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Collaborative Research: St. Elias Erosion and Tectonics Project (STEEP)

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Preview of Award 1009626 - Final Project Report

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
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Project Title:	COLLABORATIVE RESEARCH: St. Elias Erosion and Tectonics Project (STEEP)
PD/PI Name:	Peter O Koons, Principal Investigator Phaedra Upton, Co-Principal Investigator
Recipient Organization:	University of Maine
Project/Grant Period:	10/01/2010 - 08/31/2013
Reporting Period:	10/01/2012 - 08/31/2013
Submitting Official (if other than PD\PI):	Peter O Koons Principal Investigator
Submission Date:	06/18/2014
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Peter O Koons

Accomplishments

*** What are the major goals of the project?**

1) Refinement of a regional scale model to include an approximation of the true 3D geometry of

the orogen.

2) Develop a new local-scale model that incorporates topography, GPS data, and glacial

erosion processes to refine the initial results.

3) Develop a modeling experiment to test the hypothesis that the rise and fall of ice masses

during glacial cycles might influence where deformation is focused at any given time.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: see pdf

Specific Objectives: see pdf

Significant Results: The pattern of strain after glacial unloading differs from the tectonic contribution but is less than the changes in strain due to glacial loading. Based on the glacial unloading results for southeast Alaska, we suggest that most of these changes take place immediately or shortly after the glacial load is reduced and manifest in seismic releases along both the Alpine fault and northeast of the Ben Ohau region along the Ostler fault. Unfortunately, the record of paleo-seismicity for the Ostler fault is not high enough resolution and does not show significant or any change in the strain rates during the LGM making quantitative comparison of natural and model results difficult.

The influence of deglaciation on a region is very location specific, and when comparing New Zealand to southeast Alaska these results offer little insight to unloading of valley glaciers. Results show that in an obliquely convergent margin with valley glaciation there is likely to be changes in strain along the valley walls which may lead to seismic events. The response is influenced by the size of the load and the rheology of the region, as well as the inclusion and locations of faults.

For both the faulted and unfaulted models in Alaska and New Zealand, glacial loading changes the pattern and magnitude of strain. The strain is influenced more during glacial loading than unloading due to the fact that the unloading response occurs rapidly after removing the glacial load and isn't well resolved in the strain increment. The faulted model matches observations best for both regions, results show higher strain along the faulted boundary because less stress is required to overcome the strength along that boundary. After glacial unloading in the Alaska model there is a steep gradient in YZI in the Yakutat bay region. This corresponds well with the epicenters of the 1899 earthquakes in Yakutat Bay, a combined tectonic and glacial isostatic response to LIA unloading. The models capture a response to a much larger unloading event, the LGM, at a low frequency and long wavelength and indicate that the response to glacial loading and unloading can still be detected at low frequencies and longer wavelengths.

These results are valuable because they demonstrate that the pattern of strain in an actively deforming orogen can be changed with glacial loading and that even after unloading, the strain records these changes. Observations indicate that these changes in strain due to unloading can lead to increased seismicity in both Alaska and New Zealand. Results from the faulted Alaska model match well with observations of past seismic releases. In a tectonically active region where mass loss is likely going to continue, this should be considered in estimates of seismic hazard. From these models we conclude that it is possible to predict areas of increased seismicity due to modern unloading.

Results from the New Zealand models demonstrate that smaller valley glaciers can influence local tectonics. In a faulted region, this could result in seismic release(s) along those faults. The influence of deglaciation is very region specific and changes based on the location of faults, the incoming plate vector, and the rheology of the region. Therefore using the LGM New Zealand results as an analog to modern mass loss in Alaska is not

the best method to assess future seismic hazards. Overall, rheology is the primary control on the response to glacial loading. For this reason, the rheology of a given study area should be considered carefully for each model, especially models that are used to test the response to some perturbation (e.g. glacial loading and unloading).

Key outcomes or Other achievements: see pdf

*** What opportunities for training and professional development has the project provided?**

This project has partially or completely funded one MS graduate student and two undergraduate students and provided opportunities for travel, field work, exposure to national and international workshops. In addition, these students have had the opportunity to become familiar with the basic tools of large scale numerical computation of earth systems including 3D finite element techniques, mesoscale modeling of the atmosphere, data visualization and ice sheet modeling. The MS student, L. Wheeler has presented her work at AGU, NSF-funded workshops, IGNS- New Zealand and has bee awarded an NSF EAPSI Fellowship for travel and research in New Zealand.

*** How have the results been disseminated to communities of interest?**

Results from the modeling have been presented at international meetings (AGU, GSA) in oral and poster form; at NSF-funded workshops for STEEP participants (Seattle, 2012; Austin, 2013); in publications (see list below) and in open lectures (Seattle, 2013; Orono; 2012).

Koons has continued to support development of UMaine web based high resolution climate modeling capacity with S. Birkel, partially supported by STEEP during his PhD, and undergraduate research assistants. The direction for this year has been to concentrate on global and local representations of mesoscale atmospheric circulation model, and expand the publicly available website for viewing reanalysis datasets in the Geodynamic numerical lab funded in part by STEEP funds. See: http://cci-reanalyzer.org/

Supporting Files

Filename	Description	Uploaded By	Uploaded On
STEEP_annual_report_2014_activities.pdf	The attached pdf contains text and figures describing activities, model results and project outcomes.	Peter Koons	06/18/2014

Products

Books
Nothing to report.

Book Chapters
Nothing to report.

Conference Papers and Presentations
Nothing to report.

Inventions
Nothing to report.

Journals
Nothing to report.

Licenses
Nothing to report.

Other Products
Nothing to report.

Other Publications
Nothing to report.

Patents
Nothing to report.

Technologies or Techniques
Nothing to report.

Thesis/Dissertations
Nothing to report.

Websites
Nothing to report.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
steep annual report 2014 products_publications.pdf	File contains citations for publications and presentations partly or completely funded by this project	Peter Koons	06/18/2014

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Koons, Peter	PD/PI	2
Upton, Phaedra	Co PD/PI	1
Wheeler, Lauren	Graduate Student (research assistant)	12
Johnson, Cory	Undergraduate Student	3
O'Neil, James	Undergraduate Student	3

Full details of individuals who have worked on the project:

Peter O Koons
Email: Peter.Koons@maine.edu

Most Senior Project Role: PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: Director of Geodynamic modeling

Funding Support: No funds from this grant supported Koons' salary. Support for presentation came from this grant

International Collaboration: Yes, New Zealand
International Travel: No

Phaedra Upton
Email: phaedra.upton@maine.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Geodynamic modeler, programmer, advisor

Funding Support: 1 month of salary was provided over two years for Upton.

International Collaboration: Yes, New Zealand
International Travel: Yes, New Zealand - 5 years, 0 months, 0 days

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Lauren Wheeler
Email: lauren.bronwyn.wheeler@gmail.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: As RA on this project, Lauren developed and executed programs for the coupled Climate/Ice Sheet/ Geodynamic modeling with results described in the "Accomplishments" section.

Funding Support: Supported by stipend from this project.

International Collaboration: Yes, New Zealand
International Travel: Yes, New Zealand - 0 years, 3 months, 0 days

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Cory Johnson
Email: cory.j.johnson@maine.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Cory prepared numerical results for visualisation in the UMaine Geodynamics facility.

Funding Support: Funded at hourly rate by this project for 2 semesters

International Collaboration: No
International Travel: No

James O'Neil
Email: james_oneil@umit.maine.edu

Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: James prepared numerical results for visualisation in the UMaine Geodynamic facility

Funding Support: Funded by this project for hourly work over 2 semesters

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
IGNS New Zealand	State or Local Government	New Zealand

Full details of organizations that have been involved as partners:

IGNS New Zealand

Organization Type: State or Local Government
Organization Location: New Zealand

Partner's Contribution to the Project:
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution: Upton contributed to the project and Wheeler visited IGNS and use numerical facilities in 2013

Have other collaborators or contacts been involved? No

Impacts

What is the impact on the development of the principal discipline(s) of the project?

We have produced the first model that couples a dynamic climate' s influence on ice sheet development and then the influence of that ice sheet and its changes on the 3D geodynamics of any piece of Earth.

In looking at the earth response to the glacial load within a convergent setting, we can provide previously unavailable constraints on crustal rheology.

What is the impact on other disciplines?

The effect of glacial unloading provides information for the interpretation of the paleo-seismicity record within orogens undergoing both glaciation and tectonic deformation, including Southeast Alaska and Southern New Zealand.

What is the impact on the development of human resources?

Our outreach program permits open access to climate interogation and modeling.

What is the impact on physical resources that form infrastructure?
Nothing to report.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?

Generation of a coupled climate- ice sheet- geodynamic model for general use at UMaine facilities.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?

Provides information on Southeast Alaskan human migration potential during LGM;

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.
Nothing to report.