FARMING SYSTEMS MODELING USING THE OBJECT MODELING SYSTEM (OMS): OVERVIEW, APPLICATIONS, AND FUTURE PLANS

Jack R. Carlson[1]; James C. Ascough II[1]; Olaf David[2];; Lane C. Price[4]; Timothy R. Green[1]; Ken Rojas[3], Lajpat R. Ahuja[1]; and W. Frank Geter[3]

[1] USDA-ARS-NPA, ASRU, Fort Collins, CO 80526 USA
[2] Dept. of Civil and Environmental Engineering and Dept. of Computer Science, Colorado State University, Fort Collins, CO 80523 USA
[3] USDA-NRCS, Information Technology Center, Fort Collins, CO 80526 USA
[4] USDA-NRCS, National Conservation Delivery Streamlining Initiative, Raleigh, NC 27609 USA

INTRODUCTION

The United States Department of Agriculture (USDA) delivers technical assistance to operators of approximately two million farms and ranches through a network of about 2,800 county level field service center offices. USDA field consultants must understand the producer's farming system, and the technical assistance they provide usually involves proposed enhancements to the system. The consultant and producer identify the concerns or opportunities to be addressed, inventory the existing system, and formulate solution alternatives and modifications to the current system. Two analytical approaches can be employed. The consultant and producer may add practices to the current system and then model (estimate) the effects of the enhancements on the identified concerns or opportunities, continuing to plug-and-play until suitable alternatives emerge. Or, in somewhat reverse order they can model the desired state and select from a suite of management options that satisfy the criteria for the expected outcome.

USDA field consultants currently use an array of analytical tools when providing technical assistance, including Web Soil Survey, Revised Universal Soil Loss Equation, Wind Erosion Equation, Nutrition Balance Analyzer, Soil Quality Index, Pesticide Screening Tool, Phosphorus Index, Energy Estimators, Cost and Returns Estimator, among several others. They increasingly will use more comprehensive tools, such as the Agricultural Policy Extender (APEX) and the Agricultural Nonpoint Source (annAGNPS) models, or at least the technology contained within them, for on-farm system analysis. Unfortunately, each tool comes with its own data provisioning requirements, unique user interface, and processing requirements. Field consultants hit a wall of complexity and resource constraints, and the tools are not used to their full potential.

To remedy the problem, the Natural Resource Conservation Service (NRCS) has initiated a Conservation Delivery Streamlining Initiative (CDSI) to integrate technology components with the workflows of the field consultant (USDA-NRCS, 2009). CDSI provides the framework and common user interface for the field consultant. The Agricultural Research Service (ARS) led the development of the Object Modeling System (OMS) to integrate the science components across models and tools into model bases (USDA-ARS et al, 2009), one of which will integrate with the CDSI framework. The purpose of the model base is to deliver science deployed as services available to the CDSI workflow.

OBJECT MODELING SYSTEM (OMS)

Using OMS 2.2 USDA and Colorado State University scientists are building a new USDA Conservation Effects Assessment Project (CEAP) watershed level model, and integrating the Precipitation and Runoff Modeling System (PRMS) in annual water supply forecasting by NRCS for 600 locations. OMS is being expanded to include data provisioning, production run-time, and knowledge base platforms, infrastructural enhancements to satisfy anticipated greater demand for model services by USDA programs, including CDSI. The OMS team has developed a new standard to remove framework invasiveness from component code, employed the use of

annotations, and added multi-language support. These enhancements make it easier to integrate legacy models and components into model bases supporting CDSI and other initiatives.

FARMING SYSTEM MODEL BASE

The new field level farming system model base supporting CDSI will include climate, hydrology, crop/plant growth, nutrient fate/transport, pesticide fate/transport, erosion, soil quality, economic analysis, and other biophysical components. The sources for these components are the models listed in the introduction above, as well as new science as it is certified for technology transfer and becomes available. The model base will contain several model instances, primarily instances for different physiographic regions. In certain cases, it will make sense to deploy a model instance limited to a particular concern, for example, erosion estimation deployed as a model service supporting heavy user load during an agency program sign-up period.

RESULTS AND DISCUSSION

The farming system model base is proceeding through a requirements phase. Core concepts for CDSI have been documented in an ontology using Protégé 4.0 (oms.javaforge.com). The primary purpose of ontologies is to maintain core domain knowledge in a transparent and structured state, rather than buried in code and partially represented in data models. CDSI ontology concepts relating to the farming or ranching operation include area of interest, problem area, management concern, treatment unit, management system, management practice, structural practice, management period, crop/plant cover, management operation, response unit, and management effect. Inputs to a model instance supporting a CDSI workflow usually will include management practice, structural practice, management period, and crop/plant cover data. Output of a model run produces one or more management effects. Conversely, desired management effects may be inputs, with outputs containing various combinations of management practices and cropping options. As the effort moves forward, other ontologies will be leveraged as feasible, including those from CUAHSI (http://his.cuahsi.org) and SEAMLESS (Athanasiadis et al, 2009).

The farming system model base will be deployed to the OMS production run-time platform, which leverages cloud computing technology. The platform has been successfully tested and prototyped on the Amazon Elastic Computing Cloud (EC2) with multi-threaded model runs enabled by Terracotta network attached memory (NAM) technology.

Data provisioning and model calibration currently are the primary constraints to rapid progress towards an operational model base for CDSI. The model base must serve offices across the U.S., including Alaska, the Caribbean, and Pacific Basin. Several tools are being added to the OMS framework to facilitate model calibration, sensitivity, and uncertainty analysis. Data provisioning mostly involves re-orienting existing resources and data assets to create the data marts and access services to support the model base.

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