

A Framework for Analyzing the Community Land Model within CESM



D. Wang¹, W. Wu², Y. Xu², T. Janjusic³, W. Ding³, F. Winkler³, N. Forrington³, O. Hernandez³

¹Climate Change Sciences Institute, Oak Ridge National Laboratory, wangd@ornl.gov

²University of Tennessee, Knoxville, {wwu12, yxu30@vols.utk.edu}

³Computer Science and Mathematics Division, Oak Ridge National Laboratory, {janjusict, winklerf, dingw, forringtonn, oscar}@ornl.gov



1) Background

- Along with the deeper understanding of earth system processes, the software complexity of the community land Model (CLM) within the earth system models [1] becomes a barrier for rapid model improvements and validation, as well as efficient code porting to next generation HPCs [2,3].

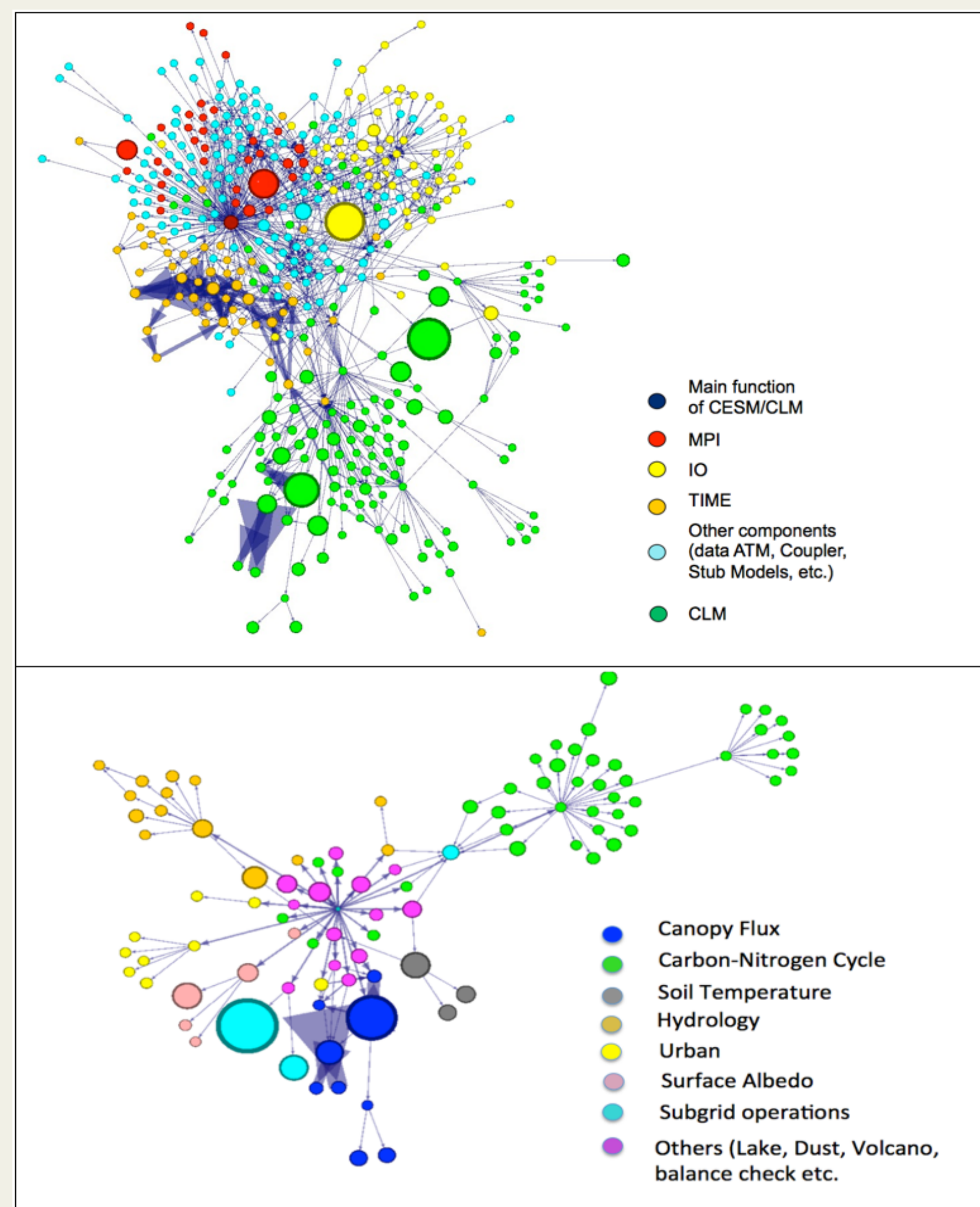


Figure 1: The software structure of the CLM. 1800 source files and over 350,000 lines of source code

2) Objectives

- Create web-based interactive views for new module development via BER's MODEX approach;
- Overcome software complexity barriers via automatic multiscale ecosystem mechanistic modular design
- Develop advanced tools for code analysis and porting on next generation HPCs.
- Engage board user communities via web services and cloud computing.

3) Visual Analytic System (significant improvements from [4])

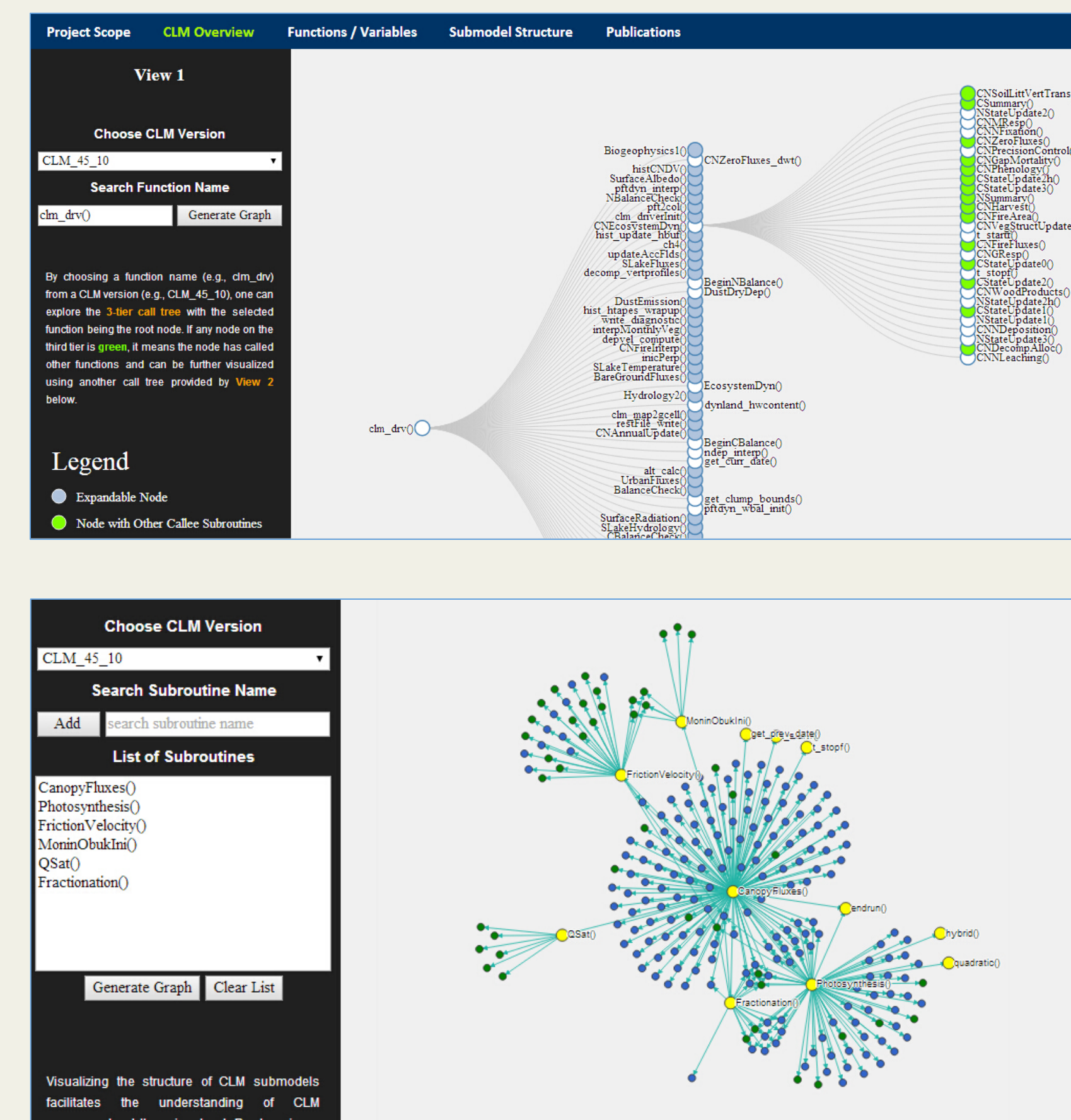


Figure 2: CLM Structure and Submodel Exploration

4) Ecosystem Function Testing System (compiler-assisted software analysis [5])

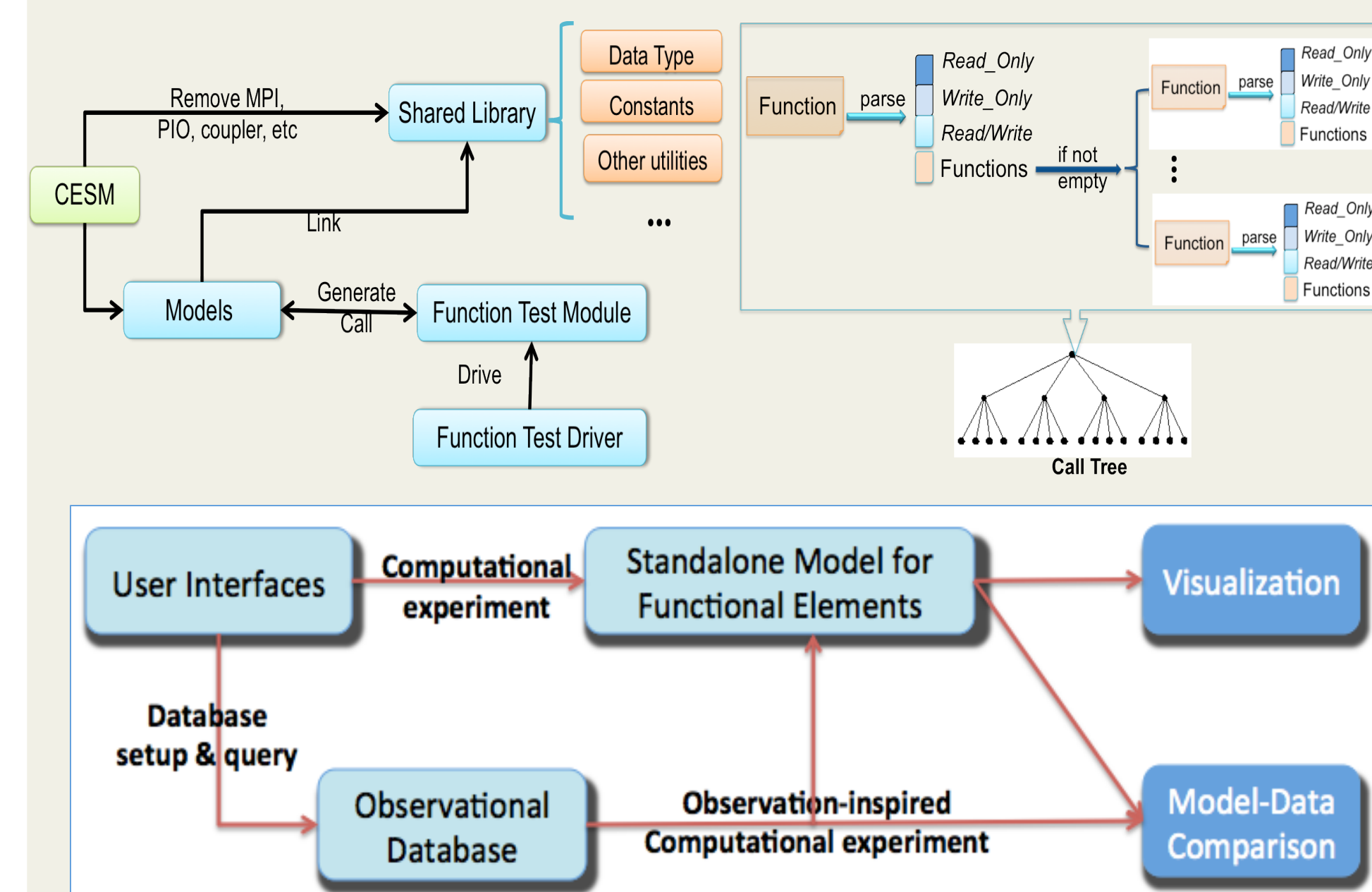


Figure 3: Automatic ecosystem functional testing with online observational datasets

5) Code Analysis and Porting Preparation for PreExascale HPCs

- Compiler based CLM software structure similarity analysis[6].
- Memory-access pattern analysis using Gleipnir [7].
- Runtime performance profiling using Vampir [8].
- Pilot study on code porting using OpenACC [9]

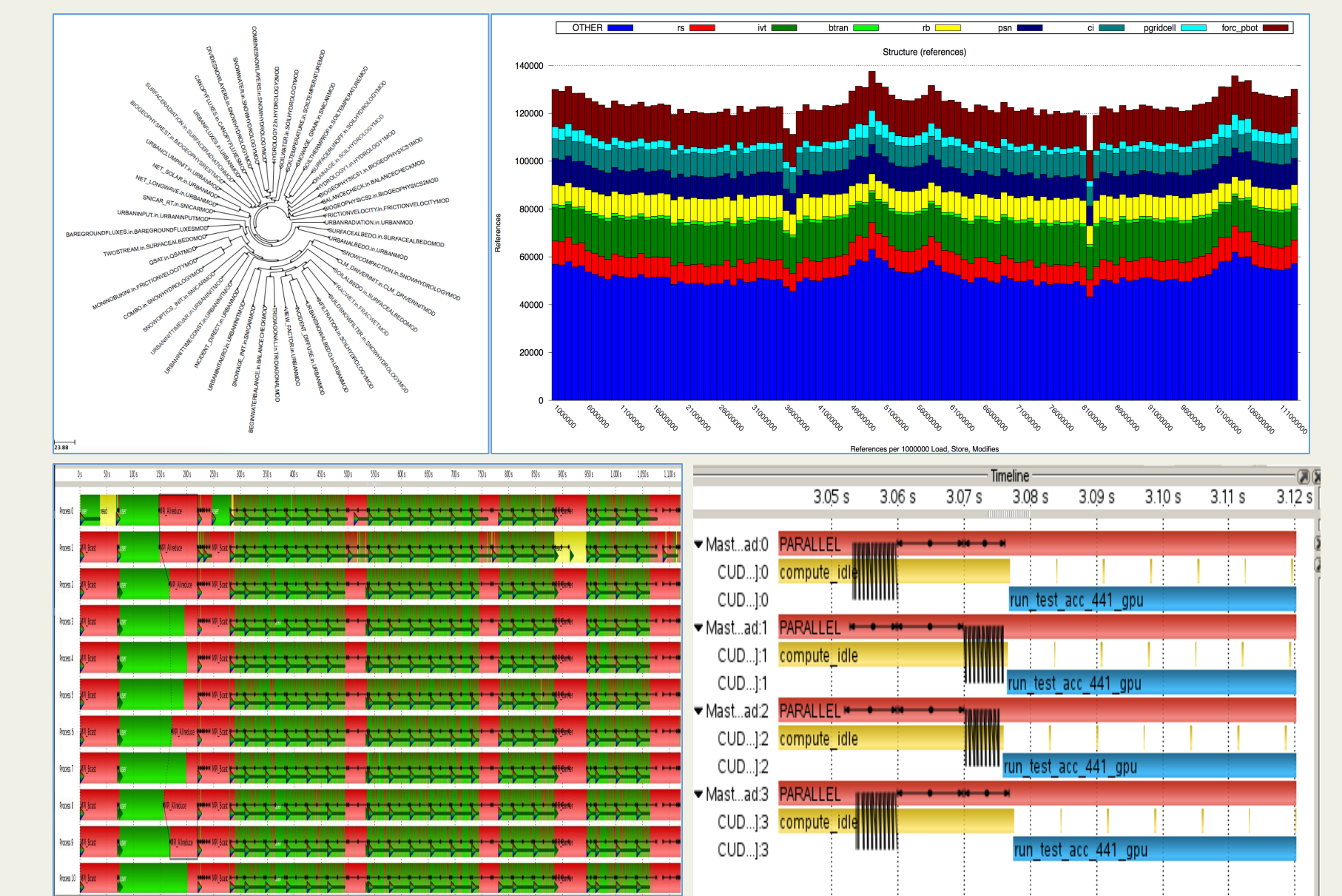


Figure 4: CLM Preparation for preExaScale Computers

6) Community Engagement Practices

- Web-based visual analytic system to explore and analyze the CLM software structure and software analysis results;
- Cloud-based functional testing platform directly connect to online databases for direct model-data comparison (within CADES, ongoing)

7) Reference

- Oleson, K., Lawrence, D., Gordon, B., Flanner, M., Kluzek, E., Peter, J., Levis, S., Swenson, S., Thornton, P., and Feddema J., 2010, Technical description of version 4.0 of the Community Land Model (CLM).
- Wang, D., Post, W., Wilson, B., 2011. Climate Change Modeling: Computational Opportunities and Challenges, IEEE Computing in Science and Engineering, Vol 13(5), pp36-42
- Wang, D., Schuchart, J., Janjusic, T., Winkler, F., and Xu, Y. 2014a. Toward Better Understanding of the Community Land Model within the Earth System Modeling Framework, International Conference on Computational Science, Cairns, Australia, 2014,
- Xu, Y., Wang, D., Janjusic, T., Xu, X., A Web-based Visual Analytic System for Understanding the Structure of Community Land Model, International Conference on Software Engineering Research and Practice, June, 2014.
- Wang, D., Xu, Y., Thornton, P., King, A., Gu, L., Steed, C., Schuchart, J., 2014. A Functional Testing Platform for the Community Land Model, Environmental Modeling and Software, Vol. 55, pp25-31, 10.1016/j.envsoft.2014.01.015
- Ding, W., Hsu, C. H., Hernandez, O., Chapman, B., & Graham, R. (2013). KILONOS: Similarity-based planning tool support for porting scientific applications. *Concurrency and Computation: Practice and Experience*, 25(8), 1072-1088.
- Tomislav Janjusic, Christos Kartsaklis, Dali Wang, Scalability Analysis of Gleipnir: A Memory Tracing and Profiling Tool on Titan, Cray User Group, May, 2014, Switzerland
- Domke, J., Wang, D., Runtime Tracing of the Community Earth System Model: Feasibility Study and Benefits, 12th Workshop on Tools for Program Development and Analysis in Computational Science, Omaha, Nebraska, June 2012, procedia CS 9: pp1950-1958, 2012
- Wang, D., Wu, W., Winkler, F., Ding, W., Hernandez, O., Feasibility Study on Porting CLM onto Accelerators using OpenACC, in preparation.
- Webstie: cem-base.ornl.gov/CLM_Web/CLM_Web.html CADES: cades.ornl.gov
- YouTube: https://www.youtube.com/watch?v=-4sn_wT0dMU

Acknowledgement

This research was partially funded by Accelerated Climate Model for Energy (ACME), Terrestrial Ecosystem Sciences (TES) Program and Climate Sciences for Sustainable Energy Future (CSSEF) Program under the Biological and Environmental Research (BER) under the Office of Science of the U.S. Department of Energy (DOE). This research used resources of the Oak Ridge Leadership Computing Facility, located in the National Center for Computational Sciences at Oak Ridge National Laboratory, which is managed by UT-Battelle LLC for the Department of Energy under contract DE-AC05-00OR22725.