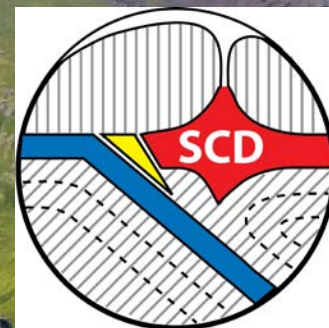




# Subduction Cycles and Deformation (SCD)

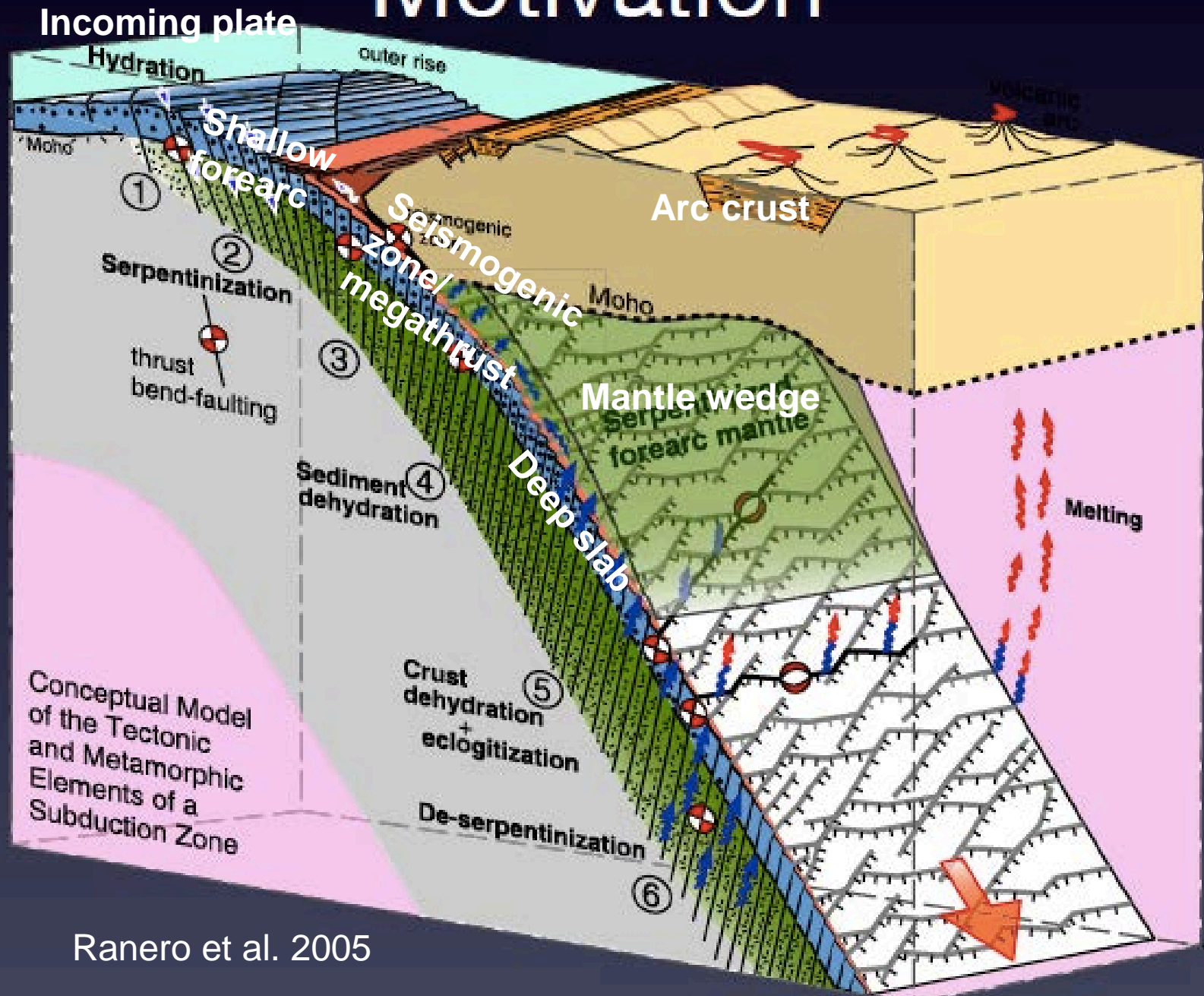


*Sarah Penniston-Dorland, Univ of Maryland*

# GeoPRISMS:

- Is a **community-driven** science program aimed at understanding active processes along continental margins, through integrative approaches that span the shoreline.
- Is a vibrant **interdisciplinary** research community (look around!) and an intellectual incubator for collaborative research...
- Addresses **first-order questions** about Earth's most active tectonic, mass transfer, and sedimentary systems - relevant to major geohazards that affect population centers, including large earthquakes, volcanic eruptions, tsunamis, and landslides.
- Is an NSF funding opportunity, based on a science plan developed by the community.

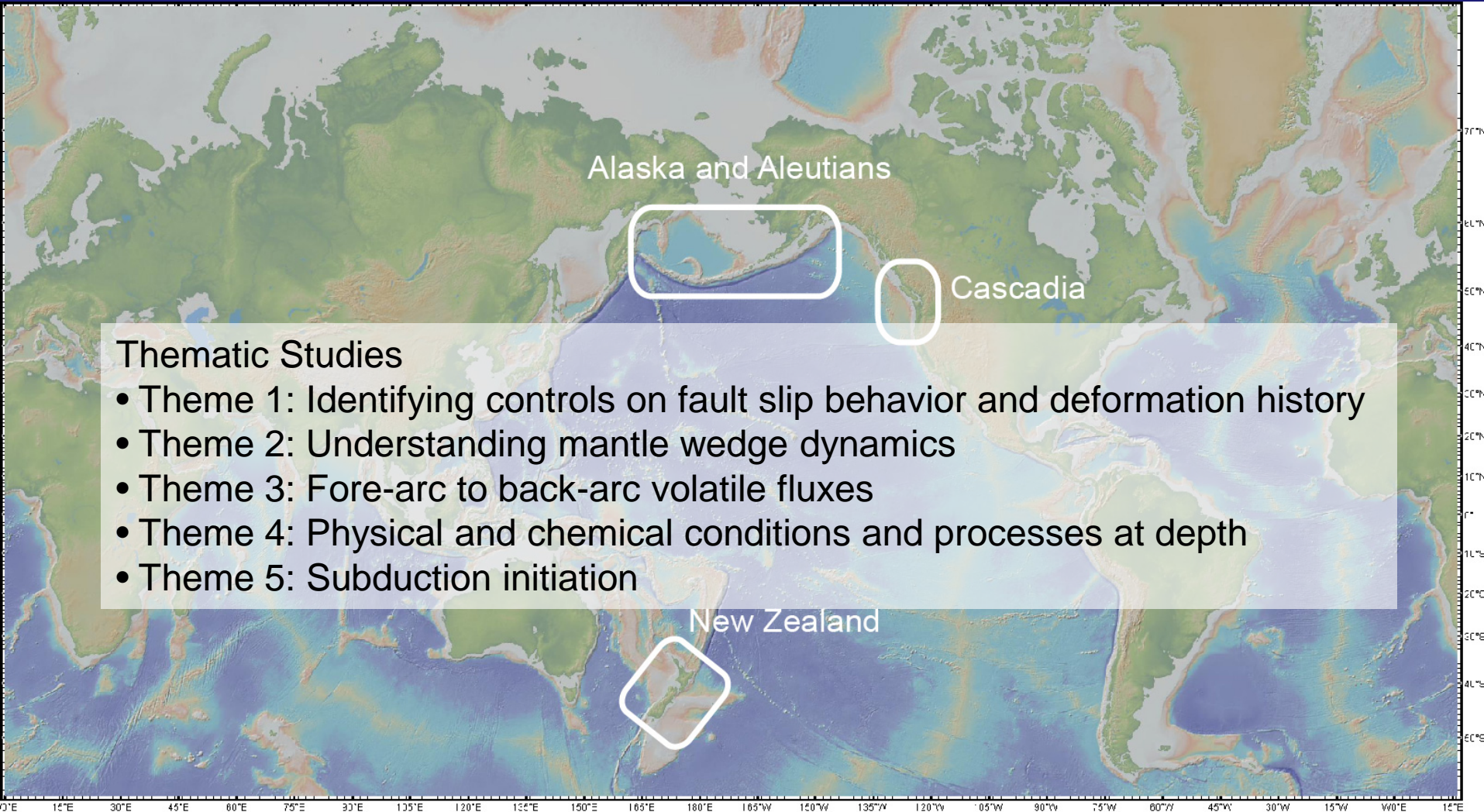
# Motivation



# SCD Key Questions


- What governs the size of great subduction zone earthquakes?
- How do subduction zones initiate?
- How does volatile release affect rheology?
- How are fluids and melts released and stored in a subduction system?
- What are the products of subduction?
- What feedbacks exist between surface processes and subduction mechanics?

# SCD Primary Sites and Initiatives



# SCD Primary Sites Phased Funding



A scenic landscape photograph of a fjord. In the foreground, a small blue boat is on the dark blue water. The middle ground shows steep, green mountainsides. In the background, more mountains are visible under a cloudy sky, with a layer of white mist or fog settling in the valleys between the peaks.

# Subduction Cycles and Deformation (SCD) Planning and Meetings

Jan, 2011: SCD Implementation (Bastrop, TX)

Sep, 2011: Alaska Primary Site Planning (Portland, OR)

Apr, 2012: Cascadia Primary Site Planning (Portland, OR)

Apr, 2013: New Zealand Primary Site Planning (Wellington, NZ)

Oct, 2015: SCD TEI (Redondo Beach, CA)

# Subduction Cycles and Deformation (SCD) Mini-workshops

Dec, 2011: ExTerra: Understanding Convergent Margin Processes through studies of Exhumed Terranes, Integrating CRISP IODP drilling and 3D seismic study, Using Geoinformatics resources to explore the generation of convergent margin magmas

Dec, 2012: IODP Opportunities for SCD, Marine Geophysics in the Cascadia Primary Site

Aug, 2013: ExTerra: Understanding Subduction through studies of exhumed terranes

Dec, 2013: Kermadec Arc-Havre Trough-Planning, Field Logistics for GeoPRISMS Research in the Aleutian Arc, Exploring the interplay between solid Earth tectonics and surface processes

Dec, 2014: Cultivate and coordinate GeoPRISMS studies of the Hikurangi subduction margin, South Island New Zealand Primary Site

Dec, 2015: Himalayan Seismogenic Zone

Dec, 2016: EarthScope-type Canadian Cordiller Seismic Array and GPS Network, Volcanoes in Extensional and Compressional Settings

Dec, 2017: Amphibious community experiments in Alaska and related opportunities

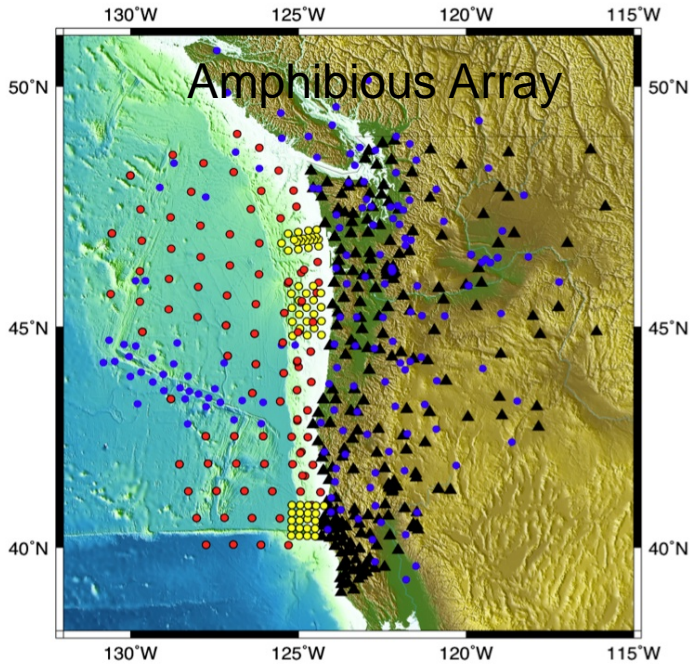
Dec, 2018: ExTerra: Evolution of arc crust; Investigating subduction processes at the Hikurangi Margin, New Zealand



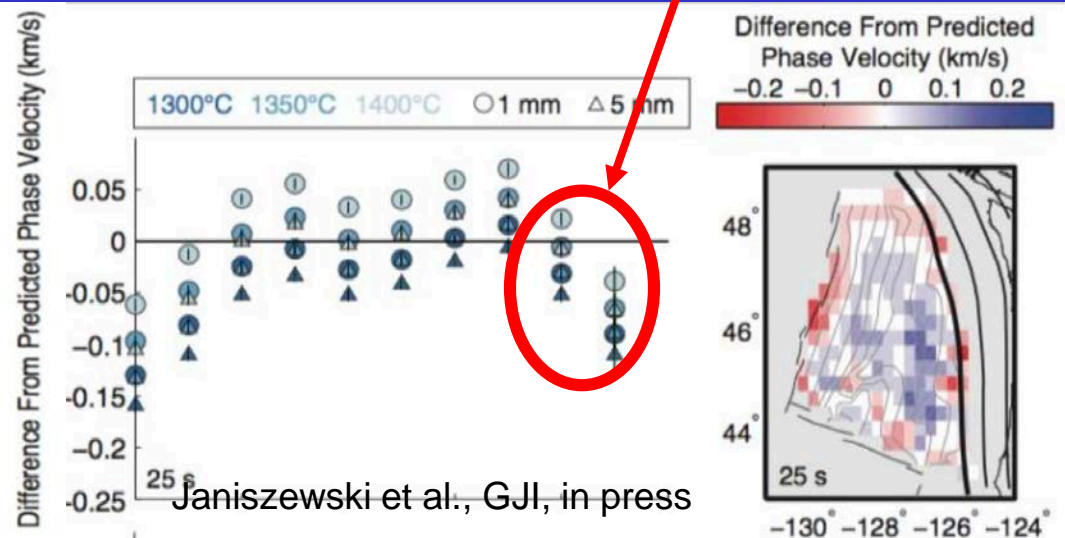
# Cascadia

## RATIONALE

- Highly accessible for fieldwork, can leverage existing infrastructure and co-located research efforts
- Build on broad spectrum of existing geological and geophysical data
- A young, hot endmember subduction zone
- Well-suited for studying nature and origin of episodic tremor and slip (ETS)



Reduced upper mantle velocities near trench – hydration?

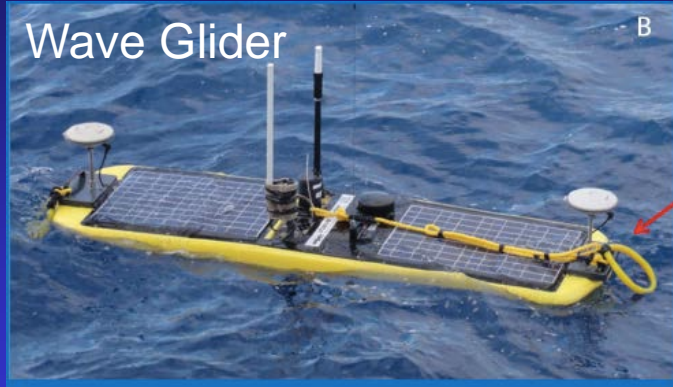


## COMMUNITY EFFORTS

*Cascadia Initiative* (2009-2014) – community experiment - an onshore-offshore geophysical and geodetic project including deployment of the Amphibious Array.



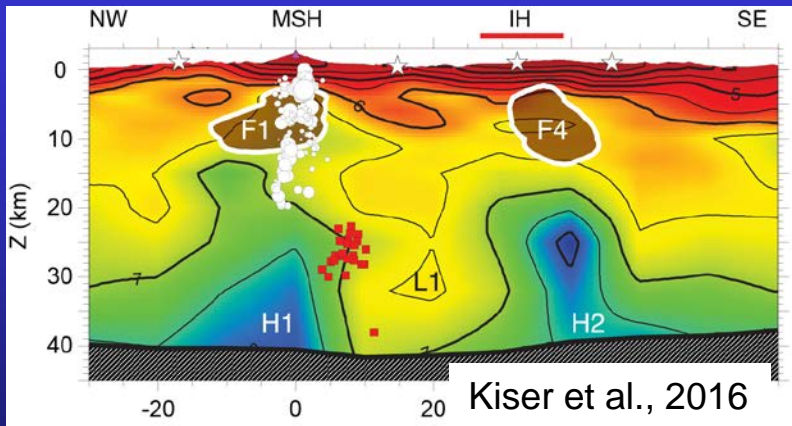
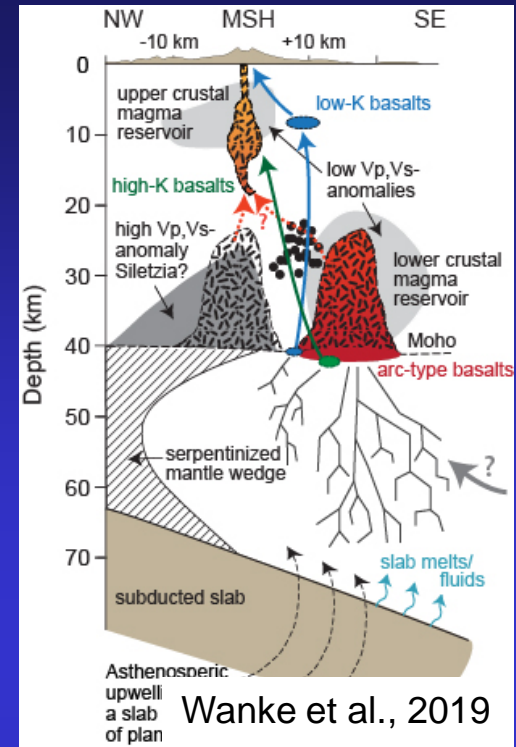
# Cascadia



Wave Glider

Constraining slip distribution of the Cascadia Subduction Zone Offshore (2012-2016) – use GPS-Acoustic seafloor geodesy to measure slip deficit offshore.

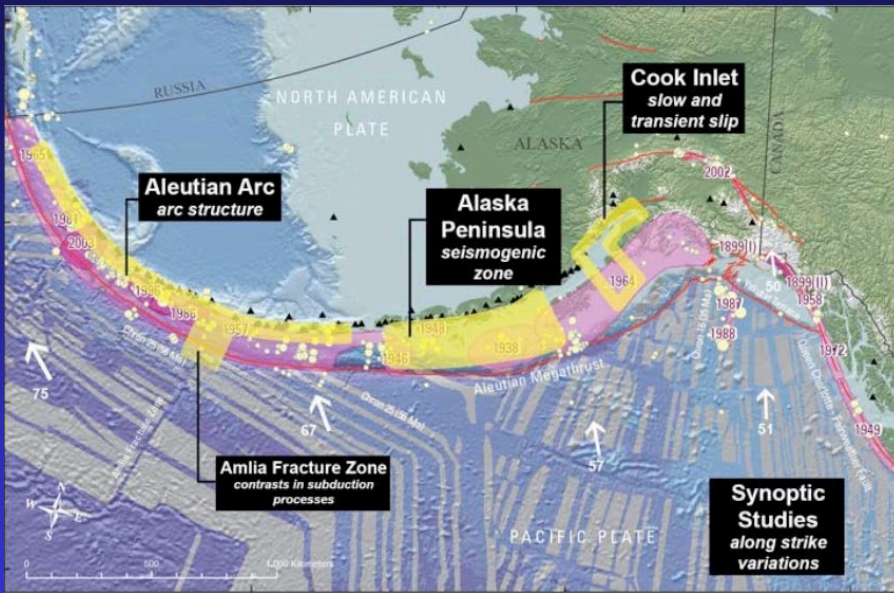
*iMUSH* (2012-2016)– image architecture of Mount St. Helens magmatic system from the subducted plate to surface using geophysical and petrological approaches



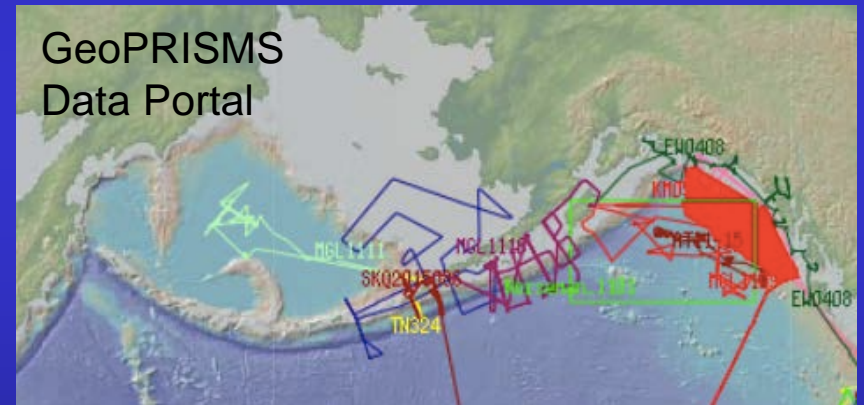
# Alaska and Aleutian

## RATIONALE

- Both ocean-ocean and ocean-continent boundaries
- Different modes of slip and different stages of earthquake cycle in segments, some locked, some creeping
- Leverage Plate Boundary Observatory, US Transportable Array & existing USGS work



Evolution of the chemically diverse Aleutian Arc



Geochemistry of volcanic fluids, Katmai

Dredging in the Aleutians



Investigating older rocks in the oceanic Aleutian volcanic arc east of Adak



MT & seismic investigation of arc melt generation, delivery and storage beneath Okmok volcano



# Alaska and Aleutian

## COMMUNITY EFFORTS

*Field Campaigns to the Aleutians (2015-2016)*

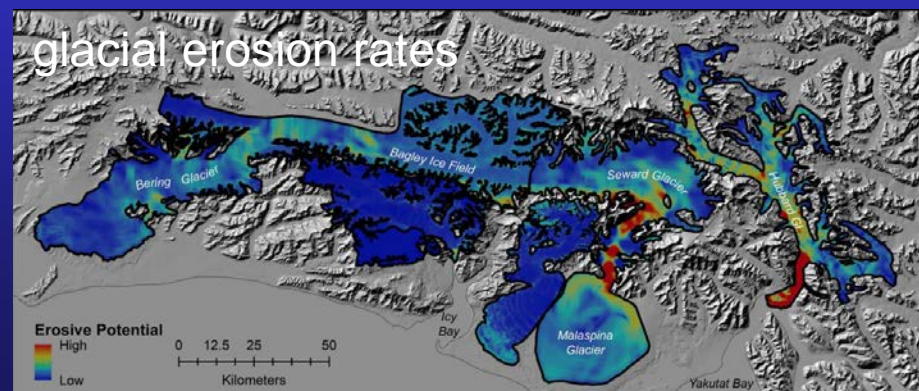
Islands of Four Mountains to Unimak: From the slab to the surface



Seeking the origins of continents in the western Aleutian island arc



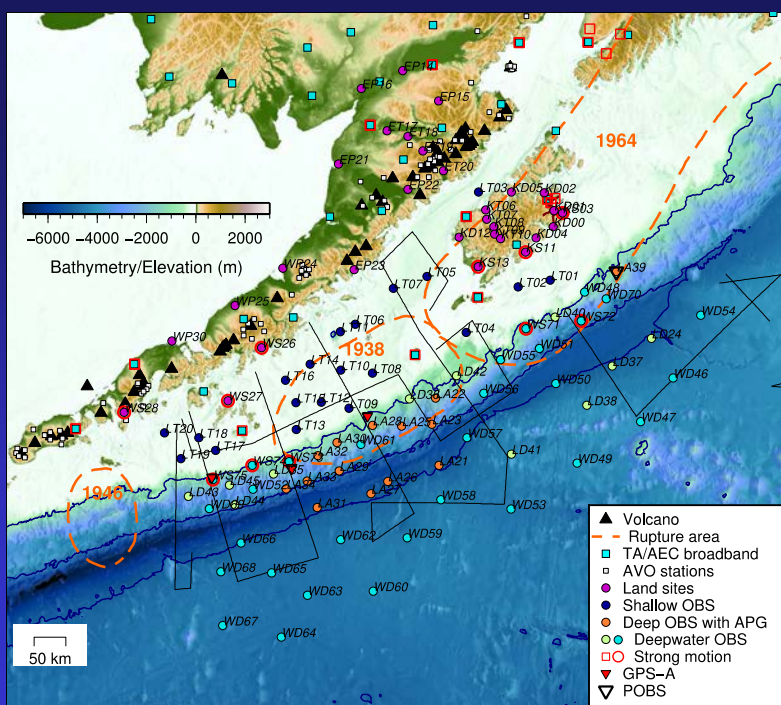
Modeling sediment production from glaciers off south-central Alaska



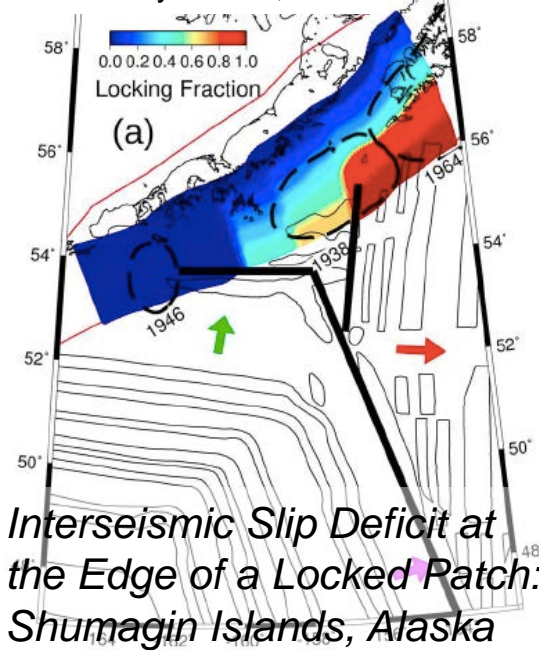
# Alaska and Aleutian

*Alaska Amphibious Community Seismic Experiment (2018-2019)* 75 broadband OBS, 30 land broadband sensors, covers incoming plate-megathrust-volcanic arc-distal backarc (even when integrated with TA)

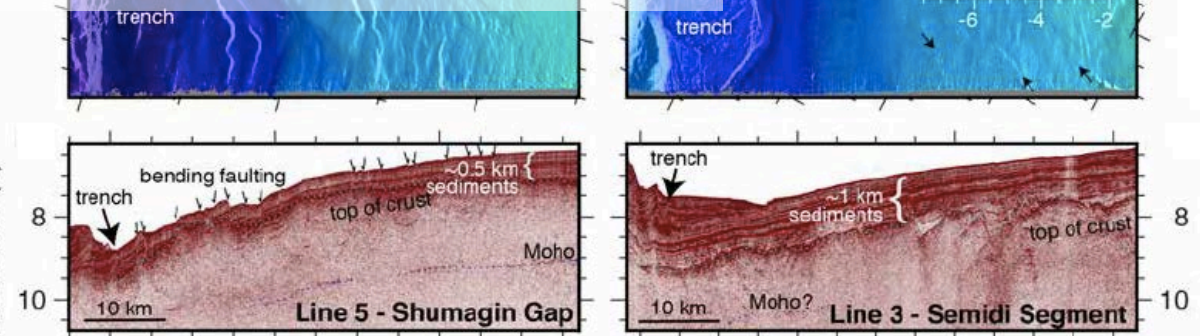
Links between structures (plate bend normal faults) in downgoing plate and hydration and seismicity in subduction zone



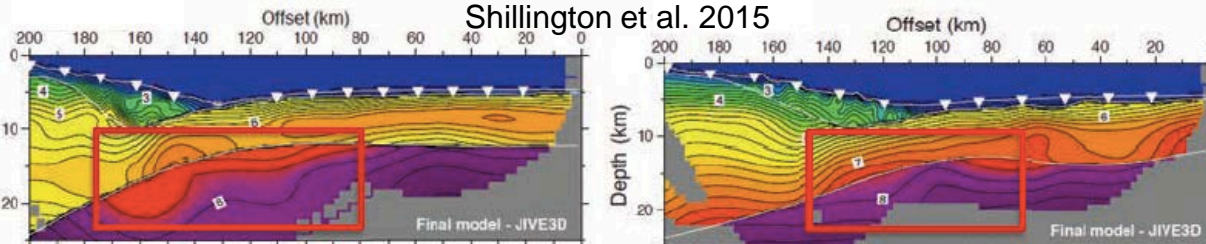
Li and Freymueller, 2018



Mapping the Alaska Megathrust



Shillington et al. 2015



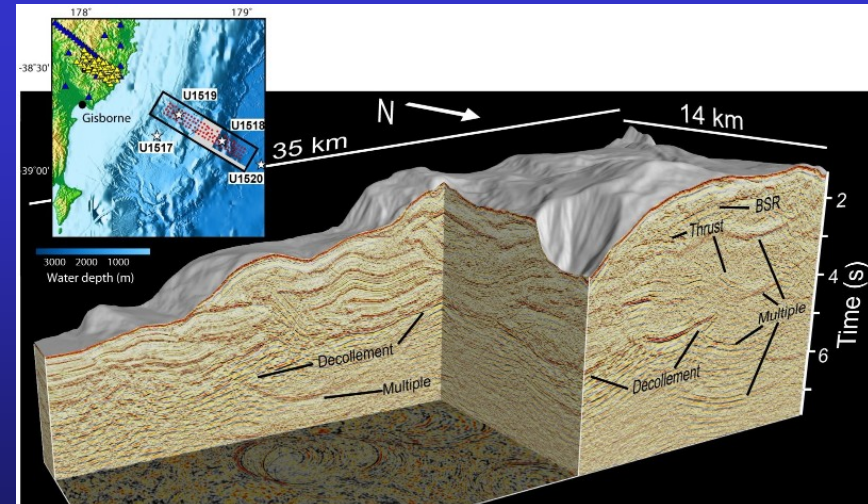
# New Zealand

## RATIONALE

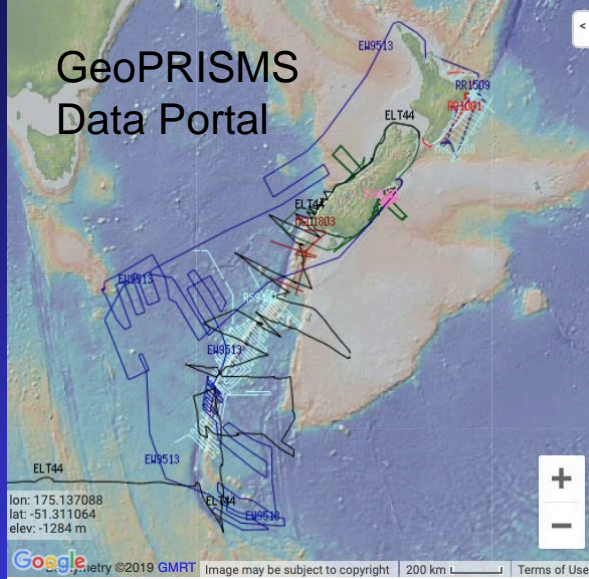
- Range of fault slip and volcanic phenomena with along-strike variation in small, compact setting
- Active subduction initiation (Puysegur Ridge), exhumed arc crust (Fiordland), seismogenic zone, sedimentation, & forearc deformation (Hikurangi Margin), arc volcanism (Taupo Volcanic Zone, Kermadec Arc), back-arc rifting (Taupo, Havre Trough)
- Government investments in onshore and offshore scientific infrastructure

## COMMUNITY EFFORTS

*NZ3D & IODP Drilling (2017-2019)* – Seismic reflection study and ocean drilling of Hikurangi margin to understand controls on slow slip events.

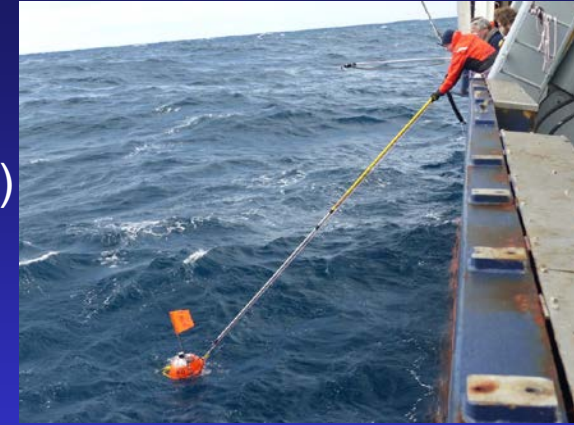


## GeoPRISMS Data Portal



# New Zealand

*SISIE South Island Subduction  
Initiation Experiment (2018-2019)*  
-collecting onshore and offshore  
geophysical data across  
Puysegur trench



*SHIRE Seismogenesis at Hikurangi  
Integrated Research Experiment –*  
Geophysical imaging, Paleoseismology &  
morphotectonics, and Numerical  
modeling to investigate megathrust  
behavior and controls on seismogenesis

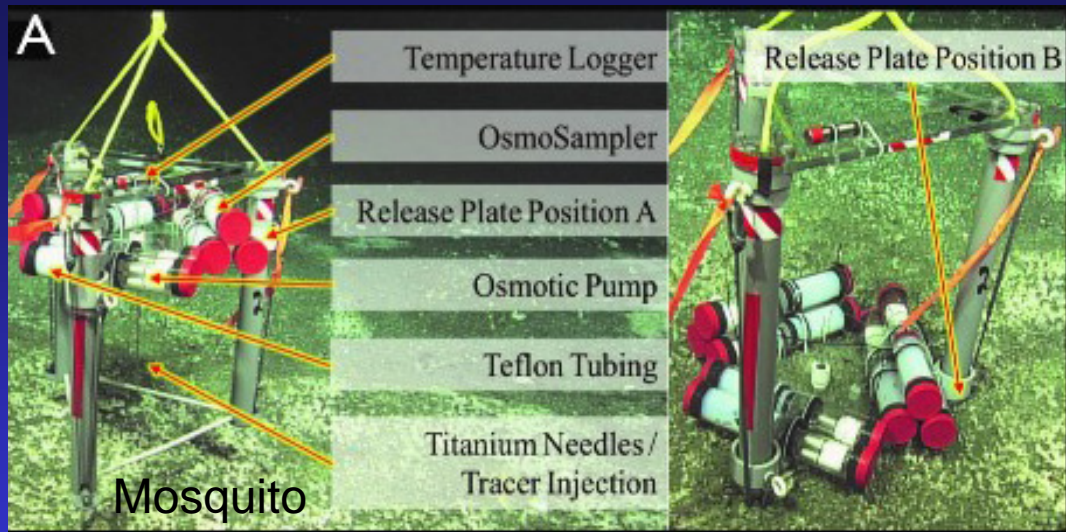
Volatile cycling through the Hikurangi forearc,  
New Zealand



Assessing changes in the state of magma storage  
system over caldera-forming eruption cycles, Taupo



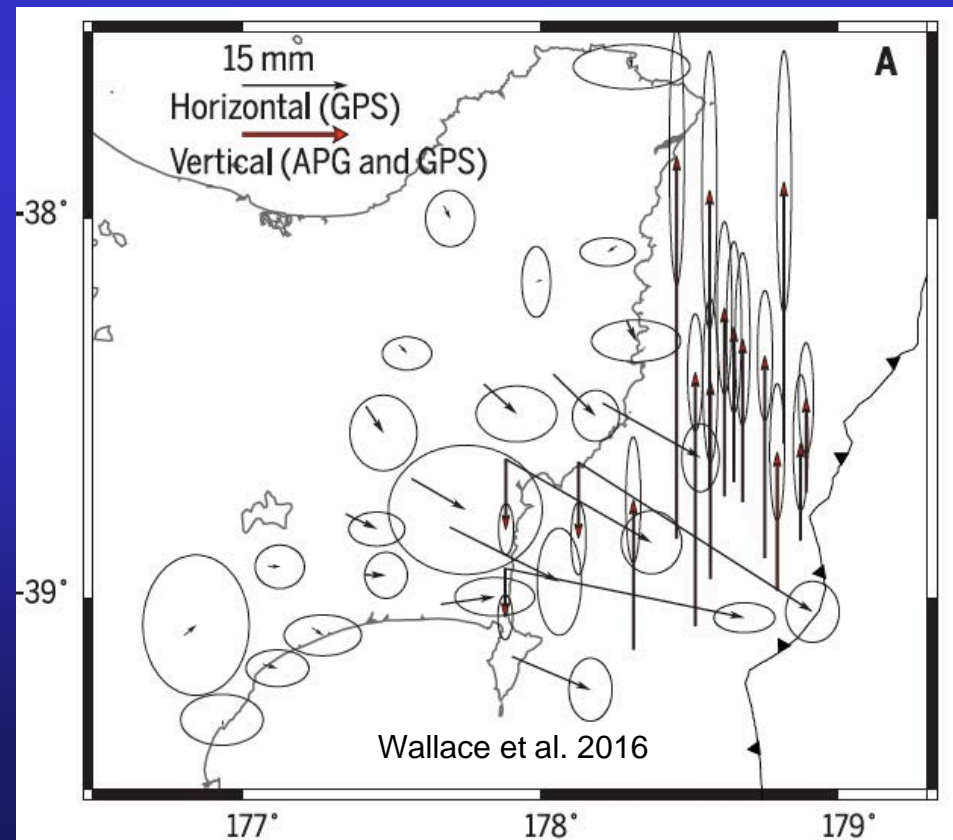




# New Zealand

*SAFFRONZ Slow-slip and Fluid Flow Response Offshore New Zealand (2019-2021) – Measure heat flow, fluid flow, and fluid composition at on- and off-fault locations*

*HOBITSS Hikurangi Ocean Bottom Investigation of Tremor and Slow Slip (2014-2015) – Ocean bottom pressure sensors (APGs) and seismometers deployed. First detailed view of seafloor deformation during SSE. SSEs occur on shallowest reaches of megathrust, within 2 km of seafloor*



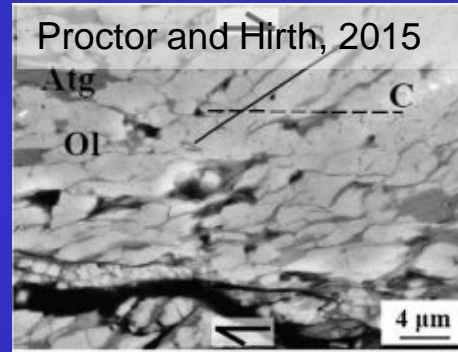
# Thematic studies

## RATIONALE

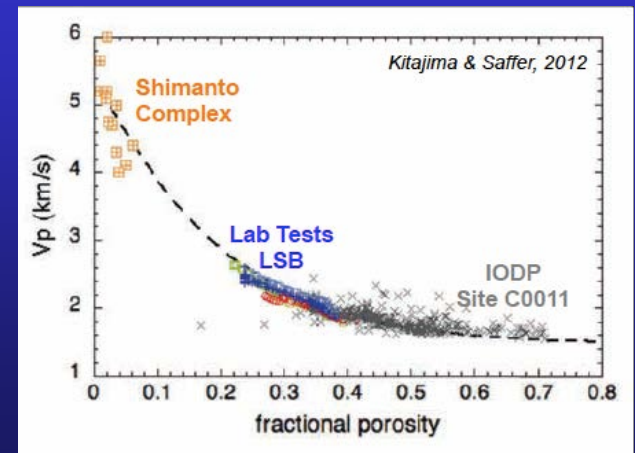
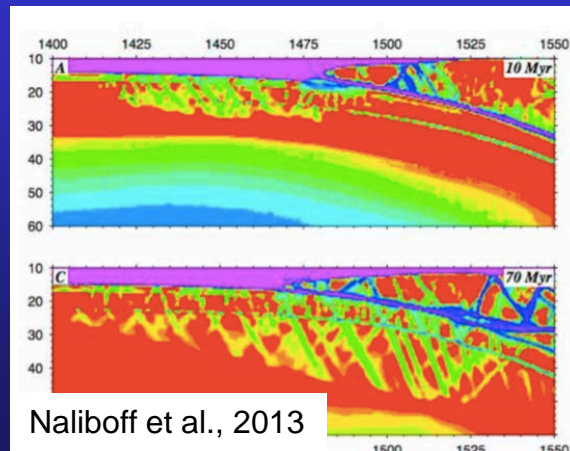
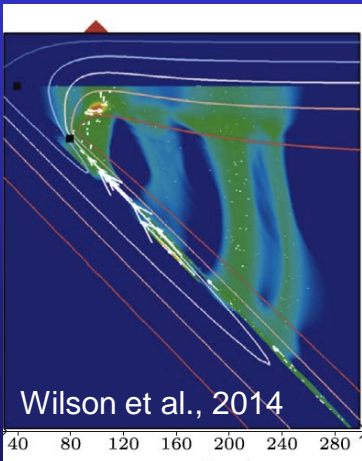
- Thematic studies include broader research approaches than can be achieved at primary sites.



*E-FIRE ExTerra (Exhumed Terranes) Field Institute and Research Endeavor (2015-2021)* Collect exhumed subduction-related rocks in the Western Alps to investigate geochemical cycling, fluid release, and rheology.



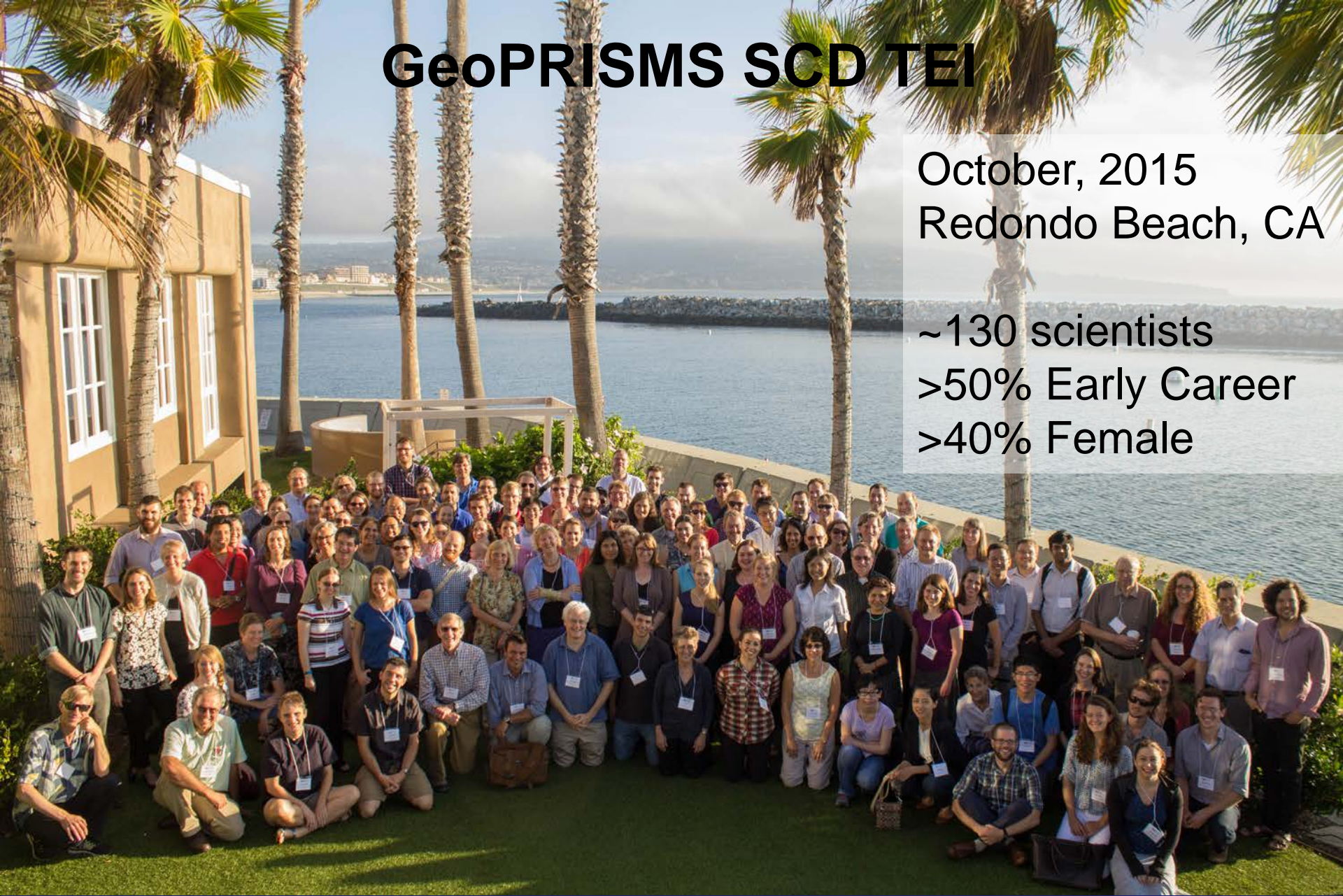
## Modeling and laboratory experiments



# GeoPRISMS SCD TEI

October, 2015  
Redondo Beach, CA

~130 scientists  
>50% Early Career  
>40% Female



**Community-driven**

# Interdisciplinary

