COMPUTATIONAL INFRASTRUCTURE FOR GEODYNAMICS

2015-2016
Annual Report

CIG

NSF AWARD NUMBER EAR-0949446

July 2016

Executive Summary

The Computational Infrastructure for Geodynamics (CIG) is a Geoinformatics project funded by the National Science Foundation (NSF) to support and promote development, dissemination, and use of high-quality software for modeling geodynamical and seismological processes. Each year, CIG undertakes a strategic planning process, in which CIG's staff, governing committees, and working groups assess CIG's status, progress, and impact; develop goals for the coming year and beyond, and outline the strategy and work plans for allocating resources to achieve these goals. During this last year of the current grant, our planning process resulted in a renewal proposal, which outlines the planned activities for the next five years. This document therefore focuses on reporting CIG's activities and impacts.

This year, CIG's new activities included the first ever "all hands" meeting of the CIG community, a week-long event involving 8 tutorials and 2.5 days of plenary talks, panels, lightening talks, and poster sessions,. Approximately 100 scientists participated, including a large proportion of early career scientists and new members of the CIG community. We continued regular meetings for three software development projects, developed and offered tutorials for new codes, completed and published the international benchmarking project for the geodynamo group, and ran an 8 day hackathon resulting in new developments for the mantle convection code ASPECT. We revised the software best practices document, developed a best practices document for software tutorials, and followed up on last year's publication on future directions for long-term tectonics modeling with regular meetings and work towards a benchmark activity for this community. CIG continued to advance software development in mantle convection, crustal dynamics, geodynamo, long-term tectonics, seismology, and evaluated future directions for these codes. Our webinar series focused on software best practices, validation and verification, and uncertainty quantification in scientific software. CIG supported community development and knowledge transfer through workshops, webinars, newsletters, tutorials, e-mail distribution lists, and joint workshops with other organizations. We continued working with the community to develop methods to provide attribution and citation of scientific software (Software Attribution for Geoscience Applications, SAGA).

Figure 1. Figure 1. Download map of codes from CIG's software repositories 2015.

We tracked various metrics aimed at measuring the impact of CIG's activities, including participation in events, downloads of software (Figure 1), and (when available) presentations and publications that use CIG software. We developed a new, searchable database of CIG associated publications (available on the geodynamics.org website). We partnered with other organizations, including ACES, CIDER, EGU, ELSI (U. Tokyo), GEOMOD, IRIS, and SCEC. We co-hosted supported participation by US scientists to the biannual EGU workshop on mantle-lithosphere dynamics and
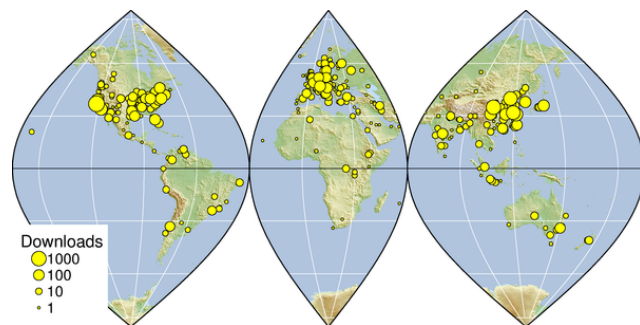
provided administrative support to the ACES workshop on earthquake simulation, supporting participation by U.S. early career scientists in these meetings.

CIG is a partner in a 150 M core hour allocation on Mira for 2016, the 5th fastest computer in the world, operated by the Argonne Leadership Computing Facility (ALCF). The PI of this allocation is Jon Aurnou of UCLA, lead of the CIG Geodynamo Working Group, and the allocation is dedicated to running the planetary dynamos code Rayleigh, developed with CIG support by Nick Featherstone. This past year the group began simulation of non-rotating solar convection models and initial runs of convection for Jupiter in anticipation of Juno's arrival, and to fully understand the performance of the software in preparation for the more complex Earth models. The 3 year plan of this group is to run models of Earth, Jupiter, and the Sun.

Our plans for the coming year include continued development of codes across the scientific domains represented by geodynamics, including release of new codes and new versions of established codes. CIG working groups plan to establish new, and continue working on, community benchmarks in geodynamo and mantle convection, define scientific goals and capabilities in long-term tectonics, and support donations of codes for normal modes and workflows for seismology, multiphysics, ice sheet modeling, and other topics as code-donation requests arise through the year through our established approval process. We will run an online tutorial on PyLith, hold an in-person tutorial at the Geological Society of America meeting, contribute to tutorials at CIDER, and plan to continue community activities and development (especially for early-career scientists) through workshops, meetings, tutorials, hackathons and webinars. We continue to develop partnerships with national computing facilities, other partner organizations, and EarthCube. These include managing and renewing CIG's allocation on XSEDE, collaborating with DOE's INCITE program on dynamo models, and working with library and information scientists on the SAGA project to improve mechanisms for software citation.

CIG Director Louise Kellogg represented the CIG community at a meeting of the NRC Committee on Seismology and Geodynamics open forum on high performance computing, at the NSF Workshop on Data and Software Citation (http://www.software4data.com/) and at similar events. Associate Director Lorraine Hwang represented CIG at the IRIS national meeting and at the 3rd Workshop on Sustainable Software for Science: Practice and Experiences (WSSSPE3) and Force11 (https://www.force11.org/). The WSSSPE3, Force11, and Software4Data projects all represent CIG outreach to and participation in communities who are considering the role of cyberinfrastructure in scholarly communication. CIG held its annual business meeting at the Fall American Geophysical Union annual meeting, Dec. 2015.

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CIG Overview

The Computational Infrastructure for Geodynamics (CIG) supports computation and research in geodynamics. CIG achieves this by developing, supporting, and disseminating high-quality software for the geoscience community and enabling better access to and use of cyberinfrastructure including high-performance computing. This cyber-enabled geosciences community is maintained and grows through workshops, training, outreach, and partnerships with other organizations. The software maintained and developed by CIG addresses research problems that range widely through the earth sciences and includes mantle convection; the geodynamo; magma, crustal and earthquake dynamics; and seismology. With 76 member institutions including 15 international affiliates, CIG is a member-governed organization with a high level of community participation.

This document updates CIG operational status and covers the period from July 1, 2014 through June 30, 2015 unless otherwise noted.

Prior reports and documents can be found at geodynamics.org.

CIG Management and Governance

Membership (76)

	Institutional Members	Location	Member Representative
1	Argonne National	Argonne, IL	Matthew Knepley
2	Arizona State University	Tempe, AZ	Allen McNamara
3	Boston University	Boston, MA	Paul Hall
4	Brown University	Providence, RI	E.M. (Marc) Parmentier
5	California Institute of Technology	Pasadena, CA	Jean-Paul (Pablo) Ampuero
6	California State University, Northridge	Northridge, CA	Dayanthie S. Weeraratne
7	Carnegie Institution of Science, DTM*	Washington, D.C.	Peter Driscoll
8	Clemson University	Clemson, SC	Timo Heister
9	Colorado School of Mines	Golden, CO	Paul Sava
10	Colorado State University	Ft Collins, CO	Dennis Harry
11	Columbia University	New York, NY	Marc Spiegelman
12	Cornell University	Ithaca, NY	Jason Phipps Morgan
13	Georgia Institute of Technology	Atlanta, GA	Josef Dufek
14	Harvard University	Cambridge, MA	Jeremy Bloxham
15	Indiana University	Bloomington, IN	Geoffrey Fox
16	Johns Hopkins University	Baltimore, MD	Peter Olson
17	Lawrence Livermore National Laboratory	Livermore, CA	Arthur Rodgers
18	Los Alamos National Laboratory (ES)	Los Alamos, NM	Carl Gable
19	Massachusetts Institute of Technology	Cambridge, MA	Bradford Hager
20	National Center for Atmospheric Research	Boulder, CO	Mark Miesch
21	New Mexico Institute of Mining and	Socorro, NM	Jolante van Wijk
22	Northwestern University	Evanston, IL	Suzan van der Lee
23	Oregon State University	Corvallis, OR	Gary D. Egbert
24	Pennsylvania State University	University Park, PA	Kevin Furlong
25	Portland State University*	Portland, Oregon	Maxwell Rudolph
26	Princeton University	Princeton, NJ	Jeroen Tromp
27	Purdue University	West Lafayette, IN	Andrew Freed
28	Rensselaer Polytechnic Institute	Troy, NY	Steve Roecker
29	Rice University	Houston, TX	Alan Levander
30	State University of New York at Buffalo	Buffalo, NY	Abani Patra
31	State University of New York at Stony	Stony Brook, NY	Lianxing Wen
32	Texas A&M University	College Station, TX	Wolfgang Bangerth
33	U.S. Geological Survey (Menlo Park)	Menlo Park, CA	Brad Aagaard
34	University of Alaska, Fairbanks	Fairbanks, AK	Carl Tape
35	University of Arizona	Tucson, AZ	Noah Fay
36	University of California San Diego	San Diego, CA	David Stegman
37	University of California Santa Cruz	Santa Cruz, CA	Thorne Lay
38	University of California, Berkeley	Berkeley, CA	Bruce Buffett
39	University of California, Davis	Davis, CA	Magali Billen
40	University of California, Los Angeles	Los Angeles, CA	Jonathan Aurnou
41	University of Colorado	Boulder, CO	Shijie Zhong
42	University of Connecticut	Storrs, CT	Vernon Cormier
43	University of Hawaii	Honolulu, HI	Garrett Ito
44	University of Houston	Houston, TX	Margarete Jadamec
45	University of Maine	Orono, ME	Peter Koons

46	University of Maryland	College Park, MD	Laurent Montési
47	University of Memphis*	Memphis, TN	Eunseo Choi
48	University of Michigan	Ann Arbor, MI	Peter Van Keken
49	University of Minnesota	Minneapolis, MN	David Yuen
50	University of Missouri-Columbia	Columbia, MO	Mian Liu
51	University of Nevada, Reno	Reno, NV	John Louie
52	University of New Mexico	Albuquerque, NM	Mousumi Roy
53	University of Oregon	Eugene, OR	Douglas Toomey
54	University of Rochester	Rochester, NY	Cynthia Ebinger
55	University of Southern California	Los Angeles, CA	Thorsten Becker
56	University of Texas at Austin	Austin, TX	Luc Lavier
57	University of Washington	Seattle, WA	Ken Creager
58	Virginia Polytechnic Institute and State	Blacksburg VA	Scott King
59	Washington State University*	Pullman, WA	Catherine Cooper
60	Washington University in St. Louis	Saint Louis, MO	Michael Wysession
61	Woods Hole Oceanographic Institution	Woods Hole, MA	Jeff McGuire

Foreign Affiliates

1	Australian National University	Acton, Australia	Jean Braun
2	Cardiff University	Cardiff, United	J. Huw Davies
3	Earth Observatory of Singapore	Singapore	Emma Hill
4	Geological Survey of Norway (NGU)	Trondheim,	Susanne Buiter
5	GNS Science	Avalon, New	Susan Ellis
6	Johanes Gutenberg University Mainz*	Mainz, Germany	Boris Kaus
7	Monash University	Clayton, Australia	Louis Moresi
8	Munich University LMU	Munich, Germany	Hans-Peter Bunge, Heiner Igel
9	University of Alberta	Calgary, Alberta	Claire Currie
10	University College London	London, United	Carolina Lithgow-Bertelloni
11	University of Bristol, UK	Bristol, United	James Wookey
12	University of Science and Technology of	Hefei, Anhui, China	Sidao Ni
13	University of Sydney	Darlington,	Dietmar Muller
14	University of Tuebingen, Germany	Tuebingen,	Todd Ehlers
15	Victorian Partnership for Advanced	Melbourne,	Bill Appelbe

*New Members

Executive Committee
- *Chair,* Bruce Buffet (2016), University of California, Berkeley
- Magali Billen (2018), University of California, Davis
- David Bercovici (2016), Yale University
- Omar Ghattas (2017), University of Texas, Austin
- Louis Moresi (2018), University of Melbourne
- *Ex officio*, Brad Aagaard (2016), United States Geological Survey
- *Ex officio,* Louise Kellogg, Director CIG

Science Steering Committee
- *Chair,* Brad Aagaard (2016), United States Geological Survey
- Tim Ahern (2016), IRIS
- Jed Brown, (2017), Argonne National Lab
- Katie Cooper (2018), Washington State University
- Boris Kaus (2018), University of Mainz
- David May (2017), ETH Zurich
- Sabine Stanley (2018), University of Toronto
- Carl Tape (2017), University of Alaska, Fairbanks
- *Ex officio,* Bruce Buffet (2016), University of California, Berkeley
- *Ex officio,* Louise Kellogg, Director CIG

Working Group Members

Computational Science (7)
- Brad Aagaard (U.S. Geological Survey)
- Wolfgang Bangerth (Texas A&M University)
- Jed Brown (Argonne National Laboratory)
- Nick Featherstone (University of Colorado, Boulder)
- Timo Heister (Texas A&M University)
- Matthew Knepley (University of Chicago)
- Marc Spiegelman (Columbia University)

Geodynamo (9)
- *Lead,* Jon Aurnou, University of California, Los Angeles
- Ben Brown, University of Wisconsin-Madison
- Bruce Buffett, University of California, Berkeley
- Nick Featherstone, University of Colorado, Boulder
- Gary Glatzmaier, University of California, Santa Cruz
- Moritz Heimpel, University of Alberta
- Hiroaki Matsui, University of California, Davis
- Peter Olson, Johns Hopkins University
- Sabine Stanley, University of Toronto

Long-Term Tectonics (4)

- *Lead,* Claire Currie, University of Alberta
- Susanne Buiter, Norwegian Geological Survey
- Katie Cooper, Washington State University
- Lijun Liu, University of Illinois, Urbana-Champaign
- Eric Mittelstaedt, University of Idaho
- John Naliboff, University of California, Davis
- Cedric Thieulot, Utrecht University
- Jolante van Wijk, New Mexico Tech

Magma Migration (8)

- *Lead,* Marc Spiegelman, Columbia University
- Mark Behn, Woods Hole Oceanographic Institution
- Marc Hesse, University of Texas, Austin
- Garrett Ito, University of Hawaii
- Richard Katz, Oxford University
- Matt Knepley, University of Chicago
- Ikuko Wada, Woods Hole Oceanographic Institution
- Cian Wilson, Columbia University

Mantle Convection (7)

- *Lead,* Scott King, Virginia Polytechnic Institute
- *Lead,* Shijie Zhong, University of Colorado, Boulder
- *Lead,* Thorsten Becker, University of Southern California
- Juliane Dannberg, GFZ Potsdam
- Timo Heister, Clemson University
- Margarete Jadamec, University of Houston
- Mark Richards, University of California, Berkeley

Seismology (6)

- *Lead,* Arthur Rodgers, Lawrence Livermore National Lab
- Tim Ahern, IRIS Data Management System, Seattle
- David Al-Attar, University of Cambridge
- Carene Larmat, Los Alamos National Lab
- Carl Tape, University of Alaska at Fairbanks
- Michael Wysession, Washington University at St. Louis

Short-Term Crustal Dynamics (5)

- *Lead,* Brad Aagaard, U.S. Geological Survey
- Eric Hetland, University of Michigan
- Eric Lindsey, University of California, Davis
- Jeanne Sauber-Rosenberg, NASA Goddard

- Charles Williams, GNS Science

CIG Staff

- *Director,* Professor Louise Kellogg
- *Associate Director,* Dr. Lorraine Hwang
- *Project Scientist,* Dr. John Naliboff
- *Software Developer,* Dr. Hiroaki Matsui
- *Software Engineer,* Tyler Esser
- *Software Research Engineer,* Harsha Lokavarapu
- *HPC Support,* Bill Broadley*
- *HPC Support,* Terri Knight*
- *Executive and Event Support,* Carla Datanagan*
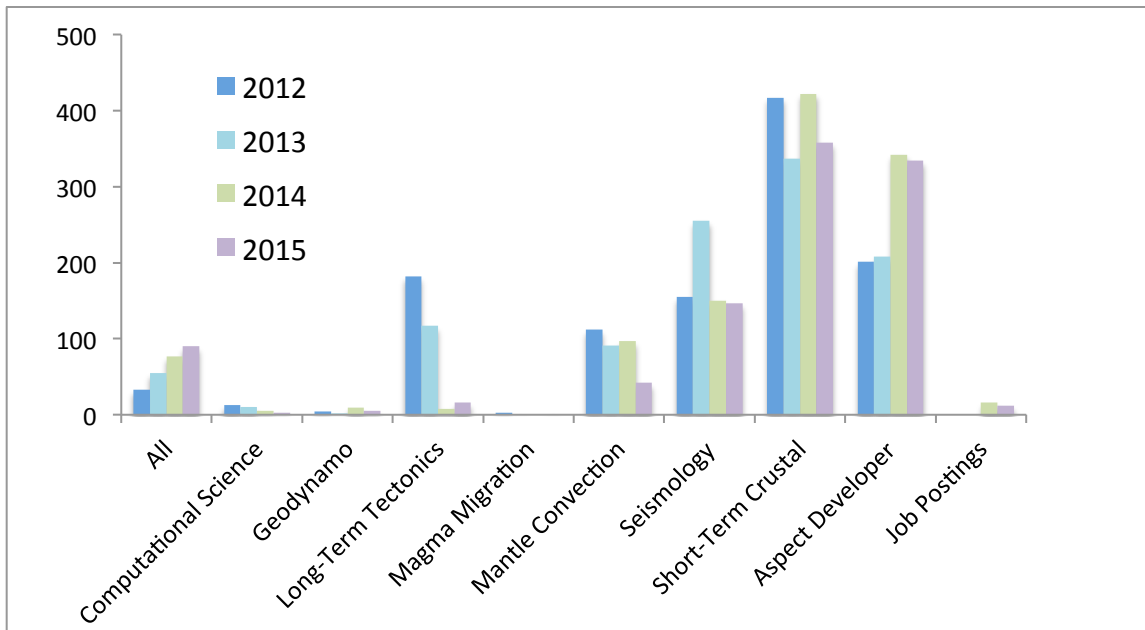- *Project Specialist,* Angela Hawkins*

*part time effort for CIG

Communications

January 1, 2015 through December 31, 2015
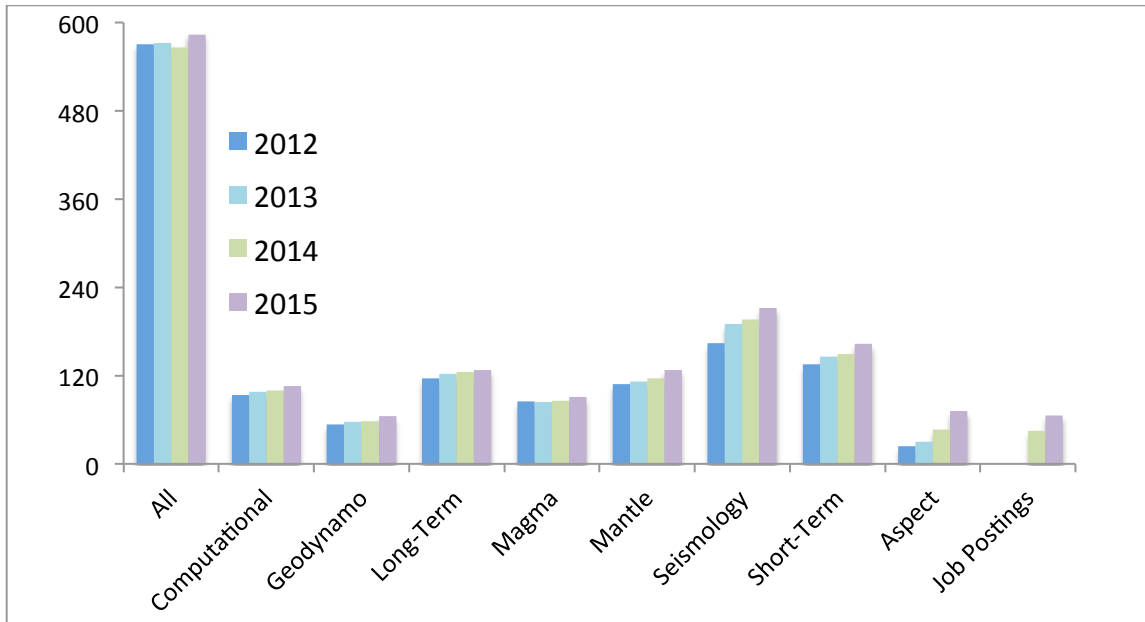
CIG mailing list served 930 unique individuals in 2015.

CIG mailing list sent 1008 messages in 2015.

Facility Status

This section describes the CIG software repository, portal, and high performance computing allocations. Download maps are available for each software suite at geodynamics.org. Software in CIG's open source library are assigned one of the following support categories:

Developed: Actively adding features to support improved science or performance by CIG [D_CIG] or by community contributors [D_CONTRIB].

Supported: Actively supported, maintained and upgraded by CIG [S_CIG] or by community contributors [S_CONTRIB].

Archived: No development activity; not supported. No commitment to updates. [A]

Developed Codes have been validated, passed benchmarks established by the appropriate community, and are leading edge codes in geodynamics. Developed codes may either be donated or developed by CIG Staff or the community. These codes are under active development or enhancements and often are actively supported by CIG through maintenance, technical assistance, training and documentation.

Supported Codes are mature codes that meet community standards but are no longer undergoing active development. Codes have been benchmarked and documented with examples and references such that they remain useful research tools. Supported codes include codes donated to CIG from members of our community. Minor changes such as bug fixes and binary upgrades are supported.

Archived Codes. Bug reports can be submitted via github but no resources are available for its development, maintenance, or support.

CIG Code Repository

	Version	# of single downloads	Lines of Code	% Change	Commits	Support Level
Short-Term Crustal Dynamics						
Pylith	*2.1.3	691	160,482	0%	158	D_CIG
Relax	1.0.7	289	20,259	32%	86	D_CONTRIB
VirtualQuake	*2.1.2	87	22,296	27%	333	D_CONTRIB
SELEN	*2.9.12	193	15,050	0%	5	S_CONTRIB
LithoMop	0.7.2	50	36,123	0%	0	A
Long-Term Tectonics						
Gale	1.6.1/2.0.1	318	3,748,303	0%	0	A
Plasti	1.0.0	27	7,375	0%	0	A
SNAC	1.2.0	49	174,838	0%	0	A
Mantle Convection						
ASPECT	*1.4	120	56,878	28%	764	D_CIG
CitcomCU	1.03	218	19,425	0%	0	D_CONTRIB
CitcomS	3.3.1	522	39,213	0%	0	D_CONTRIB
ConMan	2.0.0	28	7,123	0%	0	S_CONTRIB
Ellipsis3d	1.0.2	76	28,469	0%	0	A
HC	*1.0.5	83	15,534	0%	2	A
Seismology						
Axisem	*1.3	56	38,819	2%	49	D_CONTRIB
Burnman	*0.9	18	17,184	17%	308	D_CONTRIB
Mineos	1.0.2	302	6,636	0%	0	A
Flexwin	1.0.1	49	8,953	0%	0	A
Seismic CPML		70	9,222	24%	9	S_CONTRIB
Specfem3D		100	356,977	14%	316	D_CIG
Specfem3D Globe	*7.0.0	75	148,436	2%	88	D_CIG
Specfem3D Geotech	1.1	161	8,709	0%	0	D_CONTRIB
Specfem2D		86	163,936	4%	308	D_CONTRIB
Specfem1D		15	2,274	-2%	36	S_CONTRIB
SW4	1.1	158	68,892	12%	19	D_CONTRIB
Geodynamo						
Calypso	1.1.1	35	111,636	27%	2	D_CIG
MAG	1.0.2	27	9,001	0%	0	A
Computational Science						
Cigma	1.0.0	47	26,412	0%	0	A
Exchanger	1.0.1	8	2,734	0%	0	A
Nemesis	1.1.0	19	89	0%	0	S_CONTRIB
Pythia	*0.8.1.17	23	13,849	0%	0	S_CONTRIB

*new releases in 2015

Web Portal Statistics

Website: www.geodynamics.org
Unique visitors: 64,979
Visits: 301,939
Hits: 3,563,170 hits
Downloads 4,276 files
Page Views: 1,238,575

High Performance Computing Statistics

	SUs	Resource
XSEDE	1,040,677	Stampede
INCITE	150,00,000	Mira*
*dedicated to geodynamo project		

Other Support Received

Funding

EAGER: Development of software citation methodology for open source computational science
NSF Award Number: 1448633
Principal Investigator: Louise Kellogg
Co-Principal Investigators: MacKenzie Smith, Joseph Dumit, Lorraine Hwang
Organization: University of California, Davis
NSF Organization: SMA
Start Date: 09/01/2014;
Award Amount: $299,999

ACES Symposium, Chengdu, China, August 10-16, 2015*
NSF Award Number: 1542668
Principal Investigator: John Rundle
Co-Principal Investigator: Louise Kellogg
Organization: University of California, Davis
NSF Organization: EAR
Start Date: 07/15/2015
Award Amount:$20,000
* CIG provided administrative support for this workshop.

Allocations of Computing Cycles

XSEDE: CIG Science Gateway and Community Codes for the Geodynamics Community
PI: Louise Kellogg
Allocation Hours on TACC Stampede: 1,040,676

ALCF INCITE program (2015 component of a 3 year allocation): Frontiers in Planetary and Stellar Magnetism through High-Performance Computing
PI: Jonathan Aurnou, University of California, Los Angeles
Allocation Hours at ALCF: 83 Million on Mira

Knowledge Transfer

Workshops, Training, and Engagement with Other Communities

Date	Title	Codes	# Participants
2015			
May 19-30	ASPECT Hackathon	ASPECT	23
August 24-25	PyLith Modeling Tutorial	PyLith	72
2016			
June 17-19	PyLith Modeling Tutorial	PyLith	31
June 19	rayleigh Tutorial	Rayleigh	16
June 20-22	CIG'16 Interdisciplinary Directions in Computational Geophysics		77
June 21	Introduction to Python		28
June 23	ObsPy Tutorial	ObsPy	22
	Underworld II Tutorial	Underworld II	19
	ASPECT Tutorial	ASPECT	25
June 24	SPECFEM3D Tutorial	SPECFEM3D Globe	19
	SW4 Tutorial	SW4	19
June 24-July 2	ASPECT Hackathon	ASPECT	22

Webinars

Date	Presenter(s)	Title
October 8	Sanne Cottaar, Timo Heister, Bob Myhill, Ian Rose, and Cayman Unterborn	*An introduction to BurnMan - a mineral physics toolkit*
November 12	Anders Petersson	*Simulating seismic wave propagation with SW4*
December 3	Kasey Schultz & John Wilson	*An introduction to Virtual Quake*
January 14	William Oberkampf	*Verification, Validation, and Predictive Capability: What's What?*
February 11	Habib Najm	*Uncertainty Quantification in Computational Models of Physical Systems*
March 10	Anna M. Michalak	Statistical and computational challenges of constraining greenhouse gas budgets
May 12	Andreas Fichtner	*Resolution analysis by random probing*

YouTube

CIG's YouTube channel, *CIG Geodynamics*, hosts videos produced from simulations contributed by the community, recordings of past webinars and tutorials, and links to playlists of other community members (such as recorded lectures). Visitors are directed to the site mainly as a referral through YouTube and through geodynamics.org. Visitors come from an international community – 91 countries total. The page has 148 subscribers and approximately 3544 views, recent and past webinars being the most popular.

Activities at American Geophysical Union Annual Meeting (2015)

We hold the annual CIG Business Meeting in conjunction with the American Geophysical Union (AGU) Fall Meeting each year, taking advantage of the presence of more than 24,000 geophysicists in one place. The evening meeting provides a forum for information exchange and discussion about CIG operations.

The community self-reported AGU abstracts that they wish to see highlighted on the CIG website for research presentations featuring CIG software. Community members reported submitting 37 abstracts for posting for the 2015 Fall AGU Meeting in areas of Study of Earth's Deep Interior, Geodesy, Seismology, Tectonophysics, and Volcanology among others.

Monday, December 15

DI13B-2661. Numerical Models of Subduction Beneath Non-Uniform Overriding Plates. Implications for Subduction Velocity and Seismic Anisotropy, J. Rodriguez-Gonzalez, M.I. Billen, A.M. Negredo, L.G.J. Montesi.

DI13B-2667. 2D Dynamic Models of Subduction: Links between Surface Plate Motion and Deformation in the Transition Zone from Observations of Deep Slab Seismicity, Katrina Arredondo, Magali Billen.

G13A-1010. Revised Interseismic Coupling Models for the North Island, New Zealand, Using FEM-Derived Green's Functions, C. Williams and L. Wallace.

S11B-01.The influence of the Moho in local and teleseismic wavefield simulations, C. Tape and P.Tong.

S12A-08. Triggered Swarms and Induced Aftershock Sequences in Geothermal Systems, Robert Shcherbakov, Donald Turcotte, and M. Burak Yikilmaz.

S12B-04. Towards exascale seismic imaging & inversion, Tromp, J., Bozdag, E., Lefebvre, M., Smith, J., Lei, W., and Ruan, Y.

S13B-2807. Statistical Properties of Induced and Triggered Earthquakes at The Geysers, California, Angela Hawkins, Donald Turcotte, and Louise Kellogg.

S13C-04. Spectral-infinite-element Simulations of Self-gravitating Seismic Wave Propagation Gharti, H.N., and Tromp, J.

S13-06. Plumes, hotspots and slabs imaged by global adjoint tomography, Bozdag, E., Lefebvre, M., Lei, W., Peter, D., Smith, J., Komatitsch, D., and Tromp, J.

T11B-2874. Flat Slab Formation and Evolution below Cratonic Lithosphere: Insights from 3D Time-Dependent Modeling, J.M. Taramon, A.M. Negredo, J. Rodriguez-Gonzalez, M.I. Billen.

T11D-2934. Mantle Flow Pattern and Dynamic Topography beneath the Eastern US, Liu, S. and King, S. D., Adam, C., Long M. H., Benoit, M., Kirby, E.

T13A-2972. Rayleigh-Taylor instability as an interpretation of subduction initiation: implications for onset of plate tectonics on terrestrial planets, Teresa Wong and Slava Solomatov.

Tuesday, December 16

DI23A-04. Slab stagnation: How, when, and where?, King, S. D., Frost, D. Rubie, D.

ED22B-06. 3D movies for teaching seafloor bathymetry, plate tectonics, and ocean circulation in large undergraduate classes, Carlye Peterson, Lorraine Lisiecki, Geoffrey Gebbie, Bernd Hamann, Louise Kellogg, Oliver Kreylos, Markus Kronenberger, Howard Spero, Gregory Streletz, and Christopher Weber.

H21E-1411. Reservoir Characterization in an Underground Gas Storage Field Using Joint Inversion of Flow and Geodetic Data/Energy Development and Storage in the Subsurface: Modeling and Monitoring Challenges and Solution Strategies I Posters, Birendra Jha, Marc Hesse, and Beatrix Becker.

S21E-05. Mantle structure assessed from tomography models coupled with thermodynamic constraints, Adam, C., King, S. D.

S21E-06. Towards Full-Waveform Tomography of the Italian Lithosphere, F. Magnoni, E. Casarotti, D. Komatitsch, D. Melini, A. Michelini, A. Piersanti, C. Tape, J. Tromp.
S23C-2713. Advances in Global Adjoint Tomography -- Massive Data Assimilation, Y. Ruan, W. Lei, E. Bozdag, M. Lefebvre, J. Smith, L. Krisher, and J. Tromp.
T21E-2875. Sudden subduction channel and mantle wedge weakening leads to the vertical deformation pattern changes before and after great subduction zone earthquakes
U22A-04. Post-Earthquake Geology in the Era of Ubiquitous Point Clouds, Michael Oskin, Ramon Arrowsmith, Edwin Nissen, Alexander Morelan, Charles Trexler, Peter Gold, Austin Elliott, Christopher Crosby, and Louise Kellogg.
V23A-3086. Numerical Modeling of Surface Deformation due to Magma Chamber Inflation/Deflation in a Heterogeneous Viscoelastic Half-space / Styles of Volcanism: Forecasting, Pattern Recognition, and Monitoring Developing Eruptions, Michal Dichter

Wednesday, December 17

DI31B-2581. 3D Compressible Melt Transport with Mesh Adaptivity, Juliane Dannberg, and Timo Heister.
DI31B-2604. Heating and Cooling in Small Undifferentiated Planetary Interiors, Louise Kellogg, Marie Weisfeiler, and Donald Turcotte.
P33B-2130. Surface Temperatures of Exoplanets, Marie Weisfeiler, Donald Turcotte, and Louise Kellogg.
S33C-2785. Spectral-Element Seismic Wave Propagation Codes for both Forward Modeling in Complex Media and Adjoint Tomography, Smith, J.A., Komatitsch, D., Lefebvre, M., Peter, D., Tromp, J., and the entire SPECFEM3D Development Team
T33E-2975. Pointwise functions for flexible implementation of crustal deformation physics in PyLith, Brad Aagaard, Matthew Knepley, Charles Williams.
T33E-2980. Free surface calculations in mantle convection, Ian Rose, Bruce Buffett, and Timo Heister.
T33E-2983. Comparison of Nonlinear and Linear Stabilization Schemes for Advection-Diffusion Equations, Ryan Grove, and Timo Heister.
T33E-2984. Recent Developments in the Community Code ASPECT, Timo Heister, Wolfgang Bangerth, Juliane Dannberg, and Rene Gassmoeller.
Thursday, December 18
GP43B-1253. Optimization of Parallel Legendre Transform using Graphics Processing Unit (GPU) for a Geodynamo Code, Harsha Lokavarapu, Hiroaki Matsui.
GP43B-1254. Performance and accuracy benchmarks for a next generation geodynamo simulation, Hiroaki Matsui and CIG dynamo working group.
P42A-08. *T*he role of the icy shell in the thermal evolution of Ceres, King, S. D.
T42B-05. Earthquake source studies and seismic imaging in Alaska, C. Tape and V. Silwal.
T44C-08. Kinematics and Dynamics of Observed Along-Rift Surface Motions in the East African Rift System, D.S. Stamps, W. Bangerth, B. Hager.

Friday, December 19

IN53B-1846. Software Attribution for Geoscience Applications in the Computational Infrastructure for Geodynamics, Lorraine Hwang, Joseph Dumit, Alison Fish, Laura Soito, Louise H Kellogg and MacKenzie Smith.
S51A-2661. CMT Source Inversions for Massive Data Assimilation in Global Adjoint Tomography, Lei, W., Ruan, Y., Bozdag, E., Lefebvre, M., Liu, Q., Peter, D., Smith, J., Song, X., Komatitsch, D., and Tromp, J.
S53A-2769. ASDF: An Adaptable Seismic Data Format with Full Provenance, Smith, J.A., Krischer, L., Lefebvre, M., and Tromp, J.

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