

# The Community Surface Dynamics Modeling System: Experiences on Building a Collaborative Modeling Platform

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**CSDMS**  
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

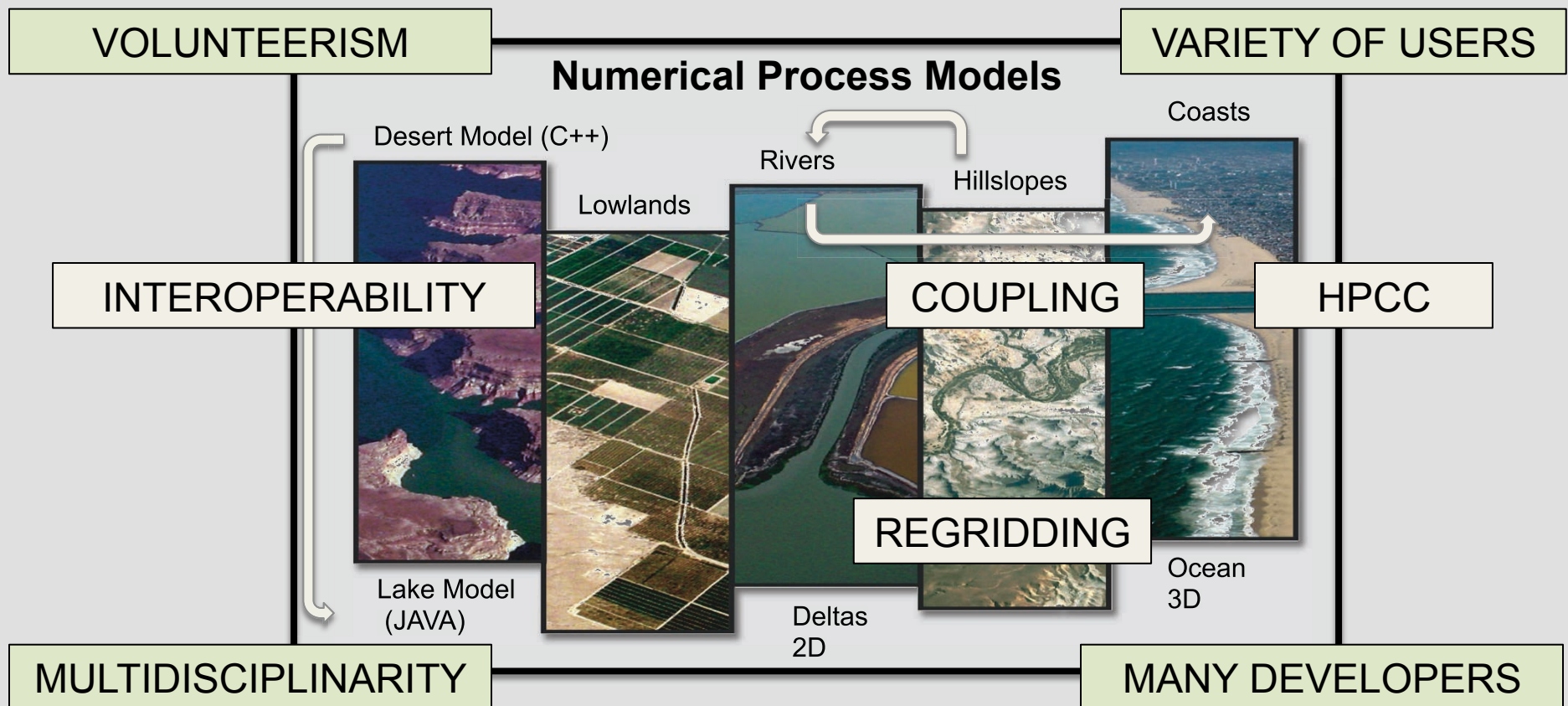
# Outline

- What is CSDMS?
- Overview of CSDMS Members and Governance
- Tools for Collaboration
  - 1) CSDMS Wiki
  - 2) CSDMS Modeling Tool
- Strategies for Transparent Model Development
- Data Analysis of Community Participation and Contribution
- Data Analysis Novice User Engagement
- Future

# What is CSDMS: the Community Surface Dynamics Modeling System

Develops, integrates and disseminates software to define the earth's surface dynamics by simulating the movement of water, sediment and nutrients through landscapes and seascapes.

**Grand Challenge: Building a Toolbox of Component Models with guidance and input of a large community of scientists**



# CSDMS Community



*Workshops, symposia & Working Group meetings*

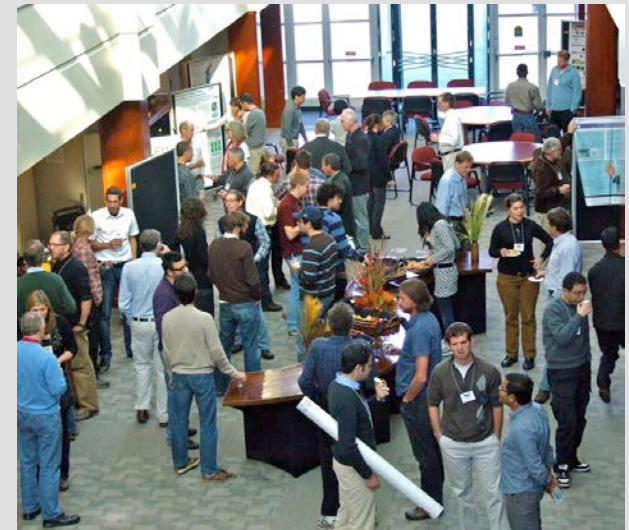


*12 CSDMS Short Courses (U.S.A., Germany, Korea, New Zealand)*

**CSDMS meets face-to-face, but is mostly virtual**

- Annual All-Hands Member Meeting (1/year)
- Working Group Meetings (1/year)
- Executive Committee Meeting (2/year)
- Steering Committee Meeting (1/year)

Beyond meetings we are a virtual community:  
CSDMS Wiki, Reports and Email Lists  
<http://csdms.colorado.edu>



*Annual all-hands meeting*

# CSDMS Community & Governance

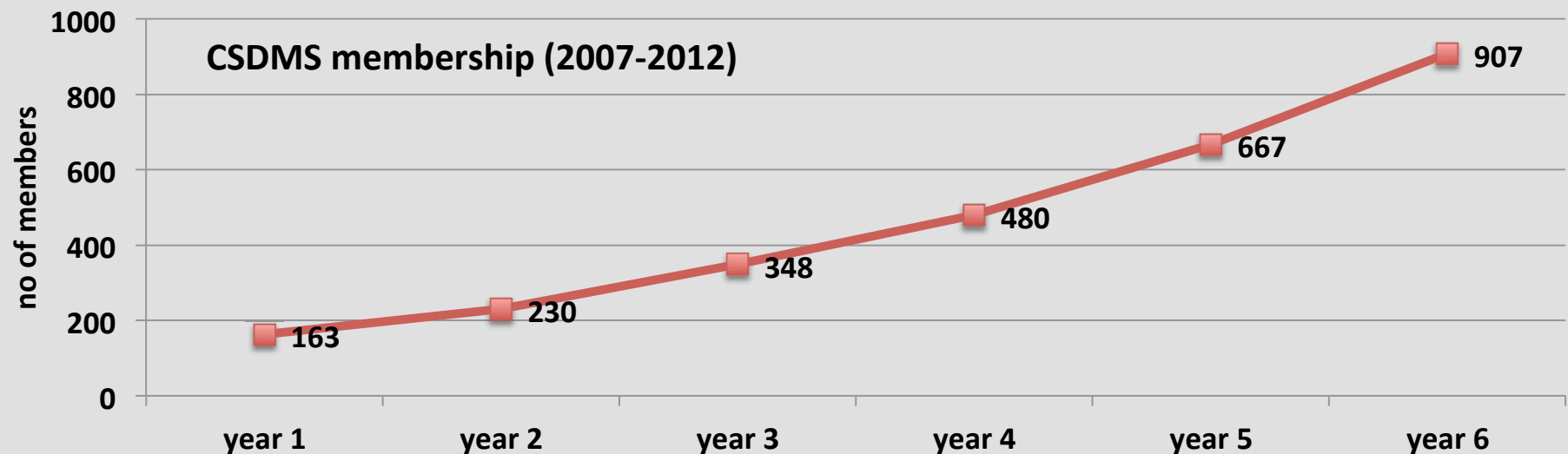
## Members

Terrestrial	417
Coastal	330
Hydrology	321
Marine	227
Cyber	142
EKT	135
Carbonate	63
Chesapeake	44

~Now 907 members

## Governance

- 8 Elected Working Group Chairs, CSDMS Director, and Senior Software Architect comprise the Executive Committee.
- 10 Steering Committee Members, (NSF Program Officer and CSDMS Director serve as ex-officio).



# CSDMS Wiki: a Platform for our Virtual Community

The image shows a screenshot of the CSDMS Wiki homepage. At the top left is the CSDMS logo with the tagline 'COMMUNITY SURFACE DYNAMICS MODELING SYSTEM'. To the right are 'create account' and 'log in' buttons, and a search bar. Below the logo is a navigation menu with items: Models, CMT, Supercomputing, Education, Data, Community, Meetings, Help, and Wiki tools. A central banner reads 'Explore Earth's surface with community software'. On the right side, a vertical list of links includes 'CSDMS for you', 'Get started with CMT', 'Contribute', 'Download', 'Announcements', and 'Help'. The main content area features a large banner with the text 'Welcome your chairs for the next years' and an image of goldfish, with a callout box stating 'Members Share in Governance'. Below this are two sections: 'Model highlight' with a sub-section 'Modeling Transition from Tidal Flat to Salt Marsh' and 'Science in the spotlight' with a sub-section 'Extensive Sands Deposited By Mississippi Floodwaters'. A callout box at the bottom center says 'Keep Members Engaged in Science'. On the far right, another callout box says 'Low threshold for users and contributors' with an arrow pointing to the 'Contribute' link.

Upfront Access to CSDMS Resources and Services

Wiki functionality allows member input

Members Share in Governance

Low threshold for users and contributors

Keep Members Engaged in Science

# Web-Forms for Model Metadata, Educational Material, Data

## Module questionnaire for module: Test

Make sure that after you complete the questionnaire you submit for your module will be created instantly on submission.

Summary Contact Technical specs In/Output Process Testing Other Comp

Module type

**Module name:** Test

**Also known as:**

**Module type:**

Module identity

**Module domain:**

- Model domain
- Carbonate
- Climate
- Coastal
- Hydrology
- Marine
- Terrestrial

**Spatial dimensions:**  
*(More options possible)*

1D      For example:

- 1.5D      • 1D: profiles
- 2D      • 1.5D: 2D projections extracted from 1

Summary Contact Technical specs In/Output Pro

Technical information

**Supported platforms:**  
*(More options possible)*

- Unix
- Linux
- Mac OS
- Windows

**Other platform:**

**Programming language:**

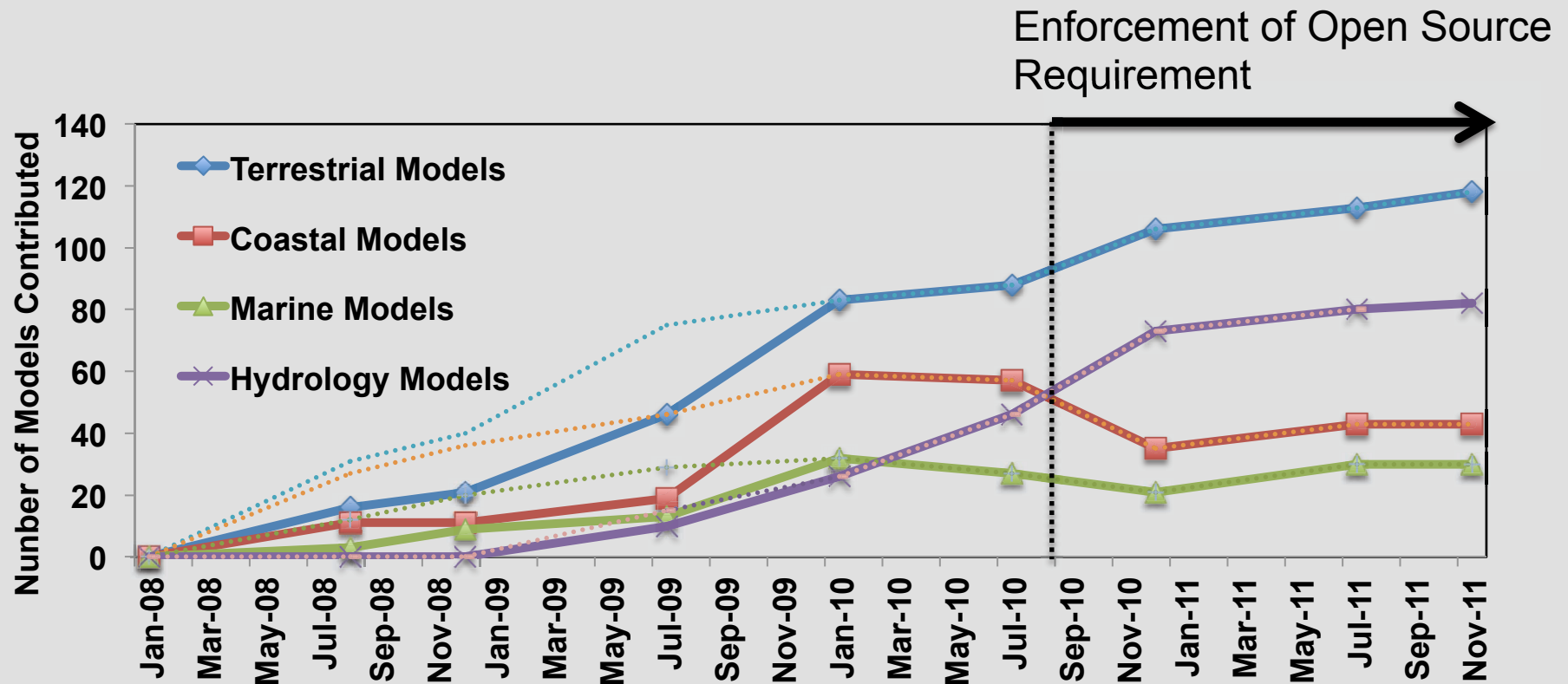
- Fortran77
- Fortran90
- C
- C++
- Python
- Java
- IDL
- Matlab

CSDMS requires metadata and source code, developer can submit through a web-based database.

[http://csdms.colorado.edu/wiki/Contribute\\_model](http://csdms.colorado.edu/wiki/Contribute_model)

CSDMS test whether code compiles. Metadata becomes accessible for everyone, code is archived in Subversion and downloadable.

# Open-Source Model Repository



- As of end 2012, 94 model developers (or teams) contributed their source code.
- Total of 165 models are now available (>6.7 million lines of code).
- Often different models for similar processes have been submitted
- Recorded 9788 downloads from 2008 onwards, 20 models have >100 downloads



# Governance through CSDMS wiki?

## Coastal models (51)

Program	Description	Developer	Voting results
2DFLOWVEL	Tidal & wind-driven coastal circulation routine	Slingerland, Rudy	0
ADCIRC	Coastal Circulation and Storm Surge Model	Luettich, Rick	0.73 (1 voter)
AlluvStrat	Rules-based model to generate a 2-dimensional cross section of alluvial stratigraphy based on fluvial processes	Wickert, Andy	👎
AquaTellUs	Fluvial-dominated delta sedimentation model	Overeem, Irina	👎
Avulsion A.k.a. <i>Debouche</i>	Stream avulsion model	Hutton, Eric	✅
CEM	Coastline evolution model	Murray, A. Brad	✅
CMFT	Coupled salt Marsh - tidal Flat Transect model	Mariotti, Giulio	1 (1 voter)
DELTA	Simulates circulation and sedimentation in a 2D turbulent plane jet and resulting delta growth	Slingerland, Rudy	1 (1 voter)
DROG3D	3-DIMENSIONAL DROGUE TRACKING ALGORITHM FOR A FINITE ELEMENT GRID WITH LINEAR FINITE ELEMENTS	Blanton, Brian	0
Delft3D	3D hydrodynamic and sediment transport model	Delft3D, Support	3.95 (5 voters)

'Online Voting' to Prioritize Models finds limited use

## Roadmap AquaTellUs component status:

Project owner CSMDS-IF: [Irina Overeem](#)  
 Start date project: 05/22/2011  
 Estimated release date: **12/31/2012**  
 Project status: 53%

## Milestone: Executable



Status	Task	Task owner	Information	Estimated completion date
✅	Provide metadata	Irina Overeem	<a href="#">More...</a>	02/12/2009

'Roadmap' Developers hardly use project timeline tracking on the wiki

# CSDMS CMT - component modeling tool

## CSDMS CMT Framework & Services:

- (1) Platform-independent Modeling Tool *CMT* (Linux, Mac OS X, Windows)
- (2) Language interoperability (C, C++, Java, Python, Fortran) with *Babel*;
- (3) Component preparation & project management using *Bocca*;
- (4) Low-level model coupling within a HPC environment using *Ccaffeine*;
- (5) Single-processor spatial regridding (*OpenMI Regrid*) or multi-processor spatial regridding (*ESMF Regrid*) – all grid types;
- (6) Component interface standards BMI & CMI;
- (7) Open-source standards (e.g. CCA, SIDL, OGC, MPI, NetCDF, OpenDAP).
- (8) Visualization of large datasets in a multiple processor environment (*VisIt*)
- (9) Message passing within the HPC environment using *MPI (MPICH)* & *OpenMP with PETSc* - Portable Extensible Toolkit for Scientific Computation

# Developed Tool for running CSDMS-component models

The image displays the CSDMS Modeling Tool interface. The main window shows a workspace for 'TopoFlow + GC2D'. A 'Driver' panel on the left lists various components, with 'TopoFlow' selected and circled in red. A 'Hydro Model: TopoFlow Parameters' dialog box is open, showing input parameters such as 'Component status: Enabled', 'Input directory: /data/sims/topoflow/treynor\_iowa/', and 'Output directory: ~/CMT\_Output/'. The 'Help' button in this dialog is also circled in red. In the background, a browser window displays the 'CSDMS Help System' with a tutorial titled 'Getting Started with TopoFlow 1.5 - A Short Tutorial'. The tutorial text includes an introduction to TopoFlow and a section on 'How to Set Up a Model Run'.

**Getting Started with TopoFlow 1.5 - A Short Tutorial**

**Introduction**

TopoFlow is a free, spatially-distributed hydrologic model with a user-friendly, wizard-style interface. TopoFlow evolved from the merger of a previous rainfall-runoff model based on DEM-derived D8 flow grids and a model called ARHYTHM that was designed and tested for modeling Arctic watersheds. For this reason, it offers sophisticated methods for modeling temperature-dependent processes such as snowmelt, evaporation, infiltration (frozen ground) and shallow subsurface flow. TopoFlow is highly modular and was designed to be user-extensible. In virtually every input dialog, users also have the flexibility of entering any input parameter in any of the following forms:

... used for every pixel and all times)  
(to be used for every pixel)  
(to be used for all times) or  
... (corresponding to the timestep for that process).

... features that sets TopoFlow apart from most other spatial hydrologic models.

... the Data Language) source code for TopoFlow is open, but subject to a [license agreement](#). By any ... represents a substantial programming effort. Version 1.5 consists of about 40,500 lines of IDL ... (normal comments). Assuming 60 lines per page, printing out the source code would therefore require ... written in a lower-level language like C, it would require at least 5 to 10 times more code.] ... in progress by multiple programmer-hydrologists and we welcome feedback and bug reports from

... work with TopoFlow, you may find it helpful to review the concepts behind spatially-distributed ... One paper that you might find helpful is a draft book chapter on spatial hydrologic modeling written ... a), for an Elsevier book called **Geomorphometry**. Another paper that contains a great deal of ... information is the one by [Zhang et al. \(2000\)](#), that describes the ARHYTHM model. If you would like ... the point-and-click, hydrologic GIS program called RiverTools, you may also be interested in this ... written by [Peckham \(2007b\)](#), also for the **Geomorphometry** book.

Additional information is available on the official TopoFlow website at: <http://instaar.colorado.edu/topoflow/>.

**How to Set Up a Model Run**

**Step 1.** Obtain a DEM (digital elevation model) for the basin that you wish to model. If the DEM has dimensions greater than about 300 columns and 300 rows, then it is usually best to subsample the DEM (by averaging) to have dimensions in this range. Using larger DEMs will result in longer model runs and may result in RTS files (RiverTools Sequence) for which you do not have enough space on your hard drive. It is good to start with smaller DEMs and then to increase the size/resolution of your DEM for subsequent model runs if you determine that higher resolution is necessary and you have sufficient time and disk space. Tools for mosaicking, subsetting and subsampling DEMs are available in hydrologic GIS software such as RiverTools 3.0.

**Step 2.** Create a D8 flow grid, area grid, slope grid and Horton-Strahler order grid for your DEM using RiverTools 3.0 or a similar program. The flow grid should be computed, if necessary, to have the RiverTools flow codes (the standard

**Online Wiki-Based CMT 'help system' avoids black-box syndrome  
Designed to become an interactive user platform, tightly linked to CSDMS wiki.**

# Model Coupling Example

The screenshot shows the CSDMS Modeling Tool interface. At the top, there is a menu bar (File, Edit, View, Tools, Help) and a toolbar with icons for file operations and execution. The main workspace displays a diagram of a coupled model system. The diagram includes a 'Driver: CEM' box on the left, which is connected to three component boxes: 'Component: Avulsion' (labeled 'Delta Avulsion'), 'Component: Waves', and 'Component: HydroTrend'. The 'Delta Avulsion' component has 'Discharge' and 'Elevation' outputs. The 'Component: Waves' has a 'Waves' output. The 'Component: HydroTrend' has a 'Discharge' output. A 'CMT Console' window at the bottom shows the following text:

```
Return value: False
for command [ -f ~/.cmt/cmt_project_list.cfg ] && echo True || echo False
*****
Checking working directory status of ~/CMT_Output/
Directory exist...
```

Running CMT allows a user's computer to become a client that connects remotely to a server on the CSDMS HPC cluster, where the model computation takes place



Coupled code has 3 legacy models and 1 new model of > 7 developers linked.

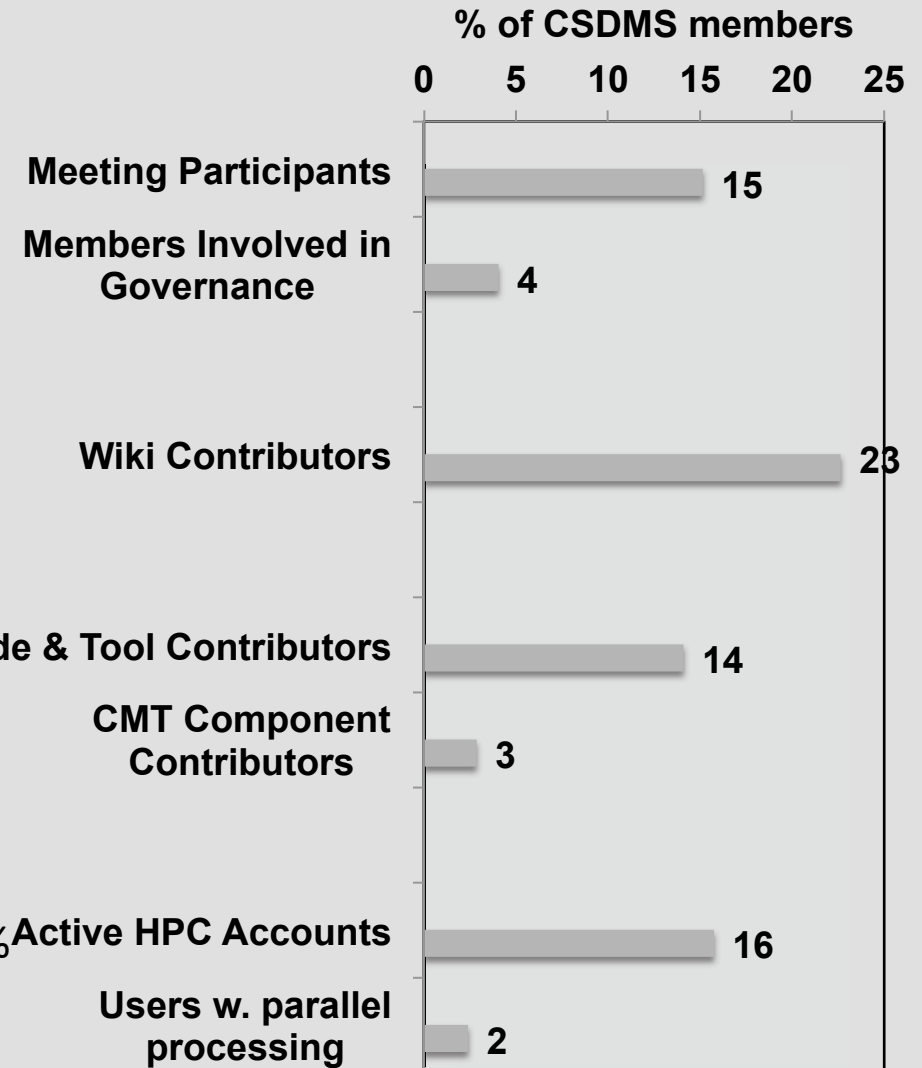
# Community Participation

## Volunteers vs. Staff

Funded staff has an essential role in web development, coupling software development, education of modelers, development of data and teaching resources.





About 23% of members contributed edits to the wiki, still the greater part of web building and editing is done by the web specialist and staff.

Protocols for the CSDMS infrastructure are entirely designed, developed and documented by CSDMS-funded staff, with critical feedback from volunteers. About 14% of all members are most active code contributors, IF staff contributed ~20% of models and tools.



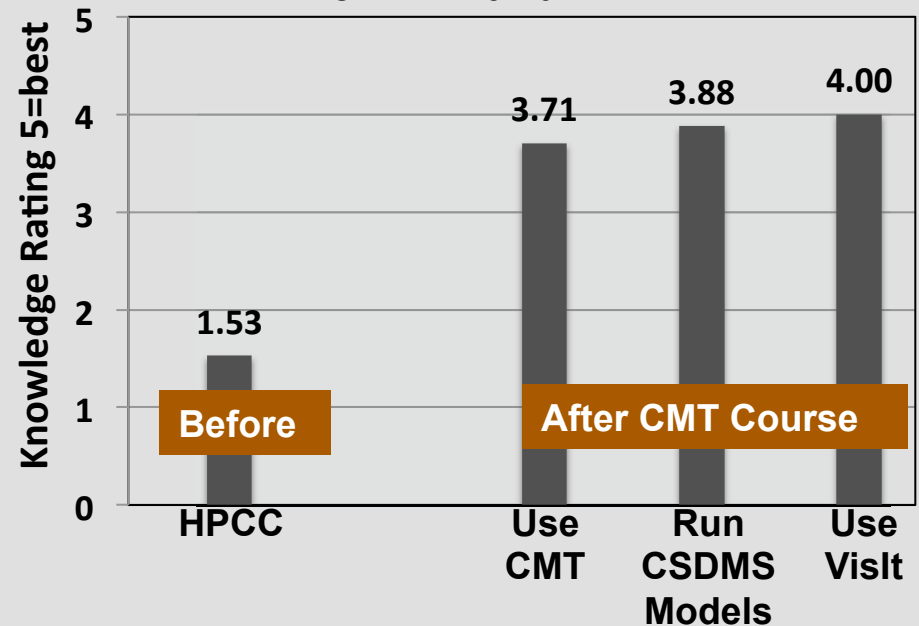
# CSDMS Engagement of Novice Users

## Instructional videos

Description	Link
<p><a href="#">How to connect to the supercomputer</a></p> <p>An instructional video that shows how to connect to the CSDMS High Performance Computer Cluster (HPCC; beach) and the CSDMS Modeling Tool (CMT; model coupling GUI).</p>	
<p><a href="#">How to contribute to the CSDMS repositories</a></p> <p>A step by step video of how to contribute a model to the CSDMS model repository and show how to edit your entries.</p>	
<p><a href="#">How to use the model repository</a></p> <p>A brief video of how to use the model repository</p>	
<p><a href="#">How to become a member</a></p> <p>A short description of how to become a member and what are the benefits of a CSDMS member.</p>	

CSDMS instructional videos offer step by step instruction on how to use the various tools and facilities of CSDMS.

## Graduate Student Learning of CMT and HPCC



Courses engage students in modeling and HPC-simulations (2 credit graduate course, 2 day summer institute / every year)

## Future CSDMS

- Discussion is ongoing to expand governance of increasing working groups, to include co-chairs or core-teams.
- CSDMS wiki can be a platform for discussion and user interaction.
- Increase ease-of-use of CMT:
  - 1) A web-based Component Modeling Tool will allow users to run coupled models directly through a web browser
  - 2) Pre-built executables of models and tools able to run on a wide range of platforms, should facilitate use.
  - 3) Automate 'wrapping' processes to allow legacy code in the repository to become CSDMS components faster