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Novel Spatial Data Approach to Improve Production and Reduce Risks of Impacts Associated with Unconventional Resource Development –
Using Geospatial & Geostatistical Analyses to Improve Science-Based Decision Making

Kelly Rose[1], Jennifer Bauer[1], and Deborah Glosser[2]

[1]U.S Department of Energy, National Energy Technology Laboratory, Albany, OR, USA
[2]U.S Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA, USA

Abstract

Over the past decade large natural gas reserves identified in shale systems in the eastern United States have resulted in significant and widespread drilling and production activities. An EIA study (EIA, 2011) reported the technically recoverable volume of natural gas estimated to reside in these reservoirs worldwide is 5,760 trillion cubic feet (tcf) of gas, 862 tcf of which was identified in the United States. These resources have significantly impacted the natural gas resource supply in the United States, including reducing the country's reliance on foreign imports. However, the increased infrastructure, drilling, and production activities associated with the development of this resource has resulted in public concerns. In particular, horizontal drilling and hydraulic fracturing of gas shale reservoirs has been implicated as the cause of negative impacts to human health and environmental resources (e.g. Boyer et al., 2011, Considine et al., 2012, Jackson et al., 2011, Myers, 2012, Osborn et al., 2011, Swartz, 2011). However, the results of these and other studies have been called into question (Molofsky et al., 2012, Saba and Orzechowski, 2011) and highlight the need for additional information, approaches and techniques to assess risks and potential impacts associated with unconventional resource development, in particular with stimulation practices utilized to access these resources. In addition, the horizontal drilling and hydraulic fracturing techniques frequently used to produce hydrocarbons are still relatively inefficient particularly in unconventional, low permeability systems. Thus, for some plays a significant amount of the resource can remain unrecovered.

Both improving production efficiency and reducing risks of impacts associated with hydrocarbon production techniques requires improved approaches to assist with predicting the behavior of subsurface systems spanning from the reservoir to the surface. For many subsurface plays, data used to characterize and constrain subsurface phenomenon are tied to wellbore and geophysical based datasets. These are utilized for assessments and planning purposes by a variety of end users including operators, regulators, and scientists. However, most of the data utilized from these systems is acquired via indirect detection techniques with varying degrees of uncertainty. When these data are used in a variety of spatial analyses to represent continuous phenomena they are often presented without clear explanations of the uncertainty associated with the interpolated values. As a result, many data-driven analyses and products are provided with insufficient information to effectively support advanced computational analyses, engineering plans, or operator/regulatory planning decisions based on these results.

As the volume and variety of big data types and analytical approaches evolves for subsurface characterization, there is a growing need for a reliable approach to support quantitatively producing and communicating spatial data analyses and their inherent uncertainties. To address this need, NETL has developed the Variable Grid Method (VGM). The VGM approach is flexible and designed to apply to a variety of analyses and use case scenarios where users need a method to effectively study, evaluate, and analyze spatial trends and patterns while communicating the uncertainty in the underlying spatial datasets. This includes support for better understanding subsurface reservoir, tectonic, and migration pathway trends that are pertinent to more efficient and safe production from these systems. NETL's VGM approach outputs a visual representative of the spatial data analyses while simultaneously quantifying underlying uncertainties. The approach can be used for a range of spatially relevant data assessments and the uncertainties associated with these parameters can be related to sample density, sample variance, interpolation error, uncertainty calculated from multiple simulations, etc. Individual attribute analyses can be conducted using the VGM approach or they can be used as input layers for more complex multi-variate assessments or simulations. Results of analyses based on the VGM approach can be utilized to quantify key spatial trends and patterns for subsurface data interpolations and their uncertainties and leverage these results to evaluate in situ resource potential, trends in structural features such as fractures or faults, stress fields, as well as for understanding potential risks associated with the proximity and/or density of existing wellbore systems, natural fracture systems, and proximity to near-surface receptors such as groundwater systems. The use of the VGM approach is anticipated to support science-based decision making by a range of stakeholders, offering insights and critical information about the relationship between uncertainty and spatial data that is necessary to better support their use in advanced computational analyses and informing operations, research, management and policy decisions.