EON-ROSE (and CCArray)

Presented by: Katherine Boggs (MRU)

Eaton, D., Sideris, M., Donovan, E. (UofC), Hyndman, R., James, T., Ulmi, M. (PGC/UVic), Audet, P. (UofO), Elliot, J. (Purdue), Freymueller, J. (UAF; EarthScope), Aster, R., Schutt, D. (CSU), Rowe, C. (McGill), Morell, K. (UCSB), Leonard, L. (UVic), and many others

The Blue Marble

(Apollo 17 – Dec 7, 1972; ~45,000km)

Concept:

1. Create new research networks to improve holistic understanding of entire Earth Systems
2. Make Earth Systems science main stream (community engagement & outreach)
3. Public benefits – hazard mitigation, strategic significance for transportation corridors

Godfrey Nowlan: "We have only one planet and it is important to us"

Takeaways

1. **New pan-Canadian research initiative**
2. **Call for collaborations – intrigued?**

   Want to be involved?

   Is there someone else who we should talk to?
3. **Comments, suggestions?**
4. **Please spread the word**

Please contact one of the authors (or Katherine Boggs at kboggs@mtroyal.ca)

"EON-ROSE" – Motivation:
(Earth Systems Observation Network)

Maintain North American Mega Earth Sciences Research Program Momentum

Consortium for Continental Reflection Profiling
11,000km - 30 US states

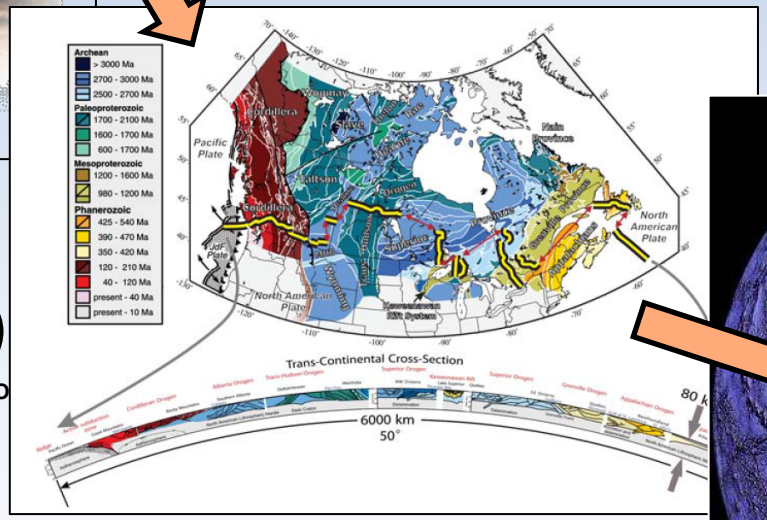
(~1980 to 1997)

http://www.geo.cornell.edu/geology/cocorp/COCO

LITHOPROBE
1000 geoscientists
& 1500 scientific pubs

(1984 to 2004)

(Hammer et al 2011; GSA Today)

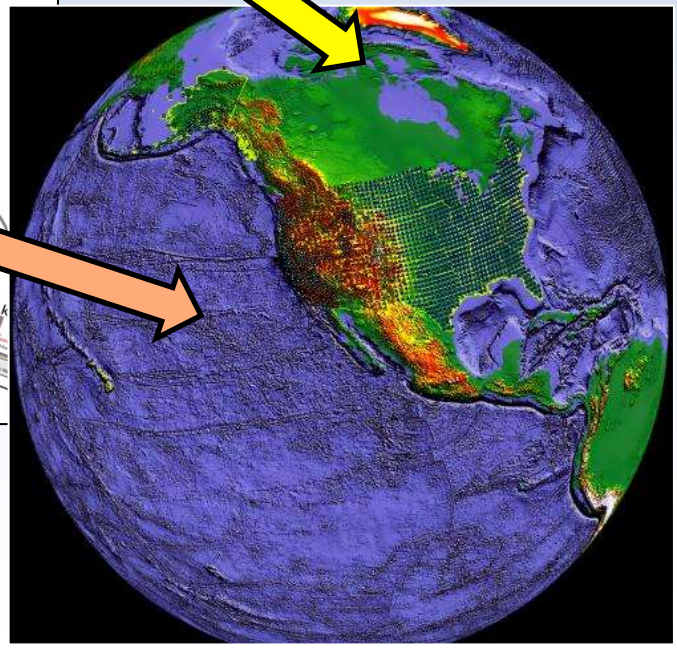


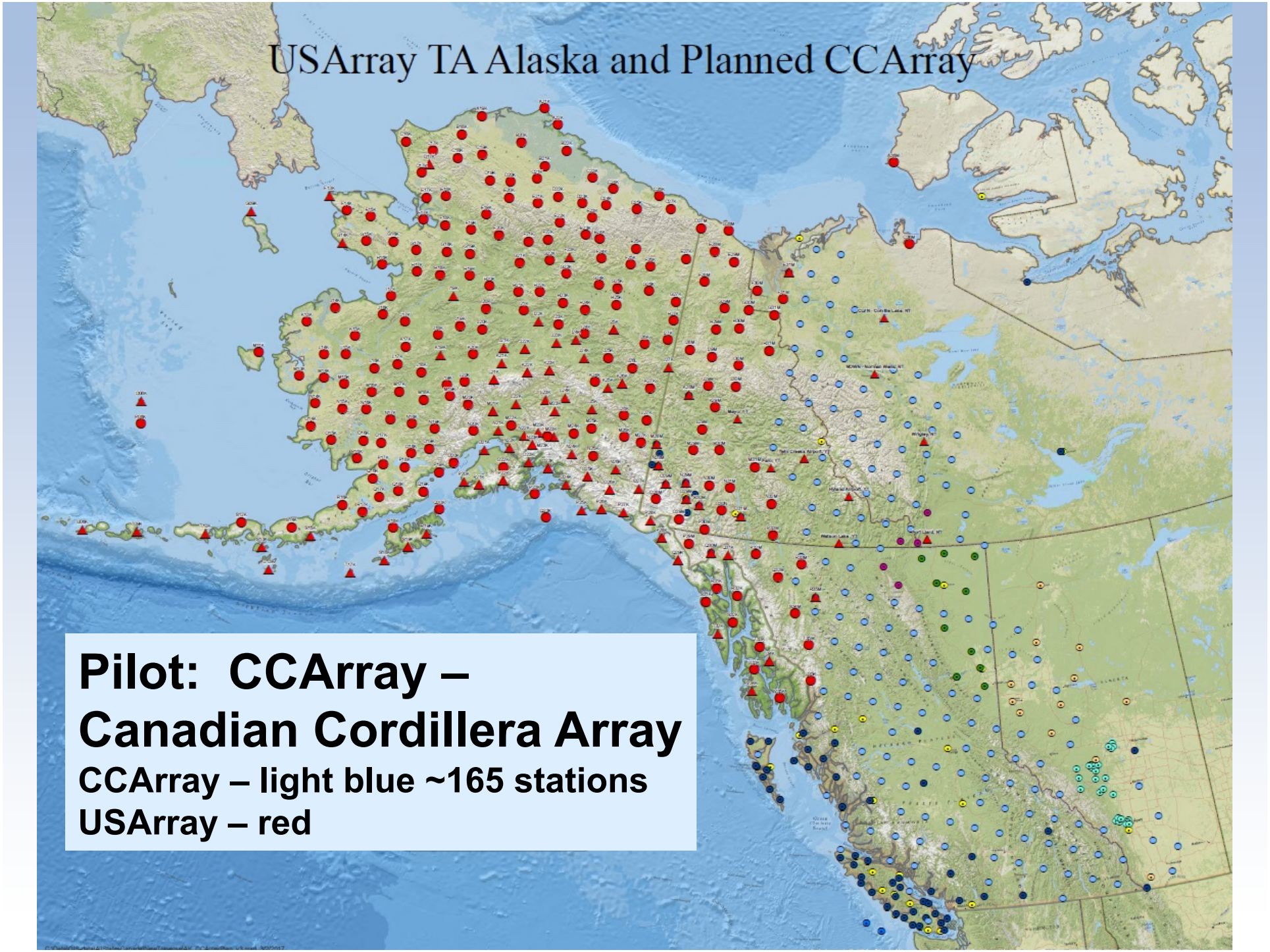
Earthscope (IRIS)
TA – 2226 sites
>290 scientific pubs 2009 to 2013

(2004 to ~2020)

http://www.earthscope.org

"EON-ROSE?"
~2018 to ???



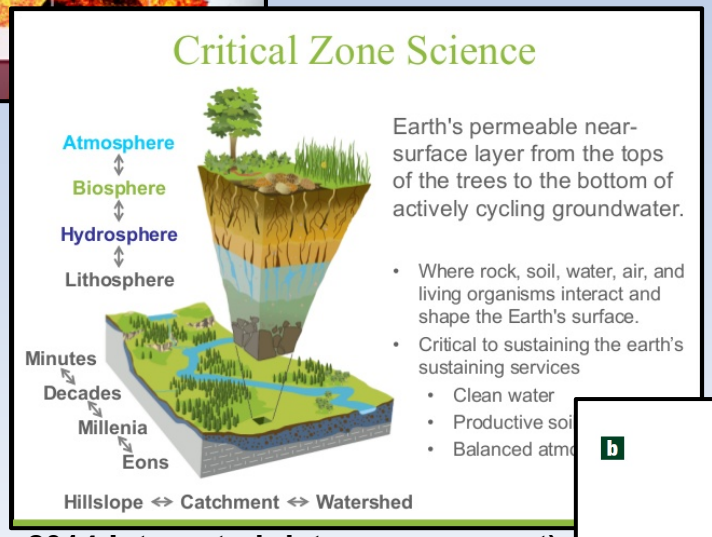

USArray TA Alaska and Planned CCArray
Pilot: CCArray –
Canadian Cordillera Array
CCArray – light blue ~165 stations
USArray – red

Why? Auroras through Critical Zone To Tomography?

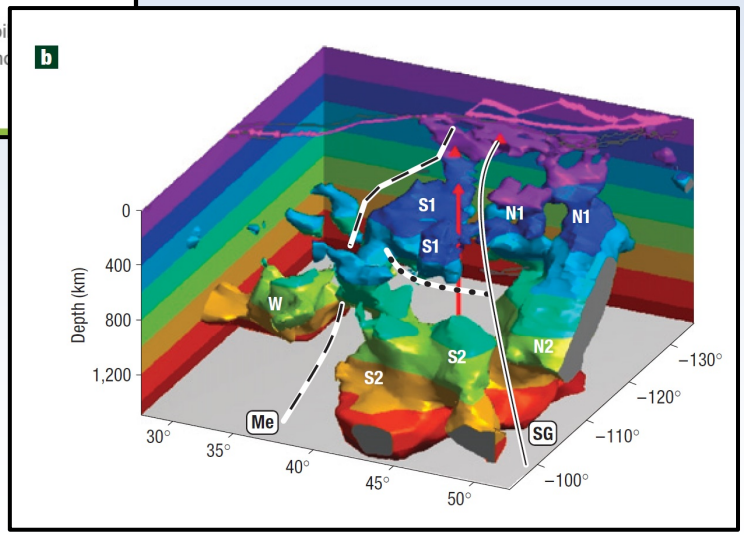
Magnetosphere & Auroras
(SWARM (ESA) logo)

Need to understand entire

Earth Systems before



(ahm-2014-Integrated-data-management)



(Sigloch et al, 2008; Nature Geoscience)

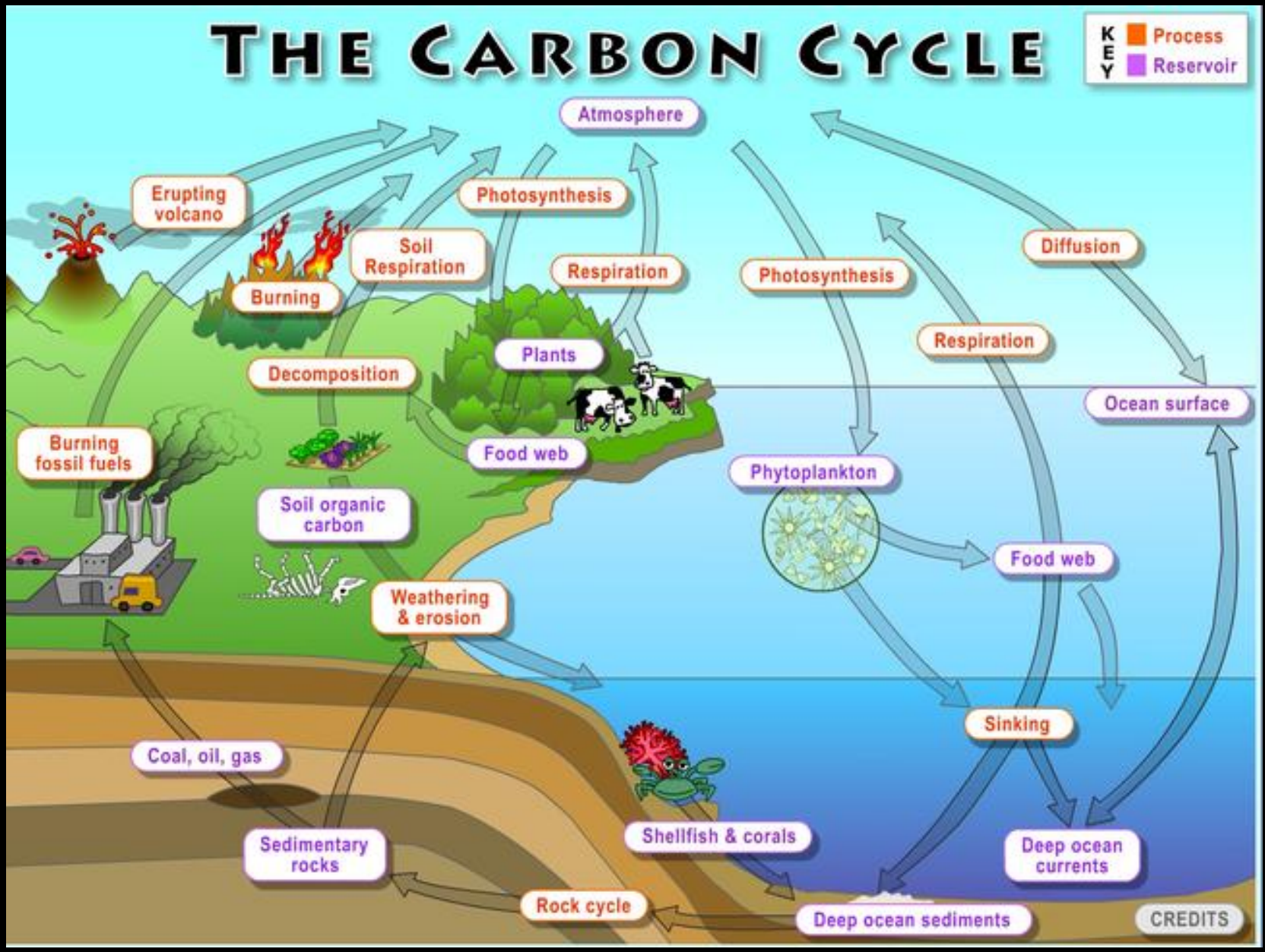
We can be sustainable

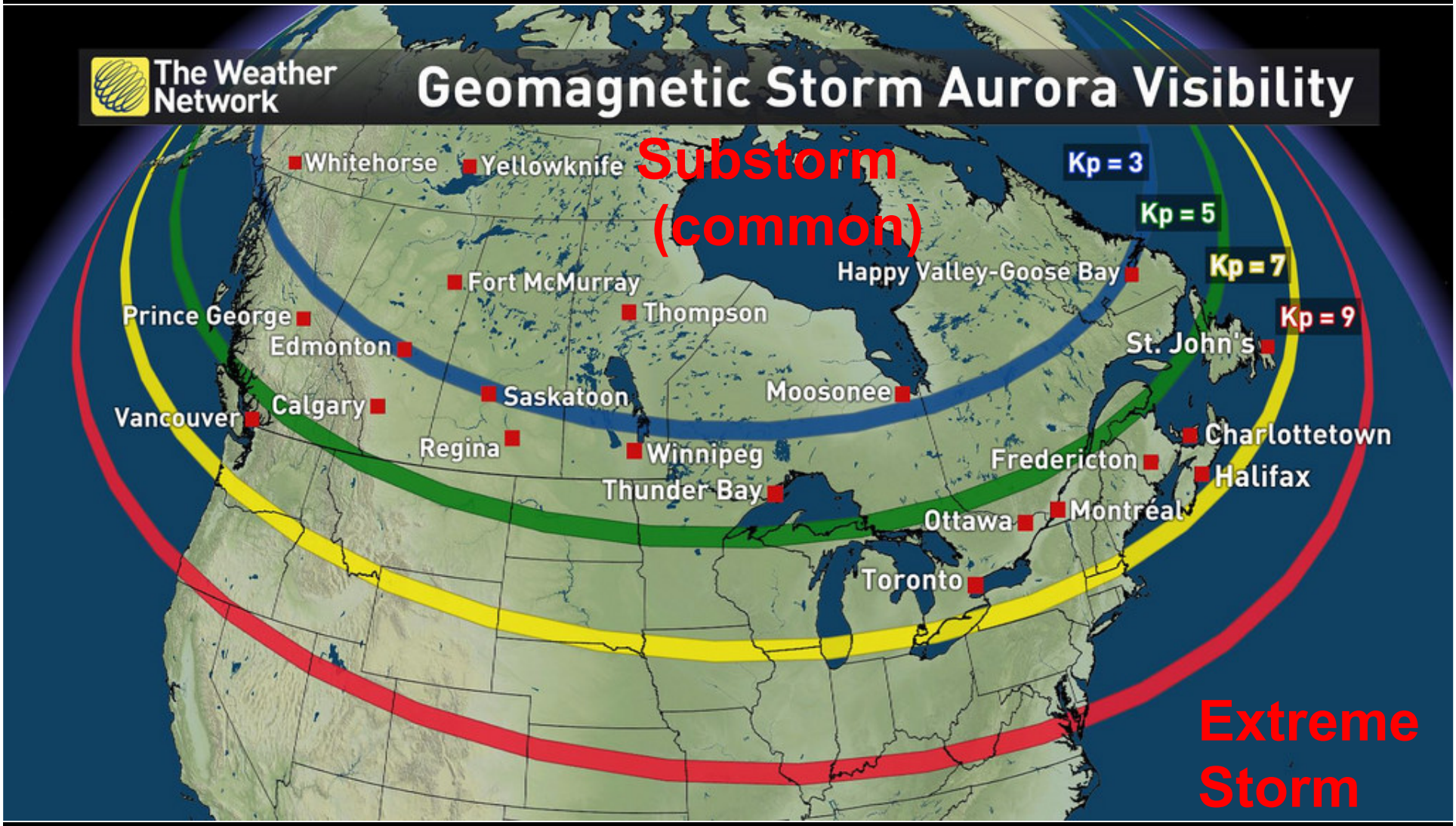
to support humanity

EON-ROSE – Possibilities

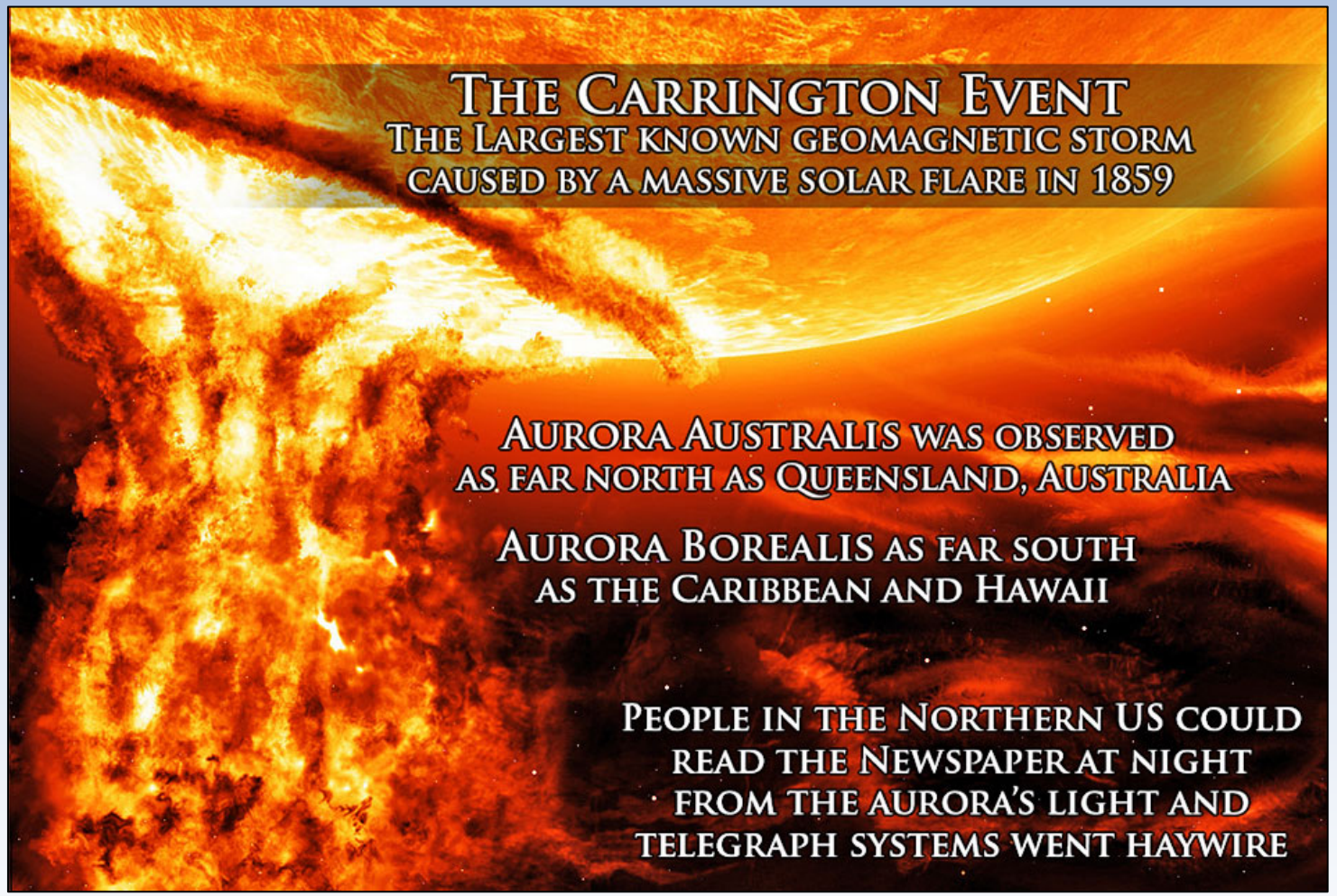
Limited by Imagination:

1. Entire Earth Systems
2. Magnetosphere and Space Weather
3. Environmental Monitoring
4. Numerical Weather Modeling
5. Pre-emptive Mineral Exploration Program
6. Critical Zone – Arctic, Coastal, Carbonates
   -Bumble bees and soil
6. Tomography
7. Also hazards…

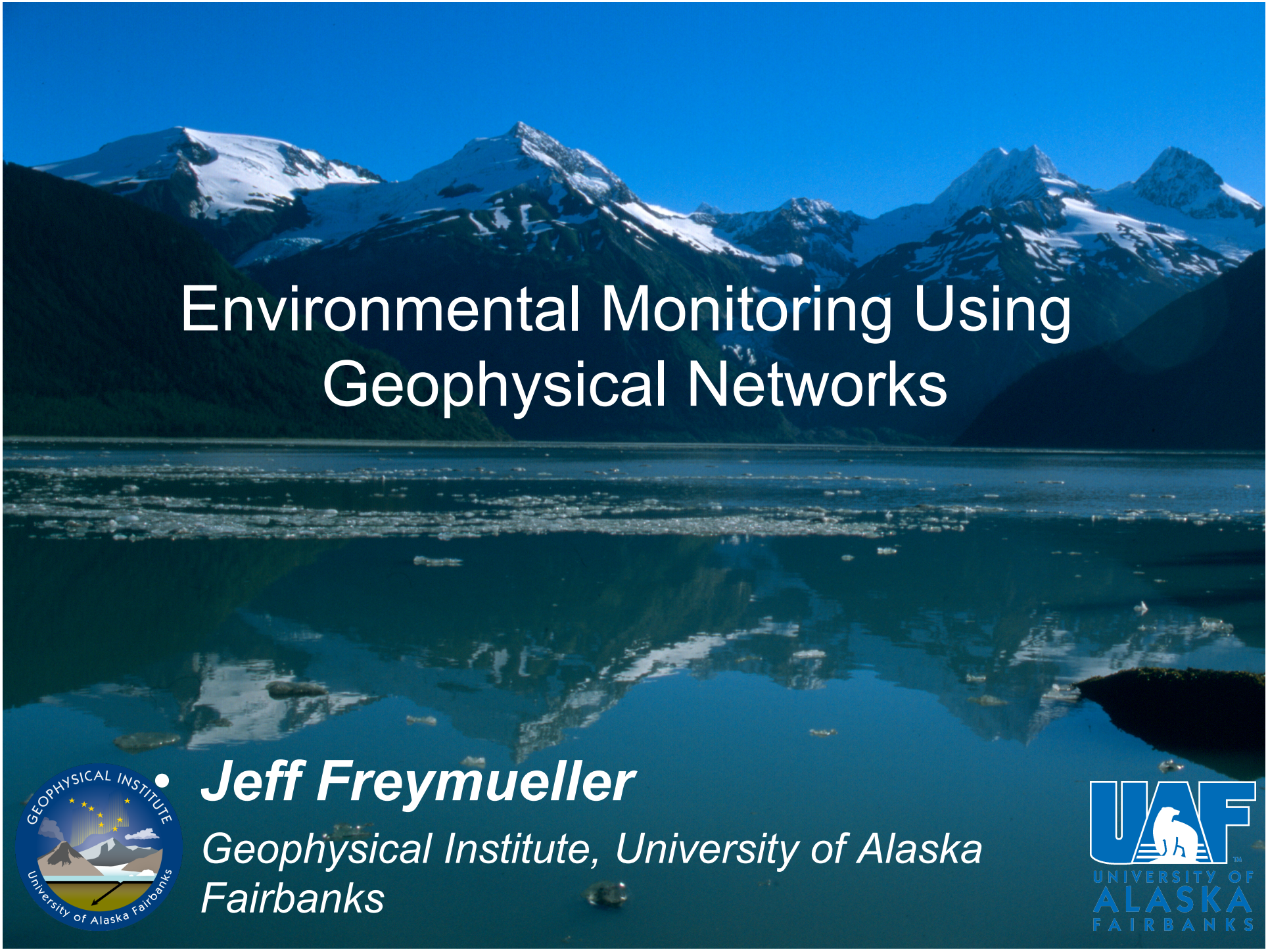



The Weather Network
Geomagnetic Storm Aurora Visibility
Substorm (common)
Kp = 3
Kp = 5
Kp = 7
Kp = 9
Whitehorse
Yellowknife
Fort McMurray
Happy Valley-Goose Bay
Prince George
Thompson
Edmonton
St. John's
Saskatoon
Moosonee
Vancouver
Calgary
Charlottetown
Regina
Winnipeg
Fredericton
Halifax
Thunder Bay
Ottawa
Montréal
Toronto
Extreme Storm (rare)

Why care about space weather?



One "Carrington" event today would cause >1T$ of damage
-destroy all satellites and severely damage most power grids



Environmental Monitoring Using Geophysical Networks

Jeff Freymueller

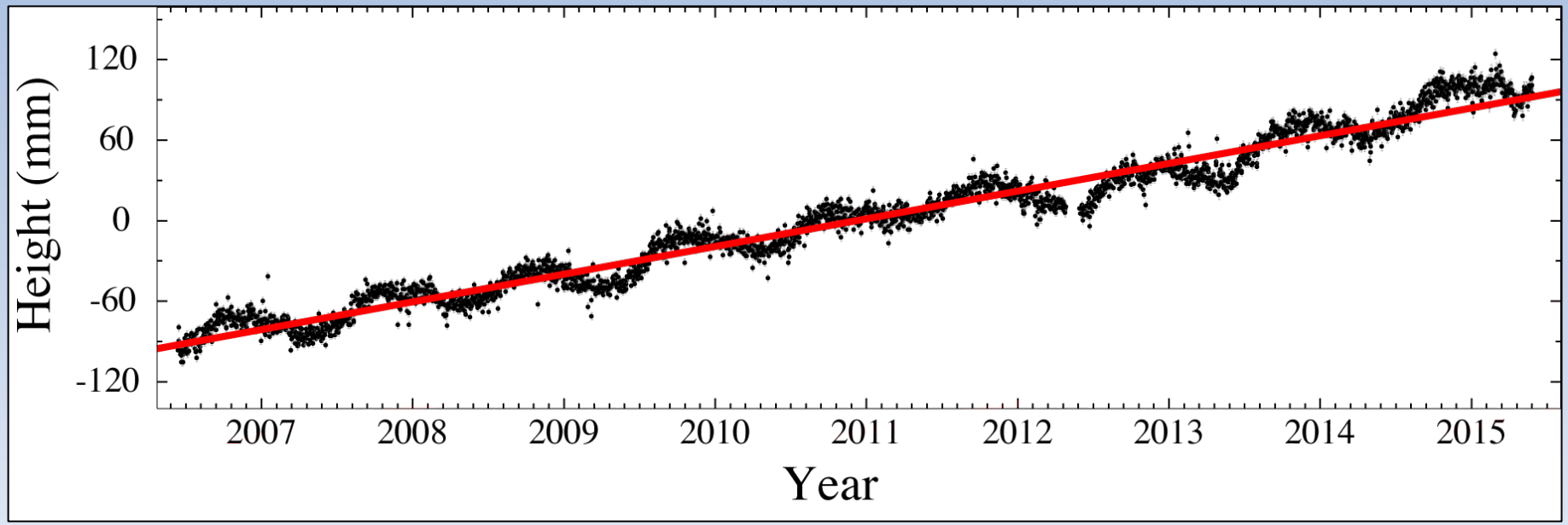
Geophysical Institute, University of Alaska Fairbanks

Topics

GNSS – Global Navigational Satellite System (US GPS + Chinese, European, etc)

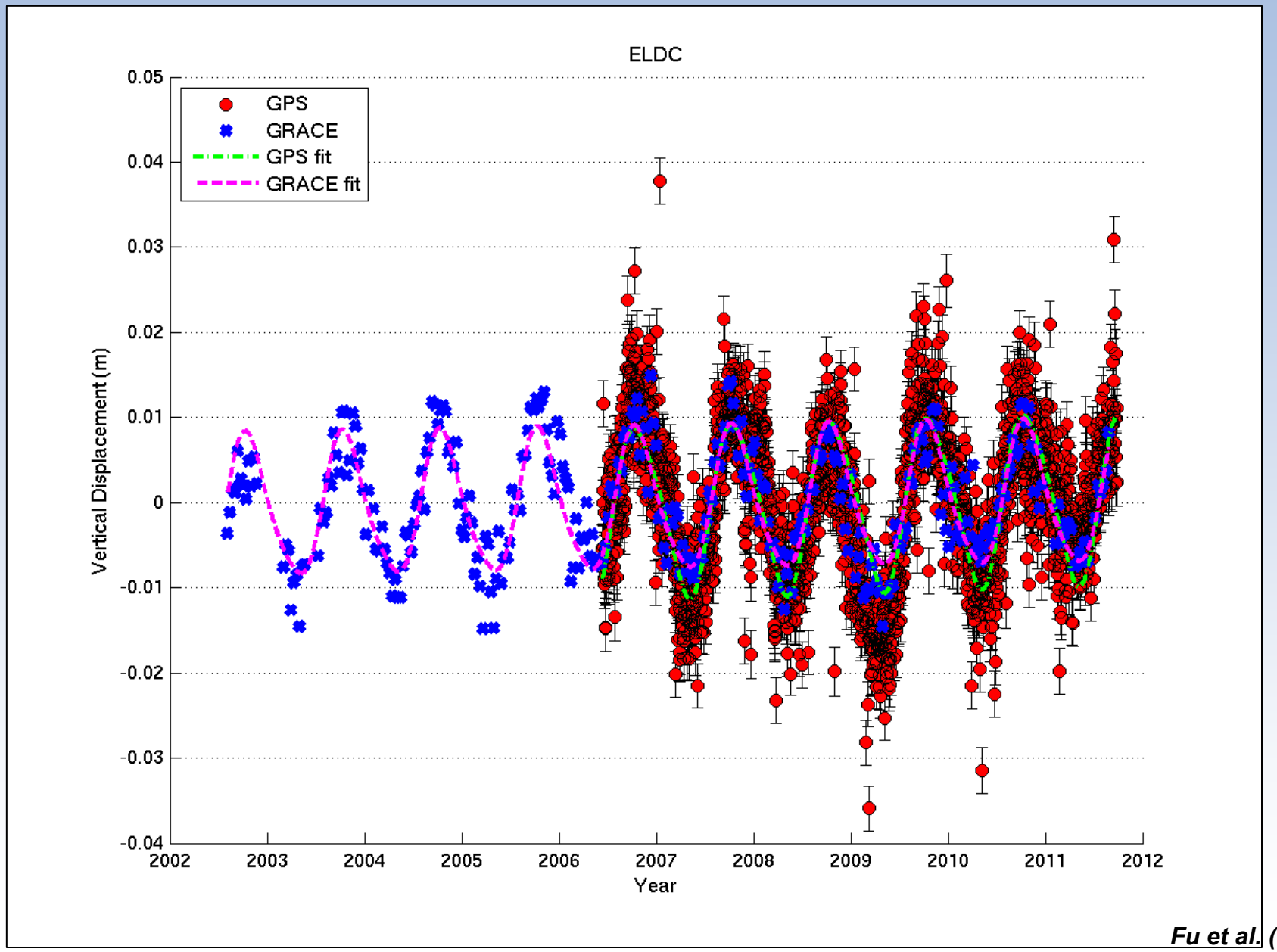
- Weighing the Water
  - Snow, glaciers, groundwater, drought
- Reflectometry for Sensing the Surface
  - Snow depth, Tide levels, permafrost
  - Soil moisture, vegetation water content

Earth is an Elastic "Scale"



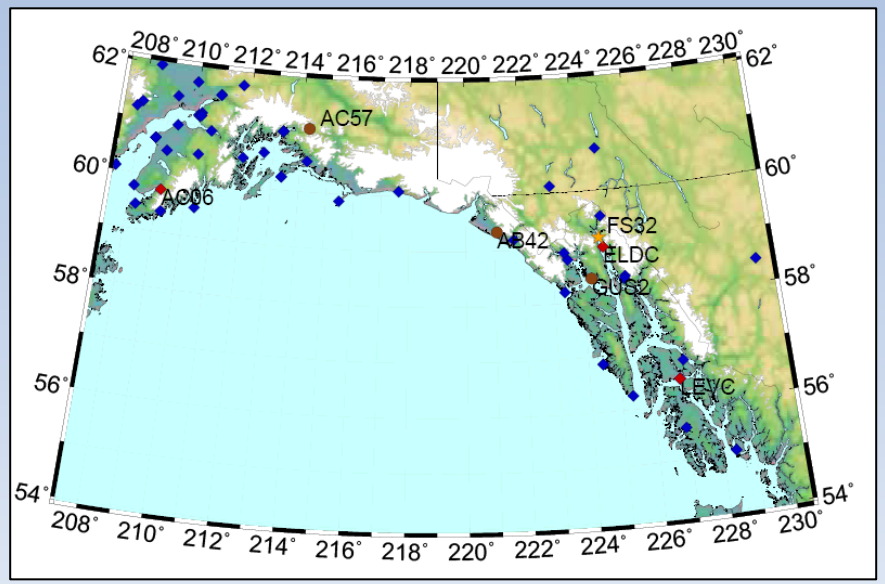
- Changing surface forces due to weight of water (liquid, snow, groundwater) causes deformation of solid Earth and change in gravity field.
- Elastic loading relates surface load model to deformation.

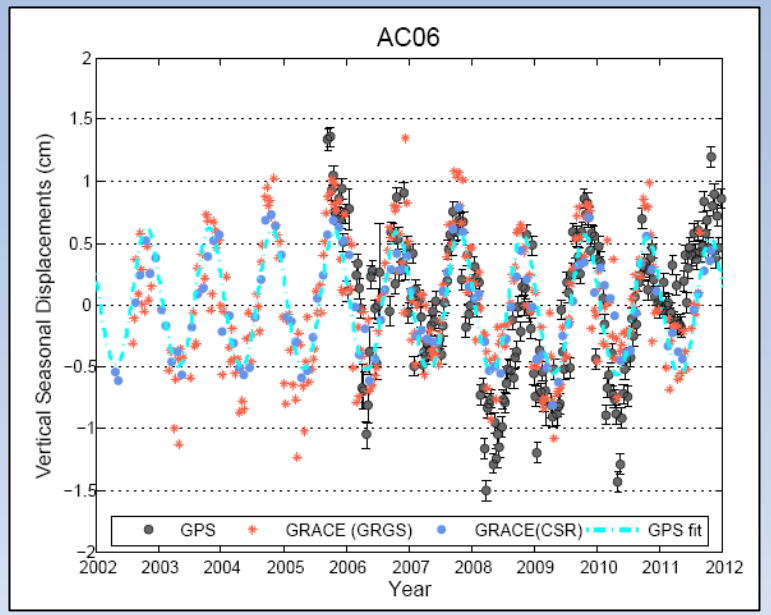
Comparing GPS and GRACE

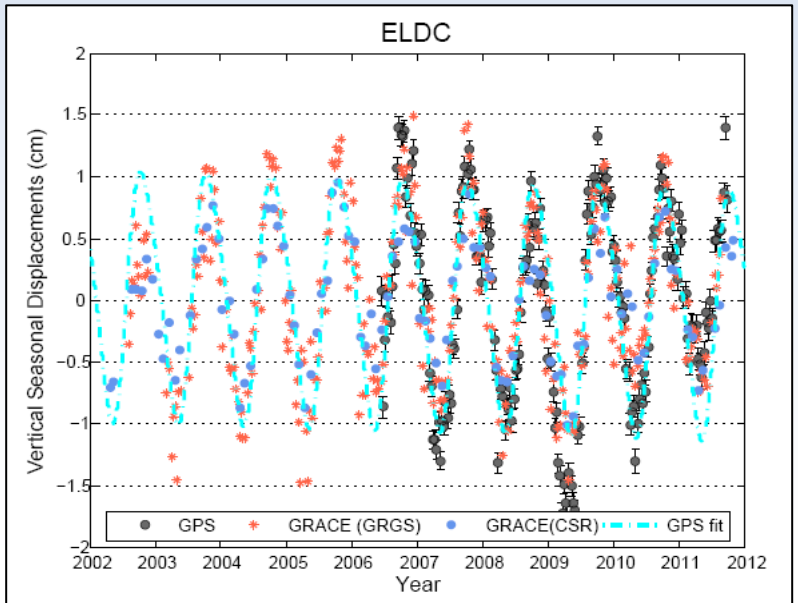


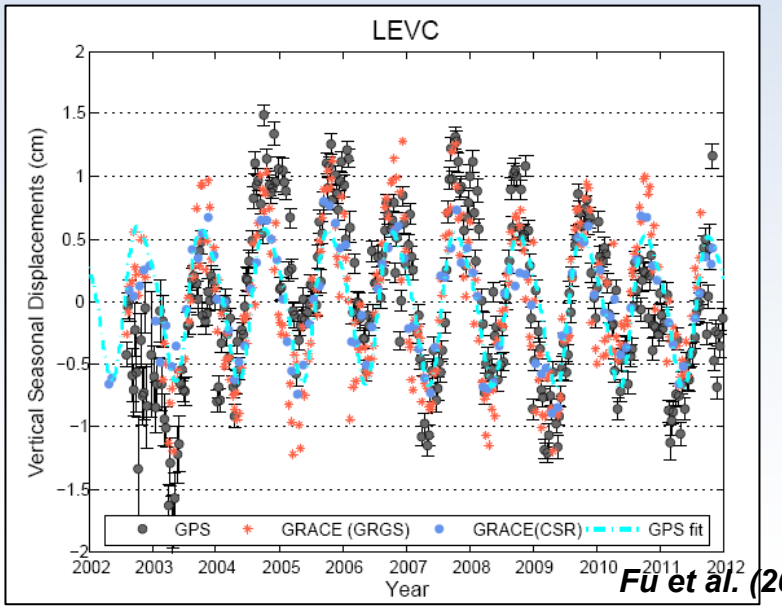
Fu et al. (2012)

Seasonal Hydrologic Loading in Southern Alaska







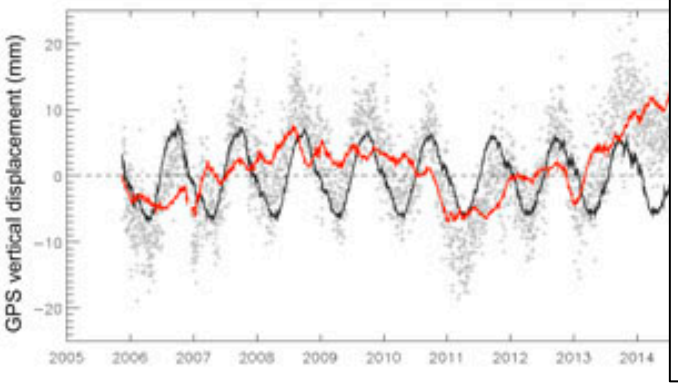


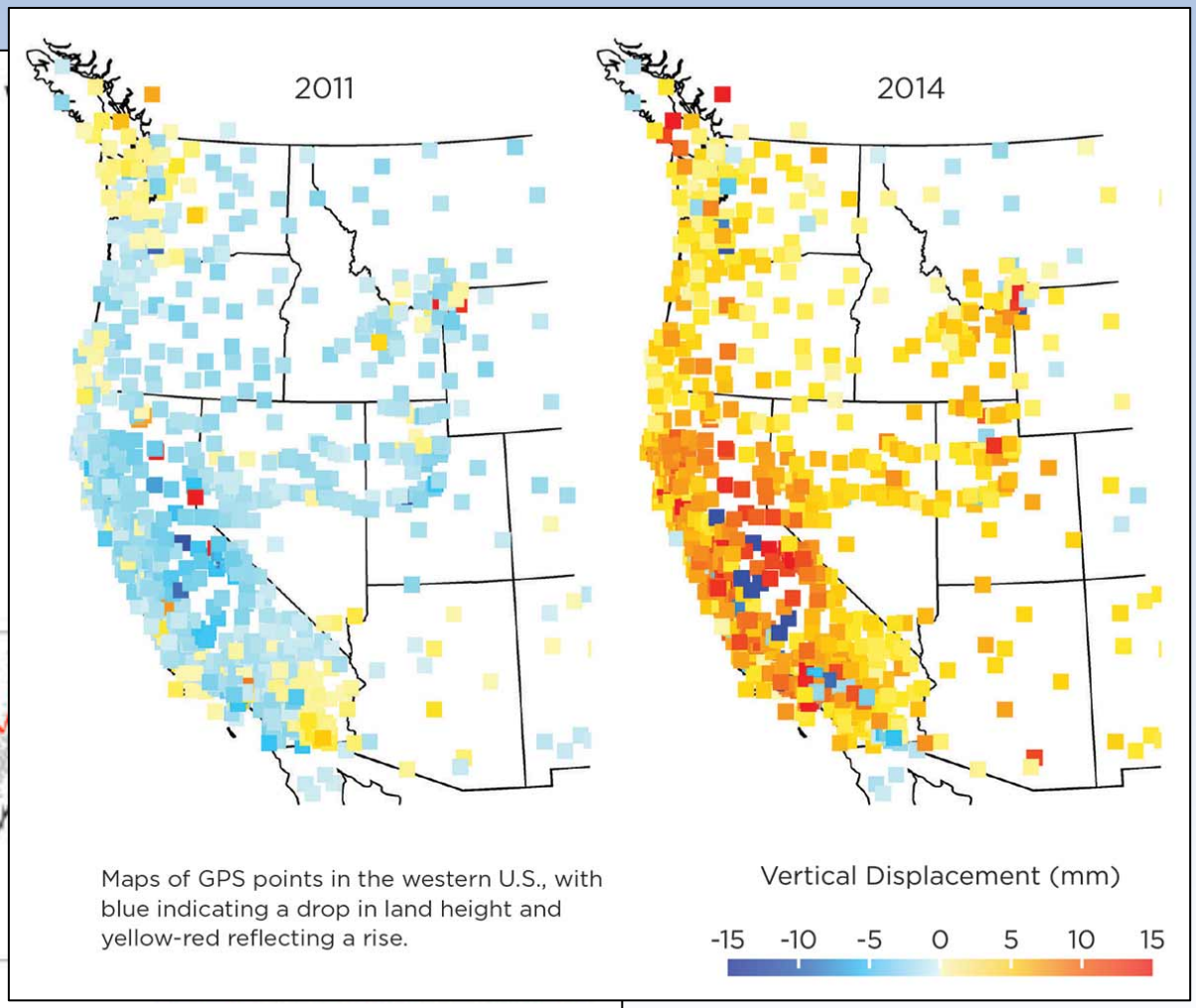
Fu et al. (2012)

West Coast Drought

Adrian Borsa
University of California, San Diego

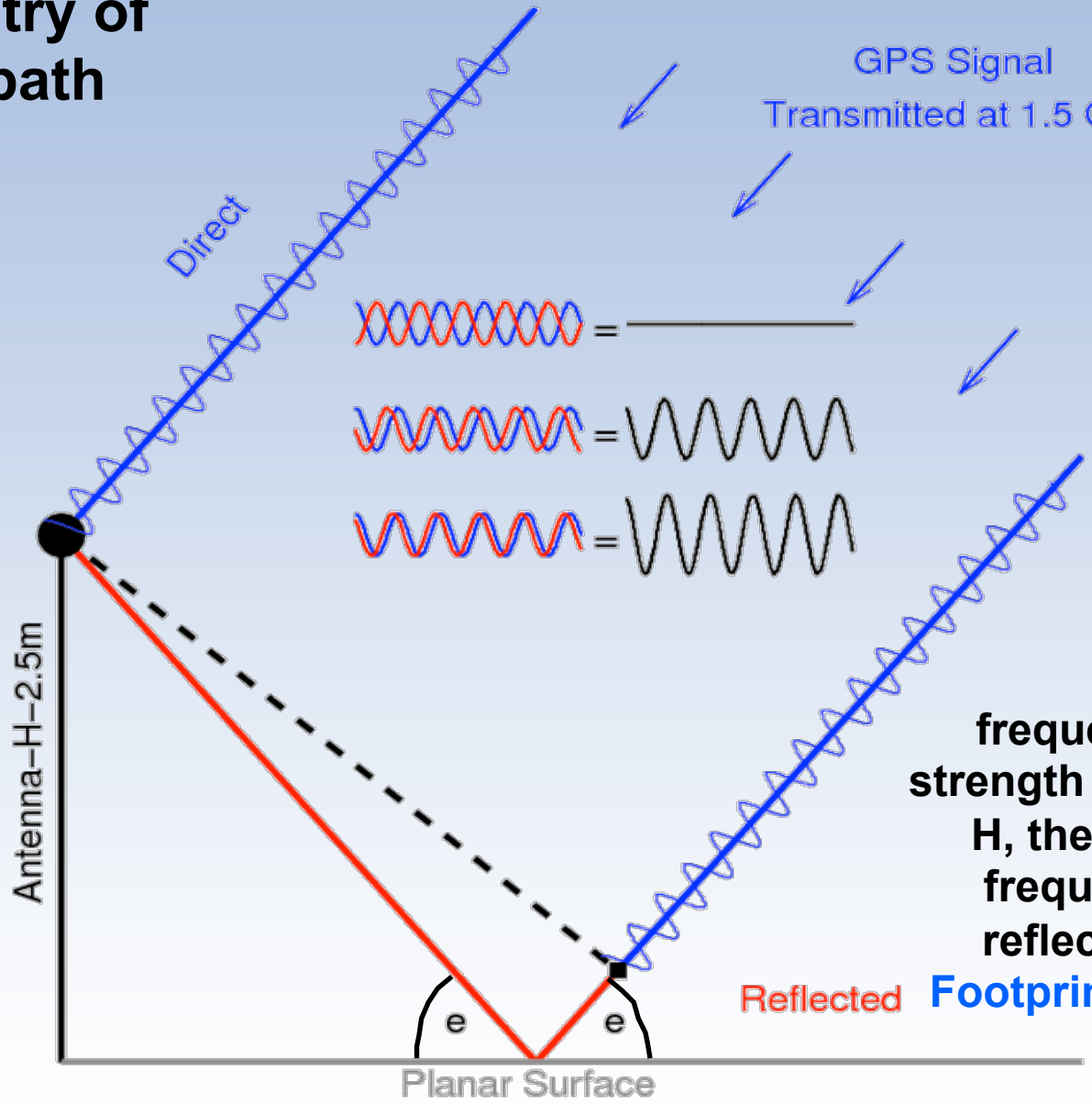
GPS provides a new observational





Borsa et al. (2014)

Geometry of Multipath



frequency of signal strength data depends on H, the GPS transmit frequency, and the reflecting medium.

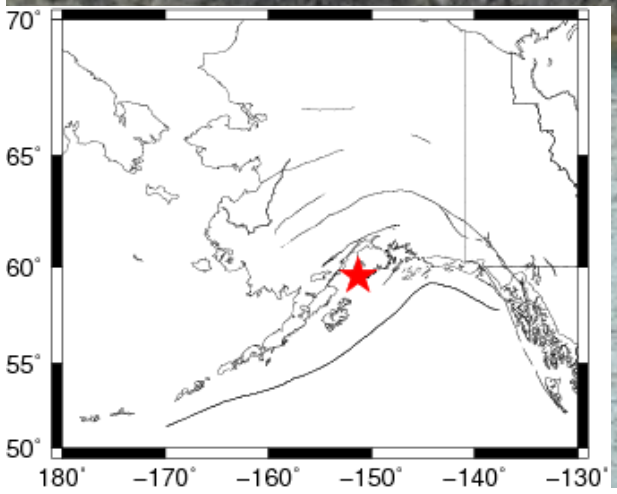
Footprint depends on H and e.

GPS site becomes an interferometer

from K. Larson

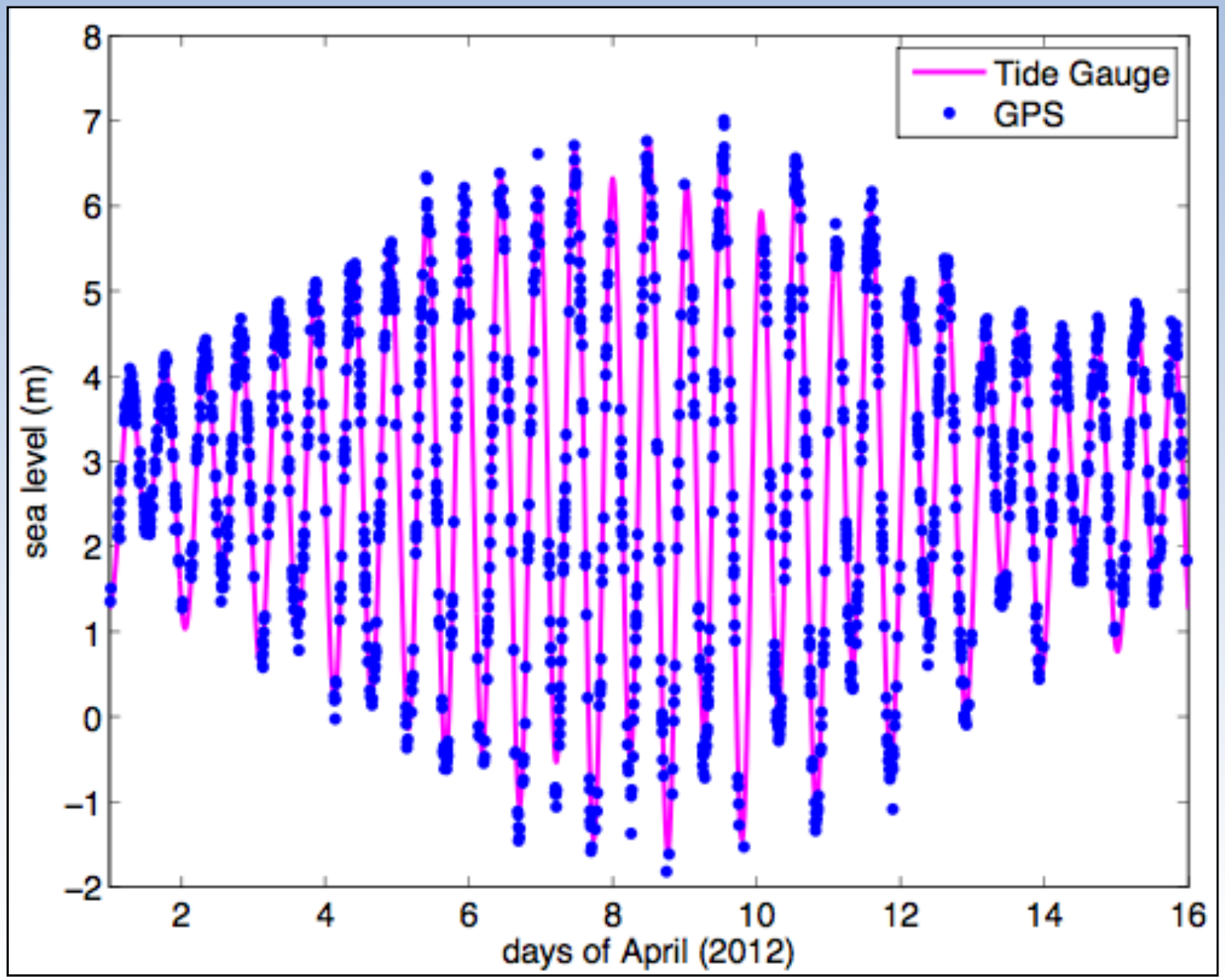
The Accidental Tide Gauge
Peterson Bay, Alaska

Larson, K.M., R. Ray, F. Nievinski, and J. Freymueller (2013)



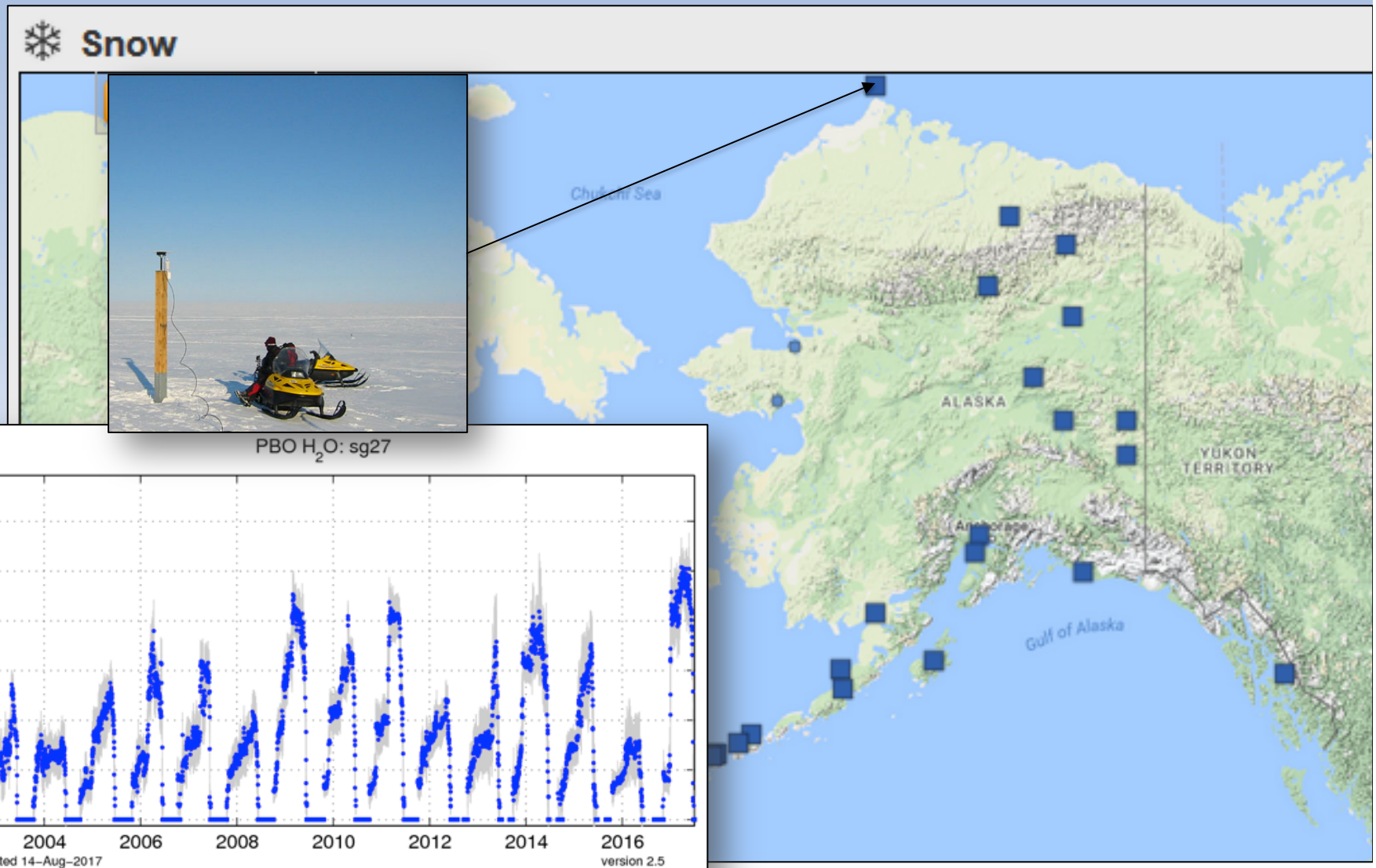
“PBAY” was originally installed by UAF GI (Freymueller and others) to monitor crustal deformation

Comparison between GPS and Seldovia NWLON Record



Larson et al., The Accidental Tide Gauge, IEEE GRSL, 2013

Snow Depth Sites in Alaska



PBO H_2O: sg27

Data also available at the NSIDC

PBO H_2O

http://xenon.colorado.edu/portal

The Value of Weather Observations for Numerical Weather Prediction

Topics:
1. NWP Overview
2. Ensemble Fcsts.
3. Nowcasting
4. Applications
5. Weather Obs. Sites

Roland Stull & Rosie Howard
University of British Columbia (UBC)
Vancouver, Canada
Aug 2017

Colleagues:
Dominique Bourdin
Maggie Campbell
Tim Chui
Anthony DiStefano
Maria Frediani
Matt Fung
Rosie Howard
Yu Ito
Bryan Jansens
Julia Jeworrek
Henryk Modzelewski
Nadya Moisseeva
Pedro Odon
Kyle Sha
Roland Schigas
David Siuta
Greg West

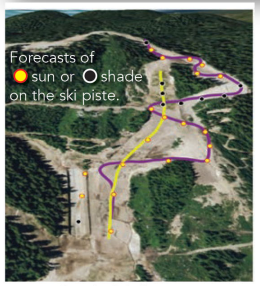
Geophysical Disaster Computational Fluid Dynamics Center

• University of British Columbia – Vancouver • Dept. of Earth, Ocean & Atmospheric Sciences • Weather Forecast Research Team • Directed by Prof. Roland Stull •

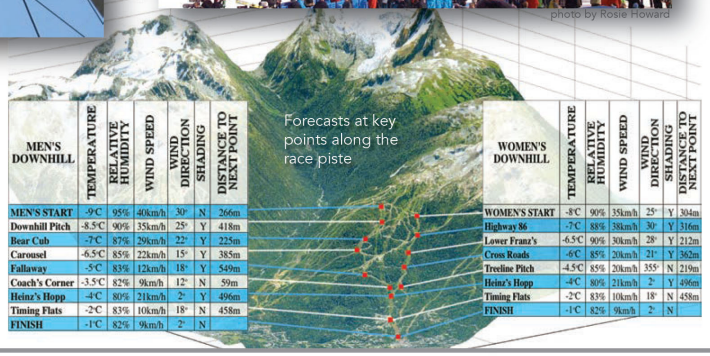
What we do.

Weather Forecasts for Special Events/Projects

- 2010 Winter Olympics
- Project Firestorm
- Rocketsonde Buoys
- Canadian Arctic

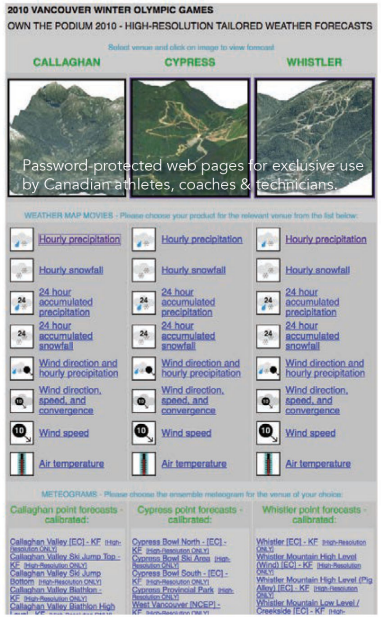


photos by R. Stull



MEN'S DOWNHILL	TEMPERATURE	RELATIVE HUMIDITY	WIND SPEED	WIND DIRECTION	SHADING	DISTANCE TO NEXT POINT
MEN'S START	-9°C	95%	40km/h	30°	N	266m
Downhill Pitch	-8.5°C	90%	35km/h	25°	Y	418m
Bear Cub	-7°C	87%	29km/h	22°	Y	225m
Carousel	-6.5°C	85%	22km/h	15°	Y	385m
Fallaway	-5°C	83%	12km/h	18°	Y	549m
Coach's Corner	-3.5°C	82%	9km/h	12°	N	59m
Heinz's Hopp	-4°C	80%	21km/h	2°	Y	496m
Timing Flats	-2°C	83%	10km/h	18°	N	458m
FINISH	-1°C	82%	9km/h	2°	N	

WOMEN'S DOWNHILL	TEMPERATURE	RELATIVE HUMIDITY	WIND SPEED	WIND DIRECTION	SHADING	DISTANCE TO NEXT POINT
WOMEN'S START	-8°C	90%	35km/h	25°	Y	304m
Highway 86	-7°C	88%	38km/h	30°	Y	316m
Lower Franz's	-6.5°C	90%	30km/h	28°	Y	212m
Cross Roads	-6°C	85%	20km/h	21°	Y	362m
Treeline Pitch	-4.5°C	85%	20km/h	355°	N	219m
Heinz's Hopp	-4°C	80%	21km/h	2°	Y	496m
Timing Flats	-2°C	83%	10km/h	18°	N	458m
FINISH	-1°C	82%	9km/h	2°	N	



Sponsor: 2010 Vancouver Olympic Committee & OTP

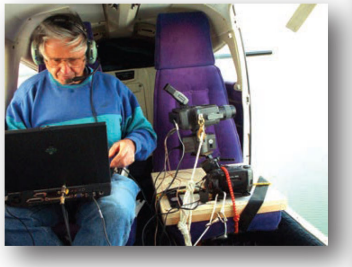
Region: Whistler, Callaghan, Cypress Ski Resorts, BC.

Tailored weather forecasts for athletes & technicians, and research on snow race surfaces.

Sponsor: Forest Renewal BC

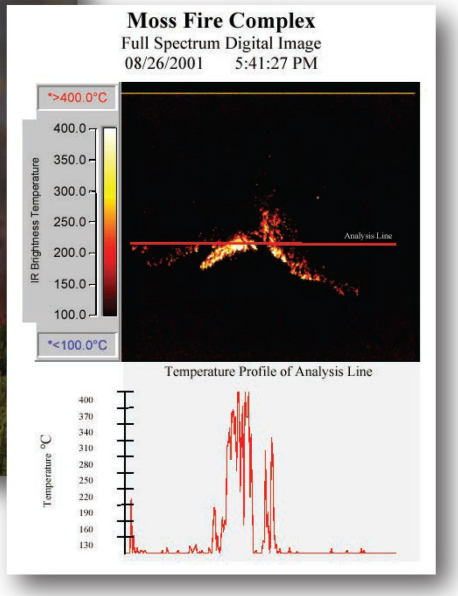
Region: BC.

Research aircraft observations of active forest fires to verify our coupled forest-fire / weather-forecast models.



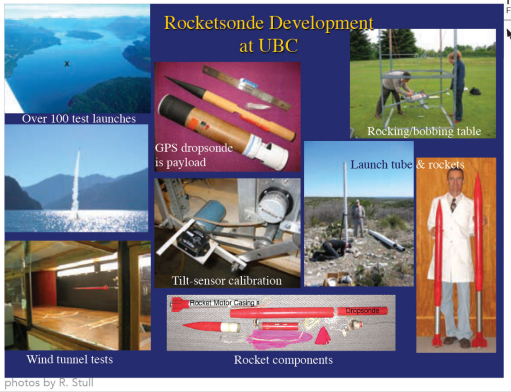
photos by R. Stull

photo by Coast Fire Centre, Wildfire Management Branch, BC Min. of Forests

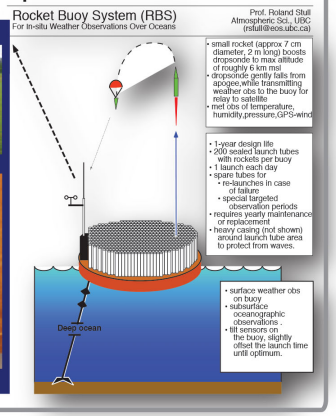


Sponsor: Canadian Foundation for Climate & Atmospheric Science (CFCAS)

Prototyping of an autonomous rocket sounding system for data upwind of BC.

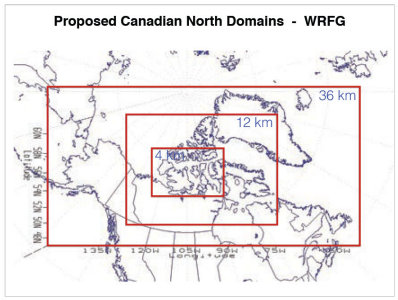


photos by R. Stull

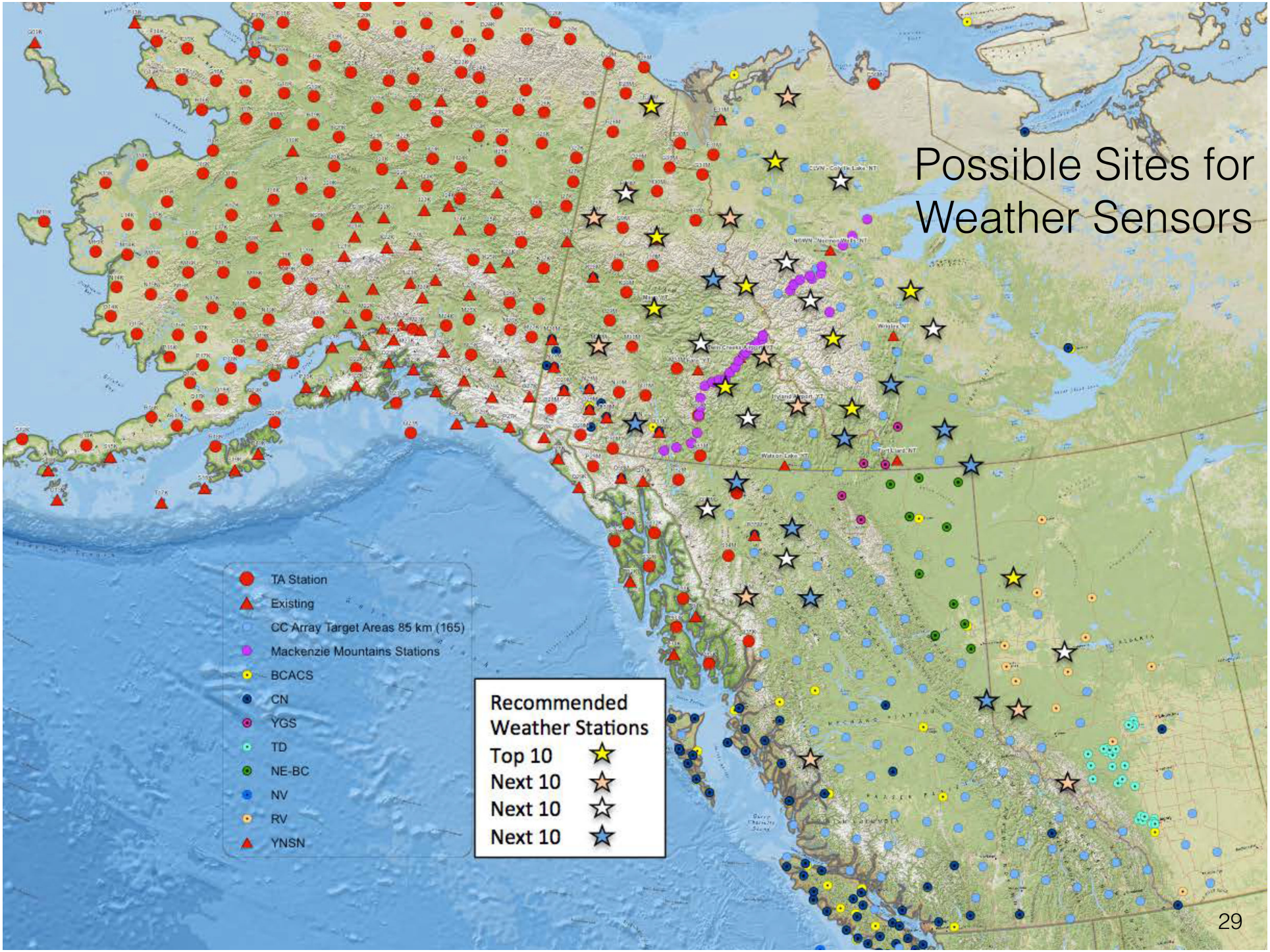


For more info, contact:

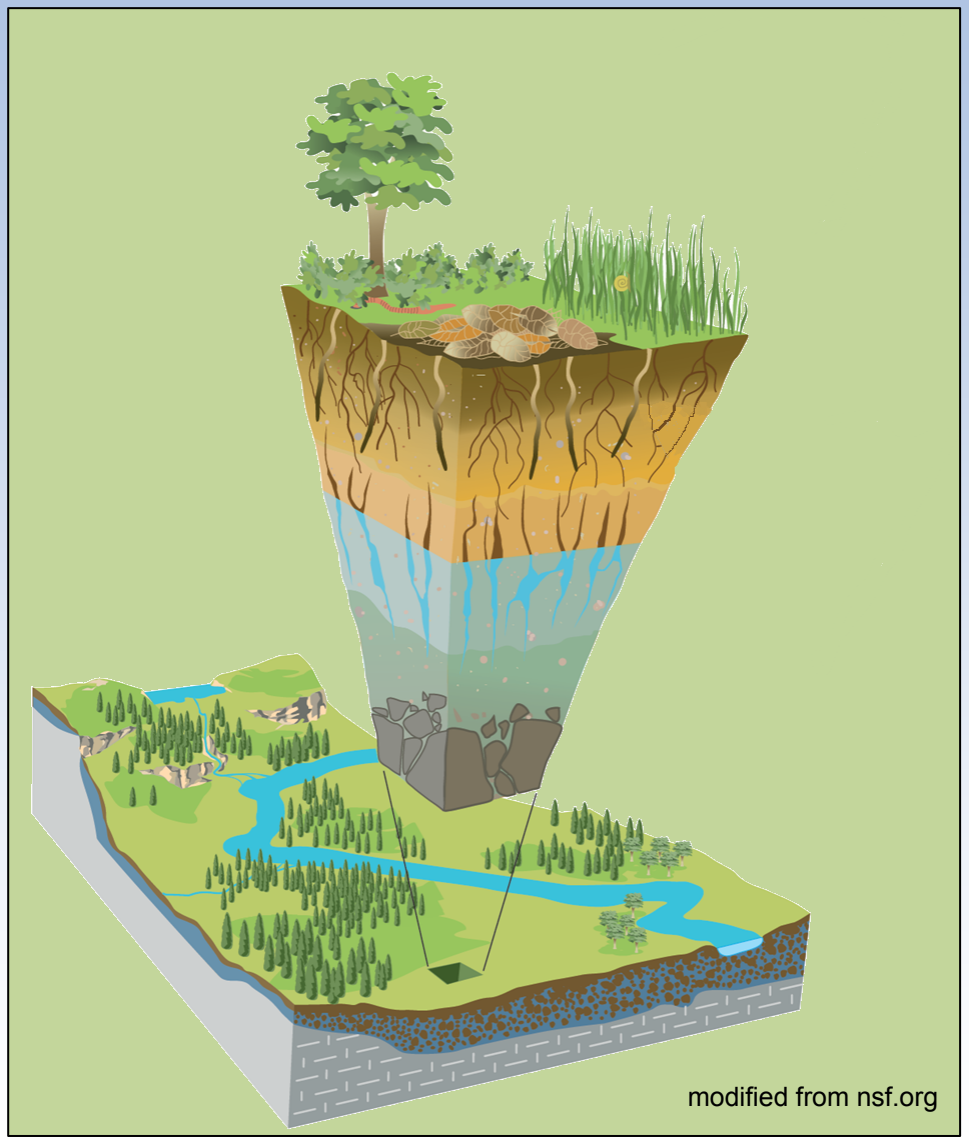
Prof. Roland Stull
UBC EOAS Dept.
2020-2207 Main Mall
Vancouver, BC V6T 1Z4
Canada
rstull@eos.ubc.ca
604-822-5901



Strategic Expansion into Canadian Arctic to serve northern communities, diamond exploration, shipping, & aviation.


Possible Sites for Weather Sensors
TA Station
Existing
CC Array Target Areas 85 km (165)
Mackenzie Mountains Stations
BCACS
CN
YGS
TD
NE-BC
NV
RV
YNSN
Recommended Weather Stations
Top 10
Next 10
Next 10
Next 10

What is the Critical Zone? (West (CMU) AGU 2017)



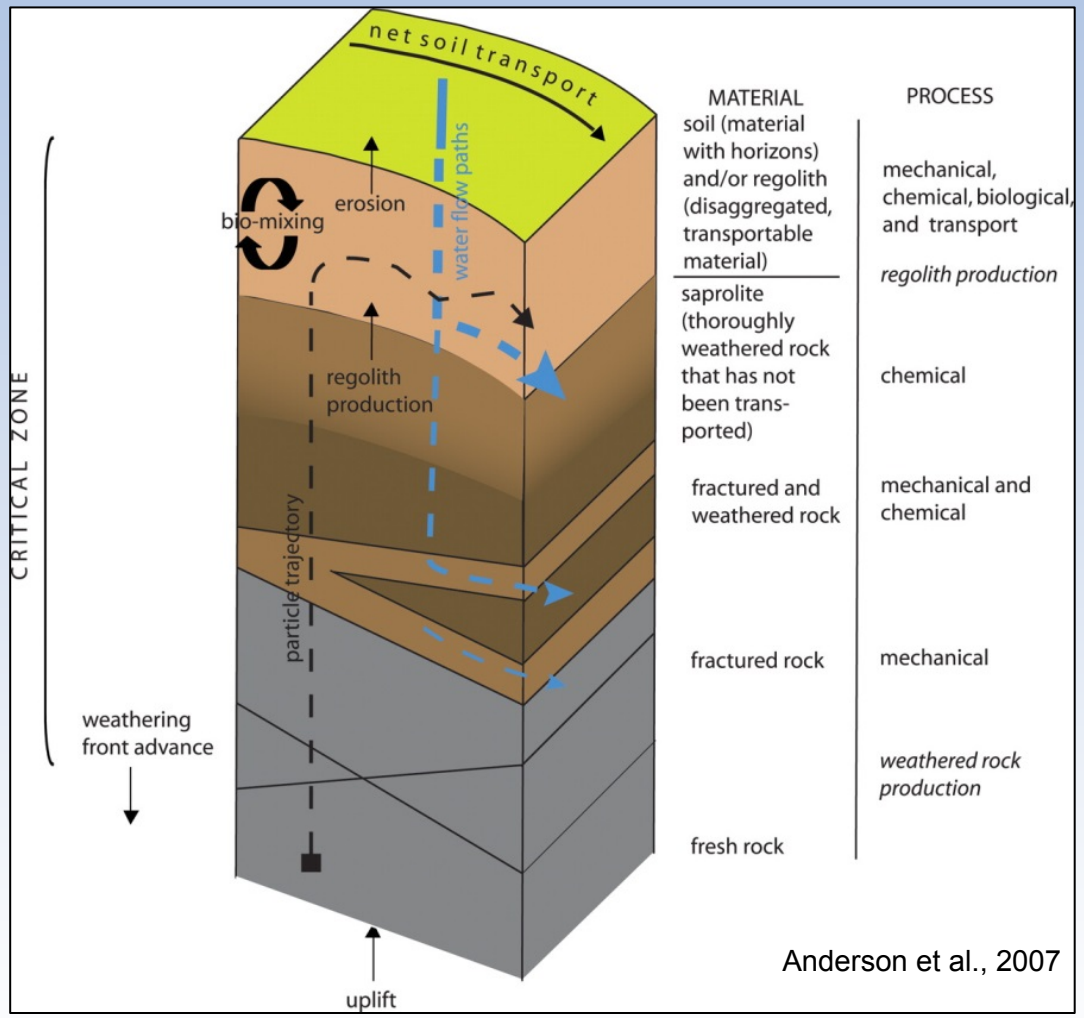
-from the top of the tree canopy to the deepest penetration of groundwater

-region where life interacts with the hydrosphere, lithosphere, and atmosphere

Therefore, understanding the functioning of the critical zone and how it evolves is of “critical” importance

Critical Zone Science examines the interactions between these spheres at a range of spatial and temporal scales

Fundamental architecture - governed by the transformation of bedrock to regolith

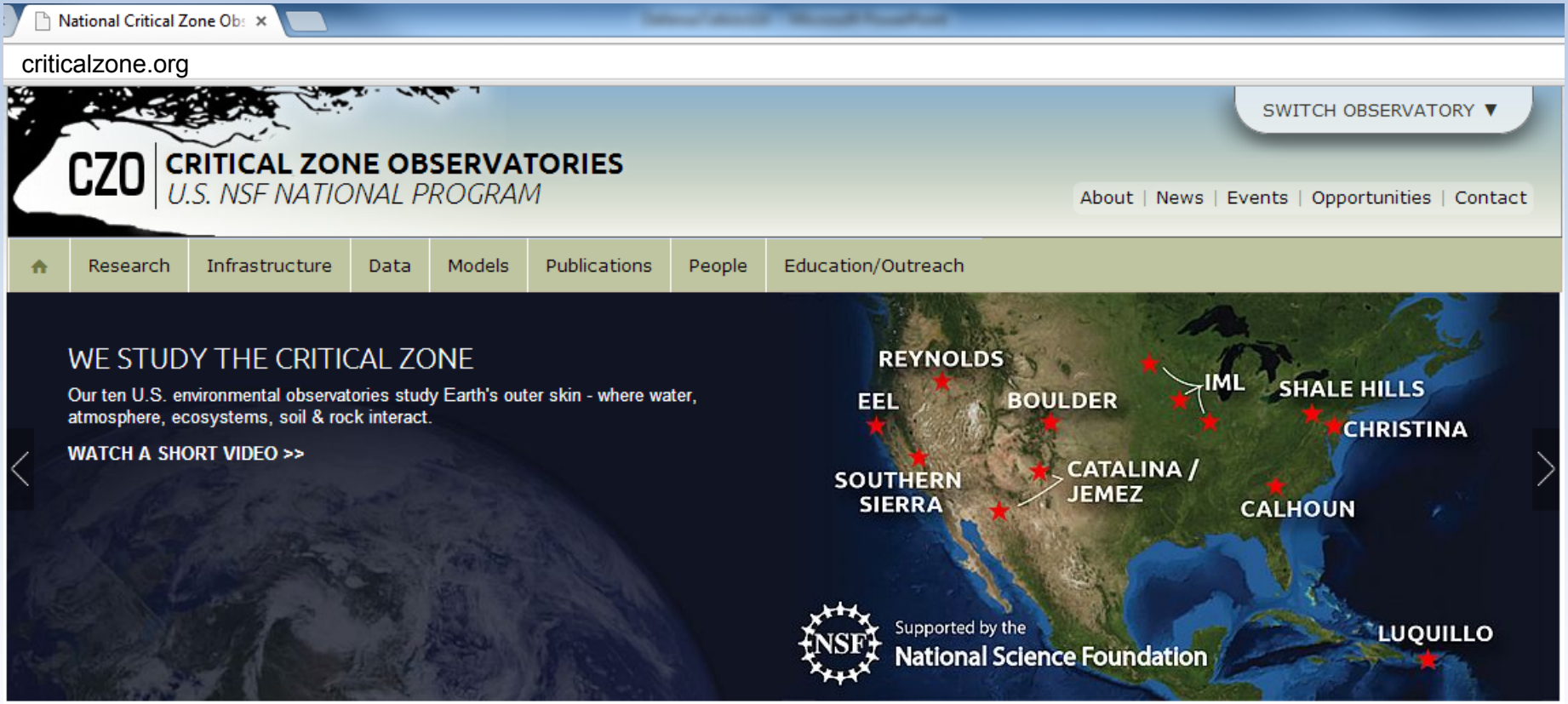


Anderson et al., 2007

What are the primary processes and rate laws that set the physical characteristics of the Critical Zone?

How does the architecture of the critical zone change in response to climatic, base level, and land use perturbations?

CZO: provides a natural laboratory to study the effects of lithology, climate, and tectonics on surface and near-surface processes



Critical Zone Observatory Plan for CCArray

"Legacy Stations"

★ **Partial CZO in place**

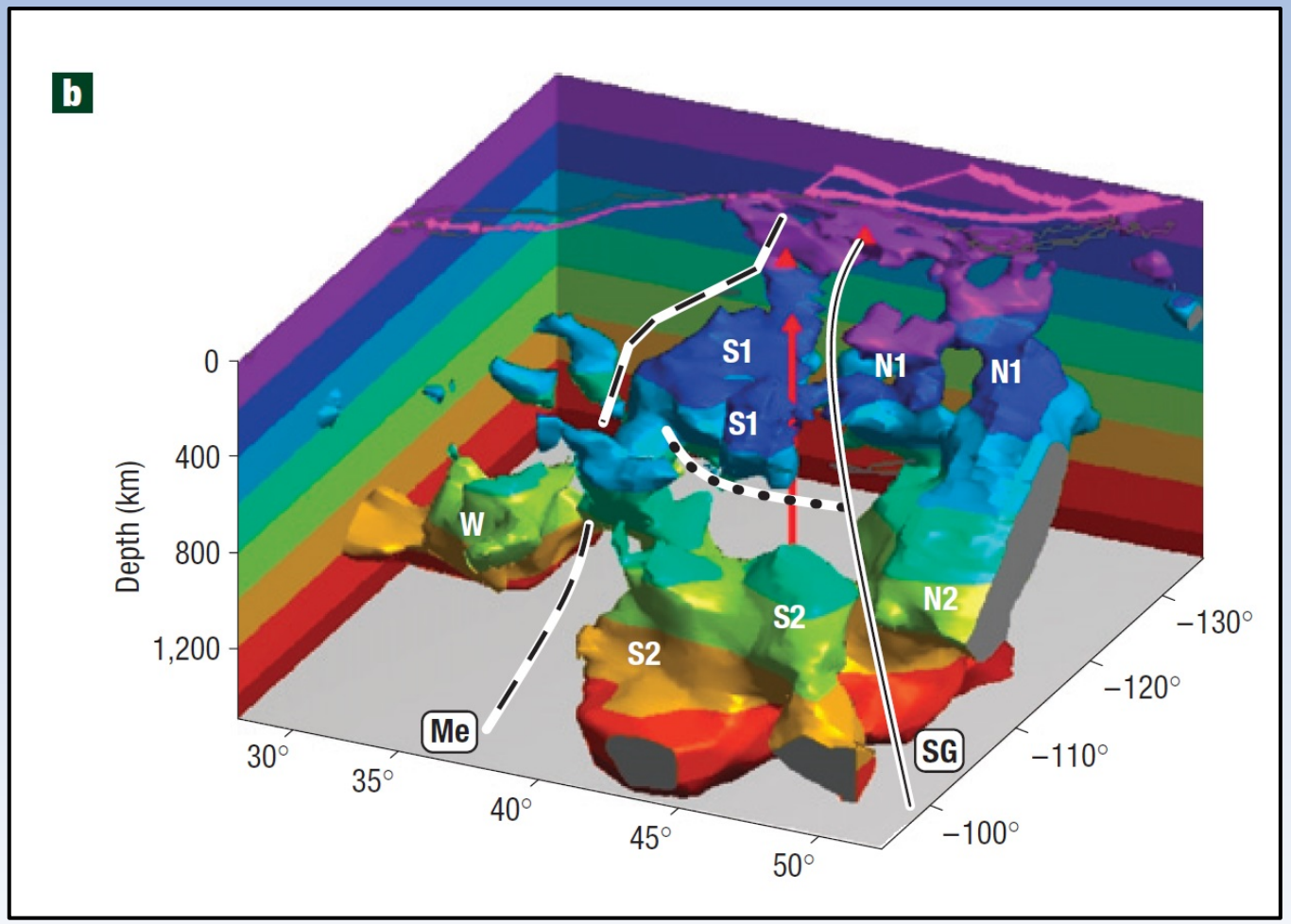
- **T – Tuktoyaktuk**
- **Kl – Kluane**
- **C – Calvert Island**
- **Q – Quesnel River**
- **Ka – Kananaskis**
- **A – ASCCA**

☆ **Proposed new CZO**

- **In – Inuvik**
- **NW – Norman Wells**
- **EP – Eagle Plains**
- **WL – Watson Lake**
- **PR – Prince Rupert**
- **GP – Grand Prairie (or)**
- **TR – Tumbler Ridge**

(Stats Canada)

Why care about tomography?



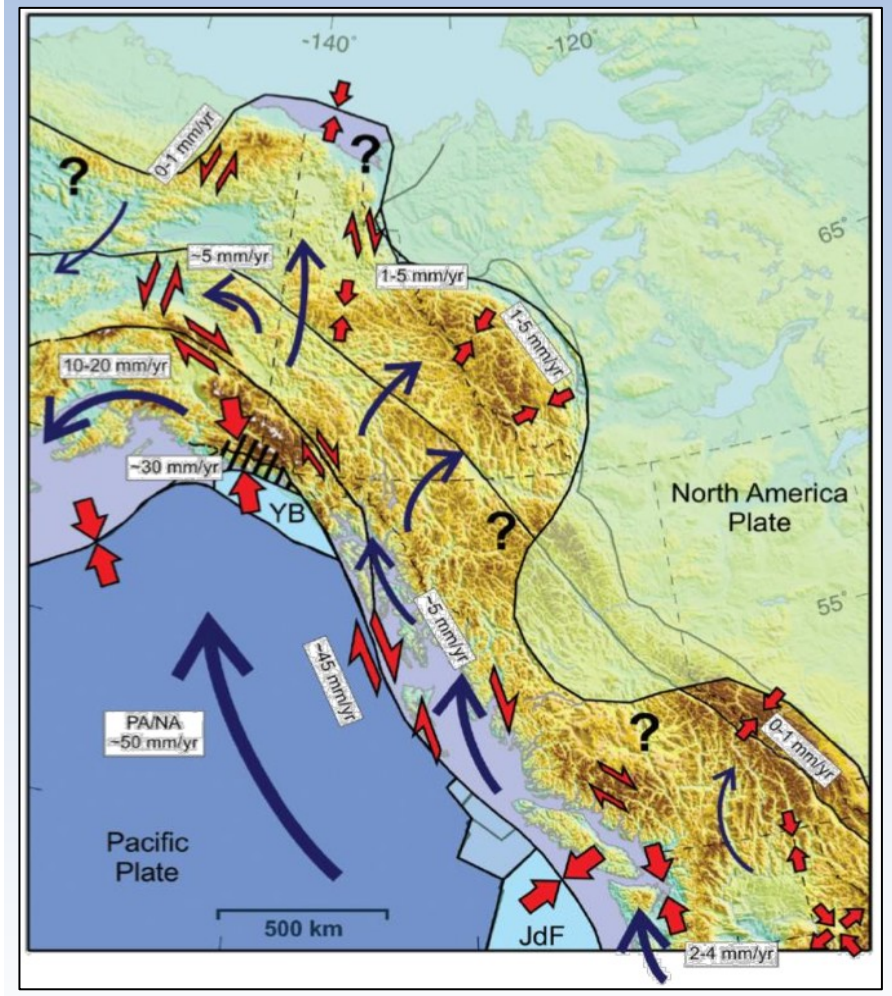
(Sigloch et al, 2008; Nature Geoscience)

Improve understanding of subduction slab mechanics

Greatly improved resolution possible due to array

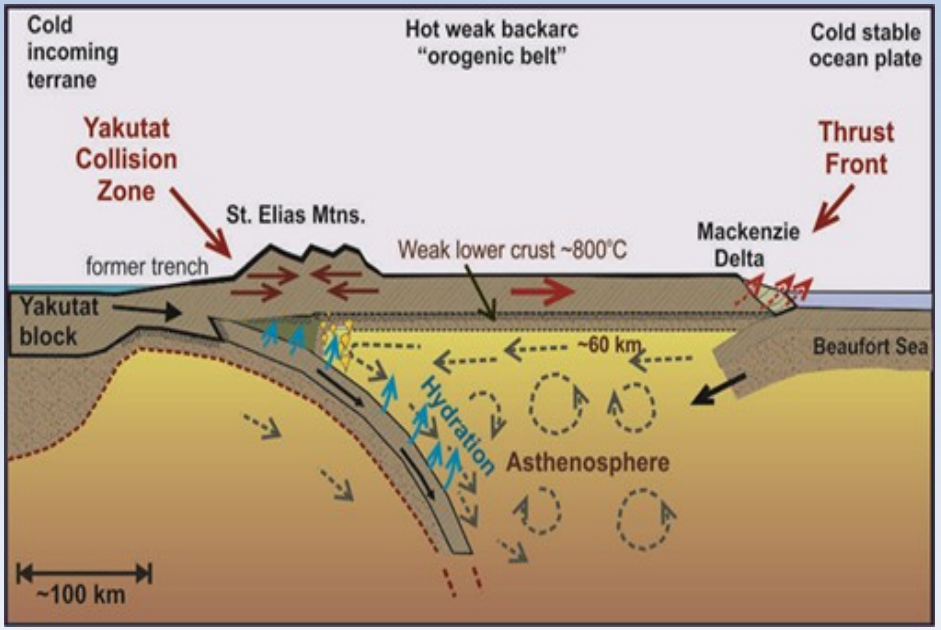
Bird's eye view from ne of Cascadia subduction system. Me (dashed) – continuation of Mendocino fracture zone underground. SG (solid) – slab gap; 2500km long tear in the current subducting slab. The dotted line represents the lateral tear between upper and lower mantle.

“Mini Himalayas” Yakutat Block



(Mazzotti et al 2008)

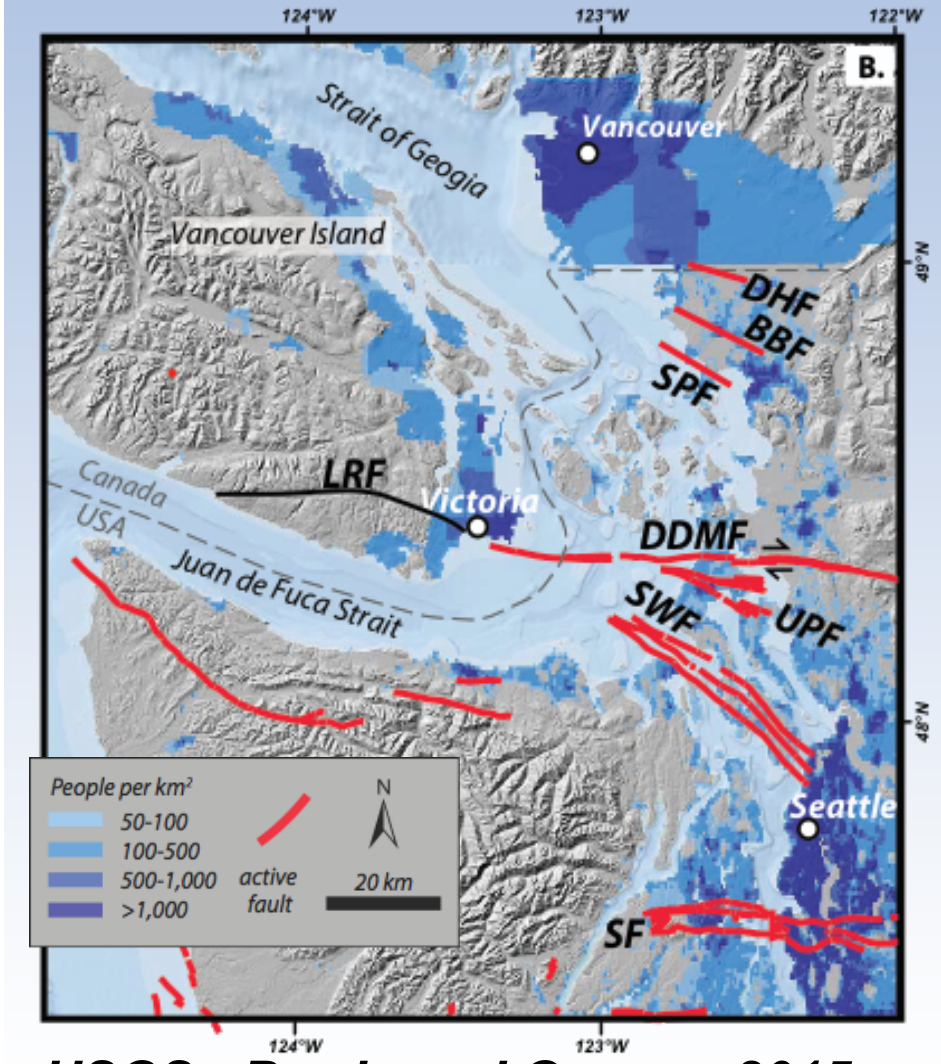
Orogenic Float Model



(Hyndman & Mazzotti 2002)

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)



USGS - Barrie and Greene, 2015

Red – active crustal faults

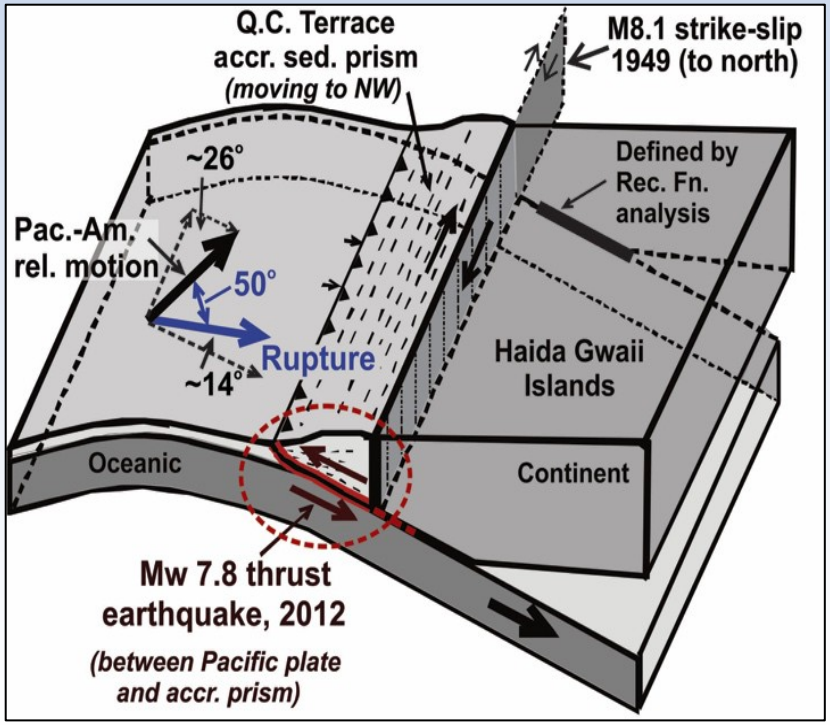
No previous active faults ID in Canada

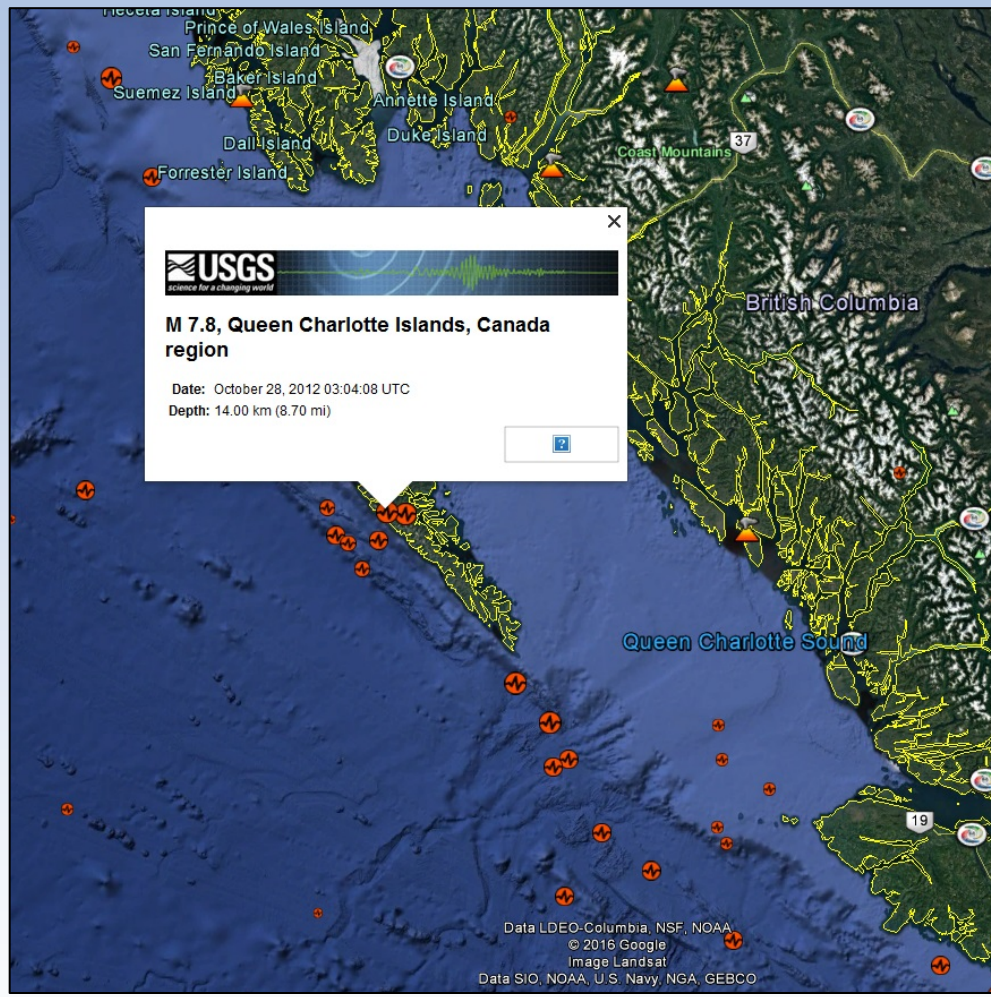
Recent lidar, field work, & paleoseismic trenching
→ large (M6-7) late Quaternary Eq on Leech River Fault

Proposed:
Expand lidar, seismic, GPS
→ fieldwork, trenching
→ ID other active crustal faults in western (and NW) Canada

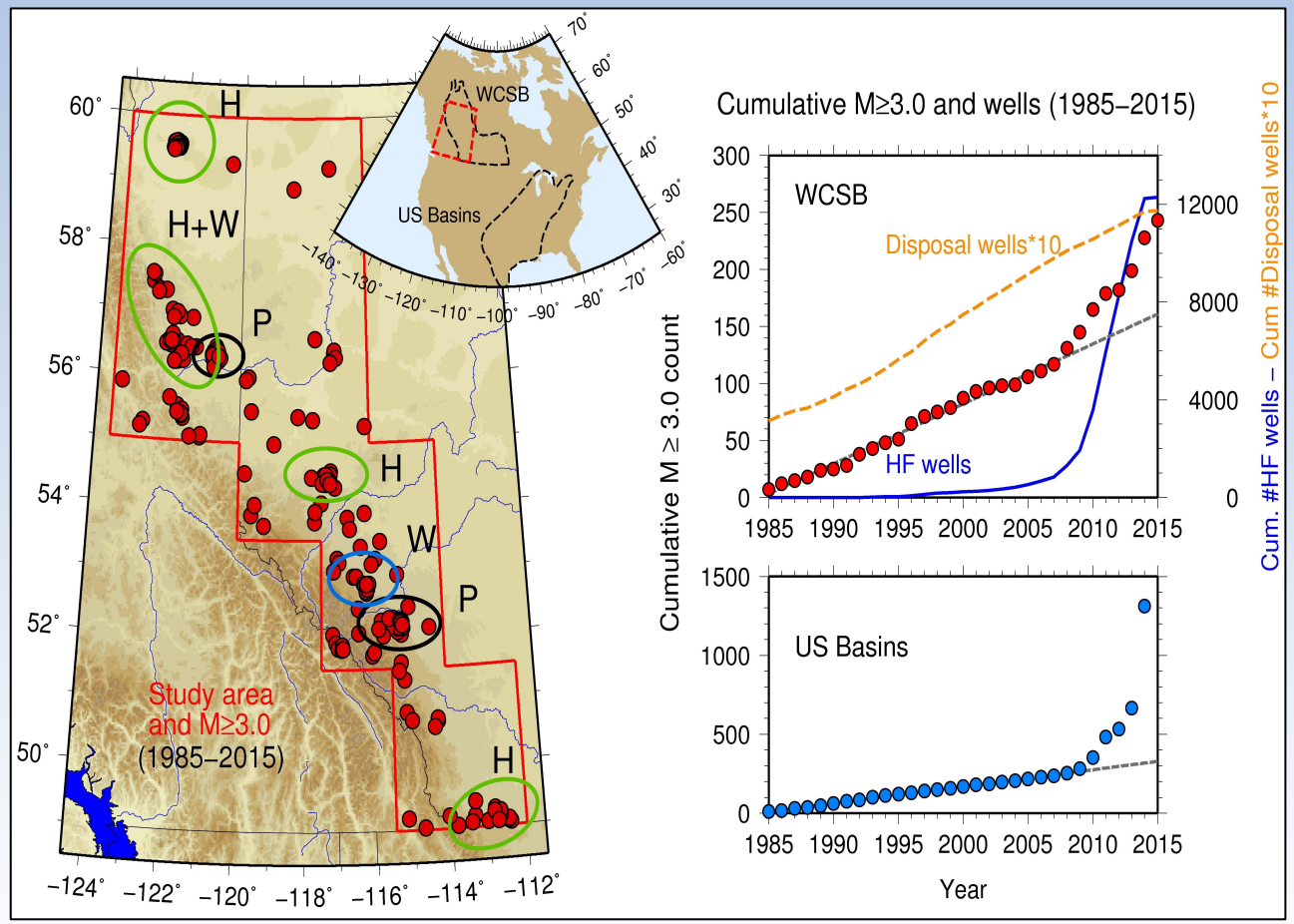
Subduction initiation

Haida Gwaii Margin
-partition of oblique convergence into strike slip
-2012 thrust Eq
(Hyndman et al 2014)





Induced seismicity; eastern margin Canadian Cordillera



(Atkinson et al 2016)

Ovals – seismicity attributed to: Hydraulic fracturing (H) Wastewater injection (W) Production (P)

Grey line – expected rates for stationary process

Next Steps?

1. **Funding** – estimate cost $45M for CCArray

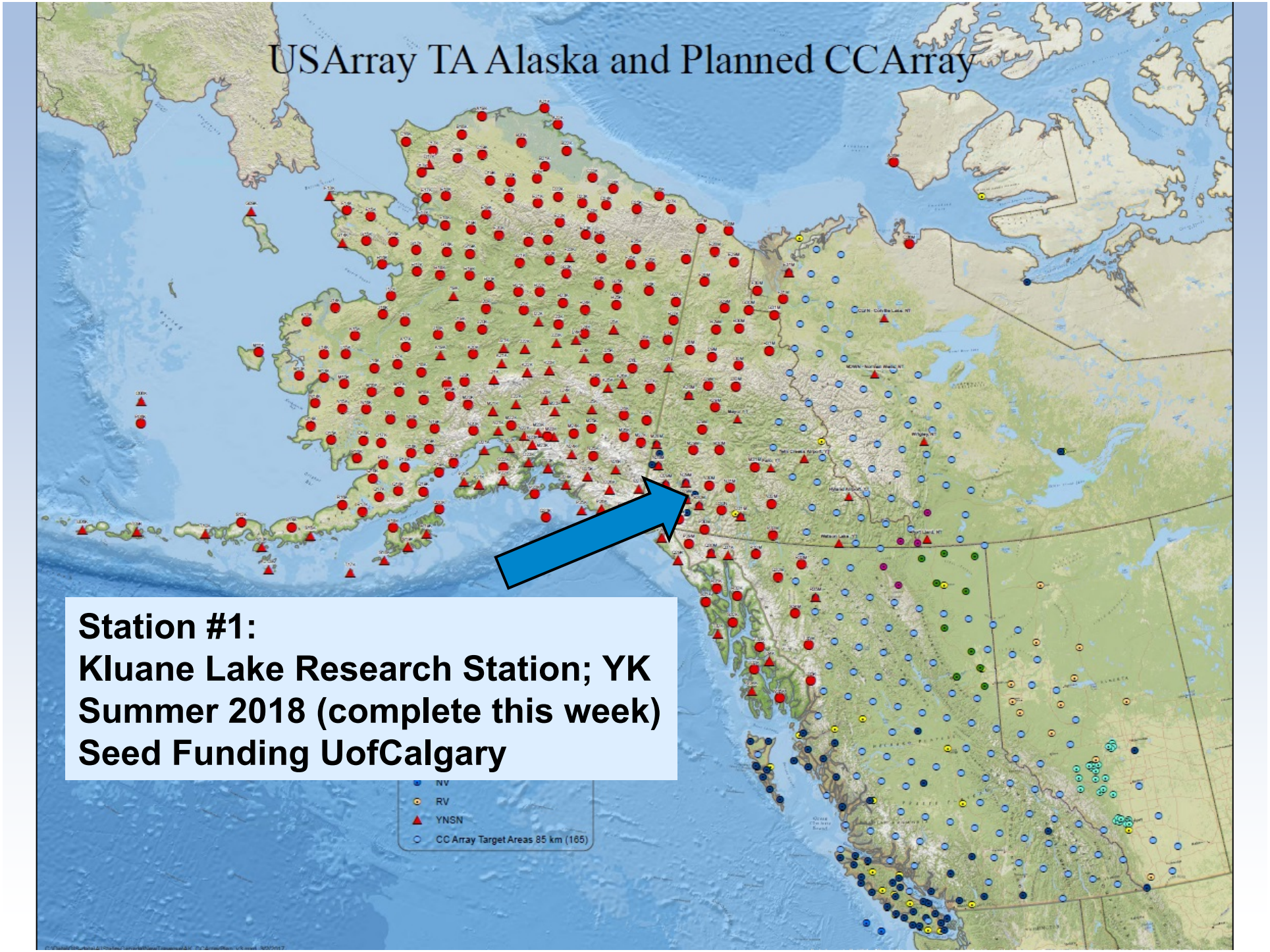
a) Seed Funding ($300K) from UofCalgary

b) Workshops supported by NSERC CONNECT Grants, Nanometrics, MRU and Uof Ottawa

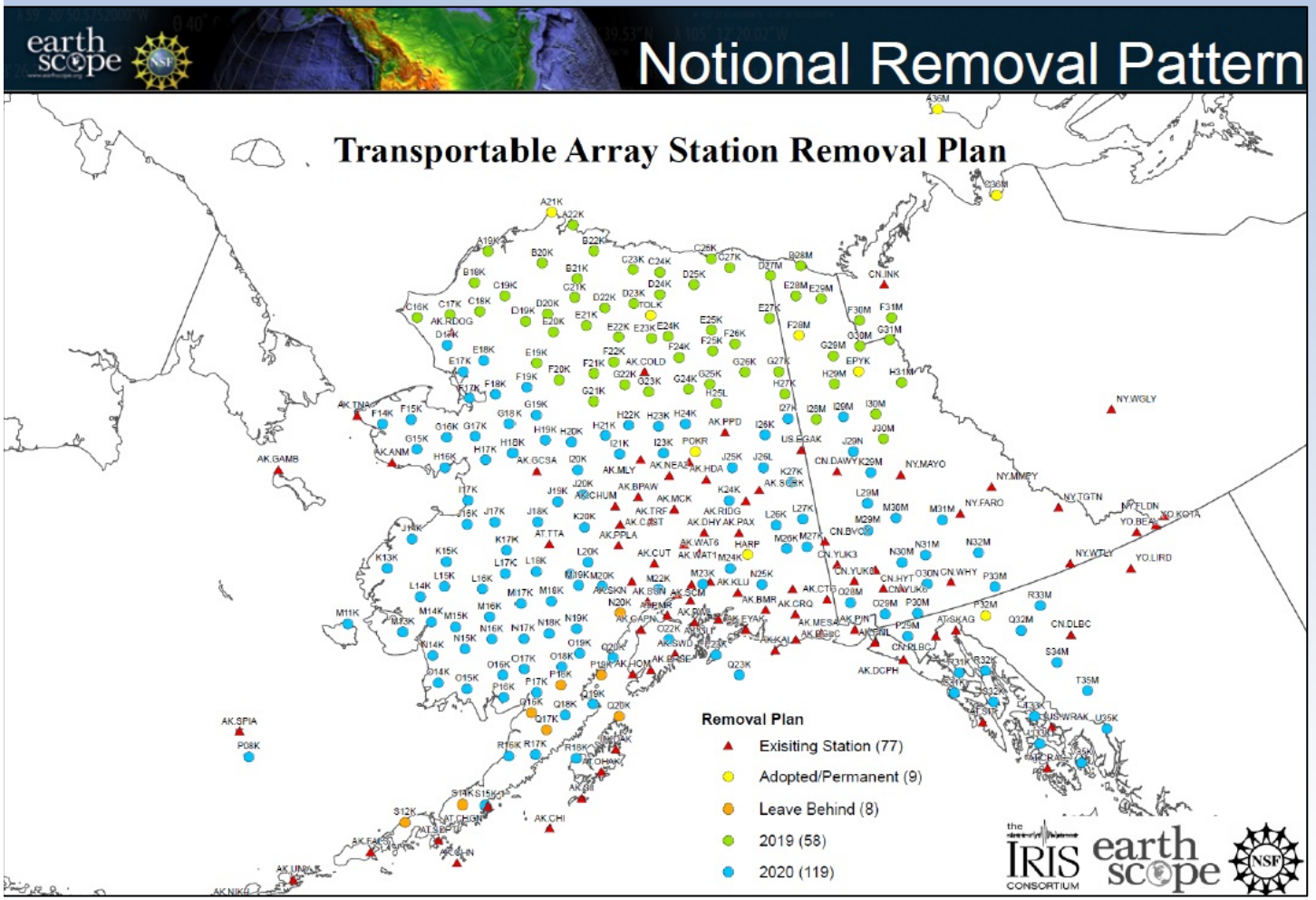
c) Web design and outreach grant from Cdn Geoscience Foundation

d) MOU being processed with Helmholtz Association in Germany for 40-50 stations that will start being installed summer 2019

e) More NSERC, CFI, proposals soon…also US NSF


USArray TA Alaska and Planned CCArray
Station #1:
Kluane Lake Research Station; YK
Summer 2018 (complete this week)
Seed Funding UofCalgary
RV
YNSN
CC Array Target Areas 85 km (165)

2. Adopt TA stations in Canada

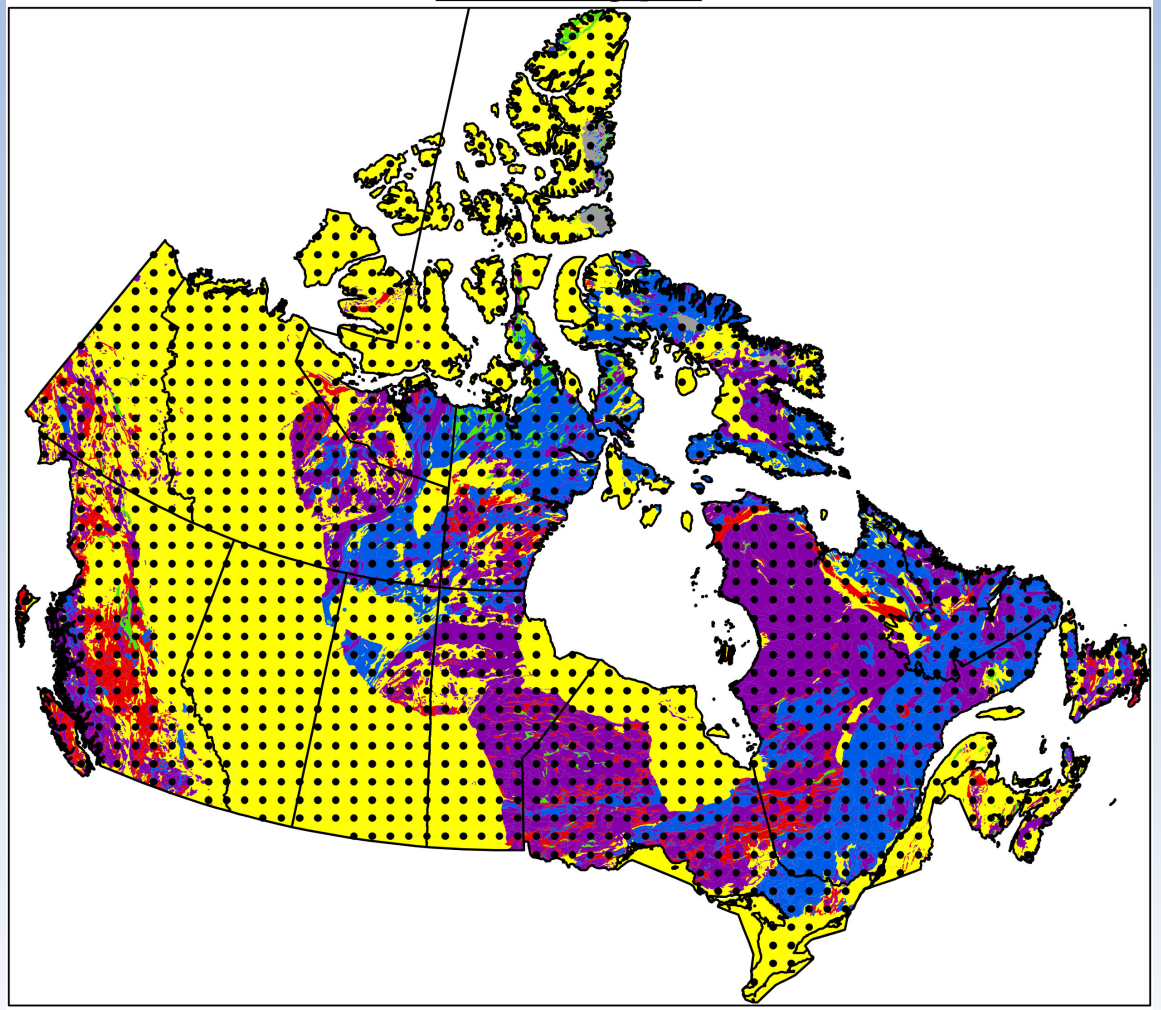


Green:
~13 – 2019
Blue:
~21 – 2020

(From Busby, AGU 2017)

Start planning For both EON-ROSE (and CCArray)

EON-ROSE Potential Sites Rock Type



Upcoming events:

- Fall 2018 – 2nd CCArray Townhall
- Keep developing website (ccarray.org)
- Start developing the Community Science Liaison program – community engagement and outreach
- SINOPROBE Conference October 2018
- AGU CCArray Dinner #2 Washington, Dec 18
- IUGG July 8-18, 2019 Montreal
- Penrose – EarthScope Transition to EON-ROSE (Sept 2019 Sitka to Whitehorse); 1st annual
- Many more funding applications…

FUTURE – Design EON-ROSE

Takeaways

1. **New pan-Canadian research initiative**
2. **Call for collaborations – intrigued?**

   Want to be involved?

   Is there someone else who we should talk to?
3. **Comments, suggestions?**
4. **Please spread the word**

Please contact one of the authors (or Katherine Boggs at kboggs@mtroyal.ca)