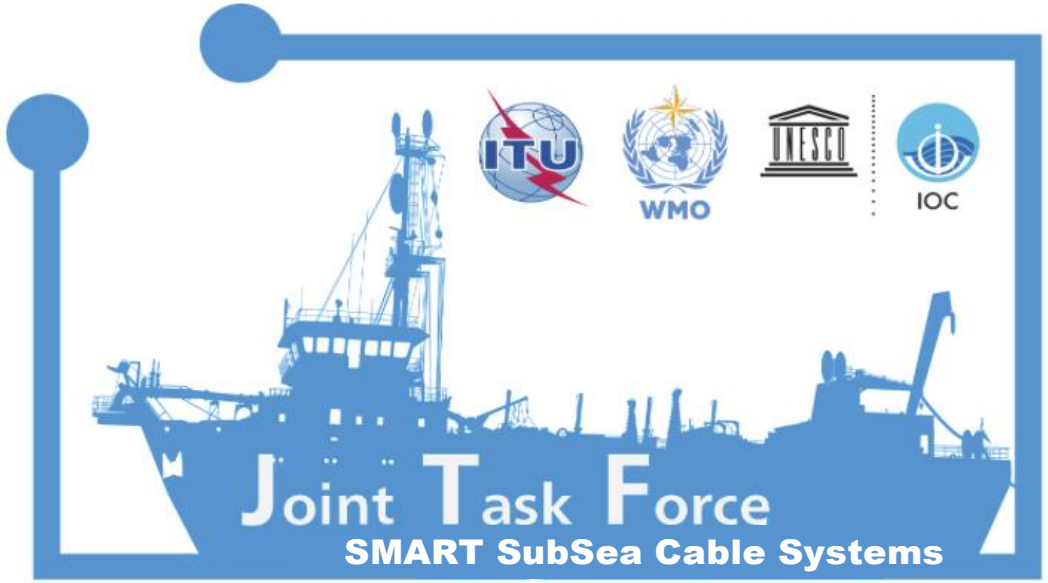
SMART Subsea Cable Systems:

*S*cientific *M*onitoring *A*nd *R*eliable *T*elecommunications for Climate Monitoring and Disaster Mitigation



ITU/WMO/IOC Joint Task Force (JTF)

Bruce Howe
Chair, JTF
University of Hawaii at Manoa

Information and Communications Technology and Disaster Risk Reduction Division
United Nations Economic and Social Commission for Asia and the Pacific
United Nations Centre, Bangkok, Thailand
1 November 2019

Outline

- SMART Overview: who, what, why
- System Technology to draw on (where are we now?)
- Systems under consideration (where are we going?)
- ESCAP and ESBN
- Concluding Remarks

SMART Cable Initiative led by UN ITU-WMO-IOC

Joint Task Force (JTF)

150 Members from 90 organizations

- Raise awareness, educate and publicize, workshops
- Search out the **funds** and potential **investors**
- Collaborate for a general solution that can be tailored to specific deployments
- Educate governments to facilitate permits and **funding**, and to utilize new data
- Link to global initiatives, e.g., UN Decade, GOOS, DOOS, JCOMM, etc
- Facilitate implementation

Endorsed by JCOMM, DBCP, PTWS, POGO

OceanObs19 Community White Paper

Sci + Soc
Sci Comm

Strategy
Rhett Butler

Legal
Kent Bressie

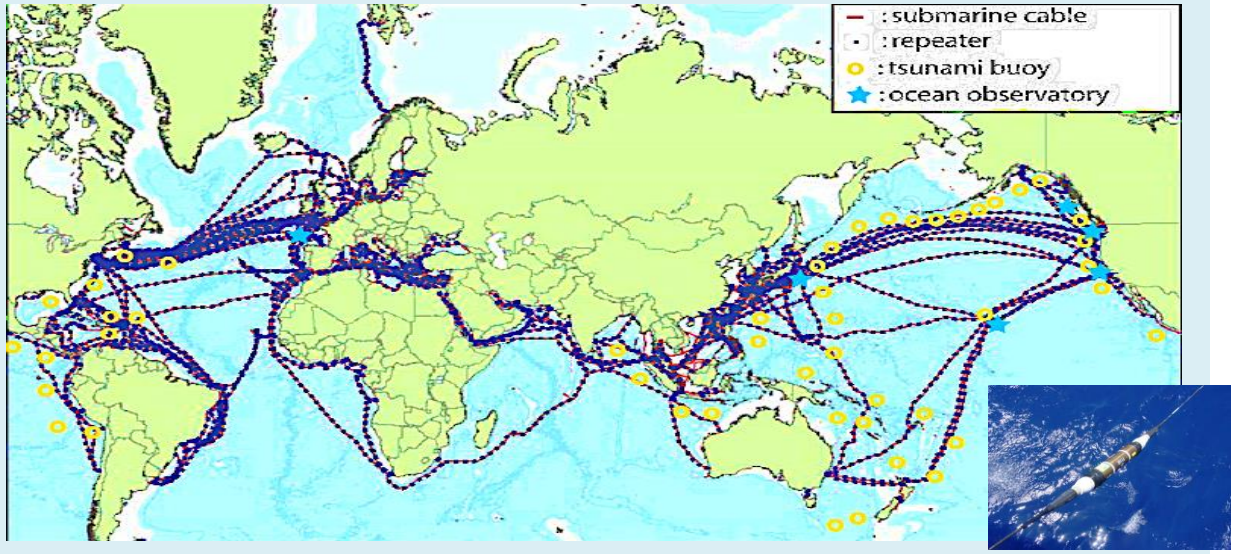
Engineering
Peter Phibbs

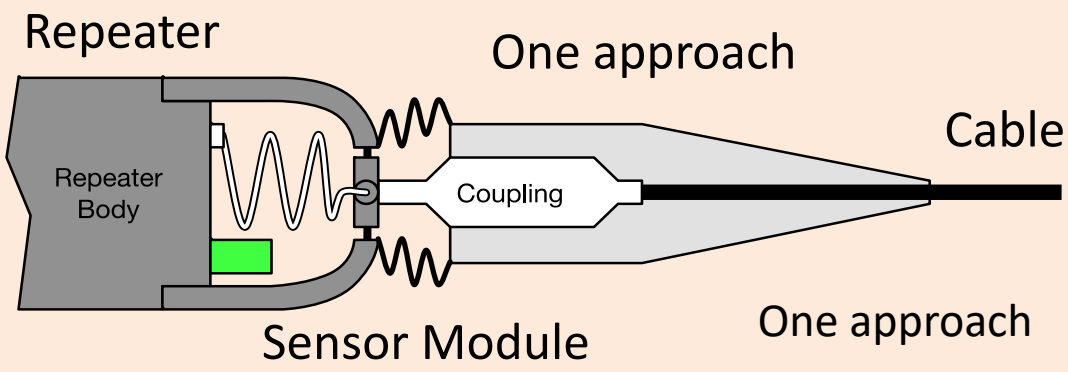
https://www.itu.int/en/ITU-T/climatechange/task-force-sc/Pages/default.aspx

SMART Cables - Basic Concepts

Global Array: Climate, Oceans, Sea Level, Earthquakes, Tsunamis

SMART cables: 1st order addition to Ocean-Earth observing system, with unique contributions that will strengthen and complement satellite and in-situ systems





Install routinely on new cables
Deploy by cable ship, no maintenance

- **Telecom + science, shared infrastructure, $ ↓**
- Sensors in Repeaters, so do not interfere
- Reach: Global, Trans-ocean, 1+ million km
  ~10,000+ repeaters (~100 km)
  10-25 year refresh cycle
- Initial: **bottom pressure, temperature and acceleration**; Later: supplement (fiber sensing…)

https://www.itu.int/en/ITU-T/climatechange/task-force-sc/Pages/default.aspx

John You, Nature, 2010 – Harnessing telecoms cable for science

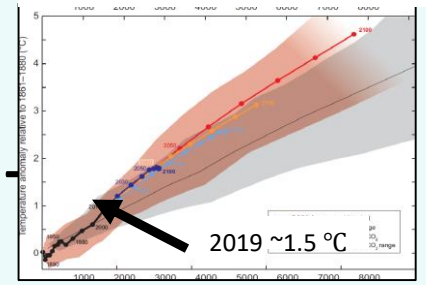
Societal Benefits – Adding Sensors

Climate change – humanity's greatest existential threat

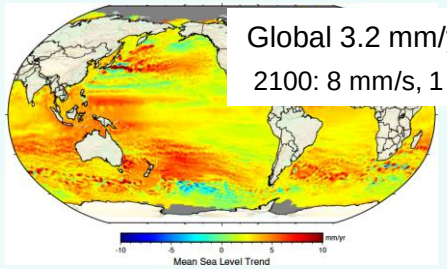
Societal and environmental issues

Impacts are Global, Regional, and Local

Cumulative emissions CO2 vs Temperature since start of industrial revolution
IPCC, WG 1, 2013



SDG 13 Climate – **Climate change** – ocean temperature, circulation – direct impact on societies, short and long term



SDG 14 Ocean – **Sea level rise** – hazard for coasts, island, cities

UNDRR Sendai – **Disaster warning** – tsunami and earthquake monitoring throughout ocean basins and coastal margins

The SMART Cable Opportunity

Better observe the ocean

Flywheel of Climate, Source of Hazards

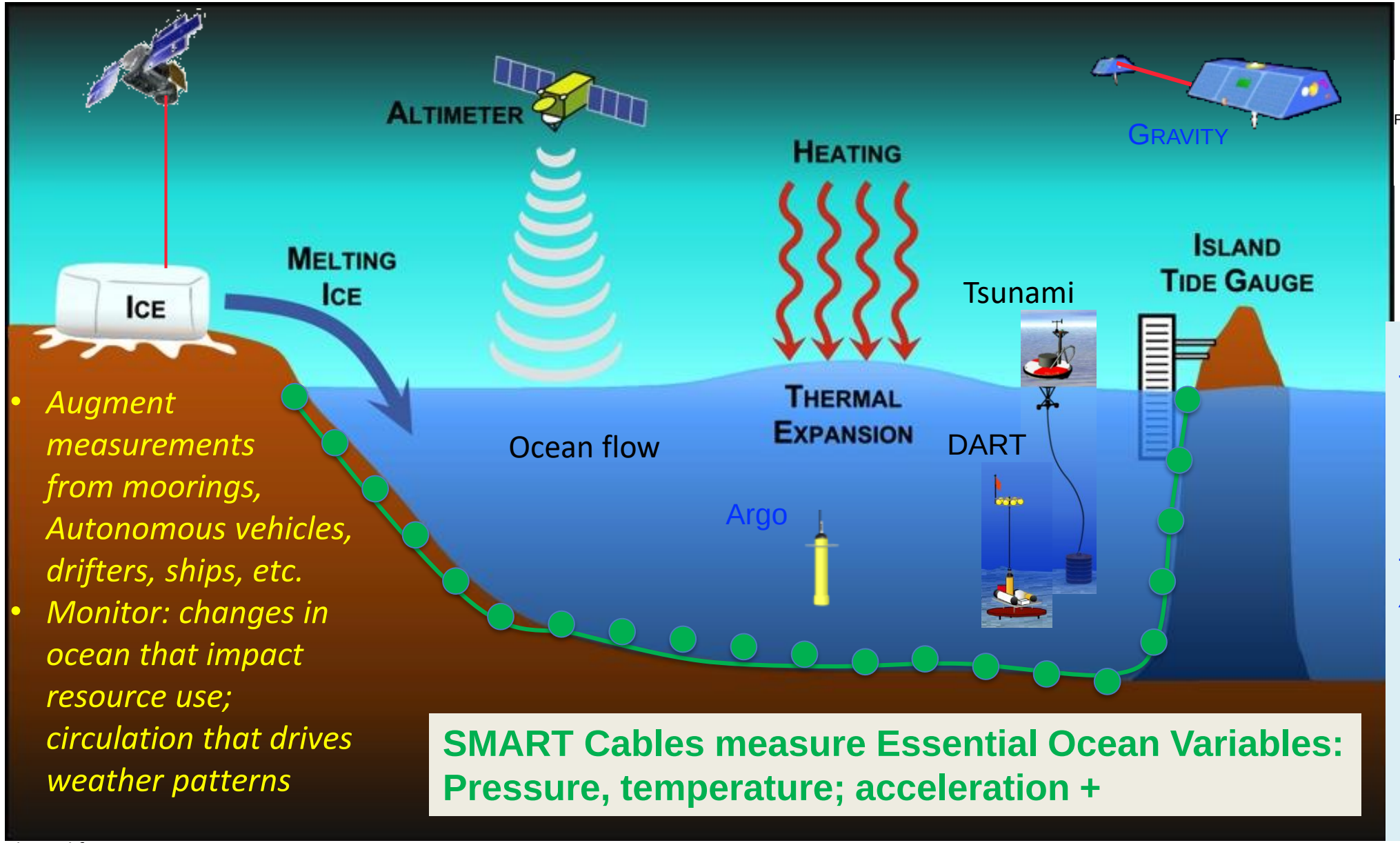
More Sensors

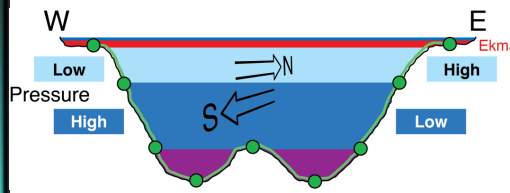
A global network of
ocean floor observation stations

Less Money

Harness 3rd party investment
to save millions in deployment costs

Tools





- *Augment measurements from moorings, Autonomous vehicles, drifters, ships, etc.*
- *Monitor: changes in ocean that impact resource use; circulation that drives weather patterns*

SMART Cables measure Essential Ocean Variables: Pressure, temperature; acceleration +

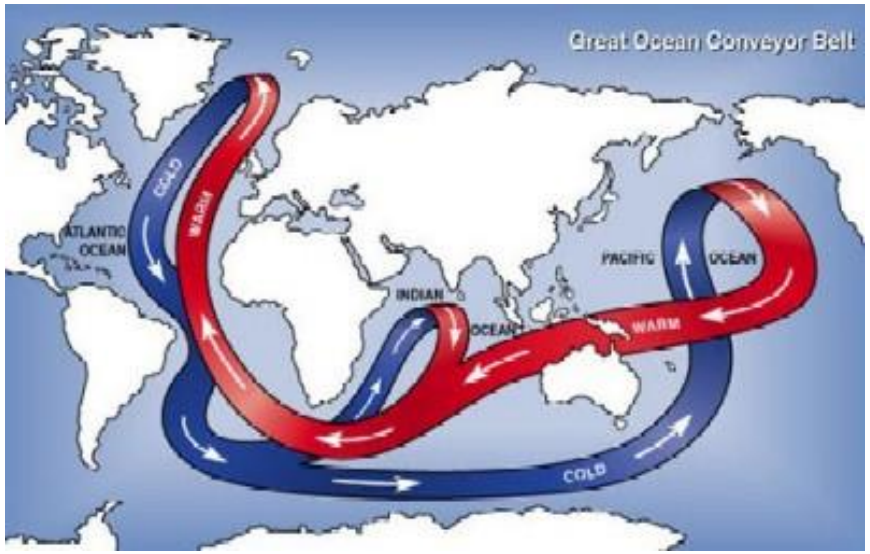
Now:
Few bottom obs

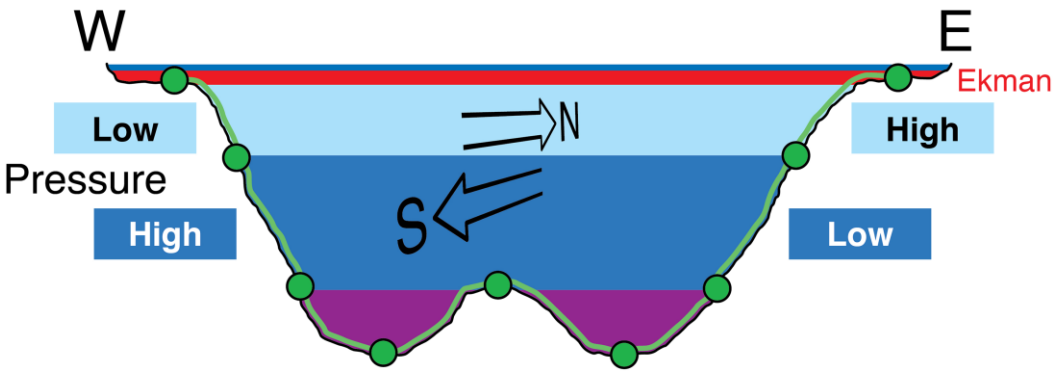
Future:
Add SMART Cables
- Unique
- Augment
- Complement

Adapted from Nerem, 2016

Temp and Pressure (x,y,t) along route

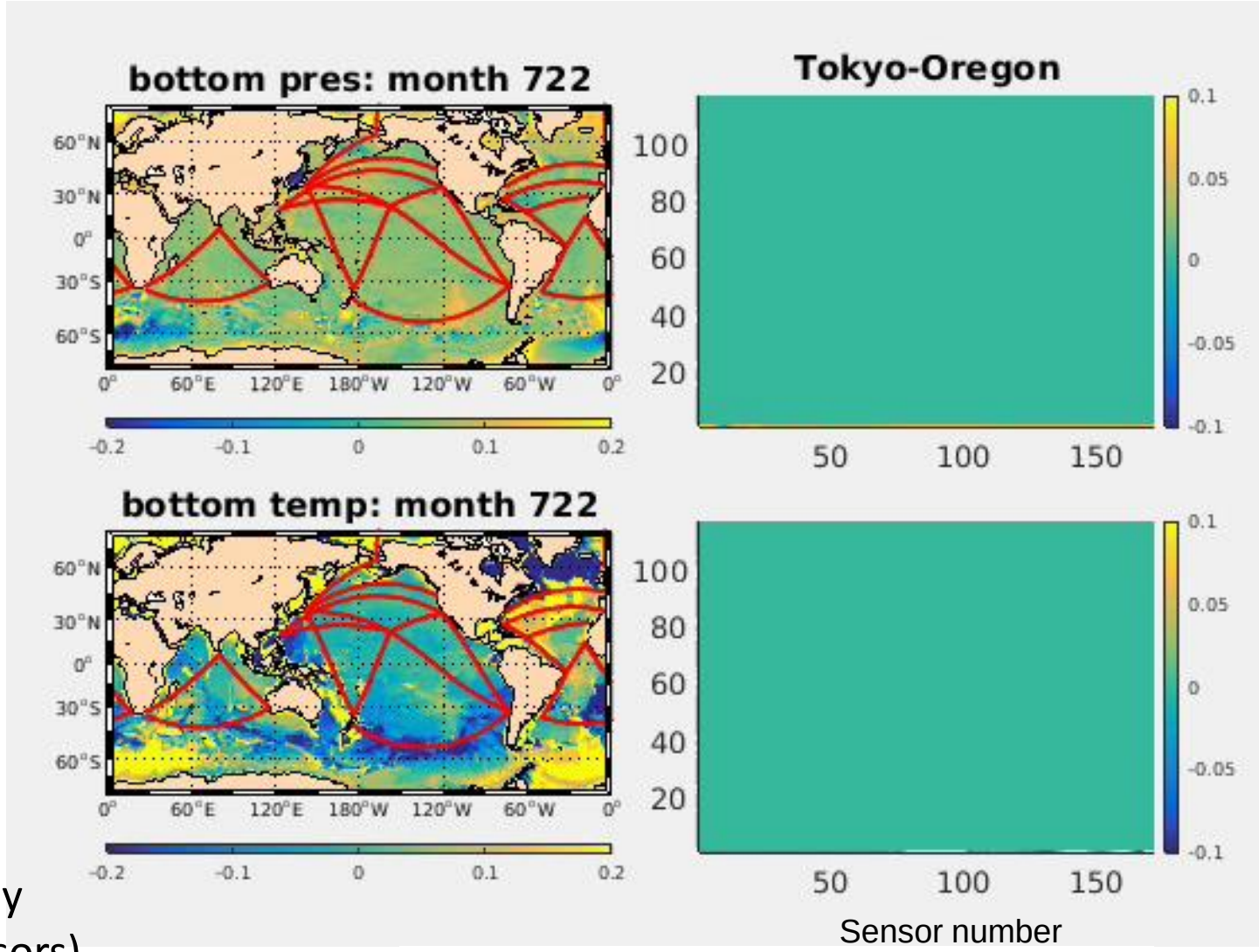
Global meridional overturning circulation – climate





Water flows from high to low pressure, deflected by Earth's rotation (green dots = SMART pressure sensors)

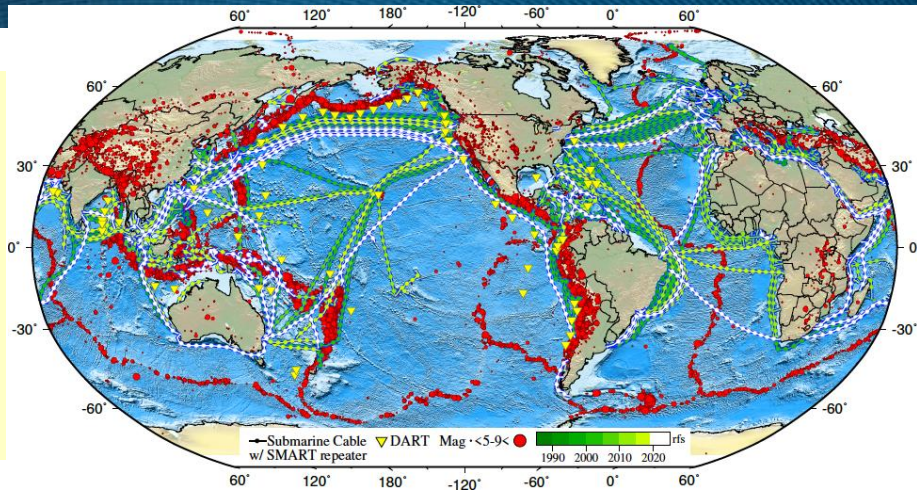
Mission Simulator



Tony Song, JPL/CalTech

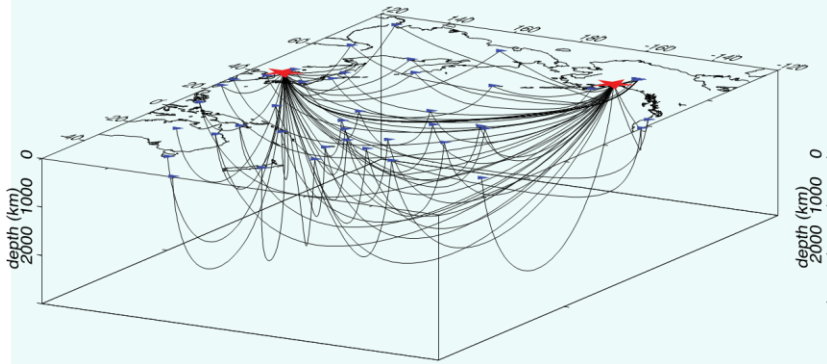
SMART Cables for seismology, tsunami warning

Denser sampler for greater global coverage
➔ reduce earthquake location uncertainties,
➔ accurate earthquake fault rupture
➔ faster, accurate tsunami forecast

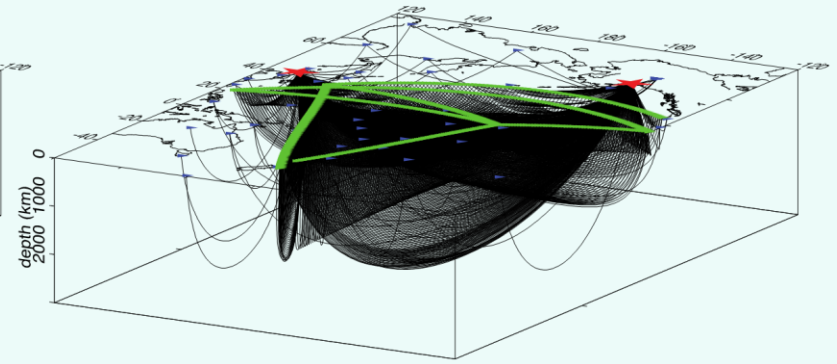


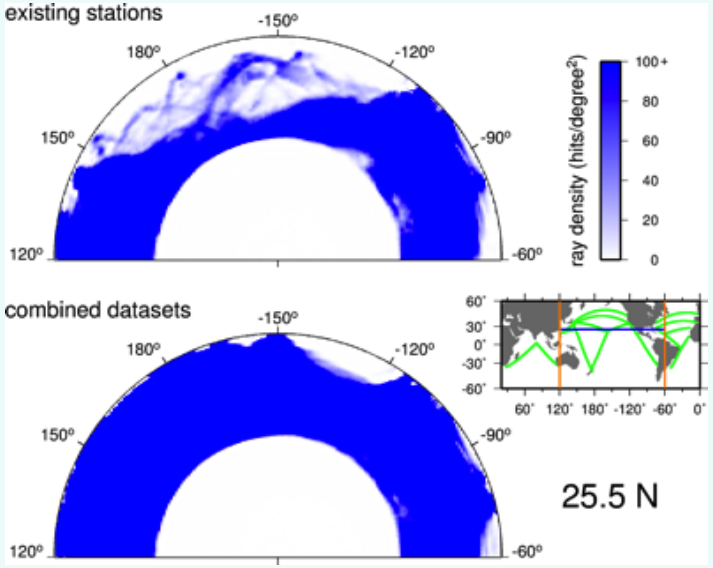
DART buoys sparse, expensive, 11/39 not operating, 2/2019

Current array (with 2 sources) sparsely samples the crust and upper mantle.



Rays to SMART Cable sensors provide improved coverage over large areas.

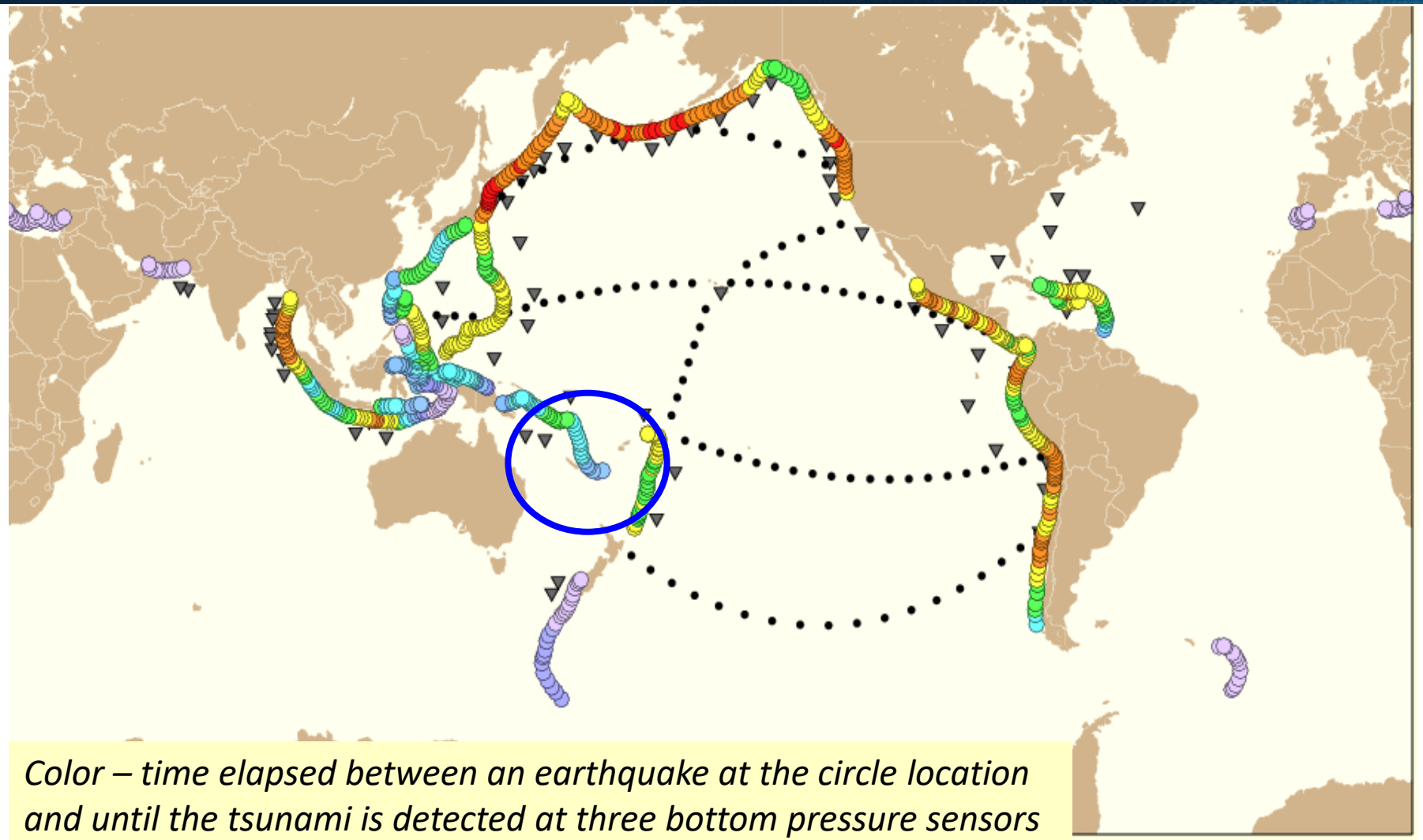




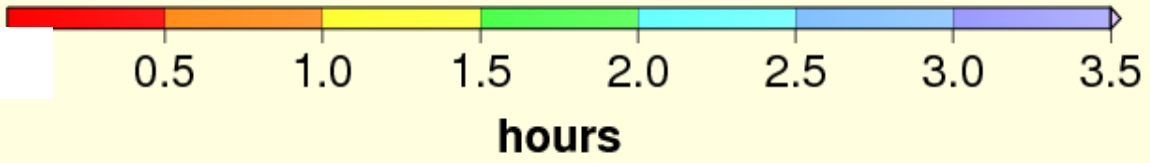
Addtl sampling w/SMART cables in Pacific, => 20 y earthquake sources

N. Ranasinghe, C. Rowe et al., Enhanced global seismic resolution using transoceanic SMART cables, Seismol. Res. Lett., 2017.

Tsunami Detection Time – 3 bottom pressure recorders (2016)



Color – time elapsed between an earthquake at the circle location and until the tsunami is detected at three bottom pressure sensors



N. Becker, PTWC

Add SMART
500 km spacing

Circles:
Simulated Earthquakes

Time to issue warning reduced from 2.1 to 1.6 hours – ***25%***
Important!

Better with 50 or 100 km spacing

OCEAN OBS'19

AN OCEAN OF OPPORTUNITY
September 16-20, 2019

Global decadal meeting to improve response to scientific and societal needs of a fit-for-purpose integrated ocean observing system, for better understanding the environment of the Earth, monitoring climate, and informing adaptation strategies as well as the sustainable use of ocean resources.

Special Session on Innovation in ocean observing platforms and infrastructure - Recommendation

Transition telecom+sensing SMART subsea cable systems from present pilots to trans-ocean and global implementation, to support climate, ocean circulation, sea level monitoring, and tsunami and earthquake early warning and disaster risk reduction.

Comments

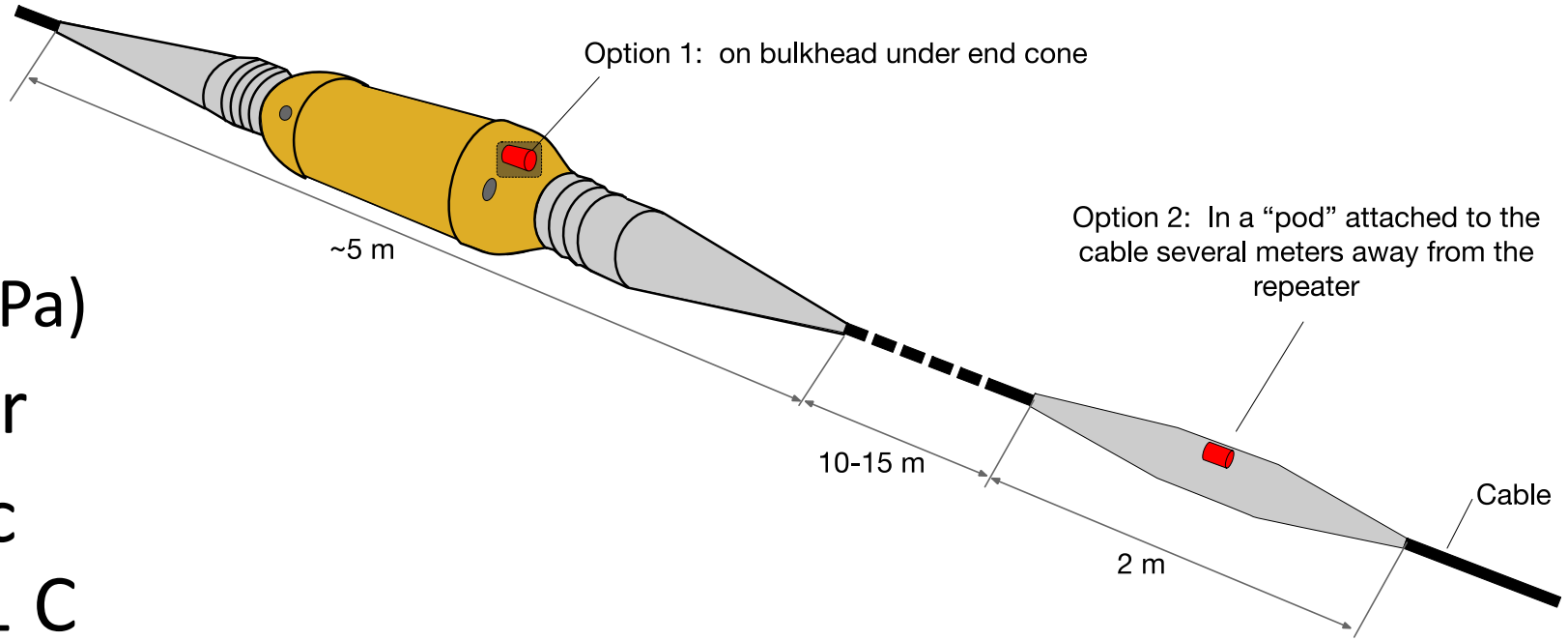
- Funding for development and initial systems present challenge – governments, MLDBs – others? – **but successes now** …!
- First modest projects just starting (next slides)
- All suppliers – incremental engineering, just time and funds
- Need development of submarine qualified SMART repeater – need “off-the-shelf” – from wet demos and pilots
- Commercial challenges – risk(time, cost, reliability)
- Legal/permitting/security – all tractable but concerns
- **Approach – start with countries that need SMART capability – tsunami, earthquake, sea level, etc. Engaged governments. Access to Development Bank funds**.
- ***5 year – pilots operating – Decade in all ocean basins***

Sensors and Mounting - KISS

Sensors

- Possible sensors
- Depth Sensor
  - 0-7,000 m H2O (70 MPa)
- Triaxial Accelerometer
- Digital Oceanographic Thermometer – 0.001 C

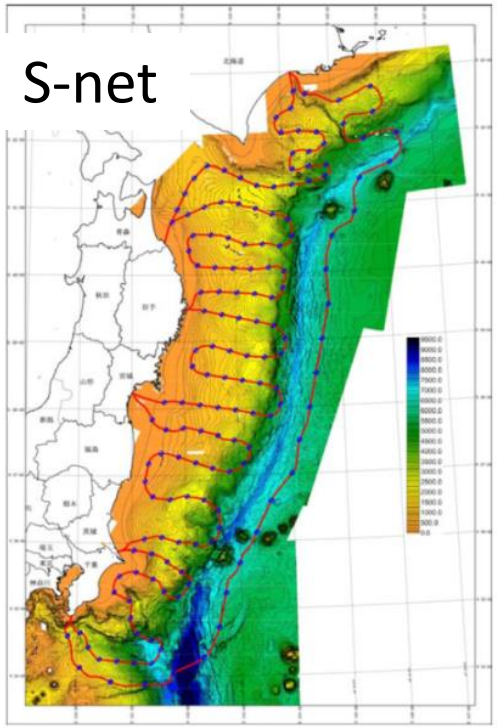
Sensor Mounting / Attachment

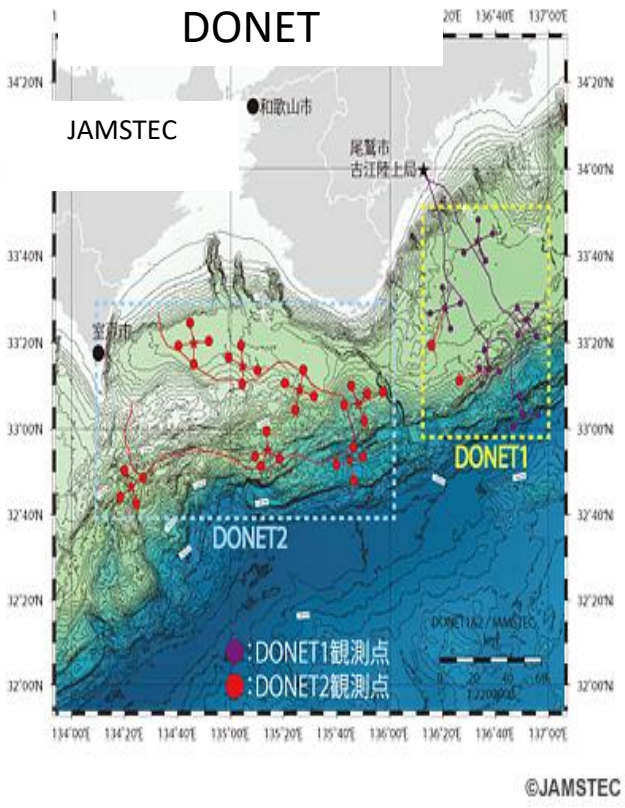


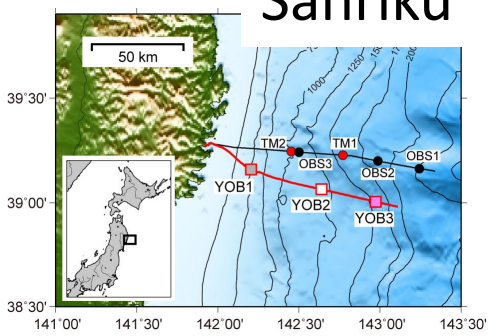
- Two approaches: both should be tested

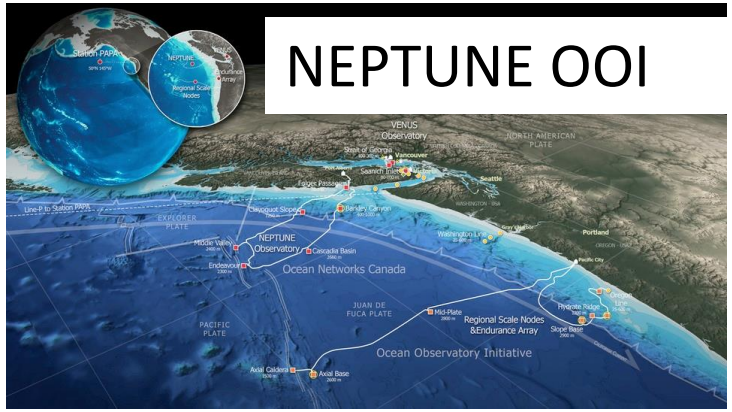
Existing tech components to draw on

- Dedicated cable systems
  - Existing and proven:
    - S-Net, Sanriku
    - DONET, perhaps NEPTUNE, OOI-RCA (high power, ROV)
    - ***N-Net – new***
  - Sanriku lower cost, close to SMART
- Or use Branch unit on commercial cable – wet demo





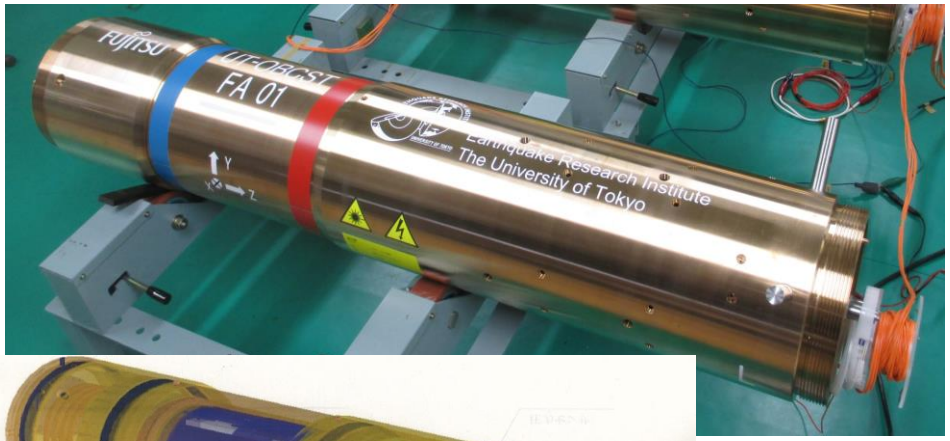


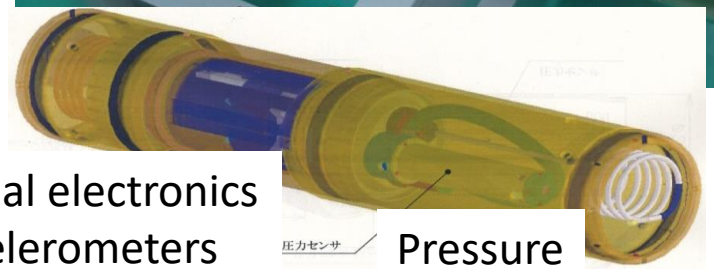


Wet Demo - Sanriku as example

- Wet Demo – step to full SMART
- External, flooded section
  - +Sensor electronics
  - Pressure
  - +Temperature, sensors along cable

Compact
Ethernet
~commercial

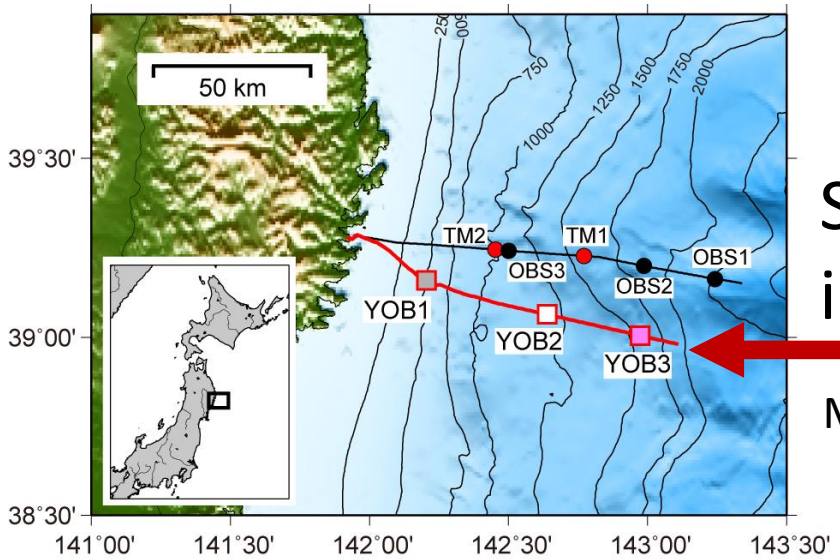




Internal electronics
+ accelerometers

Pressure

Fujitsu



Sanriku, 2nd installed 2015

M. Shinohara, ERI, UTokyo

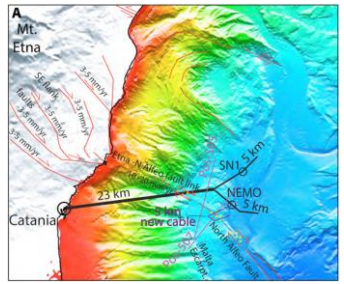
Add Temperature sensors

TE Subcom

PROGRESS – CABLE SYSTEMS (2011-2019)

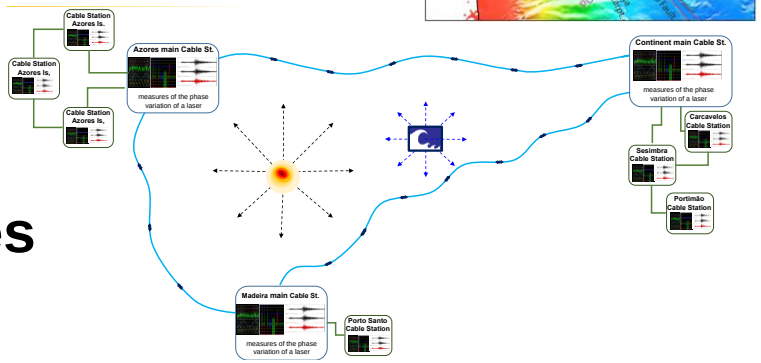
INGV–Italy–Sicily: InSea Project – wet demo

- Funded June 2019,
- Mechanical, Science
- SMART prototype step



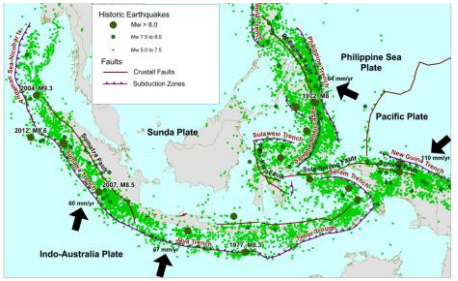
CAM2 – Portugual-Azores-Maderia Ring

- Proposed 2018
- Explcitly SMART + optical fiber sensing + observatories



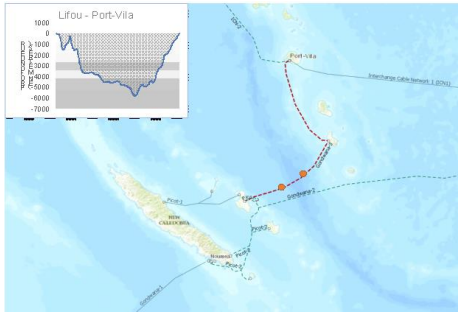
Indonesia (2019+)

- Tsunami Warning, ocean, climate, ITF
- Cable-based technology, considering SMART phased in next 10-20 years
- Sustainable, reliable (minimal vandalism), good coverage



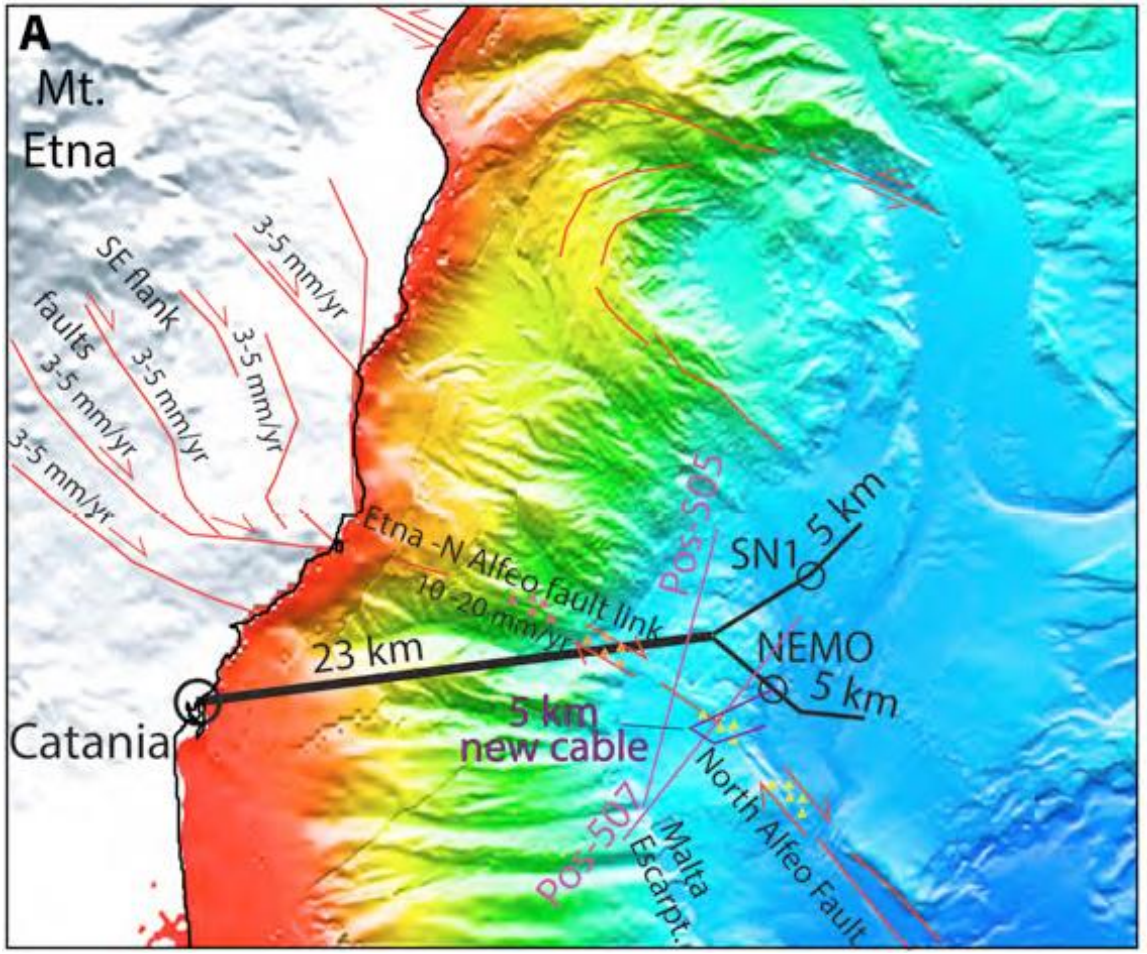
New Caledonia–Vanuatu SMART Cable Gondwana-3

- 70% Funded, France, September 2019
- Sea Level, Disaster warning
- 300 km 2 SMART repeaters



INGV – Italy – Sicily

- InSea Project
- **Funded 6/2019**
- **32 months, € 2.4M**
- **Wet demo**
  - Demo mechanical, science
  - Test system on spur
  - Attached to observatory
  - Possibly use recovered repeater housings/cable, SMART prototype



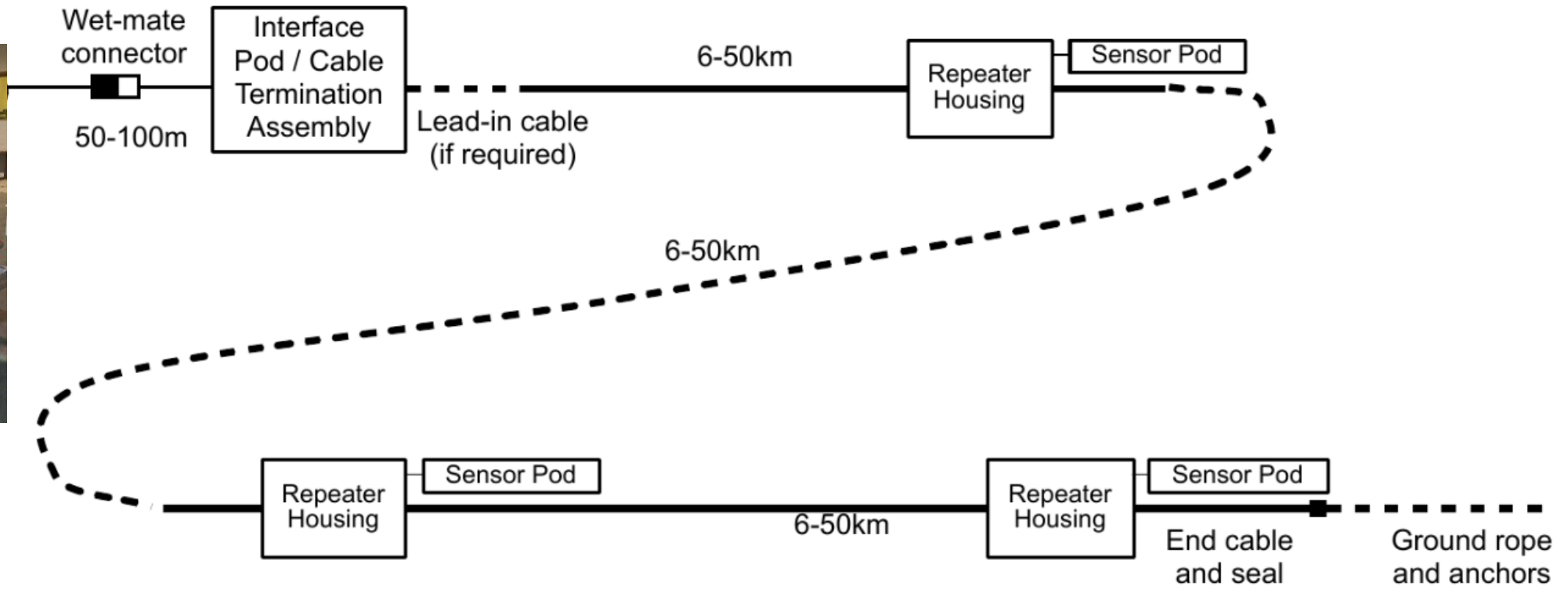
Ionian SMART cable pilot project (InSea)

Initiatives in Supporting consolidation and enhancement of EMSO infrastructure & related Activities

- SMART Cable System: Wet Demonstrator Project – JTF White paper 2016
- Functional requirements of “green” submarine cable systems - 2015

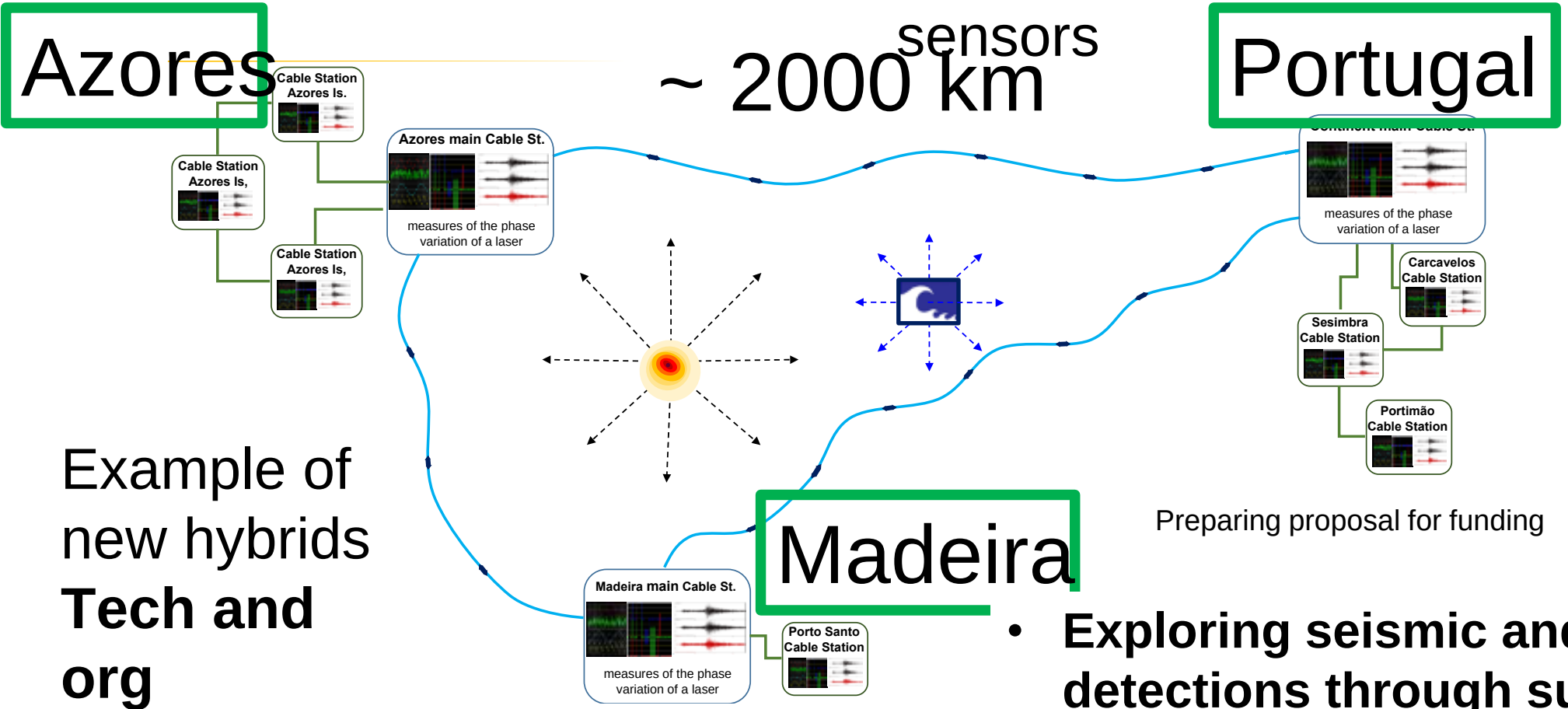
JB Catania @2000 m bsl

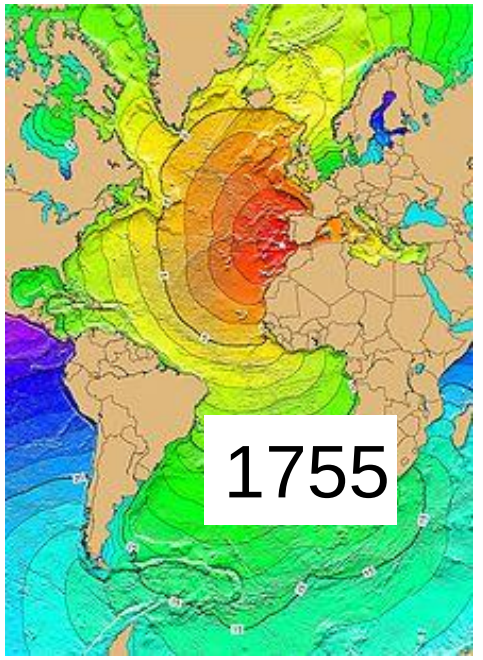
300 VDC 500 W
2 fibers
1310/1490 nm



Example - CAM: Portugal – Azores – Madeira

Fiber strain (backscatter, interferometer), sensors in repeaters, other wet sensors





Preparing proposal for funding

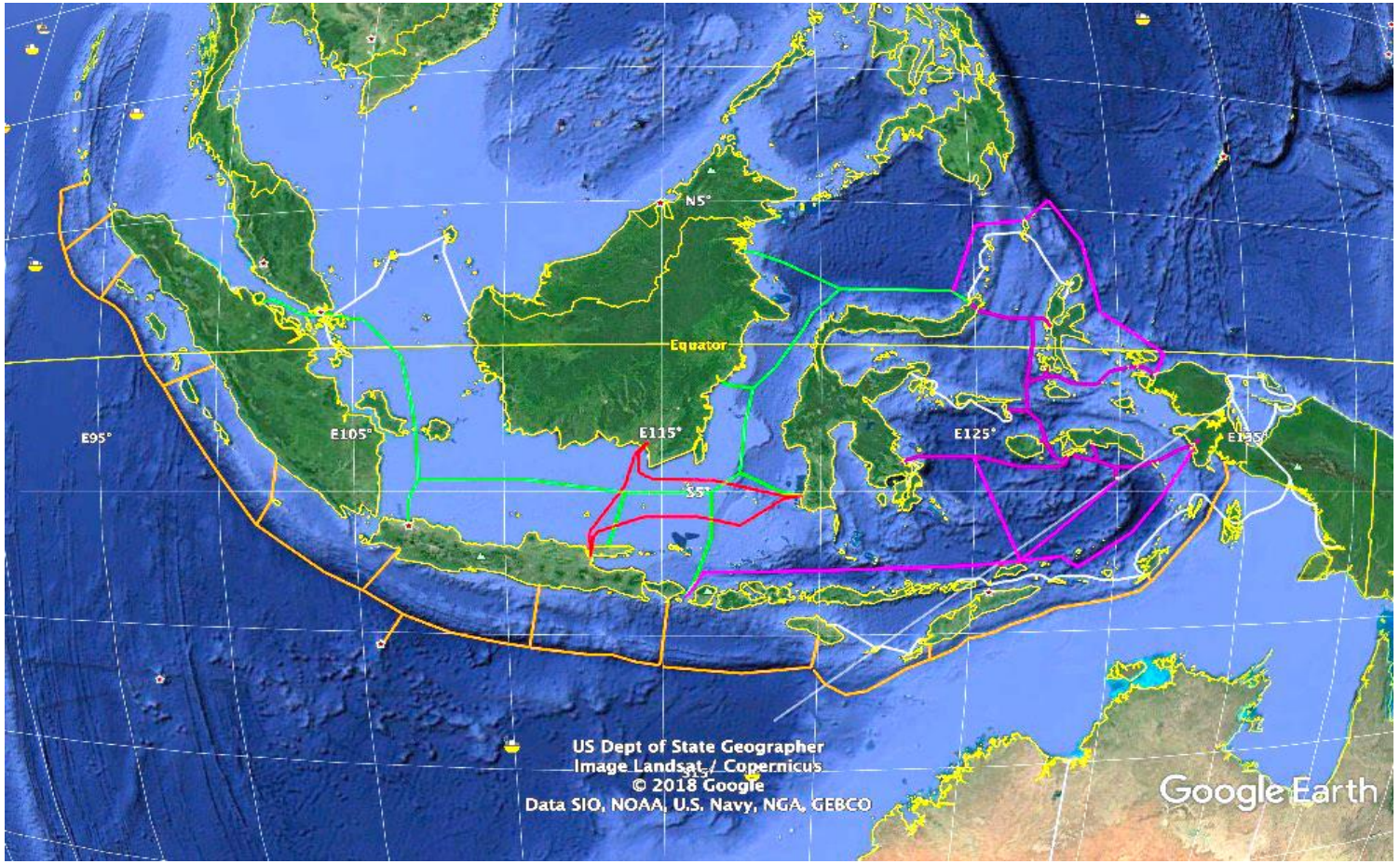
Example of new hybrids **Tech and org**

ANACOM
Government telecom regulatory

- **Exploring seismic and other kinds of detections through submarine cables in CAM Zone**
- **Smart, Green & Blue CAM Ring**
- **ANACOM, CIVISA, FCT, IPMA, IT, IVAR**

Indonesia ”CBT” – SMART

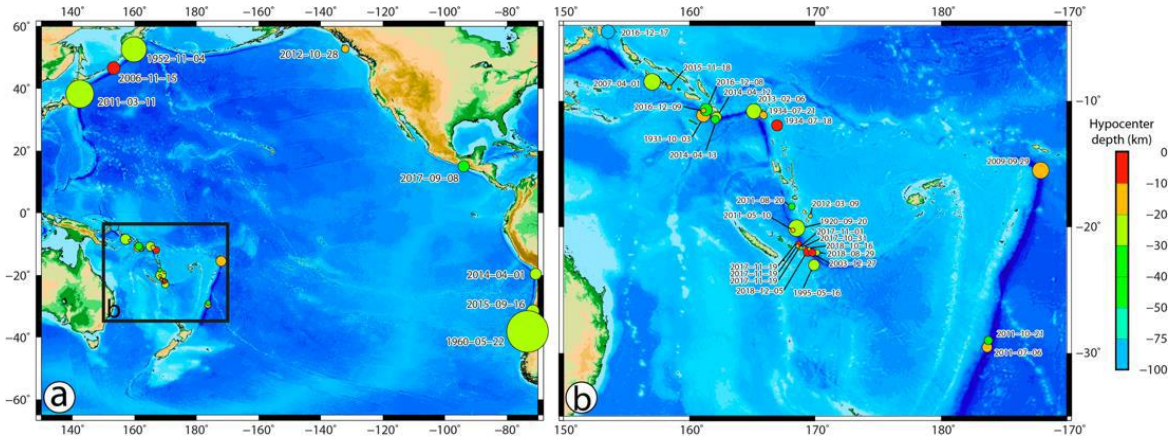
CBT
Cable Based Tsunami Warning System



Possible SMART cable routes for tsunami early warning. New cables (south) essential because of trenches and earthquake risk. On north side, a combination of new cable routes (3 bright purple ones to east), and existing cable routes shown (example of possible routes, include Palapa Ring cables + 3 other cable systems.

Gondwana-3, New Caledonia–Vanuatu

- Perfect pilot:
  - Cooperating countries want/need it
  - Both early warning/science + telecom
  - Backup for international connectivity
  - Right scale – 2 repeaters, 300 km
  - Right cost – modest
  - Non-traditional funding sources
  - Includes SMART repeater development – enables future projects
- Funding:
  - OPT
    - Proposal to French government mid-2019
      - Funded ~$4M (SMART part); cost share? Public-Private Partnership?
    - OPT funds $1M
  - Vanuatu: ?request from ADB High-Level Technology Fund (~$5M); other?
  - Need $0-5M – French, ADB, other…?
  - Expect modest telecom profit (see OPT)



Earthquakes that triggered tsunamis in New Caledonia.
Transoceanic tsunamis and regional scale