

THE LAND ICE VERIFICATION AND VALIDATION TOOLKIT (LIVVKIT)

The Land Ice Verification and Validation Toolkit (LIVVkit) is an open-source, Python-based software package that addresses the pressing need of earth system modelers to evaluate and improve the simulation of continental-scale, dynamic ice-sheet models.

In Greenland and the Antarctic, massive ice sheets—built up over millions of years and containing the majority of Earth’s fresh water—have been evolving and melting. To project future sea-level rise, scientists must understand and simulate or model ice-sheet mechanisms and their response to shifting earth system patterns.

Field research in Greenland and the Antarctic is both difficult and costly. As a result, these land ice sheets are among the least measured of all earth systems. Data, in fact, are largely limited to the past couple of decades. A second major challenge is to create models of ice sheets which evolve slowly in time and couple them accurately to parts of the Earth’s systems that evolve more quickly, including the ocean and atmosphere.

The impact is uncertainty in our understanding of the future of these immense ice sheets, their interactions with the other earth systems, and ultimately, their continued contribution to sea-level rise.



As ice sheets continue to change, scientists can expand LIVVkit to better inform the ice-sheet developments.

A DIAGNOSTIC TOOL FOR EARTH SYSTEM MODELERS

LIVVkit assists ice-sheet modelers by focusing on two basic techniques to produce credible models — *verification and validation*. Verification ensures that all model aspects are accurately constructed. Validation tests how capable models are at representing the real world.

LIVVkit provides an easily extensible framework to, for example, expand its capability to include new observational data and assess models on new

computing platforms. Moreover, it is designed for quick adaptation to multiple ice-sheet models using flexible code, functions, and configurations. Ultimately, LIVVkit can help scientists build confidence in their models and enhance the credibility of ice-sheet models overall.

Get LIVVkit 2.1.1

Download the Land Ice Verification and Validation Toolkit (LIVVkit) Project source code and software documentation:

- <https://github.com/LIVVkit>

INTEGRATED, WITH VERIFICATION AND VALIDATION

LIVVkit is designed to be integrated into the model development workflow and allow developers to provide regular, automated verification and validation testing. Within a development cycle, individual developers can test their incremental changes by running a small, quick set of verification tests. As their features are ready for integration into the model, a larger, comprehensive verification and validation test suite is run before changes are accepted.

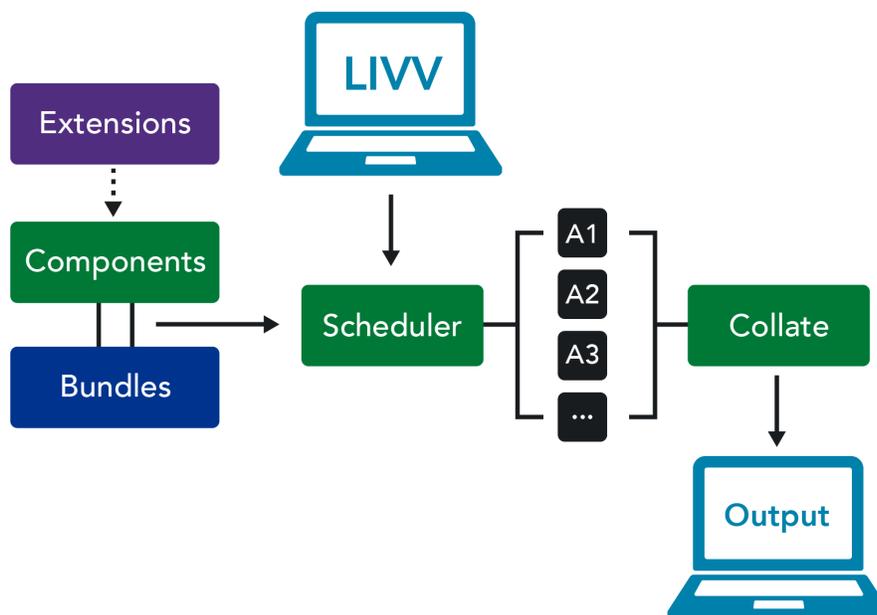
LIVVkit has been successfully integrated into Community Ice Sheet Model (CISM) development workflow and is currently being extended to target new **Energy Exascale Earth System Model (E3SM)** configurations of interest to ice-sheet modelers.

EXTENSIBLE, FLEXIBLE, NIMBLE, PORTABLE AND QUICK

The output of LIVVkit will be examined by broader audiences, including the extended scientific community. Therefore, LIVVkit is designed to be:

Extensible: LIVVkit accommodates new models and tests to keep pace with future developments.

Flexible: LIVVkit permits multiple use cases and integrates into different workflows. Internal functions and modules are easily imported into larger testing frameworks. This allows LIVVkit to be deployed and used by larger earth system models, such as E3SM.



This schematic of LIVVkit architecture illustrates how the interface is used to schedule a series of analyses. Analysis codes are pulled from required bundles, components, and extensions, and then the analysis is executed in parallel.

Nimble: LIVVkit performs sets of analyses with minimum overhead and time to results. To complete analysis quickly, it runs analyses in parallel with an internal scheduling system.

Portable: LIVVkit has a limited number of internal (Python) and external dependencies, all of which are commonly used within the community and are typically available on the supercomputers running ice-sheet models.

Quick: Advanced technical skills are not needed. LIVVkit is driven by a command line interface in which two primary arguments enable/disable available analyses—a process familiar to ice-sheet modelers. It can be used on personal computers and supercomputers.

For further reading on the LIVVkit project, see "**LIVVkit: An Extensible, Python-Based, Land Ice Verification**

and Validation Toolkit for Ice Sheet Models," "Open-Source Tool Aims to Boost Confidence in Ice Sheet Models."

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CONTACTS

Joseph Kennedy, Ph.D. and Katherine Evans, Ph.D.
Co-Principal Investigators
Oak Ridge National Laboratory
kennedyjh@ornl.gov, evanskj@ornl.gov

Dorothy Koch, Ph.D.
DOE Program Manager
Earth System Modeling
dorothy.koch@science.doe.gov