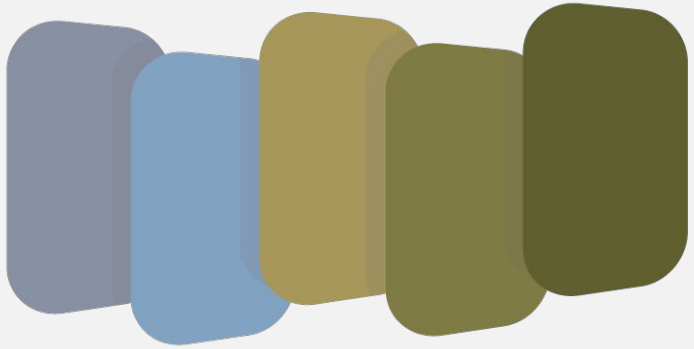


CSDMS

community surface
dynamics modeling system

# **Changing landscapes and seascapes:** modeling for discovery, decision making, and communication

Greg Tucker, CSDMS Executive Director

CSDMS Annual (virtual) Meeting,
May 2021

CSDMS*
community surface dynamics modeling system

NSF

# CSDMS supports computational modeling in earth-surface science by engaging ***community***, providing ***computing*** resources, and promoting ***education***

Earth-surface processes

*share resources, collaborate*

**COMMUNITY**
SUPPORT

*create, run, test, analyze, and apply models*

**COMPUTING**
RESOURCES

*learn and teach*

**EDUCATION**
OPPORTUNITIES

2,075 members
75 countries
several hundred institutions


Integration Facility at
University of Colorado Boulder

*(*pronounced "systems")*

***https://csdms.colorado.edu***

# Working & Focus Research Groups

## TERRESTRIAL


Nicole Gasparini & Leslie Hsu

## COASTAL


Andrew Ashton & Talea Mayo

## MARINE


Julia Moriarty & Mike Steckler

## EDUCATION (EKT)

Kehui (Kevin) Xu

## CYBER & NUMERICS


Olaf David & Scott Peckham

## HYDROLOGY


Christina Bandaragoda & Venkat Lakshmi

## CARBONATES & BIOGENICS


Chris Jenkins & Peter Burgess

## CHESAPEAKE

Raleigh Hood

## GEODYNAMICS


Phaedra Upton & Mark Behn

## CRITICAL ZONE


Lejo Flores & Michael Young

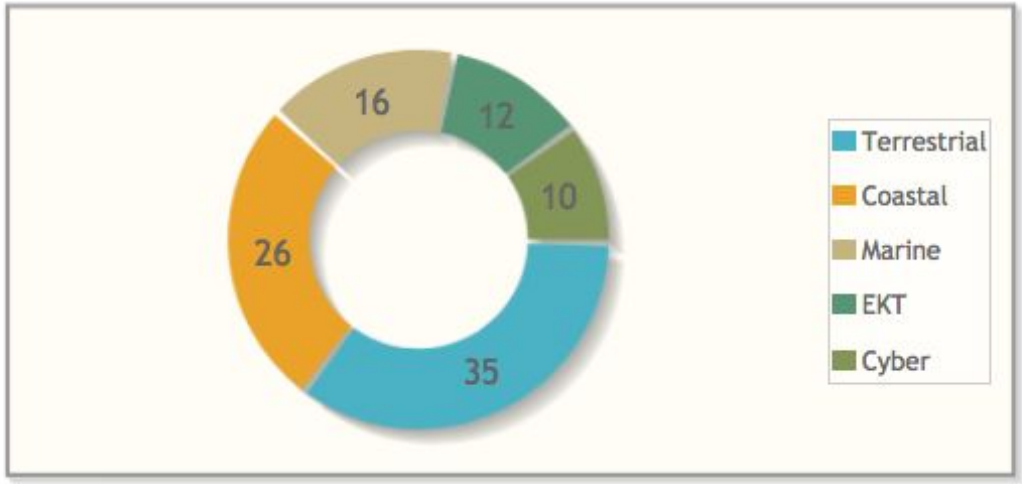
## HUMAN DIMENSIONS


Moira Zellner & Derek Robinson

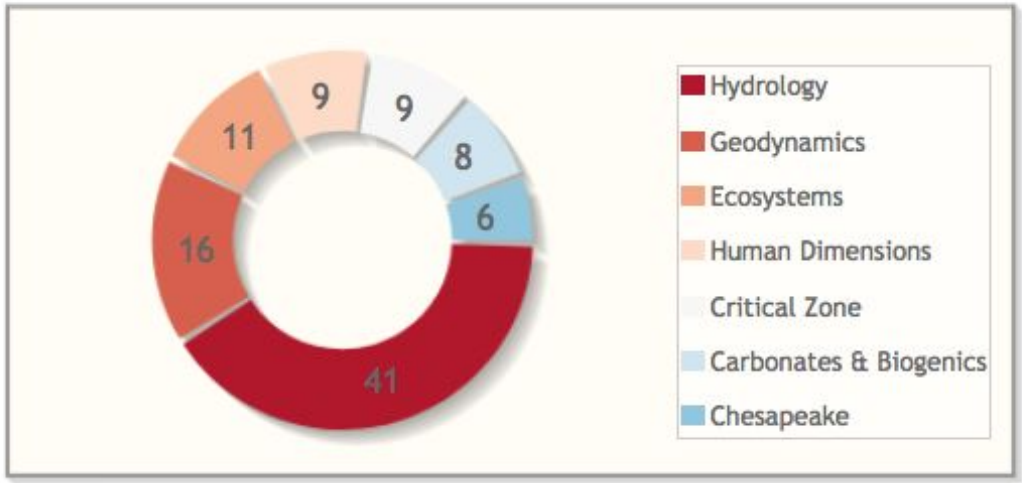
## ECOSYSTEM DYNAMICS


Brian Fath & Kim De Mutsert

## Working Groups members (%)




## Focus Research Groups members (%)



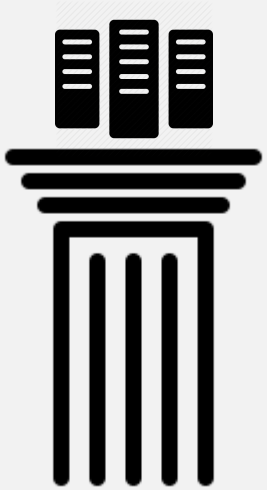
CSDMS
community surface dynamics modeling system

CSDMS supports computational modeling in earth-surface science by engaging ***community***, providing ***computing*** resources, and promoting ***education***

*share resources, collaborate*

**COMMUNITY**
SUPPORT

*create, run, test, analyze, and apply models*

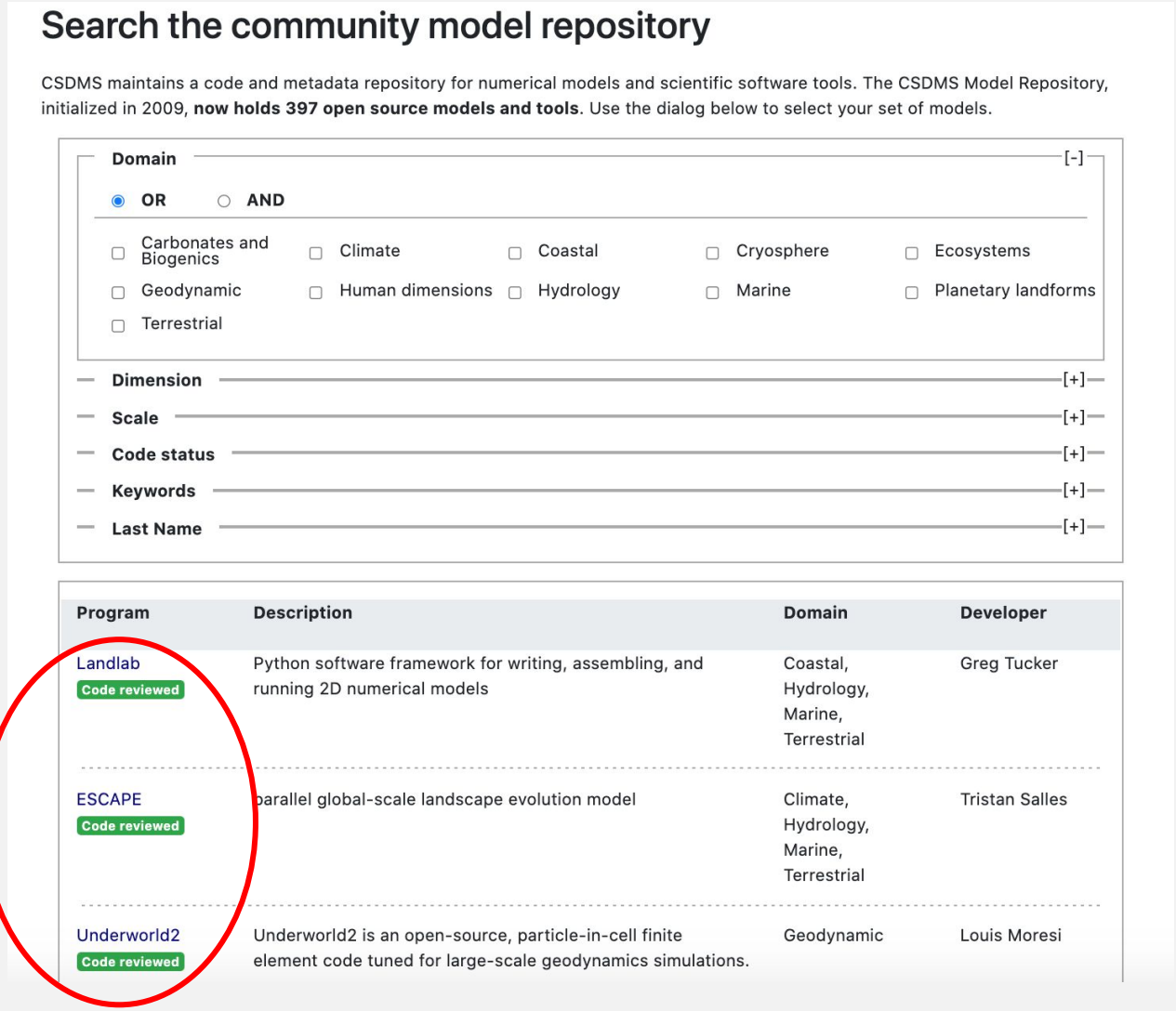


**COMPUTING**
RESOURCES

*learn and teach*

**EDUCATION**
OPPORTUNITIES

# Model Repository: new capabilities



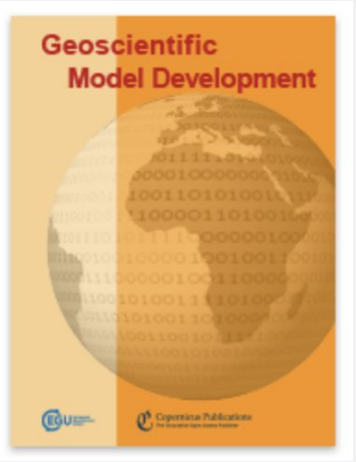

- New **dynamic search**
- **Dynamic, live – on the fly – filtering of models** based on user-selectable criteria
- **Why:** nearly **400** community contributed model and tool descriptions
- Includes peer **Code Reviewed** indicator

# How to get your code peer-reviewed

- Submit for publication in a software review journal
  - Ex: **Journal of Open Source Software**, **Journal of Open Research Software**
- Get a code peer-review and “badge”
  - Ex: **COMSESnet**, **pyOpenSci**, **ROpenSci**
- Submit for publication a (written) paper about your software
  - Ex: **Geoscientific Model Development**, **Computers & Geosciences**, **Environmental Modelling & Software**



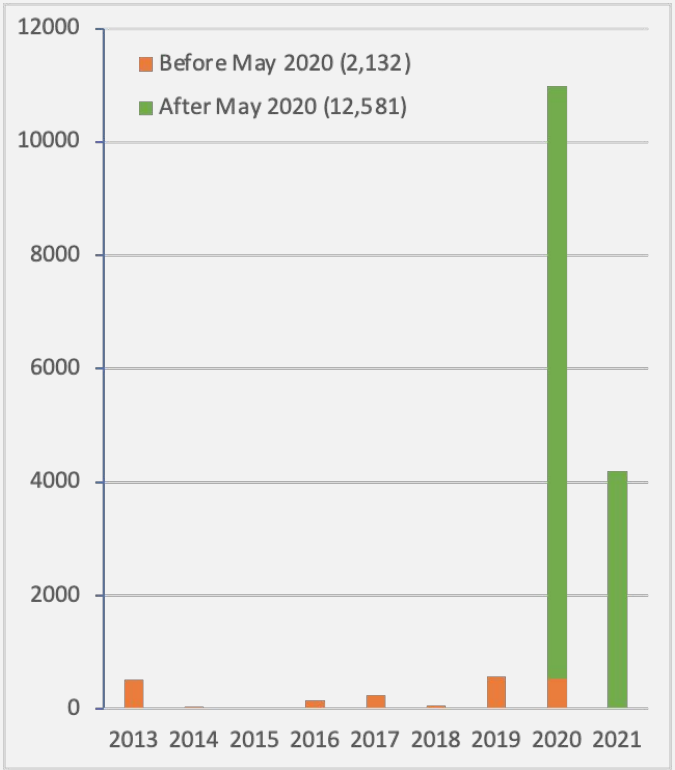


# Model Repository: new capabilities

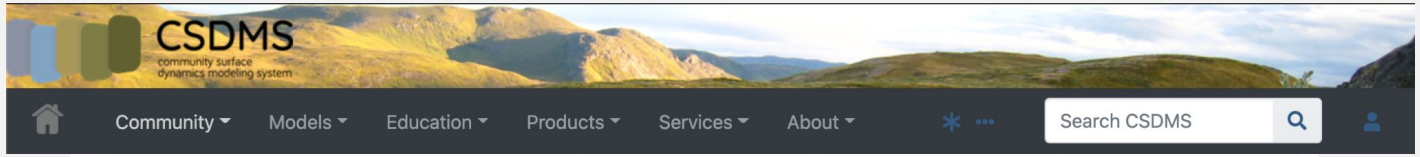
**For each model:**

- Comprehensive list of publications
- Model h-index
- Annual publications
- Annual citations




**How:**

Automated publication search for 141 of the 397 models based on keywords, resulted in a total of **14641 model references**




| Model | Nr. of pubs | Citations | H-index |
|---|---|---|---|
| WRF | 1184 | 77925 | 117 |
| SWAT | 1140 | 67645 | 108 |
| VIC | 587 | 26608 | 77 |
| TOPMODEL | 529 | 23876 | 77 |
| MODFLOW | 1018 | 29707 | 68 |
| ApsimX | 832 | 23680 | 68 |
| SWAN | 899 | 20381 | 62 |
| OpenFOAM | 1016 | 20507 | 56 |
| Ecopath with Ecosim | 362 | 11910 | 53 |
| ROMS | 441 | 14082 | 50 |
| WAVEWATCH III ^TM | 558 | 9117 | 48 |
| HBV | 239 | 7448 | 44 |
| SICOPOLIS | 134 | 5683 | 43 |
| Princeton Ocean Model (POM) | 350 | 9218 | 41 |
| ADCIRC | 411 | 6504 | 39 |
| Delft3D | 663 | 7818 | 39 |
| LISFLOOD | 147 | 5076 | 37 |
| RHESSys | 125 | 4801 | 36 |

CSDMS
community surface dynamics modeling system

Community | Models | Education | Products | Services | About | Search CSDMS

# References WRF

| Publication(s) | Year | Type | Cited |
|---|---|---|---|
| Feng, Jin-Ming; Wang, Yong-Li; Ma, Zhu-Guo; Liu, Yong-He; 2012. Simulating the Regional Impacts of Urbanization and Anthropogenic Heat Release on Climate across China. Journal of Climate, 25, 7187–7203. 10.1175/JCLI-D-11-00333.1 (View/edit entry) | 2012 | Model application | 104 |
| Klemp, J. B.; Skamarock, W. C.; Dudhia, J.; 2007. Conservative Split-Explicit Time Integration Methods for the Compressible Nonhydrostatic Equations. Monthly Weather Review, 135, 2897–2913. 10.1175/MWR3440.1 (View/edit entry) | 2007 | Model overview | 211 |
| Skamarock, William C.; Klemp, Joseph B.; 2008. A time-split nonhydrostatic atmospheric model for weather research and forecasting applications. Journal of Computational Physics, 227, 3465–3485. 10.1016/j.jcp.2007.01.037 (View/edit entry) | 2008 | Model overview | 1283 |
| Skamarock, William C.; 2006. Positive-Definite and Monotonic Limiters for Unrestricted-Time-Step Transport Schemes. Monthly Weather Review, 134, 2241–2250. 10.1175/MWR3170.1 (View/edit entry) | 2006 | Model overview | 67 |
| Skamarock, W.C.; Klemp, J. B.; Dudhia, J.; Gill, D.O.; Barker, D.M.; Wang, W.; Powers, J.G.; 2005. A description of the Advanced Research WRF Version 2.. NCAR Tech Notes-468+STR.. (View/edit entry) | 2005 | Model overview | 1532 |
| Skamarock, William C.; 2004. Evaluating Mesoscale NWP Models Using Kinetic Energy Spectra. Monthly Weather Review, 132, 3019–3032. 10.1175/MWR2830.1 (View/edit entry) | 2004 | Model overview | 656 |
| Wicker, Louis J.; Skamarock, William C.; 2002. Time-Splitting Methods for Elastic Models Using Forward Time Schemes. Monthly Weather Review, 130, 2088–2097. <2088:TSMFEM>2.0.CO;2 10.1175/1520-0493(2002)130<2088:TSMFEM>2.0.CO;2 (View/edit entry) | 2002 | Model overview | 610 |
| Done, James; Davis, Christopher A.; Weisman, Morris; 2004. The next generation of NWP: explicit forecasts of convection using the weather research and forecasting (WRF) model. Atmospheric Science Letters, 5, 110–117. 10.1002/asl.72 (View/edit entry) | 2004 | Model application | 330 |
| Wyszogrodzki, Andrzej A.; Liu, Yubao; Jacobs, Neil; Childs, Peter; Zhang, Yongxin; Roux, Gregory; Warner, Thomas T.; 2013. Analysis of the surface temperature and wind forecast errors of | 2013 | Model application | 26 |

**References are automatically added**

*Our search algorithms might occasionally miss, or accidentally include a reference. If so, feel free add a missing reference by using the buttons below, or notify csdmsweb@colorado.edu*

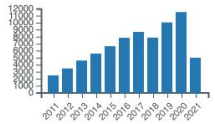
**Add references**

Use a DOI

Manually

**Citations**

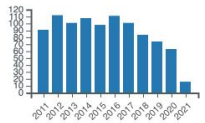
View all



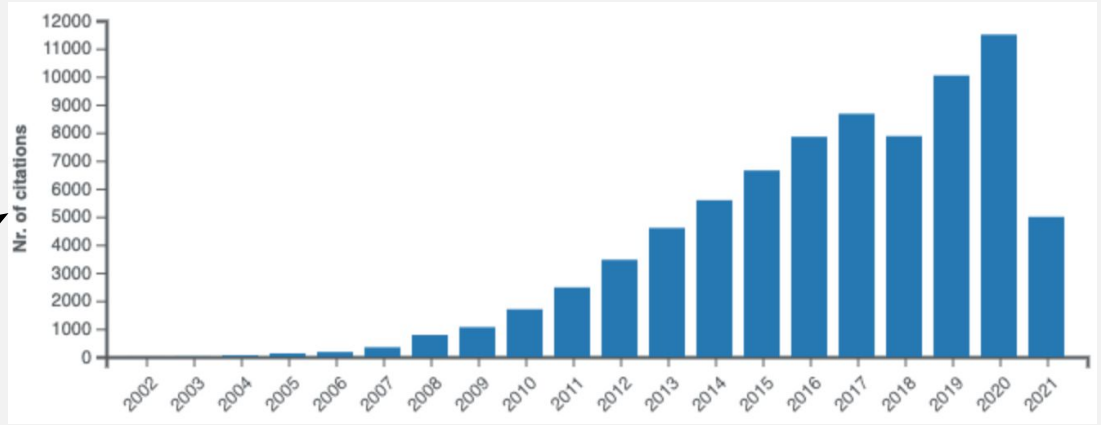
Nr. of publications: 1184
Total citations: 77925
h-index: 117

**Publications per year**

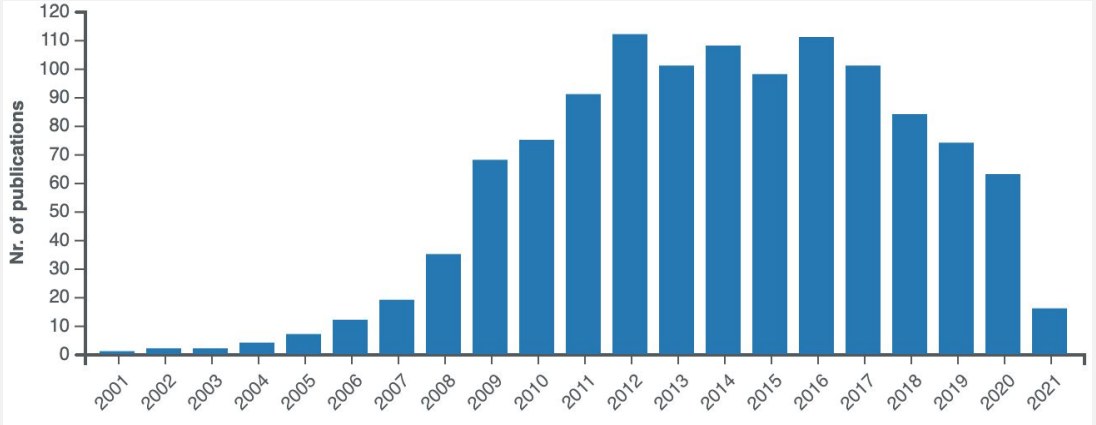
View all



## Number of citations per year

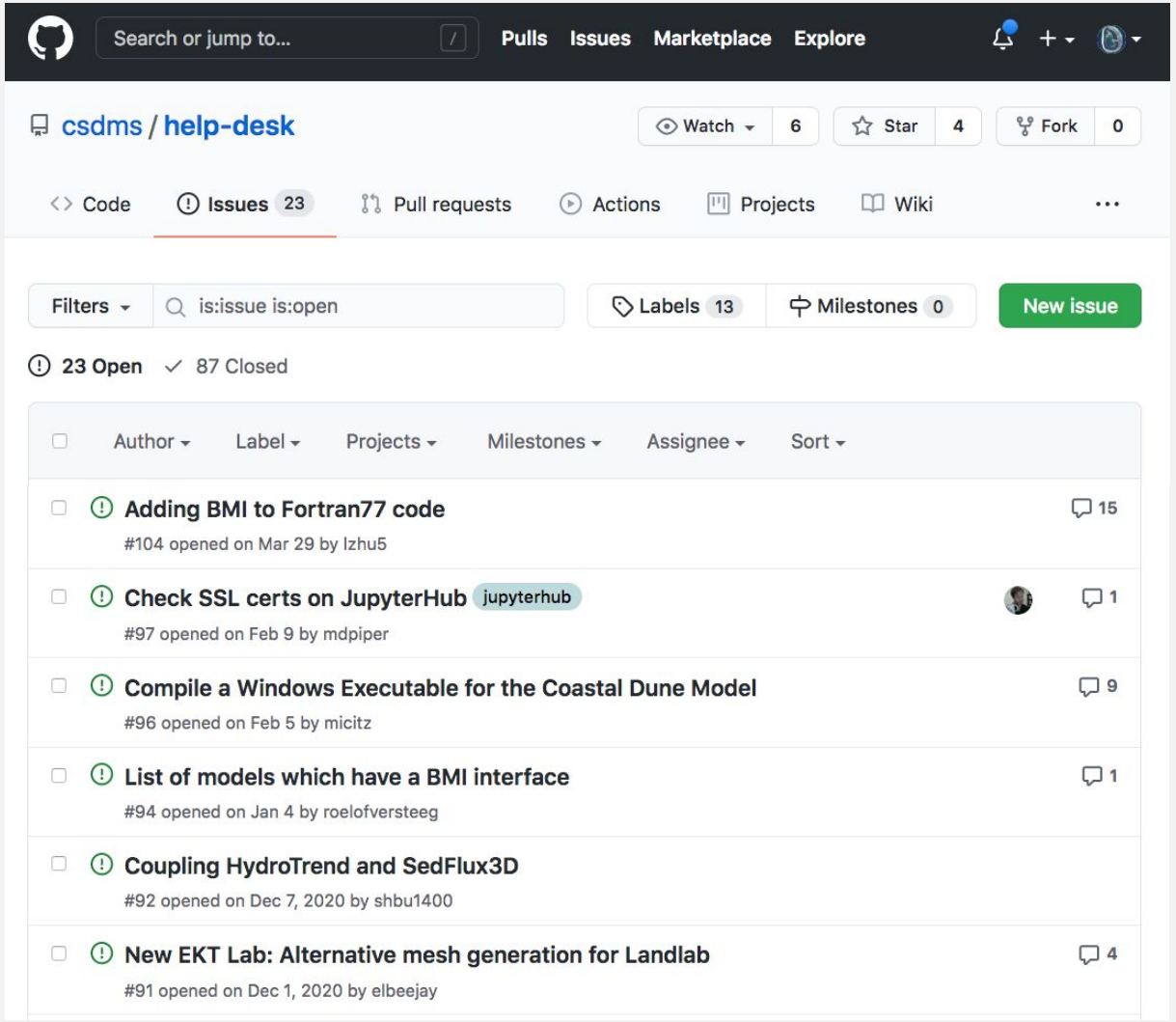



## Number of publications per year



# Member support: Help Desk

**https://github.com/csdms/help-desk**



# Member support:
# research software engineer consulting

**PROPOSAL SUPPORT**


Enhance the **broader impacts** of your project by creating robust, reusable, and well-documented software

**PROJECT SUPPORT**


**Engage support** of a CSDMS research software engineer though a rate-based service agreement

Contact the CSDMS Integration Facility at **csdms@colorado.edu**

# Software Cyberinfrastructure: **CSDMS Workbench**


1. Interface standard (BMI)

2. Language interoperability (Babelizer)

3. Model and data components


4. Model-building toolkit (Landlab)


5. Execution and coupling framework (PyMT)

COMPUTING

# Basic Model Interface (BMI): specifies a common set of control functions:

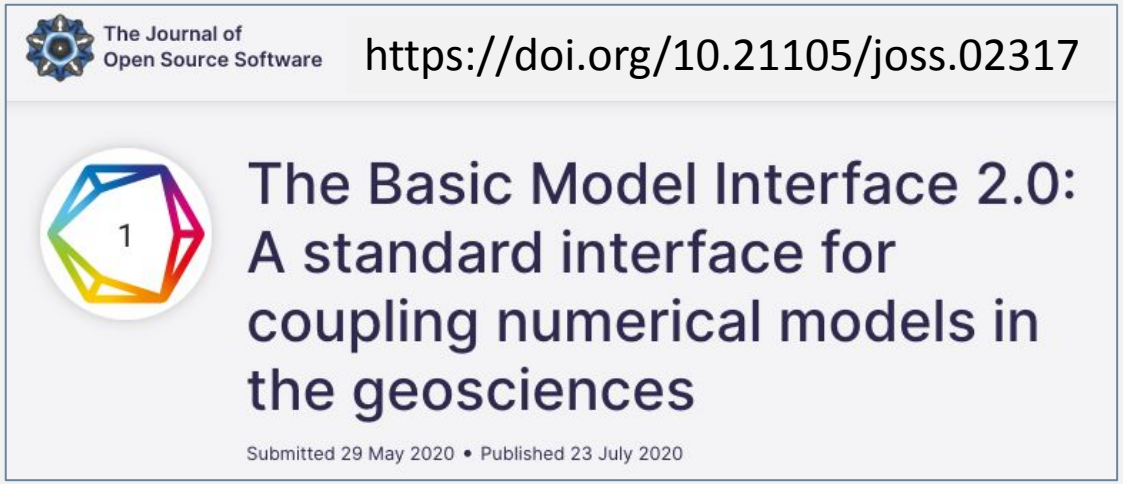

`initialize()`

`update()`


`get_value()`


`set_value()`


`finalize()`



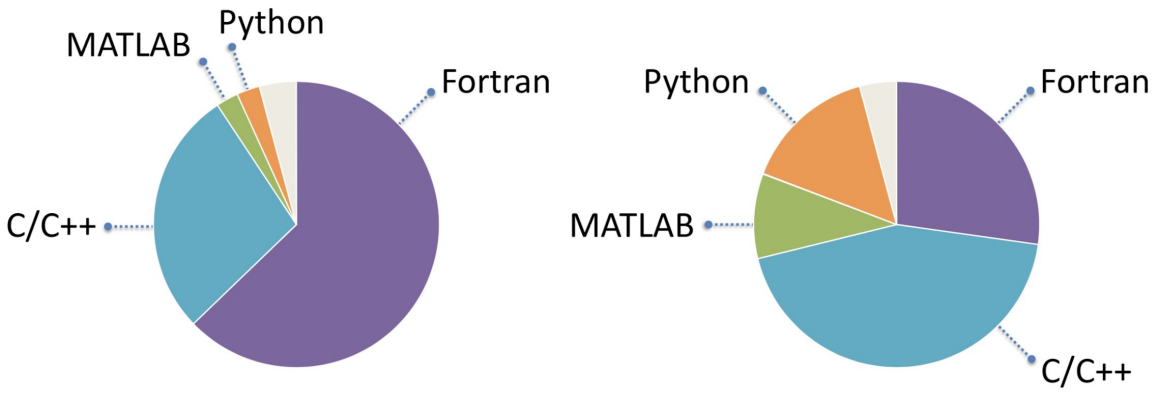

**https://bmi.readthedocs.io**

**BMI webinar: https://csdms.colorado.edu/wiki/Presenters-0409**

# Language interoperability

## The CSDMS Model Repository

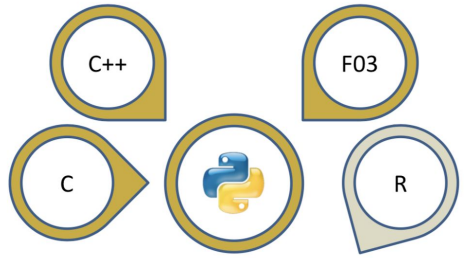
***Over 300 community-contributed Earth-system models.***




Fraction of Earth-system models as contributed to the CSDMS model repository as measured by lines of code (left) and number of models (right).

## Language Interoperability: *The Babelizer*

***Inter-language communication between models.***

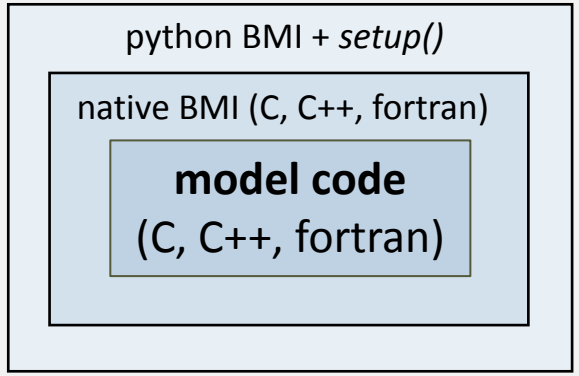


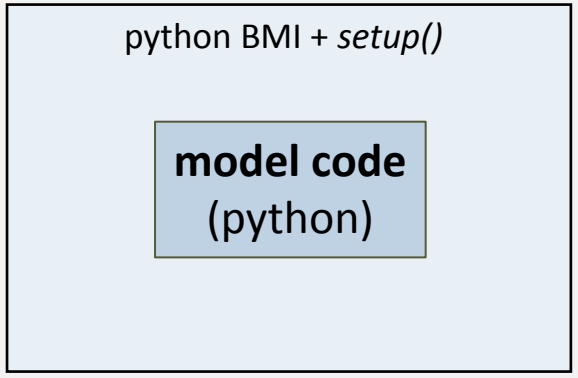

The CSDMS *Babelizer* automatically generates the necessary code to wrap shared libraries that expose a Basic Model Interface so that they can be imported into a Python environment. Currently, the Babelizer supports libraries written in *C*, *C++*, *FORTRAN* (and *Python*, obvs). We will look to add addition languages (like *R*) as needs arise.

**https://babelizer.readthedocs.io**

# Modeling with interoperable **components**

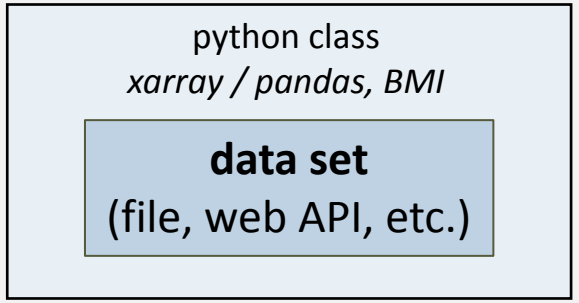
## Model Components




Currently available model components:
https://pymt.readthedocs.io/en/latest/models.html

## Data Components




| | |
|---|---|
| OpenTopography | USGS NWIS |
| GeoTiff | National Water Model |
| SoilGrids | GridMet |

https://csdms.colorado.edu/wiki/DataComponents

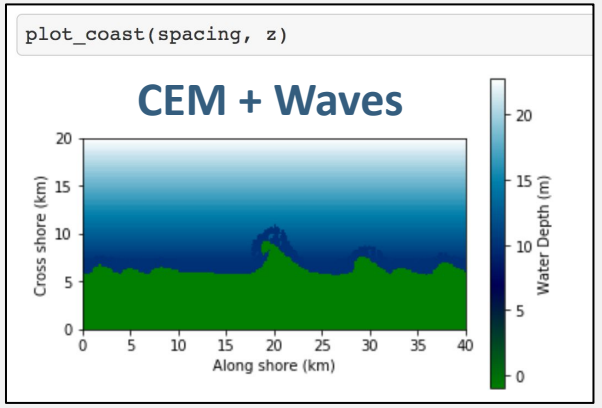
# pymt

https://pymt.readthedocs.io

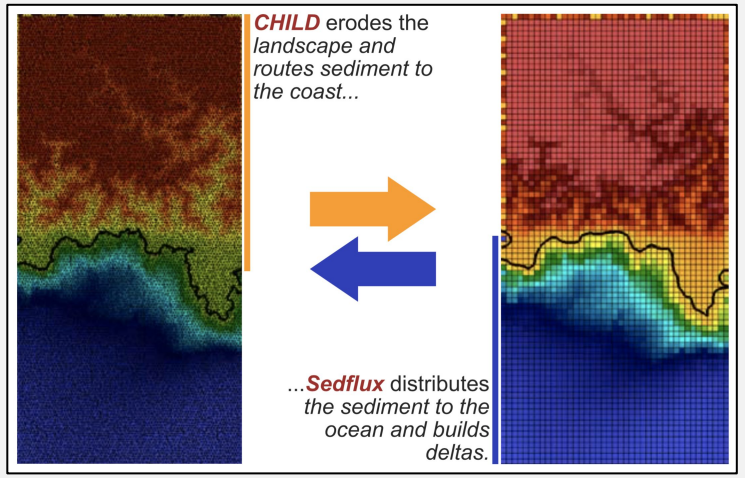
a Python toolkit for coupling and running Earth surface models

Install Quickstart User Guide Examples Reference Manual Source

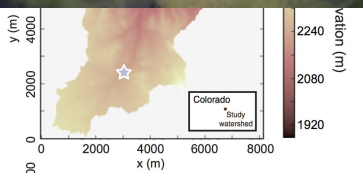
```
# Initialize the CEM and Waves models
from pymt import models
cem, waves = models.Cem(), models.Waves()
args = cem.setup(number_of_rows=100,
                 number_of_cols=200,
                 grid_spacing=200.)
cem.initialize(*args)
args = waves.setup()
waves.initialize(*args)

# (additional initialization code not shown)

# Run the models iteratively & exchange data
for time in range(num_time_steps):
    waves.update()
    angle = waves.get_value(wave_angle_name)
    cem.set_value(wave_angle_name, angle)
    cem.update()
```

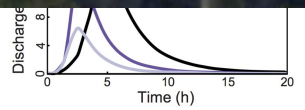



example of pymt grid mapping

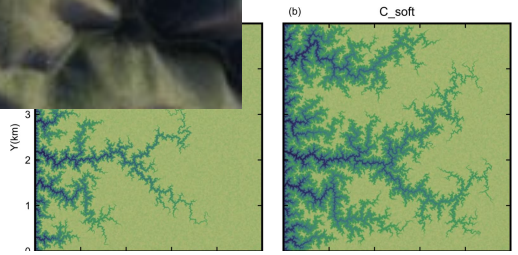


# https://landlab.github.io

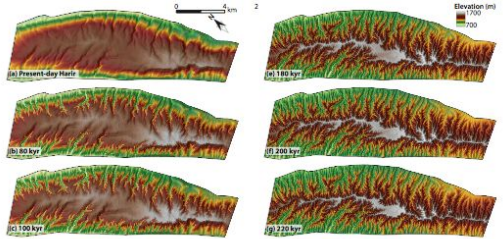


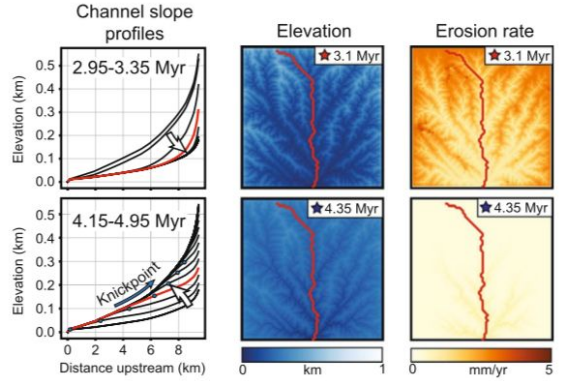

Rainfall-runoff
(Adams et al., 2017)



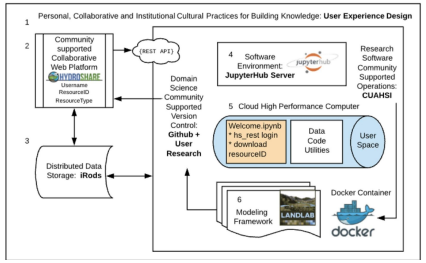

Post-glacial drainage nets (Lai & Anders, 2017)



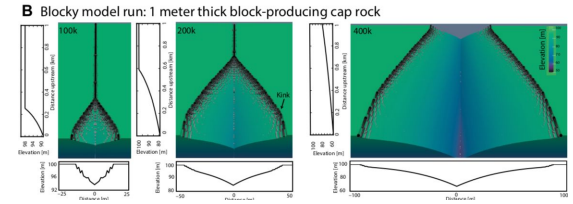
Evolution of anticlines (Zebari et al., 2019)



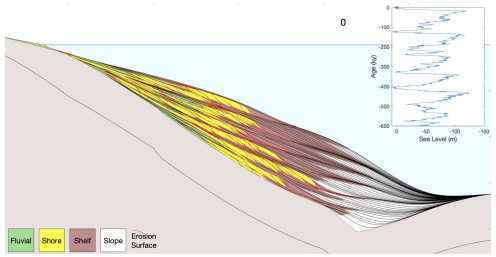

Sediment provenance as a signal of climate and tectonics in sedimentary basins (Sharman et al., 2019)



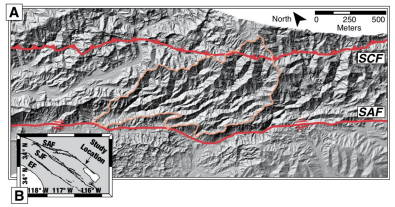

Hydrology education (Bandaragoda et al., 2019)



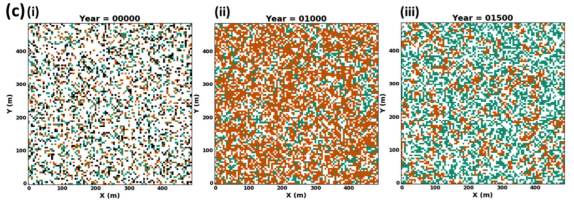

Influence of boulders on hillslope and channel evolution (Glade et al., 2019)



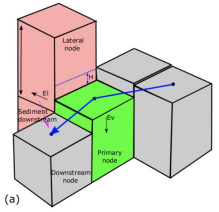

Basin stratigraphy (Steckler et al., in prep)



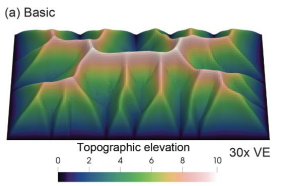

Tectonic shear (Gray et al., 2017)

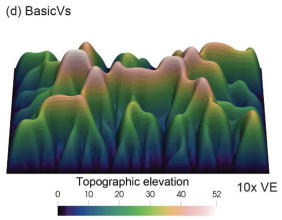



Vegetation dynanamics (Nudurupati et al., in review)

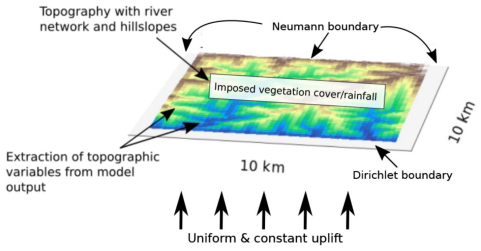



Valley widening
(Langston et al., 2018)

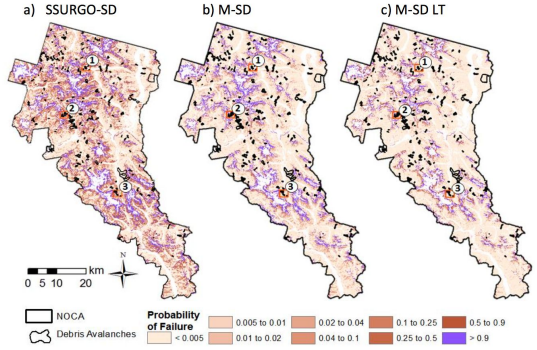



Landform evolution
(Barnhart et al., 2019)

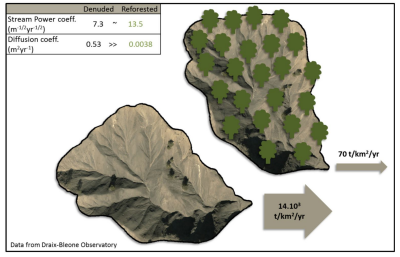



Vegetation & erosion (Schmid et al., 2018)




Landslide probability (Strauch et al., 2018)

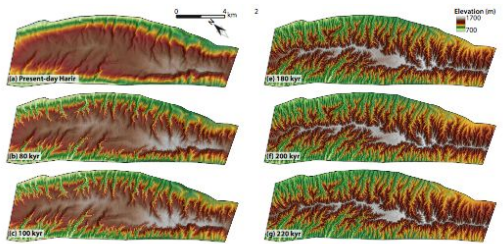
Tidal flow



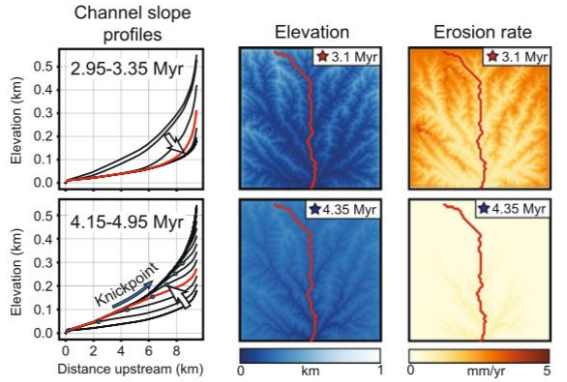

Sediment yield (Carriere et al., 2019)

# LANDLAB

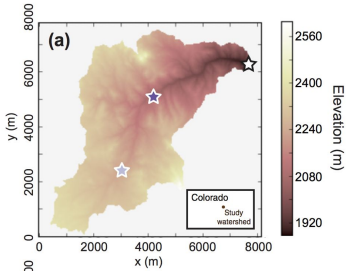
# https://landlab.github.io

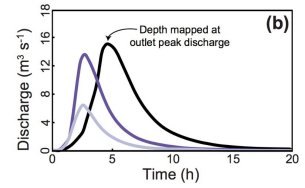


Evolution of anticlines (Zebari et al., 2019)

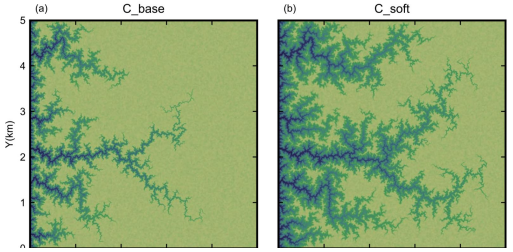



Sediment provenance as a signal of climate and tectonics in sedimentary basins (Sharman et al., 2019)

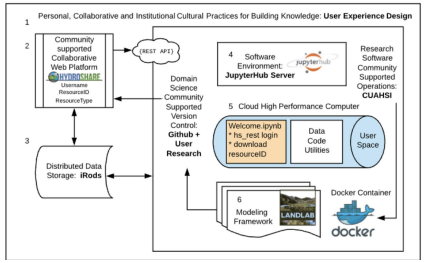


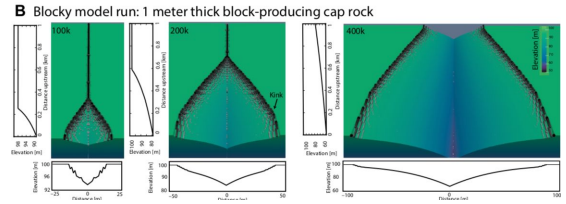

Rainfall-runoff (Adams et al., 2017)



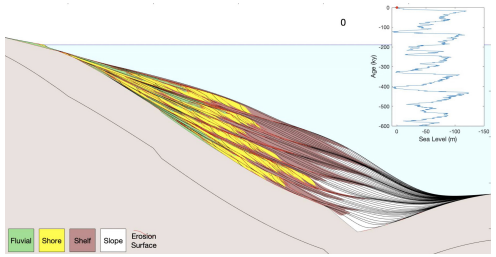

Post-glacial drainage nets (Lai & Anders, 2017)



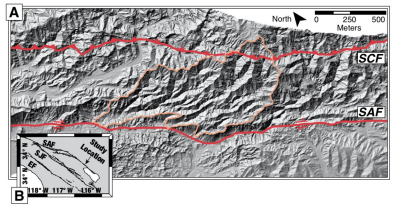

Hydrology education (Bandaragoda et al., 2019)



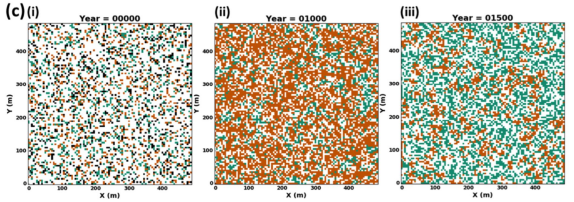

Influence of boulders on hillslope and channel evolution (Glade et al., 2019)



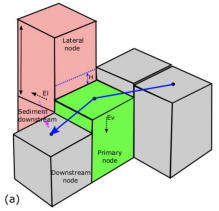

Basin stratigraphy (Steckler et al., in prep)



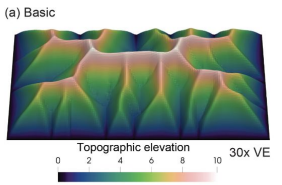

Tectonic shear (Gray et al., 2017)

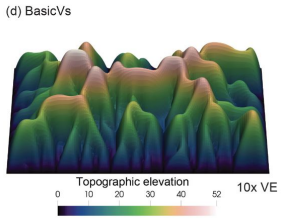



Vegetation dynanamics (Nudurupati et al., in review)

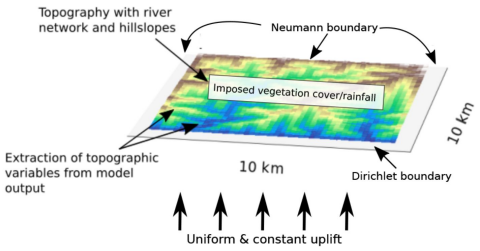



Valley widening (Langston et al., 2018)

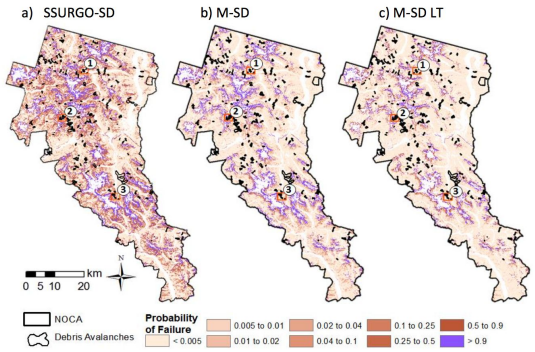



Landform evolution (Barnhart et al., 2019)

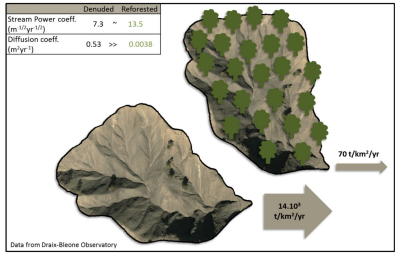



Vegetation & erosion (Schmid et al., 2018)




Landslide probability (Strauch et al., 2018)

Tidal flow




Sediment yield (Carriere et al., 2019)

# Community publications using CSDMS tools & protocols, 2020 and early 2021


Anand, S. K., Hooshyar, M., & Porporato, A. (2020). **Linear layout of multiple flow-direction networks for landscape-evolution simulations.** *Environmental Modelling & Software,* 133, 104804, https://doi.org/10.1016/j.envsoft.2020.104804.

Barnhart, K.R., Hutton, E.W.H., Tucker, G.E., Gasparini, N.M., Istanbulluoglu, E., Hobley, D.E.J., Lyons, N.J., Mouchene, M., Nudurupati, S.S., Adams, J.M., and Bandaragoda, C. (2020) **Short communication: Landlab 2.0: A software package for Earth surface dynamics.** *Earth Surface Dynamics,* 8, 379–397, doi:10.5194/esurf-8-379-2020.

Barnhart, K. R., Tucker, G. E., Doty, S. G., Glade, R. C., Shobe, C. M., Rossi, M. W., & Hill, M. C. (2020). **Projections of landscape evolution on a 10,000 year timescale with assessment and partitioning of uncertainty sources.** *Journal of Geophysical Research: Earth Surface,* 125(12), e2020JF005795, https://doi.org/10.1029/2020JF005795.

Barnhart, K. R., Tucker, G. E., Doty, S., Shobe, C. M., Glade, R. C., Rossi, M. W., & Hill, M. C. (2020). **Inverting topography for landscape evolution model process representation: Part 1, conceptualization and sensitivity analysis.** *Journal of Geophysical Research: Earth Surface,* e2018JF004961. https://doi.org/10.1029/2018JF004961.

Barnhart, K. R., Tucker, G. E., Doty, S., Shobe, C. M., Glade, R. C., Rossi, M. W., & Hill, M. C. (2020). **Inverting topography for landscape evolution model process representation: Part 2, calibration and validation.** *Journal of Geophysical Research: Earth Surface,* e2018JF004963. https://doi.org/10.1029/2018JF004963.

Barnhart, K. R., Tucker, G. E., Doty, S., Shobe, C. M., Glade, R. C., Rossi, M. W., & Hill, M. C. (2020). **Inverting topography for landscape evolution model process representation: Part 3, Determining parameter ranges for select mature geomorphic transport laws and connecting changes in fluvial erodibility to changes in climate.** *Journal of Geophysical Research: Earth Surface,* e2019JF005287, https://doi.org/10.1029/2019JF005287.

Carriere, A., Le Bouteiller, C., Tucker, G.E., Klotz, S., and Naaim, M. (2020) **Impact of vegetation on erosion: Insights from the calibration and test of a landscape evolution model in alpine badland catchments.** *Earth Surface Processes and Landforms.* https://doi.org/10.1002/esp.4741.

Evans, M. J., Scheele, B. C., Westgate, M. J., Yebra, M., Newport, J. S., & Manning, A. D. (2020). **Beyond the pond: Terrestrial habitat use by frogs in a changing climate**. Biological Conservation, 249, 108712., https://doi.org/10.1016/j.biocon.2020.108712.

den Haan, R.J., van der Voort, M.C., Baart, F., Berends, K.D., van den Berg, M.C., Straatsma, M.W., Geenen, A.J.P., and Hulscher, S.J.M.H. **The Virtual River Game: Gaming using models to collaboratively explore river management complexity.** *Journal of Environmental Modelling and Software*, December 2020. doi:10.1016/j.envsoft.2020.104855

Hutton, E.W.H., Piper, M.D., and Tucker, G.E. **The Basic Model Interface 2.0: A Standard Interface for Coupling Numerical Models in the Geosciences.** *The Journal of Open Source Software*, July 2020. doi:10.21105/joss.02317

Iwanaga, T., Partington, D., Ticehurst, J., Croke, B.F.W., and Jakeman, A.J. **A socio-environmental model for exploring sustainable water management futures: Participatory and collaborative modelling in the Lower Campaspe catchment.** *Journal of Hydrology: Regional Studies*, April 2020. doi:10.1016/j.ejrh.2020.100669

Lai, J., & Anders, A. M. (2020). **Tectonic controls on rates and spatial patterns of glacial erosion through geothermal heat flux.** *Earth and Planetary Science Letters,* 543, 116348, https://doi.org/10.1016/j.epsl.2020.116348.

Lipp, A. G., Roberts, G. G., Whittaker, A. C., Gowing, C. J., & Fernandes, V. M. (2020). **River sediment geochemistry as a conservative mixture of source regions: Observations and predictions from the Cairngorms, UK.** *Journal of Geophysical Research: Earth Surface,* 125(12), https://doi.org/10.1029/2020JF005700.

Litwin, D.G., Tucker, G.E., Barnhart, K.R., and Harman, C.J. (2020) **GroundwaterDupuitPercolator: A Landlab component for groundwater flow,** *Journal of Open Source Software,* 5(46), 1935, https://doi.org/10.21105/joss.01935.

Lyons, N.J., Albert, J.S., and Gasparini, N.M. (2020). **SpeciesEvolver: A Landlab component to evolve life in simulated landscapes.** *Journal of Open Source Software,* 5(46), 2066, https://doi.org/10.21105/joss.02066.

Lyons, N. J., Val, P., Albert, J. S., Willenbring, J. K., & Gasparini, N. M. (2020). **Topographic controls on divide migration, stream capture, and diversification in riverine life.** *Earth Surface Dynamics,* 8(4), 893-912, https://doi.org/10.5194/esurf-8-893-2020.

Pan, B., Cai, S., & Geng, H. (2021). **Numerical simulation of landscape evolution and mountain uplift history constrain-A case study from the youthful stage mountains around the central Hexi Corridor, NE Tibetan Plateau.** *Science China Earth Sciences,* 1-13, https://doi.org/10.1007/s11430-020-9716-6.

Pfeiffer, A.M., Barnhart, K.R., Czuba, J.A., and Hutton, E.W.H. (2020). **NetworkSedimentTransporter: A Landlab component for bed material transport through river networks.** *Journal of Open Source Software,* 5(53), 2341, https://doi.org/10.21105/joss.02341.

Ratliff, K.M., Hutton, E.H.W., and Murray, A.B., 2021. **Modeling long-term delta dynamics reveals persistent geometric river avulsion locations,** Earth and Planetary Science Letters, 559, doi:10.1016/j.epsl.2021.116786.

Sheehan, C.E., and Ward, D.J. (2020). **Migrating Transverse Escarpments in Strike Valleys on the Colorado Plateau.** *Journal of Geophysical Research: Earth Surface,* 125(3), e2019JF005260, https://doi.org/10.1029/2019JF005260.

Shen, H., Lynch, B., Poulsen, C. J., & Yanites, B. J. (2021). **A modeling framework (WRF-Landlab) for simulating orogen-scale climate-erosion coupling.** *Computers & Geosciences,* 146, 104625, https://doi.org/10.1016/j.cageo.2020.104625.

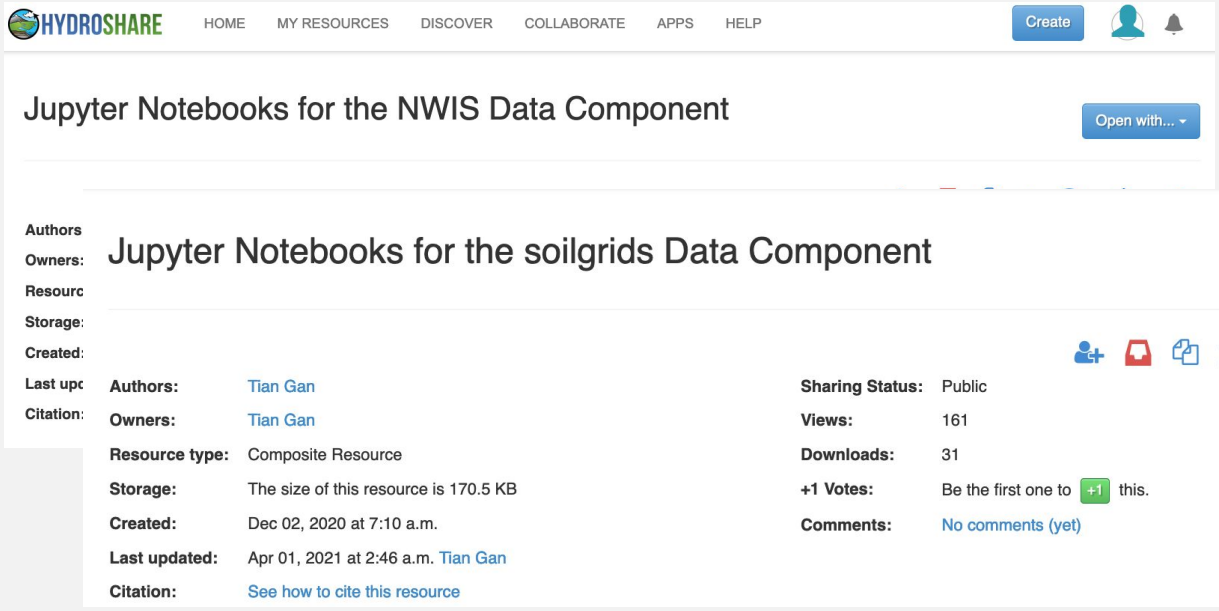
Tucker, G. E., Hobley, D.E.J., McCoy, S.W., and Struble, W.T. (2020) **Modeling the shape and evolution of normal-fault facets.** *Journal of Geophysical Research: Earth Surface,* 125, https://doi.org/10.1029/2019JF005305.

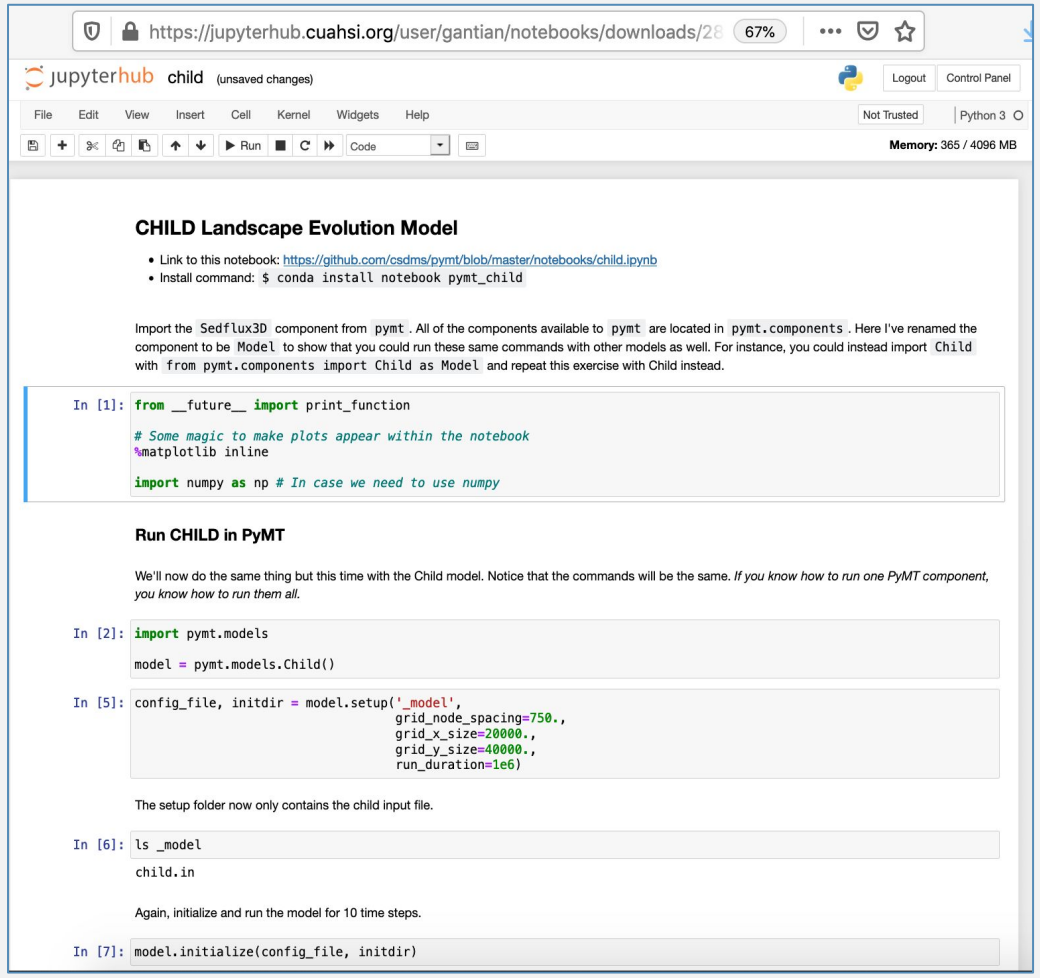
Wang, K., Jafarov, E., and Overeem, I. **Sensitivity evaluation of the Kudryavtsev permafrost model.** Journal of Science of the Total Environment, June 2020. https://doi.org/10.1016/j.scitotenv.2020.137538.

Walker, S. J., Wilkinson, S. N., van Dijk, A. I., & Hairsine, P. B. (2020). **A multi-resolution method to map and identify locations of future gully and channel incision.** *Geomorphology,* 358, 107115, https://doi.org/10.1016/j.geomorph.2020.107115.

# CSDMS@HydroShare

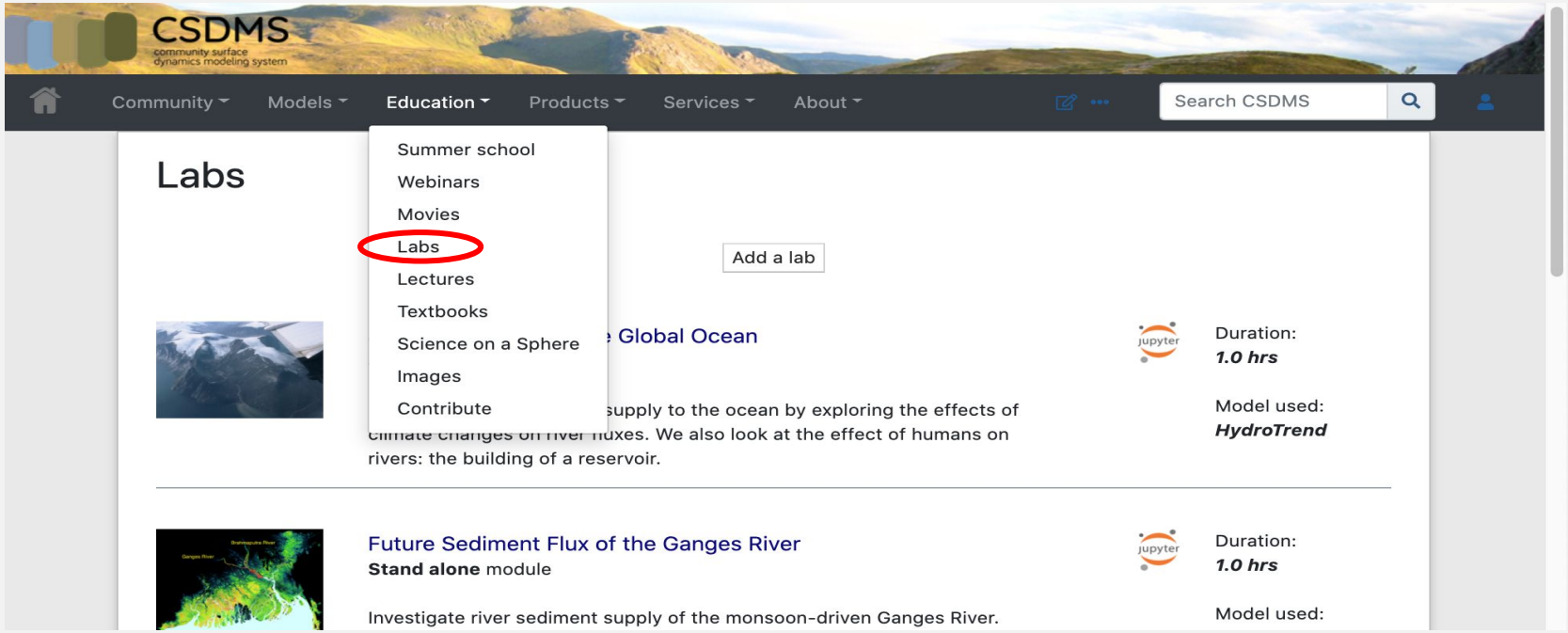
- New model component added  in CUAHSI JupyterHub
- Data components available in HydroShare
- Clinic in 2021 Annual meeting




https://hydroshare.org

# **Labs** for teaching & learning




- **22 labs available** (50% increase since last year)
- Many labs are based on **Jupyter Notebooks** (NB)
- Most NB can **directly run through Binder or CSDMS JupyterHub** and are downloadable to run local if preferred

## Lab topics:

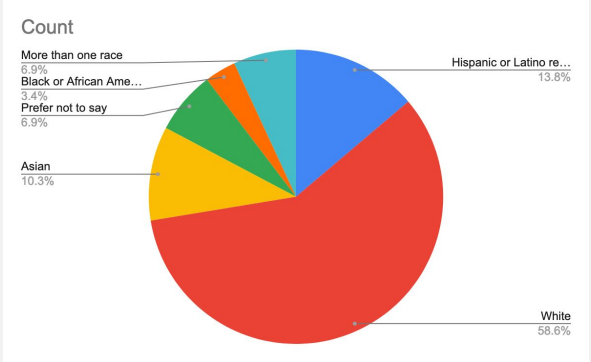
- **Rivers:** discharge - flood frequency - sediment load - evolution of meanders - evolution of channels
- **Permafrost:** spatial patterns of occurrence - active layer - future scenarios
- **Glaciers:** growth and retreat of a valley glaciers
- **Intro to CSDMS tools:** Landlab - BMI - PyMT
- **Data components:** SoilGrid - NWM

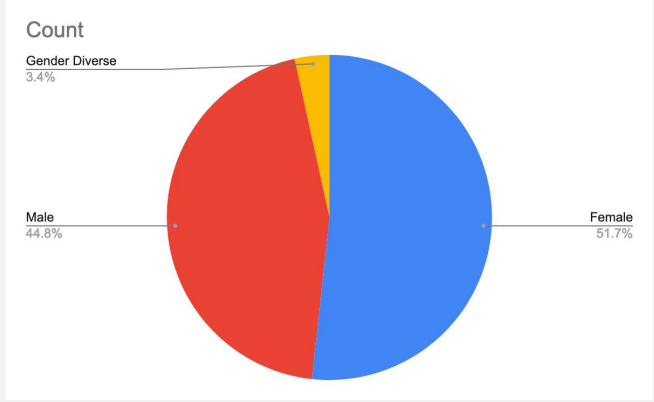
https://csdms.colorado.edu

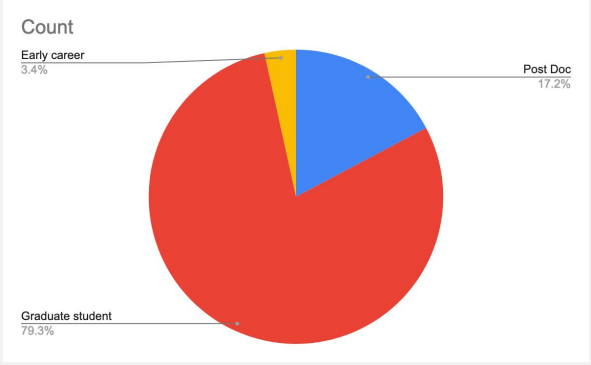
# ESPIn2021
# 8th - 17th June

Goal: expand the use of cyberinfrastructure among early-career members of the ESP research community with training that increases their competence and confidence with using cyberinfrastructure tools to advance the fundamental science of ESP.

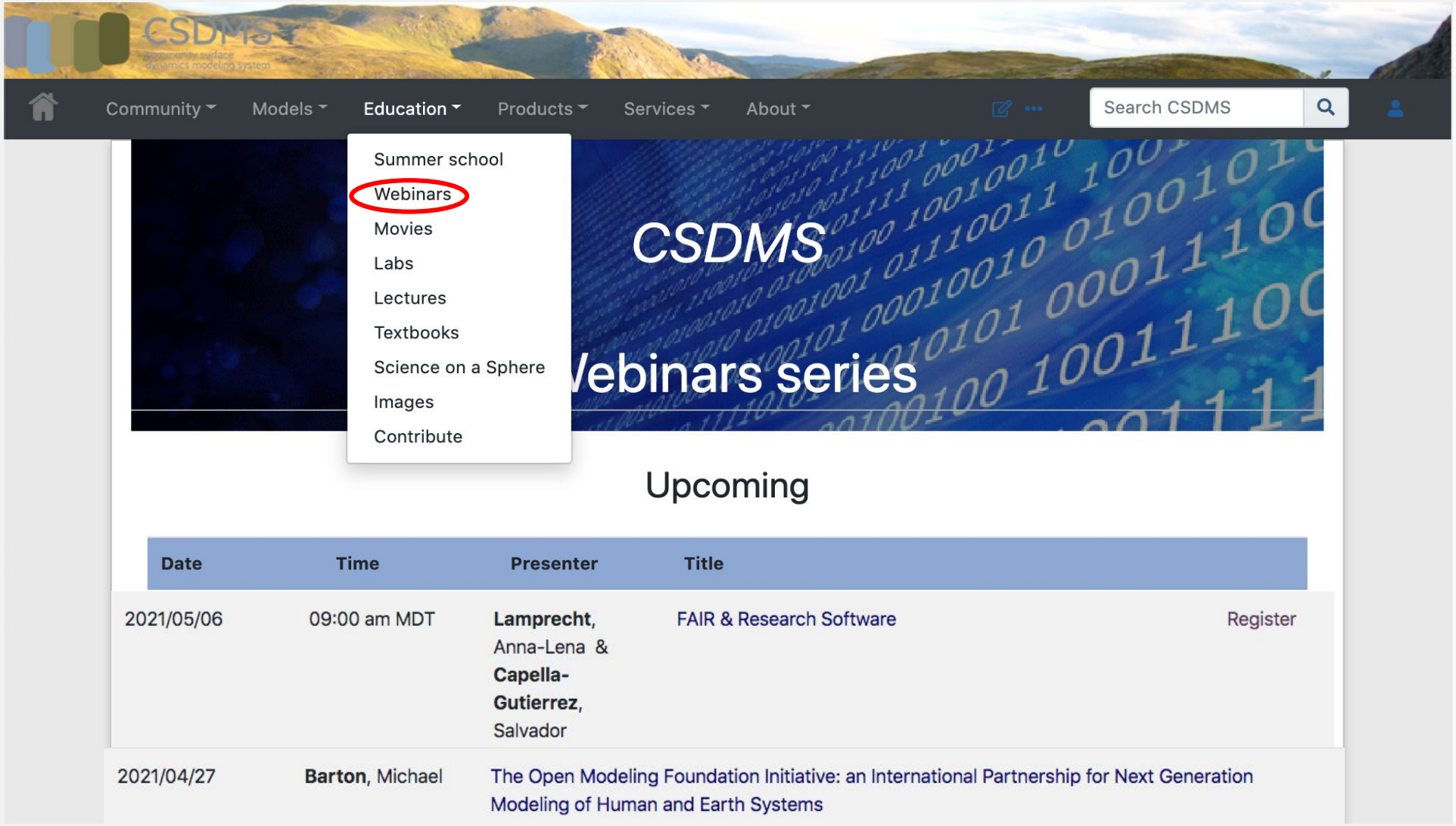
- received 94 applications in March 2021.
- redesigned ESPIn2021 to be online for 8 days
- developed non-biased selection metrics and blind candidate review
- Resulted in a diverse group of 29 participants
- 6 science lectures
- Professional panel



# Webinars



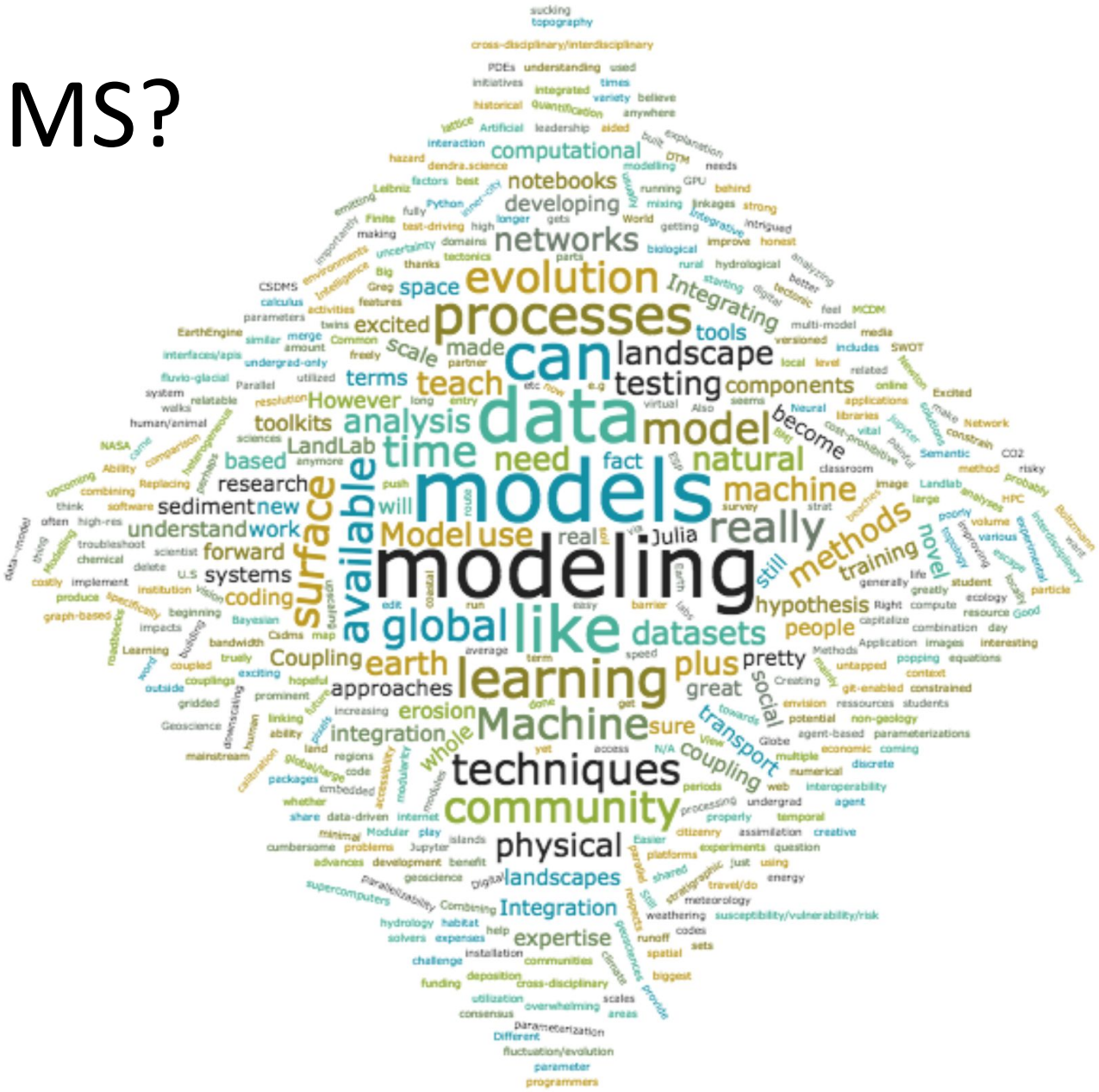

- Every semester 3-4 webinars
- **Wide variety of topics** around modeling, best modeling practices, modeling tools, etc.
- Webinars are **recorded & posted on CSDMS YouTube-channel**, so can be viewed later https://www.youtube.com/user/CSDMSmovie/playlists

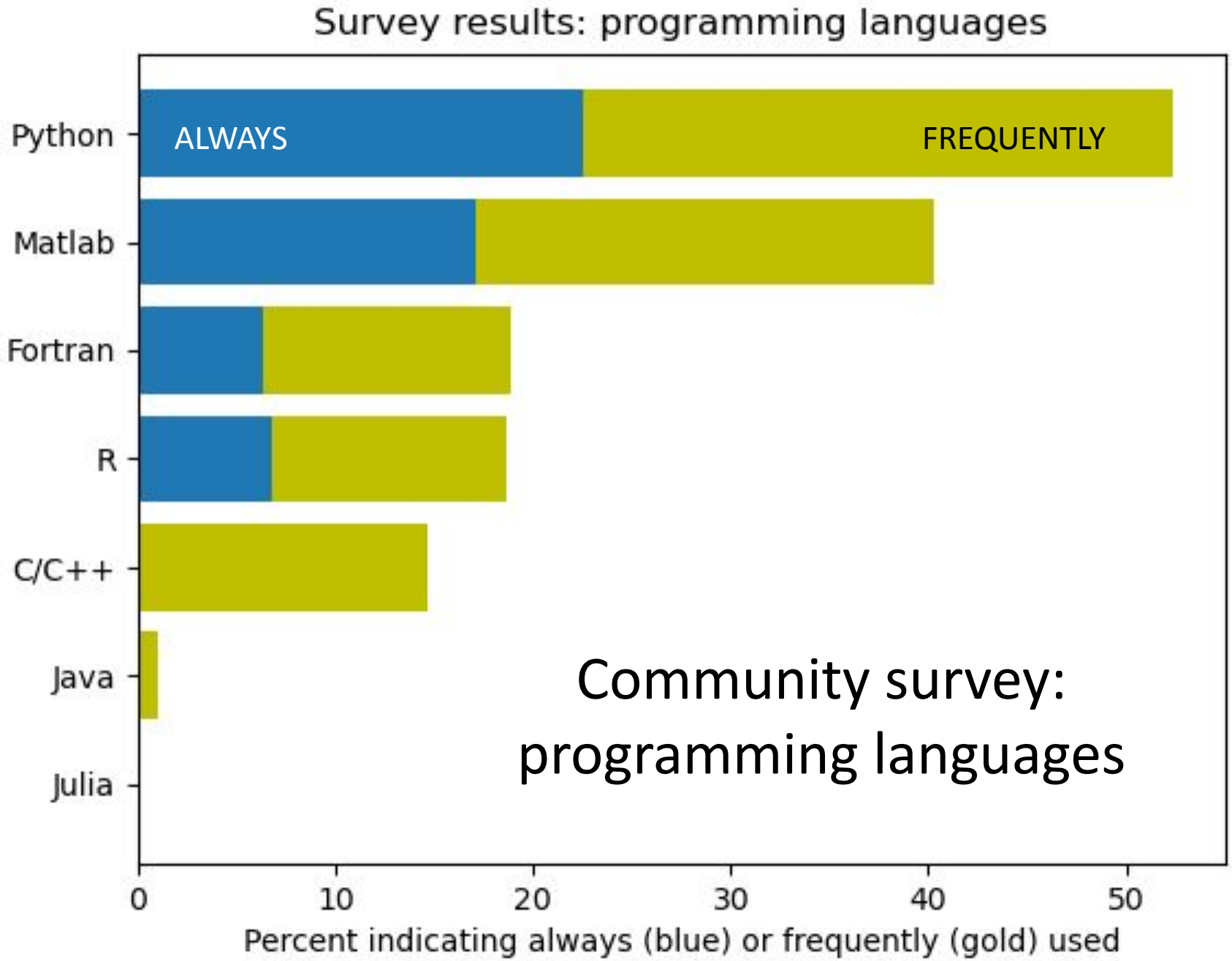
https://csdms.colorado.edu/

# What's next for CSDMS?

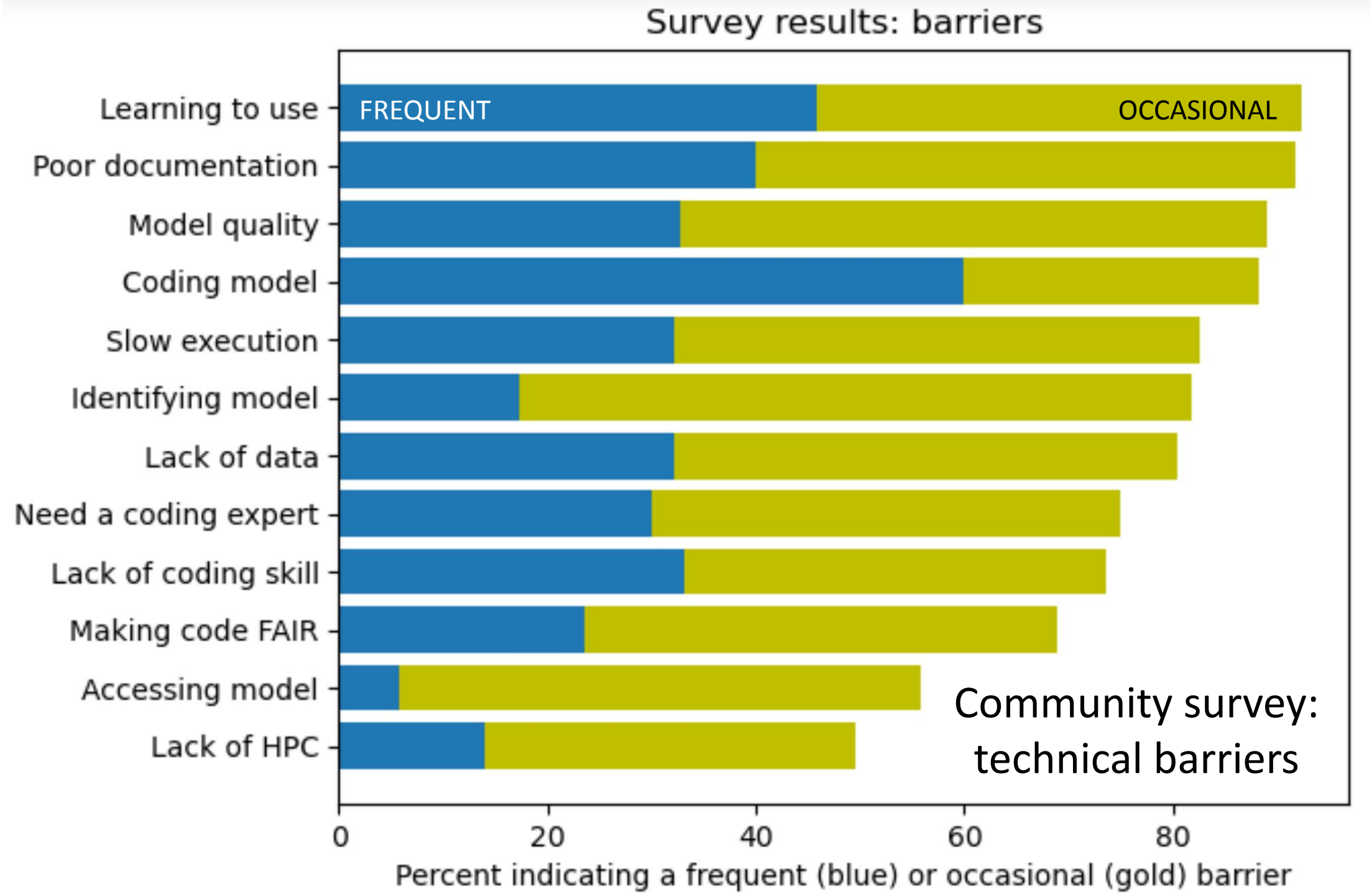
*We want to hear from you!*

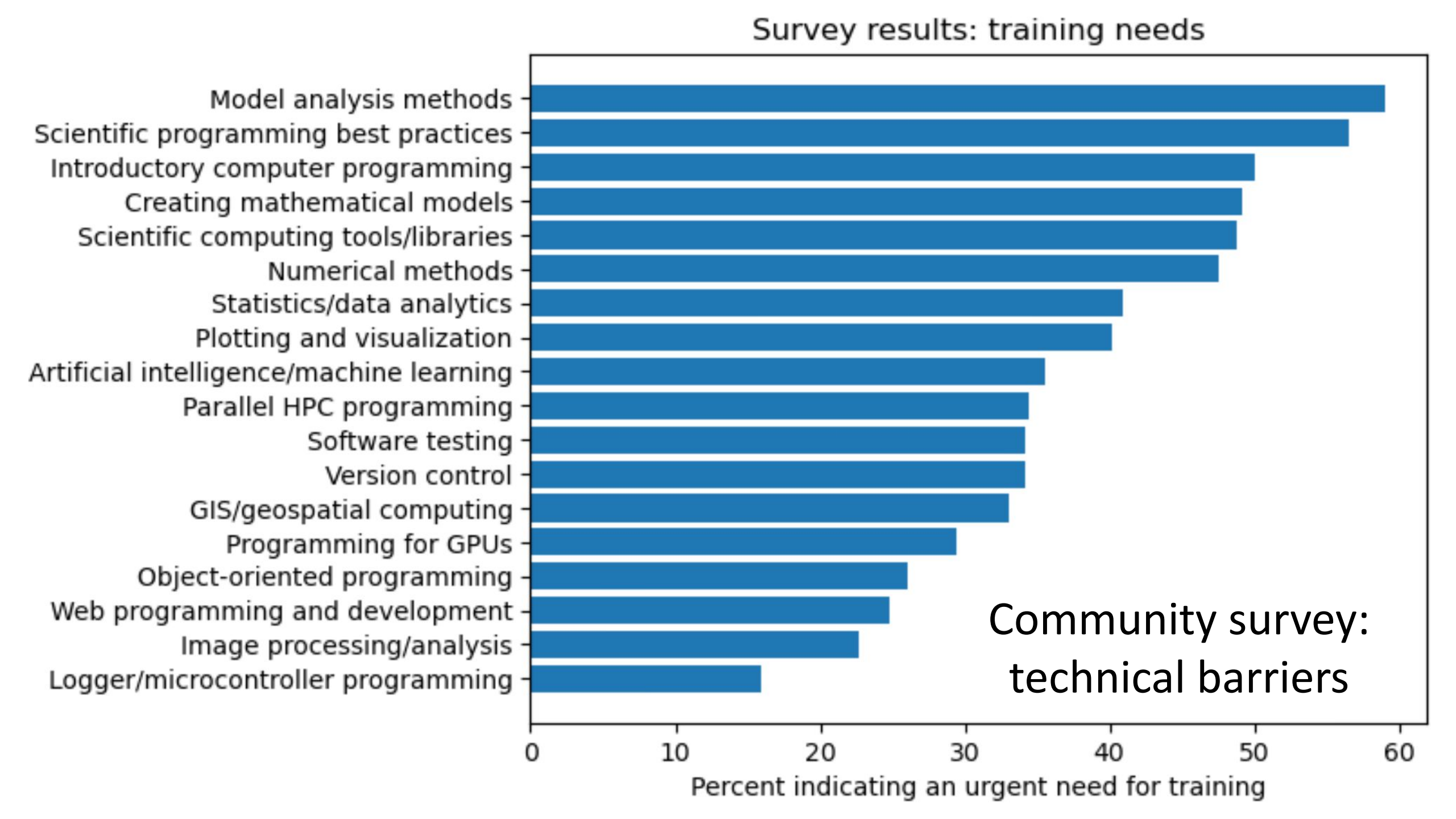
- Community survey
- Breakout discussions: Tuesday & Wednesday
- Send your thoughts to: **csdms@colorado.edu**






Community survey:
programming languages


Survey results: barriers
FREQUENT
OCCASIONAL
Learning to use
Poor documentation
Model quality
Coding model
Slow execution
Identifying model
Lack of data
Need a coding expert
Lack of coding skill
Making code FAIR
Accessing model
Lack of HPC
0
20
40
60
80
Percent indicating a frequent (blue) or occasional (gold) barrier
Community survey:
technical barriers


Survey results: training needs
Model analysis methods
Scientific programming best practices
Introductory computer programming
Creating mathematical models
Scientific computing tools/libraries
Numerical methods
Statistics/data analytics
Plotting and visualization
Artificial intelligence/machine learning
Parallel HPC programming
Software testing
Version control
GIS/geospatial computing
Programming for GPUs
Object-oriented programming
Web programming and development
Image processing/analysis
Logger/microcontroller programming
0
10
20
30
40
50
60
Percent indicating an urgent need for training
Community survey:
technical barriers

CSDMS
community surface dynamics modeling system

# 2021 CSDMS Integration Facility Staff

**Greg Tucker**
Executive Director

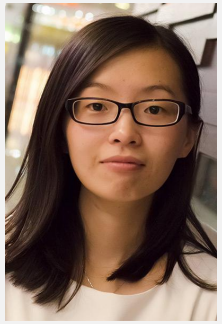
**Irina Overeem**
Deputy Director

**Eric Hutton**
Senior Software Engineer

**Albert Kettner**
Cyber Com & Data

**Mark Piper**
Software Engineer

**Lynn McCready**
CSDMS Program Coordinator



**Tian Gan**
Postdoc, RSE

**Benjamin Campforts**
Postdoc, ESPIn EKT

**Chad Stoffel**
IT Administrator

**Jean Lindhal**
Accountant

NSF

# Meeting program

| MONDAY 17 MAY | TUESDAY 18 MAY | WEDNESDAY 19 MAY | THURSDAY 20 MAY |
|---|---|---|---|
| | keynotes | keynotes | keynotes |
| | | | |
| | clinics | clinics | clinics |
| | breakout groups | breakout groups | science jam |
| opening & town hall<br>awards ceremony<br>happy hour | posters | posters | |

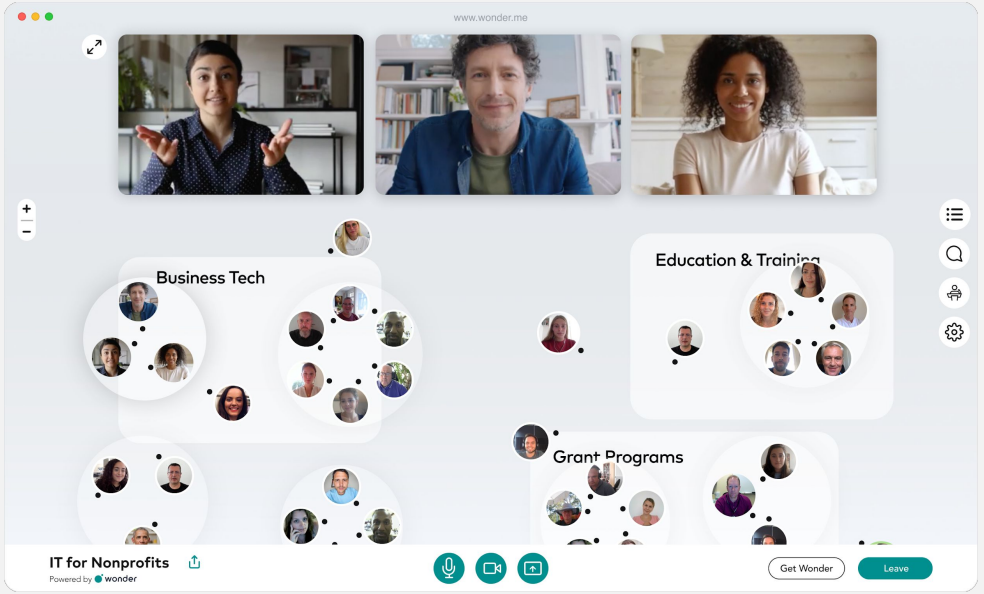
# About the Science Jam

Self-organizing discussions on the wonder.me platform

You pick the discussion topics…

*Send topics before Thursday to:*

**csdms@colorado.edu**



CSDMS
community surface dynamics modeling system

*share resources, collaborate*

**COMMUNITY** SUPPORT

*create, run, test, analyze, and apply models*

**COMPUTING** RESOURCES

*learn and teach*

**EDUCATION** OPPORTUNITIES

# Questions?

What are your computing barriers and needs?

What would you like to see in CSDMS 4.0?

csdms@colorado.edu