Development of a New Mexico Statewide Land Surface Model for Water Availability Analysis

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Introduction

As one of the driest states in the United States (US), New Mexico has faced a serious issue with water availability and many scientists often hypothesize that it will only become worse under anticipated climate change conditions. The Union of Concerned Scientists (UCS) (2016) expressed their concerns about this drought problem in the state and argued that we need "to prepare for the expected impacts of these climate trends." However, to the best of the authors' knowledge, New Mexico still does not have a high-resolution statewide physically-based model that is capable of simulating and predicting the future availability of surface water and groundwater resources. The project funded by the U.S. Geological Survey aims to close this gap by creating an efficient modeling framework for statewide high-resolution hydrologic modeling. We present methods for the development of a statewide surface water model.

Objectives

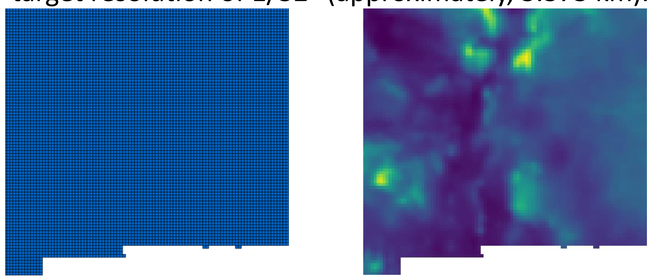
Our objective is to develop a distributed computing framework for the Variable Infiltration Capacity (VIC) (Hamman et al., 2018) macro-scale land surface model for the entire New Mexico so that we can later couple this surface water model with a statewide groundwater model based on the parallel version of MODFLOW.

Materials and Methods

Yang et al. (2019) recently created a 1/16° Contiguous US (CONUS)-scale VIC model and calibrated its parameters. However, its resolution can be too coarse for statewide modeling such that there are only 11 and 5 grid cells for Albuquerque and Las Cruces, respectively. We will quadruple the number of grid cells across the state.

Parameter Discretization: We will compare different methods for downscaling of the model parameters: 1) bilinear interpolation, 2) statistical regionalization using external data, and 3) machine learning using external data.

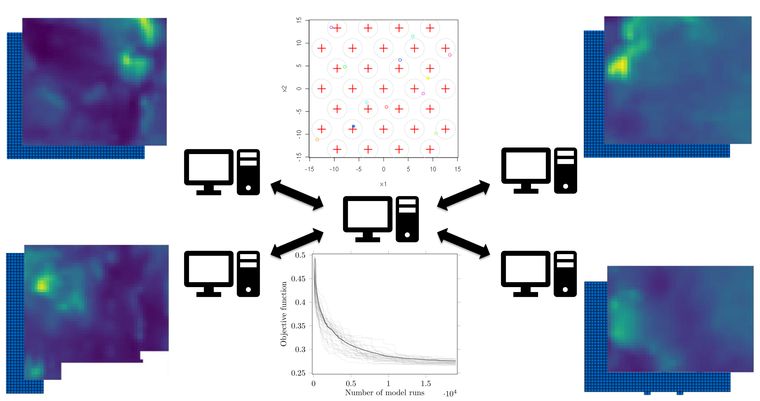
Weather Forcing Data: We will use the Parameter-elevation Regressions on Independent Slopes Model (PRISM) for weather forcing because its daily datasets are already spatially interpolated at a 4-km resolution, which is close to our target resolution of 1/32° (approximately, 3.375 km).



Parallelization and Optimization of VIC: It can computationally be intensive to run the model with 31,820 grid cells for ensemble simulations. We will parallelize VIC for High-Performance Computing (HPC) using the Message Passing Interface (MPI). We will use a metaheuristic called Isolated-Speciation-Based Particle Swarm Optimization (ISPSO) (Cho et al., 2011) for model optimization to address the common "equifinality" problem where similar model results can be produced by distinctively different parameter sets.

Expected Results

We expect to create an efficient distributed computing framework for statewide surface water modeling.



Conclusions

We will use the developed land surface model for New Mexico to evaluate its water availability under climate change scenarios. The latter part of the project will focus on development of a statewide groundwater model and coupling of both the land surface and groundwater models.

Implications

The new distributed modeling framework for VIC will be general and scale-/state-agnostic such that it can be utilized for similar hydrologic modeling efforts for other states or even the CONUS.

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