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Building confidence in the Community Ice Sheet Model (CISM) with LIVVkit, the land-ice validation and verification toolkit

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SciDAC
Scientific Discovery through Advanced Computing

OLCF
Oak Ridge Leadership Computing Facility

Confidence and credibility

Confidence: feeling or belief that one can rely on something
Credibility: the quality of being trusted and believed in

- Verification and validation (V&V) is a set of confidence building techniques.
- V&V is a continuous process tandem to, and essential to, development.
- V&V is not enough! Credibility relies on:
  - Reproducibility
  - Transparency
  - Discoverability

LIVVkit is designed to build user and developer confidence, as well as, scientific credibility

- Tests and analyses can be quickly repeated
- Results are portable and web-ready
- Integrates easily into the developer workflow
- Nightly builds and tests of CISM (the community ice sheet model)
  - http://blizzard.ornl.gov
- Runs on PCs and HPCs with the same interface
- Public code releases on github:
  - Code: https://github.com/LIVVkit/LIVVkit
  - Docs: https://github.com/LIVVkit/LIVVkit/wiki
  - Example: http://livvkit.github.io/LIVVkit/
- Private development to protect novel analyses and intellectual property
  - Code: https://github.com/ACME-Climate/LIVV
  - Example: http://acme-climate.github.io/LIVV/index.html

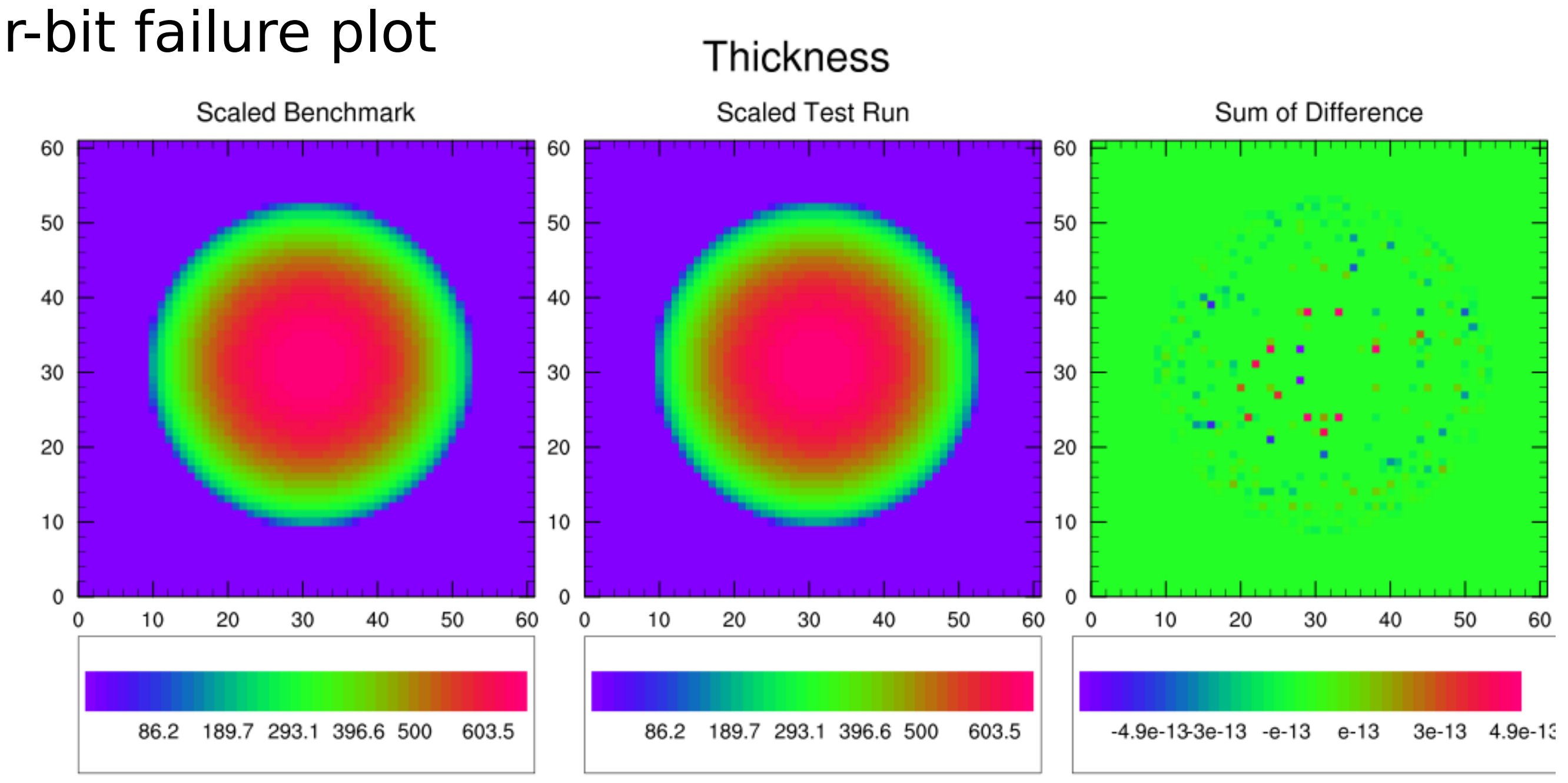
Verification

Software verification   LIVVkit: verification

The process of determining if the software's implementation accurately represents the developers' specifications. This is an **engineering** problem:

"Did we build what we intended?"

Bit-for-bit failure plot



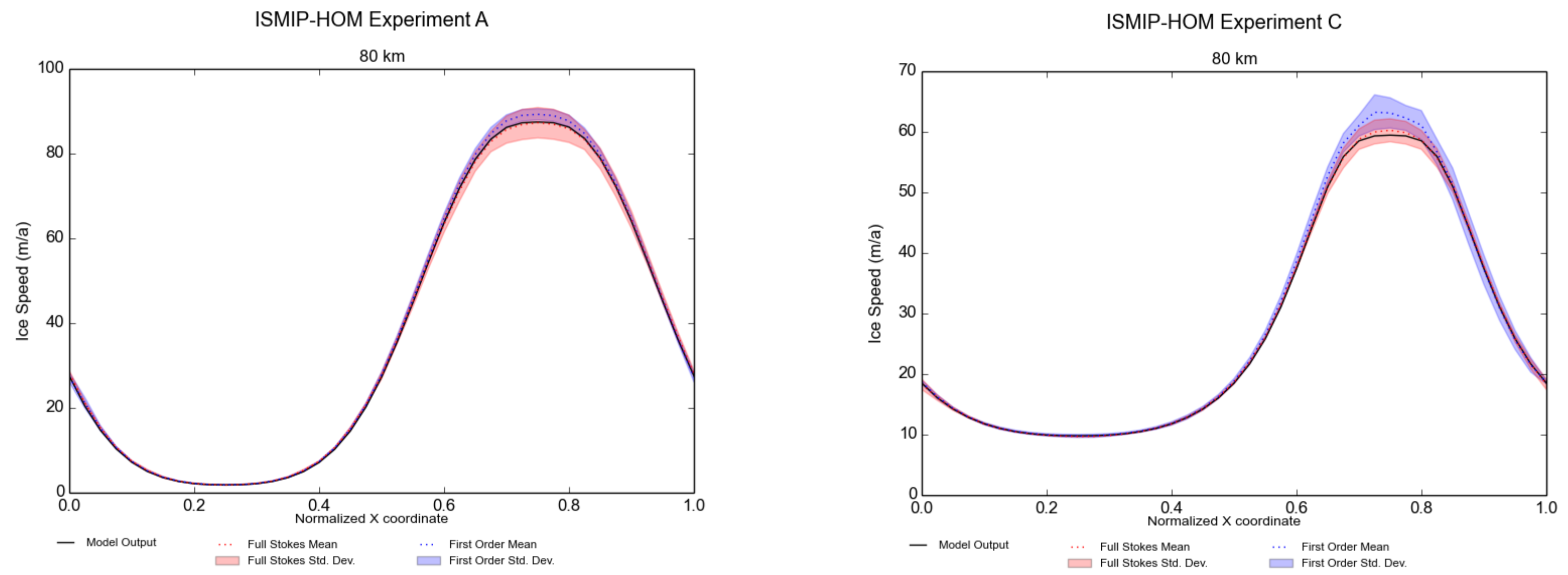
- Failure description with error details -- max and RMSE
- Test configuration comparison
- Bit-for-bit analysis of multiple, relevant variables
- Automatic failure plot generation

Numerical (algorithm) verification   LIVVkit: numerics

The process of comparing the approximate numerical solution of the model, or parts of the model, against a numerical benchmark (e.g., an analytical solution or a manufactured solution). This is a **math** problem:

"Are we solving the equations correctly?"

ISMIP-HOM comparison for HO dynamics:



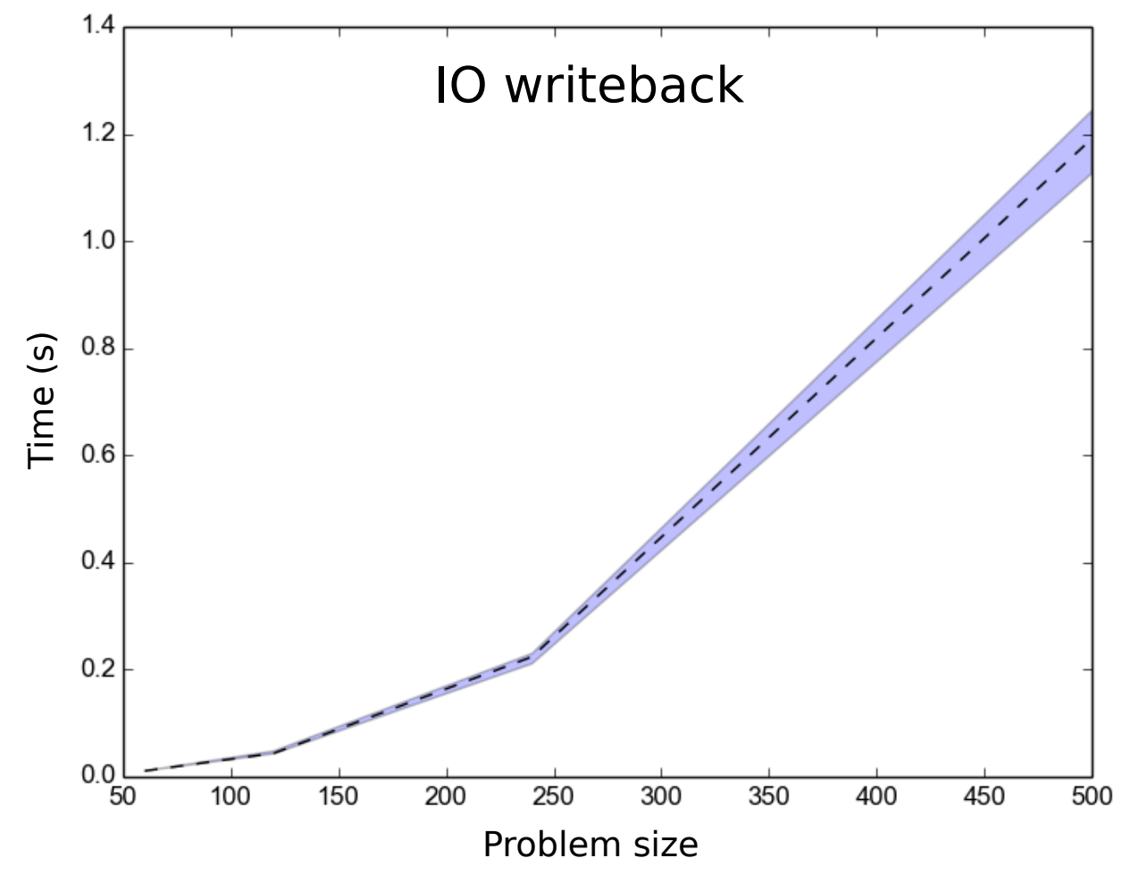
Validation

Software validation   LIVVkit: performance

The process of determining how well the software is able to be used for its intended task. In the case of ice-sheet models, especially for those coupled to a global-climate model, *performance* aspects will be the focus of software validation. This is a **design** problem:

"Did we build what the users needed?"

Scaling plot



- Automatically parse GPTL timing files
- Timing summary for multiple simulations -- min, max,and mean
- Automatic scaling plot generation -- strong and weak

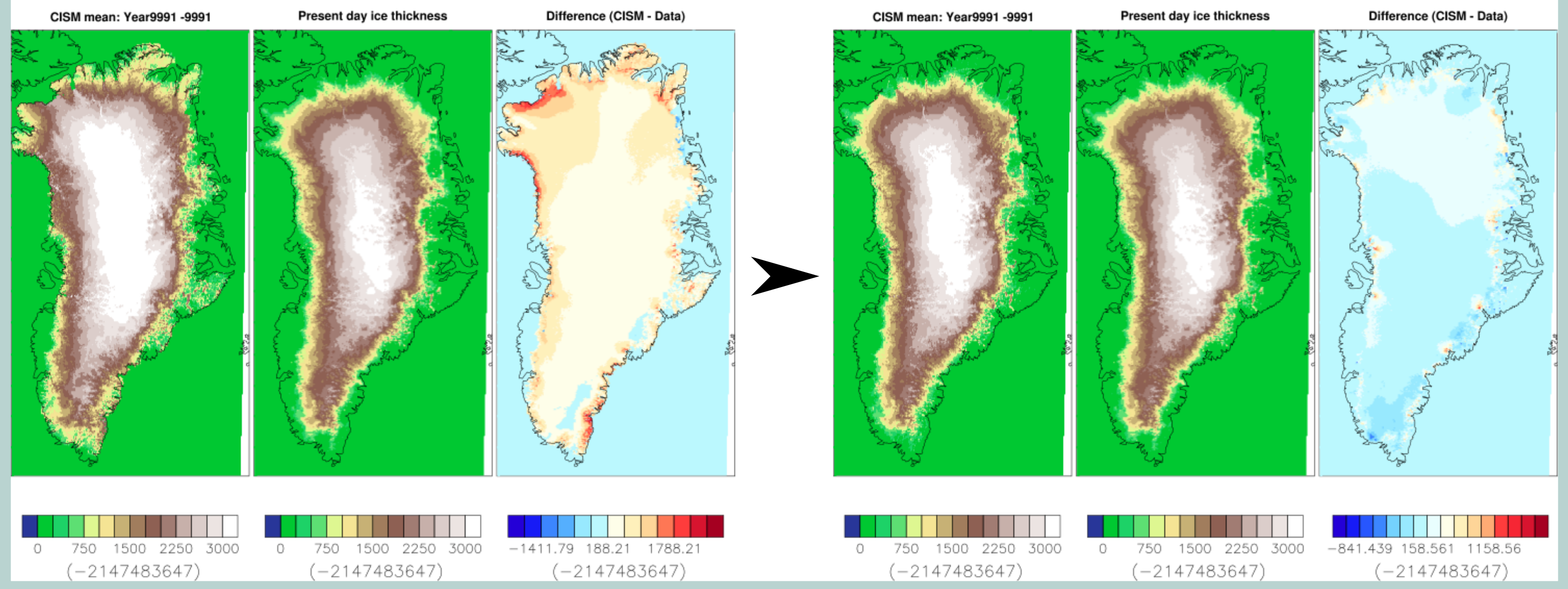
Physical validation   LIVVkit: validation

The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model. This is a **physics** problem:

"Are we using the right physics?"

User example

Jeremy Fyke (LANL) is using LIVVkit to analyze ongoing open-beta stress testing of CISM2 in a 'real-world' configuration, using a validation test module that he and Lauren Vargo (UNM/LANL) developed for LIVVkit. The were able to fix a bad configuration setting that resulted in a 2.5 km high ice cliff (bottom-left). All plots were produced by LIVVkit.



LIVVkit

Good Design = Good Tools

Easy deployment

- Internal dependency management
- Automatic website generation

User friendly

- Command line options or saved configurations

Increase productivity

Extensible and maintainable

- Python code base
  - Modular for easy test and feature additions
  - Commonly used by scientists
- Jinja2 for website generation
  - Templated for easy changes

Planned development

Released soon

- Support more CISM dycores
- Better performance metrics and plots
- Initial validation tests
- Numerics module

Later

- Interactive tables and plots
- Support other ice-sheet models
- Antarctica!
- **Suggestions?**

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