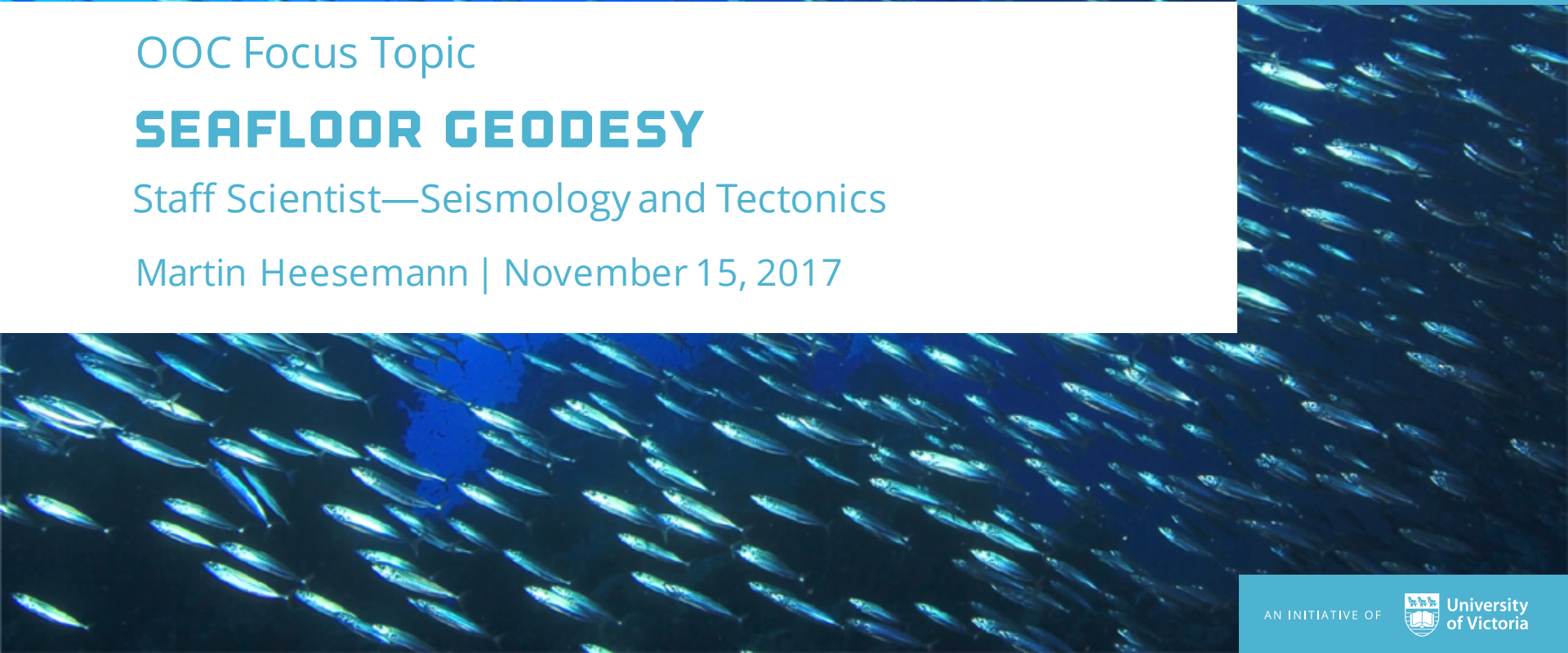
OCEAN NETWORKS CANADA

OOC Focus Topic

SEAFLOOR GEODESY

Staff Scientist—Seismology and Tectonics

Martin Heesemann | November 15, 2017



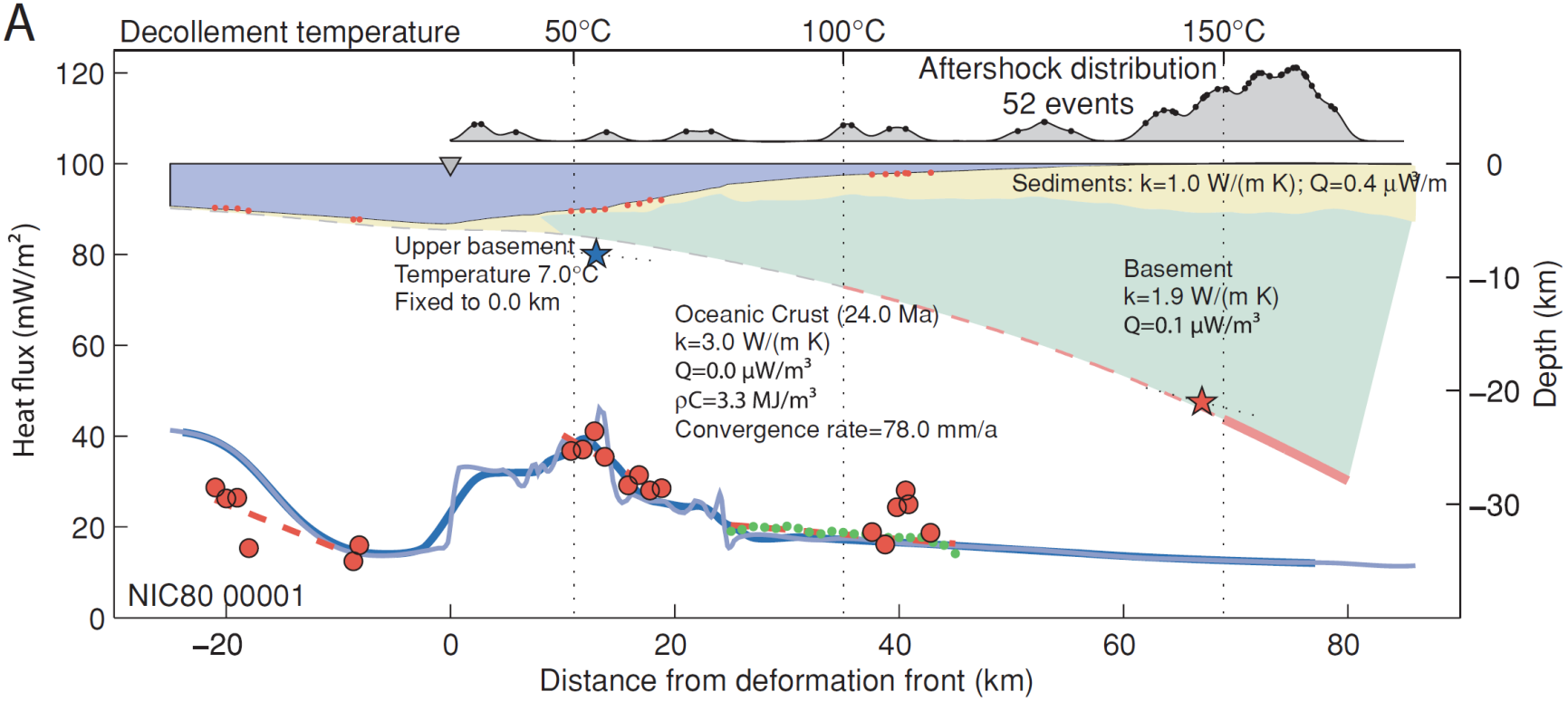
I AM A MARINE GEOPHYSICIST

Before ONC:

- In-situ heat-flux, sediment temperature, and pressure measurements
- Numerical models of subduction zones and instrument responses
- Instrument development and deployments
- Ocean drilling

IN ESSENCE...

A



OCEAN NETWORKS CANADA

INVOLVEMENT WITH ONC/NEPTUNE

- Followed wife to Canada in 2009
  - Started to work with Earl Davis on ONC CORK borehole observatories and Bottom Pressure Recorders.
- NEPTUNE Research Theme Integrator, 2010
  - Installed CORK 1364A at Clayoquot Slope with Earl Davis.
  - Responsibility for Seismograph Network (Garry Rogers)
  - CORK and BPR network/tsunamis
  - Data access
    - Station codes/infamous search tree
    - Webservices

SEVEN YEARS ONE AND A CHILD LATER...

… THIS IS WHAT KEEPS ME BUSY

- CORK 1364A with new instrumentation connected
- Finish installation of seismometer network in 2018
- Coogan Endeavour expansion
- $600k for CANARIE for webservices and sandbox
- New seafloor tiltmeters for EEW and geodesy
- Attend half a dozen workshops and conferences each year
- Co-teach EOS 350
- Support users
- Co-author publications
- Negotiate with Navies
- Left field projects
  - MTC Borehole seismometers
- Prioritize, record metrics, organize workshops, …

MY MISSION

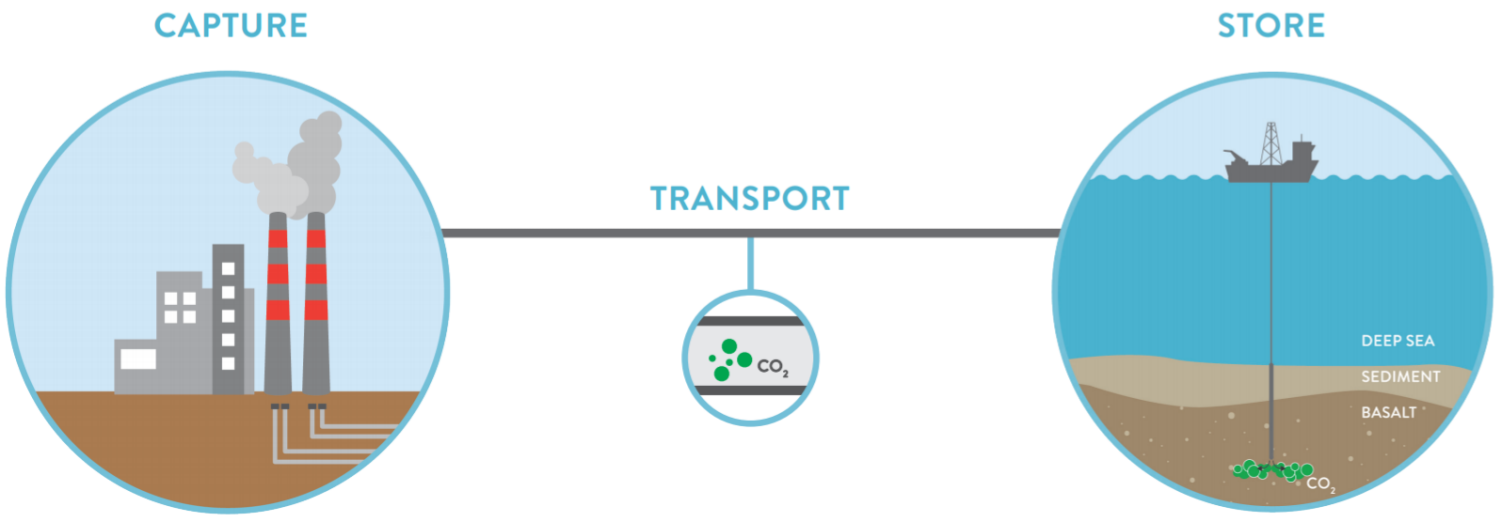
- Engage and build new communities
- Become a community leader

DOE: CARBONSAFE

CarbonSAFE CASCADIA PROJECT
PRE-FEASIBILITY STUDY FOR
INTEGRATED CO_2 CAPTURE & STORAGE

WHAT IS AN INTEGRATED CARBON CAPTURE & STORAGE PROJECT?

Carbon capture and storage is a technology where carbon dioxide (CO_2) is captured at power plants or other industrial facilities, transported to a specific storage site, and injected underground for long-term storage. The goal is to prevent greenhouse gas emissions that cause climate change from being released into the atmosphere.



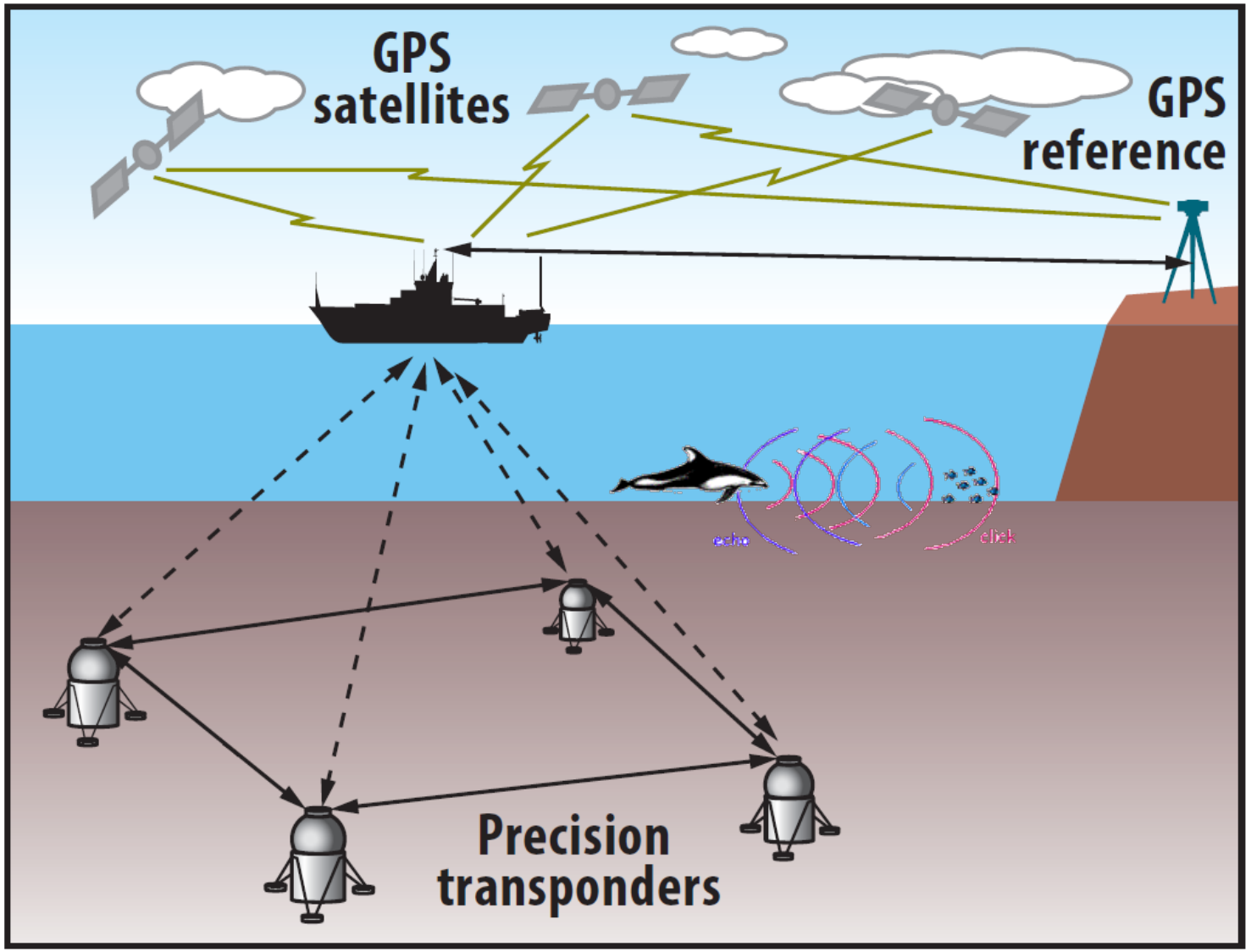
BUILD SEAFLOOR GEODESY COMMUNITY

New community that aims to measure the shape and deformation of the seafloor.

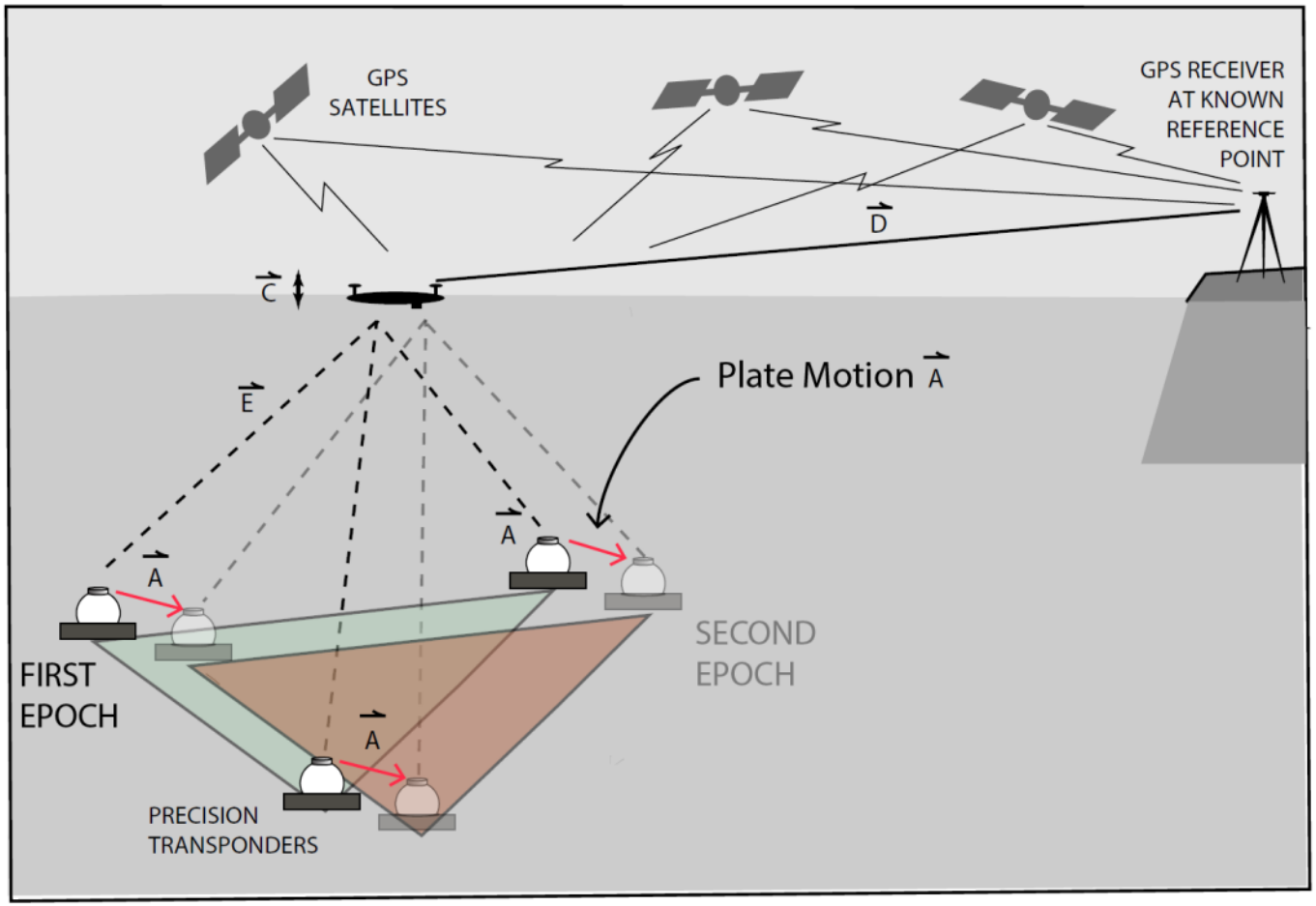
So far I

1. Supported Jeff McGuire et al. with deployment of borehole tiltmeter.
2. Supported Earl Davis in developing new tools and techniques to measure seafloor tilt.
3. Lead CFI proposal to monitor the Cascadia Subduction Zone using GPS-A ($6.1M)

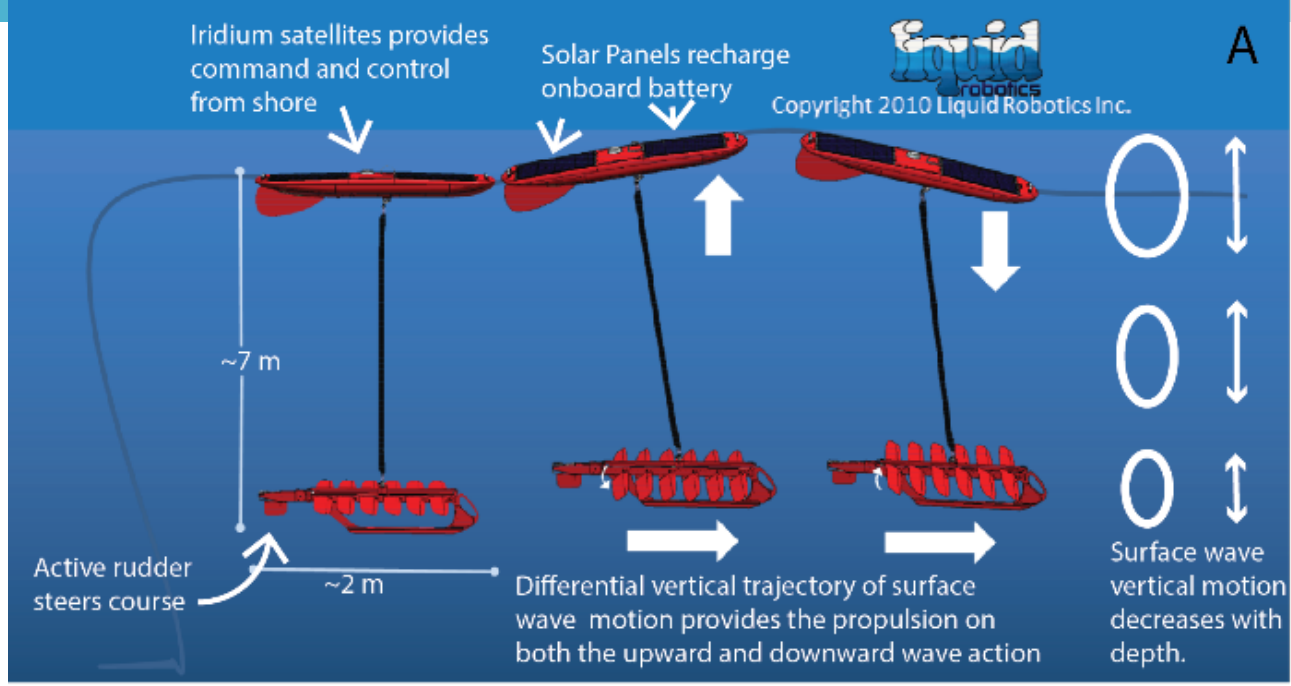
GPS-A positioning

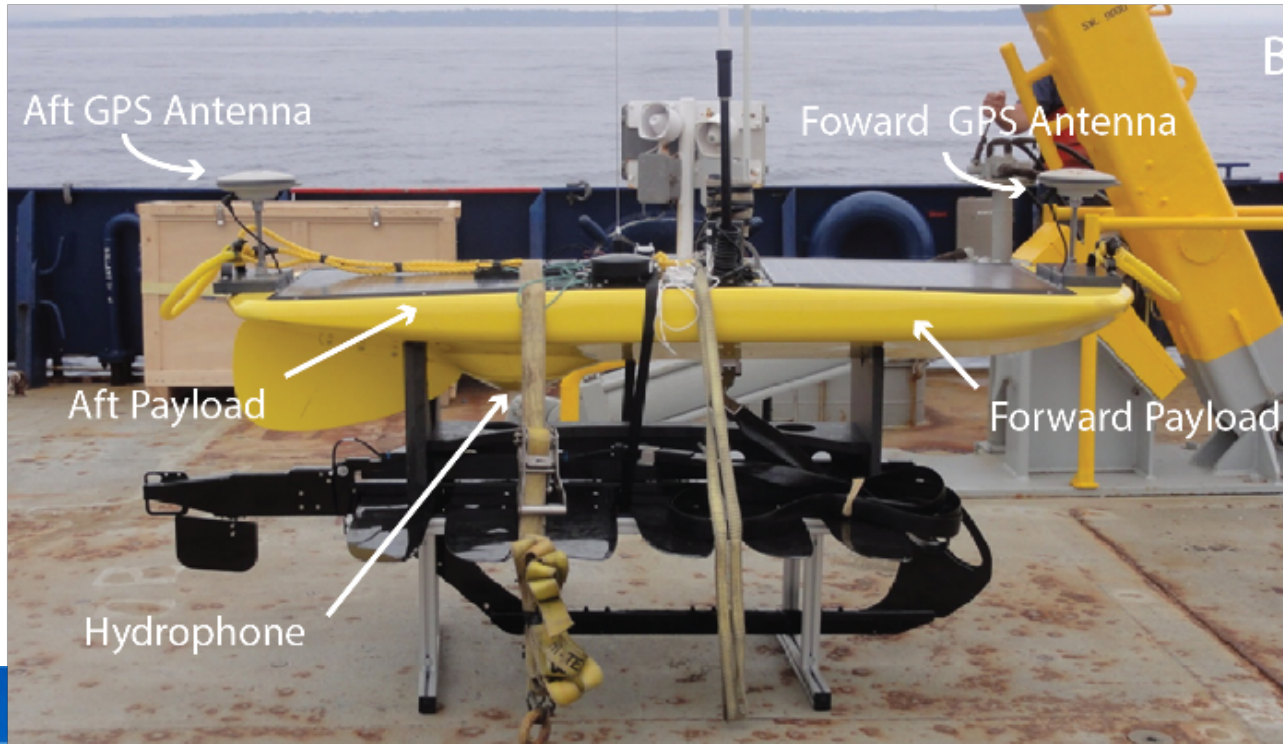


[*Bürgmann and Chadwell*, 2014]

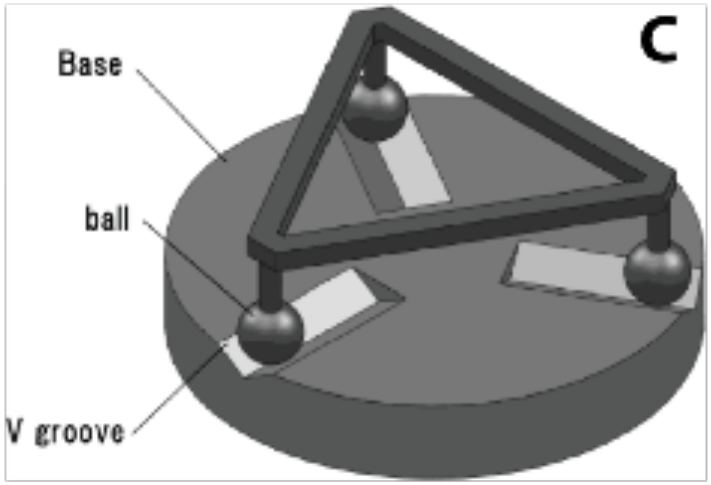

GPS
SATELLITES
GPS RECEIVER
AT KNOWN
REFERENCE
POINT
D
C
E
Plate Motion A
A
A
A
FIRST
EPOCH
SECOND
EPOCH
PRECISION
TRANSPONDERS

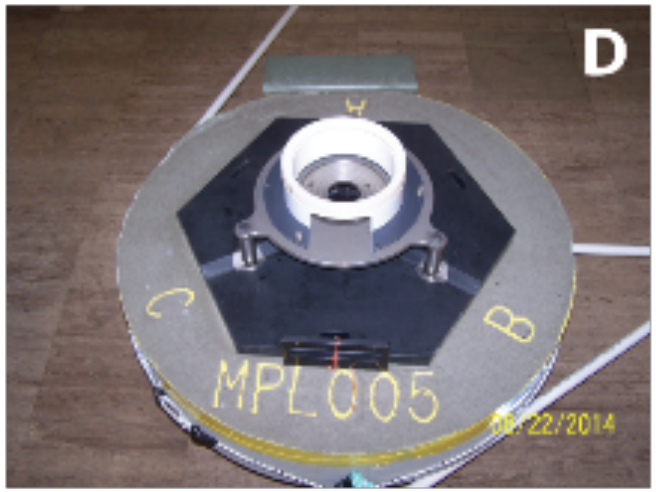
WAVEGLIDER TO SAVE SHIP-TIME

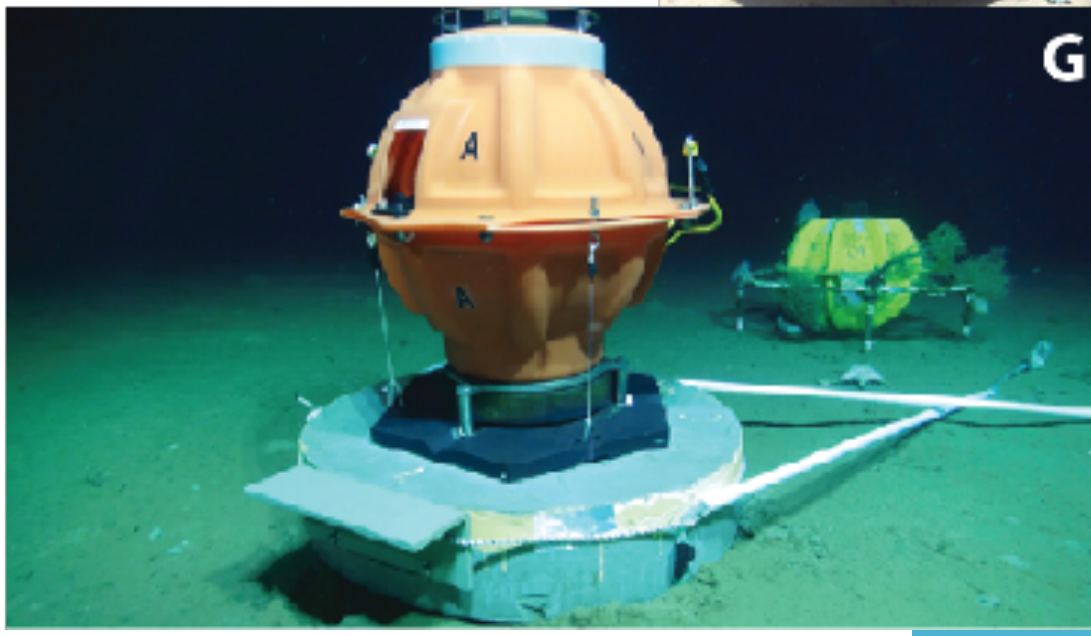




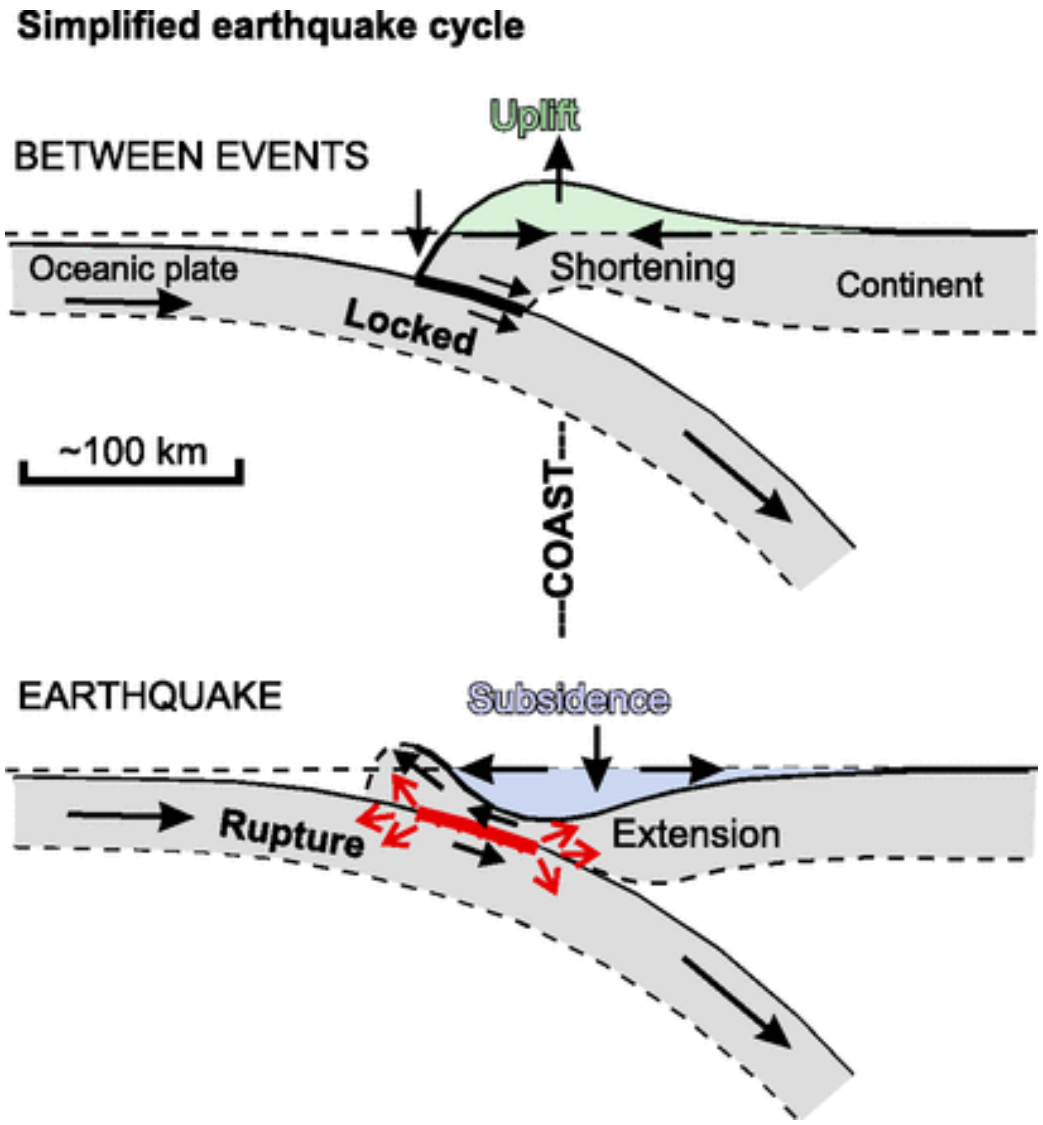
MONUMENTS LEAVE A LEGACY





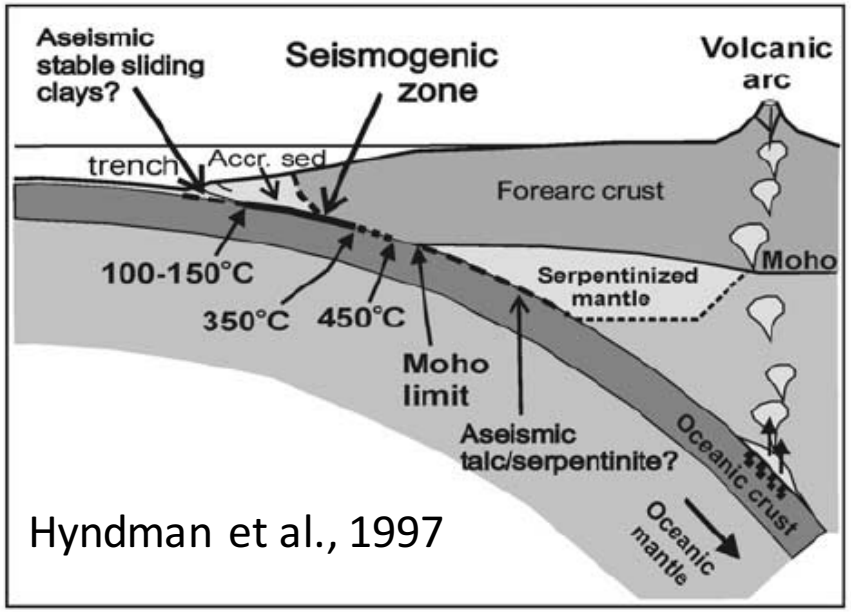


WHY DO ALL THIS?



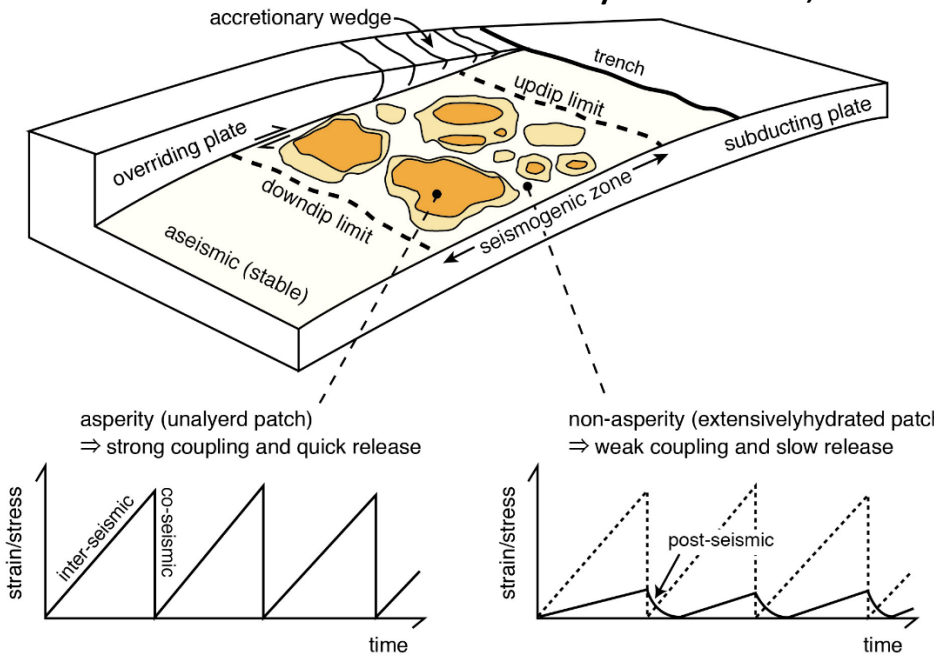
Rogers & Hyndman

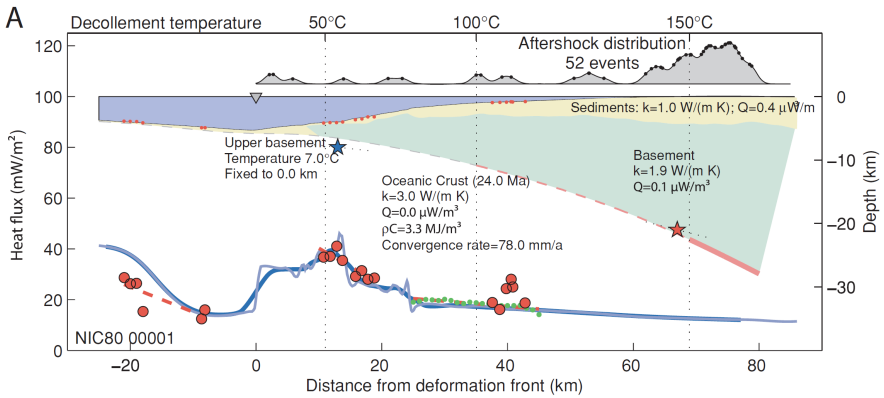
OUR MODELS OF SUBDUCTION ZONES EVOLVE



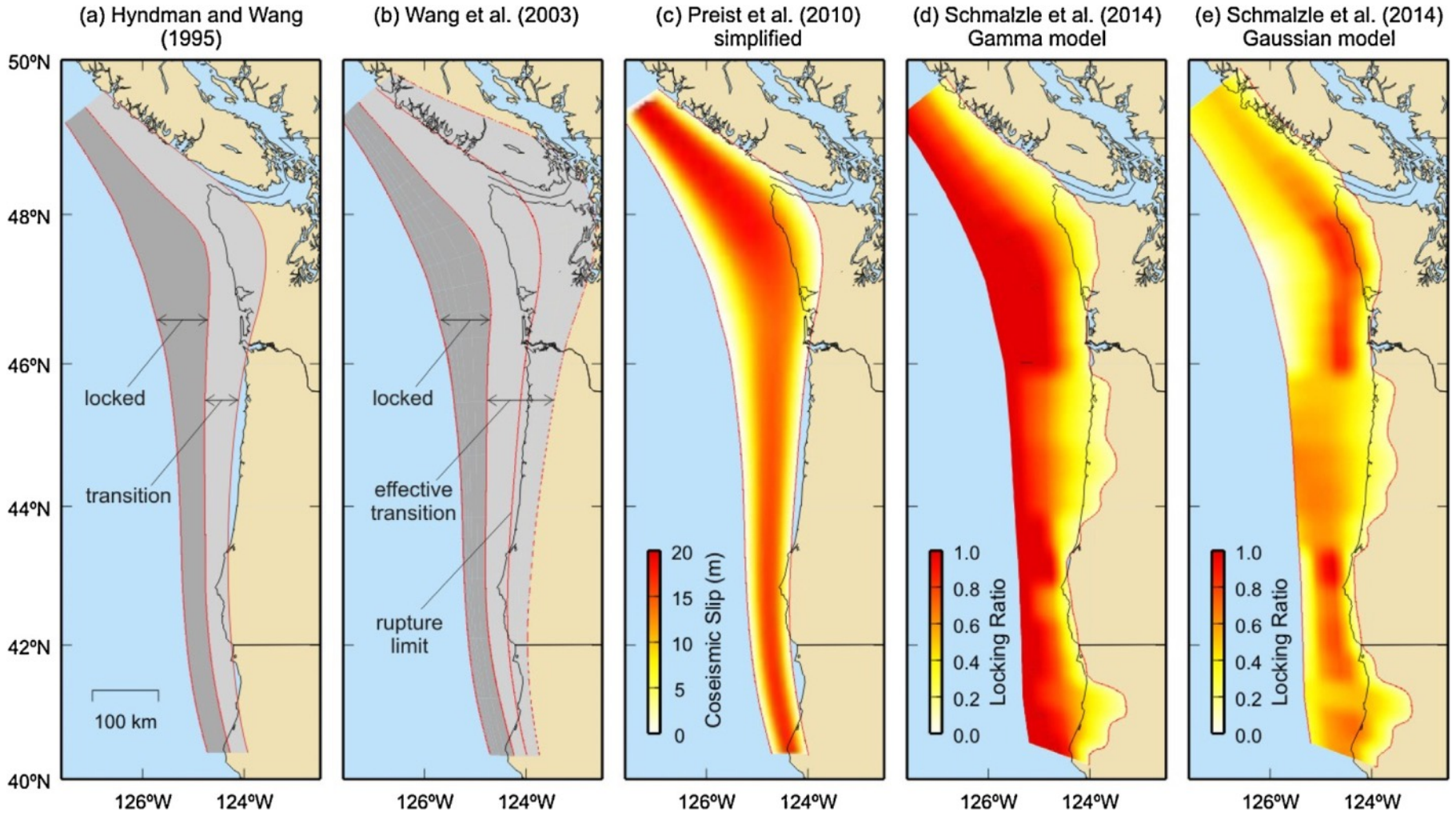
Hyndman et al., 1997

Katayama et al., 2015





WHAT ABOUT CASCADIA?



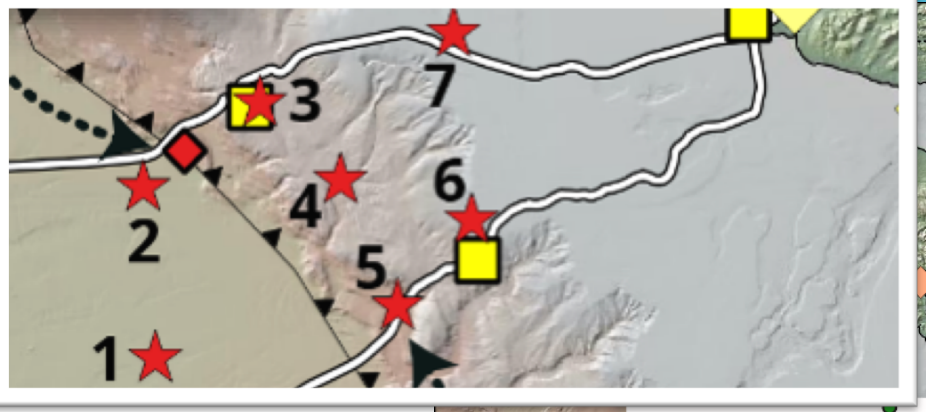
GPS measurements on land do not provide sufficient constraints for offshore locking pattern!

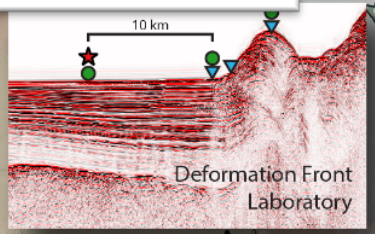
[*Wang and Tréhu*, 2016]

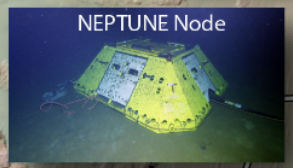
1 JdF reference

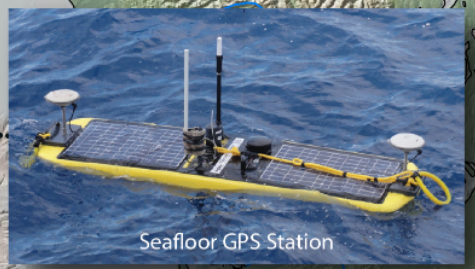
2-3 across deformation front

6 cabled testbed for continuous GPS-A







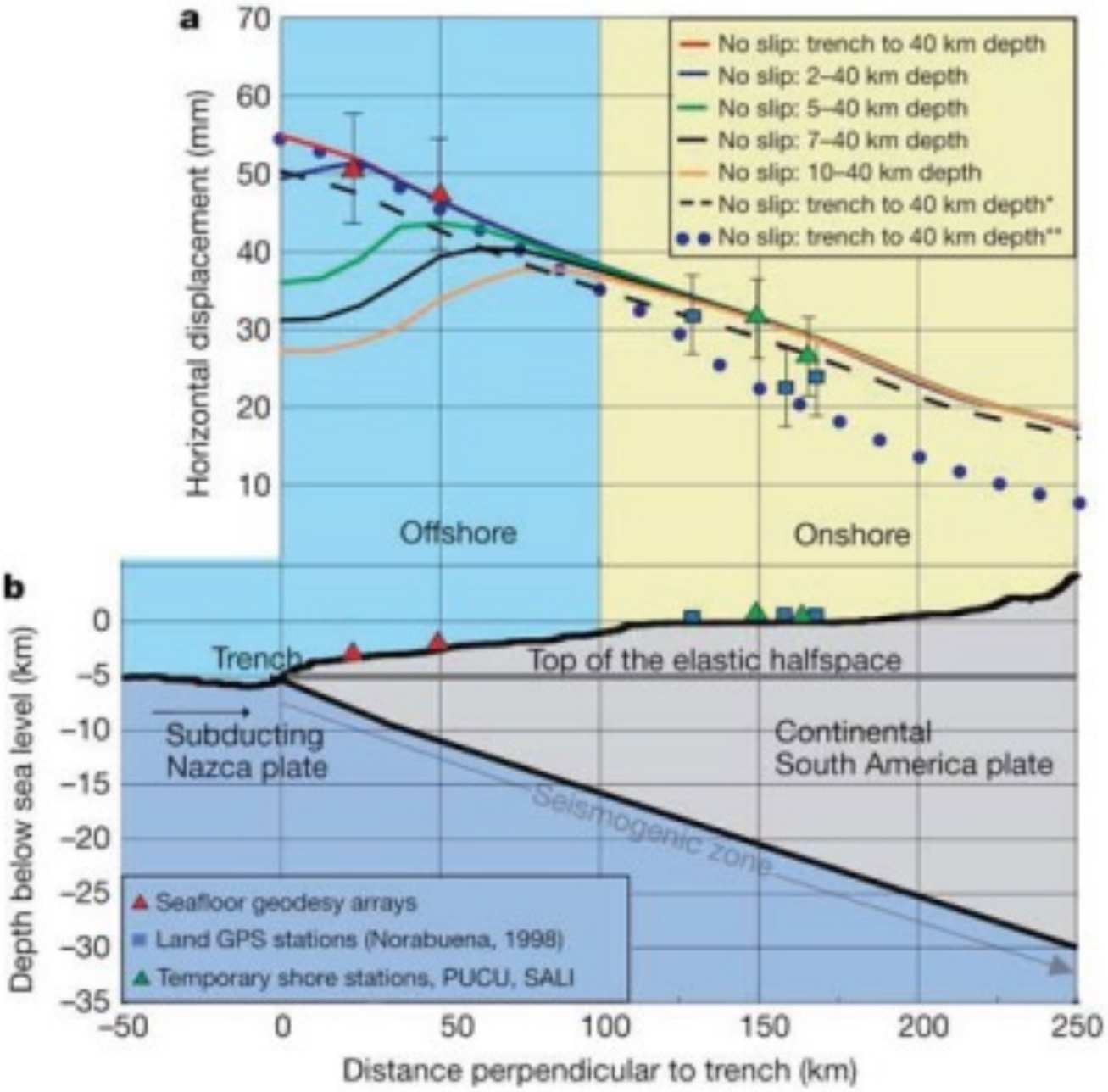


Seafloor geodesy
- Seafloor GPS station
- Deformation Front Laboratory

NRCan Stations
- Existing GPS Station
- New GPS Station

NEPTUNE Observatory
- Node
- Cable

PLATE LOCKING OFFSHORE PERU



[*Gagnon et al.*, 2005]

NCSZO IS FUNDED (ALMOST)

The next logical step is to measure vertical deformation!

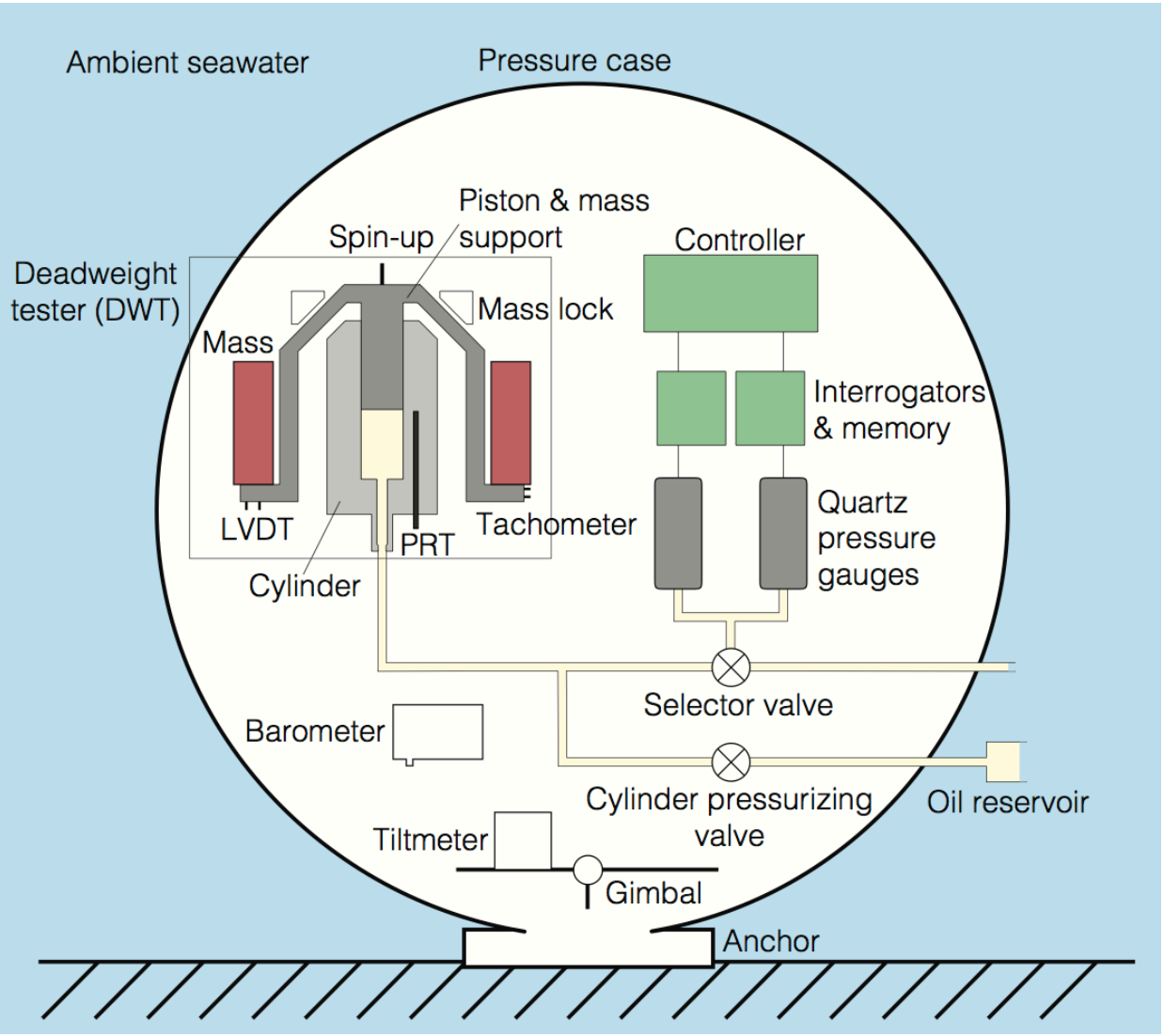
Vertical deformation can be measured using Bottom Pressure Recorders (BPR)

-> Long term drift is a problem

Matthew Cook (Scripps) presented a solution:

pressure gauges
self-calibrating
pressure recorder

1) pressure gauges measure ambient seawater pressure
2) once every X days, a valve changes so the gauges measure the reference pressure produced by the deadweight calibrator
3) after Y minutes, the selector valve changes so the gauges measure seawater pressure again



pressure gauges

self-calibrating pressure recorder

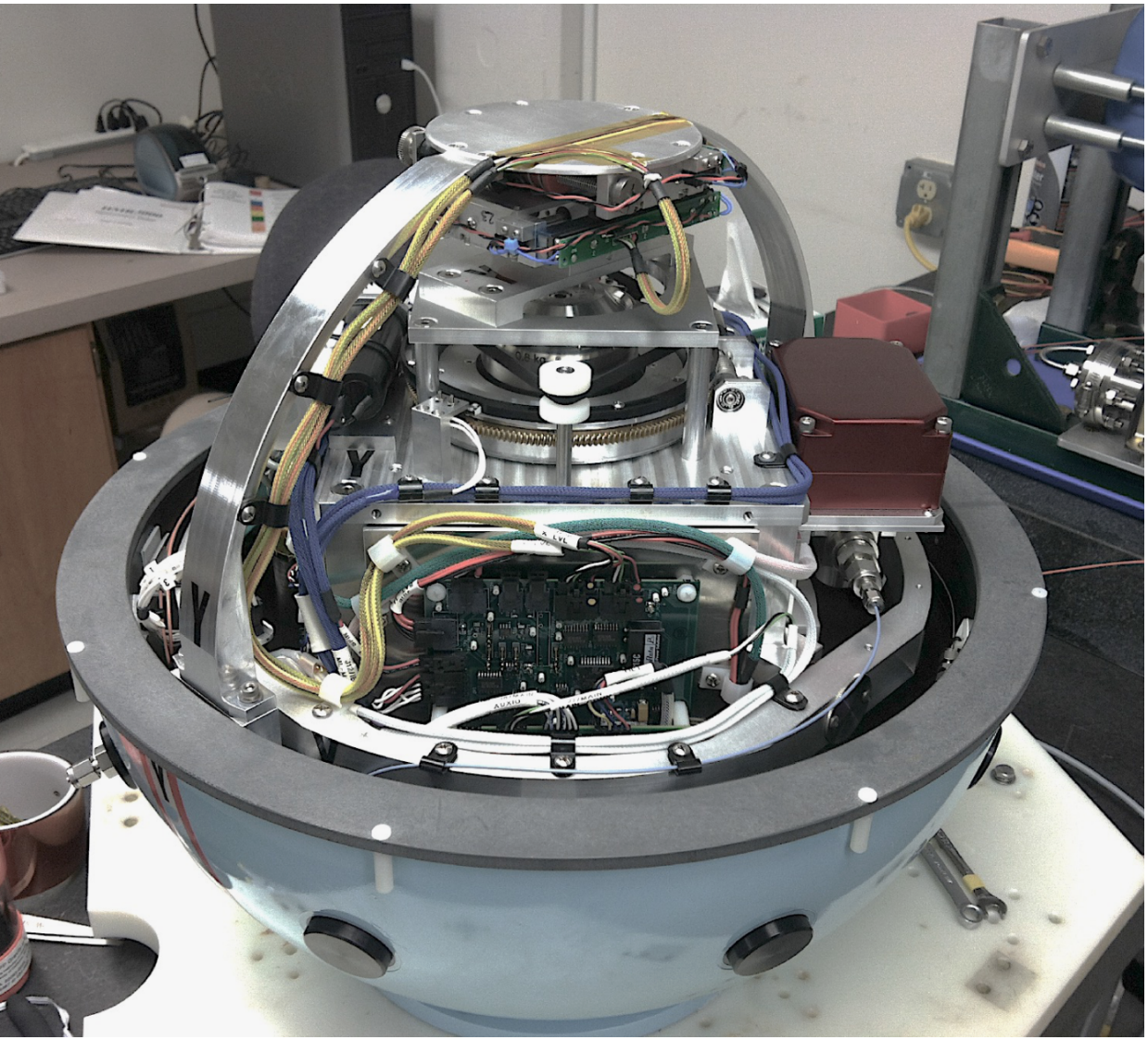
the reference pressure to first-order is expressed:

$$P=Mg/A$$

other terms become important to correct . . .

$$P=M(1-\rho_{air}/\rho_M)g(1-\theta^2/2)+\gamma C/(A(1+bP_0)(1+2\alpha\Delta T))$$

. . . but are straightforward to measure.



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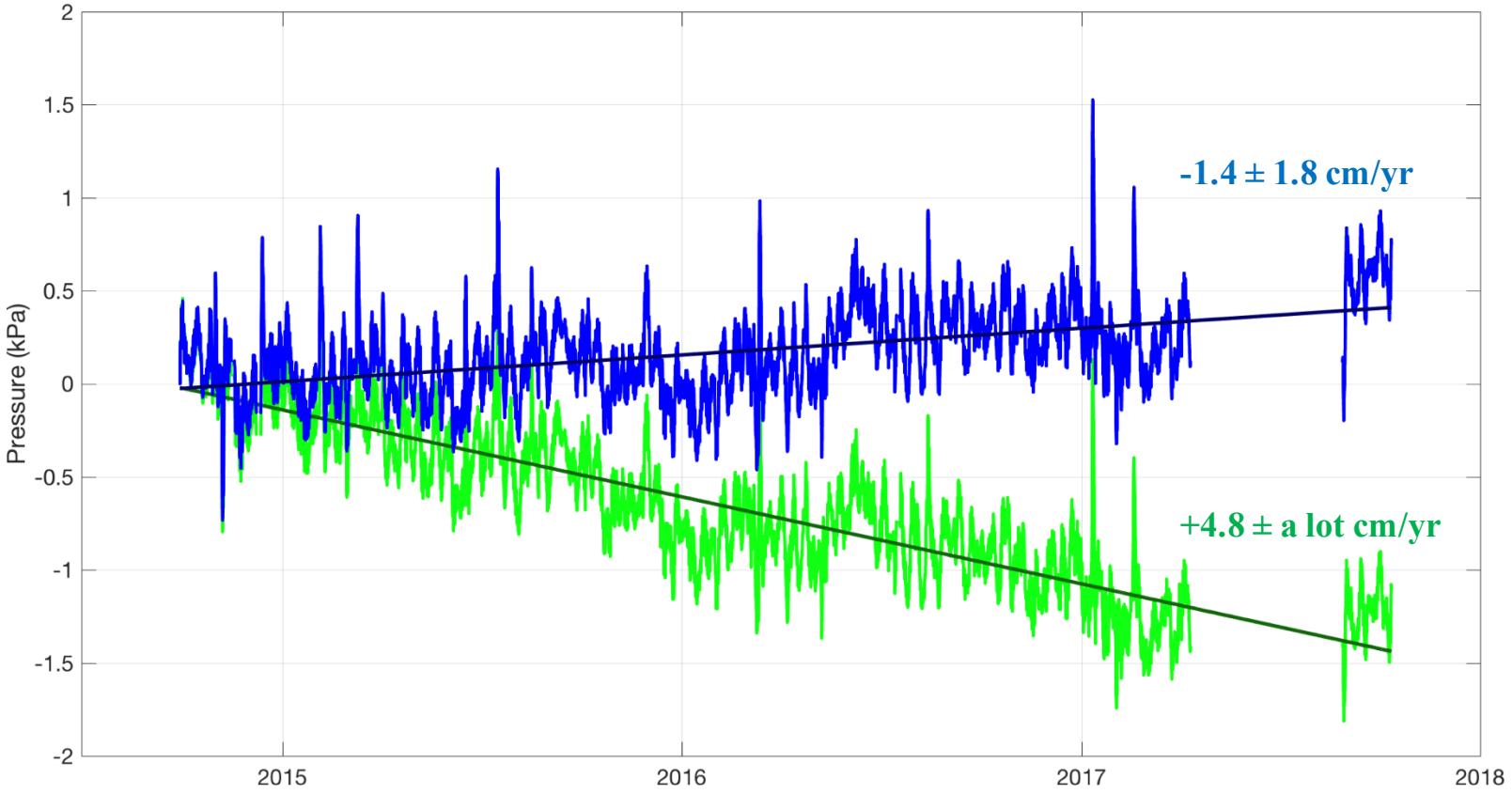
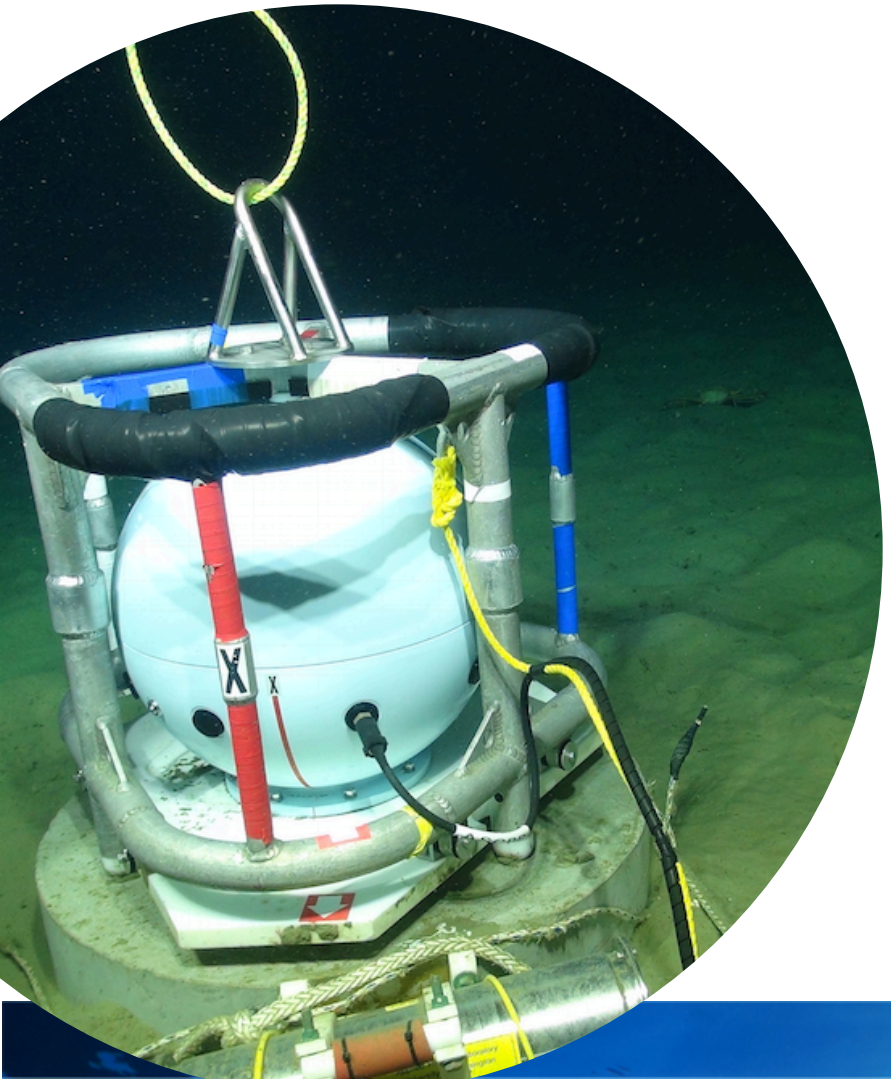
Cascadia subduction zone

processing the pressure data



the absolute self-calibrating pressure recorder



absolute seafloor pressure measurements offer a lot of utility. . .

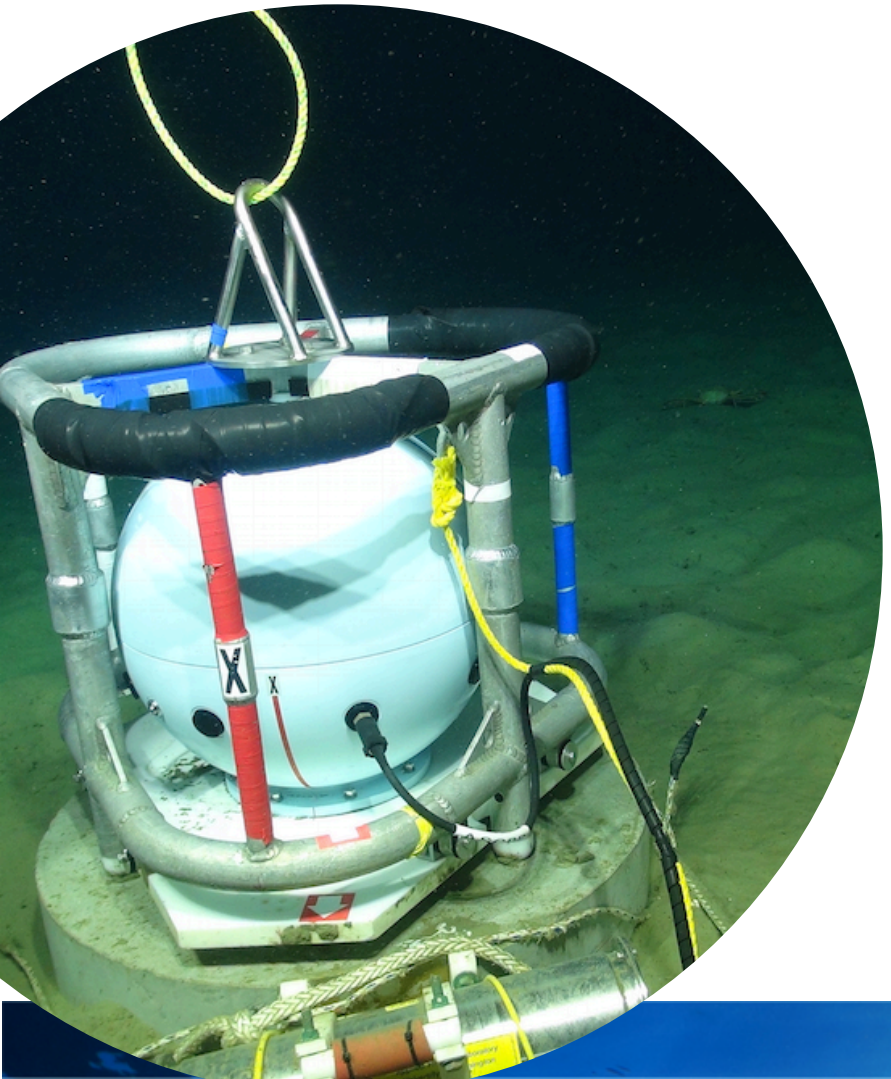
measurements are independent of instrument - metrology addresses differences between instruments

calibrate nearby continuous BPRs

epoch points in a long-term time series

ground truth altimetry and satellite products

the absolute self-calibrating pressure recorder



absolute seafloor pressure measurements offer a lot of utility. . .

if benchmarks existed around the world, they could be visited once every 1, 2, 5, or even 10 years

insights into long-term physical oceanography as well as secular vertical geodesy

QUESTIONS

Simple concrete benchmarks (at BPR sites) are key and could be carrot for upcoming proposals:

- Should ONC take initiative and install benchmarks if good opportunity arises?
- What is the right way to evaluate projects and opportunities like this?

Overall:

- Am I on the right track?

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THANK YOU!

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