PMESP Annual Report and Work Plan for Year 1, 2022–23

for National Science Foundation Cooperative Agreement EAR-2148762

June 2023

1 Introduction

This document reports Year 1 progress and Year 2 planning for Cooperative Agreement EAR-2148762 "Engaging a thriving community of practice in Earth-surface dynamics", based on the Project Management Engagement and Sustainability Plan (PMESP). The report covers activities, accomplishments, and plans in three major activity areas: Community Engagement (Section 2), Cyberinfrastructure (Section 3), and Governance, Management, and Operations (Section 4). For each of these major activity areas, the report describes Year 1 tasks and accomplishments, projected Year 1 expenditures, plans for Year 2, and the budget request for Year 2. The report also evaluates progress against various metrics that were identified in the PMESP. Note that the PMESP had also identified a fourth category, "Other", that was significantly smaller than the other three in terms of effort and budget. For the sake of simplification, that category is now merged into the "Governance, Management, and Operations" activity area in this report.

2 Community Engagement

2.1 Year 1 activities and accomplishments

Primary tasks and activities related to the Community Engagement activity area for Year 1 include the following:

- Conduct the 2023 CSDMS All-Hands Meeting
- Teach the 2023 Earth Surface Processes Institute (ESPIn)
- Develop asynchronous learning resources
- Conduct CSDMS Roadshows
- Operate Research Software Engineering as a Service (RSEaaS) program
- Establish and operate an online community forum
- Conduct a trial of executable notebook publications
- Disseminate project results through travel and publication

As of late May 2023, CSDMS has 2,316 members. This exceeds the aspirational target metric of 2,300 members by the end of Year 1. Progress on other community engagement metrics is noted in the sub-sections below.

2.1.1 Annual meetings

The 2023 Annual Meeting, with the theme of "Patterns and Processes Across Scales," was attended by 125 community members. The meeting was held from May 16–18 at the Sustainability Energy and Environment Community (SEEC) facility on the University of Colorado's Boulder campus. Plenary sessions were also live-streamed using the Zoom videoconferencing application. The program included 12 invited keynote lectures (including 2 student talks), 11 clinics, a plenary panel discussion on "AI in Earth Surface Research," 54 poster presentations, two electronic paper presentations, and 7 final-project presentations by the ESPIn students (described below). The meeting also included an awards ceremony, with presentation of the Student Modeler Award and the Lifetime Achievement Award. Details of the meeting program can be found on the CSDMS web portal at `https://csdms.colorado.edu/wiki/CSDMS_meeting_2023`. Demographic details (reported in percentages) are listed in Table 1 below.

The annual meeting attendance of 125 falls between the basic target of 100 attendees and the aspirational target of 140. There were approximately 25 remote attendees at the peak, which falls between the basic target of 20 and the aspirational target of 60. Among the attendees, nearly all enrolled in clinics, which exceeds the aspirational target of 105. Although we did not formally count the number of first-time attendees, a show of hands on the morning of the first day suggested that roughly 1/3, likely between 30 and 40, were first-time attendees. This figure exceeds the aspirational target of 30 per meeting. The 54 poster presentations fell between the basic and aspirational targets of 40 and 60, respectively. There were two software posters, which fell short of the basic target of five per meeting (six abstracts were submitted but only two of those actually produced software posters). The gender ratio among keynote speakers was 7:5, better than the AGU membership ratio of 1:2 and close to the aspirational target of parity (we did not ask keynote speakers to disclose their ethnic or racial identification). Fifteen scholarships aimed at encouraging participation among members of underrepresented groups were provided, meeting the target.

Demographic		Participant Share (%)
Gender	Female	44
	Male	54
	Gender diverse	2
Domain	Academia	86
	Goverment/NGO	12
	Private Sector	2
Career stage	Graduate Student	34
	Postdoc	12
	Early-career	22
	Mid-career	25
	Late-career	7

Table 1: Demographics of 2023 CSDMS Annual Meeting in-person attendees.

2.1.2 ESPIn

The Earth Surface Processes Institute (ESPIn) is organized by members of the CSDMS Integration Facility (Overeem, Piper, and Rossi) and Prof. Gasparini of Tulane University, with assistance from other team members. ESPIn 2023 was timed to precede the 2023 CSDMS Annual Meeting, with immersive training and team projects scheduled for May 8–15th, 2023.

We received 74 applications from around the world for ESPIn 2023. In the application, we requested a one-page CV, a concise motivation statement, and a statement about contributions to DEI in the field of earth science. The selection committee used a metrics-based, blind review, and equity-conscious approach to select a group of 26 participants. All selected students accepted and attended ESPIn 2023. Demographic information for the participants is given in Table 2 below.

Demographic		Participant Share (%)	AGU (%)	USA (%)
Gender	Female	63	32	51
	Male	25	68	49
	Nonbinary	6	n/r	n/r
	Prefer not to say	6	n/r	n/r
Ethnicity	White (non-hispanic)	33	82	76
	Asian	29	9	6
	Hispanic or Latinx	23	6	19
	Black	14	2	14

Table 2: Demographics of ESPIn 2023. AGU figures are based on 2020 member demographics excluding the categories of "not listed" and "unknown." USA figures are from the 2020 census, as reported by the Census Bureau.

Instructors presented tutorials and hands-on activities on Project Jupyter, shell scripting, Python programming, and extensive CSDMS Landlab and Python modeling tool resources.

Invited speakers presented earth surface modeling science lectures. ESPIn promotes community networking over different 'generations' of early career scientists, so we engaged with four early career speakers, two of whom were previous ESPIn attendees: Prof. Alejandra Geiger-Ortiz (Colby College), Prof. Julia Moriarty (University of Colorado Boulder), Prof. Danica Roth (Colorado School of Mines), Dr. Jayaram Hariharan (U.S. Geological Survey). In addition, Prof. Greg Tucker (University of Colorado Boulder) presented a science lecture to showcase an advanced landscape evolution modeling and sensitivity testing example for nuclear waste disposal safety assesment.

Explicitly, ESPIn aims to help participants with professional networking and community building. Informal mini-poster presentations were presented on the first day, allowing people to get to know each other from a science perspective and a bit more personally. Another important element of the community building is to work on team projects. Project topics allow for free brainstorming, exchange of science ideas, exploration of resources to build upon, and collaborative programming. Each team has 3–6 people and works for 12+ hours on their project. Peer mentors from previous years of ESPIn assist during brainstorming sessions, and help the teams with some debugging and programming design decisions. Four mentors assisted in 2023. On the last day of the formal program a career panel takes place, with representatives from industry, federal government, and academia all discussing career decisions, answering questions on day-to-day work experience, flexibility in job searches, work-life balance, academic considerations like two-body hiring, and other topics. This is always really well received and presents another opportunity for students and early-career scientists to use their peers as a sounding board for decision upon entering the workforce.

ESPIn team projects result in 1) a working Jupyter Notebook with open source licensing available to be used as an educational resource, and 2) a short presentation at the CSDMS Annual Meeting to show the larger community these accomplishments and resource. Products are posted on GitHub: `https://github.com/csdms-espin`. Team projects focused on landslide vulnerability, landscape evolution under precipitation gradients, vegetation and sediment transport and erodibility, glaciers, and snow melt dynamics and runoff.

At the time of reporting, we have not analyzed pre- and post-class survey results for 2023, but these will be forthcoming and are being used to continue to improve the program.

One of the metrics for the ESPIn program was to achieve a female:male ratio of the AGU member population (1:2) (basic target) or parity (aspirational target). This year's ratio of approximately 2.5:1 exceeded the aspiration. In terms of other demographics, and with the usual caveat about the statistics of small numbers, the makeup of the 2023 ESPIn cohort was generally closer to that of the USA as a whole than to that of the AGU membership. Two of the ESPIn participants came from a minority-serving institution (MSI), falling short of the basic target of 3.

2.1.3 Asynchronous learning resources

Development of asynchronous learning modules is spearheaded by Rossi in coordination with other education and outreach efforts conducted by the CSDMS Integration Facility (Overeem, Piper, Tucker). The platform for delivering these modules is the EarthscapeHub (a cloud-based JupyterHub operated by the CSDMS Integration Facility). Descriptions of modules will be provided on the CSDMS website, which will then link to course materials

once the course materials are launched. New users will be prompted to signup for a free account.

Design Philosophy In total, four modules are being developed: one CSDMS Carpentry Module and three Project Modules. The CSDMS Carpentry Module (or prior experience with Python, Landlab, and pymt) is a pre-requisite to the 3 Project Modules. The Project Modules themselves do not depend on each other. Each is a self-contained, multi-chapter sequence of exercises that require 15–20 hours to complete. The goal of each module is to guide students through a multi-part workflow that addresses objectives relevant to the diverse use-cases of the CSDMS Working and Focus Research groups. Each Project Module will have a different disciplinary focus. Year 1 efforts focused on development of the CSDMS Carpentry Module and the first of the three Project Modules. Each Project Module is contextualized using a motivational project. The general structure of a module is one introductory chapter, four sequenced chapters, and one application chapter. Chapter 1 provides students with resources describing the project, a conceptual map showing which concepts will be introduced in the module, prompts for developing a plan of action to address central questions, and survey questions that assess student understanding of the processes and skills covered in the module. Chapters 2–5 are a coordinated sequence of guided exercises introducing new concepts, new Landlab modeling components, and new Data Components. Each chapter includes a list of learning goals and learning outcomes. Chapter 6 requires students to pull concepts and skills together to address the project motivation.

CSDMS Carpentry Module development The CSDMS Carpentry Module is a condensed version of many of the skills introduced in ESPIn. As such, the approach and sequencing will be revised in coordination with ESPIn materials. Exercises primarily focus on Python programming, Jupyter Notebooks, building models in Landlab, and introducing students to pymt and the Basic Model Interface. In place of teacher prompts in the asynchronous environment, interactivity is built into Jupyter Notebooks using Jupyter Widgets. After an internal review of alignment with ESPIn and solicitation for community feedback, this module will be piloted with a limited number of students in Fall 2023.

Project Module 1 development The first project module is motivated by the 2013 Colorado flood and landslides. Students are introduced to Data Components (to import topography) and a variety of model components (to simulate rainfall, infiltration, overland flow, and slope stability) in Landlab. The sequence of guided exercises is as follows: Ch. 1: Intro to 2013 Colorado Event, Ch. 2: Simulating stochastic rainfall, Ch. 3: Hillslope response to rainstorms, Ch. 4: Runoff generation and river flooding, Ch. 5: Soil saturation and slope stability, Ch. 6: Synthesis. After an internal review of learning goals, learning outcomes, and course materials, and solicitation for community feedback, this module will be piloted with a limited number of students in Fall 2023.

2.1.4 Roadshows

The goal of the CSDMS Roadshow is to provide expanded training opportunities to groups that may not be able to travel to the CSDMS Annual Meeting or ESPIn. CSDMS Roadshow

#1 was held 2023 March 7–9 at Montclair State University, hosted by Prof. Jorge Lorenzo Trueba of the Department of Earth and Environmental Studies. Eleven participants, mostly graduate students, learned about shell commands, version control with Git, Python programming, and Landlab. Roadshow #2 is planned for 2023 August 16–18 at the University of Minnesota Twin Cities, hosted by Prof. Andrew Wickert of the Department of Earth and Environmental Sciences.

In terms of metrics, by the time the project year has ended, two Roadshows will have been held, meeting the target of 2 events per year. The 11 attendees at the first Roadshow met the basic target of 8 attendees per event but not the aspirational target of 16. To get feedback on the session, we prepared an online survey and received 4 responses (this was in lieu of planned interviews; the original basic target was one interview per event). All participants were MSI-affiliated (Montclair State is an MSI), so the aspirational target of 4 MSI affiliated participants per event was exceeded.

2.1.5 RSEaaS

The Research Software Engineering as a Service (RSEaaS) program was expanded to include CSDMS Office Hours, a once-a-week open Zoom session where CSDMS members can schedule time with a CSDMS Research Software Engineer (RSE) to discuss issues related to scientific software development. Office Hours were introduced in January 2023. By the end of May 2023, Office Hours had been used 15 times by CSDMS members. This meets the aspirational target of 12 CSDMS members helped per project year. In terms of RSEaaS-assisted products, we are aware of three that were completed during the reporting year: a new PyMT Component for permafrost dynamics, installation of the Meillionen coupling tool on the CSDMS EarthscapeHub, and adding a BMI to the SimpleCrop model. This exceeds the aspirational target of two RSEaaS-assisted products per year.

2.1.6 Community forum

The CSDMS Forum was launched in January 2023, using GitHub Discussions as a platform. Unlike the CSDMS Help Desk, where CSDMS staff answer questions from community members, the Forum provides a place for community members to interact directly with one another. While the Forum has been advertised on Twitter and in the quarterly CSDMS Newletter, it has seen little use as of May 2023.

2.1.7 Executable publications

With the 2023 Annual Meeting, the CSDMS integration facility offered for the first time the option of submitting Executable Publications (Epubs). Inspired by an EarthCube pilot test of the concept, this provides a way to publish computational science through executable notebooks. Executable notebooks represent a relatively new, more modern way of publishing science, which is starting to be adopted by mature publishers as well. To ensure that the minimal requirements for submissions are closely in line with those of established academic societies, we participated during the last year in numerous discussions with the AGU representatives.

On the registration website of the CSDMS Annual Meeting 2023, we made for the first time the option available for meeting participants to submit one or more Epubs. This was a test phase to see if our documentation and infrastructure is sufficient to guide participants through the submission. Initially six participants indicated interest; ultimately, three submissions were received (likely because Epubs take somewhat more time to develop compared to, e.g., a poster; two were submitted by one participant). The Epubs were presented by community members at the CSDMS 2023 annual meeting. To create extra awareness of this alternative presentation format, five-minute oral presentation slots were reserved for each Epub, in addition to the presentation time that was given to Epub presenters during the poster session.

Each submitted Epub was peer-reviewed. In the coming weeks a DOI will be assigned to each, and we will finalize a more prominent portal on the CSDMS website through which people can submit, read, download locally to execute existing Epub publications, and setup a Jupyter hub where accepted submitted notebooks can be executed through the web (estimated to be finalized by fall 2023).

The submission of 3 notebooks fell short of the basic target of 5 submissions per year. We hope to see an increase next year, as word gets out, and are encouraged by expressions of interest in Epubs during the Focus Group discussions at the 2023 annual meeting.

2.1.8 Travel, dissemination, and other events

Activities in this category include conference presentations, short courses, publications, and other means of communicating information about the CSDMS, the resources it provides, and results from applications of those resources. Project team publications and conference presentations for the reporting year are listed in Appendix A.

2.2 Community engagement Year 1 costs and projections

The projected total Year 1 expenditure on Community Engagement activities is about 5.4% less than originally budgeted (Table 3). Most of the difference relates to unused travel funds for Integration Facility Personnel as well as the Executive and Steering Committees. Integration Facility travel cost was reduced because, by the time the project was awarded, team members had already made plans to attend conferences such as GSA, AGU, and EGU using other sources of support. As noted below, we request to carry forward these funds to Year 2, when we anticipate increased travel costs related to Roadshows, the Annual Meeting, and other activities. We also anticipate increased travel costs for the Executive and Steering Committee at the 2024 Annual Meeting, given the higher lodging and related expenses in the greater New York area. Reduced expenditure also reflected departure of a staff member who would otherwise have contributed to the ESPIn program (see Section 3.2).

2.3 Community engagement Year 2 plans

This section summarizes plans for project Year 2. Plans are described under the main task and activity headings.

Category	Year 1 budgeted	Year 1 actual	% Difference
Community engagement	$529,017	$500,532	-5.4%
Cyberinfrastructure	$469,403	$391,602	-16.6%
Governance, management, operations	$377,133	$306,358	-18.8%
Total	$1,375,553	$1,198,492	-12.9%

Table 3: Year 1 budgeted and actual (projected to August 31, 2023) expenditures by major activity area.

2.3.1 Annual Meeting

The 2024 Annual Meeting, with the theme of "Coastlines, Critical Zones, and Cascading Hazards: Modeling Dynamic Interfaces from Deep Time to Human Time" will be hosted at Montclair State University (MSU), Montclair, New Jersey, and it is projected to be attended by 100–150 community members. The exact dates of the meeting are still to be set pending availability of the main conference facilty at MSU; current target dates are May 21–23. The program will include approximately 12 invited keynote lectures (including ∼2 student talks), 10–12 clinics, a plenary panel discussion or similar event (to be determined by the Scientific Program Committee), poster presentations, and Epub presentations. The meeting will also include community building/networking events such as an awards ceremony and participant banquet. MSU is a designated Minority Serving Institution.

2.3.2 ESPIn

ESPIn 2024 is tentatively planned to be held at the University of Colorado Boulder in summer 2024. As with 2023, we anticipate about 25 participants.

2.3.3 Roadshows

Roadshows #3 and #4 are tentatively planned to be held at the University of Washington and Tulane University, with North Carolina State University as a backup.

2.3.4 RSEaaS

We plan to continue holding CSDMS Office Hours once per week in Year 2 of the project.

2.3.5 Community forum

We plan to maintain the CSDMS Forum in Year 2 of the project.

2.3.6 Executable publications

The 2024 Annual Meeting will include a call for Executable Publications, which will be presented during the meeting and published online after successful peer review.

2.4 Community engagement: Year 2 budget justification

The 2024 Annual Meeting will be held at Montclair State University in Montclair, New Jersey. Due to the location, there will be increased costs for facility rental (CU Boulder-based meetings do not require facility rental), catering (estimated based on new catering vendor pricing), participant travel support (5–7 additional students/MSI early career support), and travel for five CSDMS Integration Facility Staff to participate in the meeting (carry-over funding from Year 1 will be used to cover travel for the remainder of the Integration Facility staff). Additional expenses associated with conducting the 2024 CSDMS Annual Meeting at Montclair State University are detailed in Table 4. Note that these expenses are partly offset by cost savings in other areas, such that the total budget request for Year 2 is only 1.5% ($19,838) higher than the original Year 2 request (Table 5; see also Section 5). In addition to this Year 2 request, we also request to carry over unexpended Community Engagement funds from Year 1.

Expense	Estimate	Description
Facility Rental	$8,500	Rental fee was not in original Year 2 budget
Catering	$10,000	Orig. Y2 budget $18,457; new total $28,457
Participant Travel Reimbursement	$10,000	Orig. Y2 budget $33,797; new total $43,797
Domestic Travel (5 staff)	$10,875	Travel to Montclair State University
Total Additional Request	$39,375	

Table 4: Estimates of additional Year 2 Annual Meeting expenses.

Category	Year 2 original	Year 2 revised	% Difference
Community engagement	$523,792	$559,425	+6.8%
Cyberinfrastructure	$460,697	$461,374	+0.2%
Governance, management, operations	$349,156	$332,684	-4.7%
Total	$1,333,645	$1,353,483	+1.5%

Table 5: Summary of budget request for Year 2, by major activity category. (Note that request is in addition to requested carry-over of unexpended Year 1 funds.)

3 Cyberinfrastructure

Tasks and activities related to the Cyberinfrastructure activity area for Year 1 include:

- Work on next-generation code repositories
- Improvements to the CSDMS Workbench
- Initial development and testing of the participatory modeling platform

- Maintenance, support, and community access for high-performance computing resources
- Demonstration project on coupled coastal process modeling

One of the metrics for the Cyberinfrastructure activity area is community usage of cyber resources. Community usage is tracked by identifying publications and conference presentations that involve the use of CSDMS cyber resources. For this metric, we exclude publications and presentations that include any co-authors who are on the project team.

During the project year to date, we have identified 20 community publications that use CSDMS cyber resources (7 using the Basic Model Interface [BMI], 7 using Landlab, and 6 using other CSDMS resources). We identified 11 community conference presentations on research that uses CSDMS resources (1 BMI and 10 Landlab). These community publications and presentations are listed in Appendix B. The number of publications hits the aspirational target of 20 per year. The number of presentations meets the basic target of 10 per year.

3.1 Year 1 Cyberinfrastructure activities and accomplishments

3.1.1 Next-generation code repositories

In Year 1 we identified four community repositories to upgrade to following best practices, allowing them to be more sustainable, collaborative, and accessible to both users and developers. We chose these particular repositories because they are being actively developed, and were seeing possible developer turnover. Some upgrades to these repositories would help put new developers in a better position for success.

The chosen repositories were all coastal models that are part of the UNC-CECL (University of North Carolina UNC Coastal Environmental Change Lab) organization:

- CASCADE: The CoAStal Community-lAnDscape Evolution (CASCADE) model
- BRIE: The Barrier Inlet Environment model
- Barrier3D: A spatially explicit exploratory model of coastal barrier evolution
- CDM v3.0: Coastal Dune Model, which includes updated vegetation and wrack dynamics

Enhancements to these repositories include the following (some of which are language dependent):

- Continuous integration that includes running unit tests, checking for code lint (including coding style, possible bugs), testing generated documentation
- Documentation about how to install and use the model along with a general description of the model and how to contribute to its development
- Pre-built binaries that can be easily installed (on Linux, Mac, and Windows) with the conda package manager.

- Example Jupyter notebooks that demonstrate model usage.

Bringing these four repositories up to speed with modern research software engineering standards exceeds the aspirational Year 1 target metric of two repositories improved.

3.1.2 CSDMS Workbench

In Year 1, the ROMS Data Component was created. This Data Component provides programmatic access to the Regional Ocean Modeling System (ROMS `https://www.myroms.org/`) model output from a NetCDF file, through either a local file path or a remote OPeNDAP data URL. The Data Component wraps the datasets with a Basic Model Interface (BMI), allowing them to be coupled with other Model and Data Components from pymt or Landlab. We also implemented use cases for the Data Components as Jupyter Notebooks to demonstrate their capabilities and applications for Earth surface processes modeling research.

In the first year of this project, we began to combine two tools of the CSDMS workbench: *Landlab* and *PyMT*. This combination will bring together some of the powerful coupling utilities of *PyMT* (e.g., grid mappers, unit converters) and legacy models, written in a variety of languages, into the popular, easy to use *Landlab* Python package where users *build new models* from these components.

To be accessible to a wide range of users, *Landlab* is available for the *Linux*, *Mac*, and *Windows* operating systems. *PyMT*, however, was not available for *Windows* (primarily because of the grid mappers). In this first year we have built *PyMT* so that it is now available for *Windows* users, and can be combined into *Landlab*. In the remaining months of this first year, we will bring the coupling utilities of *PyMT* into *Landlab* so that they can be used with *Landlab* grids and components. (Note that formal metrics have not been defined for these particular CSDMS Workbench enhancements, but they are occurring on schedule.)

3.1.3 Participatory modeling

The NU team has worked on building out and testing a prototype of fora.ai, a participatory modeling platform that is currently working with the Landscape Green Infrastructure Design (L-GrID) model to help the collaborative planning of green infrastructure solutions to urban flooding. In parallel, the CSDMS team has been working on developing APIs to work with this platform.

We conducted a preliminary test with stakeholders in the City of Chelsea (funded partially by another project), while we continue the conversation with the City of Boston to apply our tools and approaches in some of the city's most vulnerable neighborhoods.

During initial design sessions, we realized that the platform needed to be refactored, which is currently underway. Lessons learned from preliminary community trials confirm the need for this pathway.

We held a clinic at the CSDMS 2023 Annual Meeting with earth scientists and modelers to gauge expert user experience with such tools. We have started crafting the detailed assessment instruments for this project, based on the preliminary trials. The lessons learned from preliminary trials with expert and novice model users are currently being derived and informing the revisions/refactoring underway.

Relative to our plan of work, we are on schedule; relative to the metrics for the activity, we have held the planned test session for Year 1, and have already held one workshop (originally scheduled for Year 2).

3.1.4 High-performance and cloud computing

CSDMS owns compute nodes in the Blanca condo cluster maintained by the Rocky Mountain Advanced Computing Consortium (RMACC). While the CSDMS nodes on Blanca are nearing the end of their service plan, we continue to help CSDMS members access them with credentials from the NSF-sponsored ACCESS-CI program. As of the end of May 2023, there were 71 CSDMS community-member users of Blanca, which exceeds our aspirational target of 8.

3.1.5 Demonstration project in hydrodynamics, sediment, carbon, and biota

In Year 1, a coastal ocean Data Component for the Regional Ocean Modeling Sytsem (ROMS) was implemented, as described in Section 3.1.2. This Data Component uses standardized routines to read in model output from ROMS and it can be easily coupled with models that are exposed with BMI for Earth Surface Processes modeling. The Data Component is being tested and integrated into a Landlab component that simulates sediment dispersal on the Beaufort Sea shelf. This landlab component will serve as a demonstration project for the ROMS Data Component. (No formal metrics were defined for this activity, but it is on schedule.)

3.2 Cyberinfrastructure Year 1 costs and projections

Actual and projected Cyberinfrastructure expenditures for Year 1 are about 16.6% lower than budgeted (Table 3). The difference primarily reflects two factors: (1) the departure of a staff member (a postdoctoral scientist) in mid-year, and (2) an earlier-than-anticipated project start date. The staff member left CU Boulder to start a faculty position in Europe in February 2023. Although this staff loss did not prevent the team from hitting its main Cyberinfrastructure targets in Year 1, it slowed down progress in areas like the development and testing of new Landlab components, preparation of tutorial notebooks, and general maintenance.

The other main reason for the difference between budgeted and actual expenditures is that the September 1, 2022 start date led to some overlap with the completion of activities from the prior facility award. In addition, the planned recruitment of a graduate student at Northeastern University has been deferred to project Year 2, to align with the academic year cycle.

3.3 Cyberinfrastructure Year 2 plans

3.3.1 Next-generation code repositories

In Year 2, we will identify new repositories as potential targets for upgrading to become part of our next-generation collection of repositories. We will also begin to look to automation

to more easily maintain these upgrades as standards change and advance.

3.3.2 CSDMS Workbench

We will implement new data components for widely used datasets by the community. We will provide documentation for how to implement the Data Component and encourage the community to contribute new Data Components.

In the coming year, we will continue to bring the coupling tools of *PyMT* into *Landlab* framework, including testing, documentation, and example notebooks of the new utilities. We will also begin to bring the components of *PyMT* into *Landlab* by providing a BMI-to-Landlab bridge.

3.3.3 Participatory modeling

The Northeastern University team will perform the first stage in refactoring the fora.ai platform. In parallel, the CSDMS Integration Facility team will set up a prototype server with a model of overland flow hydrodynamics, and use it to test the interface communication between fora.ai and the CSDMS server. We will hold a user-test workshop with the coupled fora.ai-CSDMS technology.

3.3.4 High-performance and cloud computing

We will continue to help community members obtain ACCESS-CI credentials and broker access to RMACC supercomputing resources in Year 2 of the project.

3.3.5 Demonstration project in hydrodynamics, sediment, carbon, and biota

In Year 2, we will finalize the implementation of the demonstration project for the ROMS Data Component and provide associated documentation.

3.4 Justification for requested budget for Year 2 Cyberinfrastructure activities

The revised Year 2 budget request is 0.2% higher than the original Year 2 budget (Table 5). This is in addition to a requested carry-over of unexpended Cyberinfrastructure Year 1 funds to Year 2. Carry-over funds will be used to support catch-up activities related to the Cyberinfrastructure activity, such as deferred software mainenance.

4 Governance, Management, and Operations

This major activity area includes working with the CSDMS governing bodies (the Executive and Steering Committees), handling day-to-day Integration Facility operations, and performing ongoing maintenance of CSDMS technology.

4.1 Year 1 activities and accomplishments

4.1.1 Governance

In Year 1, the CSDMS Executive Committee met for a 4-hour meeting on Friday, October 21st, 2022, and again for a 2-hour meeting on Friday, May 19th, 2023. During Year 1, two new Working Group co-chairs were elected: Prof. Andrew Wickert of the University of Minnesota as co-chair of the Terrestrial Working Group, and Prof. Alejandra Ortiz of Colby College as co-chair of the Coastal Working Group. In consultation with CUAHSI, Dr. Anthony Castronova of CUAHSI was appointed as chair of the Hydrology Focus Research Group. In consultation with the International Soil Modeling Consortium (ISMC), Dr. Sagar Gautam of Sandia National Labs was appointed as chair of the Critical Zone Focus Research Group. In consultation with Cyberinfrastructure In Geodynamics (CIG), Prof. Wolfgang Bangerth of Colorado State University was appointed co-chair of the Geodynamics Focus Research Group, and Prof. Mark Behn of Boston College and WHOI agreed to extend his term as co-chair. In consultation with the International Society for Ecological Modeling (ISEM), Dr. Todd Swannock and Dr. Candice Piercy, both of the US Army Corps of Engineers, were appointed co-chairs of the Ecosystem Dynamics Focus Research Group.

Prof. Paola Passalacqua of the University of Texas at Austin was elected as Steering Committee chair in October 2022. The CSDMS Steering Committee held its 2022 annual meeting on Friday, October 28, 2022 (by videoconference, the original in-person meeting having been postponed from May due to weather). The Steering Committee held its 2023 annual meeting in Boulder, CO, on Friday, May 19th, 2023, immediately following the CSDMS Annual Meeting.

The diversity metrics for the Executive and Steering Committees are intended to measure the degree to which the demographics of these leadership bodies are similar to those of the community they represent, which provides an indicator of inclusivity. The combined membership of the Executive and Steering Committees (excluding ex-offio members and Integration Facility staff representatives) numbers 26 people. The female:male gender ratio of 1:1.6 falls somewhere between our basic target of AGU's 1:2 ratio and our aspirational target of parity. Although the numbers are quite small for a meaningful statistical comparison of ethnic/racial demographics, we can at least observe that the fraction of the EC-SC membership that identifies as white non-hispanic (69%) is roughly similar to US proportion (76% according to the US 2020 Census), given the uncertainty inherent to the statistics of small numbers.

4.1.2 Management

We performed day-to-day management of the project. This activity area included, among other things, conducting weekly project-team meetings, holding quarterly project review and planning meetings, communicating with the community through email newsletters and periodic social media posts, and corresponding with various stakeholder constituencies. In fall 2022, in consultation with the Executive and Steering Committees, we prepared the Project Management, Engagement, and Sustainability Plan (PMESP).

4.1.3 Operations and maintenance

In Year 1, CSDMS RSEs maintained and improved the CSDMS Ivy course material used in ESPIn and the Roadshows. We updated the permamodel project, including adding a new version of the Ku model. We maintained the pymt, babelizer, bmi-topography, Landlab, and PRMS projects, mainly keeping their packaging and distributions up to date, ensuring that they work with the latest Python versions. We also assisted community members in addressing posted issues and reviewing pull requests.

4.1.4 Metrics dashboard

For the first year, we have identified key metrics and an additional set of desired metrics to include in the Community Metrics Dashboard. This dashboard is part of the CSDMS web portal, and is currently developed to provide transparency and accountability, for anyone who is interested in tracking project performance. Key metrics include but are not limited to (a) Community Engagement metrics such as CSDMS membership, ESPIn summer school enrollment, Roadshows, Annual Meeting attendance, JEDI metrics (gender and demographics), RSEaaS, and Epubs; and (b) Cyberinfrastructure metrics such as models launched through the website, number of NextGen code repositories, enhancements to the Workbench, and number of users of our hardware resources (cloud computing and HPCC).

4.2 Year 1 costs and projections

Actual and projected Year 1 expenditures on the Governance, Management, and Operations activity area are about 18.8% lower than budgeted (Table 3). Much of the difference reflects a temporary reduction in digital resource maintenance (and consequent accumulation of "technical debt") following the departure of a staff member. Part also reflects the need to devote some staff time toward wrapping up CSDMS 3.0 activities during the project year.

4.3 Justification for requested budget for Year 2 activities

The requested Year 2 budget for Governance, Management, and Operations is about 4.7% less than the original Year 2 budget request (Table 5). This is largely due to a change in the need for computing equipment for Integration Facility staff; because most staff members are currently working with up-to-date equipment, there will not be a need for equipment replacement in Year 2. In addition to the requested Year 2 budget, we also request a carry-over of unexpended funds in the Governance, Management, and Operations activity area from Year 1 to Year 2.

5 Overview of Year 1 budget and expenditures by Form 1030 categories

This section reviews the Year 1 budget and actual (projected) expenditures according to the high-level Form 1030 categories of (1) salary and benefits, (2) travel, (3) participant support, and (4) other direct costs.

5.1 Salary and benefits

The projected total expenditure on salary and benefits for Year 1 is about 13% less than budgeted (Table 6). Most of the difference reflects the departure of one of the Integration Facility staff members in February 2023, when a postdoctoral research scientist left the University of Colorado to take up a faculty position in Europe. Another staff member was able to pick up some but not all of the work in Year 1. Rather than hiring another postdoctoral associate, we request to carry this budget item forward to Years 2 and 3 to support additional work by other members of Integration Facility staff. This approach is more efficient because it recognizes the value of skilled and increasingly experienced staff members, and avoids the additional expense of a search process. The only disadvantage is that it will likely delay some of the planned cyberinfrastructure work from Year 2 to Year 3, but we do not anticipate this delay having a major impact on overall project objectives.

Category	Year 1 budget	Year 1 actual	% Difference
Salary and benefits	$667,232	$581,040	-12.9%
Travel	$67,813	$52,372	-22.3%
Participant support	$100,400	$99,218	-1.2%
Other direct costs	$84,258	$70,266	-16.6%
Indirect costs	$455,852	$395,598	-13.2%
Total	$1,375,555	$1,198,494	-12.9%

Table 6: Summary of Year 1 budget and expenditures by NSF Form 1030 categories.

For Northeastern University, it was also necessary to shift the recruiting of a graduate student to Year 2 in order to align with the academic calendar.

We request to carry over unexpended Year 1 salary and benefit category funds to Year 2.

5.2 Travel

Projected travel expenditure for Year 1 will be about 22% lower than budgeted (Table 6). As noted in Section 2.2, Integration Facility conference travel had already been planned out by the time this award began, so some of the travel funds for this project were not used. There was also a cost saving on travel for the Executive and Steering Committees. We request to carry over these funds to Year 2 to cover the anticipated higher travel costs associated with the planned out-of-state annual meeting.

5.3 Participant support

Projected Year 1 expenditure on Participant Support is within 1.2% of the budgeted amount (expenditure of $99,218 against budget of $100,400). We request to carry over the small remainder to Year 2.

5.4 Other direct costs

Projected Year 1 expenditure on the "Other Direct Costs" Form 1030 is about 17% lower than budgeted. Most of the difference reflects unspent tuition remission for a graduate student. We request carry-over of Other Direct Cost funds to Year 2, which will enable support for student tuition in Year 2.

A List of relevant presentations and publications by team members

A.1 Peer-reviewed publications

Barton, M., Lee, A., Janssen, M., van der Leeuw, S., Tucker, G., Porter, C., Greenburg, J., Swantek, L., Frank, K., Chen, M. and Jagers, A. (2022, August) How to make models more useful. Proceedings of the National Academy of Sciences, V119, i35. https://doi.org/10.1073/pnas.2202112119

Litwin, D., Tucker, G., Barnhart, K. and Harman, C. (2023) Catchment coevolution and the geomorphic origins of variable source area hydrology. Water Resources Research, manuscript submitted 02/2023.

Nienhuis, J. H., et al. (2022) Global-scale human impact on delta morphology has led to net land area gain 2020). Nature, 608.7921 (vol 577, 514, E13-E13. https://doi.org/10.1038/s41586-019-1905-9

Nienhuis, J.H., Ashton, A.D., Edmonds, D.A. et al. Author Correction: Global-scale human impact on delta morphology has led to net land area gain. Nature 608, E13 (2022). https://doi.org/10.1038/s41586-022-05079-0

Nienhuis, J., Ashton, A., Edmonds, D., Hoitink, A., Kettner, A., Rowland, J. and Tornqvist, T. (2023, February) Reply to: Concerns about data linking delta gain to human action. Nature, V614, i7947. https://doi.org/10.1038/s41586-019-1905-9

Xu, K., Chen, M., Kettner, A., Barton, M., Croke, B., Jakeman, A., Ames, D., Wang, H., Cuddy, S., Yue, S., Wen, Y., Zhang, Y. and Lu, G. (2022, December) A new academic impact metric for evaluating geographic simulation models. International Journal of Digital Earth, V15, i1. https://doi.org/10.1080/17538947.2022.2138589

A.2 Publications in preparation or review

Gan, T., Tucker, G.E., Hutton, E.W.H., Piper, M.D., Overeem, O., Kettenr, A.J., Campforts, B., Moriarty, J.M., Undzis, B., Pierce, E., and McCready, L. (2023) CSDMS Data Components: data-model integration for earth surface processes modeling. Geoscientific Model Development (in preparation, to be submitted June 2023)

A.3 Conference presentations

Aranguiz, T., Duvall, A., Tucker, G. and Campforts, B. (2022, December) Impact of the Frequency and Intensity of Wet Periods in a Laterally Advected Landscape under Hyper-arid Conditions. Paper presented at American Geophysical Union Fall Meeting.

Campforts, B., Duvall, A., Shobe, C., Tucker, G., and Overeem, I.: Are spatial and temporal patterns of landslide triggering events reflected in topography and sediment dynamics? EGU General Assembly 2023, Vienna, Austria, 24—28 Apr 2023, EGU23-3684, https://doi.org/10.5194/egusphere-egu23-3684.

Campforts, B., Shobe, C., Overeem, I. and Tucker, G. (2022, August) The art of landslides: How stochastic mass wasting shapes topography and influences landscape dynamics. Journal of Geophysical Research: Earth Science, V 127, i8. https://doi.org/10.1029/2022JF006745

Carlson, B., Overeem, I., Pierce, E., Moodie, A. and Lintern, G. (2022, December) Linking Subaerial and Subaqueous Channel Dynamics in Fluvioglacial Fjord Deltas. Paper presented at American Geophysical Union Fall Meeting.

Gan, T., Tucker, G., Hutton, E., Piper, M., Overeem, O. and Campforts, B. (2022, December) CSDMS Data Components: Data-model Integration for Earth Surface Processes Modeling. Paper presented at American Geophysical Union Fall Meeting.

Hut, R., Aerts, J., Wiersma, P., Hoogelander, V., van de Giesen, N., Drost, N., Kalverla, P., van Werkhoven, B., Verhoeven, S., Alidoost, F., Hutton, E., Vreede, B., and Liu, Y.: The eWaterCycle platform for open and FAIR hydrological collaboration, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-5702, https://doi.org/10.5194/egusphere-egu23-5702.

Hutton, E. and Tucker, G.: Landlab: a modeling platform that promotes the building of FAIR research software, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-12443, https://doi.org/10.5194/egusphere-egu23-12443.

Hutton, E., Steckler, M. and Tucker, G. (2022, December) Taking the Land Out of Landlab: Building a Marine Sequence-Stratigraphic Model Using Landlab. Paper presented at American Geophysical Union Fall Meeting.

Kettner, A., Tucker, G., Overeem, O., Gan, T., Hutton, E. and Piper, M. (2022, December) Overcoming challenges in adopting FAIR principals for community open-source software. Paper presented at American Geophysical Union Fall Meeting.

Li, D., Xixi, L., Overeem, I., Walling, D., Syvitski, J., Kettner, A., Bookhagen, B. and Zhang, T. (2022, December) Warmer and muddier rivers in High Mountain Asia. Paper presented at American Geophysical Union Fall Meeting.

Litwin, D., Tucker, G., Barnhart, K. and Harman, C. (2022, December) DupuitLEM and the Search for Fundamental Insights into the Coevolution of Landscape Hydrology and Geomorphology. Paper presented at American Geophysical Union Fall Meeting.

Litwin, D., Tucker, G., Barnhart, K. and Harman, C. (2022, December) The Geomorphic Origins of Variable Source Area Hydrology. Paper presented at American Geophysical Union Fall Meeting.

Nienhuis, J., Ashton, A., Hoitink, T., Kettner, A., Rowland, J. and Tornqvist, T. (2022, December) Why do some rivers build deltas and others don't? Paper presented at American Geophysical Union Fall Meeting.

Piper, M., Hutton, E. and Tucker, G. (2022, December) The (Bright) Future of the Basic Model Interface (BMI). Paper presented at American Geophysical Union Fall Meeting.

Rossi, M.W., Tucker, G.E., Anderson, R.S., and Anderson, S.P. (2022, December) Linking forest dynamics to soil production and hillslope denudation using numerical modeling and high-resolution mapping. Paper presented at American Geophysical Union Fall Meeting.

Shmilovitz, Y., Rossi, M., Tucker, G., Campforts, B., Pederson, J., Morin, E., Armon, M., Enzel, Y., and Haviv, I.: Simulating dryland cliffs evolution in response to extreme rainstorms, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-9185, https://doi.org/10.5194/egusphere-egu23-9185.

Tucker, G., Hutton, E., Piper, M., Kettner, A., Overeem, I., Gan, T. and Campforts, B. (2022, December) OpenEarthscape and CSDMS: Modeling Resources by and for the Earth and Planetary Surface Processes Community. Paper presented at American Geophysical Union Fall Meeting.

Tucker, G and Gabel, V. (2022, December) River and Rocks: Integrating Channel Adjustment, Gravel Attrition, and Bedrock Wear in a Model of River Long-profile Evolution. Paper presented at American Geophysical Union Fall Meeting.

Tucker, G.E., Gabel, V., and Campforts, B. (2023, January) Exploring the implications of equilibrium channel geometry for long-term landscape evolution. Invited keynote lecture at Gravel Bed Rivers: Processes, resilience and management in a changing environment, Villarrica, Chile.

Tucker, G., Kettner, A., Hutton, E., Piper, M., Gan, T., Campforts, B., Overeem, I., and Rossi, M.: Lessons in FAIR software from the Community Surface Dynamics Modeling System, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-3711, https://doi.org/10.5194/egusphere-egu23-3711.

Undzis, B., and Moriarty, J. (2023, May) Variability in Bed Shear Stresses and Resuspension on the Alaskan Beaufort Sea Shelf: A Numerical Modeling Study. Poster presented at CSDMS 2023 Annual Meeting, Boulder, CO.

Wu, H., Ward, P., Kettner, A. and Cohen, S. (2022, December) Global Floods: Forecasting, Monitoring, Risk Assessment, and Socioeconomic Responses III Oral. Paper presented at American Geophysical Union Fall Meeting.

Zhang, T., Li, D., Kettner, A., and Lu, X.: Simulating climate-cryosphere-driven sediment transport dynamics in cold regions by Sediment-Availability-Transport Model, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-1499, https://doi.org/10.5194/egusphere-egu23-1499.

B List of community publications using CSDMS products and services

B.1 Using BMI

Velásquez, N.; Vélez, J.I.; Álvarez-Villa, O.D.; Salamanca, S.P. Comprehensive Analysis of Hydrological Processes in a Programmable Environment: The Watershed Modeling Framework. Hydrology 2023, 10, 76. https://doi.org/10.3390/hydrology10040076.

Van Westen, B., Leijnse, T., De Schipper, M., Cohn, N. and Luijendijk, A. (2023) Integrated Modeling of Coastal Landforms. The Proceedings of Coastal Sediments 2023, 760-771. https://doi.org/10.1142/9789811275135_0071.

Zhu, L., Chen, Q., Cohn, N., Johnson, C. and Johnson, B. (2023) Modeling Long-term Evolution of a Beach-Dune System: Caminada Headlands, Louisiana. The Proceedings of Coastal Sediments 2023, 782-796. https://doi.org/10.1142/9789811275135_0073.

Hallouin, T., Ellis, R., Clark, D., Dadsin, S., Hughes, A., Lawrence, B., Lister, G. and Polcher, J. (2022) UniFHy v0.1.1: a community modeling framework for the terrestrial water cycle in Python. Geoscientific Model Development, 15, 24, https://doi.org/10.5194/gmd-15-9177-2022.

Guillaumot, L., Smilovic, M., Burek, P., de Bruijn, J., Greve, P., Kahil, T. and Wada, Y. Coupling a large-scale hydrological model (CWatM v1. 1) with a high-resolution groundwater flow model (MODFLOW 6) to assess the impact of irrigation at regional scale. Geoscientific Model Development, 15, 18, https://doi.org/10.5194/gmd-15-7099-2022.

Aerts, J., Hut, R., van de Giesen, N., Drost, N., van Verseveld, J., Weerts, A. and Hazeburg, P. (2022) Large-sample assessment of varying spatial resolution on the streamflow estimates of the wflow_sbm hydrological model. Hydrology and Earth System Sciences, 26, 16. https://doi.org/10.5194/hess-26-4407-2022

Verseveld, W., Weerts, A., Visser, M., Buitink, J., Imhoff, R., Boisgontier, H., Bouaziz, L., Eilander, D., Hegnauer, M., ten Velden, C., and Russell, B. (2022) Wflow_sbm v0.6.1, a spatially distributed hydrologic model: from global data to local applications. Geoscientific Model Development (preprint), https://doi.org/10.5194/gmd-2022-182.

(ABSTRACT) Sheshadrivasan, V., and Langhammer, J. Performance assessment and Benchmarking of a conceptually coupled groundwater - surface-water model, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-6432, https://doi.org/10.5194/egusphere-egu23-6432,2023.

B.2 Using Landlab

(ABSTRACT) Mohr, C., Dietz, M., Tolorza, V., Gonzalez, E., Sotomayor, B., Iroume, A., Gilfert, S. and Tautz, F. (2023, April) Ideas and Perspectives: Sensing Energy and Matter fluxes in a biota dominated Patagonian landscape through environmental seismology - Introducing the Pumalin Critical Zone Observatory. EGUsphere (preprint). https://doi.org/10.5194/egusphere-2023-789

Fiolleau, S., Uhlemann, S., Falco, N., and Dafflon, B. (2023). Assessing probability of failure of urban landslides through rapid characterization of soil properties and vegetation distribution. Geomorphology, 423, 108560, https://doi.org/10.1016/j.geomorph.2022.108560.

Rosier, I., Diels, J., Somers, B., and Van Orshoven, J. (2023). The impact of vegetated landscape elements on runoff in a small agricultural watershed: A modelling study. Journal of Hydrology, 129144, https://doi.org/10.1016/j.jhydrol.2023.129144.

Cardenas, B. T., Lamb, M. P., and Grotzinger, J. P. (2022). Martian landscapes of fluvial ridges carved from ancient sedimentary basin fill. Nature Geoscience, 1–7. https://www.nature.com/articles/s41561-022-01058-2.

Cullen, C., Anders, A. M., Lai, J., and Druhan, J. L. (2022). Numerical modeling of groundwater-driven stream network evolution in low-relief post-glacial landscapes. Earth Surface Processes and Landforms, 47(2), 658-671, https://doi.org/10.1002/esp.5278.

Maneerat, P., Bürgmann, R., and Betka, P. M. (2022). Thrust Sequence in the Western Fold-and-Thrust Belt of the Indo-Burma Range Determined from Fluvial Profile Analysis and Dynamic Landform Modeling. Tectonophysics, 845, 229638, https://doi.org/10.1016/j.tecto.2022.229638.

Zhao, H., Lin, Y., Zhou, J., Delang, C. O., and He, H. (2022). Simulation of Holocene soil erosion and sediment deposition processes in the Yellow River basin during the Holocene. Catena, 219, 106600, https://doi.org/10.1016/j.catena.2022.106600.

Kim, D., Weber, J., Seong, Y., Reminga-De Young, K. and Yu, B. (2023). Late Quaternary-Recent intraplate topographic uplift of the St. Francois Mountains (Ozark Plateau), Missouri (USA), driven by differential density and erosion. Geology, 51, 4, https://doi.org/10.1130/G50585.1.

(ABSTRACT) Aranguiz, T., and Duvall, A. (2023, May) Comparing numerical simulations and field studies of strike-slip faults from the hyper-arid Atacama Desert to Tararua Mountains, New Zealand. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

(ABSTRACT) Foxfoot, I., Piercy, C., and Swannack, T. (2023, May) Using Landlab and Mesa to Simulate Oyster Ecohydraulic Feedbacks. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

(ABSTRACT) Guirro, M., Hodge, R., Clubb, F., and Turnbull-Lloyd, L.: Exploring controls on the spatial distribution of bedrock exposure in a mixed bedrock-alluvial river system, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-9835, https://doi.org/10.5194/egusphere-egu23-9835,2023.

(ABSTRACT) Istanbulluoglu, E., and Nudurupati, S.S. (2023, May) Transient ecosystem response to climatic variability since the late Pleistocene in central New Mexico modeled with Landlab. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

(ABSTRACT) Langston, A. (2023, May) Modeling the development of wide bedrock valleys as a function of collapsed bedrock block size, bed sediment, and discharge variability. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

(ABSTRACT) Long-Reid, A., and Pfeiffer, A. (2023, May) Simulated river channel response to a coarse sediment pulse with and without bed material abrasion. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

(ABSTRACT) Robertson, C. (2023, May) Evaluating the Impact of Talus Piles on the Evolution of Wide Bedrock River Valleys. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

(ABSTRACT) Russ, E., Piercy, C., Carillo, C., and Swannack, T. (2023, May) GenVeg: development of an individual-based plant population dynamics model for Landlab. Paper presented at CSDMS Annual Meeting, Boulder, Colorado.

B.3 Using Other CSDMS Products and Services

Rowland, S.M., Korolev, S., Hagadorn, J.W., and Ghosh, K., 2023, Frenchman Mountain Dolo stone: A new formation of the Cambrian Tonto Group, Grand Canyon and Basin and Range, USA: Geosphere, v. 19, no. X, p. 1– 29, https://doi.org/10.1130/GES02514.1.

Valentine, K., Herbert, E.R., Walters, D.C. et al. Climate-driven tradeoffs between landscape connectivity and the maintenance of the coastal carbon sink. Nat Commun 14, 1137 (2023). https://doi.org/10.1038/s41467-023-36803-7

Wild, A.L.; Kwoll, E.; Lintern, D.G.; Fargey, S. (2023). Fluvial Response to Climate Change in the Pacific Northwest: Skeena River Discharge and Sediment Yield. Water, 15, 167. https://doi.org/10.3390/w15010167

Córdova P, Flores RP. Hydrodynamic and Particle Drift Modeling as a Support System for Maritime Search and Rescue (SAR) Emergencies: Application to the C-212 Aircraft Accident on 2 September, 2011, in the Juan Fernández Archipelago, Chile. Journal of Marine Science and Engineering. 2022; 10(11):1649. https://doi.org/10.3390/jmse10111649

Kim, H., Kang, H. and Zhang, C. (2022). Ecosystem-based fisheries risk assessment and forecasting considering a spatio-temporal component in Korean waters. Ocean and Coastal Management, 230. https://doi.org/10.1016/j.ocecoaman.2022.106356

Xu, Z., Hariharan, J., Passalacqua, P., Steel, E., Chadwick, A., Paola, C., Paldor, A. and Michael, H. (2022). Effects of Geologic Setting on Contaminant Transport in Deltaic Aquifers. Water Resources Research, 58, 9. https://doi.org/10.1029/2022WR031943