

# The National Center for Earth-surface Dynamics: version 2.0

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## INTRODUCTION

From 2002 to 2012, the National Center for Earth-surface Dynamics (NCED; <http://nced.umn.edu>) was funded by the National Science Foundation (NSF) as a Science and Technology Center (STC) focused on predicting the evolution of the coupled landscape-water-biotic-human system that comprises the Earth's surface. During that time, NCED carried out research (<http://nced.umn.edu/publications>) and also established a number of community-oriented initiatives in keeping with its status as the first-ever STC devoted to the integrated science of the Earth's surface. The research landscape has changed a great deal since 2002: a new focus group and a new journal devoted to Earth and planetary surfaces were launched at AGU, with parallel developments at EGU; work on creating a vision for the Earth sciences included a prominent role for surface dynamics in the 2009 NSF GeoVision report (NSF Advisory Committee for Geosciences 2009), together with two major surface-focused NRC reports (National Research Council 2010; National Research Council 2011); and a remarkable number of large-scale surface-focused initiatives launched in this period, including the Community Surface Dynamics Modeling System (CSDMS), National Center for Airborne Laser Mapping (NCALM), Critical Zone Observatories (CZO), Delta Dynamics Collaboratory (DDC), International Year of Deltas (IYD) (Foufoula-Georgiou et al. 2011); and the Sediment Experimentalist Network (SEN; see the companion article in this issue). It has been an exciting time!

In view of this growth, and of NCED's success in promoting and providing a stable, visible center for this diverse scientific community, the NSF programs most closely involved with NCED decided to support a continuation of its community-oriented activities. This new, much smaller center carries the same name, but we refer to it informally as "NCED2". NCED2, like the NCED STC, is headquartered at St Anthony Falls Laboratory (SAFL) of the University of Minnesota, Minneapolis. Here we provide a summary of NCED2's main activities and invite the community to join us in shaping and participating in the NCED2 program: by providing input on future themes, suggesting and

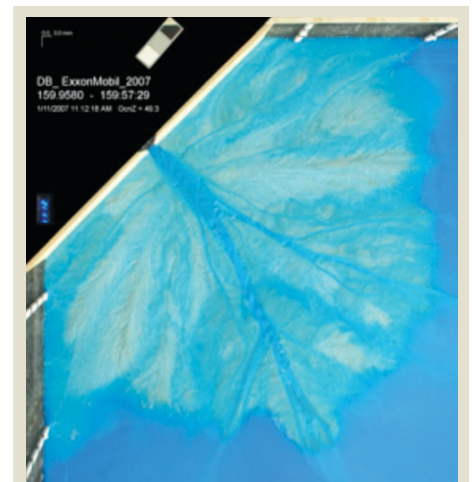
joining in community experiments, participating in postdocs, visits to SAFL or affiliated facilities, and/or proposing your own ideas for using NCED2 to promote collaborative Earth-surface research. You can reach us via the website above or by contacting the us (the authors) directly.

*Lessons from the NCED STC.* The 10-year lifespan of the NCED STC gave us time to experiment with a variety of means of growing the NCED research network. Among the best ideas to emerge from NCED have been (1) its 'extended family' model for mentoring students and postdocs; (2) hosting community activities such as workshops and shared field and experimental facilities; (3) serving as a focal point to help catalyze and launch new programs; (4) hosting focused, ambitious research activities that afford opportunities for community participation through extended visits (e.g. the StreamLab community-experiment program (Singh et al. 2013; Wilcock et al. 2008)); (5) close integration of research with informal education and Native American education, by development of a long-term working partnership with key institutions and people; and (6) hosting workshops and summer institutes, both strongly focused on young scientists. The main goal of NCED2 is to expand, extend, and build on the successes of the NCED STC.

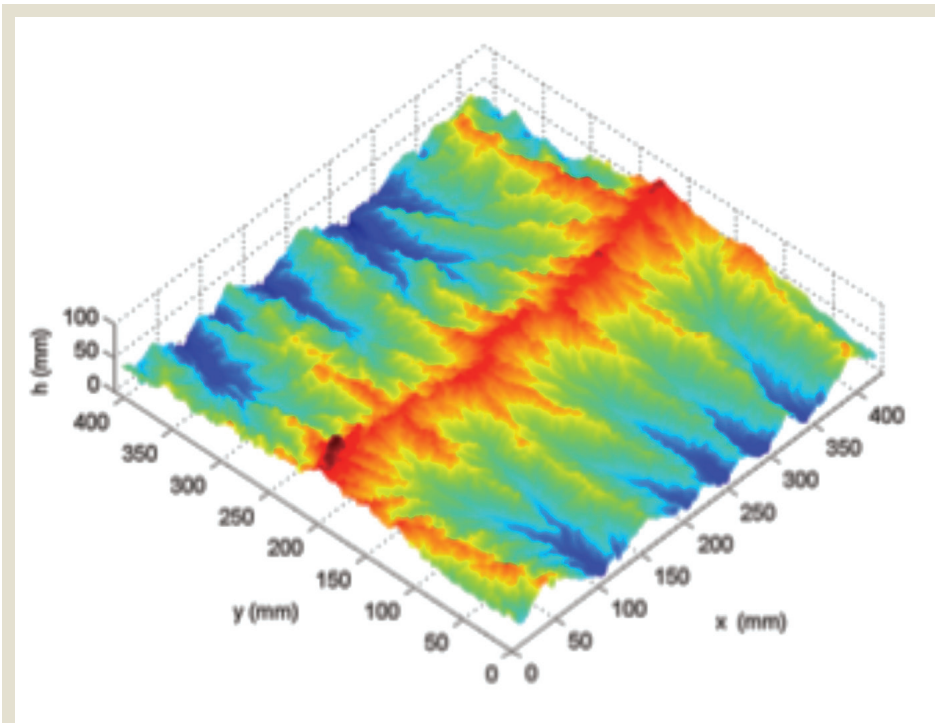
*NCED2.* The core of NCED2 is a set of linked programs open to participation by the broad ESD research community. The centerpiece of this effort (detailed below) is a program of research theme years focused on emerging research areas in Earth-surface dynamics. The theme years comprise a set of workshops, experiments, postdoc opportunities, visitor programs from undergraduate through faculty level, and informal education and Native American activities, all linked through that year's theme. These linked program components allow a broad range of surface scientists to collaborate in new ways, enhancing and accelerating their individual efforts to advance surface dynamics, as well as moving us closer to the vision of a quantitative, transdisciplinary, and predictive science of the Earth-surface environment – the scientific basis for predicting Earth's future in the face of changing climate and human influence.

open to community input; for the second full year of operation we have proposed the theme *Complexity and predictability of geomorphic systems*. We invite our colleagues to contact us with input on these and ideas for future themes (suggestions from junior colleagues are especially welcome).

*Community experiments.* Theme year community experiments focus on that year's theme, and are designed to provide data and a unifying experience for NCED2 participants. They can focus on a range of environments, from eroding uplands (Fig. 1) to deltas (Figs. 2, 3) and the submarine realm. The advent of the Sediment Experiment Network (SEN; see article in this issue) even opens the way to doing sets of community experiments in parallel. We also aim to coordinate the experiments with theoretical research (Fig. 3) such that they are mutually informative and inspiring; and with field programs to complete the triad of field-experiment-theory. As with SEN, this effort is greatly enhanced by the advent of sustained, long-term field sites such as the Wax Lake Delta FESD site (WLD) funded by NSF's Frontiers on Earth Surface Dynamics (FESD) program, the Minnesota River Basin Observatory funded by NSF's Water Sustainability and Climate (WSC) program, and Critical Zone Observatories (CZOs (Anderson et al. 2008; Brantley et al. 2007)).



**Figure 2:** Overhead image of a weakly cohesive experimental delta. Courtesy John Martin, Shell.



**Figure 1:** DEM of experimental erosional landscape formed under uniform precipitation rate and uniform uplift rate. Courtesy Arvind Singh, SAFL

## THE NCED2 PROGRAM

The NCED2 program comprises a set of linked activities designed to make NCED2 a true research commons for Earth-surface dynamics. These components are unified by the core idea of theme years under which all NCED activities in a given year will revolve around a research theme chosen with input from the research community and our Advisory Board. The theme-year idea is based on the format developed by the University of Minnesota's very successful Institute for Mathematics and Its Applications (IMA) ([www.ima.umn.edu](http://www.ima.umn.edu)). St Anthony Falls Laboratory (SAFL) provides a focal point for theme-year research via shared experiments, designed and run by the theme-year participants at SAFL and with the support of experienced SAFL staff. SAFL has just completed a major renovation, supported by NSF's Academic Research Infrastructure (ARI) program. Among other things, the renovation allows SAFL facilities to be shared virtually with the broader community, not only after the fact but also through real-time web-based

participation in experiments. The main program components are summarized in the sections below:

*Theme years.* As discussed above, the basic idea is that all NCED2 activities in a given year revolve around a single broad theme. The themes will be selected by the Advisory Board each year with input from the broader community. Theme selection criteria are:

1. Potential impact and topicality
2. Suitability for NCED2 facilities and capacity
3. Community support and enthusiasm (e.g., early commitments to participate)
4. Breadth and potential to attract wide participation
5. Broader impact and relevance to society and policy
6. Potential for fostering interdisciplinary research across NSF programs and Divisions

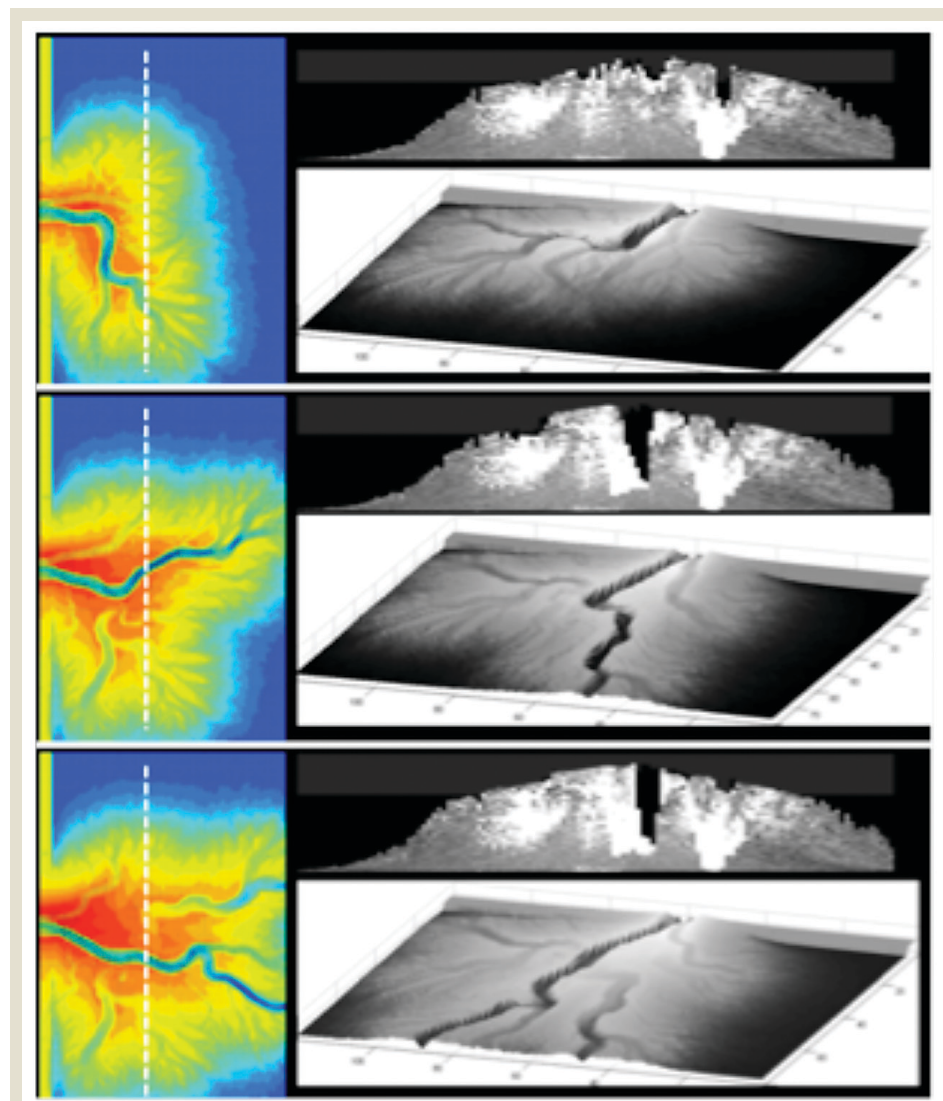
To get things started, we launched NCED2 with the theme *Subsurface to surface: recovering dynamics from stratigraphic records*. For future years we are

*Synthesis Postdocs.* Postdoctoral researchers will be the heart of the NCED2 program. The postdoc program is based on the NCED STC's 'synthesis postdoc' program, originally designed to nucleate small, innovative research teams within NCED, anchored by a dedicated postdoc. The new postdoc program is open to all, and we especially encourage junior faculty to consider teaming up with more senior colleagues to participate. Detailed guidelines are available on our website ([www.nced.umn.edu](http://www.nced.umn.edu)), but the main elements are:

1. NCED2 provides partial support (a target of 50% with some flexibility) of postdoc salary for 1-2 years. The remaining support must be provided by at least two researchers who form the team that will co-mentor the postdoctoral researcher.
2. Postdocs will be expected to participate in the NCED2 theme-year program for that year.
3. Postdocs will be encouraged to spend some time in residence at SAFL to participate in theme-year activities (e.g. community experiments, summer institutes); our aim is to have as many postdocs as possible for a given year in residence simultaneously to promote collaboration.
4. Postdoc support is open to all. Postdoc teams will be selected with input from the NCED2 advisory committee via a brief application; details are available on the website.

*Graduate Students.* NCED2 has limited funding to help graduate students to participate in NCED2 theme-year activities by paying for subsistence and travel to SAFL. Participation is open to the research community, by application.

*Undergraduate students.* NCED2 provides opportunities for undergraduates to participate in theme-year research via our ongoing REU on Sustainable Land and Water Resources and NCED2's



**Figure 3:** Stages in development of a delta from a reduced-complexity model, showing surface topography and stratigraphy. Courtesy Man Liang, University of Texas.

undergraduate summer intern programs, which are built on interdisciplinary student and mentor teams that support students from diverse backgrounds to explore research using NCED methods. Undergraduate teams can participate in research at NCED2 sites, such as SAFL and affiliated field sites (e.g., Wax Lake Delta and the Minnesota River Basin), and also at tribal colleges (Salish Kootenai College) and native reservations (Fond du Lac Band of the Lake Superior Chippewa).

*Visiting faculty support.* NCED2 can provide limited subsistence costs and technical support (but not salary) for faculty to visit SAFL for 1-6 months to participate in theme-year research.

Highest priority goes to pre-tenure faculty. Participation is by application and is open to the research community.

*Workshops.* These continue the NCED STC's successful targeted workshops such as *Stochastic Transport and Emergent Scaling on the Earth's surface (STRESS)* and *Mathematical Modeling of Geomorphic Free and Moving Boundary Problems*. The format is an intensive workshop for ~25 people over 2-3 days. We anticipate supporting 1-2 workshops per year.

*SIESD.* In 2008 the NCED STC launched the *Summer Institute for Earth Surface Dynamics (SIESD)*, which has proven extremely popular with its target participant group of young researchers





**Figure 4:** *The Future Earth exhibit under development, Science Museum of Minnesota.*

(advanced grad through junior faculty). The NCED2 version is similar to the present SIESD but with focus on each year's theme, and is held in August each year.

**Science Museum of Minnesota (SMM).** SMM links NCED2 research activities to informal education through three ongoing programs:

**Earth Buzz:** SMM originated Science Buzz in 2002 to design and test digital and exhibit templates that permit museums to rapidly add current science content to their exhibit floors. It has since grown into an online destination with a national audience and a physical presence on the exhibit floors of 15 U.S. museums. Earth Buzz is a subset of Science Buzz, which focuses on environmental issues. SMM and NCED2 faculty work with interested NCED2 graduate students and postdocs to help them learn how to translate their knowledge into blogs that are interesting and accessible to Earth Buzz's online audiences and to visitors who access the Earth Buzz kiosks installed in 11 museums around the U.S.

**Future Earth:** SMM opened its Future Earth exhibit (Fig. 4) in April 2012. This exhibit emphasizes the many ways in which humans now surpass natural processes in driving global change; that innovation of all kinds is needed for people to thrive on a human-dominated planet; and that humanity collectively has the wherewithal to address these challenges because Earth

now is home to the healthiest, wealthiest, best educated, most creative, innovative and interconnected cohort in history. One of the exhibits in Future Earth is a small theater where people can view short video interviews of individuals with interesting perspectives on the challenges of a human-dominated planet and the solutions needed in the Anthropocene. Each year, SMM and the NCED2 Research Advisory Committee will identify one graduate student or post-doc to be interviewed and filmed by Twin Cities Public Television and produced into a short 2-3 minute video for use in the Future Earth exhibit and posted online on Earth Buzz and other prominent video-sharing websites.

**Museum Assistantships.** This continues a program launched in 2004 by the NCED STC in which NCED graduate students served for a term as scientific assistants at the museum. The topics of these assistantships, termed Museum Assistantships (MA), were determined by mutual agreement among the SMM, the student, and the student's adviser. MA work involved, for instance, design of exhibits in their research areas, working with SMM staff and the public, and developing appropriately simplified versions of computer models for inclusion in SMM exhibits. Under NCED2, SMM and NCED faculty expect to recruit

one museum assistant per academic year to pursue innovative means by which NCED2 research can be communicated to the broad public.

**NCED Native Partners Program.** The Native Partners program (Fig. 5) under NCED2 focuses on 1) expanding the current *gidakiimanaaniwigamig* (Our Earth Lodge) program to reach new reservations through teacher professional development and advice and support for informal science programs; 2) working with the UMN STEM Center and other partners to build curriculum and programs focused on Climate Change impacts and adaptations in native communities; 3) working to build a knowledge transfer network on water issues for native communities that will focus on interaction with key personnel in reservation resource management departments and other groups such as the American Indian/Alaska Native Climate Change Working Group; 4) expanding our Faculty-to-Faculty program to support hydrology teaching at tribal colleges nationally with a suite of materials that focus on using data in the hydrology classroom. NCED2 is also working with the Consortium for the Advancement of Hydrologic Science, Inc. (CUAHSI) to build capacity at tribal colleges and in native communities to discover, use, store and share water data; and 5)



**Figure 5:** *Lively discussion during the final poster session of 2013 summer REU experience*

continuing to push for better coordination of efforts focused on increasing Native American participation in the geosciences that build on our system of alliances, which culminates in the Geoscience Alliance, where stakeholders from many communities can collaborate.

*Virtual NCED2.* The proliferation of social media platforms (e.g. blogging, LinkedIn, Twitter, Facebook), including professional connections, networks, and dialogue, present an opportunity for NCED2 to extend its reach in new ways that are faster and more interactive than traditional communication modes. We will work to use these new media in substantive ways. NCED's strong research reputation would make our virtual presence a natural nexus for rapid exchange of research insight and ideas, attracting new students and creating a larger community for researchers and students. Thus, one central feature of NCED2 is a *virtual research commons* where NCED2 participants – postdocs, graduate students, and other participants – can exchange ideas and information, for instance by blogging about their theme-year research findings and experiences. A forum of this kind was proposed by participants at an NCED-led AGU town hall in 2011, and we see it as an exciting new venue for exchanging ideas and creating new collaborations. Aside from providing a means for us to contribute to conversations that are already occurring in the virtual realm, engaging in these platforms raises NCED2's visibility not only to other scientists, but the public at large.

We close this short introduction to NCED2 with some thoughts about how in a broad sense a center like NCED2 can contribute to moving Earth-surface science forward. We feel strongly that 'managed' research is a bad idea – the strength of basic research and its potential to contribute to society rest on respect for the value of individual creativity, serendipity, risk-taking, unexpected

results, and learning from failure. The role of a center like NCED2, in this view, is not to provide direction so much as to provide opportunity. In particular, we learned during the NCED STC that joint research across a large group of scientists works best when it is coordinated, but not orchestrated; when the center provides general themes and guidelines but then mainly works to create a "research commons" in which people can collaborate and pursue their ideas as they see fit. Shared facilities are one great way to do this – simply being in the same place, working with a collegial group on interesting and broadly related problems creates a setting in which collaborations arise and flourish organically. Given our location, we have a particular emphasis, shared with the SEN group (see the companion paper in this issue) on experiments, and especially on opening the door to experimental surface dynamics to our colleagues who have yet to experience it. But we also look forward to bringing the NCED approach to field and theoretical surface science, working to integrate the three approaches in new and fruitful ways, and continuing to build rich, two-way links with informal-education and Native-American programs. We developed the program outlined above with these ideas in mind, and in the hope that NCED2 can give to the wider Earth-surface community some of what it gave to the researchers who participated in the STC. But ultimately this is a community based effort: we designed version 2.0 based on our experience with the STC, but versions 2.1 and up will be designed by all of you.

## ACKNOWLEDGMENTS

NCED2 is supported by the National Science Foundation via award number EAR-1246761, for which we are extremely grateful. We also thank all who participated in the original NCED STC; they have taught us far more than they realize about the pleasures of collaborating in a large

research center. Finally, we are grateful to Leslie Hsu and Rudy Slingerland for their constructive and thoughtful reviews of this paper.

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Accepted November 2013