Modeling Collaboratory for Subduction Planning RCN Kickoff Meeting Report

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Gabriel Lotto (UT Austin) - gabriel@ig.utexas.edu

Meeting Description

The Modeling Collaboratory for Subduction (MCS) Planning RCN (sz4dmcs.org) is an NSF sponsored Research Collaboration Network (RCN) with support from UTIG/UT Austin.Our Kickoff Meeting on December 9, 2018, in Washington DC was held at the Carnegie Institution of Washington DC downtown site thanks to support from DTM/Carnegie. It was also broadcast live via webinar. The kickoff meeting was our community's first opportunity to discuss the goals and of our research collaboration network (RCN) in person.

We heard brief presentations from members of our steering committee, several US agencies, and international partners represented by attendees from Japan and Europe. Along with representatives of community centers (CIG, CSDMS, SCEC) and our sister RCNs under the SZ4D framework, we discussed the broad vision of a potential Modeling Collaboratory for Subduction as suggested within the SZ4D report. The MCS RCN will lead a series of workshops and webinars focusing on understanding the underlying physical processes and modeling challenges associated with subduction zone hazards. This report summarizes the discussions and provides links to resources.

We value open communication and inclusivity as tools to enhance the state of our science, and any comments or questions can be directed to contact@sz4dmcs.org.

Table of Contents

Meeting Highlights

The first part of the day presented an overview of the objectives of the Subduction Zone Hazards in 4D Initiative (SZ4D) and featured representatives of several US agencies, international efforts, and community modeling projects.

Introduction to SZ4D and the Modeling Collaboratory for Subduction

Thorsten Becker (UT Austin), PI for the Modeling Collaboratory for Subduction Planning RCN, opened the meeting by delivering an introduction to the SZ4D initiative and the three recently funded research collaboration networks (RCNs) funded within its scope.

The broad goal of SZ4D is to better understand the processes underlying subduction zone hazards across a wide range of physical and temporal scales. To that end, the SZ4D vision document recommended planning an interdisciplinary science program, creating a community modeling collaboratory, and building a large-scale infrastructure for data and computation.

Harold Tobin (U Washington) leads the Umbrella RCN, which aims to turn the SZ4D vision document into a full implementation plan over the next three years. The Umbrella RCN will consist of four working groups, each with a different scientific focus: controls and timing of slip along the megathrust;

landslides and forearc deformation; responding to earthquakes and volcanic events around the worlds; and magmatic drivers of eruption.

The Community Network for Volcanic Eruption Response (CONVERSE) RCN, led by PI Tobias Fischer (U New Mexico), is a two year program to establish frameworks and infrastructure for collecting and integrating data during eruptions within the US. CONVERSE workshops will strengthen ties between the USGS and academia and end in a final interdisciplinary eruption response exercise.

The goal of the Modeling Collaboratory for Subduction (MCS) RCN is to bring together a community of subduction zone modelers to identify knowledge gaps and areas potential connections between different modeling efforts. The RCN will build toward a future Modeling Collaboratory convening three workshops and a series of webinars. The MCS will be tasked with building multi-scale numerical models - based on smaller building blocks - that will help guide the community's understanding of measurements and observables. The RCN aims to forge strong partnerships across US agencies and international research organizations, providing online collaboration support and focusing on long-term planning for modeling efforts.

US Science Agencies

Representatives of NSF, USGS, NASA, and NOAA introduced their agencies' interests in subduction zone science and provided several examples of useful resources for the modeling community.

Eva Zanzerkia (NSF) discussed *CORES: A Decadal Survey for NSF's Division of Earth Sciences*, a critical, ongoing NAS report that will inform funding decisions in the earth sciences. She also reported on two key NSF funding solicitations for our group: *Midscale Research Infrastructure-1* (NSF 19-537) and *Frontier Research in Earth Science* (NSF 19-531).

Mike Blanpied (USGS) introduced the report *Reducing Risk Where Tectonic Plates Collide*, which complements the SZ4D vision document and spells out USGS subduction zone science interests. He also discussed a series of ongoing Powell center meetings.

Ben Phillips (NASA) gave a high-level overview of NASA's *Early Stage Innovations* (ESI) program, the *Applied Sciences Program*, and several current and future satellites relevant to earth science goals. He assured us the community efforts like SZ4D could go a long way toward helping to determine which satellites NASA will ultimately send into orbit.

Ian Brosnan (NASA Ames) described several recent NASA Ames computational earth science projects including collaborations with their new neighbors at the USGS in Menlo Park. He provided an overview of the immense computing infrastructure available at NASA.

Diego Arcas (NOAA) walked us through SIFT, the *Operational Tsunami Forecasting System* currently in place in the US.

International Partnerships

Claudio Faccenna (Roma TRE) introduced the data infrastructure and multidisciplinary approach of the *European Plate Observing System* (EPOS). EPOS is implementing dedicated data services to ensure discoverability and interoperability among diverse data sets, as well as a trans-national data access program. Discussions in Europe are under way to explore a subduction zone science Cost program, roughly equivalent to the RCN funding scheme of NSF. Another option would be an ERC International Training

Network (ITN), which would support PhD studentships and actual science rather than science networking and workshops.

Takane Hori (JAMSTEC) and Narumi Takahashi (NIED) represented aspects of the Japanese subduction zone hazards program. Takane Hori spoke about the development of monitoring and forecasting methods for crustal activity utilizing large scale high-fidelity finite element simulations in 3D heterogeneous media. He showed simulation results from a high-fidelity FEM model for earthquake shaking, and emphasized the importance of real separation but close collaboration between physical modeling and mathematical representation (i.e., numerical modeling).

Narumi Takahashi introduced DONET, the *Dense Ocean-floor Network System for Earthquakes and Tsunamis*, a system of redundantly cabled ocean-bottom observatories that enables real-time tsunami prediction and earthquake early warning in Japan.

After the discussion of the range of connections and partnerships with agencies and international partners, we proceeded to discuss the goals of the MCS within the context of other community efforts.

Discussion on MCS Goals and Vision

Mark Behn led all attendees in person and online in a discussion about the overarching goals of the future MCS and the present RCN. He identified several possible analogues for the modeling collaboratory that already exist within the earth science community, including SCEC, CIG, and CSDMS.

Lessons learned from SCEC. SCEC is guided by the fundamental scientific objectives of understanding earthquake hazards, albeit with clear geographic focus. SCEC has community models, an earthquake engineering interface, and well organized data products for the southern California. They use benchmarking activities to help the community move toward specific science-directed targets, and they make sure that there is an answer at the end of the process.

Lessons learned from CSDMS. CSDMS experimented early on with setting up an open web portal for modelers to share their codes, and people did indeed participate. Code standards were enforced, and might be necessary if we are to use a building block approach to modeling within the MCS. We will need dedicated developers or strong partnerships between people who build the code blocks.

Lessons learned from CIG. CIG is guided by the desire to enable interactions between domain scientists and experts in applied math and computer science, and seeks to provide collaboratively developed, robust, and well documented software. CIG accepts codes that meet certain technical specifications into a Github repository. They have built up a community of users and developers, and convene bi-annual meetings that combine scientific talks and training. The visibility generated by the CIG community is especially valuable to early career scientists.

Some major takeaway points of the discussion:

- We want an understanding of physics to guide our models, and so it is important to involve experimentalists and observationalists from the start.
- Some of the connections might be non-standard. The physical oceanography community, for example, can contribute much in terms of the understanding of ocean bottom sensor signal which might be “noise” for some, while signal for others, akin to atmospheric effects on GPS signals.
- The MCS must try to lower barriers of entry to subduction zone modeling on high performance computers, especially for early career scientists.

- Model results, not just the models themselves, will be very useful for the subduction zone community.
- It is important that subduction zone data be accessible in real time during an event.
- Efforts funded through EarthCube help people access and (re-)use data, as well as publish workflows for reproducibility. There may be opportunities to develop infrastructure via Earthcube to access and distribute data streams.
- There is a tendency to focus on shorter time scale hazard modeling (~seismic cycle), but the MCS should also support longer timescale (~millions of year) system modeling as some possible interactions (e.g. seismic efficiency, coupling) might depend on cross-scale effects.
- It is important to have model outputs that can be used as inputs for other models, but the models themselves need not be hardwired together necessarily. The necessary degree of coupling for many interactions still remains to be understood.

Some key, open questions from the discussion:

- Who decides what the Modeling Collaboratory will focus on?
- In what ways would the MCS support hardware and other computational infrastructure?
- How do you structure the decision making process so that there is buy-in from the community at large, given that we want to bring in a large community?
- Should the MCS focus on megathrust and volcanic systems from the get go?
- How much should we focus on secondary hazards like landslides and tsunamis, especially at the start of the MCS?
- How do we best incorporate surface process models into the RCN workshops?

Discussion on Workshop Philosophy and Implementation

We aim to establish a set of best practices for our brand of interdisciplinary, modeling-focused workshops, ensure diversity of participation and community engagement, including the use of online participation via *Zoom*'s webinar functionality. We also hope to consistently engage participants, session chairs, and organizers before and after our workshops, using workplace tools like *Slack*. There was agreement that the MCS should not restrict its scope to short or long time scales, but should focus on any temporal scales that are ultimately relevant to understanding subduction zone hazards. For each workshop, the RCN budget provides for full travel support for about 30 US and 10 international participants.

Fluid Transport Modeling Workshop (University of Minnesota, May 29 - June 1, 2019)

Ikuko Wada (U Minnesota) and Leif Karlstrom (U Oregon) will lead the first of three in-person workshops during the scope of the MCS RCN. The goal will be to bring together modelers, experimentalists, and observationalists to discuss fluid modeling across a variety of processes and time scales relevant to earthquakes and volcanoes. This will be a key workshop that should appeal strongly to both earthquake and volcano modelers. Four major scientific themes have been identified:

- Large/regional scale fluid migration models for subduction zones
- Crust/lithosphere scale models for magma transport
- Models for microscopic and short-time-scale mechanisms
- Bridging the gaps between the other three themes

Our kickoff meeting participants identified a need for a list of specific science questions, to spur interest in the workshop, and to be geared toward products useful for individuals' research as well as the MCS. For example, what are the model commonalities between different parts of the subduction zone system? What modeling capabilities and data availability do we have as a community? How do we actually put the right physics into our codes?

Pre-workshop early career event (May 29). The purpose of the pre-workshop event will be to synthesize observations, identify challenges, and ensure ECS input and contribution throughout the workshop. The program is undecided, but could include a hands-on modeling exhibition, presentations from early career scientists, or interactive talks given by senior modelers.

Ikuko and Leif will reach out to session chairs and form a workshop organizing committee by the end of January 2019.

Megathrust Modeling Workshop (University of Oregon, October 7-9, 2019)

Amanda Thomas (U Oregon) and Eric Dunham (Stanford) are organizing the second in-person NCS workshop, which will center on modeling the subduction zone megathrust across various time scales. That includes dynamic rupture models, earthquake sequence models, and geodynamic models, as well as models that couple the above types to one another. The workshop will explicitly consider the physics of sequences of earthquakes and aseismic slip (SCEC *SEAS*), and possibly landslides and tsunamis given that they are extensions of the underlying physics involved in subduction zone earthquakes.

As with the first workshop, there was a general recognition of the importance of identifying key science questions and take home products for participants. Some example questions:

- How do models looking at different temporal and spatial scales consider fault planes, plasticity, friction coefficients, etc.?
- How can analog models inform numerical models and our understanding of physical processes?
- Which problems can be separated into building blocks and which problems are more intertwined, requiring full, two-way coupling?

Tutorial day for early career scientists. There will be tutorials for students and early career scientists, which might include unstructured "tinker time." Other possible activities include short pseudocode demonstrations or running simulations in real time in short courses.

Communication, Outreach, and Inclusivity

Magali Billen (U Davis) led a discussion about communicating with and within the RCN, building the MCS and SZ4D community, and providing an inclusive, open, and supportive environment for collaboration. There may be several technological solutions to the problem of coordinating between steering committee members, including Zoom and Slack. These collaboration platforms should be accessible before, during, and after workshops to "seed" conversations and maintain dialogue for post-workshop activities (e.g., writing white papers).

When thinking about inclusivity, it is important to think about ethnicity, gender, institution, career stage, and scientific discipline. Considering inclusivity should result in decreased bias and better science. It may be useful to maintain an internal inventory of biographical sketches for our steering committee and

other SZ4D stakeholders containing areas of expertise and connections to other research groups and disciplines.

One key product will be a diversity checklist to refer to at every step of each workshop, from selecting chairs and speakers to deciding who among the applicants we will invite to participate. Past efforts such as the CSDMS-CIG sponsored workshop on Coupling of Tectonic and Surface Processes can serve as templates for thoughtful workshop design.

Program with Links to Presentations

9:00 - 9:15 am	*Room and AV Setup*	
9:15 - 9:30	**Welcome** & **Personal Introductions**	
9:30 - 9:50	Thorsten Becker (UT)	SZ4D and the Modeling Collaboratory for Subduction
9:50 - 10:30	Eva Zanzerkia (NSF) Mike Blanpied (USGS) Ben Phillips (NASA) Ian Brosnan (NASA Ames) Diego Arcas (NOAA)	GEO/EAR & FRES USGS Earthquake Hazards Program NASA Earth Surface and Interior NASA Ames program NOAA Center for Tsunami Research
10:30 - 11:00	*Coffee break*	
11:00 - 11:30	Takane Hori (JAMSTEC) Narumi Takahashi (NIED) Claudio Faccenna (Roma TRE)	Modeling Approach at ERI using HPC DONET utilization EPOS program and COST action programs
11:30 - noon	**MCS Vision & Goals** - Discussion led by Mark Behn and Thorsten Becker	
Noon - 1:00 pm	*Lunch* - discussion about MCS philosophy	
1:00 - 1:30	**RCN Science Questions & Workshops** - Open discussion	
1:30 - 2:00	Ikuko Wada (UMN)	Fluid Transport Modeling Workshop at U of Minnesota - *May 30-June 1, 2019*
2:00 - 2:30	Amanda Thomas (Oregon) and Eric Dunham (Stanford) Open discussion	Earthquake Modeling Workshop at U of Oregon - *October 7-9, 2019* Volcano Modeling Workshop - *TBD, 2020*
2:30 - 3:00	**RCN Communication, Outreach & Inclusivity** - Discussion led by Magali Billen (UC Davis) and Gabriel Lotto (UT)	

Participant List

In Person Participants

Kyle Anderson* (United States Geological Survey)
Diego Arcas (NOAA)
Thorsten Becker* (University of Texas at Austin)
Mark Behn* (Boston College)
Magali Billen* (University of California, Davis; CIG)
Mike Blanpied (USGS)
Ian Brosnan (NASA Ames)
Chuck Connor* (University of South Florida)
Allison Duvall* (University of Washington)
Claudio Faccenna (EPOS; Roma TRE)
Tobias Fischer (University of New Mexico; CONVERSE RCN)
Takane Hori (JAMSTEC)
Kaj Johnson* (Indiana University Bloomington)
Gabriel Lotto* (University of Texas at Austin)
Ben Phillips (NASA)
Terry Plank (Lamont-Doherty Earth Observatory; SZ4D)
Narumi Takahashi (JAMSTEC; NIED)
Harold Tobin (University of Washington; SZ4D)
Greg Tucker (University of Colorado Boulder; CSDMS)
John Vidale (University of Southern California; SCEC)
Ikuko Wada* (University of Minnesota)
Alan Wray (NASA Ames)
Eva Zanzerkia (NSF)

Webinar Participants

Luciana Astiz (NSF)
Sylvain Barbot (University of Southern California)
Jonathan Bedford (GFZ Potsdam)
Eric Dunham* (Stanford University)
Alice-Agnes Gabriel (LMU Munich)
Mitchell Hastings (University of South Florida)
Amanda Thomas* (University of Oregon)
Rocco Malservisi (University of South Florida)
Laurent Montesi (University of Maryland)
Maria Pantin
Jo-Elle Wicke

* *RCN Steering Committee*

Resource List

- Modeling Collaboratory for Subduction RCN: http://sz4dmcs.org
- Converse RCN: https://volcanoresponse.org
- CIDER Summer School on Volcanoes: https://www.deep-earth.org/summer19.shtml
- NSF CORES Decadal Survey: http://dels.nas.edu/Study-In-Progress/Catalyzing-Opportunities-Research/DELS-BESR-17-06
- NSF Mid-Scale Research Infrastructure: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505602
- USGS Reducing Risk Where Tectonic Plates Collide: https://pubs.er.usgs.gov/publication/fs20173024
- USGS ETWG Subduction Zone Focus Group: https://my.usgs.gov/confluence/display/cdi/ETWG+Subduction+Zone+Focus+Group
- USGS Powell Center website, with links to existing projects: https://powellcenter.usgs.gov/
- USGS Powell Center on "Margin-wide geological and geophysical synthesis to understand the recurrence and hazards of great subduction zone earthquakes in Cascadia", starting 2019: https://powellcenter.usgs.gov/view-project/5b16f6dce4b092d9651fcbf1
    - Points of contact among the leaders are: Lydia M Staisch <lstaisch@usgs.gov> and Janet Watt <jwatt@usgs.gov>.
- Powell Center on "Tsunami Source Standardization for Hazards Mitigation in the United States", began 2018, co-led by USGS and NOAA: https://powellcenter.usgs.gov/view-project/59a06151e4b038630d030525
    - Point of contact among the leaders is Stephanie Ross <sross@usgs.gov>.
- CSDMS Coupling of Tectonic and Surface Processes Workshop: https://csdms.colorado.edu/wiki/Form:Meetingconfirmation
- NASA Advanced Information Systems Technology call for proposals: https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7BC0D379E0-B4A8-6B97-7B0C-7F5409CD2442%7D&path=&method=init
- NASA National Academies Report (Jan 2018) - Thriving on Our Changing Planet, A Decadal Strategy for Earth Observation From Space: https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth
- NSF Cyberinfrastructure for the Geosciences: https://www.nsf.gov/geo/geo-ci/index.jsp

Full Meeting Notes

Intro - Thorsten Becker

- Goal: Decadal scale physics-based modeling and forecasting for megathrust and arc volcano systems in tectonic context
- What should decadal scale coordinated subduction zone research look like?
- 3 RCN's funded:
    - Volcano (CONVERSE)
    - umbrella (turn vision into an implementation plan)
    - modeling collaboratory
- Umbrella RCN has several working groups:
    - megathrust, magmatic drivers of eruption, responding to emergent megathrust and volcanic events internationally, linking landslides to forearc deformation (and other surface processes related themes)
    - Led by Harold Tobin
- Volcano RCN (CONVERSE) is a community network for volcanic eruption response
    - Led by Tobias Fischer
    - Volcanoresponse.org
    - multi-disciplinary near real-time observations, sample and analysis for physio-chemical volcano system models
    - COVE = Brandon Schmandt, data stream available to public
    - CIDER this summer = Berkeley Summer School on Volcanoes
- Modeling Collaboratory for Subduction RCN
    - http://sz4dmcs.org
    - Led by Thorsten Becker
    - Want to build multi-scale numerical models that will help guide understanding of measurements and observables
    - Modeling framework that collaboratively incorporates a range of data, serves as a platform to talk science and facilitate training of a new generation of scientists (LEGO bricks analogy)
    - Build strong partnerships across the agencies - NSF, USGS, NASA, NOAA
    - Activities: in person workshop series, webinar series on cyberinfrastructure
    - Online collaboration support (slack), community building
    - Long term planning (similar to umbrella) for modeling

Hearing from the agencies

Eva Zanzerkia (NSF)

- Catalyzing Opportunities for Research in the Earth Sciences (CORES): A Decadal Survey for NSF's Division of Earth Sciences

    - very important report for Earth Science Division
    - discrete set of grand challenge science questions, identification of infrastructure and what are the partnerships
    - Report in 18 to 24 months
    - Critical in funding decisions, where does our funding go?
- Starting 2019, NSF invested in "Big Ideas" - 10 of them over next 5 years.
- Mid scale infrastructure to bridge the gap from small scale infrastructure (MRI) vs MREFCs. Infrastructure from 6 to 20-million-dollar range.
    - Actual building of infrastructure, but these have to be ready to go, ready to build.
    - You can also do a proposed design, design infrastructure.
- Another aspect is called "convergence" - it is about problem solving in ways not possible before. Social Science – geoscience – engineering. "harnessing the data revolution".
- New program in EAR, it is called FRES, Frontier Research in Earth Science (Feb. 20th deadline) projects outside the scope of core programs and larger budgets. Need to have impacts beyond domain or opportunities for integrative/interdisciplinary research.

Mike Blanpied (USGS)

- Reducing Risk Where Tectonic Plates Collide – A Plan to Advance Subduction Zone Science (complements the SZ4D vision document)
- Mission driven subduction zone science with practical deliverables (products/applications)
- Cascading subduction zone events (subduction zones are rich in disaster spectrum)
- Online dashboard for involvement (ETWG Subduction Zone Focus Group)

Ben Phillips (NASA)

- High-level perspective of NASA program:
    - ESI (solid earth research programs; earthquake, tsunami, volcanoes, etc.)
    - Also an applied sciences branch (disasters program) – forecasting, preparedness, response, and recovery with emphasis on partnerships with other agencies, perspective of earth observation from above
    - Examples: NISAR (under construction at JPL, scheduled for launch at end of 2021); SWOT (also 2021), sea mount mapping, etc.; GRACE follow on launch in May, soon providing data (a gravity mission); ISAT 2/JEDI (laser altimeter measurements = land elevation and shallow bathymetric in addition to ice); ecostress mission on space station, ASTER like data but on a more rapid repeat timescale for imaging processes;
- NASA published a national academy report in Jan. 2018 containing 4 main future targets.
- Science and applications needs of the SZ4D community could be considered by NASA and future missions. SZ4D and MCS community could influence what NASA will be launching in space in the future

Ian Brosnan (NASA Ames)

- NASA advanced instrumentation could be useful for SZ4D and MCS efforts

- Advanced Information Systems Technology program is thinking on a 5 to 20 year timeline, just released a solicitation
- technical details of supercomputing systems available in slides

Diego Arcas (NOAA)

- Responsible for conducting most of the research that takes place under NOAA and transitioning research to operations.
- One of primary missions is tsunami forecasting and warning. Ex.: Operational DART-based forecast, need slip distribution in 1 or 2 minutes and HPCC, then they could issue better warnings, cut latency time to within 5 minutes "near-field" problem - impact happens very fast.
- Now looking to reduce the size of the coastline where this problem exists. How long will the event last, what has actually happened, this is still vital info for emergency managers even if tsunami hit. This will save lives and property.
- They work closely with national tsunami hazard mitigation program at the federal level and with FEMA and states.

Hearing from International Partners

Claudio Faccenna (Roma TRE)

- EPOS (European plate observing system) is just for data (not a science infrastructure), including multiscale laboratories; EPOS is a very big project with lots of mixing disciplines
- Timeline 2002 – 2024 (22 year project).
- Implementing dedicated data services that will guarantee laboratory data harmonization
- Developing a trans-national access program with useful data services (GFZ Potsdam)
- "COST" = European cooperation in science and technology funding organization

Takane Hori (JAMSTEC)

- Development of monitoring and forecasting methods for crustal activity utilizing large scale high-fidelity finite element simulations with 3D heterogeneous media
- Purpose – disaster mitigation
- Made recent progress in observation with ocean bottom instrumentation - you need more than land-based data.
- Integrated simulation system for post-K project. Target = 2021.
- Showed results from high-fidelity FEM model - see slides
- Ichimura et al. (2015). Developing mesh refinement optimization for the fault
- Yamaguchi et al. (2017). They also apply this to the tsunami simulation. Just started to model southern CA with this approach.
- Collaborating with Kaj and Thorsten. Would be happy to collaborate with MCS.
- Important to separate but closely collaborate between the physical modeling with mathematical representation.

Narumi Takahashi (NIED)

- DONET = "Dense ocean floor network system for earthquakes and tsunamis"
- Cooperation with JAMSTEC
- Ground motion sensing system: broadband seismometer + strong motion sensor + pressure sensing system.
- Enables real-time tsunami prediction and earthquake early warning.

MCS Goals and Vision

- Possible analogues for a modeling collaboratory:
    - SCEC - science-directed objective
    - CIG and CSDMS support a wide variety of science goals, and are focused on code
    - CSDMS collects code blocks
- Who decides what the Modeling Collaboratory will focus on?
- John Vidale - SCEC has community models, an earthquake engineering interface, and data for California - this would be a good model if we're focusing especially on Cascadia
- Greg Tucker - CSDMS experimented early on with setting up an open web portal for people to share their codes, and people did indeed share their codes
    - Need standards for codes if you're going to build "lego blocks" - this requires developers or partnerships with people who write the code blocks
    - There is increasing acceptance of software as recognized science, that people can get credit for
    - Any checks on code standards for CSDMS? - not directly, people use the codes and find whether they work
- Magali Billen - now CIG uses a github repository, but before that why should people contribute to CIG rather than just put codes on Github?
    - What do we do to make CIG benefit people?
    - What codes should CIG accept? Contributors need to buy into technical specifications of code development but also have to be part of the community
    - Early on, CIG wanted to be involved in coupling codes via Python frameworks - it didn't work as well as hoped, and hasn't been a focus recently
    - What are the processes to bring in a community to develop code?
    - If you just put a code on Github, no one will know it's there
    - Sylvain: "In my experience, it's mostly about building a community of users and developers. Another added value is visibility. Bi-annual meetings combine scientific talks and training. It's very valuable to young scientists."
    - SCEC codes work together and are benchmarked but may be hard to use for individual researchers
- Getting physical oceanography involved
    - We definitely want physical models to guide our efforts
    - We're trying to measure subtle signals that can sometimes be swamped, but the oceanography community has been working to understand them

    - Combining tidal models and ocean circulation models with tsunami models
    - Ocean-bottom pressure gauges can also be hard to interpret
- Hardware questions
    - So far, most people have run codes on their own machines, but would this collaboratory support a hardware side? Is that important?
    - Thorsten: observatories shouldn't run their own hardware but should provide access. We must consider barriers to entry and build up expertise.
    - NSF and other agencies have long-term infrastructure and services - how can we take advantage of these partnerships?
    - Google and amazon cloud computing structures have lots of capabilities too, perhaps we don't need to reinvent the wheel
    - NISAR - big data plus computational capabilities
- Chuck Connor - model results could be useful to the community in addition to the models themselves
    - For example, NOAA runs big models every four hours that people have all sorts of uses for without having to run models themselves
- Data availability
    - Eva Zanzerkia - Earthcube helps people access and use data. Opportunities to develop infrastructure via earthcube to access and distribute data streams
    - We should look into cyberinfrastructure for geosciences from NSF - https://www.nsf.gov/geo/geo-ci/index.jsp
    - Diego - important to have real-time access to a lot of the data. This opens a whole world of research that can be done, including from UNR GPS data
    - Ben Phillips - There is value to having multiple systems distribute data, and value to having a broad data distributor from above
    - Vidale - SCEC has tried to merge GPS and INSAR datasets
- Mark - how do you structure the decision making process so that there is buy-in from the community at large, given that we want to bring in a large community
    - Vidale - SCEC picks specific scientific target and makes sure the answer is right at the end of the process
    - A lot of people don't know exactly the assumptions in their own codes
    - Having a target is really critical - you can get more specific after that, but benchmarking is really useful
    - Harold - the goal of the RCN has to be to build consensus about what we want to be modeling
    - Thorsten - there is a distinction to be made between having a common scientific goal and using the same model uniformly (the latter is bad science)
    - Diego - NOAA is starting to do ensemble modeling, bringing other models into the forecast
- Magali - there has been a focus in the room on short time scale hazard modeling, but this group should also be focused on longer scale system modeling, which will be a challenge because there are two different pathways but we want our codes to work on both scales

    - Chuck - the volcano community is great at short term modeling, but terrible at long-term modeling (over decades) - but society demands that we know about decadal scale hazards too
    - This RCN is good for asking: how well is it possible to know about long time scale hazard?
- Ikuko: Important to have model outputs that can be used as inputs for other models, but they don't have to be hardwired together

RCN workshop implementation

- Eva Zanzerkia volunteers to lead a cyberinfrastructure webinar
- Scope of RCN
    - Have we talked about landslides specifically? Of course landslides and tsunamis are important to hazard.
    - Let's start with the source process - the generation of earthquakes, before we move to other hazards
- Allison Duvall - let's make sure to represent surface processes at megathrust and volcano meetings, because they are tied together
- Bring together surface process modelers and long-term tectonics modelers - there's a lot to learn between them
- Hoping to establish best practices for workshops
    - Including online participation (online rooms) using zoom
- How do we think about time scales? Is this built into the workshops, or do we need a separate workshop for combining time scales?
    - Terry - SZ4D cares about short and long time scales that matter to hazard, not necessarily super long time scales (e.g. how did the Andes evolve?)
    - Scope is not restricted to hazard, but to the processes that underlie hazard

Fluid Transport Workshop

- Bring together modelers, experimentalists, and observationalists together to talk about a variety of processes and time scales
- Workshop in Minneapolis from May 29 to June 1, 2019
    - Gorden Deep Interior Conference is from June 2 in Massachusetts, with an Early Career Scientist event on June 1
    - Possible to fly from Twin Cities to Massachusetts in time for both
- Schedule
    - Day 1: Two morning sessions, two afternoon sessions, breakout session, poster session (with lightning talks for ECSs)
    - Day 2: Two morning sessions, one afternoon session, ECS program report (based on pre-workshop events), breakout sessions, dinner?
    - Day 3: Breakout session summaries, synthesis discussion, one final breakout discussion useful for report writing, which planning will start in the afternoon
    - Mark - should we be putting breakouts earlier in the day to avoid fatigue?

- Travel support for ~30 US and ~10 international attendees (numbers are for full support, but we may want to pay partial support for more people)
- Objectives
    - Synthesize modeling efforts for fluid and magma transport
    - Models of different scales and mechanisms, and what are the commonalities between them
    - Observationalists as session chairs and modelers as speakers
- Themes
    - large/regional scale fluid migration models for subduction zones
    - crust/lithosphere scale models for magma transport - this session will have overlap with the volcano workshop, but this is more about the fluid mechanisms
    - Models for microscopic and short-time-scale mechanisms
    - Bridging the gaps between the other three themes - this is the most challenging
- Will earthquake modelers have a place or is this magma heavy?
    - Yes, only theme 2 is solely focused on magma
    - Maybe need to add some key words to bring in the plate interface fault modelers
- Thorsten: What will a participant be able to take away from the workshop?
    - For example, can we come up with a continuum mechanics framework to encompass porous flow and viscoelastic?
    - What will the model commonalities be?
    - Finding out what modeling capabilities we have?
    - Possible outcome of workshop: defining some benchmark questions for people's codes - need to have people from various fields at the workshop
- Magali: we ought to make a list of more focused specific science questions - can we answer them and how? Prior to workshop, we should be generating that list as a community. Seed the discussion.
    - On the application for the workshop, have people add their own questions about what they don't know how to solve.
- Pre-workshop Early Career Scientist event - May 29
    - Purpose: synthesize observations, identify challenges, ensure ECS input and contribution - We can expand this to a larger pre-workshop community project
    - Hands-on/show-and-tell program to promote discussions during the workshop (not as an intro to modeling)
    - Presentations from grad students and postdocs who are doing fluid migration on boundary/initial conditions that are being applied
    - Thorsten: could have talks from senior modelers followed by sit down sessions with ECSs who "look under the hood" of the models
    - Terry - we could try to infiltrate CIDER summer workshop if we want to play with models
    - Ikuko - we could try to pass the outcome of our workshop to CIDER
    - Mark - if we call the ECS event an optional pre-workshop, will there be an audience for the speakers?
- How do we incorporate the model building block idea directly into these themes?

    - Perhaps having some more specific science questions might be more productive, rather than trying to address everything
    - How do we actually put physics into code?
    - Keep in mind the distinctions between physical models and mathematical representations (codes)
- Session chairs will help with organization and identifying key questions - these will lead the discussions and act as catalysts between different modelers
    - Thorsten: Good idea to have several online discussions with organizers and session chairs prior to workshop

Megathrust Workshop

- October 7-9, 2019 in Eugene, Oregon
- Tutorials for students and ECSs, talks and breakout discussions, short courses/lectures or code tutorials
- Modeling on various time scales
    - Dynamic rupture models
    - Earthquake sequence
    - Geodynamic
- Integrations of all the model types above
    - Can start with one-way coupling or do both directions
    - Some models have the same processes but represent things very differently, e.g. models focusing on different spatial or time scales might treat faults completely differently
    - E.g.: how do we think about friction coefficients in dynamic rupture models vs geodynamics models; what does plasticity mean in various models
- Strategies to ensure ideal participation - this will be hard to do given limited attendance
    - All stages of career
    - US and international participants
    - Gender and ethnic diversity
- We should be open to analog modeling and comparing those to numerical models, including different materials, data assimilation, rate-and-state friction
    - Invite some of these people to give talks
- Ideas for tutorial day:
    - Tinker time, collaboration promotion
    - Running simulations in real time as a group, or having models previously run and ready to show to the group
    - 10 minutes of pseudocode to bridge governing equations to code development (but this might take much longer than 10 min)
    - Suggestion: don't try to replicate a code tutorial, since there are often tutorials already available online or in other forums
- Thorsten - best to focus on tangible, take-away products by directly approaching the science problems we have

- Magali - everyone knows one part of the problem, but speakers need to be talking ultimately about the goal of connecting models together with other scientists - everyone in the room needs to learn a lot more about inter-connections
- Thorsten: for some problems, different parts are so intertwined that you can't use different model building blocks but need to develop all the physics together
    - But in other cases, it's as simple as knowing what's useful to input and output
    - Data people will help know about what is available
- Vidale: role of slow slip in workshop?
    - Sequences of Earthquakes and Aseismic Slip (SEAS) is definitely a part of the workshop, we're in Oregon after all!
    - Slow slip gives us valuable constraints on pore pressure, stress, etc.
- Joan: Are we addressing landslides and tsunamis explicitly?
    - Eric: tsunamis are just another wave generated by megathrusts, are important for hazards, and offer a constraint on slip
    - Thorsten: tsunamis and surface processes are extensions of the underlying physics involved in megathrusts
    - Diego: not enough time to get into great detail - tsunamis could be a lot to talk about
    - Terry: this RCN should be building connections to various communities including tsunamis - no need for this RCN to double other groups' efforts

Communication, Outreach and Inclusivity

- We need to bring lots of people into the MCS RCN from different science domains
- What is the science equivalent of linkedin? How is everyone at the meeting today connected scientifically?
    - Put this on the website
- Inclusivity - not just ethnicity and gender, but everything
- Promote open and supportive environment for collaboration
- Inclusivity checklist for every stage in the workshop/committee planning phase and post-workshop phase - what did we miss? What other fields should we communicate with? Include non-mainstream approaches.
- Possibility of using Slack to engage people prior to, during, and after workshop
    - Terry: Solicit 2-page white papers before meeting, have people decide what breakout ideas will be via voting
    - Have stakeholders meetings prior to workshop (we could do this online), and have people answer questions about what they care about when they sign up
- Terry: How do you decide who gets to be represented at the meeting, especially when it's a popular meeting and we can support only a limited number of attendees?