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Nathan Lighthart
Colorado State University, nathan.lighthart@colostate.edu

Olaf David
Colorado State University

Timothy R. Green

Gregory S. McMaster
USDA, Agricultural Research Service

David Arden Patterson
Colorado State University

See next page for additional authors

Presenter/Author Information

Nathan Lighthart, Olaf David, Timothy R. Green, Gregory S. McMaster, David Arden Patterson, Mazdak Arabi, and Holm Kipka

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The Agricultural Ecosystems Services (AgES) watershed model integrated into the environmental Resources Assessment and Management System (eRAMS) and Cloud Services Integration Platform (CSIP)

Nathan Lighthart[1], Olaf David[1], Timothy R. Green[2], Gregory S. McMaster[2], David Patterson[1], Holm Kipka[1], Mazdak Arabi[1]
[1]Colorado State University, Fort Collins, CO, USA (nathan.lighthart@colostate.edu; odavid@colostate.edu; david.patterson@colostate.edu; holm.kipka@colostate.edu; mazdak.arabi@colostate.edu)
[2]USDA-ARS, Center for Agricultural Resources Research, Fort Collins, Colorado, USA (tim.green@ars.usda.gov; greg.mcmaster@ars.usda.gov)

Abstract: Distributing models to various users can be difficult and prone to error, and therefore may negatively reflect on the program. Model distribution typically involves users downloading and installing the model following setup instructions. However, this step is prone to errors. Deploying a model through a web interface allows the user to focus on running the model rather than ensuring the model is set up correctly. The eRAMS/CSIP platform is designed to provide visual tools for models to be parameterized and connected to input data (eRAMS), and run using a remote web service (CSIP) as Model as a Service (MaaS). By using MaaS, the model and the user's data are accessible from any device. Further, models can take a long time to run, especially during calibration. By executing the model remotely in asynchronous mode, the user can shut down their local machine without terminating the model run. Integration of the Agricultural Ecosystems Services (AgES) watershed model into the second revision of the eRAMS/CSIP platform will be described and demonstrated. Thus, the AgES watershed model is publicly available as a CSIP MaaS, which will be linked with other applications in eRAMS, including watershed delineation into interconnected polygons or hydrological response units (HRUs) and automated generation of crop rotations and tillage operations in each HRU using LAMPS (Landuse and Agricultural Management Practices web-Service).

***Keywords**:* modeling as a service; model distribution; cloud computing; watershed modelling; ecosystem services

1 INTRODUCTION

The AgES watershed model is a distributed watershed model which is designed to be easily extended using components. The AgES model can be used across spatial scales to simulate large-scale watersheds and small-scale research plots. The model can be used to simulate a wide range of processes including multidirectional stream flow, crop growth, and soil moisture.

The deployment of the AgES model is currently done in an archaic fashion fraught with human errors. The user of the model is required to install and properly configure the correct version of Java. The user then needs to download and extract the compressed archive of the AgES model. The user then must copy or create project data in the required folder. After completing these steps, the user can then run the model using a script. Because AgES is an OMS model, it is possible to download a graphical user interface for OMS known as the OMS Console. The OMS Console is designed to be used across any OMS model and not just AgES; therefore, it is not tailored to provide the best experience of running the AgES model.

The integration of AgES into the eRAMS/CSIP platform is designed to fix these deployment issues. The eRAMS platform provides a front-end web interface that allows the user to quickly begin accessing the input data required for executing the model. As a web interface, the AgES model can now reach a wider range of platforms including mobile devices. This removes the hassle and mistakes made when manually installing the model. The eRAMS/CSIP platform handles the project data management, which removes the possible human error of not copying the appropriate data to the correct locations. When creating an application using the eRAMS platform, the interface is tailored to the model. The interface is designed with the application-specific workflow that gives the user an easy step-by-step walk-through of all the actions required to successfully execute the model.

2 MODEL INTEGRATION

To create the eRAMS and AgES application, the developers start with a blank eRAMS application which provides a Django application for the backend server and a React and Redux application for the frontend client. Django is a Python web framework designed for quick and easy development of the server-side code of a web application. React is a modern Javascript web framework designed to build responsive client-side interfaces. Redux is a Javascript framework that allows easy management of the state of an application. Using these frameworks, the developers created a customized web interface designed for executing the AgES model. The eRAMS application was then packaged in a Docker container. This docker container was merged into the rest of the eRAMS/CSIP platform where it will become accessible to the end users. When a user wants to create or open an AgES application, the eRAMS platform will create a new instance of the Docker container and mount the stored project data to the instance. After the user is done with the application, the stored project data will be unmounted and the Docker instance will be destroyed. The project data is stored on CSIP based on a user, group, and application settings. The project data will persistent between different user sessions and can be shared between users in the same group. Since, the entire application is a docker container this allows the application to be run locally without an internet connection.

Although there are many advantages to using AgES in the eRAMS/CSIP platform, there are a few disadvantages. The AgES model is very CPU-intensive for large watersheds. The performance of the AgES model is extremely important to researchers that are calibrating model parameters. Model calibration requires running the AgES model multiple times (typically thousands of iterations) with different parameters to find the most accurate parameter set. This is a process in which adding a couple of seconds to per model run may add hours or days to the model calibrations. The performance impacts of running AgES through Docker have not been fully tested and may result in a performance loss compared to running AgES locally. Another potential problem is running AgES through Docker locally. This allows the user to ensure that all the model dependencies are installed correctly, but requires the user to install and understand how Docker works, which may be more difficult than the original process of running AgES locally. Therefore, clear documentation is needed in any case.

3 CONCLUSION

The AgES model has been integrated into the eRAMS/CSIP platform to improve the process of model deployment. The original deployment process was full of potential issues due to human error. By integrating the model into eRAMS/CSIP, the model no longer needs to be installed on the user's machine, thereby removing the human error involved in the model installation. Additionally, the integration of the AgES model into the eRAMS/CSIP platform provides a tailored interface and data management for the model. However, the performance of running AgES through the eRAMS/CSIP platform has not been thoroughly test and may have a negative impact. The eRAMS/CSIP version of the AgES model can be executed on a local machine without an internet connection; however, the

installation process may be more difficult compared to the original process. Therefore, clear documentation should be provided for both local installation methods.