“Geoscience without Borders”


- Cort Christie
Complete the “structure & evolution of the North American continent”

Case One: Oct. 2012 Eq = Large tsunami not directly witnessed by a person.

Detected by a tide gauge in Hawaii.
Incipient subduction

Haida Gwaii Margin
-partition of oblique convergence into strike slip-thrust Earthquake
(Hyndman et al 2014)
Part 1: Katherine – Overview
- "EarthscAN" – CCArray – CC-NET
- Scientific goals; structure

Part 2: Tom – GNSS Workshop
- Scientific goals continued
Takeaways

1. Introduce CCArray

2. Advice, lessons learned or suggestions are appreciated!

3. We look forward to collaborations; please talk to us
“EarthscAN” – pan-Canada

“Magnetosphere through crust to core”
“EarthsCAN” – Motivation:
Maintain North American Large Geoscience Research Program Momentum

COCORP
Consortium for Continental Reflection Profiling
11,000km - 30 US states
(~1980 to 1997)
http://www.geo.cornell.edu/geology/cocorp/COCORP.html

LITHOPROBE
“Other Supporting Geosciences”
1000 geoscientists
& 1500 scientific pubs
(1984 to 2004)
(Hammer et al 2011; GSA Today)

EarthScope (IRIS)
TA – 2226 sites
>290 scientific pubs 2009 to 2013
(2004 to ~2018)
http://www.earthscope.org

“EarthsCAN?”
~2017 to ???
Why timing is critical: EarthScope – 2004 to ~2018

Instruments now in Alaska and nw Canada

Instruments could be removed as early as 2019

CCArray separated from EarthsCAN

Map courtesy S. Azevedo and R. Busby.
Subduction Zone Observatory

Canadian Cordillera Array (CCArray)

(From IRIS Workshop June 2016; EarthsCAN brainstorming workshops Calgary/Ottawa Aug. 2016; SZO Workshop Sept. 2016)
Some CCArray Scientific Targets

“Mini Himalayas” Yakutat Block

Orogenic Float Model

(Hyndman & Mazzotti 2002)

(Mazzotti et al 2008)

Missing Active Faults??
First White Paper – Cascadia Forearc active fault
(Amos (WWU), Harrington (McGill), Kirkpatrick (McGill), Leonard (UVic), Levson (UVic), Liu (McGill), Morrell (UVic), Regalla (Boston U), Rowe (McGill); Morrell et al GSA Today 2016)

Red – active crustal faults

No previous active faults proven in Canada

Recent lidar, field work, & paleoseismic trenching
→ large (M6-7) late Quaternary Eq on Leech River Fault

Proposed:
Expand lidar, seismic, GPS
→ fieldwork, trenching
→ ID other active crustal faults in western (and NW) Canada
Consider the TA as a massive collection of arrays

Use Delauney triangulation to define 580 triads

Modelling atmospheric gravity waves
(see de Groot-Hedlin & Hedlin posters)

de Groot-Hedlin, Hedlin and Walker, 2013
May-August: 2010-2014

Next stage for improving predictive Component of Numerical Weather Modelling
Weather stations On CCArray = Improved Numerical Weather Modelling East of Cordillera
Calgary Pre-Flood/Post-Flood Comparison

Before flood: Google Earth Image
September 2008

After flood: NASA/ISERV Image
June 22, 2013

This image was taken by ISERV—a new NASA-developed testbed camera onboard the International Space Station.
CC-Net (Pilot for CCArray)

CC-NET (pilot phase):

NSERC – LOI Submitted

- Create a new national research network, with Canadian and international partners
- Establish a set of pilot sites
- Commence collaborative research within 4 themes that are linked to the NSERC strategic target areas
- Create a scalable management structure

Represents a start to build upon for future larger funding

Develop protocols needed for stations to support multiple sensors
Summer 2017 – Calvert Island

1st Type I site – Calvert Island
- Hakai Institute
- seed funds from UofC

1st Type II site (?) – Valemount
- linked to geothermal E

Other Type II sites – AINA Kluane Lake, NE BC

Sponsorship – Borealis Geopower, Geoscience BC, BC Hydro
CCArray Proposed Organizational Structure

Board of Directors
Ron Clowes (past Director of LITHOPROBE), Petroleum, Mining, GSC

Director
(Dave Eaton; UofCalgary)

Operations Manager
Scientific Committee Chair
(TBD)

EOC Chair
(Katherine Boggs; MRU)

EOC Team
(being established)

Operations Team

Thematic Working Groups
- Geohazards
  Resources & Infrastructure
  Coastal Hazards / Earthquakes
  Netotectonics
- Geochem
- Critical Zone
- Tectonic Processes
  Plate Boundary Evolution
  Lithosphere Tectonics
  Crustal Deformation
- Regional Geology
  Volcanics
  Mineral Deposits
  Stratigraphy
  Metamorphic Petrology
- Geothermal Energy
- Climate Related Hazards
- A/M/WM
  Numerical Weather Modelling
  Magneto.

Advisory Board
Jeff Freymueller – UAF; earthscope
Julie Elliott – Purdue U
Derek Schutt – Colorado State U
Rick Aster – Colorado State U Geosciences (TBD)
Recent Progress
- 1st townhall April 2017
- website launched last Friday
- strategic plan in progress

CCArray Virtual Townhall Meeting
by reism  May 5, 2017  10:04 am  Leave a comment  Uncategorized

On April 26, 2017 the CCArray scientific community held a virtual townhall meeting to review the current status of the project. Notes from the meeting are available here: CCArray_Townhall_April2017
Global Navigation Satellite System (GNSS) workshop for Canadian Cordillera Array (CCArray)

March 20 & 21, 2017
Pacific Geoscience Centre
Goal of workshop

- Define high-level scientific targets and geographical regions for a densified GNSS network in western Canada as part of the Canadian Cordillera Array (CCArray) initiative, capitalizing on anticipated domestic and international opportunities for instrumentation, operations, and funding.

- About 40 participants
- One day of talks, ½ day of discussion and breakout groups
- Main output is map of proposed densified GNSS network, accompanying science rationale.
Outline

• (Some) science goals
• Present GNSS network
• Workshop outcomes
  • suggested network densification
  • additional science community engagement
  • Programmatic considerations, looking forward
Crustal Motion Measured by GNSS

- Arctic Ocean Under-thrusting
- Seismicity and Hazard Throughout
- Continent-Ocean Transform Faulting
- Subduction Initiation
- Margin Parallel Sliver Motion
- Subduction & Slab Window effects
- Craton-Cordillera lithosphere boundary

(Mazzotti et al., 2008)
Postglacial Rebound – aka Glacial Isostatic Adjustment

Uplift rates generally measured in mm/yr, horizontal motions ~1 mm/yr

Clague and James, 2002

Peltier et al., 2015
Postglacial Rebound – aka Glacial Isostatic Adjustment

Alaska, response to Neoglacial fluctuations

BC and Alaska, elastic response to present-day ice mass change

Larsen et al., 2005

T James, based on G. Cogley’s compilation.

Models require ice load history and assumed Earth structure and rheology
Sea-level projection for high-emissions scenario at 2100

Vertical crustal motion exerts a dominant control on relative sea-level projections.

Shows all sites for which projections are provided.

James et al., 2014; 2015
Lemmen et al., 2016 “Canada’s Marine Coasts in A Changing Climate”
Western Canada interior - seismicity

2001-2008 (N = 97)

2009-2016 (N = 429) Inferred link to hydraulic fracturing

1. Horn River basin (BC Oil and Gas Commission, 2012)
2. Montney (BC Oil and Gas Commission, 2013)
3. Duvernay (Schultz et al., GRL, 2015)
4. Alberta Bakken (Schultz et al., BSSA, 2014)

Source: inducedseismicity.ca/catalogues/ $M_L \geq 2.5$ (probable quarry blasts removed)

Slide courtesy D. Eaton, U. Calgary
Other Potential Topics

• Ionospheric, tropospheric studies
• Hydrological loading
• Snow, water levels, vegetation, soil moisture monitoring (PBO H20 web site)
Outline

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Western Canada and Adjacent US continuous GNSS Stations
Earthquake Early Warning
Augmentation of Network

Ocean Networks Canada – Province of BC (EMBC) – Natural Resources Canada

- **Network**: Installation by March 31, 2019
- Development of Earthquake Early Warning system targeting Cascadia Subduction Zone events;
- Installation of strong-motion and GNSS instruments, offshore component focusing on seismic instrumentation;
Outline

• (Some) science goals
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Key Elements

- Substantial interest (at workshop) in active tectonics and earthquake hazard
- Fill in gaps in interior for distributed strain
- Sites to detect present-day (and past) mountain glacier change
- Regional strain field to better understand induced seismicity
- Opportunities offered by technological developments – e.g., acoustic (sub-sea) GPS
- About 100 new sites + circles
Key elements (continued)

• GNSS distribution is ‘pure’ – generated solely based on the requirements to answer questions (mainly kinematic), but how does it relate to provisional seismic instrument distribution?
  • Co-locate sites, where feasible, price out costs

• With regard to GNSS, need to more fully engage with various communities:
  • Meteorology – numerical weather modelling
  • Glaciology
  • Volcanology
    • Mt. Meager, Garibaldi volcanic belt, Anahim VB
  • Induced seismicity
    • Regional/local targets (and INSAR/repeat LIDAR)
Key Elements (continued)

- Need to consider supporting geoscience to answer questions, e.g.,
  - INSAR/LiDAR for local/regional ground deformation;
  - surface exposure dating for glaciological history for GIA modeling;
  - glacier monitoring;

Programmatic
- Devote substantial resources to outreach and education (15-30%?)
- Be aware of data management (esp. meta-data) requirements

- Workshop report is pending
Next Steps for CCArray

- Monthly teleconferences; regular updates
- June – 2017 GSA Rocky Mtn Section Mtg in Calgary at MRU
- August – First Annual CCArray Meeting – Compose complete submission for NSERC – SPGN grant
- August – install instruments on Calvert Island
- Fall 2017 – write CFI proposal for instrumentation to co-install with seismometers
- December – AGU session
- Spring 2018 – start installing CC-NET instruments
1. Introduce CCArray

2. Advice, lessons learned or suggestions are appreciated!

3. We look forward to collaborations; please talk to us
Thank you!

Questions?