SMART Subsea Cables

Sensing the Pulse of the Planet

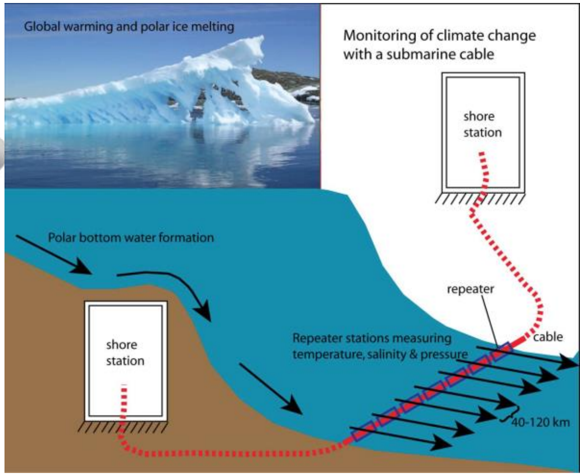
***S**cience **M**onitoring **A**nd **R**eliable **T**elecommunications*

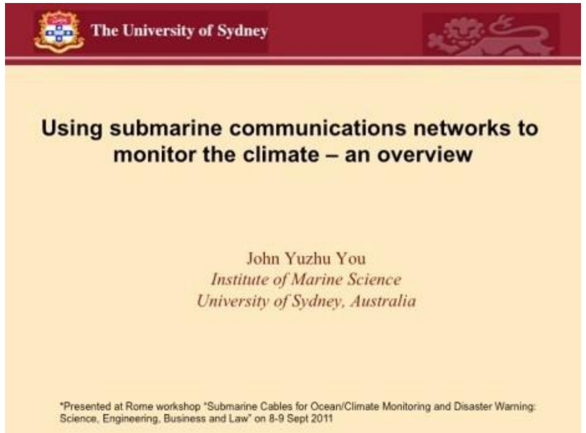
Bruce Howe

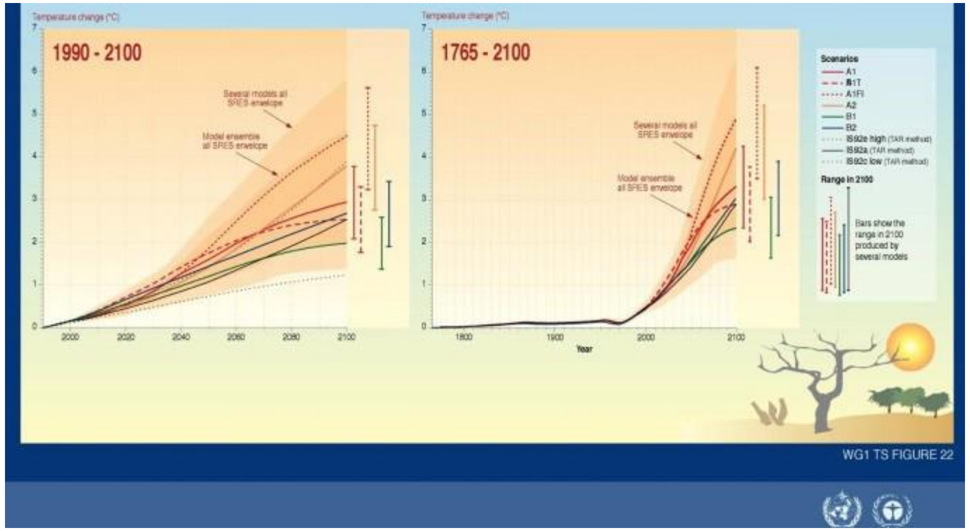
ITU/WMO/IOC Joint Task Force
and
University of Hawaii at Manoa

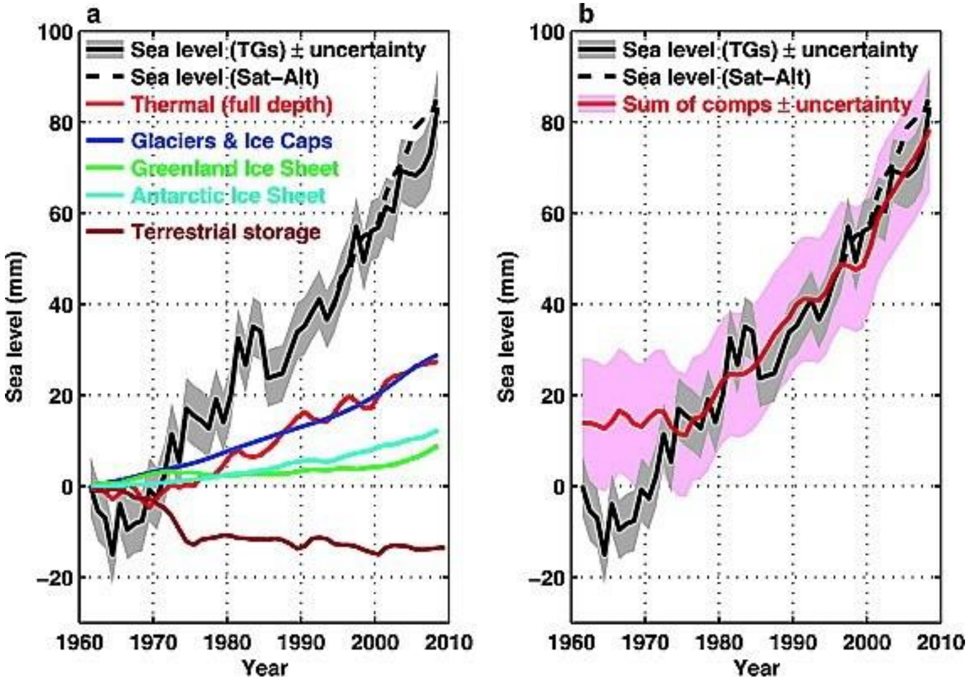
JTF Workshop: SMART Cable Systems: Science, Demonstration, and Funding
University of Bretagne and IFREMER
13 November 2017
Brest, France

How did this begin?









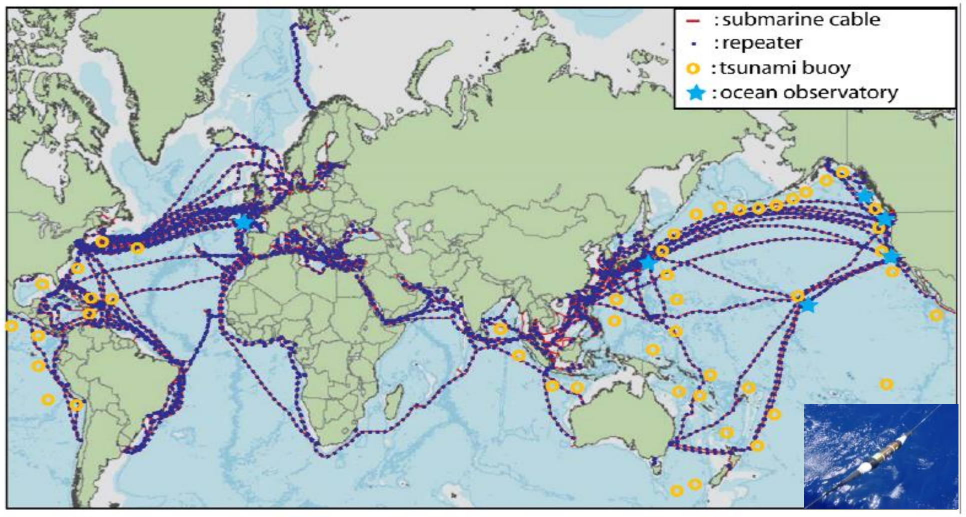
John You
Nature Opinion 2010
Harnessing telecoms
cables for science

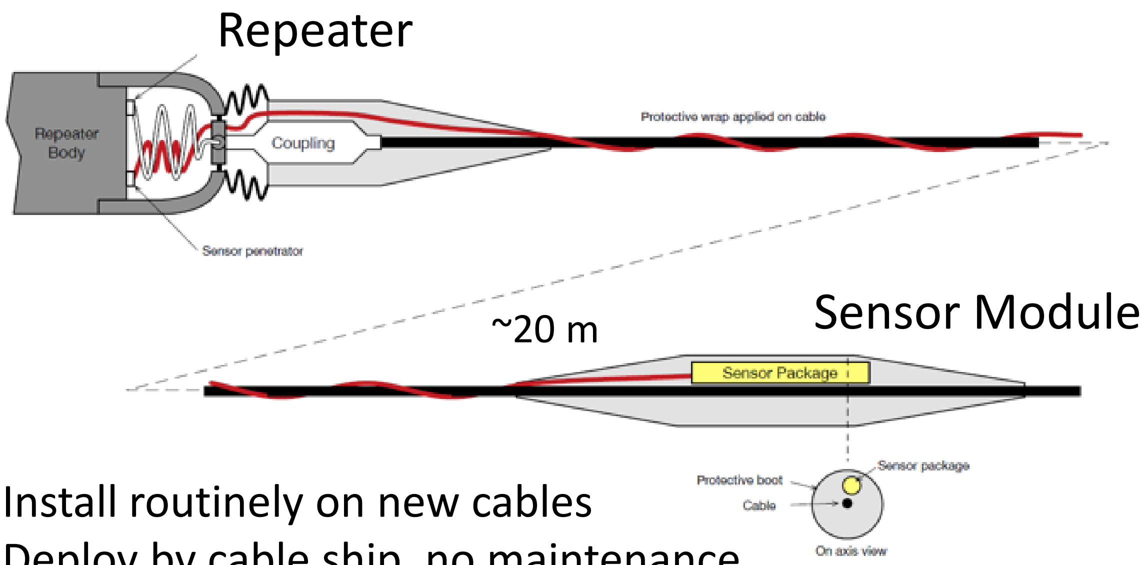
SMART Cables - The basic idea

Climate, Oceans

Earthquakes, Tsunamis – Global Array

SMART cables: first order addition to the 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
- Cable repeaters host sensors
- Potential: global spanning, trans-ocean, 1 Gm, ~10,000 repeaters (~100 km) 10-20 year refresh cycle
- Initially: **bottom pressure, temperature and acceleration**; supplement later

John You, Nature, 2010 – *Harnessing telecoms cables for science*

Societal benefits

Adding sensors for climate and disaster monitoring

Societal and environmental issues:

- Climate change – ocean temperature and circulation – direct impact on societies, short and long term
- Sea level rise – hazard for coastal states and cities
- Disaster warning – tsunami, storm surge, and earthquake monitoring throughout ocean basins and coastal margins

SMART Cables and UN

- Toward a much denser global array coverage – ocean and climate, earthquakes and tsunamis

The societal need is given, in a general sense, in:

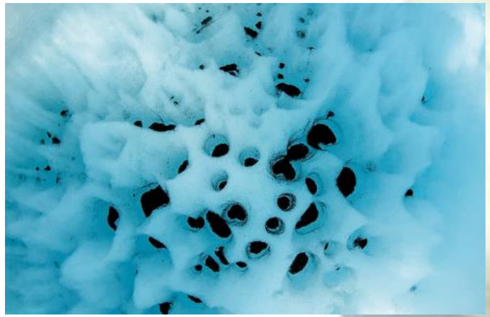
- Third UN World Conference on Disaster Risk Reduction: Sendai Framework 2015 – 2030, March 2015
- UN 2030 Agenda for Sustainable Development – January 2016
  - Goal 13. Take urgent action to combat climate change and its impacts
  - Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Paris Climate Agreement, November 2016

Known Unknowns?

The Great Greenland Meltdown

As algae, detritus, and meltwater darken Greenland's ice, it is shrinking ever faster

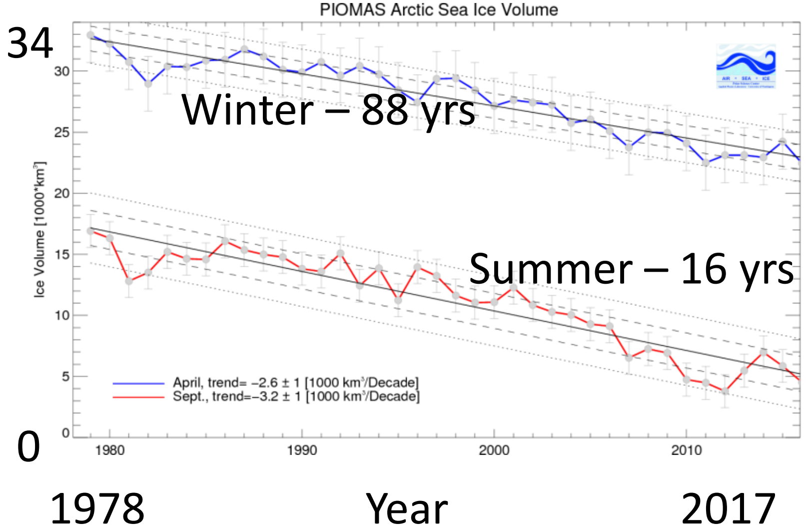
E. Kintisch, Science, 23 February 2017



1. Rounded crystals
2. Colored snow
3. Dirty ice
4. Cryoconite holes
5. Subglacial water

➔Sea Level

Arctic Sea Ice Volume – 1000*km3



PIOMAS APL-UW

Antarctica too – on all edges and interior

Nansen Ice Shelf

Kingslake, Nature, 2017

Wong Sang Lee/Korea Polar Research Institute

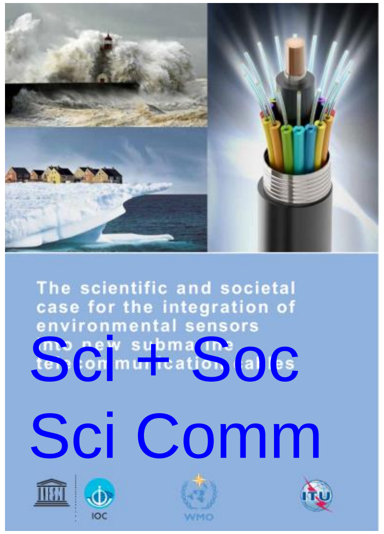
SMART Cable Initiative led by UN ITU-WMO-IOC

Joint Task Force (JTF)

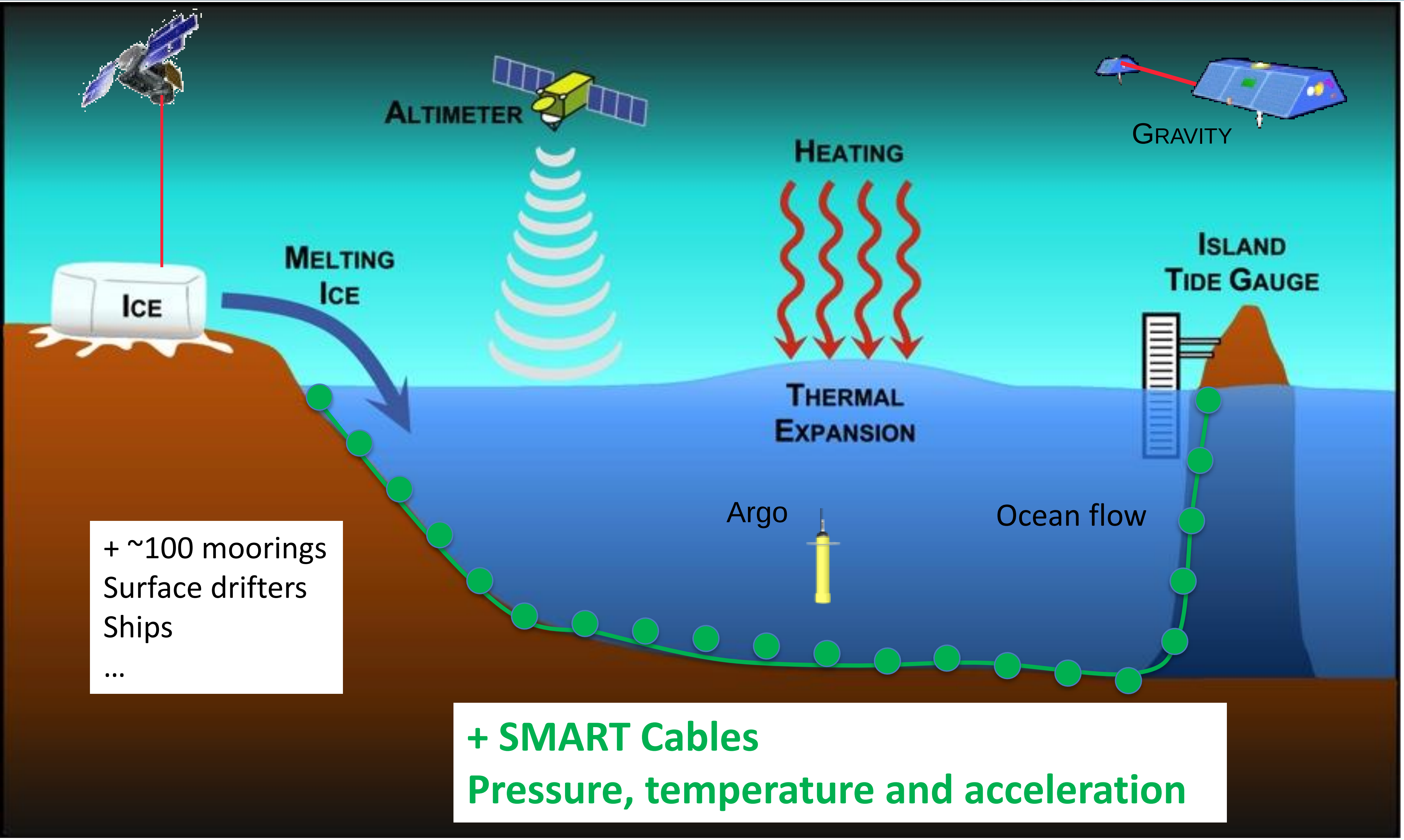
120 Members from 80 organizations

- Raise awareness, educate and publicize, workshops
- Search out the **funds** and potential **investors**
- Collaborate for an universal solution, but tailored to specific deployments
- Educate governments to facilitate permits and **funding**, and to utilize new data
- Link to global initiatives, e.g., GOOS, DOOS, JCOMM and other international agencies

- Phased (per FOO):
  - *Concept*
  - Wet demo
  - **Pilot**
  - Implementation



Measuring Sea Level and Ocean Circulation

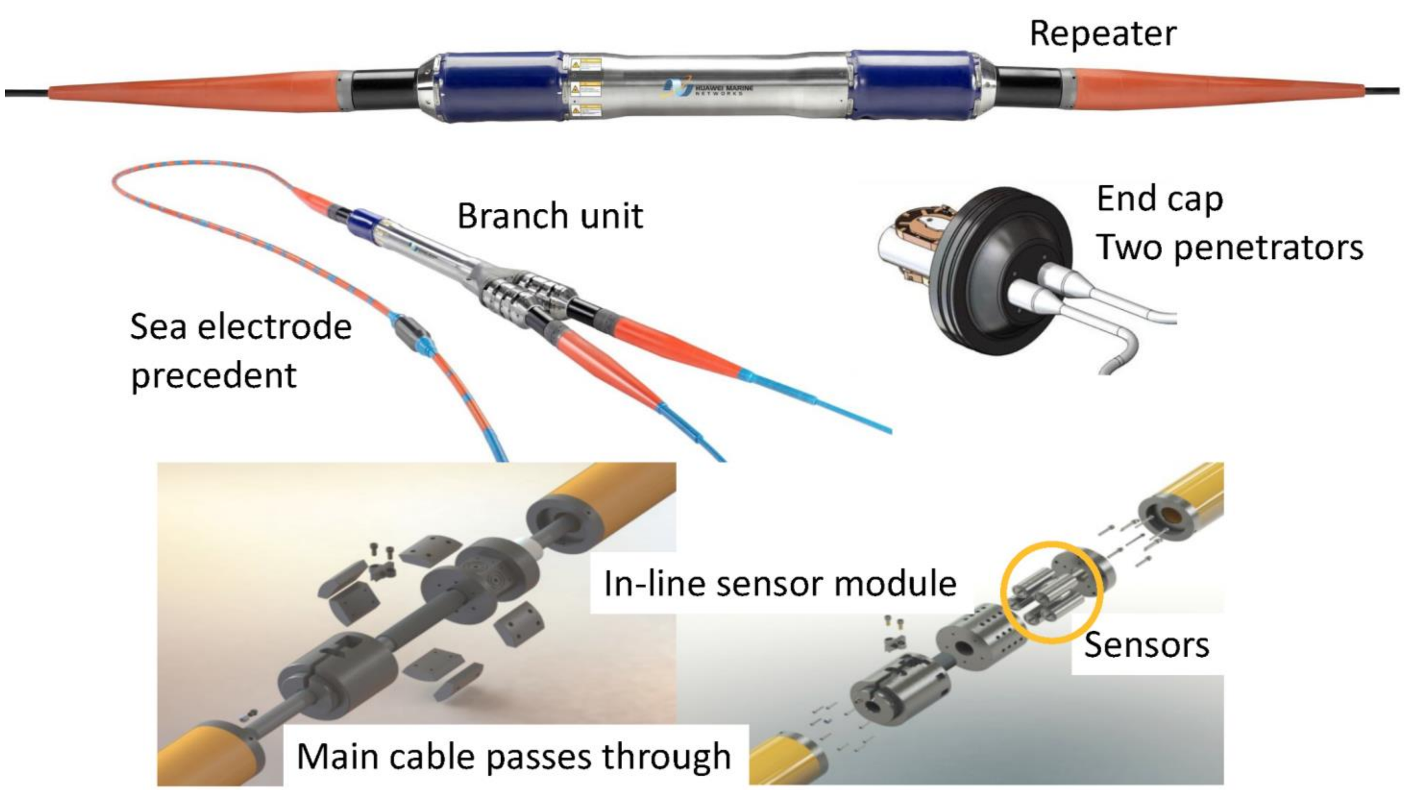


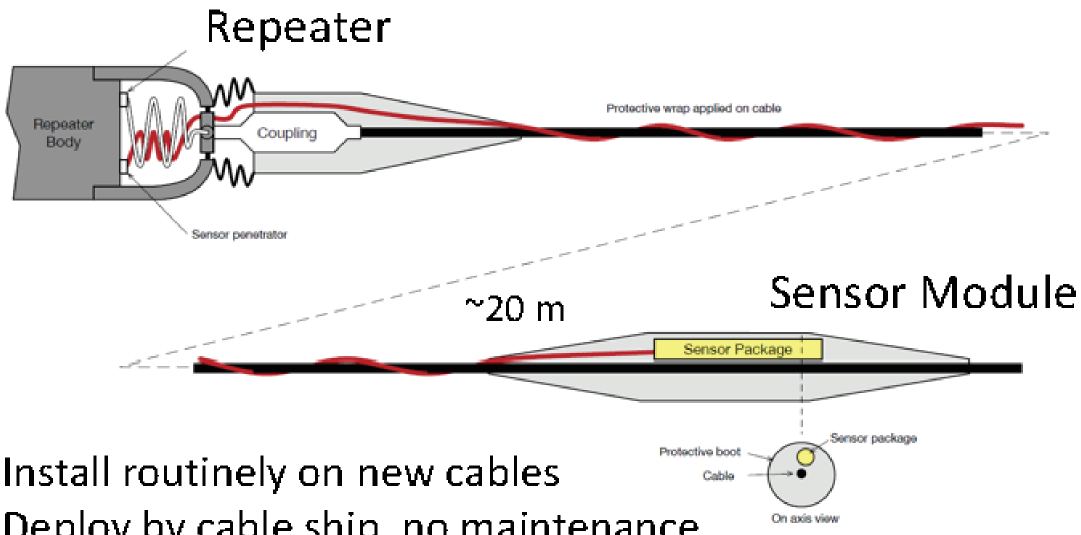
Now, few bottom obs

Add SMART cables

Adapted from Nerem, 2016

The Hardware – one approach





Install routinely on new cables
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Pressure

- Precision, short time, excellent
- Absolute
  - months – drift –cm's/y
  - New development –

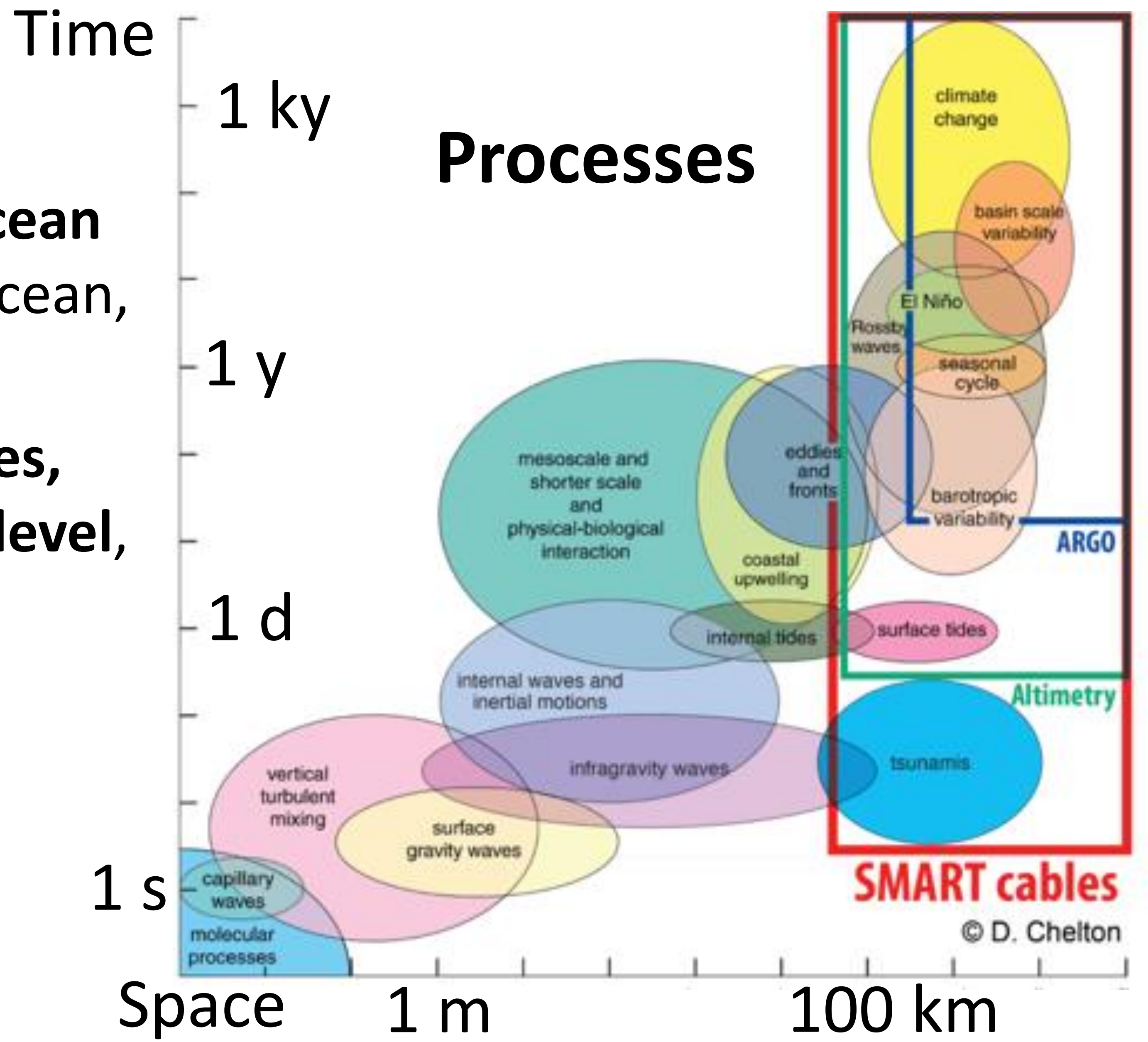
More later in workshop

- *in situ* offset claim < 1 cm p-p
- Switches external to internal p
- Testing in progress, ~1-2 mm/5 months (Wilcock, UW)
- Commercialized

SMART cables in the ocean observing system

- **Initial sensors:**
- **Temperature: variability of deep-ocean temperatures**, track heat through ocean, along boundaries
- **Bottom Pressure:** variability of **waves, tides, barotropic currents**, and **sea level, constrain tsunami amplitude**
- **Acceleration:** improve **earthquake parameters,** solid earth

Report on two NASA workshops



Observing System Simulation Experiments

GFZ Helmholtz Centre Potsdam

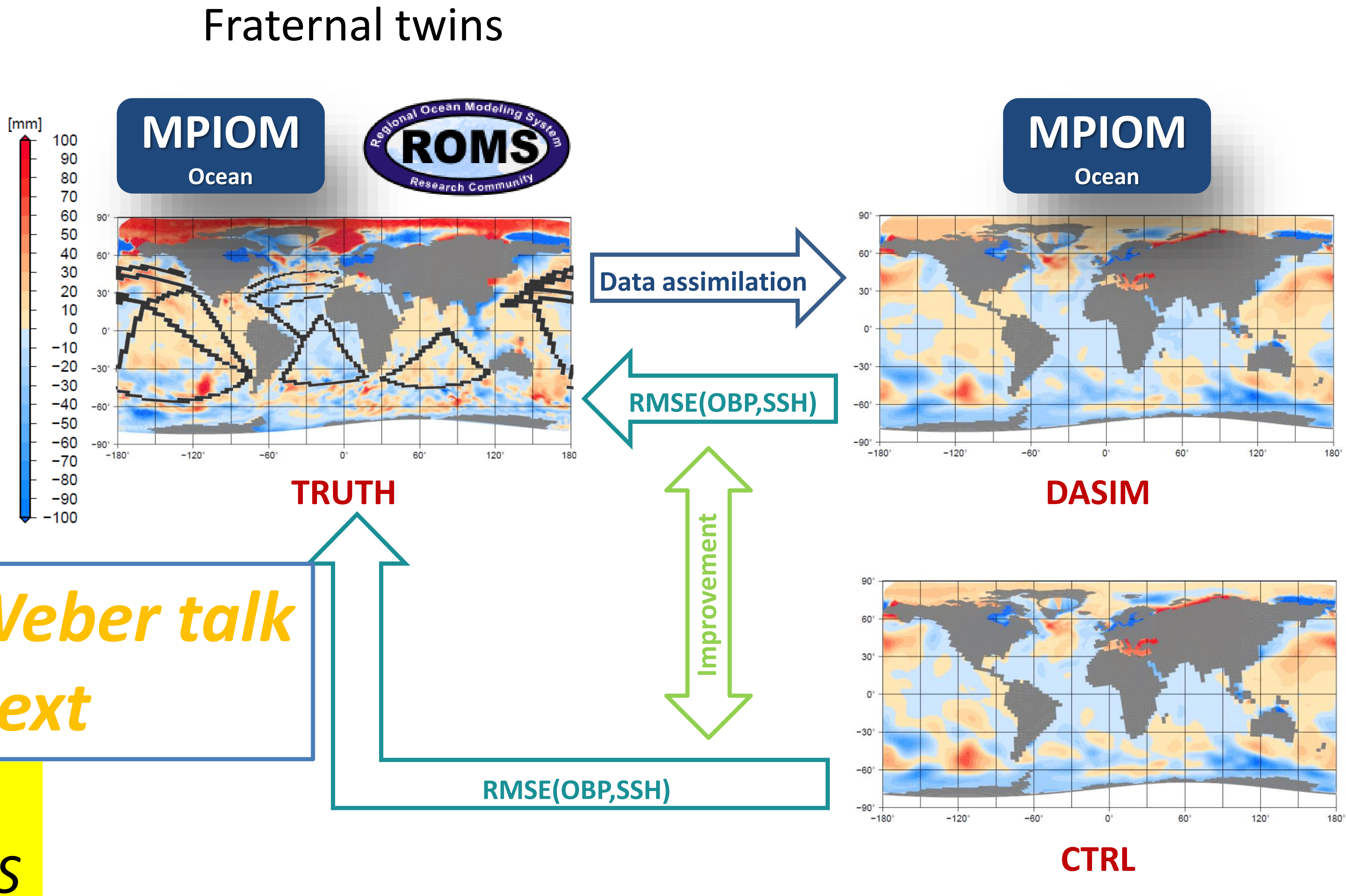
Tobias Weber et al.

OSSEs

Tony Song

Mission Simulator

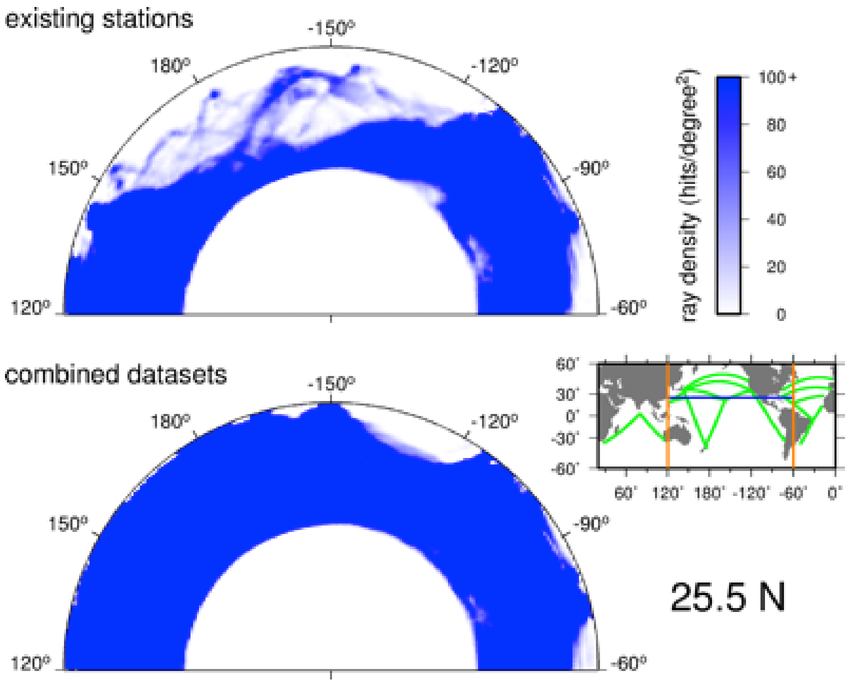
Weber talk next



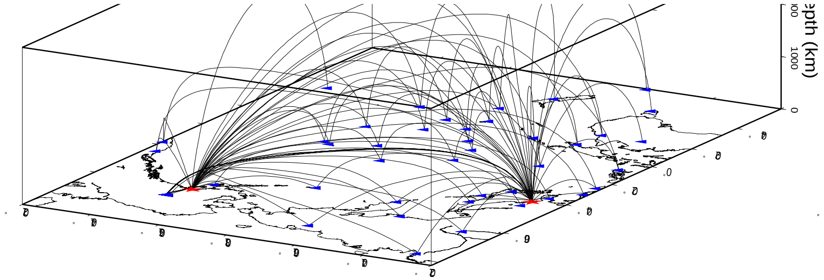
Continuing …
Weber, Submitted, J.AMES

SMART Cables for seismology

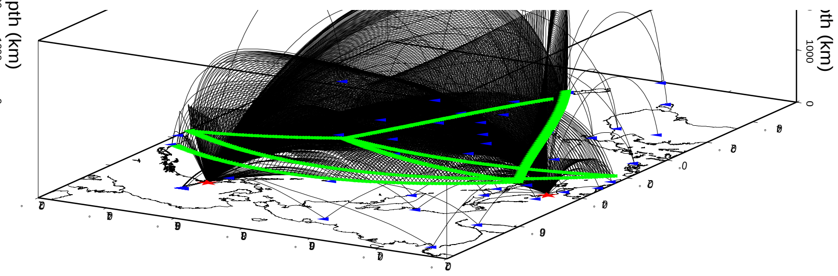
- Better sampling with SMART cables
- Forward ray modeling - significant improvement in crust and upper mantle sampling beneath the oceans with SMART cable sensors.
- **Increased – global – coverage** -> reduced location uncertainties, better magnitude calculations, may provide reduced detection thresholds.



Additional sampling with SMART cables in Pacific, 20 y earthquake sources



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

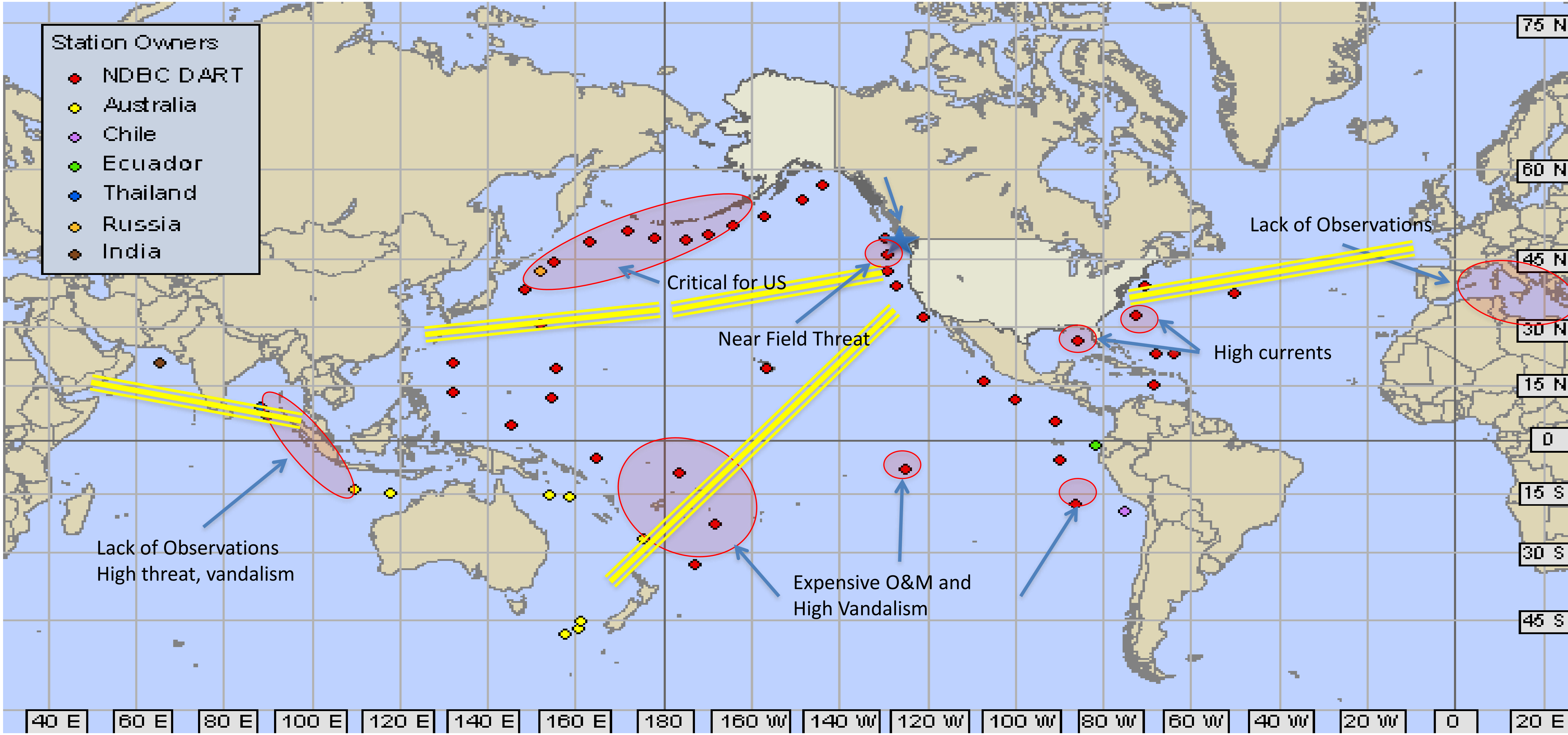


Rays to SMART Cable sensors provide improved coverage over large areas.

Accepted 11/2017

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

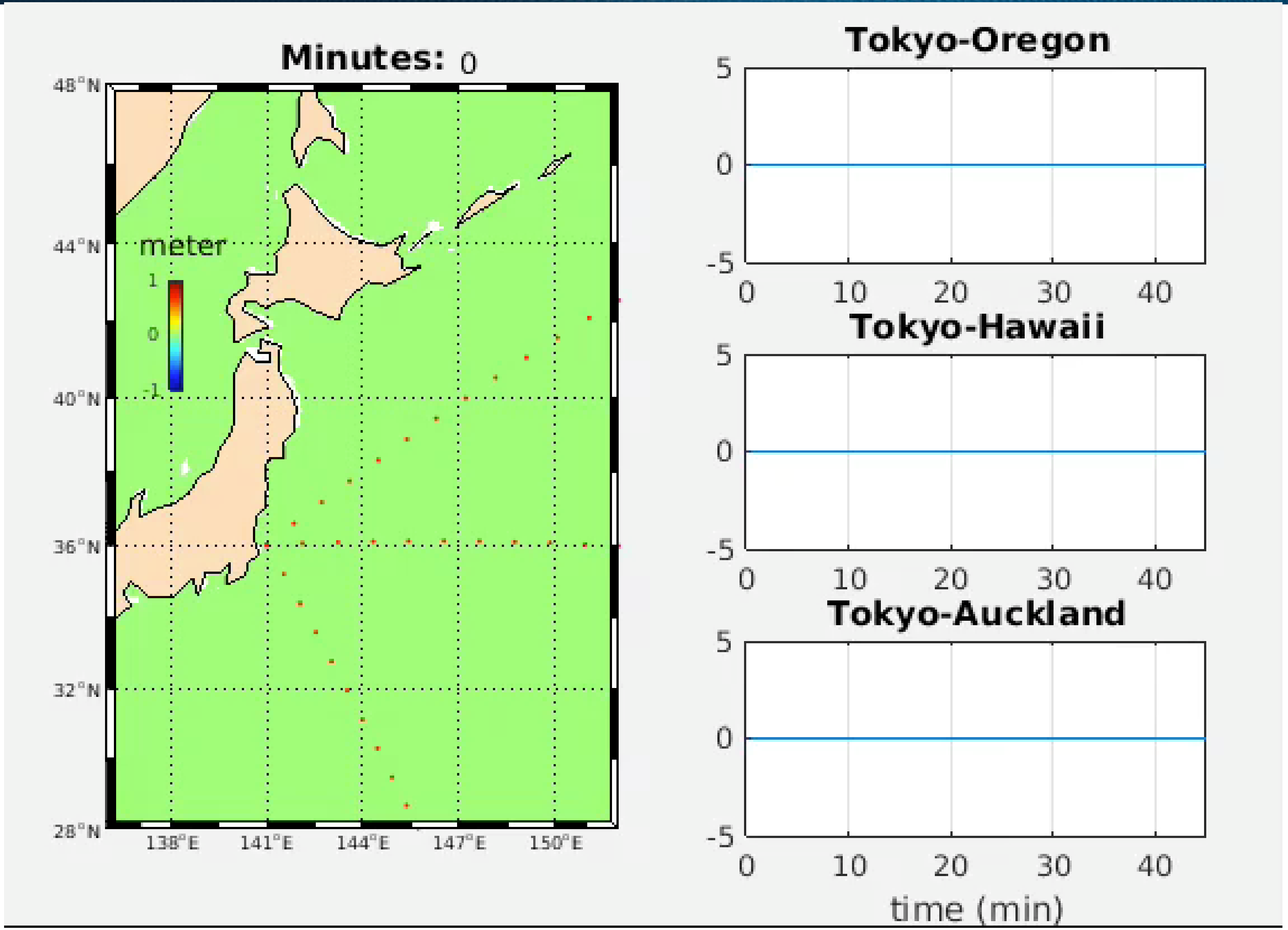
Tsunamis - Where do we need to measure?



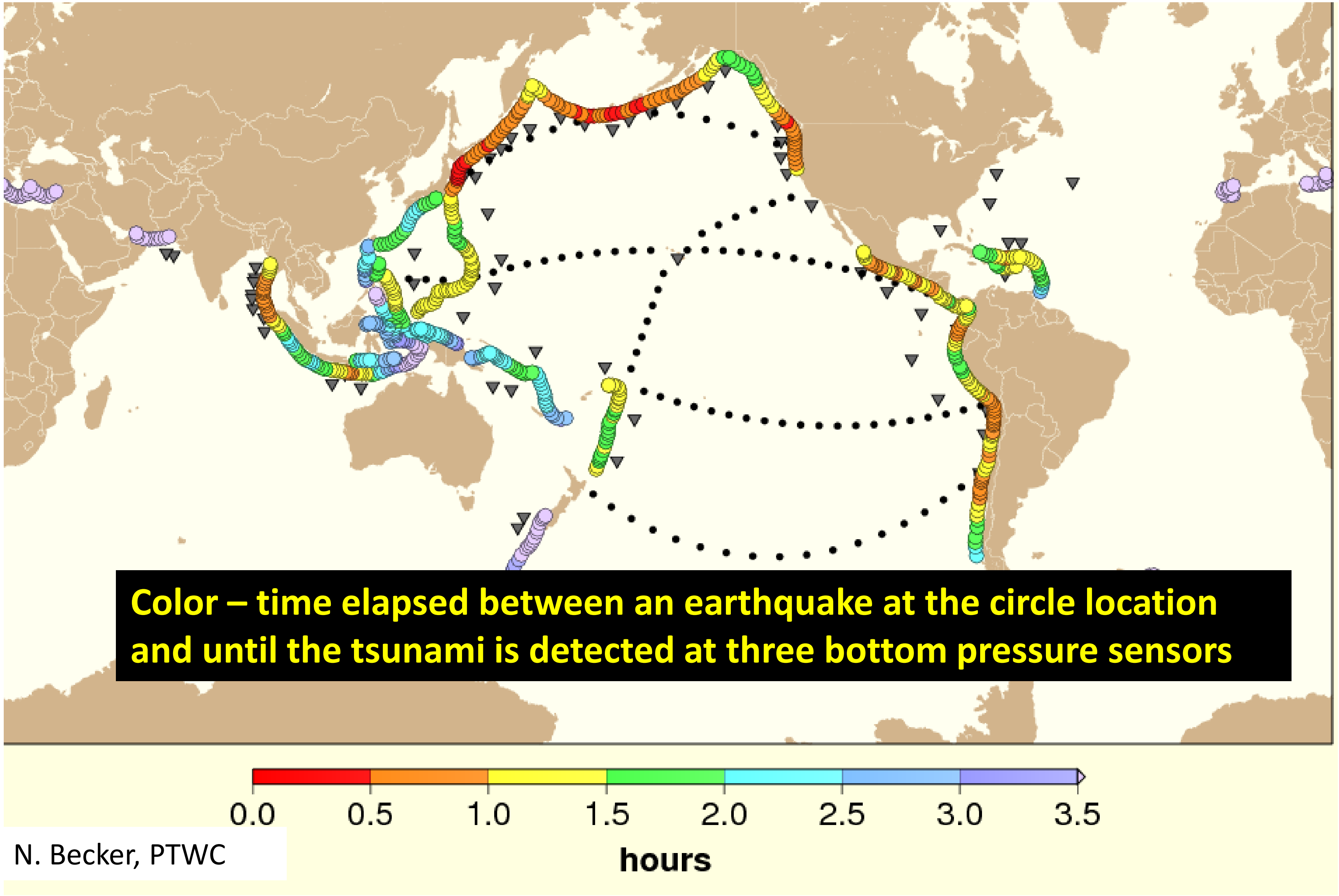
Tsunami – pressure (x,y,t)

Tony Song,
JPL/CalTech

In progress



Tsunami Detection Time at three bottom pressure recorders (2016)



N. Becker, PTWC

Add SMART

500 km spacing

Circles:

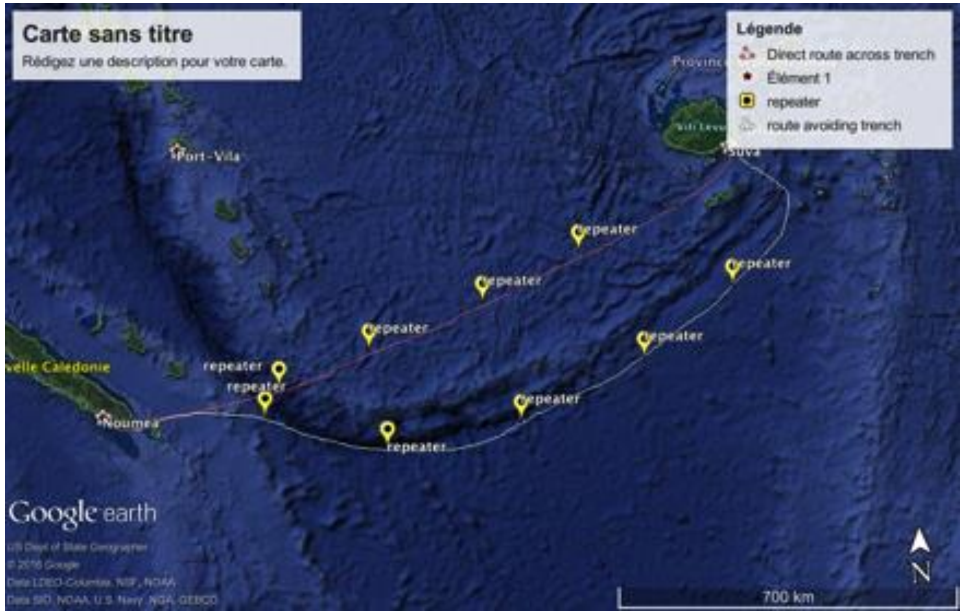
Simulated Earthquakes

Time-to-Warning reduced from 2.1 to 1.6 hours

– ***25% Important!***

Better with 50 or 100 km spacing

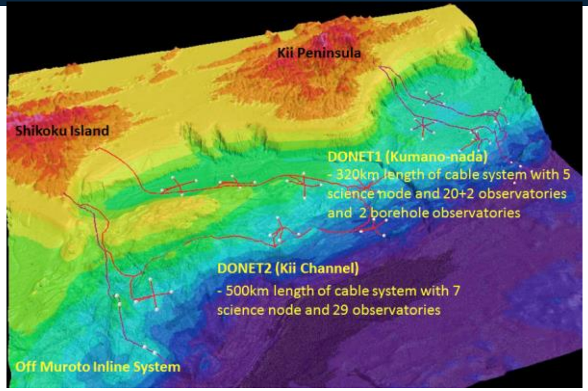
Recent



Update report from Rolin this afternoon

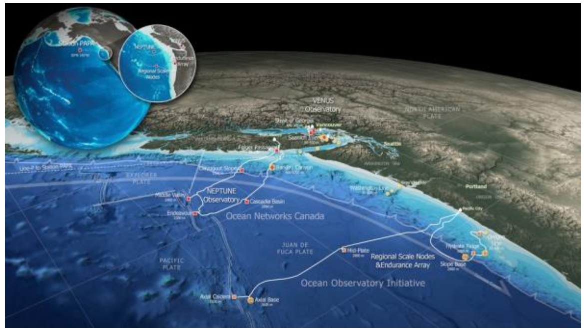
- OPT-New Caledonia system to Fiji
  - RFP issued December 2016; hear soon.
    - High earthquake/tsunami threat, oceanography
    - Project wants SMART for societal benefit
    - Modest scale (~20 repeaters)
    - Plausible can raise incremental funding required
    - Time frame reasonable
    - Demonstrate complete capability - integration into repeater power+comms, interface, external sensor package
- US Tsunami Warning, Education and Research Act 2017
  - authorizes NOAA – commercial and Federal telecom cables
  - could help with above – 3 DART buoys extremely expensive to maintain (1000 km N and E, off map)

Other Developments



DONET

S-NET



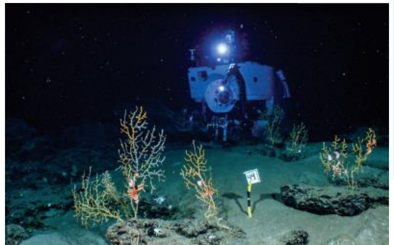
NEPTUNE

- Based on existing systems, new early warning systems being discussed: Cascadia, Chile, Pacific Islands, …
- Deep Ocean Observing Strategy (DOOS)
- International Seabed Authority (ISA)
- Integrated Arctic Observing System

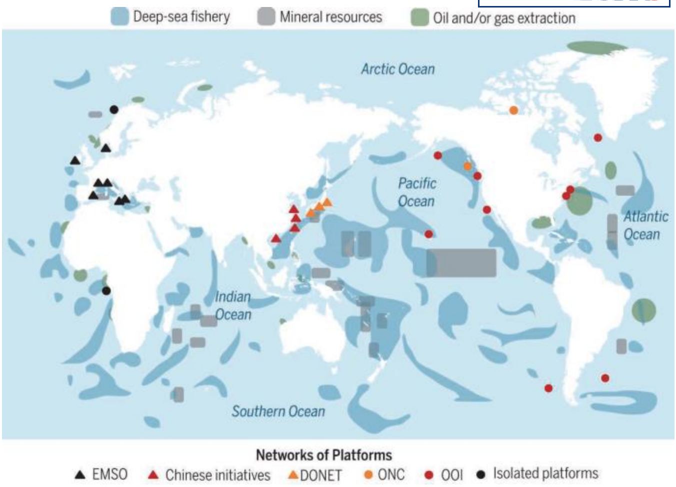
DEEP OCEAN OBSERVING STRATEGY

INTERNATIONAL SEABED AUTHORITY

INTAROS



Science AAAS



Some Challenges

- Technology
  - Telemetry
  - Security of network (intrusions)
- Legal/Permitting
- Business models and funding
  - Phased/gated
  - Depends on sources of funding: government, private, consortium, OTT, development banks, philanthropic, …

- Testing – acceptance by telecom
- Role of “societal responsibility”?

Funding

But

- NB Pacific Fibre 2012 – project deemed doable
- Xtera – repeater supplier – acceleration sensors proven
- Potential for New Caledonia-Fiji system,or similar

Industry opportunities

- Sensors
- Sensor integration
- Repeaters
- System integration, install, deploy,
- System operation, data, apps
- Extensions – new sensors, data apps
- Other applications – other ocean observing, O&G, deep sea mining, defense, …

Costs/Funding sources/sponsors

- Costs
  - Wet demo $3-10M
  - Repeater NRE ?same?
  - Unit $100-200k ea, less later

- Funding sources/sponsors
  - OPT-New Caledonia system to Fiji
    - French government labs, et al
    - Asian Development Bank – Fiji
    - NOAA
  - NOAA
    - US Tsunami Warning, … Act 2017
    - NOAA – commercial and Federal cables
    - Present budget ~$30M, $200-500k ea/y
    - Federal cables – DISA?
  - Development Banks
    - Asian Development Bank
      - General support under consideration
    - African Development Bank – if can benefit
    - World Bank – no contact yet
  - Foundations
    - Talking with Schmidt Marine
    - Mergon ?Mertech?
  - OTTs
    - Google Oceans?, one other lead
    - Microsoft, FB not responsive
  - Europe
    - EC Reseach infrastructure/Horizon 2020 2019 call; IFREMER, Helmholtz, INGV, ... (Norway)
    - Europe-US agreement
    - Norway? Other
  - Other governments
    - Direct support
    - Or loan funds/subsidize

SMART Cables - Some next steps

- Continue to integrate into the Framework for Ocean Observing
  - JCOMM-5-TECO meeting Geneva 23-29 Oct – ***Endorsed!***
  - JCOMM-OPS Data Buoy Coordination Panel, Brest, 14-16 Nov
  - Essential Ocean Variables – p, T – in process via DOOS
  - GODAE OceanView, liaison, OSSEs? in process (Bergan 9 Nov)
- Funding: EU, Banks, member states, others? – this PM
- Wet demo and pilot – possibilities – this PM
- Work towards OceanObs19 paper and endorsement
- Consider small systems – start small, government, tsunami areas
- ➜ ∑ small parts, long duration ➜ global spanning, sustained

Summary

- Science and Society needs are clear, continual
- Science consensus (white papers, workshops, pubs starting)
- Modeling in progress – quantifying benefit, need more
- Technical solutions tractable, but must be tested
- Security/network concerns need to be addressed
- Business model(s) must be formulated
- Need continuing interaction with sponsors, governments, UN, science/warning community/users buy-in
- Design, development and deployment

  - all have a common issue ➜ ***Funding*** the first pilot(s)

Workshop - Topics

- Review science including simulations, candidate sensors, and relevant data
- Discuss obtaining funding from EU/other sources and specify tasks and timeline
- Present and discuss possible power/communication/mechanical interface options
- Discuss the wet demo and pilot system processes including drafting publication(s) (tasks and timelines)
- Discuss target pilot systems and actions for contacting planners

Workshop - Outcomes

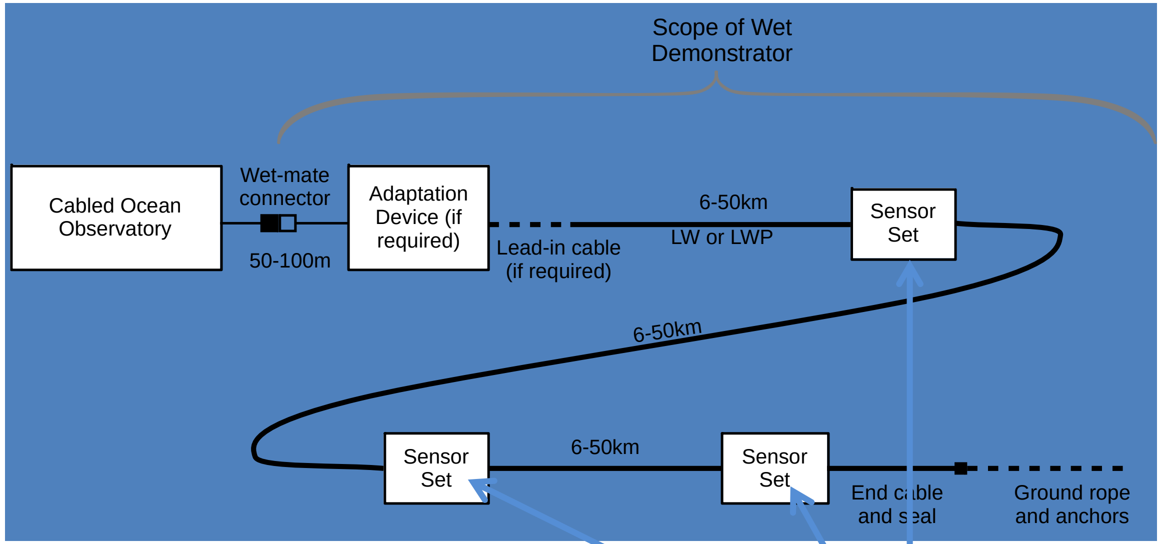
- Recommendations – Science
  - What simulations?
  - Sensors (consider other types, specs)
  - Analyze extant data/models for justify/insight
  - Form group for Science and Implementation Plan documents – OceanObs’19
- Specify tasks/timeline to EU funding
- Recommend actions to narrow repeater interface space
- Outline of wet demo steps (tasks/timeline)
- Recommend target pilot systems and actions for contacting system planners

Questions

JCOMM-5, 23-29 October 2017

- ORGANIZATIONS WITH WORKING RELATIONSHIPS WITH JCOMM
  - The International Telecommunication Union (ITU), which together with WMO and IOC, is exploring the use of undersea cables for ocean observations supporting tsunami and climate monitoring.
- INCLUSION OF NEW NETWORKS TO THE OBSERVATIONS COORDINATION GROUP (OCG) MEMBERSHIP
- Noting further the work done by the Joint Task Force of ITU, WMO and UNESCO-IOC to integrate environmental monitoring sensors into transoceanic commercial submarine telecommunication cables in order to provide tsunami warnings as well as climate-quality data from the oceans,
- Encourages the Joint Task Force (JTF) of ITU, WMO and UNESCO-IOC to continue its efforts to bring to fruition a global network of ocean sensors and requests Member States to report to their Ministries, Agencies and Institutes, to draw particular attention to the activities of the JTF and the significant societal benefits that might flow from the realisation of its objectives, notably in the field of reliable and timely tsunami warning as well as climate-quality data from the oceans, and urges all stakeholders in the endeavour to proactively contribute to the effort.

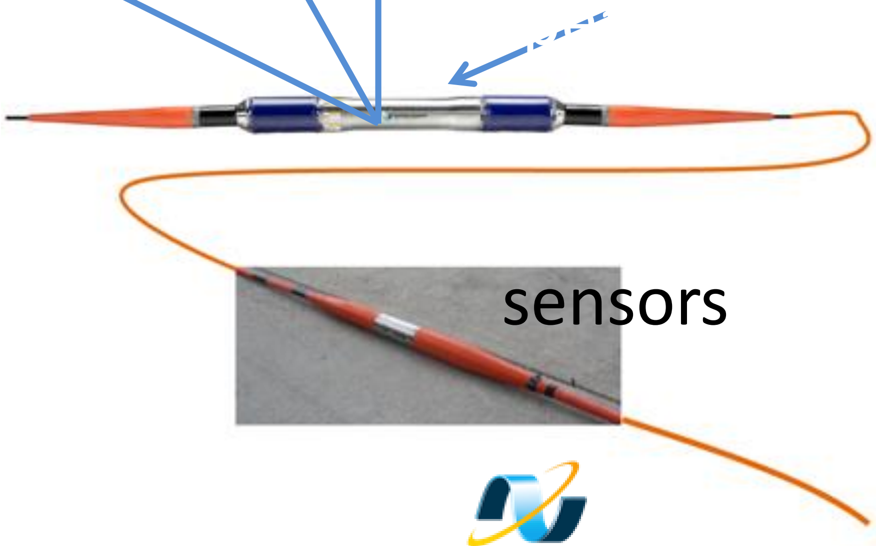
JTF Wet Demonstrator – proof of concept

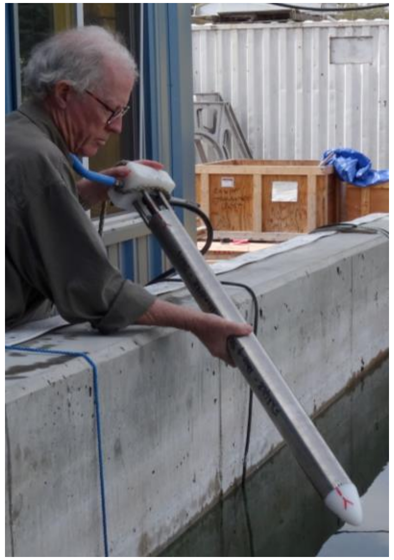


Demo:

- Mechanical deployment
- Science, good data
- $2-10M depending on in-kind (e.g., cable ship, cable)

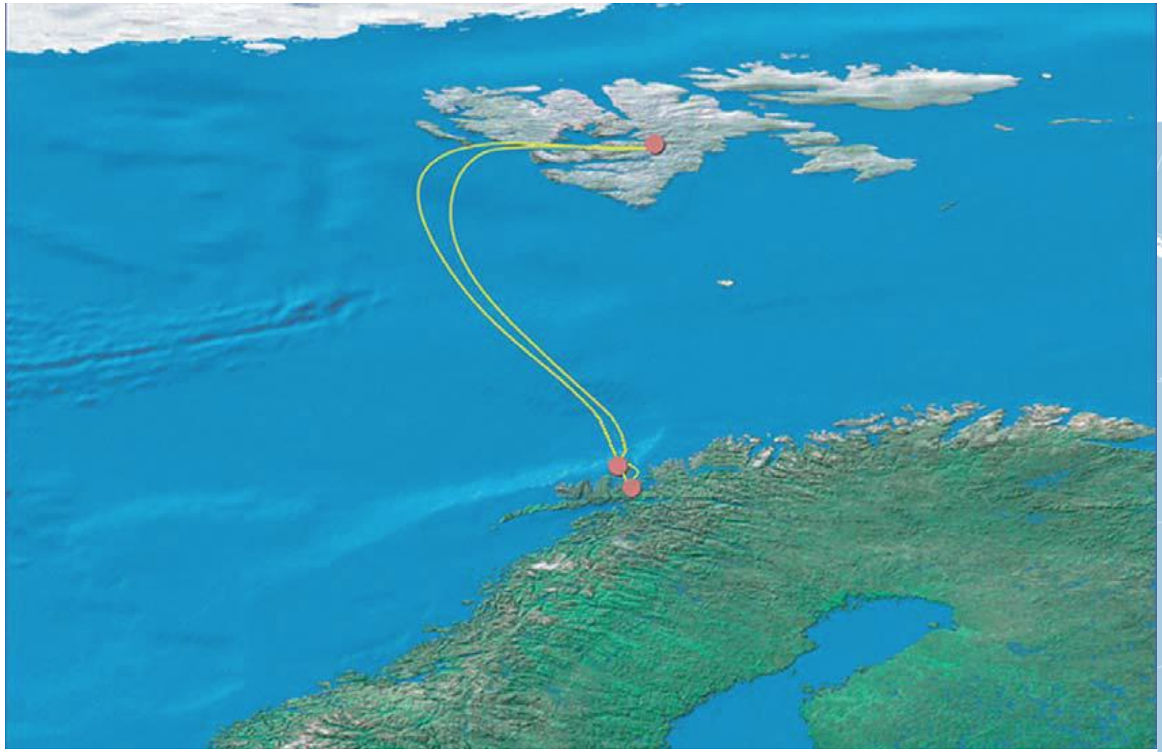
- ~three repeater/sensor sets
- Minimum separation Greater separation preferred, up to 50 km
- Potential, general interface





Finalize RFI responses, proceed to RFP

Svalbard Arctic Fiber/Quintillion



Satellite downlink + Local community
Telenor Svalbard, 2003
2 cables, each 1400 km,
20 repeaters. 4 Tb/s
NASA, NOAA $20M ea

Phase 1 done
Phase 2,3 …?

Asian Development Bank

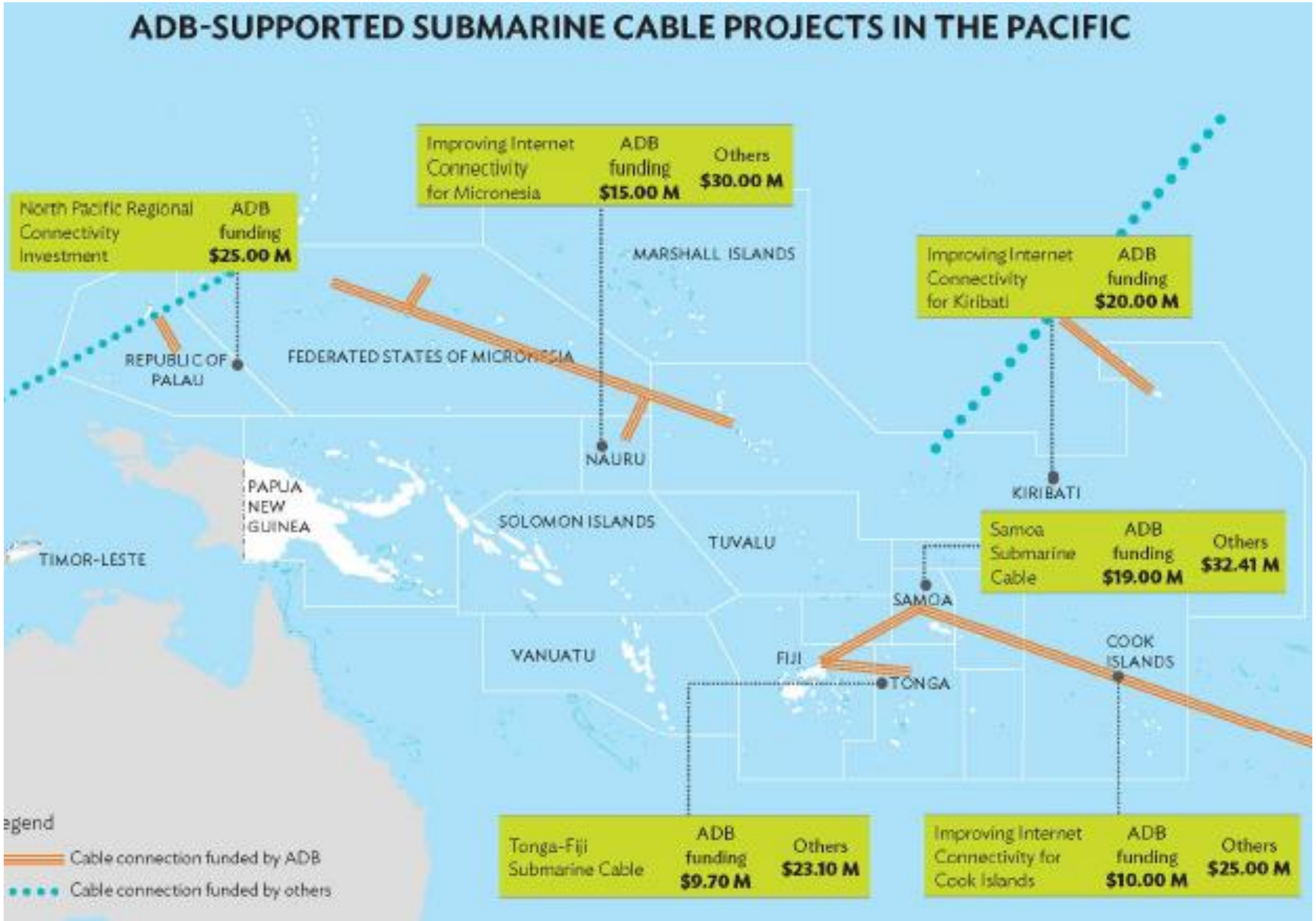
- Howe a

Cables in the Pacific?

- 2000-2010 large Pacific nations connected (PNG, Fiji) and Samoa, Marshalls and Micronesia
- Rest rely traditional satellites / O3b
- Cable investments in smaller Pacific islands constrained by
  - requirement for large up-front capital investments
  - long period of return on investments
  - inability of small private sector to mobilize large investment required

Emma Veve
ADB
SubTel 2017

Asian Development Bank



Emma Veve
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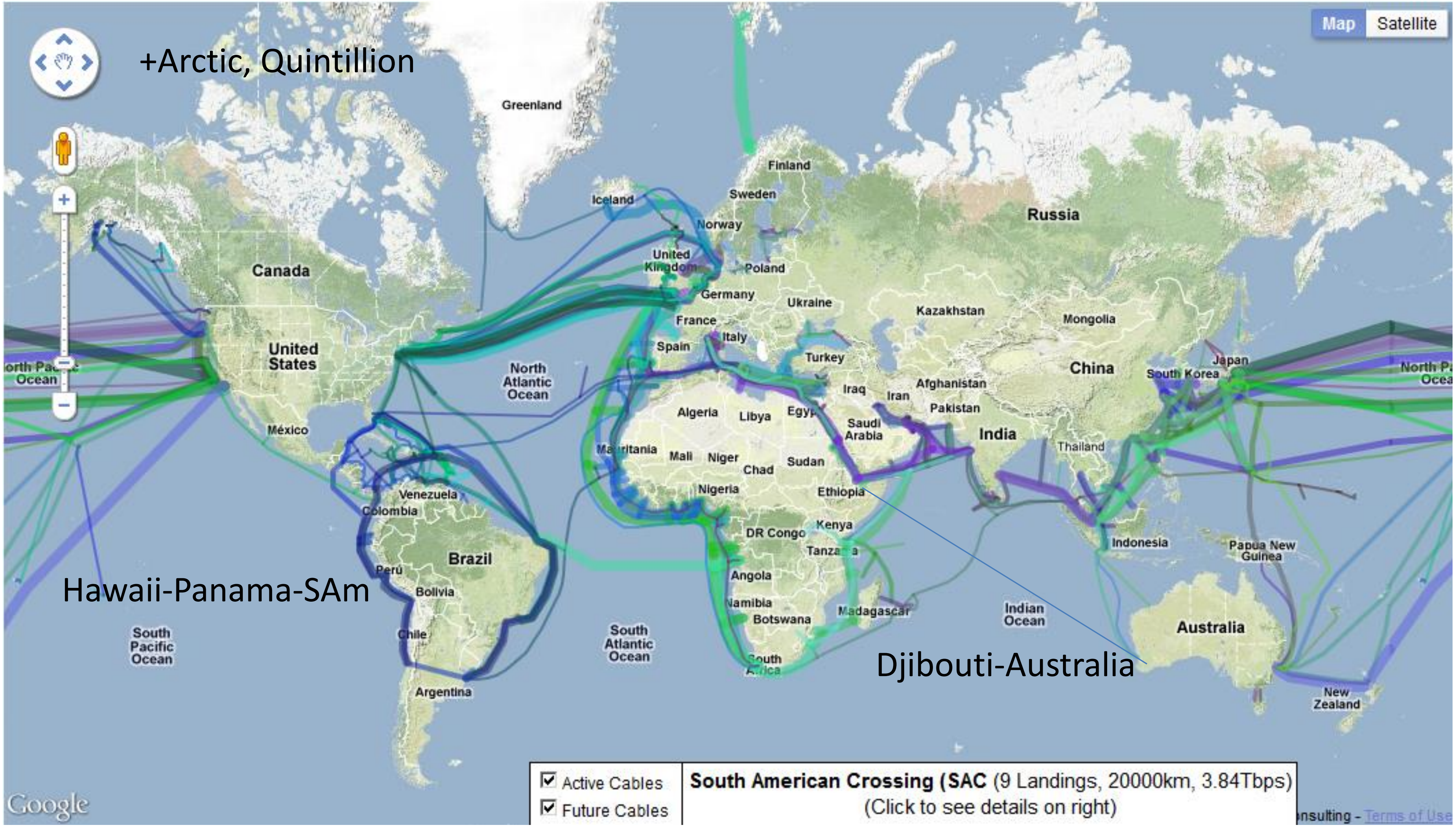
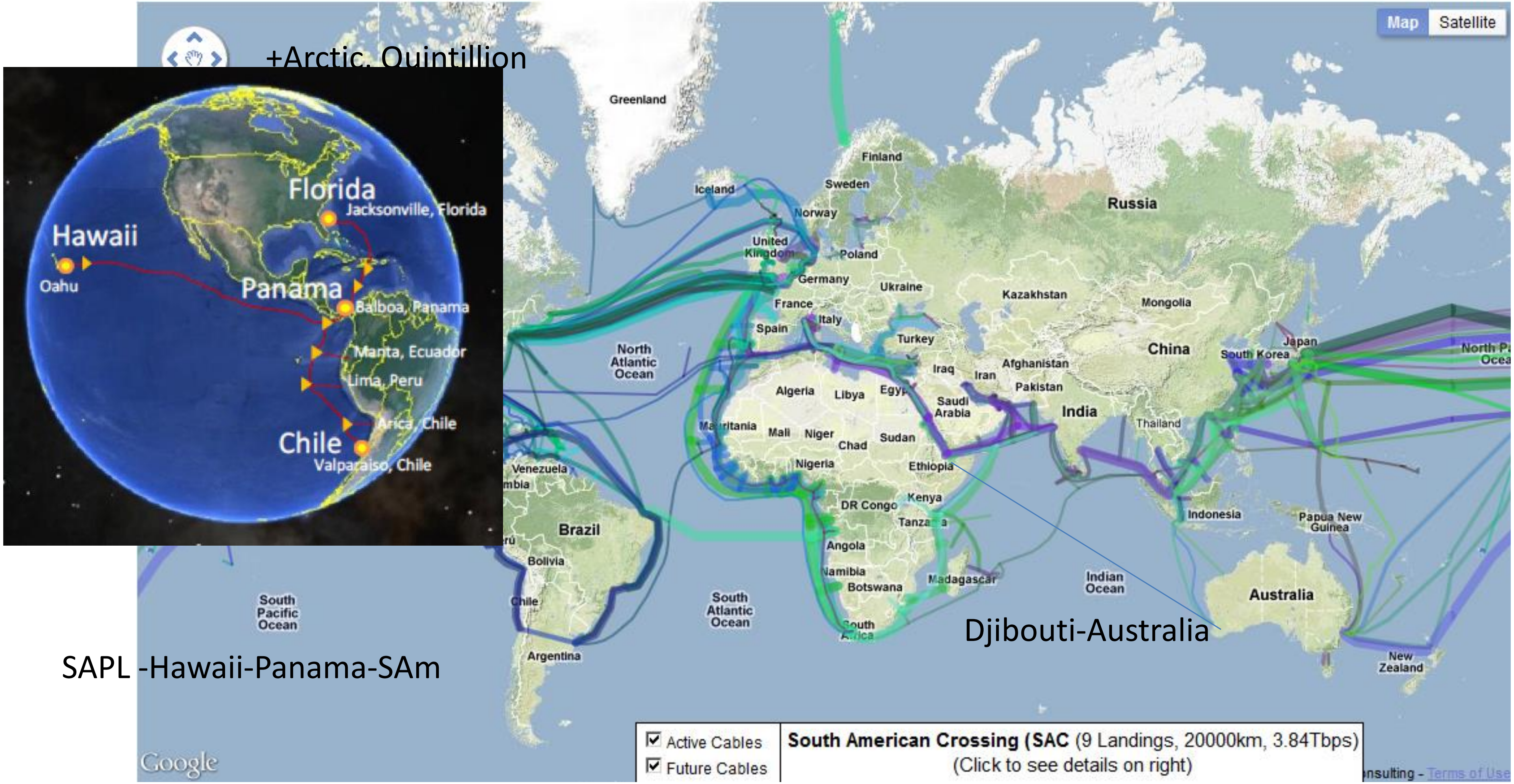
Global cables



Global cables

+Arctic, Quintillion

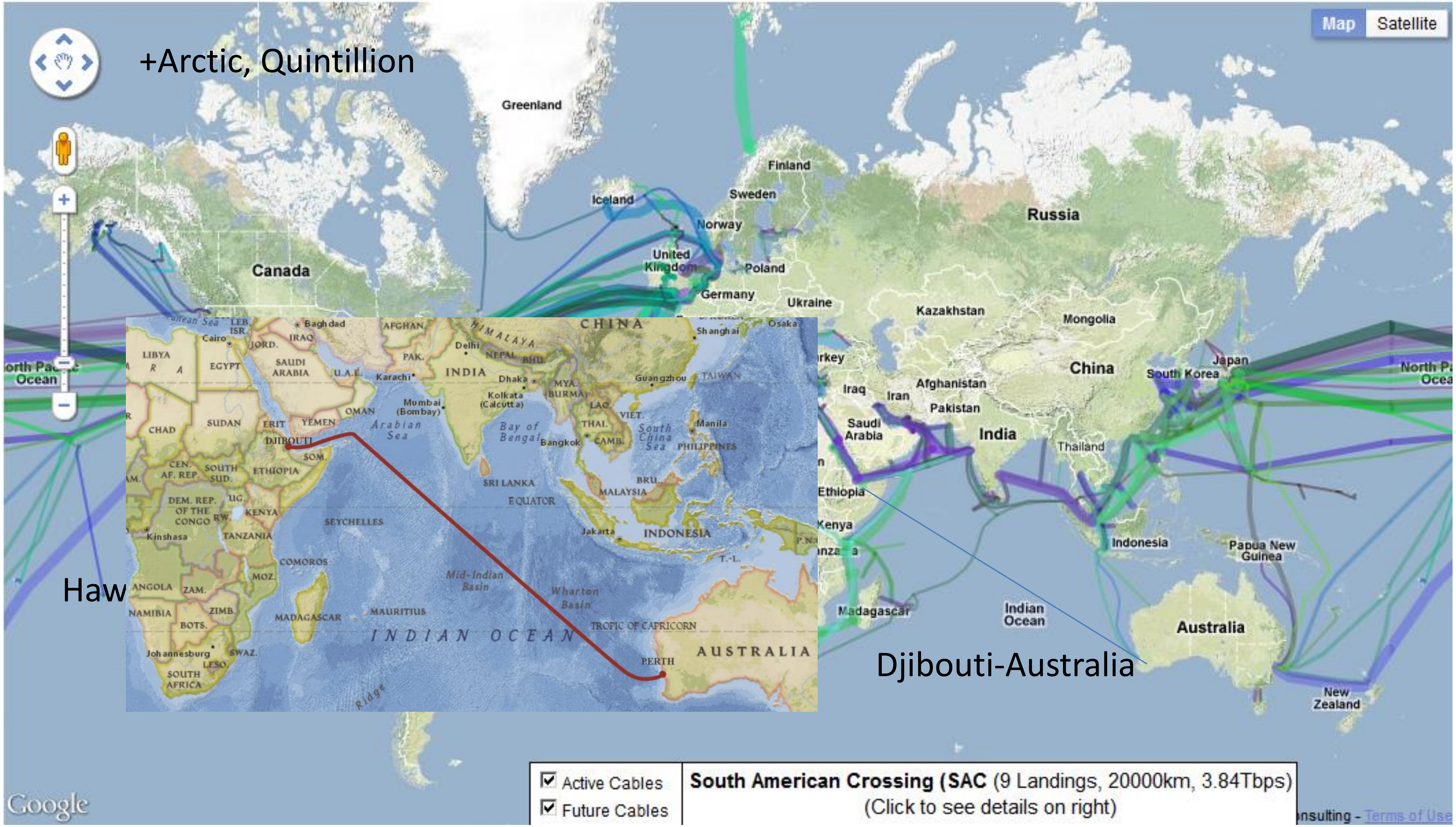


Djibouti-Australia

SAPL -Hawaii-Panama-SAm

Global cables

ctivite



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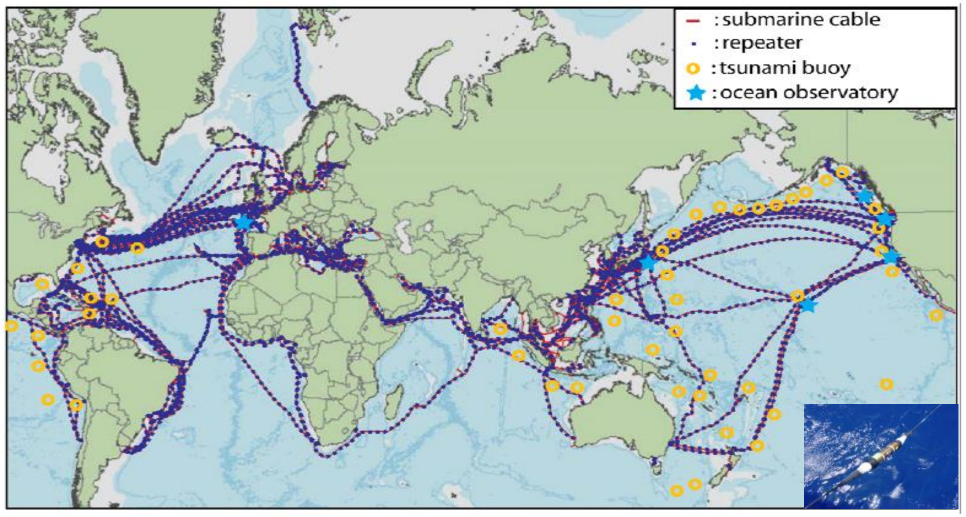

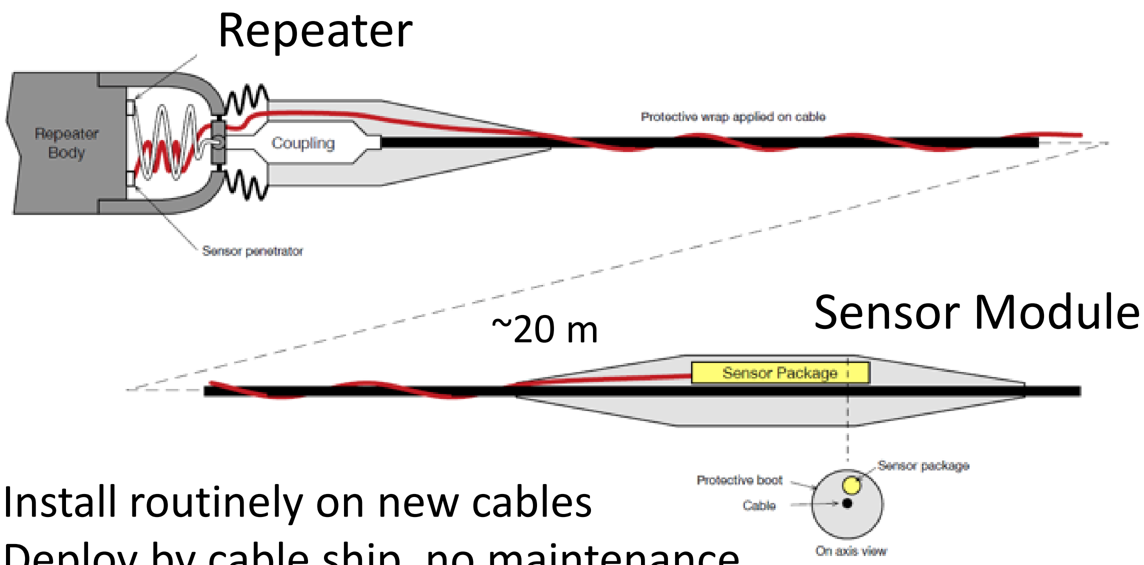

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