method and cost model for treatment of water extracted during geologic CO_2 sequestration, *International Journal of Greenhouse Gas Control* 12, 372–381, *doi.org/10.1016/j.ijggc.2012.11.007*.
70. **Middleton, R.S.**, Keating, G.N., Stauffer, P.H., Jordan, A.B., Viswanathan, H.S., Kang, Q., Sullivan, E.J., Chu, S.P., Carey, J.W., Mulkey, M.L., Esposito, R.A., Meckel, T.A. (**2012**). The cross-scale science of CO_2 capture and storage: from pore scale to regional scale, *Energy & Environmental Science* 5, 7328–7345, *doi.org/10.1039/c2ee03227a*.
71. **Middleton, R.S.**, Keating, G.N., Stauffer, P.H., Viswanathan, H.S., Pawar, R.J. (**2012**). The effect of geologic reservoir uncertainty on CCS infrastructure, *International Journal of Greenhouse Gas Control* 8, 132–142, *doi.org/10.1016/j.ijggc.2012.02.005*.
72. **Middleton, R.S.**, Kuby, M.J., Bielicki, J.M. (**2012**). Generating candidate networks for optimization: the CO_2 capture and storage optimization problem, *Computers, Environment, and Urban Systems* 36, 18–29, *doi.org/10.1016/j.compenvurbsys.2011.08.002*.
73. **Middleton, R.S.**, Kuby, M.J., Wei, R., Keating, G.N., Pawar, R.J. (**2012**). A dynamic model for optimally phasing in CCS infrastructure, *Environmental Modeling and Software* 37, 193–205, *doi.org/10.1016/j.envsoft.2012.04.003*.
74. Parish, E.S., Hilliard, M.R., Baskaran, L.M., Dale, V.H., Griffiths, N.H., Mulholland, P.J., Sorokine, A., Downing, M.E., **Middleton, R.S.**, Thomas, N.A. (**2012**). Multimetric spatial optimization of bioenergy crops across a watershed, *Biofuels, Bioproducts, and Biorefining* 6, 58–72, *doi.org/10.1002/bbb.342*.
75. Phillips, B. and **Middleton, R.S.** (**2012**). *SimWIND*: A geospatial infrastructure model for optimizing wind power generation and transmission, *Energy Policy* 43, 291–302, *doi.org/10.1016/j.enpol.2012.01.006*.
76. **Middleton, R.S.**, Bielicki, J.M., Keating, G.N., Pawar, R.J. (**2011**). Jumpstarting CCS using refinery CO_2 for enhanced oil recovery, *Energy Procedia* 4, 2185–2191, *doi.org/10.1016/j.egypro.2011.02.105*.
77. Duque, J.C., Church, R.L., **Middleton, R.S.** (**2011**). The p-regions problem, *Geographical Analysis* 43, 104–126, *doi.org/10.1111/j.1538-4632.2010.00810.x*.
78. Keating, G.N., **Middleton, R.S.**, Stauffer, P.H., Pawar, R.J. (**2011**). How storage uncertainty will drive CCS infrastructure, *Energy Procedia* 4, 2393–2400, *doi.org/10.1016/j.egypro.2011.02.132*.
79. Keating, G.N., **Middleton, R.S.**, Stauffer, P.H., Viswanathan, H.S., Letellier, B.C., Pasqualini, D., Pawar, R.J., Wolfsberg, A.V. (**2011**). Meso-scale carbon sequestration site screening and CCS infrastructure analysis, *Environmental Science & Technology* 45, 215–222, *doi.org/10.1021/es101470m*.
80. Kuby, M., Bielicki, J.M., **Middleton, R.S.** (**2011**). Optimal spatial deployment of carbon dioxide capture and

storage given a price on carbon dioxide, *International Regional Science Review* 34, 285–305, *doi.org/10.1177/0160017610397191*.

81. Kuby, M.J., **Middleton, R.S.**, Bielicki, J.M. (**2011**). Analysis of cost savings from networking pipelines in CCS infrastructure systems, *Energy Procedia* 4, 2808–2815, *doi.org/10.1016/j.egypro.2011.02.185*.
82. Stauffer, P.H., Keating, G.N., **Middleton, R.S.**, Viswanathan, H.S., Berchtold, K.A., Singh, R.P., Mancino, A., Pawar, R.J. (**2011**). Greening coal: Breakthroughs and challenges of CCS, *Environmental Science & Technology* 45, 8597–8604, *doi.org/10.1021/es200510f*.
83. **Middleton, R.S.** and Bielicki, J.M. (**2009**). A scalable infrastructure model for carbon capture and storage: *SimCCS*, *Energy Policy* 37, 1052–1060, *doi.org/10.1016/j.enpol.2008.09.049*.
84. **Middleton, R.S.** and Bielicki, J.M. (**2009**). A comprehensive carbon capture and storage infrastructure model, *Energy Procedia* 1, 1691–1698, *doi.org/10.1016/j.egypro.2009.01.221*.
85. Church, R.L., Scaparra, M.P., **Middleton, R.S.** (**2004**). Identifying critical infrastructure: the median and covering facility interdiction problems, *Annals of the Association of American Geographers* 94, 491–502, *doi.org/10.1111/j.1467-8306.2004.00410.x*.
86. Fabrikant, S.I., Montello, D.R., Ruocco, M., **Middleton, R.S.** (**2004**). The distance-similarity metaphor in network-display spatializations, *Cartography and Geographic Information Science* 31, 237–252, *doi.org/10.1559/1523040042742402*.
87. Montello, D.R., Fabrikant, S.I., Ruocco, M., **Middleton, R.S.** (**2003**). Testing the first law of cognitive geography on point-display spatializations, *Spatial Information Theory - Foundations of Geographic Information Science* 2825, 316–331, *doi.org/10.1007/978-3-540-39923-0_21*.

White Papers, Book Chapters & Reports

1. Ogland-Hand, J.D., Cox, K.J., Adams, B.M., Bennett, J.A., Johnson, P.J., Middleton, E.J., Talsma, C.J., **Middleton, R.S.** (**2023**). How to Net-Zero America: Nationwide cost and capacity estimates for geologic CO_2 storage, *Engineering Archive*, *doi.org/10.31224/3293*.
2. Sudhakar, P., Wang, J., Christie, M., Abeysinghe, E., Ellett, K., Kammer, R., Yaw, S., Hoover, B., **Middleton, R.S.** (**2020**). A Science Gateway for Simulating the Economics of Carbon Sequestration Technologies: *SimCCS*$^{2.0}$, in PEARC '20: Practice and Experience in Advanced Research Computing, In *PEARC '20: Practice and Experience in Advanced Research Computing*, Portland, USA, *dl.acm.org/doi/10.1145/3311790.3396654*.
3. Mudunuru M.K., Viswanathan, H.S., Carey, J.W., Chen, L., Kang, Q., Karra, S., Vesselinov, V.V., **Middleton, R.S.**, Johnson, P.A. (**2020**). Subsurface energy: Flow and reactive-transport in porous and fractured media. *In Handbook of Porous Media,* Vafai, K. Ed. World Scientific Publishers: Singapore, *doi.org/10.1142/9789811223419_0004*.
4. Eccles, J.K. and **Middleton R.S.** (**2018**). Large-scale energy infrastructure optimization: Breakthroughs and challenges of CO_2 capture and storage (CCS) modeling. In *Spatial Analysis and Location Modeling in Urban and Regional Systems*, Thill, J., Ed. Springer: Berlin, Germany, *doi.org/10.1007/978-3-642-37896-6_14*.
5. Church, R.L., Niblett, M.R., O'Hanley, J., **Middleton, R.S.,** Barber, K. (**2015**). Saving the forest by reducing fire severity: Selective fuels treatment location and scheduling, in *Applications of Spatial Analysis*, Eiselt, H.A. and Marianov, V., Ed., Springer, Switzerland, *doi.org/10.1007/978-3-319-20282-2_7*.
6. Viswanathan, H.S., Hyman, J.D., Karra, S., Carey, J.W., Porter, M.L., Rougier, E., Currier, R.P., Kang, Q., Zhou, L., Jimenéz-Martínez, J., Makedonska, N., Chen, L., **Middleton, R.S.** (**2015**). Using discovery science to increase efficiency of hydraulic fracturing while reducing water usage. In *Hydraulic Fracturing: Environmental Issues*, American Chemical Society, Vol. 1216, pp 71–88, *doi.org/10.1021/bk-2015-1216. ch003*.
7. Skaggs, R., Hibbard, K., Frumhoff, P., Lowry, T., **Middleton, R.S.**, Pate, R., Tidwell, V. (**2012**). Climate and energy-water-land system interactions, Pacific Northwest National Laboratory (Technical report for the 2013 National Climate Assessment), *www.pnnl.gov/main/publications/external/technical_reports/PNNL-21185.pdf*.

Invited Talks & Panels

1. **Middleton, R.S.** (**2023**). Advances in nationwide carbon storage estimates to support a net zero economy, *Annual Meeting of the American Geophysical Union*, tinyurl.com/bdz9z8au.
2. **Middleton, R.S.** (**2023**). Reaching Zero: Pathways to Decarbonize the US Electricity System with CCS, *Carbon Solutions Webinar*, *tinyurl.com/ye97el92*.
3. **Middleton, R.S.** (**2021**). Briefing: Deep decarbonization of the U.S. industrial sector, *Niskanen Center*, *tinyurl.com/ye97el92*.
4. **Middleton, R.S.** (**2021**). The time for CCS is now, Heartland U.S. CCUS Forum, Part II, *tinyurl.com/yg5979m8*.
5. **Middleton, R.S.** (**2020**). The itme for CCS is now, *King Abdullah University of Science and Technology*, Thuwal, Saudi Arabia.
6. **Middleton, R.S.** (**2018**). Understanding the impact of drought, wildfire, and infestation, *University of Virginia*, Charlottesville, VA.

7. **Middleton, R.S.** (2018). *SimCCS*: integrated CCUS infrastructure design, *State CO_2-EOR Working Group*, Chicago, IL.
8. **Middleton, R.S.** (2016). Understanding the impact of drought, wildfire, and infestation, *Pajarito Environmental Education Center*, Los Alamos NM.
9. **Middleton, R.S.** (2016). Critical watersheds: multiscale impacts of drought and fire, DOE *Office of Science (Environmental System Science PI Meeting)*, Washington, DC.
10. **Middleton, R.S.** (2015). Secure and sustainable energy infrastructure: CO_2 capture, utilization, and storage (CCUS), National Energy Technology Laboratory, Pittsburgh, PA.
11. **Middleton, R.S.** (2014). Secure and sustainable energy infrastructure: The case of CO_2 capture, utilization, and storage, *University of Pittsburgh*, Department of Civil and Environmental Engineering.
12. **Middleton, R.S.** (2011). Spatial decision making for integrated CCS systems: *SimCCS*, *Midwestern Governor's Association*.
13. **Middleton, R.S.** (2011). Spatial decision making for integrated CCS systems: *SimCCS*, *North America 2050 Partnership.*
14. **Middleton, R.S.** (2010). Spatial energy infrastructure modeling: carbon capture and storage, *George Mason University*, Department of Geography and GeoInformation Science.
15. **Middleton, R.S.** (2010). Energy development and climate change at the basin scale: the water-land-carbon nexus, *Pacific Northwest Laboratory/University of Maryland*, Joint Global Change Research Institute.
16. **Middleton, R.S.** (2010). Spatial energy infrastructure modeling: carbon capture and storage, *Stanford University*, Department of Energy Resources Engineering.
17. **Middleton, R.S.** (2007). Carbon optimizing geologic carbon sequestration and carbon credit pricing, *Lawrence Livermore National Laboratory*, National Security Engineering Division.
18. **Middleton, R.S.** (2007). Carbon capture and sequestration infrastructure and pricing modeling using linear programming, *Arizona State University*, Department of Geography.

Media & Interviews

Casper Star-Tribune 2023 UW, carbon capture company begin statewide CO_2 pipeline study *tinyurl.com/2mffk9ab*.
Albuquerque Journal 2020 AI pinpoints renewable energy resources *tinyurl.com/w95xg6q*.
Scientific American 2020 Carbon capture: Solved by software? *tinyurl.com/yet8ltqd*.
Great Plains Institute 2019 Award-winning software enables GPI to show real-world possibilities for carbon capture *tinyurl.com/yeofrjpg*.
Reuters 2019 Startups strive to recycle emissions for 'new carbon economy' *tinyurl.com/yjhzhry9*.
Le Monde 2018 Au Texas, on exploite le gaz de schiste en pleine ville (Translation: In Texas, we produce shale gas in the city *tinyurl.com/yfr7b99u*.
Albuquerque Journal 2018 New approach to extracting fossil fuels has benefits *tinyurl.com/ye3gh2vp*.
Physics Today 2017 Refracturing may not be all it's cracked up to be *tinyurl.com/yfozql6u*.
Department of Energy 2016 Plastic bags might kickstart the carbon capture industry *tinyurl.com/yhzyn656*.
New Mexico In Depth 2016 LANL scientists study impact of 'climate-driven disturbances' on water supplies *tinyurl.com/yef4u9u6*.
Los Alamos Daily Post 2016 LANL critical watersheds on exhibit at White House Water Summit *tinyurl.com/ykxtm6vx*.
Santa Fe Radio Café 2016 Critical watersheds project, CO_2 capture, utilization, and storage, and the energy-water nexus *tinyurl.com/yffrb8n9*.
KRSN 1490 AM 2016 Impact of drought, wildfire, and infestation *tinyurl.com/ye5qb3tk*.
Christian Science Monitor 2015 Saving West's iconic landscapes from wildfires, one steppe at a time *tinyurl.com/yfoz4pyl*.
Santa Fe New Mexican 2015 Science on the Hill: Jumpstarting the carbon capture industry *tinyurl.com/yjaw89bj*.

Selected Proceedings & Presentations

1. **Middleton, R.S.**, Adams, B., Cox, K., Ogland-Hand, J., Johnson, P., Middleton E. (2023). Advances in nationwide carbon storage estimates to support a net zero economy, *Carbon Capture, Annual Meeting of the American Geophysical Union, San Francisco, CA*, *tinyurl.com/bdz9z8au*.
2. **Middleton, R.S.**, Eidbo, J., Ford, M., Middleton, E.J. (2023). CCS and the Net Zero Economy: National Infrastructure, Carbon Deserts, and Regional Storage Hubs, *Carbon Capture, Utilization, and Storage (CCUS) 2023*, Houston, TX, *tinyurl.com/28ydkenn*.
3. **Middleton, R.S.**, Bennett, J.A., Ellett, K.M, Ford, M., Johnson, P., Middleton, E.J., Ogland-Hand, J.D., Talsma, C.J. (2022). Reaching Zero: Pathways to Decarbonize the US Electricity System with CCS, *16th Greenhouse Gas Control Technologies Conference*, Lyon, France, *tinyurl.com/4tkxev27*.
4. Bennett, J.A., Ogland-Hand, J.D., Cox, K., **Middleton, R.S.** (2022). Beam Me Up SCO_2T^{PRO}: A Comparison to the FE/NETL CO_2 Saline Storage Cost Model and Updates on Tool Development, *16th Greenhouse Gas*

Control Technologies Conference, Lyon, France, *tinyurl. com/bdevducd*.

5. Talsma, C.J., Middleton, E.J, **Middleton, R.S.** (**2022**) *CostMAP*^{PRO}: Addressing the Massive-Scale CO_2 Pipeline Challenge, *16th Greenhouse Gas Control Technologies Conference*, Lyon, France, *tinyurl.com/2p8n2bar*.
6. **Middleton, R.S.**, Bennett, J.A., Ellett, K.M, Ford, M., Johnson, P., Middleton, E.J., Ogland-Hand, J.D., Talsma, C.J. (**2022**). Reaching Zero: Pathways to Decarbonize the US Electricity System with CCS, *INFORMS* Annual Meeting, Indianapolis, IN.
7. **Middleton, R.S.**, Bielicki, J.M., Ellett, K.M., Hoover, B.A., Kammer, R.M., Yaw, S.P. (**2021**). *Gigatonne One*: A CCS roadmap for the United States and beyond, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/4pdcdaev*.
8. **Middleton, R.S.**, Bielicki, J.M., Chen, B., Ellett, K.M., Harp, D.R., Kammer, R.M., Ogland-Hand, J.D. (**2021**). Great *SCO$_2$T*! Rapid tool for geologic carbon sequestration science, engineering, and economics, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/ycfd4ruh*.
9. Bielciki, J.M., DeLuca, M., **Middleton, R.S.**, Langenfeld, J.S. (**2021**). Dependence of CO_2 capture, transport, and storage on reservoir leakage risk, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/ 45pfrb5h*.
10. Ellett, K.M., Wang, J., Christie, M., Pamidighantam, S., Abeysinghe, E., Kammer, R.M., **Middleton, R.S.**, Hoover, B.A., Yaw, S.P., Wei, N., Li, X. (**2021**). Development of a science gateway software platform for CCS decision support and stakeholder engagement, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/afa2j847*.
11. Kammer, R.M., **Middleton, R.S.**, Ellett, K.M (**2021**). The *SCO$_2$T* database: Improved estimates of carbon geologic storage costs and resource availability in deep saline formations, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/32fpcx8k*.
12. Scharenberg, M., Bacon, D., Blankenau, D., ... **Middleton, R.S.**, *et al.* (**2021**). Development of an integrated carbon capture, utilization, and storage hub in the United States, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/2yrf56yv*.
13. Yaw, S.P., **Middleton, R.S.**, Hoover, B.A., Ellett, K.M., Bielicki, J.M. (**2021**). Keeping up with the times: Modelling temporally phased CO_2 Capture and Storage Infrastructure, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/6he8d6p4*.
14. Yaw, S.P., **Middleton, R.S.** (**2021**). Computational challenges to realizing large-scale CO_2 capture and storage, *e-Energy '21: Proceedings of the Twelfth ACM International Conference on Future Energy Systems*, Virtual Event Italy, *doi.org/10.1145/3447555.3466577*.
15. Yaw, S.P., Whitman, C., **Middleton, R.S.**, Hoover, B.A., Ellett, K.M., Bielicki, J.N. (**2021**). Beyond regional CCS: Scalable algorithms for designing massive CO_2 capture and storage infrastructure, *15th Greenhouse Gas Control Technologies Conference*, Abu Dhabi, United Arab Emirates, *tinyurl.com/pkp3sn8b*.
16. **Middleton, R.S.**, Ellett, K.M., Hoover, B.A., Yaw, S.P. (**2020**). *SimCCS*: An open-source tool for optimizing CO_2 capture, transport, and storage infrastructure, *American Association of Geographers Annual Meeting*, Denver, Colorado, *tinyurl.com/4fc9yarb*.
17. **Middleton, R.S.**, Ellett, K.M., Hoover, B.A., Li, X., Wei, N., Yaw, S.P. (**2020**). *SimCCS*: Development and Applications, *Thirty-Seventh Annual International Pittsburgh Coal Conference*, Pittsburgh, Pennsylvania, *tinyurl.com/48v6czrp*.
18. **Middleton, R.S.**, Yaw, S.P., Hoover, B.A., Ellett, K.M. (**2018**). Uncertainty and infrastructure design: Getting commercial-scale CCS right, *14th Greenhouse Gas Control Technologies Conference*, Melbourne, Australia, *tinyurl.com/ctx9ckc9*.
19. Kammer, R.M., S.P., Ellett, K.M., **Middleton, R.S.** (**2018**). Reduced-order modeling for estimating CO_2 storage and enhanced coalbed methane of unconventional coal seam reservoirs, *14th Greenhouse Gas Control Technologies Conference*, Melbourne, Australia, *tinyurl.com/fzwxxnjn*.
20. Duguid, A., Bason, D., Blankenau, D., Divine, D., Fukai, I., Glier, J., Hawkins, J., Jimenez, M., Joeckel, R., Lee, S., **Middleton, R.S.**, Scharenberg, M. (**2018**). Integrated carbon capture, utilization, and storage for the mid-continent region of the United States, *14th Greenhouse Gas Control Technologies Conference*, Melbourne, Australia, *tinyurl.com/j75mtdkn*.
21. **Middleton, R.S.**, Yaw, S.P. (**2018**). The cost of getting CCUS wrong, *Carbon Capture, Utilization, and Storage Conference*, Nashville, TN, *tinyurl.com/sud2fumw*.
22. Yaw, S.P., **Middleton, R.S.** (**2018**). *SimCCS*: A collaborative tool for CCS infrastructure design, *Carbon Capture, Utilization, and Storage Conference*, Nashville, TN, *tinyurl.com/92kaumad*.
23. **Middleton, R.S.**, Bennett, K.E., Solander, K.S., Hopkins, E. (**2017**). Climate change, the energy-water-food nexus, and the "New" Colorado River Basin, *Annual Meeting of the American Geophysical Union*, New Orleans, LA, *tinyurl.com/mxz7dwsv*.
24. Bennett, K.E., Urrego-Blanco, J.R., Jonko, A.K., Vano, J.A., Newman, A.J., Bohn, T.J., **Middleton, R.S.** (**2017**). Colorado River basin sensitivity to disturbance impacts, *Annual Meeting of the American Geophysical Union*, New Orleans, LA, *tinyurl.com/5xmjxw9w*.

25. Atchley, A.L., Linn, R.R., **Middleton, R.S.**, Runde, I., Coon, E., Michaletz, S.T. (**2016**). Simulating fire disturbance and plant mortality using antecedent eco-hydrological conditions to inform a physically-based combustion model, *Annual Meeting of the American Geophysical Union*, San Francisco, CA, *tinyurl.com/6sv27eu4*.
26. Kikinzon, E., Atchley, A.L., Coon, E., **Middleton, R.S.** (**2016**). Modeling the hydrologic response to changes in groundcover conditions caused by fire disturbances, *Annual Meeting of the American Geophysical Union*, San Francisco, CA, *tinyurl.com/749z6vvx*.
27. Solander, K.C., Bennett, K.E., **Middleton, R.S.** (**2016**). Changes in streamflow extremes in the Colorado River Basin and implications for the water-energy nexus, *Annual Meeting of the American Geophysical Union*, San Francisco, CA, *tinyurl.com/k73m3rnv*.
28. **Middleton, R.S.**, Stauffer, P.H., Levine, J.S., Bielicki, J.M. (**2016**). Industrial CO_2 and carbon capture: near-term benefit, long-term necessity, *13th International Conference on Greenhouse Gas Technologies*, Lausanne, Switzerland, *tinyurl.com/yjh8wy94*.
29. **Middleton, R.S.**, Ellett, K.M., Stauffer, P.H., Rupp, J. (**2015**). Making carbon capture, utilization, and storage a reality: integrating science and engineering into a business plan framework, *AAPG International Conference & Exhibition*, Melbourne, Australia, *tinyurl.com/djfakhnx*.
30. **Middleton, R.S.**, Atchley, A., Coon, E., Honig, K., Kikinzon, E., Koo, E., Linn, R. McDowell, N., White, J., Xu, C. (**2015**). Critical ecosystems and disturbance science: capturing the feedbacks between climate, drought mortality, wildfire, and hydrology, *Annual Meeting of the American Geophysical Union*, San Francisco, CA, *tinyurl.com/4pwr3fzx*.
31. **Middleton, R.S.**, Dail, Z., Ellett, K.M., Rupp, J.A., Langenfeld, J.K., Bielicki, J.M., Viswanathan, H.S., Stauffer, P.H. (**2015**). Putting the U in utilization: developing a business model framework for CCUS, *Fourteenth Annual Conference on Carbon Capture, Utilization, & Sequestration*, Pittsburgh PA, *tinyurl.com/5aur58hv*.
32. Langenfeld, J.K., Bielicki, J.M., **Middleton, R.S.**, Tao, Z., Clarens, A. (**2015**). Infrastructure and supple curves for CO_2 Storage in shale, *Fourteenth Annual Conference on Carbon Capture, Utilization, & Sequestration*, Pittsburgh PA, *tinyurl.com/3jduzbm6*.
33. **Middleton, R.S.**, Levine, J., Bielicki, J.M., Stauffer, P.H. (**2014**). The Price Must Be Right: A New pathway to jump-starting CCUS, *Thirteenth Annual Conference on Carbon Capture, Utilization, & Sequestration*, Pittsburgh PA, *tinyurl.com/axbh2f8a*.
34. **Middleton, R.S.**, Viswanathan, H.S., Currier, R., Gupta, R., Carey, J.W. (**2014**). CO_2 as a fracturing fluid: Potential for commercial-scale shale gas production and CO_2 sequestration, *Thirteenth Annual Conference on Carbon Capture, Utilization, & Sequestration*, Pittsburgh PA, *tinyurl.com/mubefcu8*.
35. **Middleton, R.S.**, Stauffer, P.H., Bielicki, J.M., Gorski, A. (**2013**). The real cost of CO_2 capture and storage: variable electricity generation for coal-fired power plants, *Twelfth Annual Conference on Carbon Capture, Utilization, & Sequestration*, Pittsburgh PA, *tinyurl.com/52avsvxr*.
36. **Middleton, R.S.** (**2013**). Designing robust energy infrastructure in the face of uncertainty: CO_2 capture and storage optimization, *13th INFORMS Computing Society Conference*, Santa Fe, NM, *tinyurl.com/w3zs9dwp*.
37. **Middleton, R.S.**, Keating, G.N., Brandt, A.R., Viswanathan, H.S., Stauffer, P.H., Pawar, R.J., Bielicki, J.M. (**2012**). CO_2 leakage risks and the impact on commercial-scale CO_2 capture, transport, and storage: Alberta oil sands case study, *Eleventh Annual Conference on Carbon Capture, Utilization & Sequestration*, Pittsburgh PA, *tinyurl.com/esr7y2d4*.
38. **Middleton, R.S.**, Keating, G.N. (**2012**). Geospatially optimizing CO_2 capture and storage infrastructure with geologic uncertainty, *Annual Meeting of the Association of American Geographers*, New York, NY, *tinyurl.com/svxkbfpc*.
39. **Middleton, R.S.**, Kuby, M.J., Wei, R., Keating, G.N., Pawar, R.J. (**2011**). Spatiotemporal and economic decision making for the evolution of CCS infrastructure, *Tenth Annual Conference on Carbon Capture & Sequestration*, Pittsburgh PA, *tinyurl.com/y4j4wyy3*.
40. **Middleton, R.S.**, Bielicki, J.M., Keating, G.N., Pawar, R.J. (**2010**). Jumpstarting CCS using refinery CO_2 for enhanced oil recovery, *10th International Conference on Greenhouse Gas Technologies*, Amsterdam, The Netherlands, *tinyurl.com/f53ycp6k*.
41. Keating, G.N., **Middleton, R.S.**, Stauffer, P.H., Viswanathan, H.S., Letellier, B.C., Pasqualini, D.M., Pawar, R.J., Wolfsberg, A.V. (**2010**). How storage uncertainty will drive CCS infrastructure, *10th International Conference on Greenhouse Gas Technologies*, Amsterdam, The Netherlands, *tinyurl.com/v52c2vdp*.
42. Kuby, M.J., **Middleton, R.S.**, Bielicki, J.M. (**2010**). Analysis of cost savings from networking pipelines in CCS infrastructure systems, *10th International Conference on Greenhouse Gas Technologies*, Amsterdam, The Netherlands, *tinyurl.com/huvahxc5*.
43. Keating, G.N., **Middleton, R.S.**, Pasqualini, D.M., Pawar, R.J., Stauffer, P.H., Wolfsberg, A.V. (**2010**). Regional CCS feasibility assessment: source, network, and sinks, *Ninth Annual Conference on Carbon Capture & Sequestration*, Pittsburgh PA, *tinyurl.com/4vdaw4ye*.
44. **Middleton, R.S.**, Keating, G.N., Stauffer, P.H., Viswanathan, H.S., Pawar, R.J. (**2010**). The impact of geologic reservoir uncertainty on CCS infrastructure, *Ninth*

Annual Conference on Carbon Capture & Sequestration, Pittsburgh PA, tinyurl.com/2nrjwte5.

45. **Middleton, R.S.**, Phillips, B., Bielicki, J.M. (**2009**). The optimal spatial deployment of wind-energy and electricity transmission infrastructure, *Annual Meeting of the American Geophysical Union*, San Francisco CA, tinyurl.com/3zwx5av4.
46. **Middleton, R.S.**, Bielicki, J.M., Kuby, M.J. (**2008**). The carbon capture and storage optimization problem, *International Symposium on Locational Decisions XI*, Santa Barbara, CA.
47. **Middleton, R.S.** Bielicki, J.M. (**2008**). A comprehensive carbon capture and storage infrastructure model, *9th International Conference on Greenhouse Gas Technologies*, Washington, DC.
48. **Middleton, R.S.** (**2008**). Geospatial optimization for bioenergy infrastructure, *Annual Meeting of the Association of American Geographers*, Boston, MA.
49. **Middleton, R.S.**, Bielicki, J.M., Herzog, H.J., Kuby, M.J. (**2007**). The carbon capture and storage optimization problem, *Annual North American Meetings of the Regional Science Association International*, Savannah, GA.
50. **Middleton, R.S.**, Herzog, H.J., Keating, G.N., Kuby, M.J., Liao, X. (**2007**). Optimization for geologic carbon sequestration and carbon credit pricing. *Sixth Annual Conference on Carbon Capture & Sequestration*, Pittsburgh, PA.
51. **Middleton, R.S.**, Bielicki, J.M., Herzog, H.J. and Kuby, M.J. (**2007**). Optimization for carbon capture and storage. *Annual Meeting of the Association of American Geographers*, San Francisco, CA.
52. **Middleton, R.S.** and Duque, J.C. (**2006**). Geography and gerrymandering: a location science approach, *Annual Meeting of the Association of American Geographers*, Chicago, IL.
53. **Middleton, R.S.** and Church, R.L. (**2006**). Beyond Swapping: heuristic concentration and the p-median problem, *Western Regional Science Association Conference*, Santa Fe, NM.
54. **Middleton, R.S.** and Church, R.L. (**2005**). Heuristic distillation, *International Symposium on Location Decisions*, Sevilla, Spain.
55. **Middleton, R.S.** (**2005**). The p-median planning problem and the first law of optimization geography, *Annual Meeting of the Association of American Geographers*, Denver CO.
56. **Middleton, R.S.**, Church, R.L. (**2004**). Heuristic distillation for the *p*-median problem, *Annual North American Meetings of the Regional Science Association International*, Seattle WA.
57. **Middleton, R.S.** (**2002**). Topological integrity for multiresolution tins, *Annual Meeting of the Association of American Geographers*, Los Angeles, CA.

Public Projects (PI/Key Roles)

1. *Project WyoTCH*: Developing a Roadmap for a Sustainable Carbon Hub (**2023–25**). $3.4M (PI).
2. Time's Ticking: Embarking on the Wyoming Trails Carbon Hub ("*WyoTCH*") (**2023–25**). $5.0M (PI).
3. Uinta Basin CarbonSAFE Phase II (**2023–25**). $ 11.8M (co-PI).
4. SCO_2T^{PRO}: Unlocking the Nation's Subsurface to Support the Energy Transition (**2022–24**). $1.1M (PI).
5. *SimWIND*: Software to Support Wind Siting and Environmental (**2021–22**). $200k (PI).
6. Development and Commercialization of SCO_2T to Maximize CO_2-based Subsurface Energy Potential (**2021**). $200k (PI).
7. Pumped-Storage Hydropower using Abandoned Underground Mines (PSH-AUM) as an Innovative Energy Storage Technology for Fossil-Integrated Systems (**2021**). $200k (co-PI).
8. Cloud-based High-Performance Computing Decision-Making Software for Carbon Sequestration (**2021–22**). $200k (co-PI).
9. Detection and Attribution of No-Analog Fire (**2020**). $150k (PI).
10. Spatiotemporal Social Data Analytics and Machine Learning for Pandemic Exploration and Forecasting (**2020**). $50k (PI).
11. *SimCCS*: Development and Applications (**2018–2021**). $200k/yr (PI).
12. Carbon Utilization and Storage Partnership (CUSP) of the Western United States (**2019–2024**). $5M/yr (co-PI/POC).
13. Southeast Regional Carbon Storage Partnership USA (SECARB-USA) (**2019–2024**). $5M (co-PI/POC).
14. Salts in Hot Water – Developing a Scientific Basis for Supercritical Desalination, Strategic Metal Recovery, and Industrial Water Treatment (**2018–2021**). $4.7M (co-I).
15. Pajarito Climate Impacts Study: Feasibility (**2018–2019**). $70k (PI).
16. Integrated Midcontinent Stacked Carbon Storage Hub (**2018–2019**). $13.3M (co-PI/POC).
17. CarbonSAFE Rocky Mountains Phase I: Ensuring Safe Subsurface Storage of CO_2 in the Intermountain West (**2016–2017**). $1.3M (co-PI/POC).
18. Establishing an Early CO_2 Storage Complex in Kemper County, Mississippi (**2017**). $11.2M (co-I/POC).
19. Nebraska Basin CarbonSAFE Integrated Pre-Feasibility Project (**2016–2017**). $1.2M (co-I/POC).
20. CAB-CS: Central Appalachian Basin CarbonSAFE (**2016–2017**). $1.2M (co-I/POC).
21. CarbonSAFE in the Northern Michigan Basin Integrated Pre-Feasibility (**2017**). $1.2M (co-I/POC).
22. US-China CERC—Clean Coal Technology, Phase II (**2015**). $25M (co-I/Theme Lead).

23. Critical Watersheds: Climate change, Tipping Points, and Energy-water Security Impacts (**2014–2017**). $3.0M (PI).
24. Hydrogeologic Windows: Regional Signature Detection for Blind and Traditional Geothermal Play Fairways (**2014–2015**). $405k (PI).
25. Regional assessment for CO_2 Capture and Storage for Southern Company (**2012**). $35k (PI).
26. Evolution and Optimization of the Biofuel Supply Chain (**2008–2010**) $800k (PI).

Awards & Honors

- R&D 100 Award (IT/Electrical) | *QUIC-Fire* | *tinyurl.com/yhhdbql3* | **2020**.
- R&D 100 Award (Special Recognition: Corporate Social Responsibility) | *QUIC-Fire* | *tinyurl.com/yhhdbql3s* | **2020**.
- Highest-impact Computational Earth Science publication, Los Alamos (2017–2020) | *tinyurl.com/ygpqthqy* | **2020**.
- POWER Magazine Award, Finalist (Creative Problem Solver), *SimCCS* **2020**.
- R&D 100 Award (Software & Services) | *SimCCS* | *tinyurl.com/yy6bhvt5* | **2019**.
- R&D 100 Award (Special Recognition: Corporate Social Responsibility) | *SimCCS* | *tinyurl.com/yy6bhvt5* | **2019**.
- World "Top 10 most-cited" author in CCS research (1997–2017) | *tinyurl.com/ydv76t8e* | **2019**.
- "Top 3 publisher" for EES Division (100+ scientists), Los Alamos, 2016–2018 | **2019**.
- "#1 First-author publisher" for EES Division (100+ scientists), Los Alamos, 2011–2018 | **2018**.
- Distinguished Mentor Award, Los Alamos | **2017**.
- Strongly Endorsed Leadership Focus (SELF) for Top 10% Management Training, Los Alamos | **2015**.
- "Top 3 publisher" for EES Division (100+ scientists), Los Alamos, 2012–2014 | **2014**.
- "Top 10" presentation (of 300+ presentations) at national CCUS conference, Pittsburgh | **2013**.

Mentorship

- **Daniel Restrepo Montoya**, Universidad EAFIT (PhD).
- **Erick Jones**, University of Texas, Austin (PhD).
- **Marcos Miranda**, The Ohio State University (PhD).
- **Brendan Hoover**, University of Texas, Austin (PhD).
- **Sean Yaw**, Montana State University (Postdoctoral Researcher).
- **Loy Lobo**, Arizona State University (MS).
- **Evan Gragg**, New Mexico Institute of Mining and Technology (PhD).
- **Ryan Kammer**, Indiana University (MS).
- **Kurt Solander**, Los Alamos National Laboratory (Postdoctoral Researcher).
- **Kelsey Hunter**, The Ohio State University (MS).
- **Minh Nguyen**, University of Wyoming (MS).
- **Katrina Bennett**, Los Alamos National Laboratory (Postdoctoral Researcher).
- **Isabelle Runde**, UC Santa Barbara (BS).
- **Melissa Teter**, Los Oregon State University (BS).
- **Elias Gonzales**, Los Alamos National Laboratory (High School).
- **Nicole Pendleton**, RelayHealth (MS).
- **Glenn Sutula**, TetraTech (MS).
- **Edgar Ronquillo**, Los Alamos National Laboratory (BS).
- **Alex Gorski**, USEIA (MS).
- **Min Chen**, Los Alamos National Laboratory (Postdoctoral Researcher).
- **Marc Mulkey**, Economist at Bureau of Labor Statistics (PhD).
- **Jeffrey Bielicki**, The Ohio State University (PhD).

Synergistic Activities

- **Developer of the spatial decision framework *SimCCS***
  Decision framework to support CO_2 capture and storage infrastructure and wind energy infrastructure. SimCCS has appeared in dozens of peer-reviewed publications, taught in multiple university optimization courses, and is regularly used by more than a dozen scientists for research, presentations, and papers. SimCCS is a key part of a dozen ongoing CCS projects at Los Alamos and beyond.
- **Author for the National Petroleum Council (NPC) report on CCUS ("Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage")**
  Author for the "CO_2 Geologic Storage" and "Integrative Economics" chapters including SimCCS simulations.
- **Steering committee for National Climate Assessment (NCA)**
  Lead author for the energy-water-land (EWL) technical input report for the 2013 NCA.
- **Los Alamos energy-water nexus representative**
  Los Alamos-wide representative for all energy-water issues including regular meetings, outreach, and proposal & program development.
- **Reviewer for leading scientific journals**
  Reviewer for 20+ journals across multiple disciplines including theoretical and applied energy, fuels, hydrology, environmental science, GIScience, operations research, computational science, and economics.