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A coupled and workflow integrated modeling system applications for earth system science

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The complexity of earth system models and their applications are getting increase because of the continued development of computational resources, storage systems and distributed high-resolution observation networks. Therefore, the multi component earth system models that are used to develop these applications need to be designed in a new programming approach to make easy interaction among those model components and in between other third party applications. For this purpose, the common interfaces of earth system models can be standardized and also self-describing modeling systems can be built to increase interoperability between models and third party applications such as workflow systems, metadata/data portals, web services and scientific gateways. Fortunately, many efforts are currently underway to create standardized and easy to use multi-component earth system models and their applications such as Earth System Curator and Earth System Framework (ESMF).

In this study, it is presented and analyzed a new methodology to combine scientific workflow and modeling framework approach together to create a standardized work environment. The methodology uses the ESMF library to create and self-describing and standardized coupled modeling systems and Kepler scientific workflow application to integrate modeling system to a workflow environment. The proposed methodology is tested using two typical and realistic earth system modeling application. The results of example workflows that are based on the proposed methodology are a part of this study.

The first example allows running and analyzing a global circulation model on both a grid computing environment (TeraGrid) and a cluster system with meaningful abstraction of used model and computing environment. The development version of NCAR Community Climate System Model (CCSM4) model is used for this purpose. In this application example, the collection of provenance information has the added benefit of documenting a run in far greater detail than before. This facilitates exploration of runs and leads to possible reproducibility.

In second example, a regional coupled climate modeling system (WRF and ROMS) is developed for Mediterranean region and integrated into workflow system to provide better representation of regional climate system. This application has curial importance in downscaling output of the global circulation models over Turkey and near regions and it also can be used to create better representation of regional climate for the future scenarios. As, in the first application example, the workflow application collects provenance information automatically from the coupled earth system modeling system to reproduce, compare and debug the results.

The results show that the developed workflow environment is capable of running different earth system models on a different high performance computing resource with a meaningful abstraction. The proposed work environment acts as an abstraction layer and hides the detail of the used infrastructure and earth system model from user and it also collect standardized provenance information about both model and computing resource to represent the work environment as possible as it can.