CSDMS

community surface dynamics modeling system

Teaching with Jupyter Notebooks

Earth-surface processes

share resources, collaborate

COMMUNITY
SUPPORT

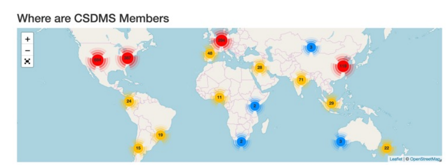
create, run, test, analyze, and apply models

COMPUTING
RESOURCES

learn and teach

EDUCATION
OPPORTUNITIES

2253 members
70+ countries



Integration Facility at
University of Colorado Boulder

Basic Logistics!

Is everyone signed up to access the jupyterhub of CSDMS?

Google "CSDMS", under services tab, find jupyterhub

Click on the link:
lab.openearthscape.org

Mark Piper mark.piper@colorado.edu
is here to help activate accounts.

Outline of today's workshop

- Introduction to teaching with Jupyter Notebooks
- Introduction to CSDMS Jupyterhub, Landlab and PyMT
- Explore resources and repositories to get impression of what is available

- Hands-on work on teaching notebook with modeling component focus
- Hands-on work on teaching notebook with data component focus

- Demonstration of HydroShare as an alternative hub to run these notebooks

- Discussion on educational resources: your contributions and your wishlists

What are jupyter notebooks?

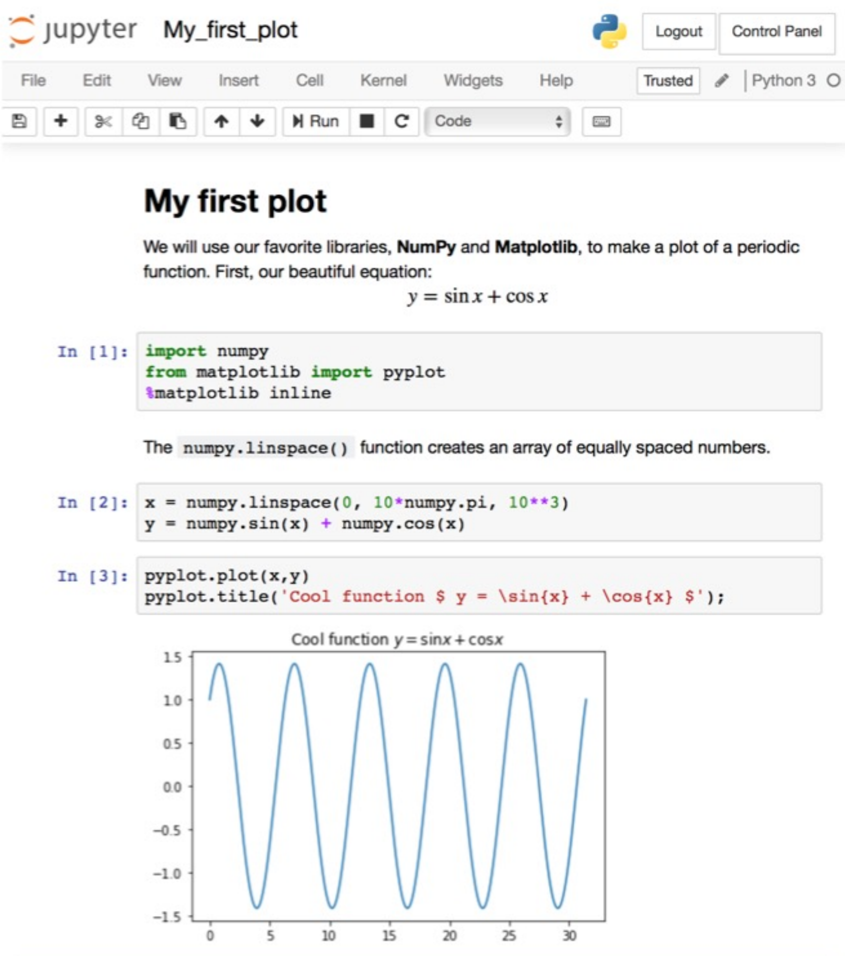
“Project Jupyter” is a broad collaboration that develops **open-source tools** for interactive and exploratory computing. The tools have a focus on **Python**, the Jupyter Notebook, JupyterHub, and an ecosystem of extensions contributed by a large community.

Notebooks are documents containing:

1. text narratives with images and math
2. combined with executable code
3. the output of that code.

From Barba et al., 2019
https://jupyter4edu.github.io/jupyter-edu-book/

What are notebooks? An example



Jupyter header and tool bar.

A markdown cell, with title, explanation, and equation.

A code cell, setting things up with needed libraries.

A short explanation.

Code cells assigning two array variables, then making a line plot.

From Barba et al., 2019 https://jupyter4edu.github.io/jupyter-edu-book/

Getting a feel for your experiences….

- How many people are already familiar with notebooks?
- Do you use notebooks in your classrooms?
- Why have you chosen to use this as platform/tool?

ArcGIS …linkage now based in notebook
Less challenges with installation/connectivity
Pedagogaicl goals on reproducibility
Accelerating of onboarding of junior team members

Why teaching with notebooks? Pedagogy

- Notebooks allow for a low-skill entry level engagement with numerical modeling, data analysis and programming (python and other languages).

- Notebooks interactive and hands-on which is shown by education research to promote learning and retention of concepts.

From Moore, M. G. (1989). Editorial: Three types of interaction. American Journal of Distance Education. https://doi.org/10.1080/08923648909526659

- Notebooks are dynamic, living documents, students can add content.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Why teaching with notebooks? Logistics

- Anyone who teaches data analysis or computing can use jupyter notebooks as a vehicle for their content
- It runs in any modern web browser. If you use a dedicated jupyterhub, students do not need to install specific software.

Teamwork in CSDMS spring school 2022

From Barba et al., 2019
https://jupyter4edu.github.io/jupyter-edu-book/

What formats for teaching?

- Notebooks as small worksheets (0.5 hrs)

Task: Visualize data in a scatterplot using matplotlib

Task: learn how to declare a numpy array

Task: write a function to convert temperature from F to C

- Notebooks to work on data analysis or run more complicated codes (3-4 hrs)

Learn about USGS discharge data, learn pandas lib and calculate hydrographs

Read paper on HydroTrend, explore environmental change scenarios for Ganges river basin

- Notebooks as a final project report (10+ hours)

Class project: gravel sediment transport in river to assess change fish habitat

Class project: coastline evolution along the Beaufort Sea

General guidelines in developing notebooks for teaching

- Specify learning goals

(topical, programming skills)

- Know your audience. Try to make content accessible for experienced and less experienced programmers. Not an easy task.

(advanced exercises at the end? Or teamwork)

- Be aware that to create more research independence we need to help participants transition to locally run codes, Anaconda/Spyder and other. May think about explicit teaching about this for graduate students.

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

create, run, test, analyze, and apply models

learn and teach

COMMUNITY
SUPPORT

COMPUTING
RESOURCES

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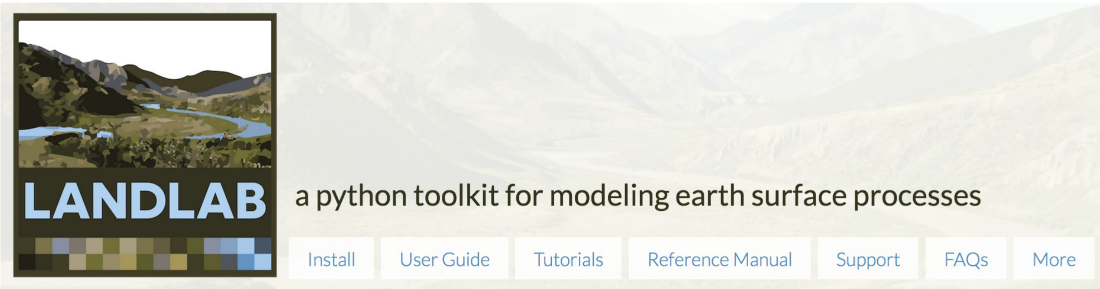
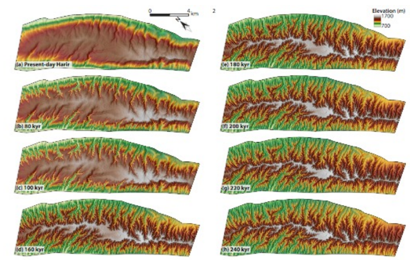
Software Cyberinfrastructure: CSDMS Modeling Framework

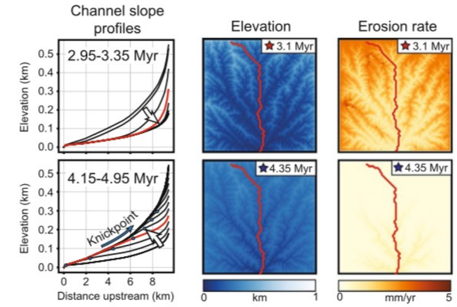
> ***"CSDMS is envisioned as a modeling environment containing a community-built, freely available suite of integrated, ever-improving software modules aimed at predicting the erosion, transport, and accumulation of sediment and solutes in landscapes and sedimentary basins over a broad range of time and space scales."***
>
> \- ***Science Plan, 2004***

1. Model-building toolkit (Landlab)
2. Execution and coupling framework (PyMT)

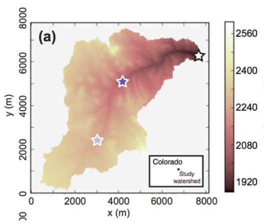


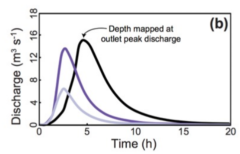


Evolution of anticlines (Zebari et al., 2019)

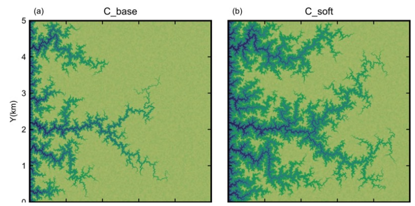


Sediment provenance as a signal of climate and tectonics in sedimentary basins (Sharman et al., 2019)

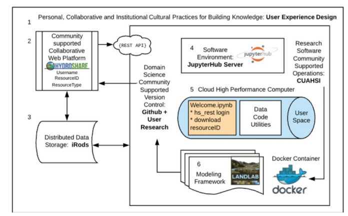




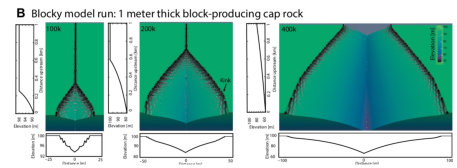
Rainfall-runoff (Adams et al., 2017)



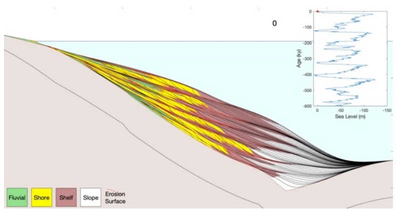
Post-glacial drainage nets (Lai & Anders, 2017)



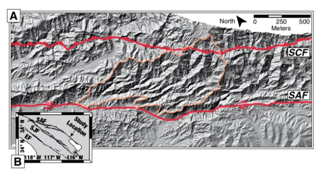
Hydrology education (Bandaragoda et al., 2019)



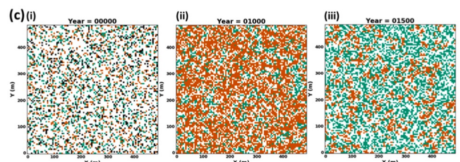
Influence of boulders on hillslope and channel evolution (Glade et al., 2019)



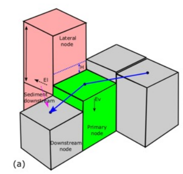
Basin stratigraphy (Steckler et al., in prep)



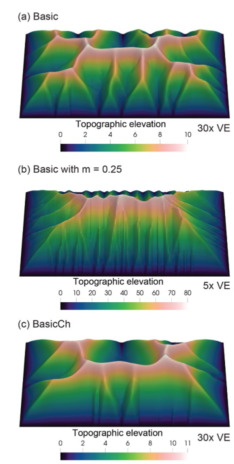
Tectonic shear (Gray et al., 2017)

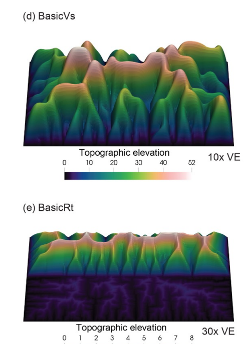


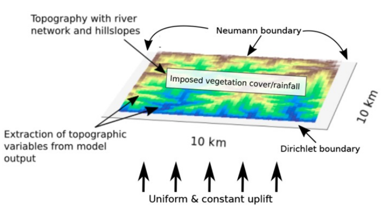
Vegetation dynamics (Nudurupati et al., in prep.)



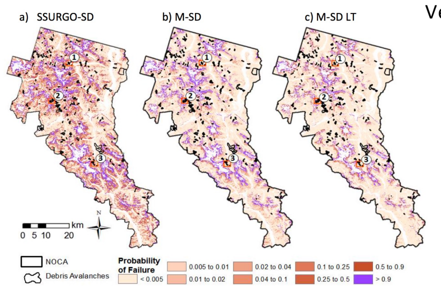
Valley widening (Langston et al., 2018)



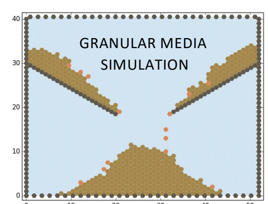




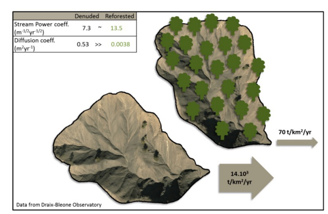
Vegetation & erosion (Schmid et al., 2018)



Landslide probability (Strauch et al., 2018)



Cellular automata (Tucker et al., 2016)



Sediment yield (Carriere et al., 2019)

Landform evolution (Barnhart et al., 2019)

Think-Pair-Explore

Go to: https://landlab.readthedocs.io/en/latest/

Explore the landlab documentation and see whether you can find the
1) teaching tutorial notebook on:
Exploring rainfall driven hydrographs with Landlab

2) Tutorial notebook on:
Flexure

Open either tutorial and see whether the notebooks work.

pymt

a Python toolkit for coupling and running Earth surface models

Install   Quickstart   User Guide   Examples   Reference Manual   Source

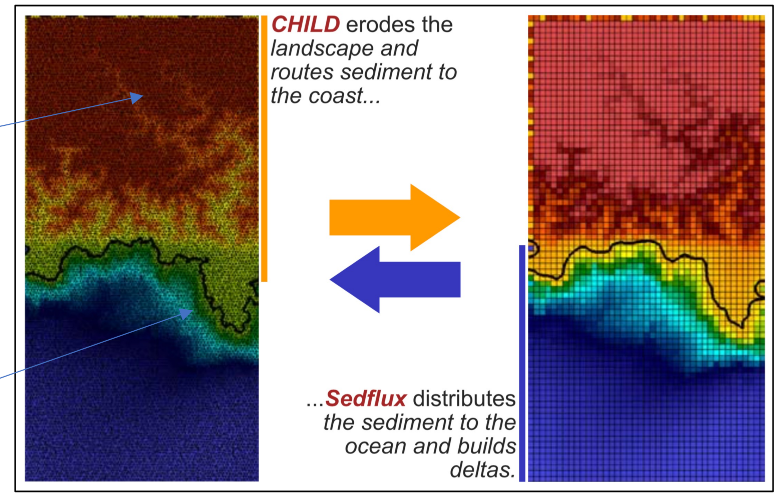
current
pymt models:

Avulsion
CEM
Child
ECSimpleSnow
FaSTMECH
FrostNumber
GIPL
Hydrotrend
Ku
Plume
Sedflux3D
Subside
Waves

```
[8]: model.initialize(config_file, dir=initdir)

[9]: model.set_value("channel_exit_water_flow__speed", 1.2)
     model.set_value("channel_exit_x-section__mean_of_width", 400.)
     model.set_value("channel_exit_x-section__mean_of_depth", 4.)
     model.set_value("channel_exit_water_sediment~suspended__mass_conc

[9]: array([ 0.01])
```

Here we update the model for 10 time steps, printing the model time after each step.

```
[10]: for t in range(10):
          model.update()
          print(model.get_current_time())

      365.00000000036493
      730.0000000010949
      1095.00000000219
      1460.00000000365
      1825.000000005475
      2190.000000007665
      2555.00000001022
      2920.00000001314
      3285.0000000164246
      3650.0000000200744
```



https://csdms.github.io/pymt/

pymt

a Python toolkit for coupling and running Earth surface models

Install Quickstart User Guide Examples Reference Manual Source

current
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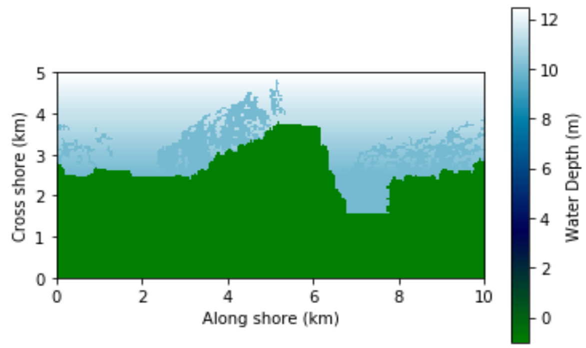


How does beach nourishment affect Flori
Lido Key and Siesta Key case study, court
Harper (CU Undergraduate Student)

pymt

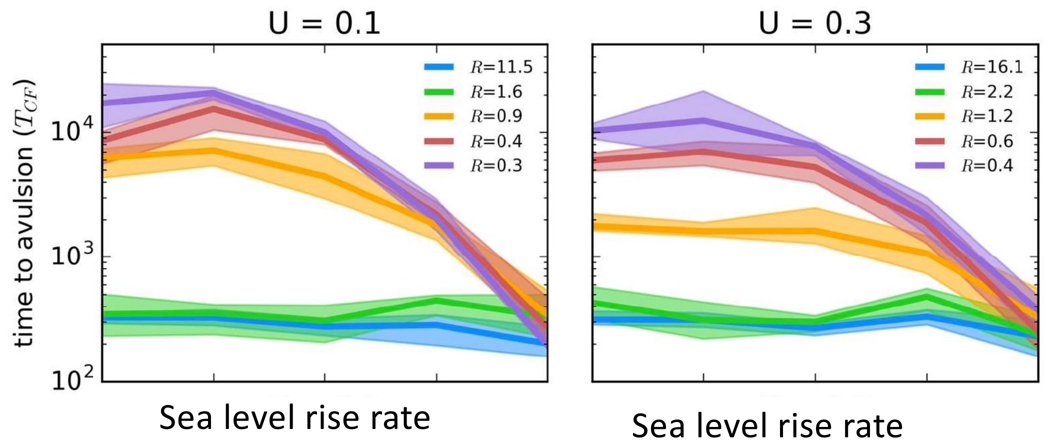
a Python toolkit for coupling and running Earth surface models

Install | Quickstart | User Guide | Examples | Reference Manual | Source

current
pymt components:

- Avulsion
- CEM
- Child
- ECSimpleSnow
- FrostNumber
- GIPL
- Hydrotrend
- Ku
- Plume
- Sedflux3D
- Subside
- Waves
- RAFEM

How does different wave diffusivity (offshore) affect progradation and in turn, upstream avulsion?



Ratliff, Hutton, and Murray, 2018 JGR-ES

https://github.com/katmratliff/rafem
https://csdms.colorado.edu/wiki/Model:RAFEM

pymt

a Python toolkit for coupling and running Earth surface models

Install Quickstart User Guide Examples Reference Manual Source

current
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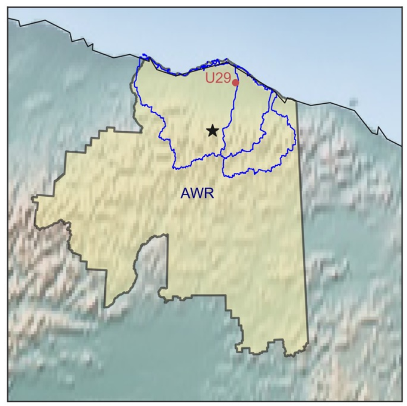
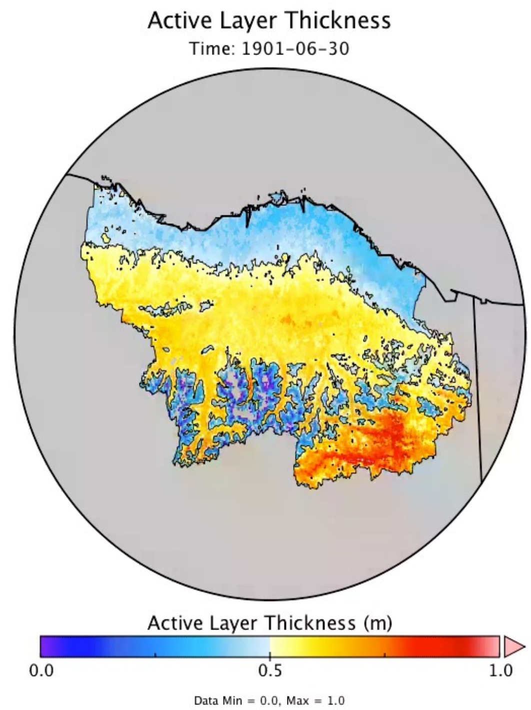
Subside
Waves
RAFEM



Predicting Permafrost Active Layer Thickness in Alaska



Think-Pair-Explore-Report Issues

Go to: https://pymt.readthedocs.io/en/latest/

Explore the pymt documentation and see whether you can find the
1) tutorial notebook on HydroTrend:

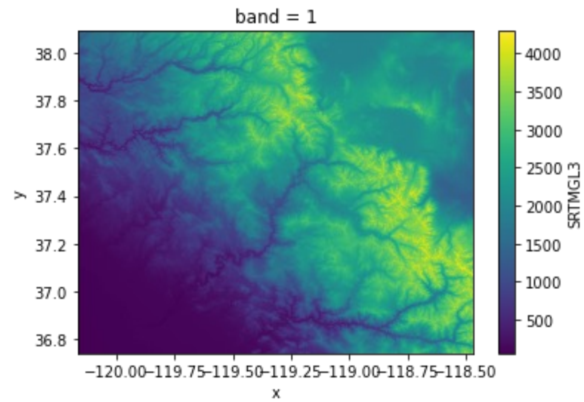
2) Tutorial notebook on a coupled model:
Coastal Evolution and Waves

Open either tutorial and see whether the notebooks work.
If they do not work, can we figure out how post an issue to the CSDMS helpdesk?
https://github.com/csdms/help-desk/issues
Any other options to try to run these notebooks?

Data Components

Implement a standard interface for key datasets that are useful input data for models

Tian Gan and Mark Piper work on these components.



Get raster topographic data from the Opentopography Repository

https://csdms.colorado.edu/wiki/Lab-0028

SoilGrids

Fetch subsets of gridded soil information from SoilGrids (https://www.isric.org/explore/soilgrids)

https://csdms.colorado.edu/wiki/Lab-0019

nwm

National Water Model data component – fetches data on streamflow

HANDS-ON EXCERCIZES

Hands-on Exercise 1 (15 mins)

- Open web browser and go to the CSDMS educational repository, under labs.
- Open the Cratered Landscapes notebook
- https://csdms.colorado.edu/wiki/Lab-0025

- Go to the jupyterhub
- Run the cratered landscapes notebook
- Make a change to the region of interest and visualize your DEM.

Hands-on Exercise 2 (15 mins)

- Open web browser and go to the CSDMS educational repository, under labs.
- Open the Open Topography Data Component
- https://csdms.colorado.edu/wiki/Lab-0028

- Go to the jupyterhub
- Run the topography notebook
- Make a change to the region of interest and visualize your DEM.

Landlab Hylands uses Toography data component

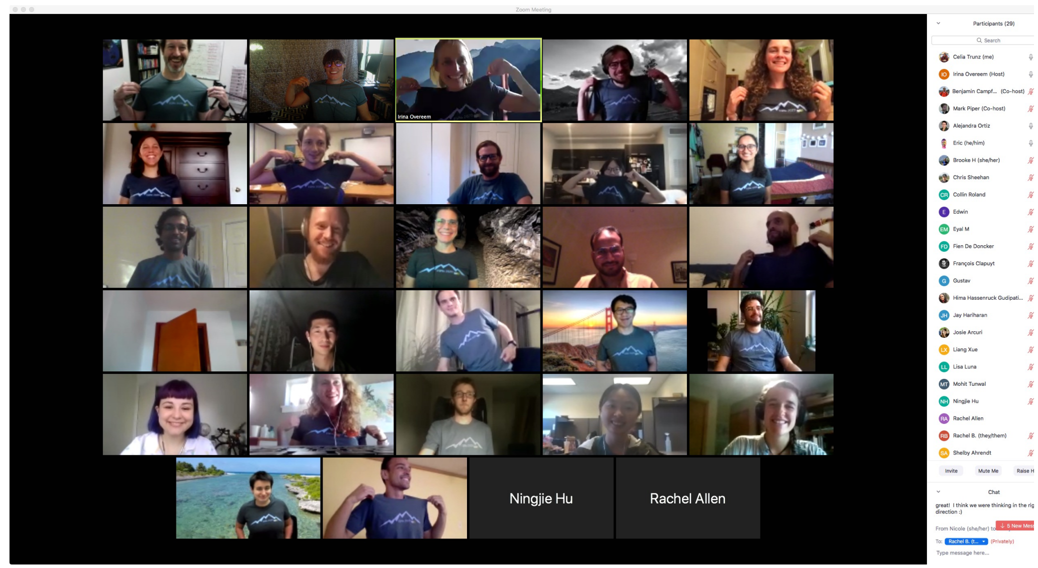
Explicit simulation of landslides in the python Landlab modeling toolkit

Bedrock landslides on existing topography (SRTM DEM)

This notebook provides a brief introduction and user's guide for the BedrockLandslider component for landscape evolution modeling. It combines two documents, a User's Manual and a notebook-based example, written Benjamin Campforts to accompany the following publication:

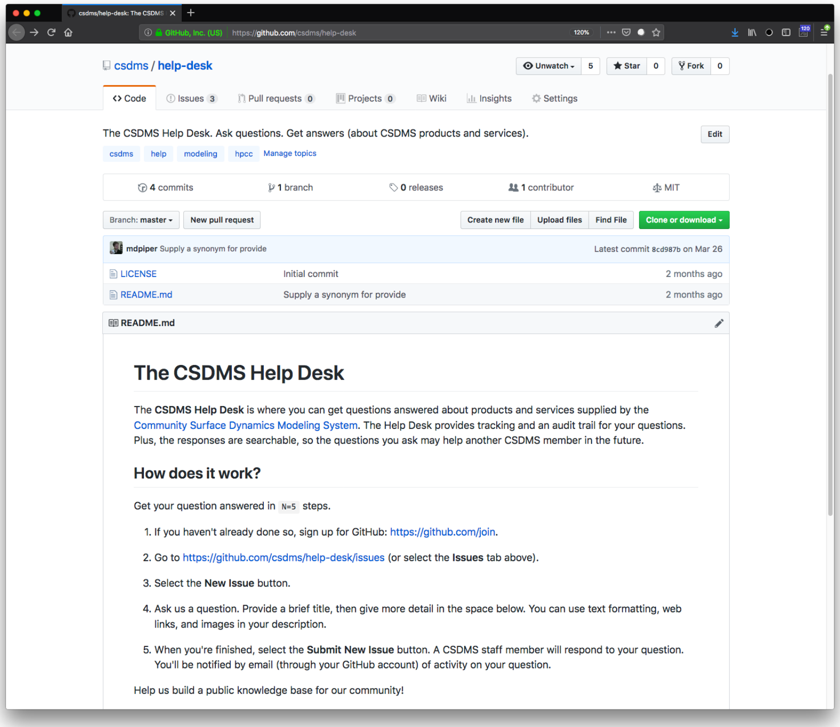
- Campforts et al. 2022, in review
- Campforts B., Shobe C.M., Steer P., Vanmaercke M., Lague D., Braun J. (2020) HyLands 1.0: a hybrid landscape evolution model to simulate the impact of landslides and landslide-derived sediment on landscape evolution. Geosci Model Dev: 13(9):3863–86.

Contributions



Cybertraining Earth Surface Processes Modeling Summer Institute 2020-2021 and 2022

More Help?



User Help Desk:
https://github.com/csdms/help-desk

Discussion (1)

- What are your teaching priorities with Notebooks?

- What topics need to be prioritized?
- What skills need to be prioritized?

Discussion (2)

- Can notebooks function as a stand-alone online resource?

- Are there creative solutions for joint online teaching with notebooks?
- A graduate student seminar focused on earth surface processes supported by notebooks?

Discussion (3)

- What are the precise guidelines
- How do we foster a culture of contributing notebooks as teaching resources
- Reminder in the newsletter, this is a broader impact!
- Would there be incentives for you to adapt your own class material for a larger audience?
- Acknowledgement of contributors
- Notebook award?
- Notebook abstracts at the meeting
- Any other creative ideas to make the resource more robusts and useable?

Have the notebooks in an overnightly testbed.
Version control is a learning goal and it is backups for students
Add extra documentation for their own local installation at the end of the notebook.

Summary

CSDMS and OpenEarthscape projects have new community jupyterhubs
https://csdms.colorado.edu/wiki/JupyterHub
Contact: DR. Mark Piper

- CSDSM and Landlab have suites of example notebooks on earth surface processes
- Now we can use data model couplings through BMI for Models and Data Components (contact dr. Tian Gan)

- We would love for people to use these in classrooms more, have had several faculty at a range of institutions use this resource.
- We would love even more if people would contribute their teaching notebooks.

References

- CSDMS: a community platform for numerical modeling of Earth surface processes. Tucker et al., 2022. Geosci. Model Dev., 15, 1413–1439, 2022. https://doi.org/10.5194/gmd-15-1413-2022

Acknowledgments

National Science Foundation under Award for the Community Surface Dynamics Modeling System – CSDMS 3.0

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National Science Foundation under Award for the Cybertraining Program Earth Surface Processes Modeling Institute 2020-2021-2022.