

E3SM New Feature Integration and Testing Process

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E3SM All-Hands Presentation

Virtual

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E3SM Deep Dive

- Based on experience putting together the V2, review how new features are brought into the model and tested.
- 16 member committee: Gautam Bisht, Andrew Bradley, Peter Caldwell, Katherine Calvin, Chris Golaz, Oksana Guba, Ben Hillman, Matt Hoffman, Robert Jacob, Philip Jones, Andrew Roberts, Jinyun Tang, Luke Van Roekel, Mark Taylor, Jon Wolfe, Walter Hannah
- Weekly meetings 2021/9 through 2022/3

Outline

- V2 case integration case studies
 - Documented 11 cases of unexpected setbacks during V2 development and how they could be prevented or caught earlier
 - <https://acme-climate.atlassian.net/wiki/spaces/CNCL/pages/3130818586/phase+1+V2+Case+Studies>
- New Policy:
 - Section 1: New Feature Request Process and Documentation Requirements
 - Section 2: PR submission: Documentation and simulation results
 - Section 3: PR review procedures
 - <https://e3sm.org/model/running-e3sm/code-review-and-new-feature-process>

Terminology

Code changes are divided into 4 categories

- BFB:
 - New code produces results which are bit-for-bit identical with old code
- Roundoff:
 - New code would match old code in exact arithmetic, but will diverge exponentially fast when using finite precision
 - Climate of new and old code will converge as the averaging time goes to infinity
- Climate changing
 - New feature is brought into the model turned on
 - Other model configuration change (parameters, resolution, forcing data)
- Stealth Feature
 - BFB code change that includes a new feature, turned off by default

Reference Solutions

The E3SM project will maintain reference solutions reflecting the current state of the 'main' branch

- Coupled model: B-case runs (~100 years) for WC, cryosphere and BGC configurations
- Component models: F, I and G cases, typically much shorter (e.g. 5 year F case with cyclic year 2010 forcing)
- Updated periodically when climate changes are integrated, or monthly (to check for unintended changes)
- New features will be evaluated with respect to these reference solutions, with documentation on the import metrics

Note: E3SM Reference solutions and related documentation not yet ready!

Section 1

New Feature Request Process and Documentation Requirements

Section 1: New Feature Request Process and Documentation Requirements

- New Feature Overview Document
 - high level description of code changes and/or new code, overview of the design, infrastructure changes
 - Expected improvements and how these will be demonstrated
 - Describe needed updates to E3SM documentation
 - Expected impacts on computational performance and mass/energy budgets.
 - If relevant: describe papers that will be published
- E3SM-SFA funded work: feature should appear in that group's roadmap
- Externally funded work: developers are encouraged to submit this document early in their development process. This will assist with later possible E3SM acceptance.

Section 1: New Feature Request Process and Documentation Requirements

- Overview Document
 - Precise format and detail depends on type of feature and may be an iterative process with the model component lead (or delegate)
 - Can be quite short: a few sentences within each category (i.e. recent work in Atmospheric Physics NGD)
 - More detailed: Proposed design document for the EAM parameterization interface (adding water loading and nonhydrostatic pressure): 8 pages
- Component lead (or delegate) reviews this document to:
 - **Determine if there is sufficient benefit to E3SM to justify the E3SM integration and future maintenance costs.**
 - For features needed to support other BER missions – consult with E3SM leadership
 - Determine if performance and infrastructure group reviews are also needed
- **Note: E3SM component groups and leads have not been created yet!**

Section 2

Collect documentation and simulation results needed for the Pull Request

Section 2: Collect documentation and simulation results needed for the Pull Request

- BFB changes
 - Follow current practices
 - BFB changes that include stealth features: see stealth features category
- Roundoff
 - Provide evidence that the changes are roundoff
 - Run the E3SM nbfb test suite. If any of them fail, additional scrutiny is needed.

Section 2: Collect documentation and simulation results needed for the Pull Request

- Stealth Features
 - Include link to the (previously approved) New Feature Overview Document
 - Demonstrated that it's possible to determine if feature is on/off via log file / namelists
 - Ensured that it's covered by a suitable timer
 - Add a test for the new feature
 - Verified that it passes the “super-BFB” test suite.
 - To verify feature preserves existing BFB reproducibility across restarts, MPI and thread changes
 - Documented performance changes via “HPC” test suite with a link to PACE results
 - For features with potential performance impact
 - Compare with component reference solution (when relevant) via E3SM diags
 - E3SM to develop an automated system to produce and archive these results
 - Sanity check “B compset”:
 - 10 year coupled simulation, compared with reference B compset
 - Stealth features need to work reasonably well in the coupled mode.

Section 2: Collect documentation and simulation results needed for the Pull Request

- Climate Changing
 - All material for a stealth feature
 - B-case “sanity check” is replaced by running the full 100 year coupled simulation and comparing against the reference solution

Section 3

Pull Request Review Process

Section 3: Pull Request Review

In addition to E3SM's current review process (external reviewer and PR assigned to an integrator), the new policy adds one additional review step, depending on the type of code change:

- BFB, Roundoff and Stealth Features:
 - **Component lead** (or delegate) ensure PR is correctly characterized, all requested material included in the PR, and reference solution comparisons are acceptable
- Climate Changing:
 - **Simulation group lead** (or delegate): ensure all requested material included in the PR and reference solution comparisons are acceptable
 - Update associated reference solutions

Summary

- New features and stealth features need a overview document and component group lead approval
- New features need long coupled simulations to compare with reference solutions (component only tests insufficient)
- Stealth features must be fully tested in component simulations and shown to work reasonably well within the coupled system
- Evaluation will ensure key metrics to be defined by the simulation leads are maintained, in addition to preserving or improving performance, BFB reproducibility, and mass/energy conservation.



Thanks!