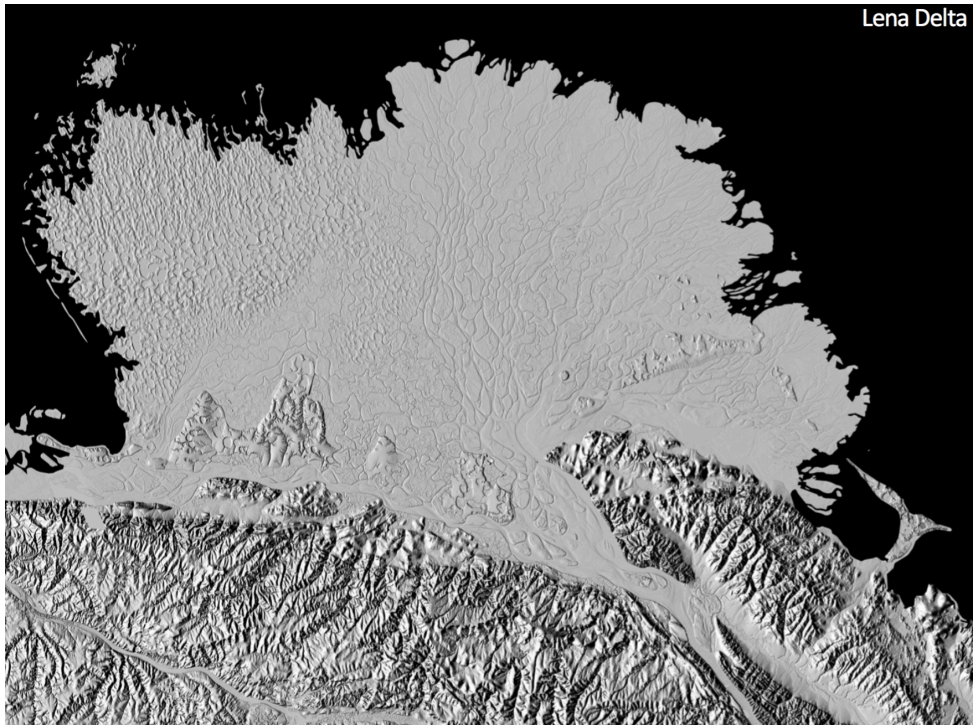
Using High Resolution Topography Data in Numerical Models

Irina Overeem

Community Surface Dynamics Modeling System
University of Colorado at Boulder

Talk Outline

- Introduction into Community Surface Dynamics Modeling System
- How do modelers perceive HRT data?
- Examples of use of HRT in numerical models
- What are challenges and opportunities?



Arctic DEM from SFM Digital Globe data, Courtesy Mike Willis

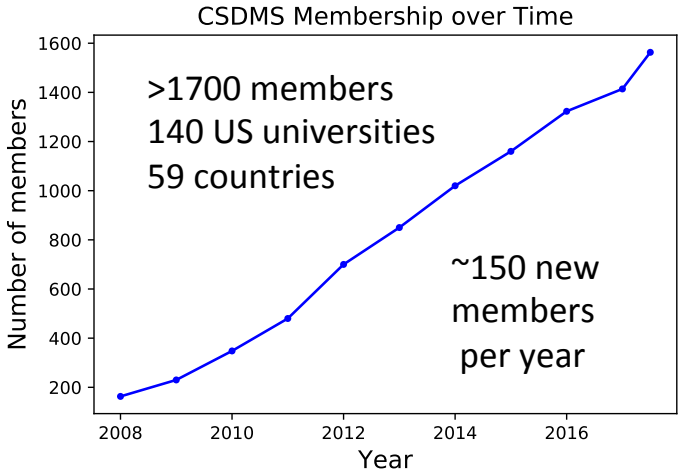
Introduction on CSDMS

Community Surface Dynamics Modeling System

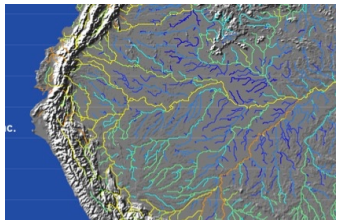
Develops, integrates & disseminates software to define the earth's surface dynamics by simulating the movement of fluids, sediment & solutes through landscapes, seascapes, and their sedimentary basins.

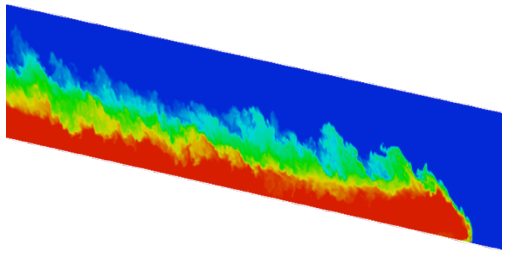
https://csdms.colorado.edu/

CSDMS COMMUNITY



- Hosts **annual meetings**
- Distributes and enhances **community-developed modeling software** *(223 models, 86 tools)*





CSDMS COMPUTING

- Builds, distributes, and maintains **model-coupling and development frameworks** *(WMT, PyMT, Landlab)*
- Helps users transition to **High-Performance Computing**
- Provides **engineering support** to investigators
- Develops **standards and protocols** *(Basic Model Interface, CSDMS Standard Names)*

CSDMS EDUCATION

- Runs **clinics, workshops, and short courses**
- Disseminates **educational resources**
- Provides **online training materials**

Strategic goals of CSDMS with relevance for high resolution topography

“to embrace the modeling challenge posed by today’s revolution in earth-surface data. The ongoing data explosion offers modelers the opportunity to expand the understanding of, and ability to forecast, the dynamics of our planet’s surface by confronting models with data and enhancing validation.”

Relevant goals for next 5 years:

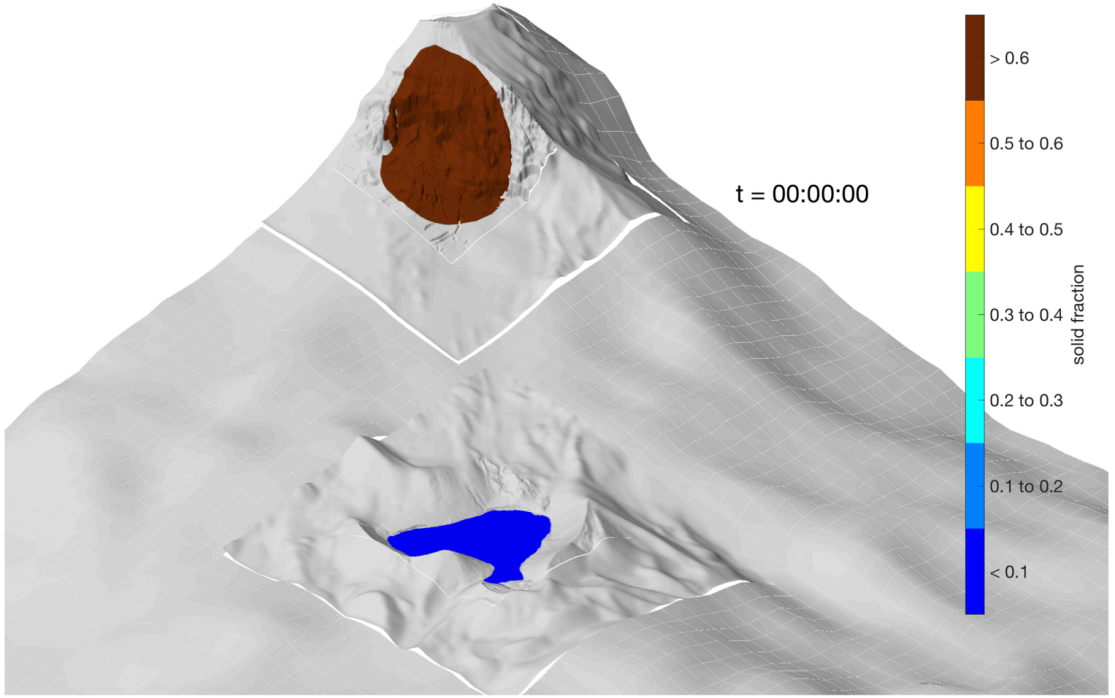
Better data-model synthesis, advancement of GIS capability and CSDMS modeling framework, make available ‘data components’.

HRT data and landslide/lake outburst modeling

Sisters, OR, Carver Lake outburst flood

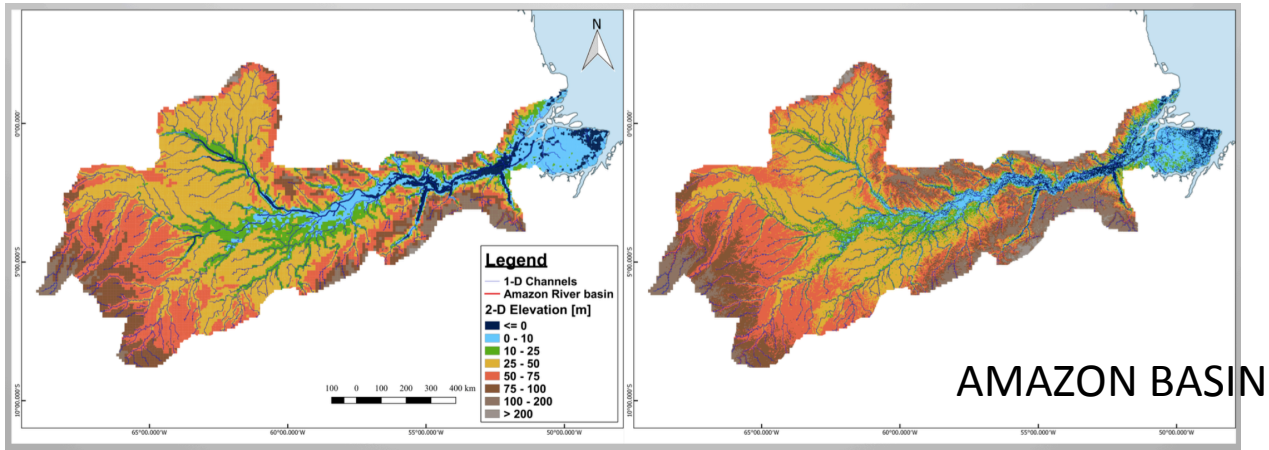
From David George & Richard Iverson, USGS

Sisters, OR, hypothetical landslide and dam failure



Clawpack numerical modeling of debris flow into lake triggering a tsunami.
Prediction of cascading hazards at high resolution

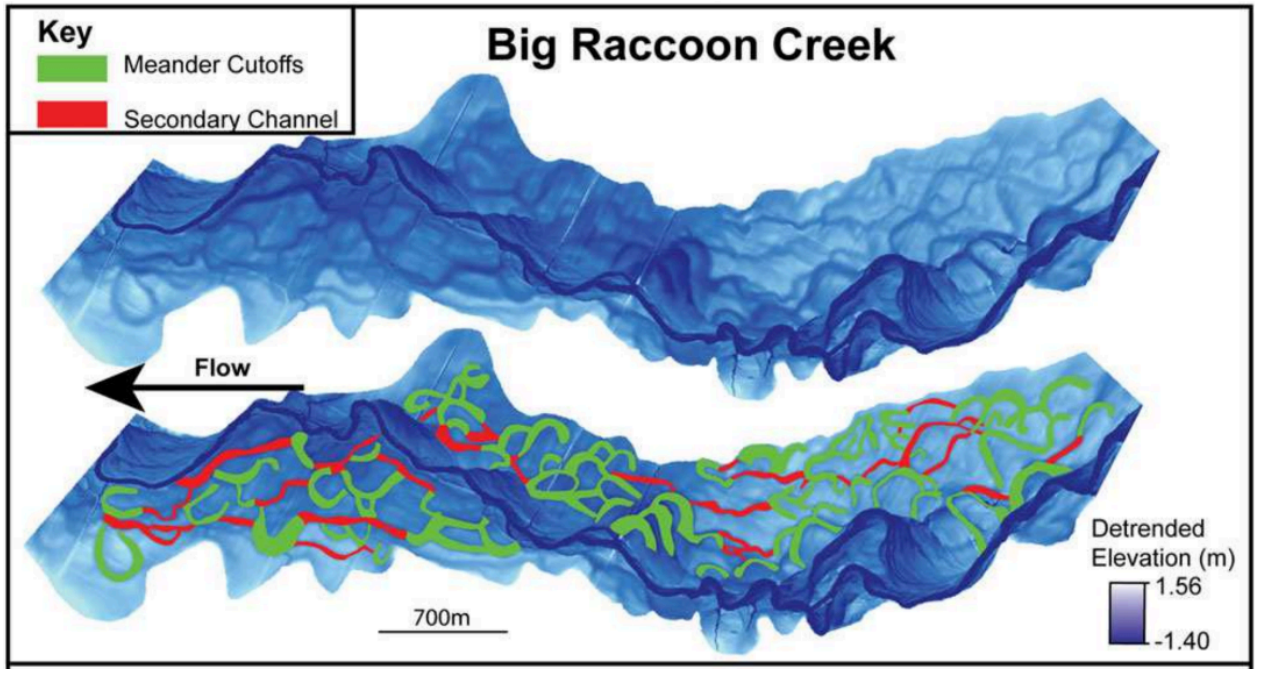
Flood Modeling at global – regional – local scale



Delft3D Flexible Mesh:	
Spatial Resolution:	2 – 10 km
Nr 2-D cells:	41,207
Nr 1-D cells:	12,185

LISFLOOD-FP:	
Spatial Resolution:	2 km
Nr 2-D cells:	174,982
Nr 1-D cells:	17,119

Courtesy Jannis Hoch, Utrecht University, The Netherlands



From Scott David, Indiana University, USA

- State-of-the-art coupled hydrological and hydrodynamic models at the continental of global scale use **2 – 10 km resolution** for topographic data (coupled Delft3D-CaMa-LISFLOOD).
- State-of-the-art hydrological and hydrodynamic models at the regional scale use **30m resolution** for topographic data (Wing et al., 2017, LIS-Flood for continental US).

Validating of model predictions with expert data, post-event SAR data

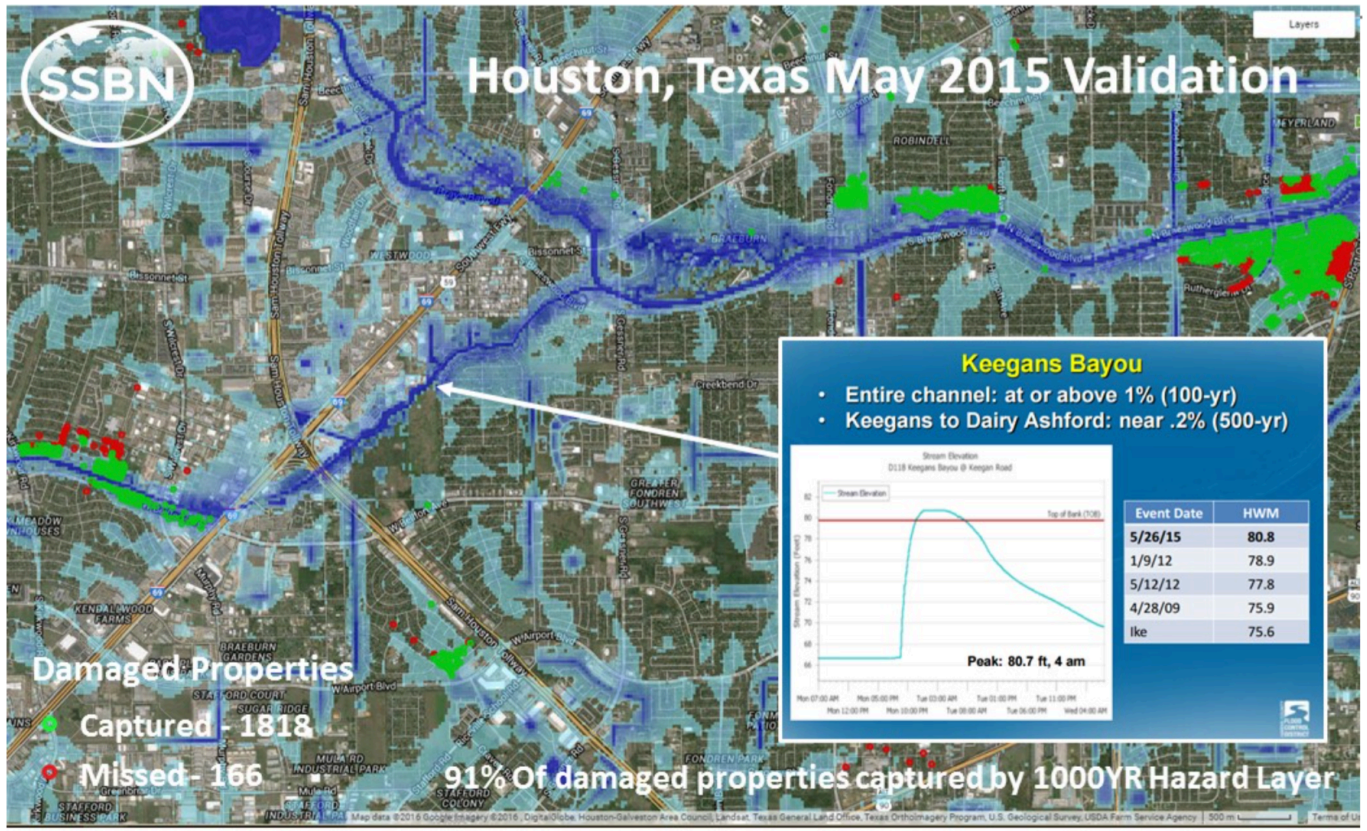


Image courtesy Paul Bates

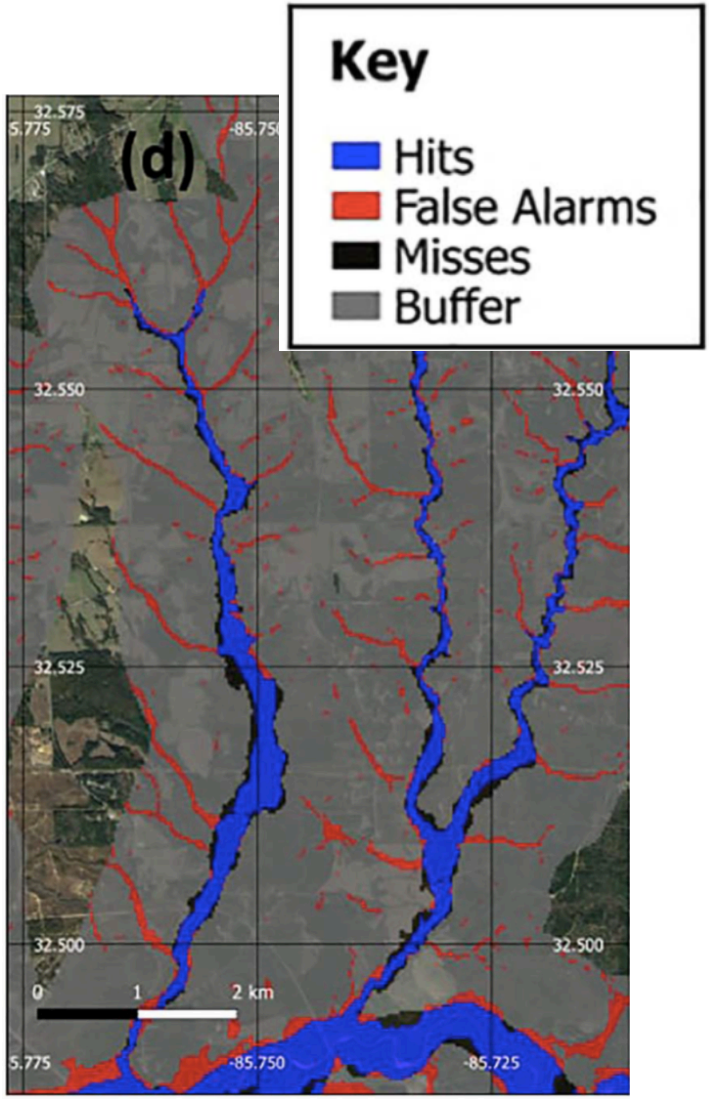
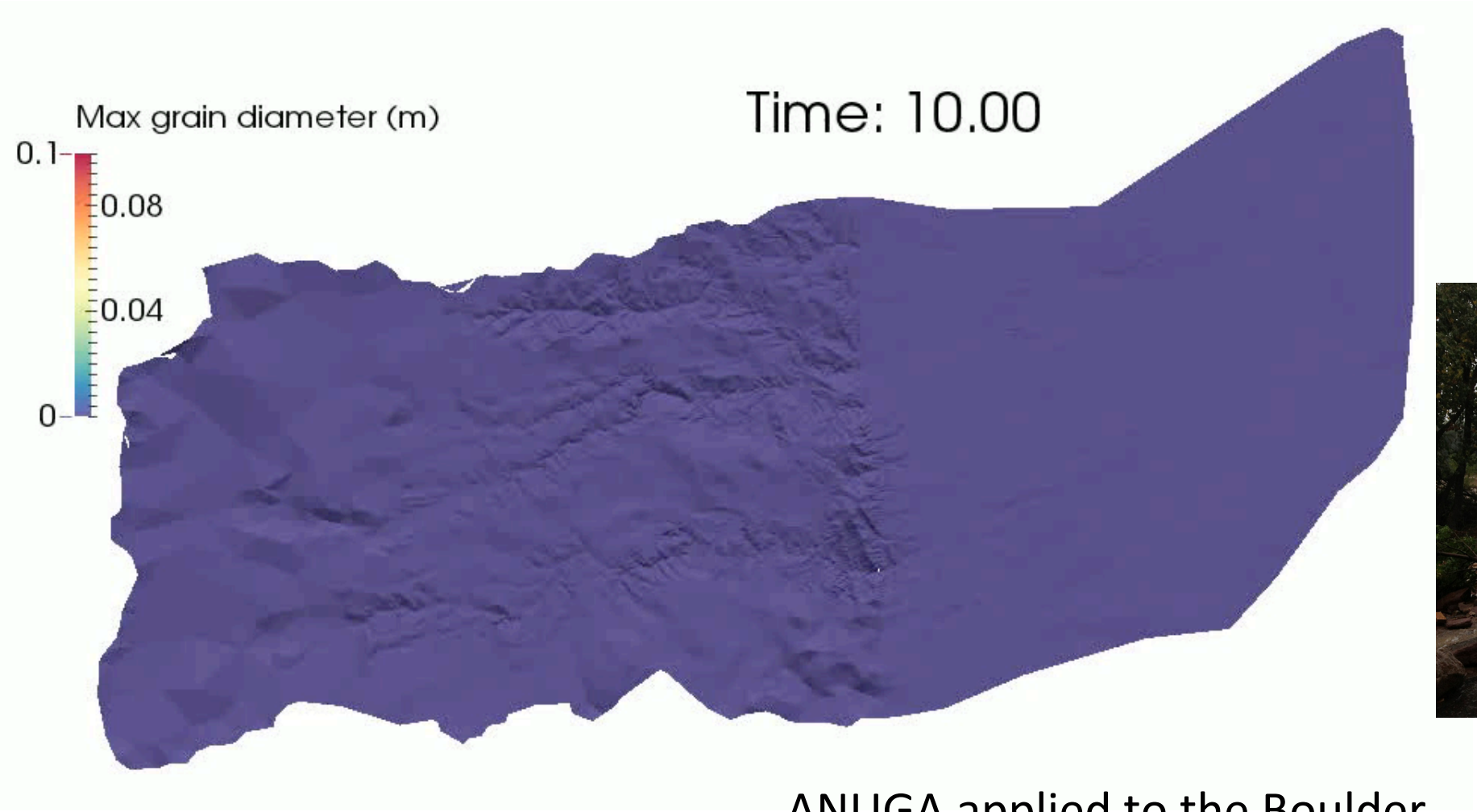


Image courtesy Paul Bates

Wing, O. E. J. et al. (2017), Validation of a 30 m resolution flood hazard model of the conterminous United States, Water Resour. Res., 53, 7968–7986, doi:10.1002/2017WR020917.

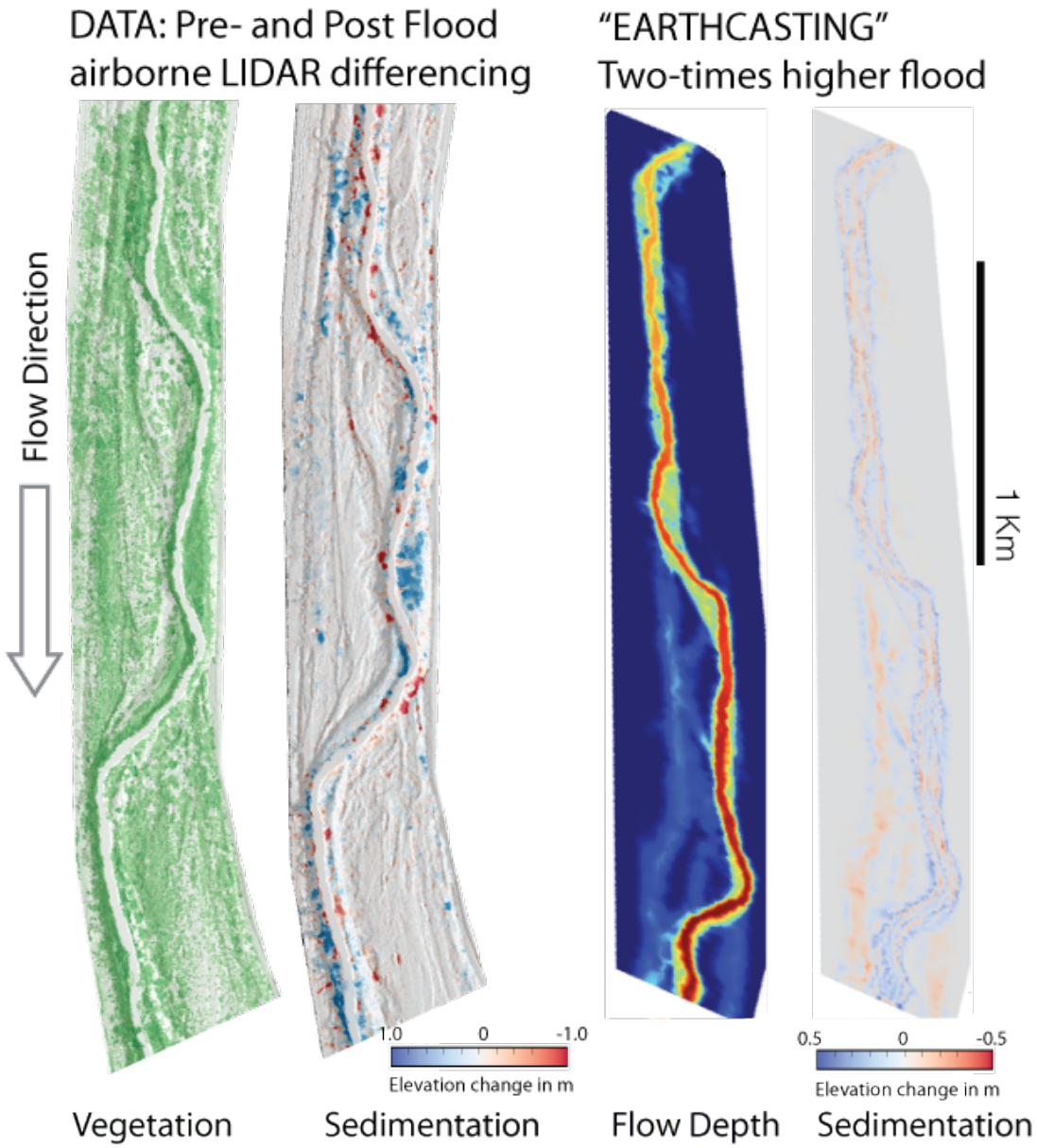
Sediment Transport Proxy using ANUGA Flow



ANUGA applied to the Boulder Floods, September 2013

Courtesy: Mariela Perignon, Univ of CO

Pre- and post event LIDAR data for model validation

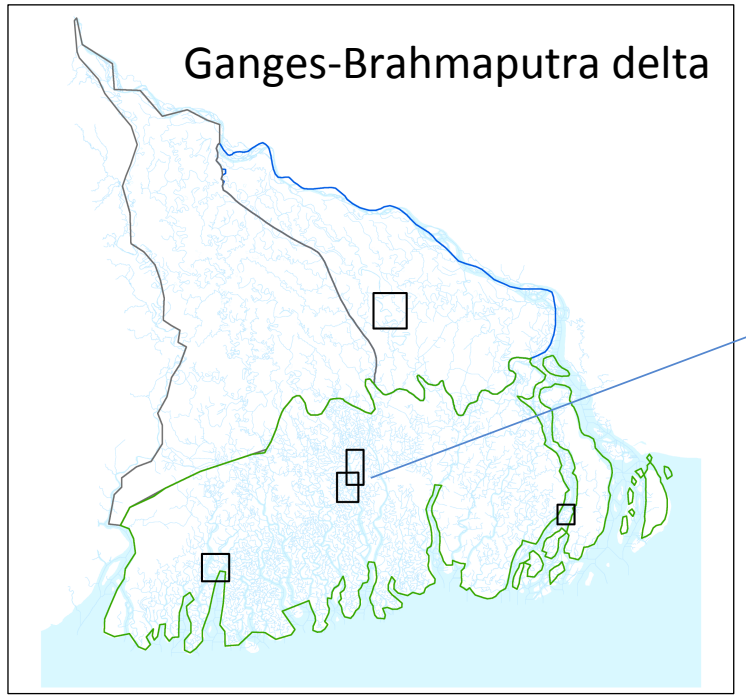


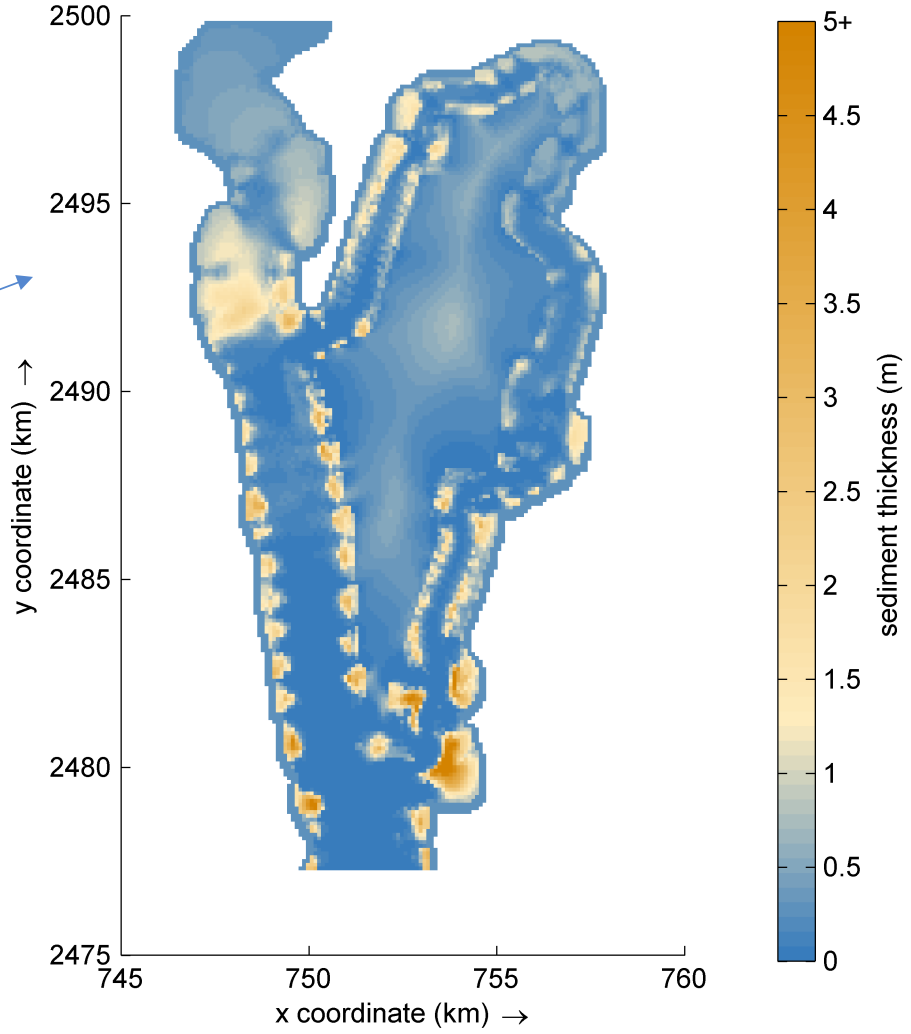
ANUGA-SED coupled with a vegetation module used LIDAR data from the Colorado River Flood Release.

Simulation of a geomorphically-effective flood released from Morelos Dam on the Colorado River delta. The flood stage at Morelos Dam is twice the stage of the 2014 pulse flood. (left) Flow depth, (right) topographic change after 1hr of simulation.

Courtesy: Mariela Perignon, Univ of CO

Sedimentation Modeling in Ganges Deltas





Discharge flows into the looped tributary preferentially

Deposition occurs in the northern portion of main channel as velocity drops

Overbanking causes deposition on the leveed portion of the Shibsa river

Floodplain deposition occurs in the interior-most zone

Nesting Approach: find representative zones, use Delft3D to model high-resolution case-studies (@15 m res).

Courtesy Jordan Adams – in prep 2018.

Protocols

- **CSDMS Basic Model Interface (BMI)** defines a common set of functions needed by models to be able to communicate with one another
- **CSDMS Standard Names** defines a common vocabulary needed by models to be able to communicate with one another

- NetCDF descriptions!

Main points

- Modeling community is excited by the prospect of input of high resolution topographic data, resolution is ‘too high’ for many applications.
- Huge opportunity to advance process knowledge and test model parametrization, especially in case of pre-post event HRT data availability.

- Cautionary note: massive runtimes for high resolution numerical modeling. Better parallelization is imperative.
- Cautionary note: other process data needs to be spatially dense to match HRT data.

- Coordinate between the HRT RCN and CSDMS on how data is made available in a format that is easy to use for modelers (NetCDF being the standard format).

Questions?

More information on CSDMS

https://csdms.colorado.edu/