# Exploring our planet through SMART cables

Subtitle (if applicable)

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By U.S. Navy photo by Photographer's Mate 2nd Class Philip A. McDaniel - This image was released by the United States Navy with the ID 050102-N-9593M-040 (next), Public Domain, https://commons.wikimedia.org/w/index.php?curid=8241767


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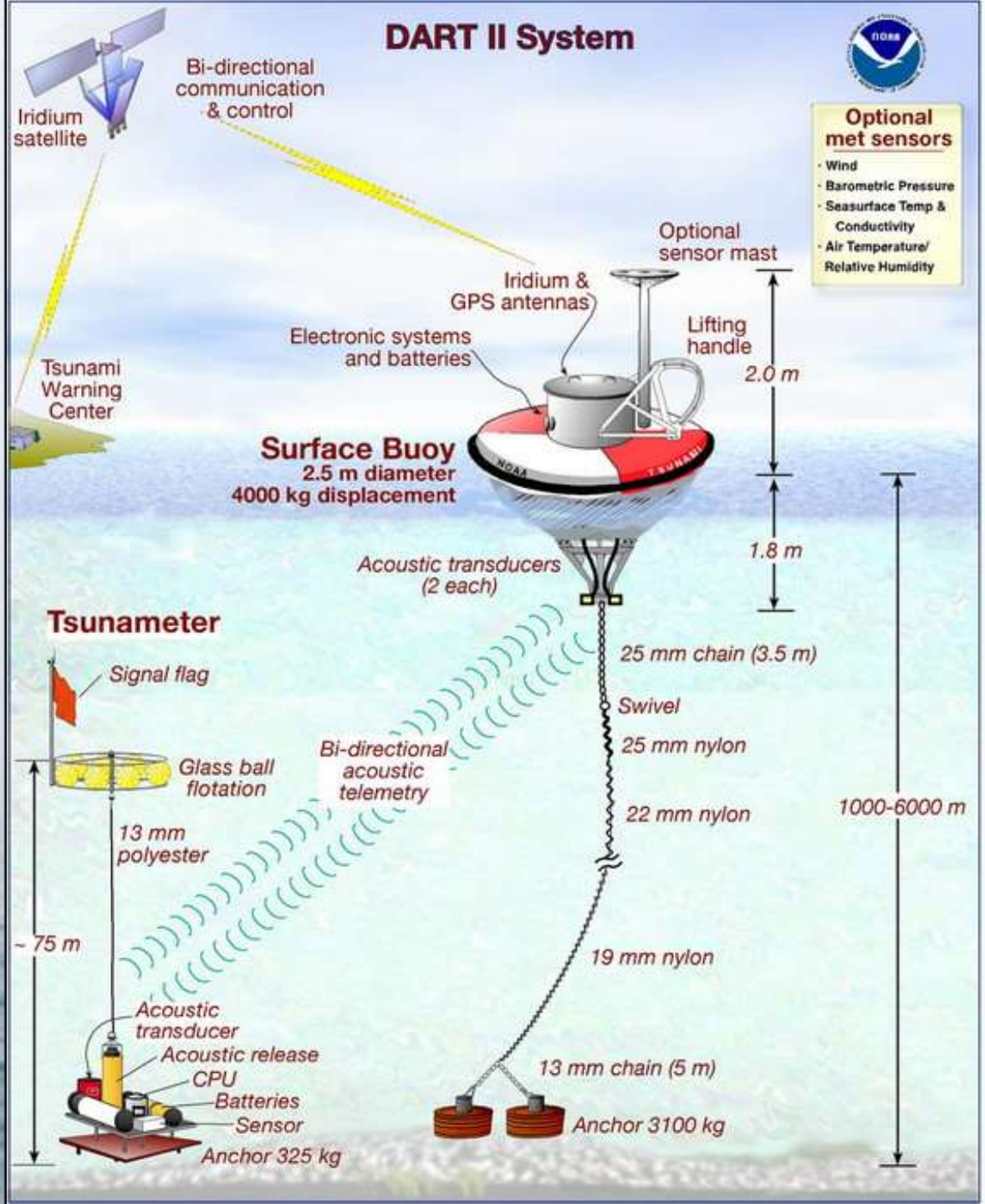
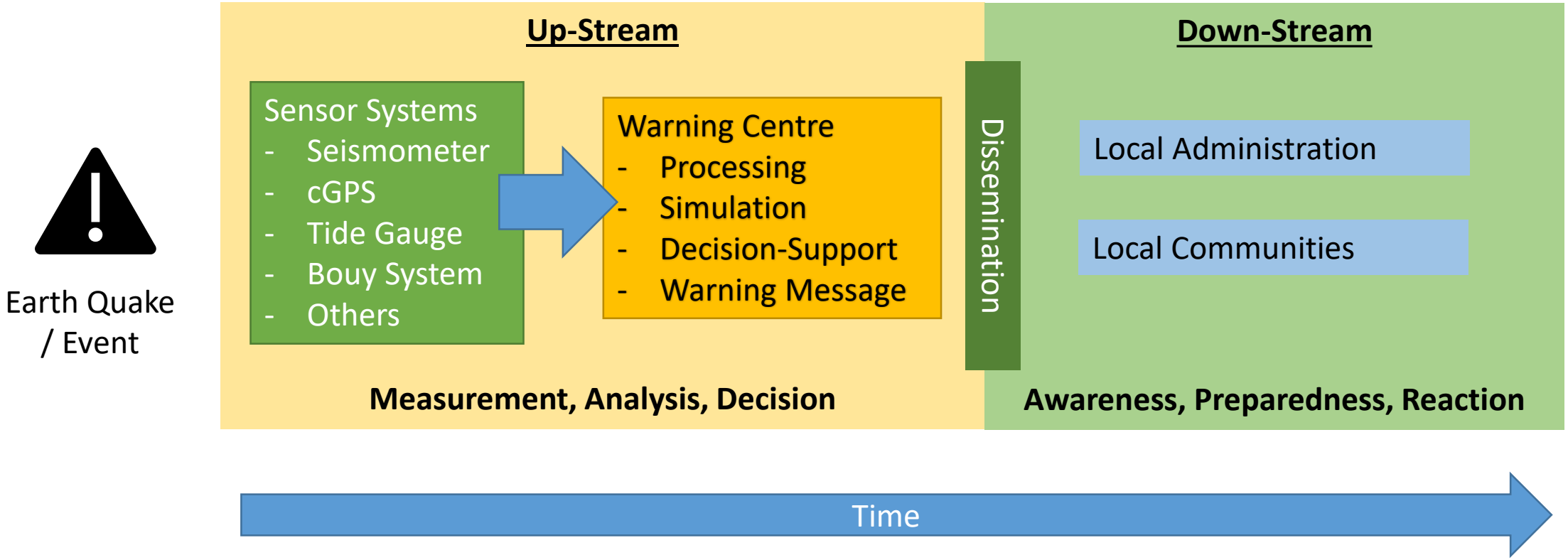
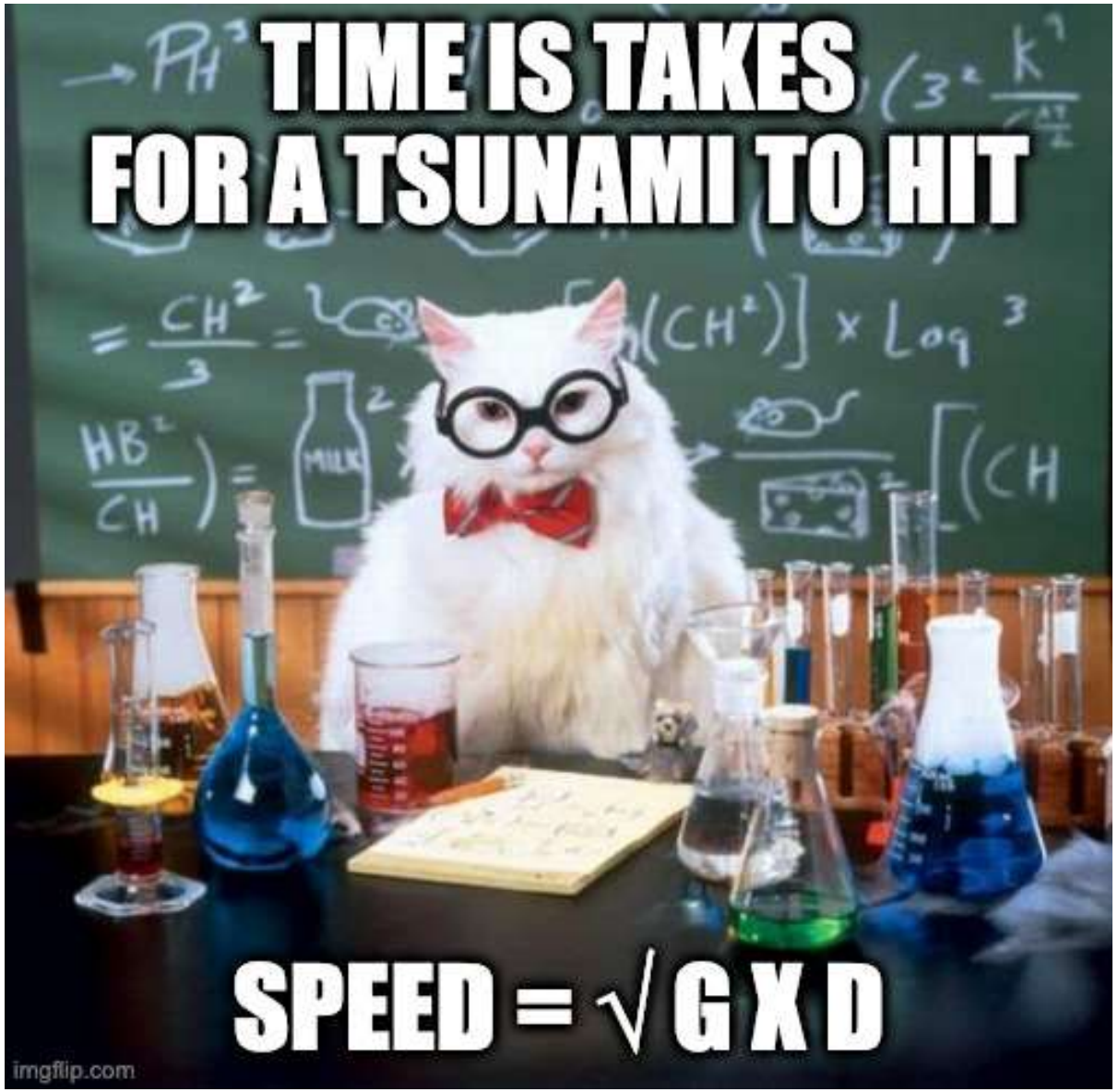


# How Tsunamis are monitored and reported




Lauterjung, J., Letz, H. (Eds.) (2017): 10 Years Indonesian Tsunami Early Warning System: Experiences, Lessons Learned and Outlook, Potsdam: GFZ German Research Centre for Geosciences, 68 p.
DOI: http://doi.org/10.2312/GFZ.7.1.2017.001



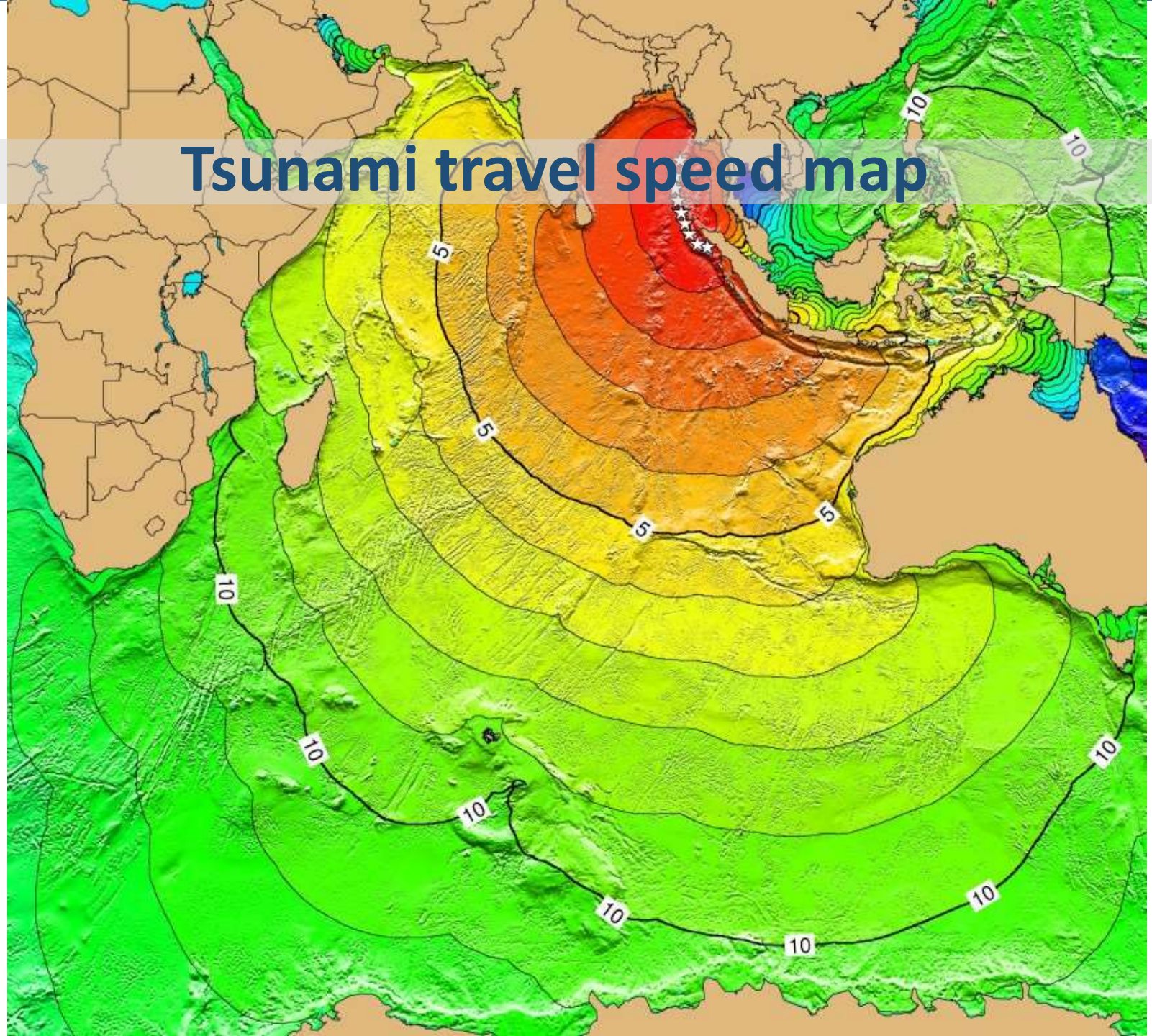

1000 meters water depth = 713 Km/s

4000 meters water depth = 198 m/s

g = 9.81

d = Depth of water

# Tsunami travel speed map




Map contours: 1-hour intervals:
Red: 1-4 hour arrival times

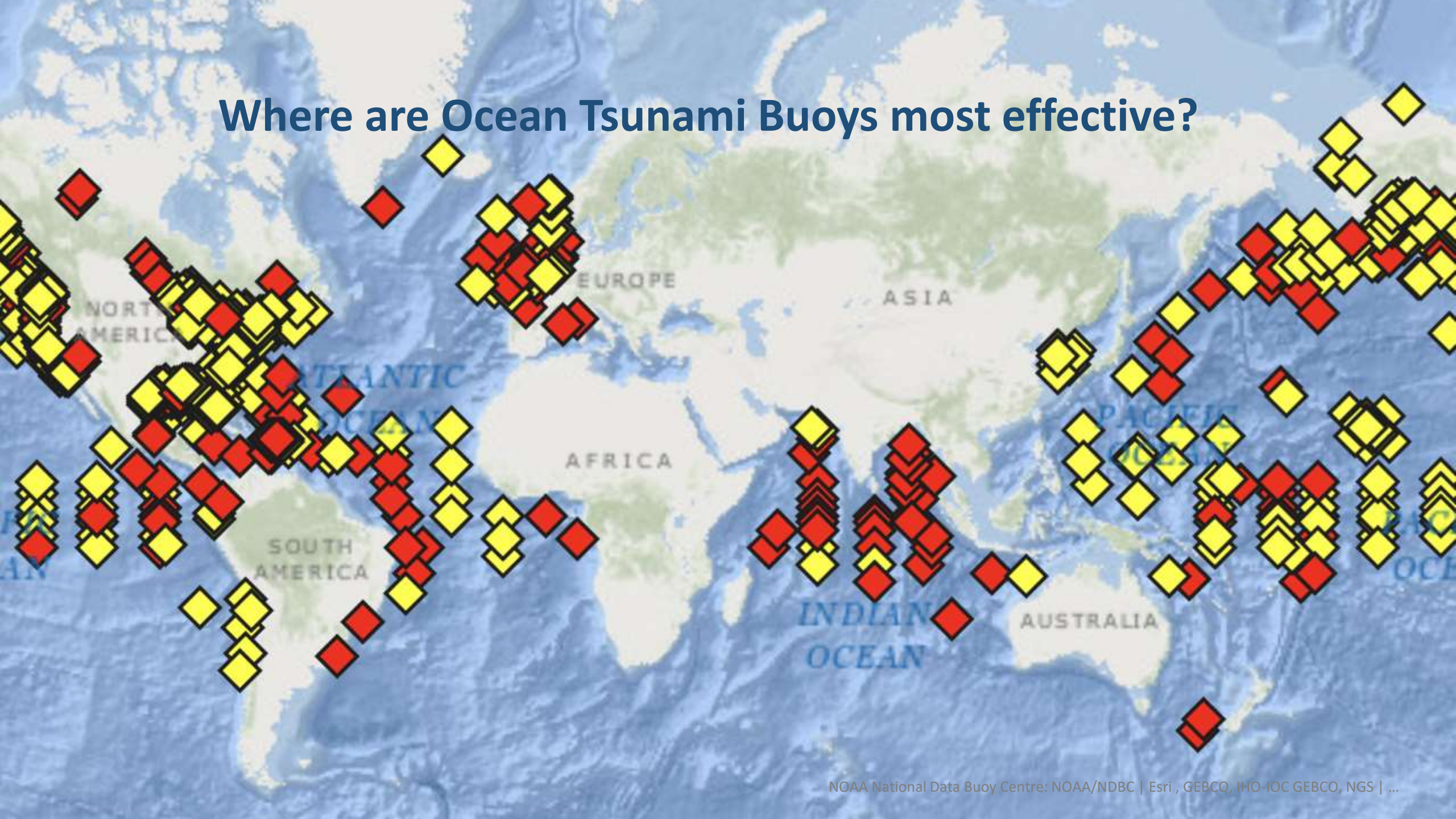
Yellow: 5-6 hour arrival times

Green: 7-14 hour arrival times

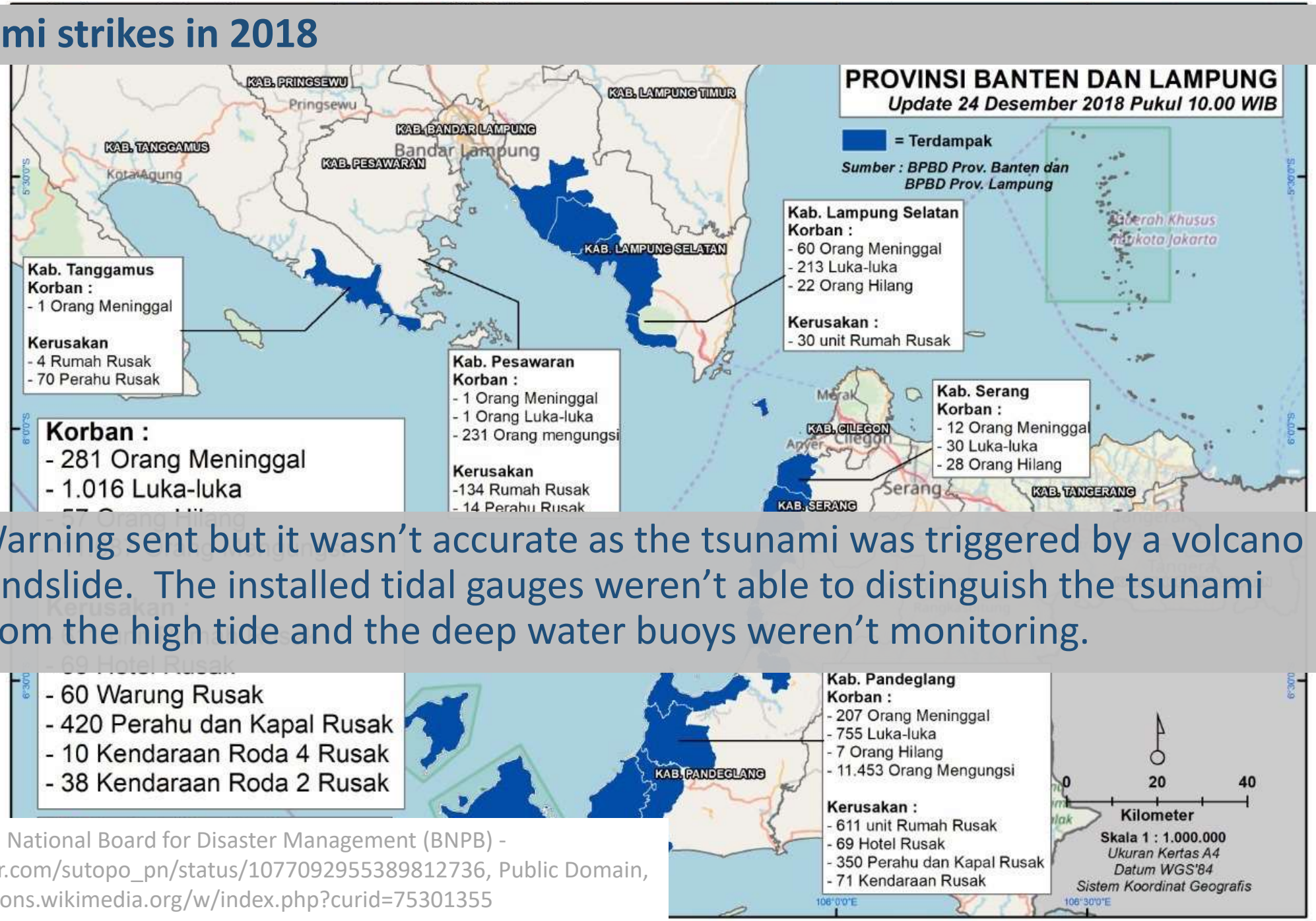
Blue: 15-21 hour arrival times

https://www.ngdc.noaa.gov/hazard/tsu_travel_time_events.shtml

# Where are Ocean Tsunami Buoys most effective?

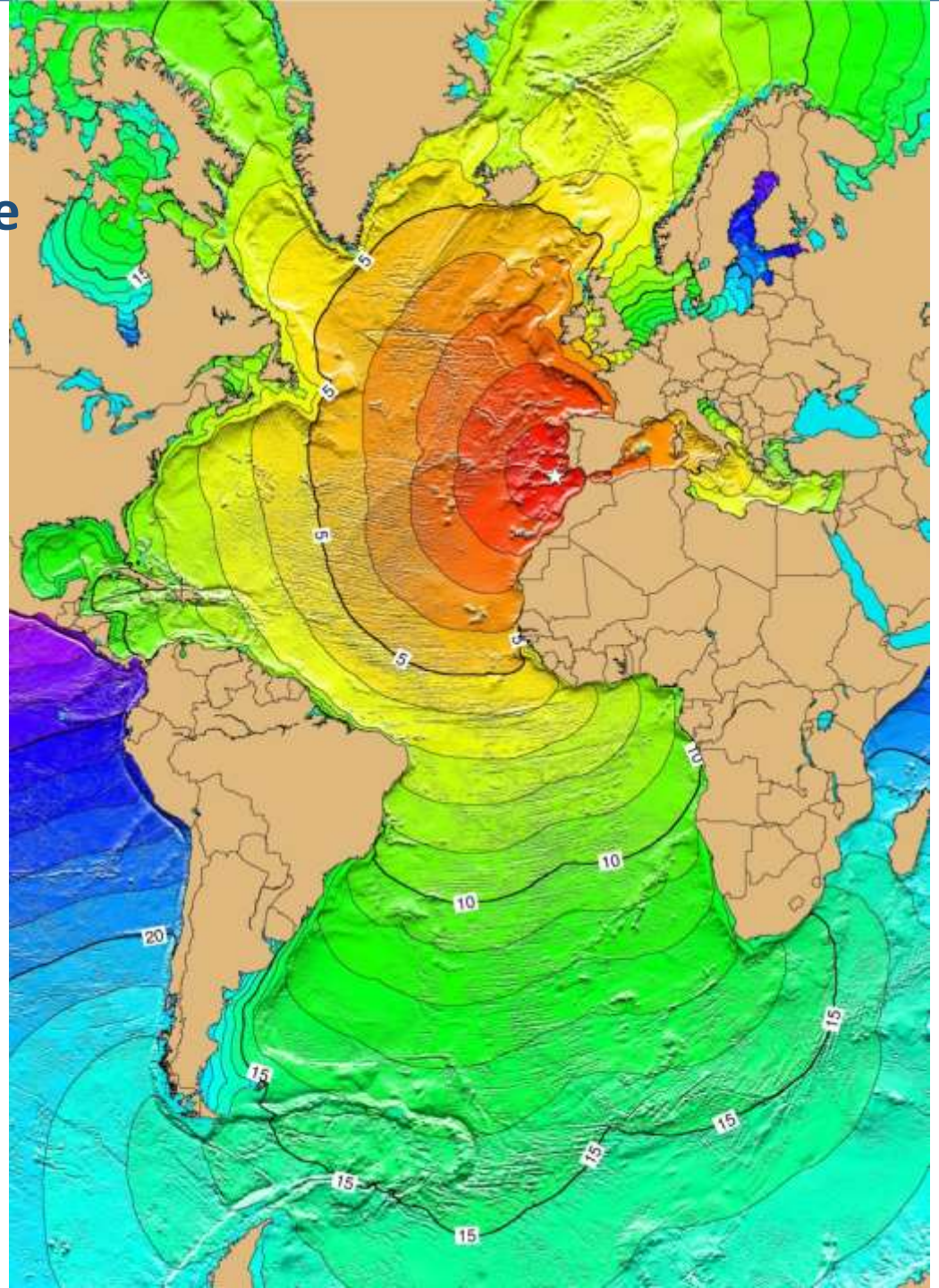


# 2 x tsunami strikes in 2018




Warning sent but it wasn't accurate as the tsunami was triggered by a volcano landslide. The installed tidal gauges weren't able to distinguish the tsunami from the high tide and the deep water buoys weren't monitoring.

# Tsunami's in Europe

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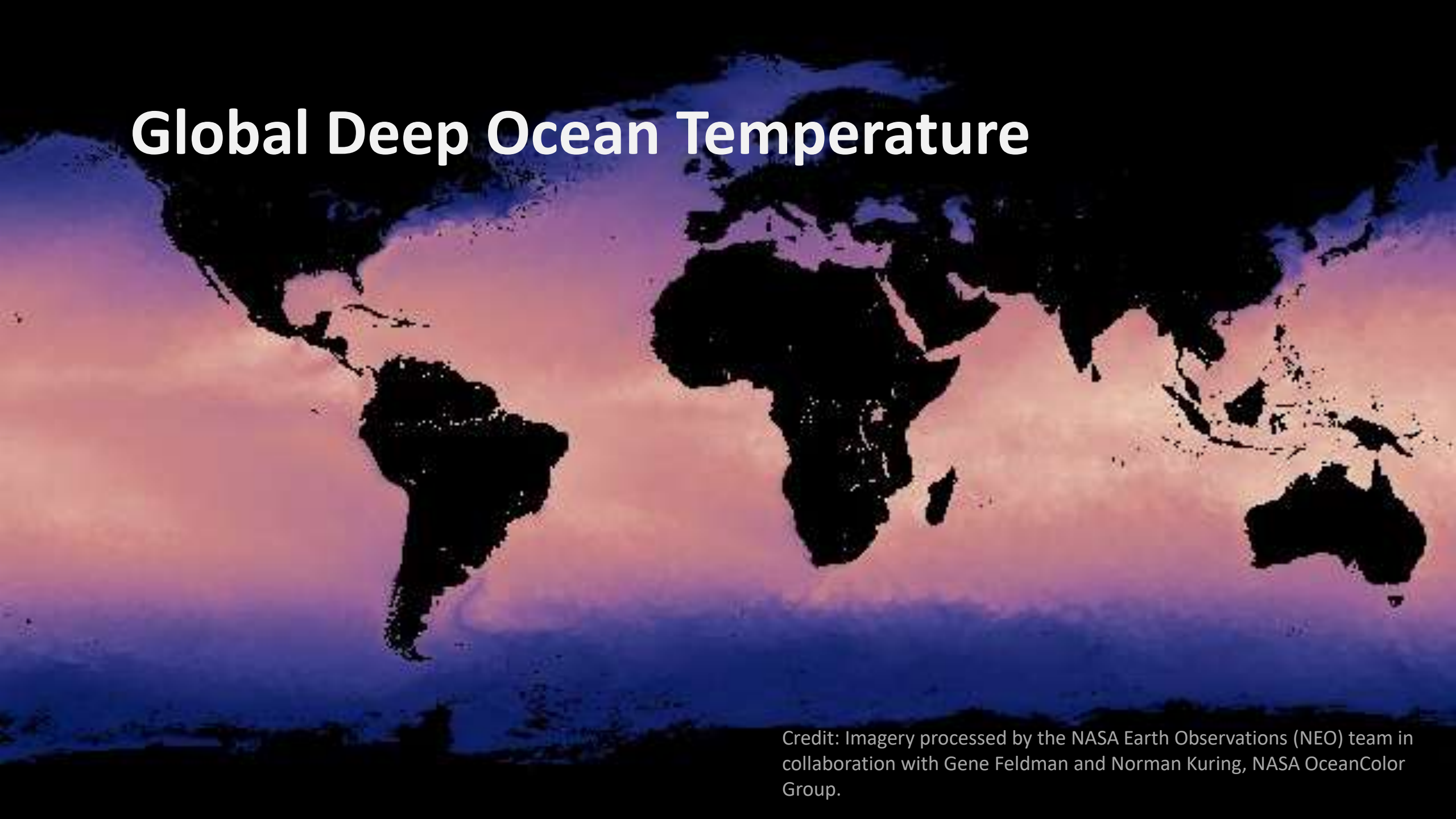
https://www.ngdc.noaa.gov/hazard/tsu_travel_time_events.shtml

# Another societal challenge from lack of deep ocean observations

Photo by Rob Curran on Unsplash

# Global Deep Ocean Temperature



Credit: Imagery processed by the NASA Earth Observations (NEO) team in collaboration with Gene Feldman and Norman Kuring, NASA OceanColor Group.

# We need more data!

Long term data sets for:

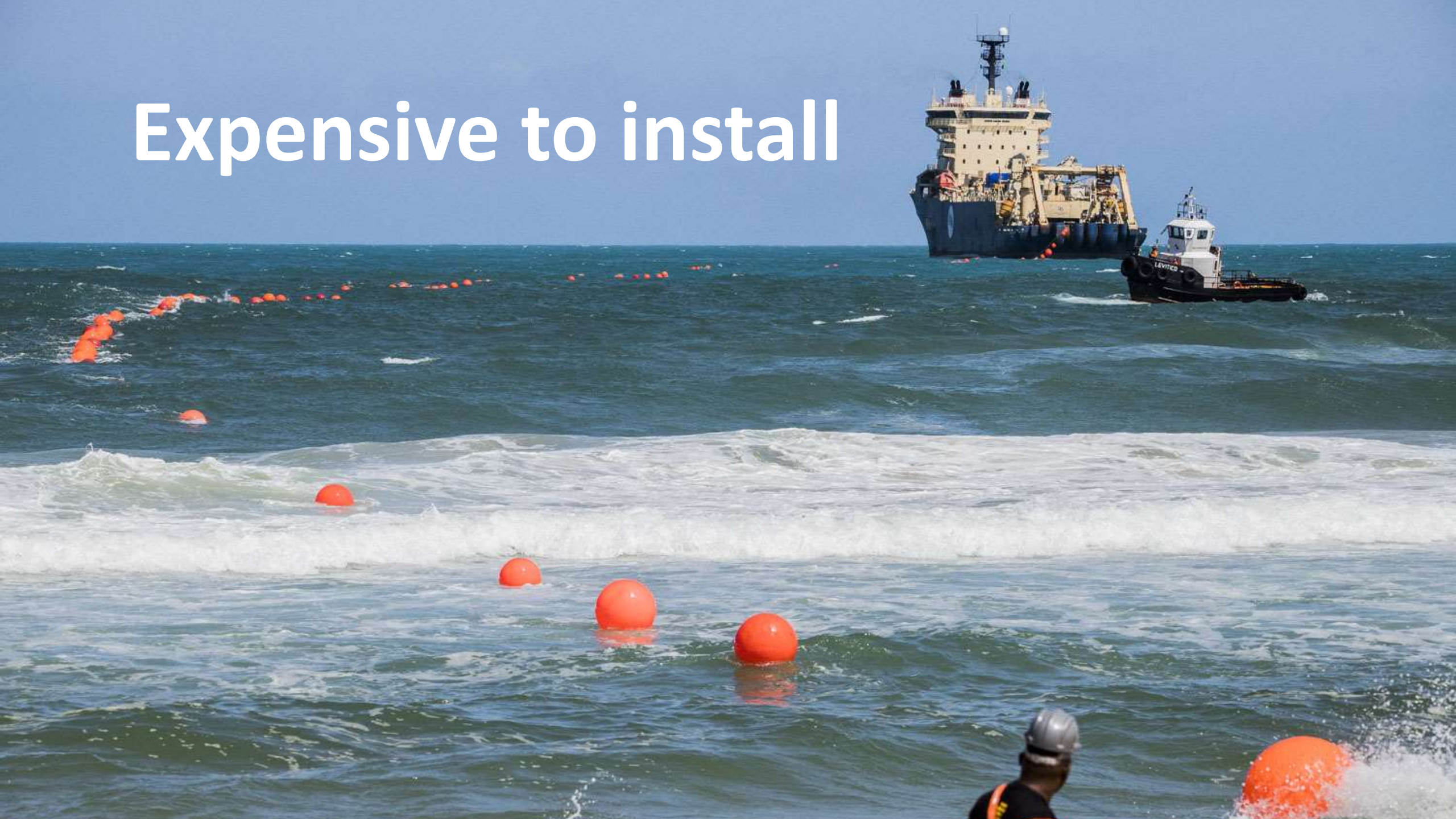
- Climate modelling
- Weather forecasting
- AI and all that

Photo by Snowscat on Unsplash

# What about dedicated infrastructure?

By John Whitehead - Ocean Instruments, Public Domain, https://commons.wikimedia.org/w/index.php?curid=15663716

# Expensive to install



# Expensive to maintain

# Who pays?

Photo by Ibrahim Boran on Unsplash

# Who is responsible?

Photo by Frederik Köberl on Unsplash

emso ERIC

About us | Observatory | Data | Science | Innov


# There have been dedicated cables and infrastructure installed!

Google

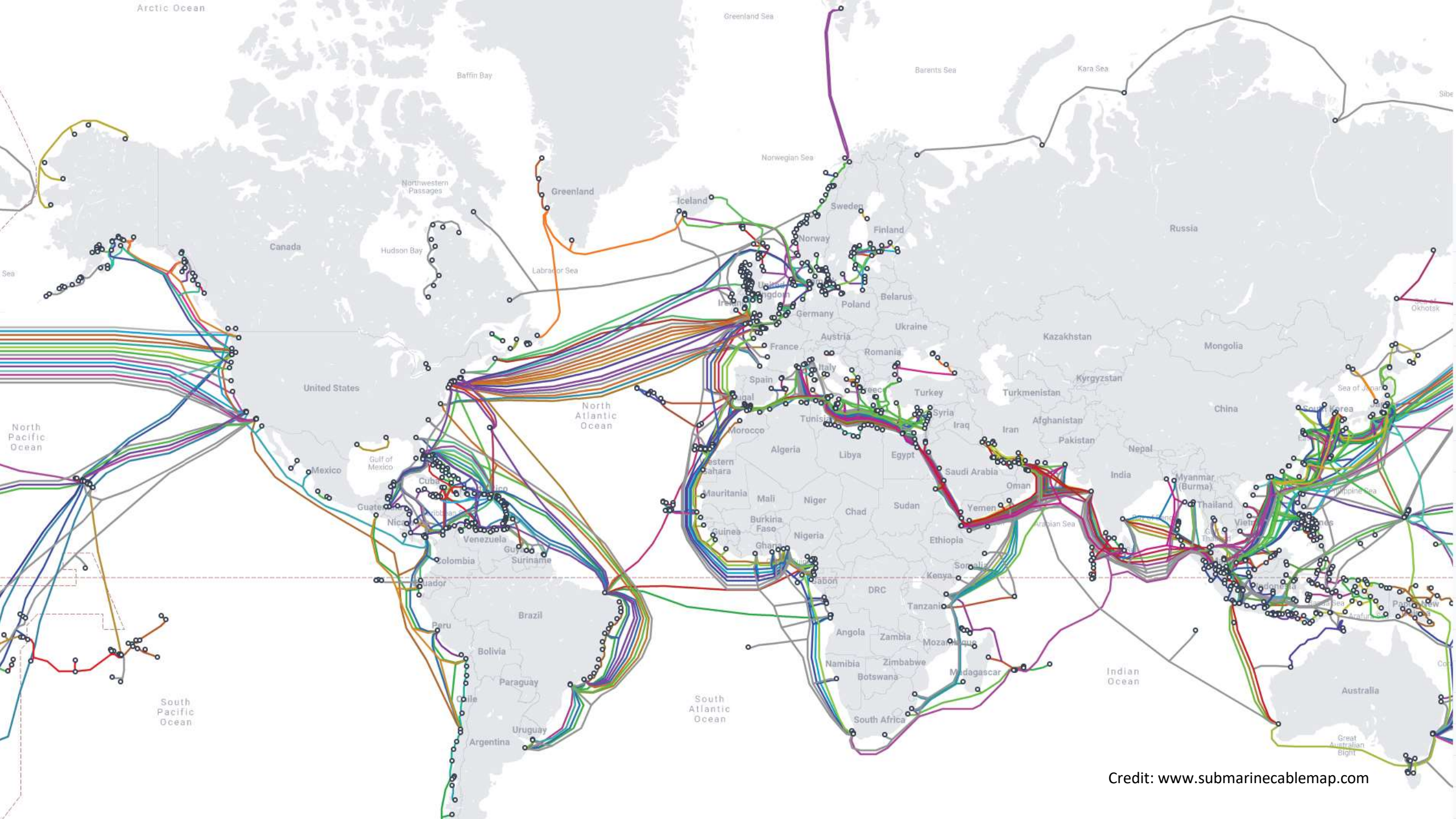
Keyboard shortcuts | Imagery ©2022 NASA, TerraMetrics | 1000 km | Terms of Use

# What about Space?

Photo by NASA on Unsplash

# This isn’t just a theoretical problem

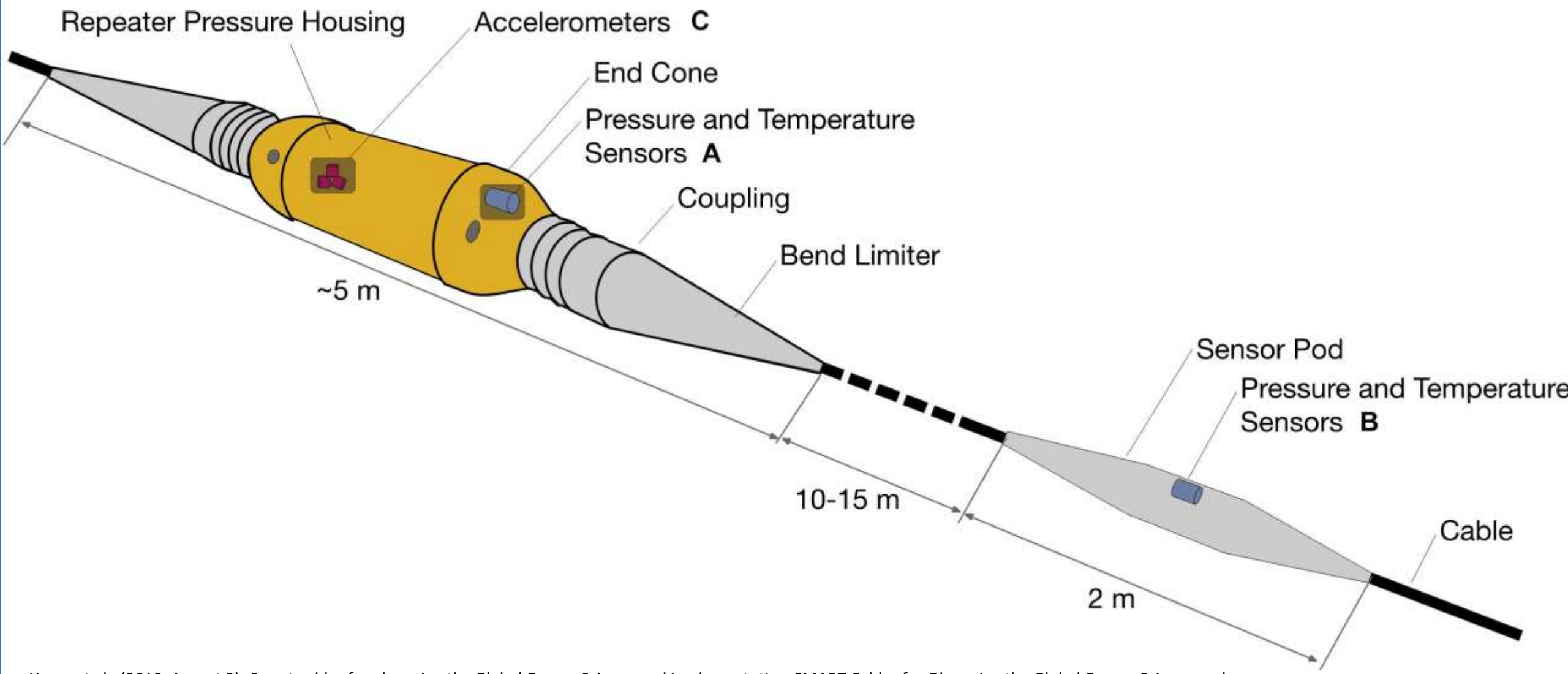





Credit: www.submarinecablemap.com

# Science Monitoring And Reliable Telecommunications

# SMART Cable concept



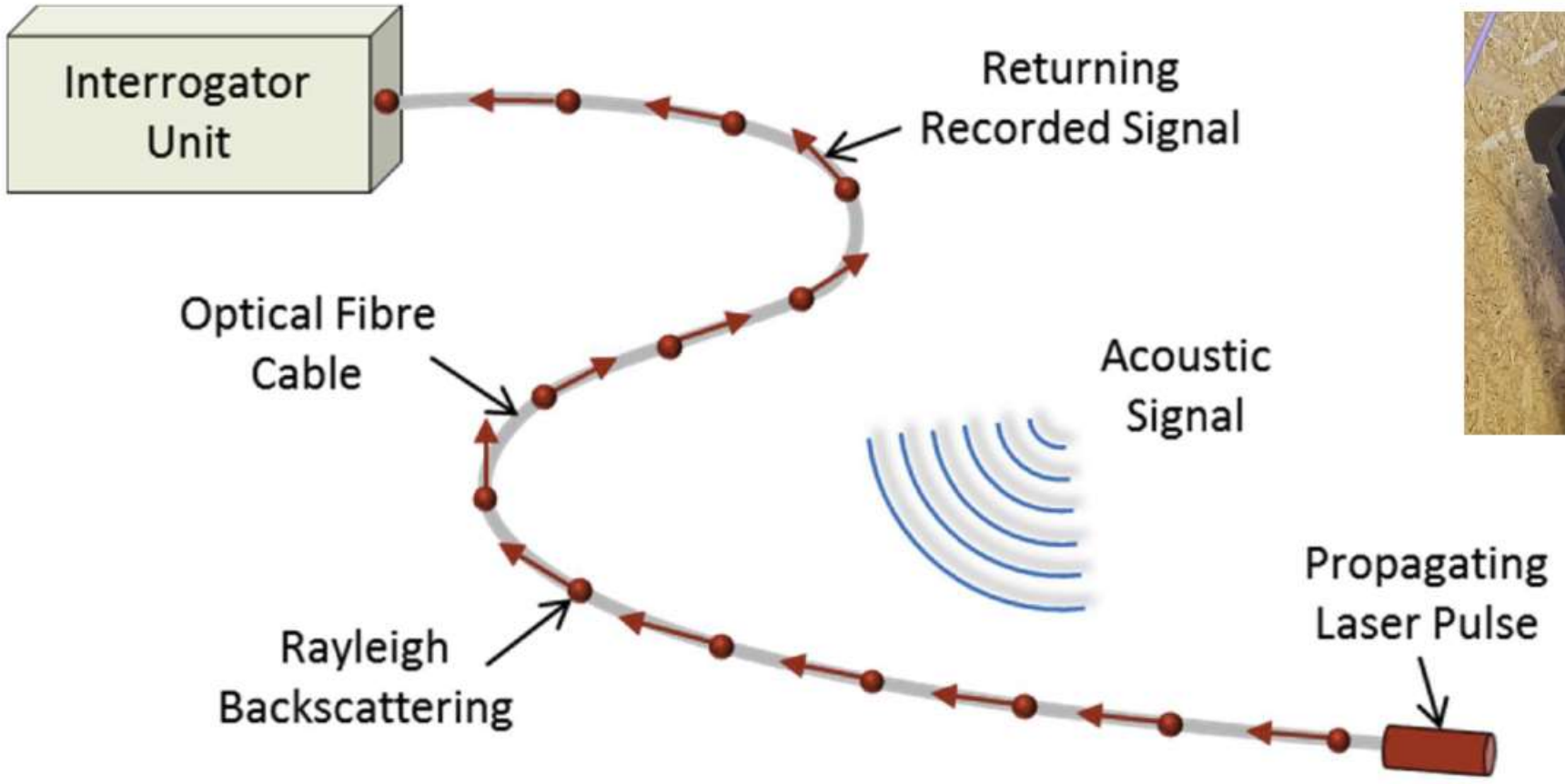

Howe et al., (2019, August 2). *Smart cables for observing the Global Ocean: Science and implementation*. SMART Cables for Observing the Global Ocean: Science and Implementation. Retrieved June 10, 2022, from https://www.frontiersin.org/articles/10.3389/fmars.2019.00424/full

# Is there another way?

Photo by Beth Macdonald on Unsplash

# DAS: Distributed Acoustic Sensing







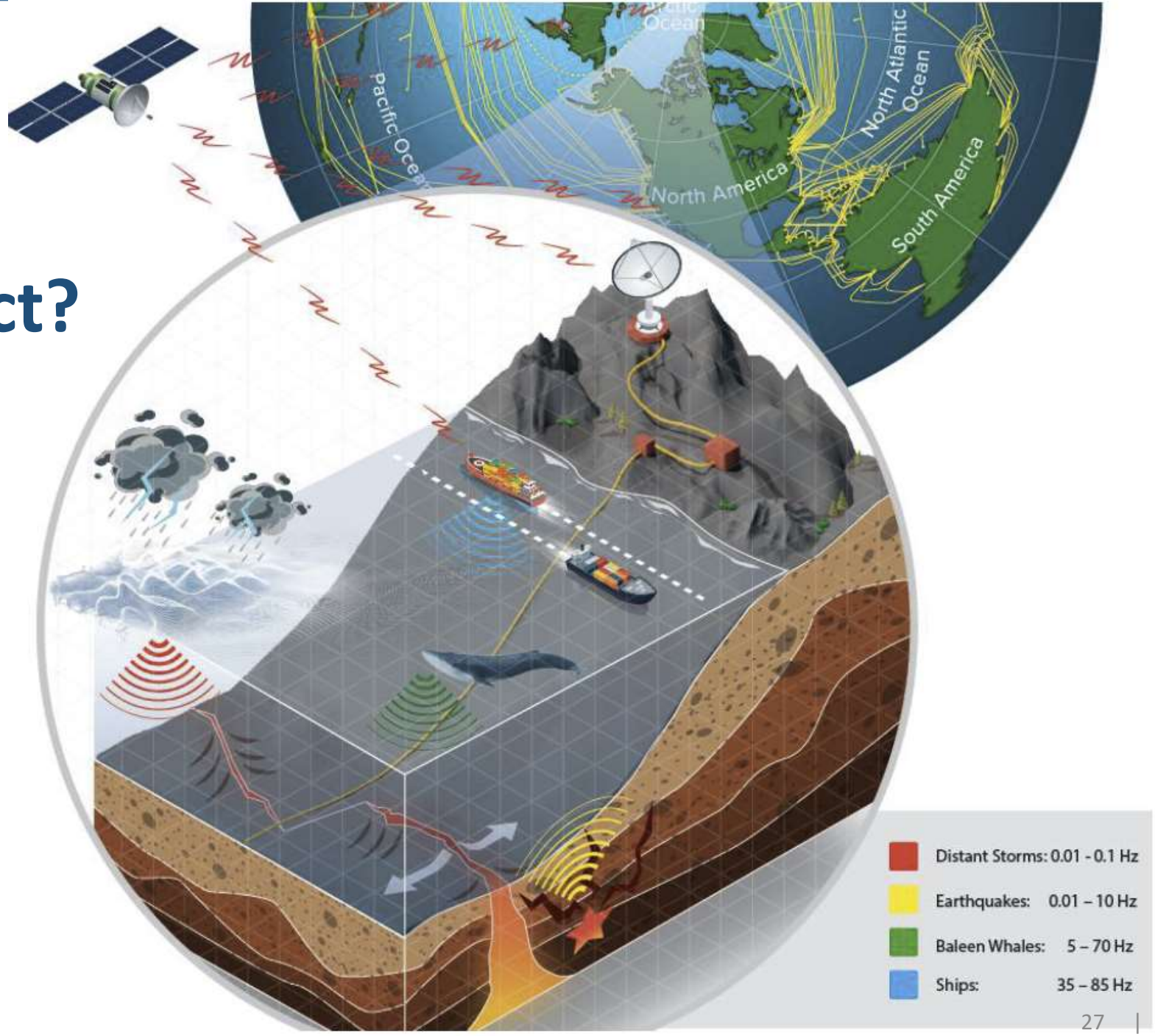
Can also measure transmitted signal or perform polarization analysis at the end of the fibre: SOP

*Figure adapted from Wilks et al. , CLIMIT poster 2016*

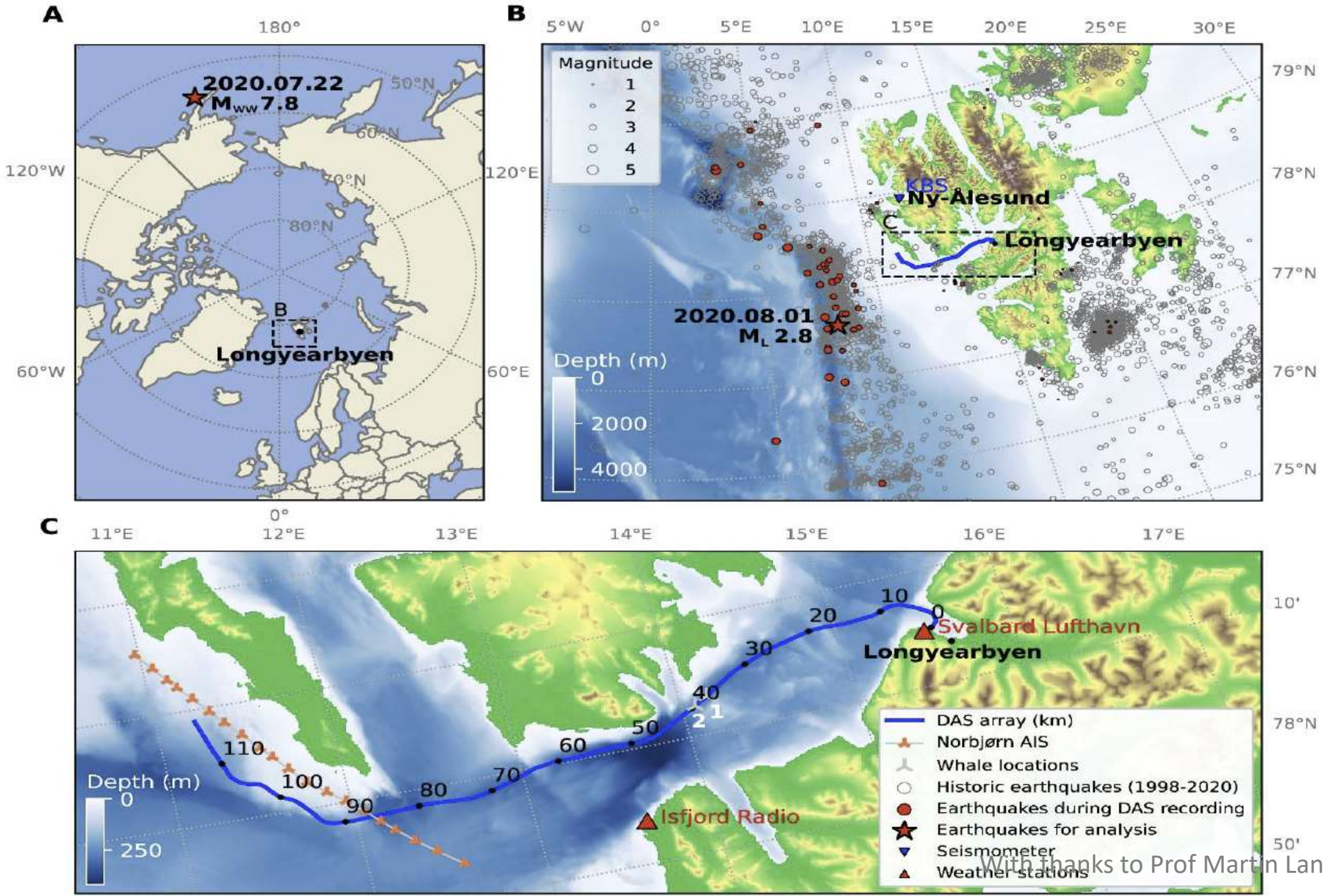
With thanks to Prof Martin Landrø, NTNU

# What can DAS detect?

- Wales
- Storms
- Ships
- Earthquakes
- And more




With thanks to Prof Martin Landrø, NTNU

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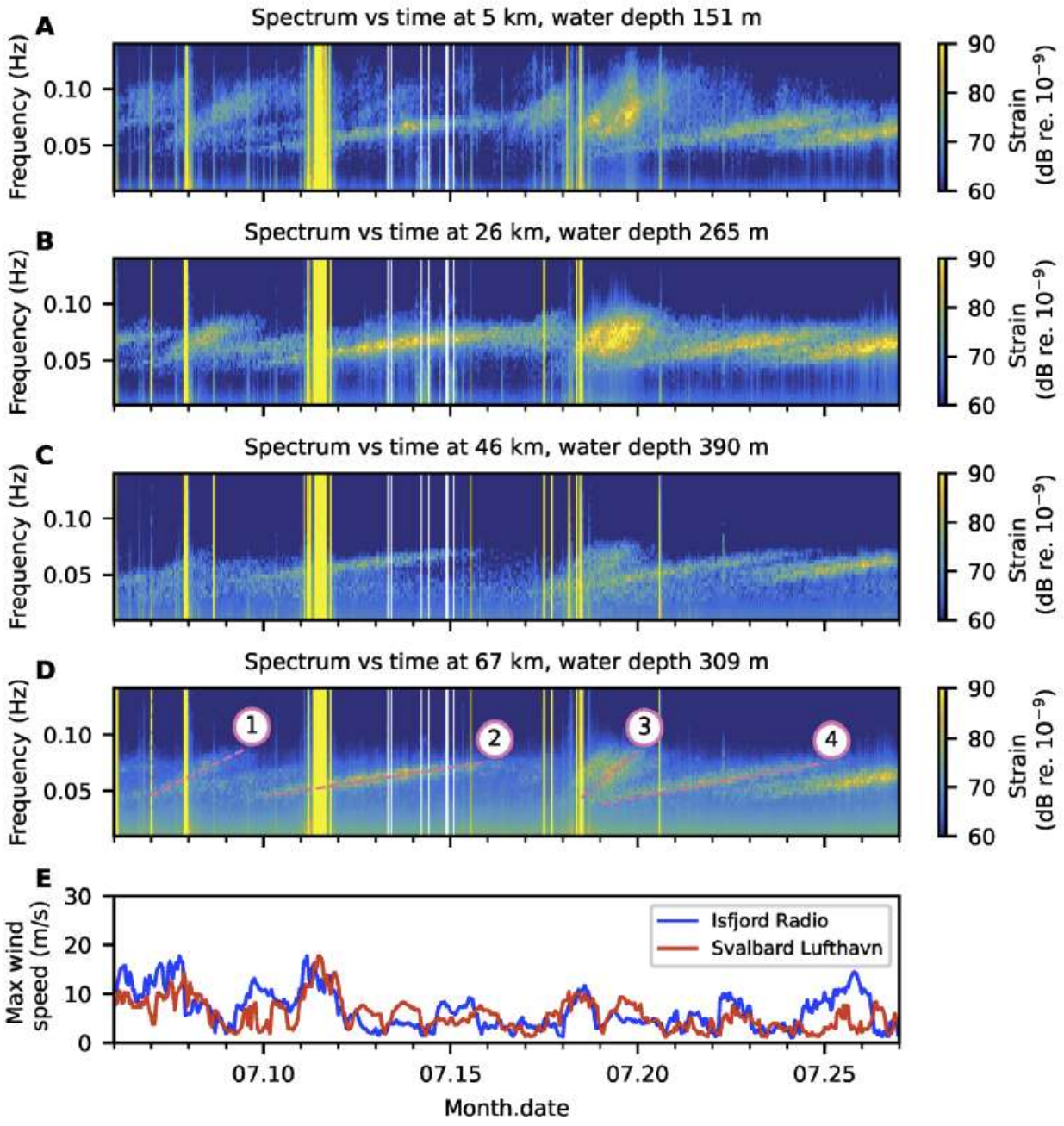
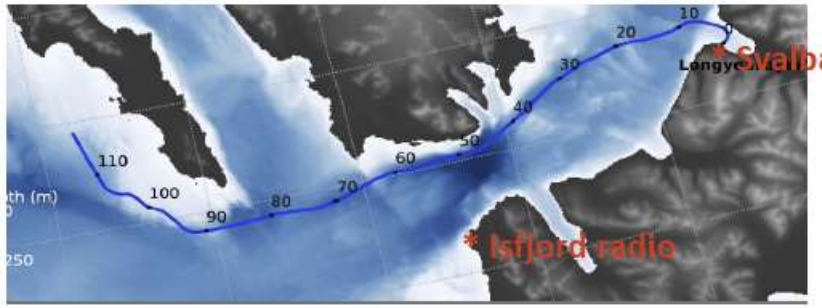



CGF SFI Centre for Geophysical Forecasting



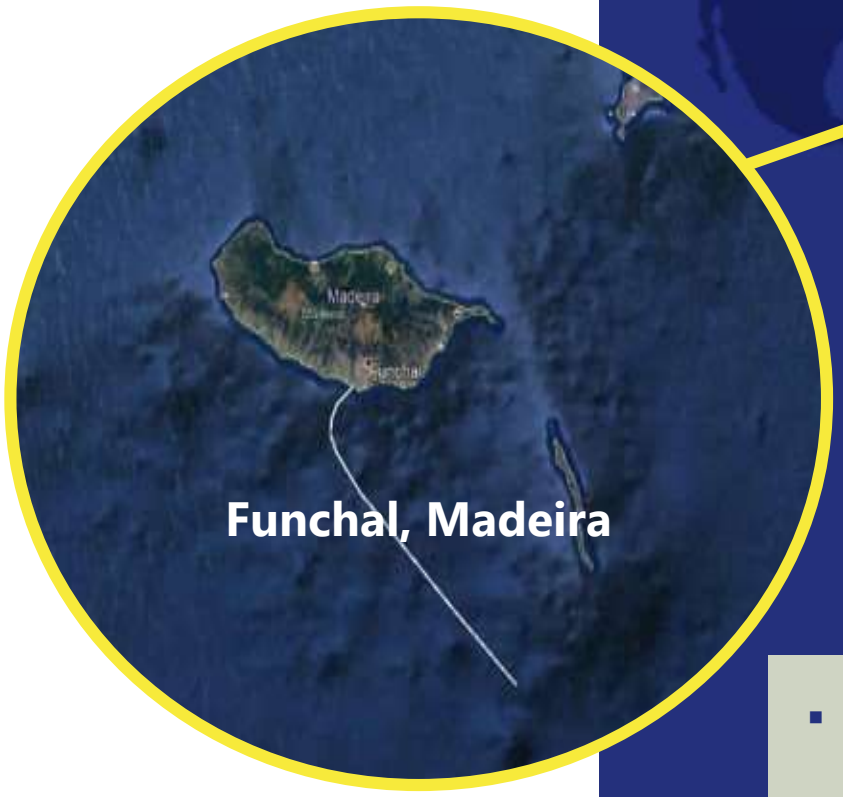

Munk, 1963: $$x = \frac{g}{4\pi\left(\frac{df}{dt}\right)},$$

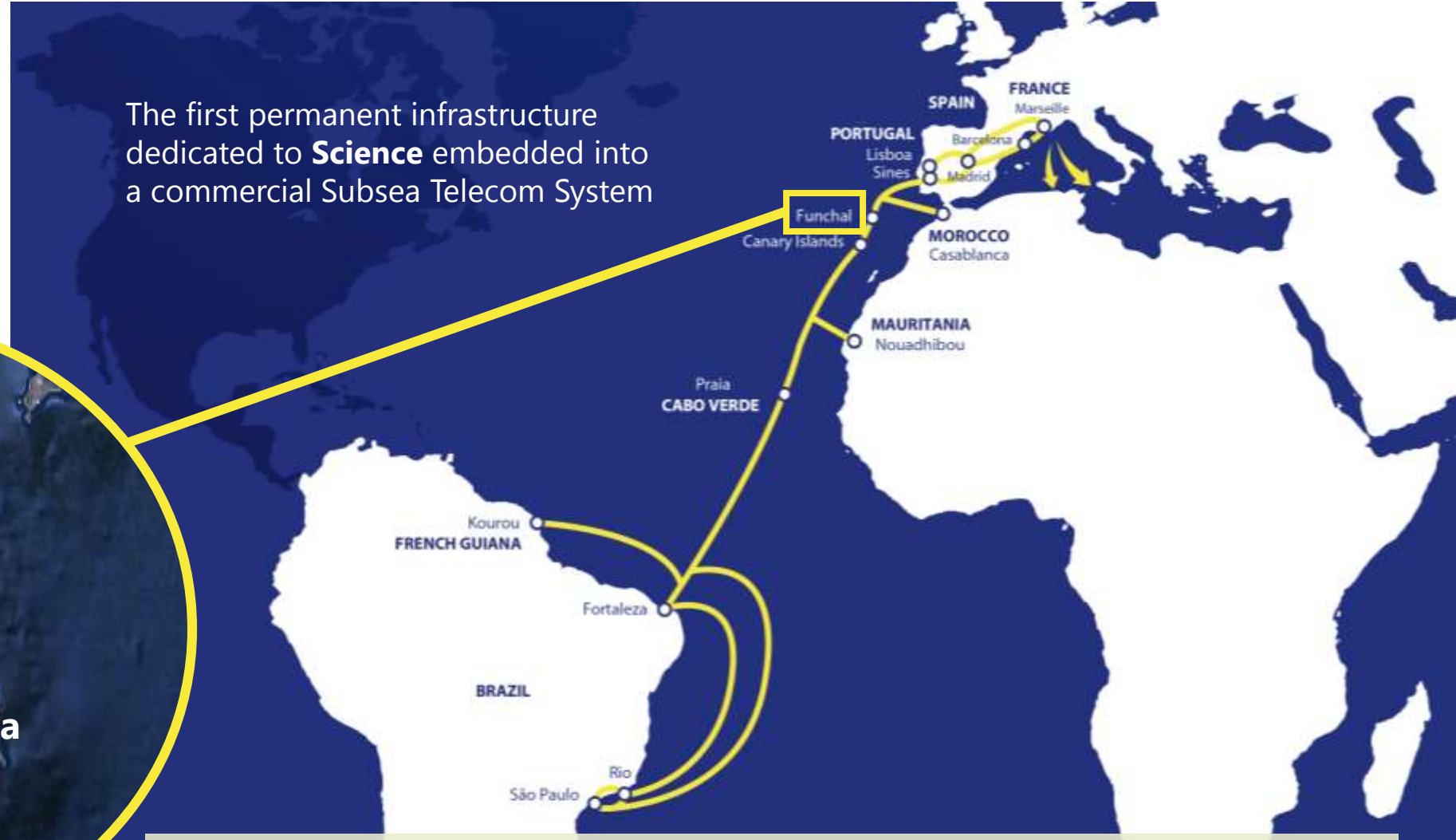
1: Edouard 4100 km
2: Offshore Brazil, 13000 km
3: Storm between Iceland and Greenland 2400 km
4: Offshore Brazil, 11 000 km

With thanks to Prof Martin Landrø, NTNU

# GeoLab

The first permanent infrastructure dedicated to **Science** embedded into a commercial Subsea Telecom System

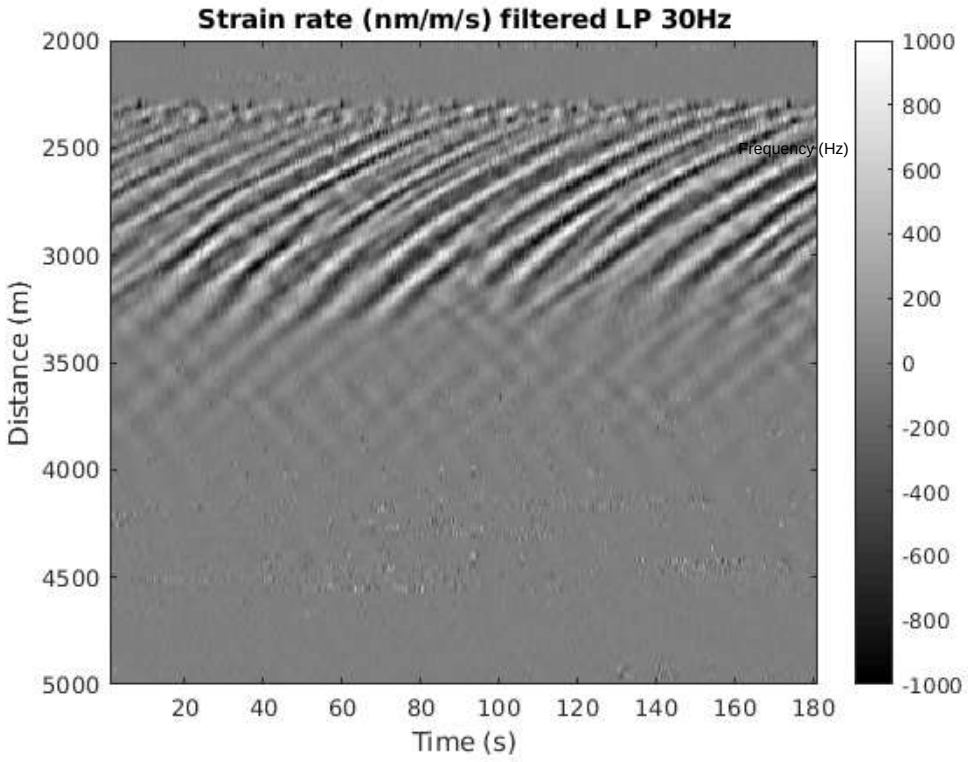


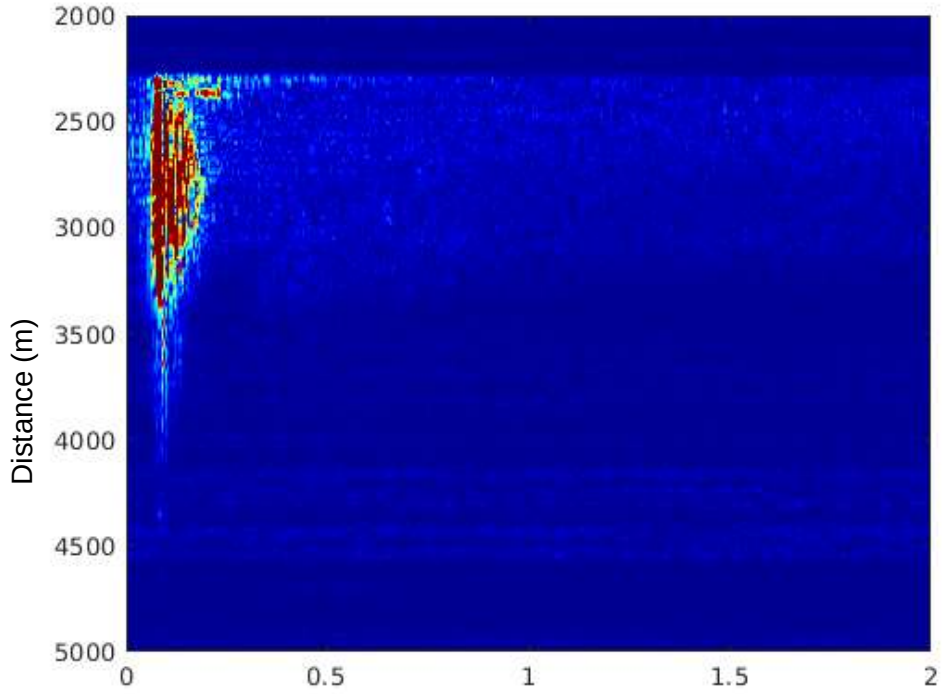




- Seismology, volcanology, marine ecology, and oceanic conditions are key to understanding the future of our planet.
- **EllaLink GeoLab** initiative aims to provide the scientific community with real-time, accurate and relevant data on seabed conditions along the EllaLink cable route.
- EllaLink is the **first telecoms submarine cable to integrate SMART cable** concepts.


Photo by FCT|FCCN

# Some initial results with a DAS at GeoLab



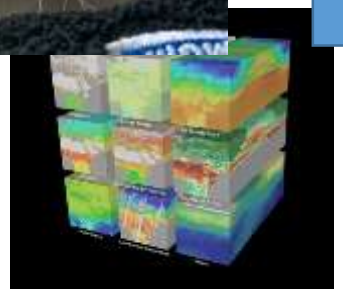

Left: Strain rate recorded at the entrance of the fibre in the water (2.25km) filtered with a low-pass filter at 30Hz. The shallow water ends after around 4.5km of cable. Right: Frequency content of strain rate signal along the fibre.

Atherton et al., (2021, June 16). *Subsea telecoms cables: A driver for scientific research*. Retrieved June 10, 2022, from https://about.geant.org/wp-content/uploads/2021/12/Geolab_white_paper.pdf

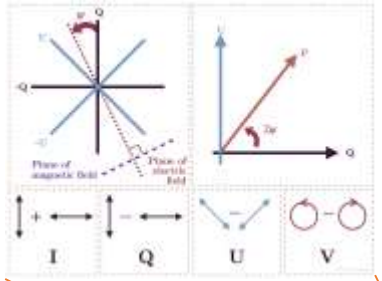
# Dedicated cable required?

Photo by Sharon McCutcheon on Unsplash

# The other technique – State of Polarisation (SoP)



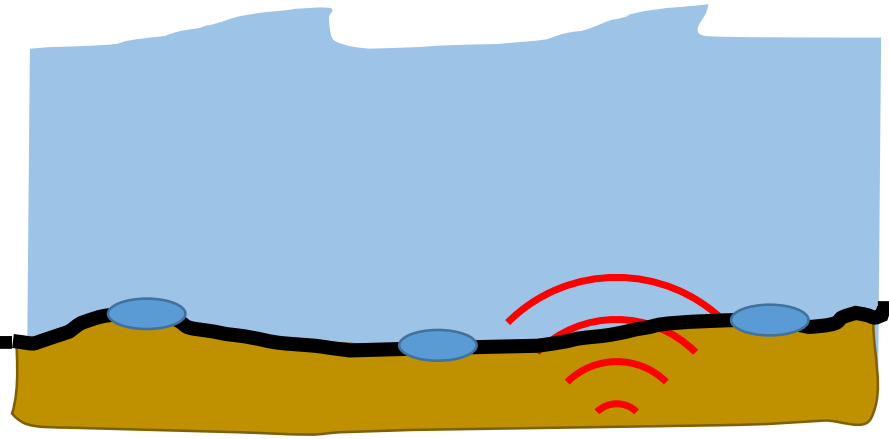
Normal telecoms traffic

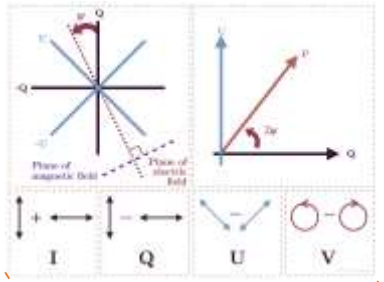



Stokes Parameter

DWDM Optical Transponder

Fibre optic Submarine telecom cable





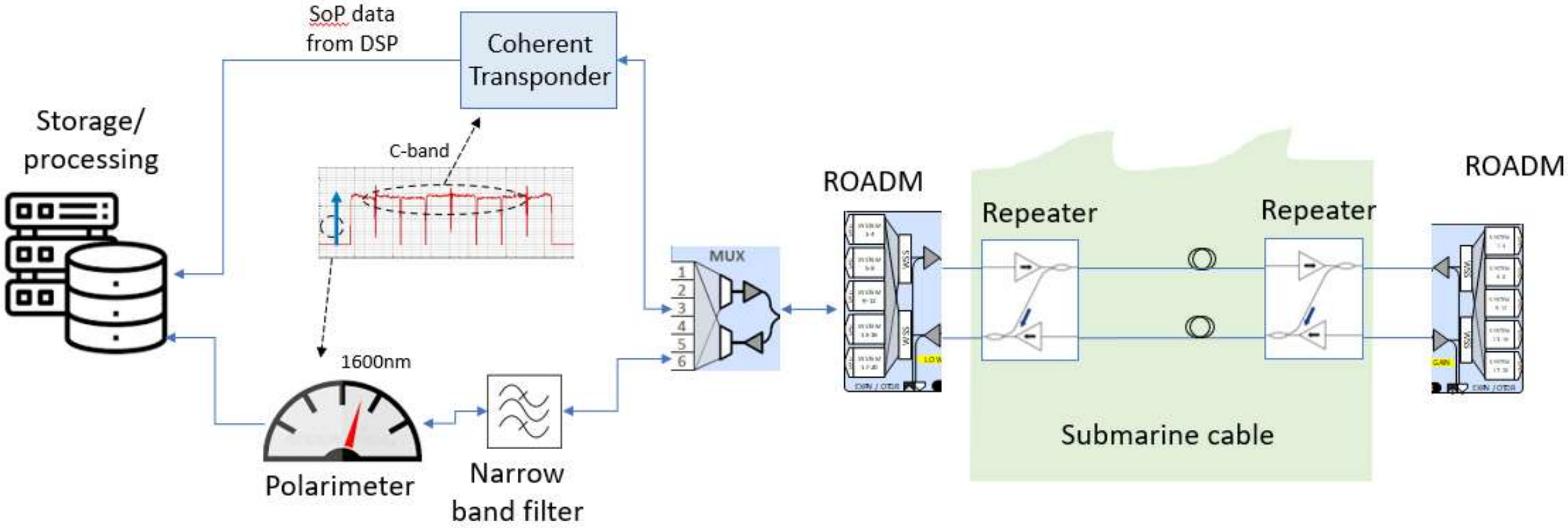

Stokes Parameter

DWDM Optical Transponder

Carrier phase and polarization can be recovered from the DSP outputs.

# SOP OTDR

## Sate of Polarization testing



# SOP OFDR

Optical phase and polarization changes can be recorded across individual cable spans (the cable spans between repeaters) based on the frequency difference between the laser source and repeater units.

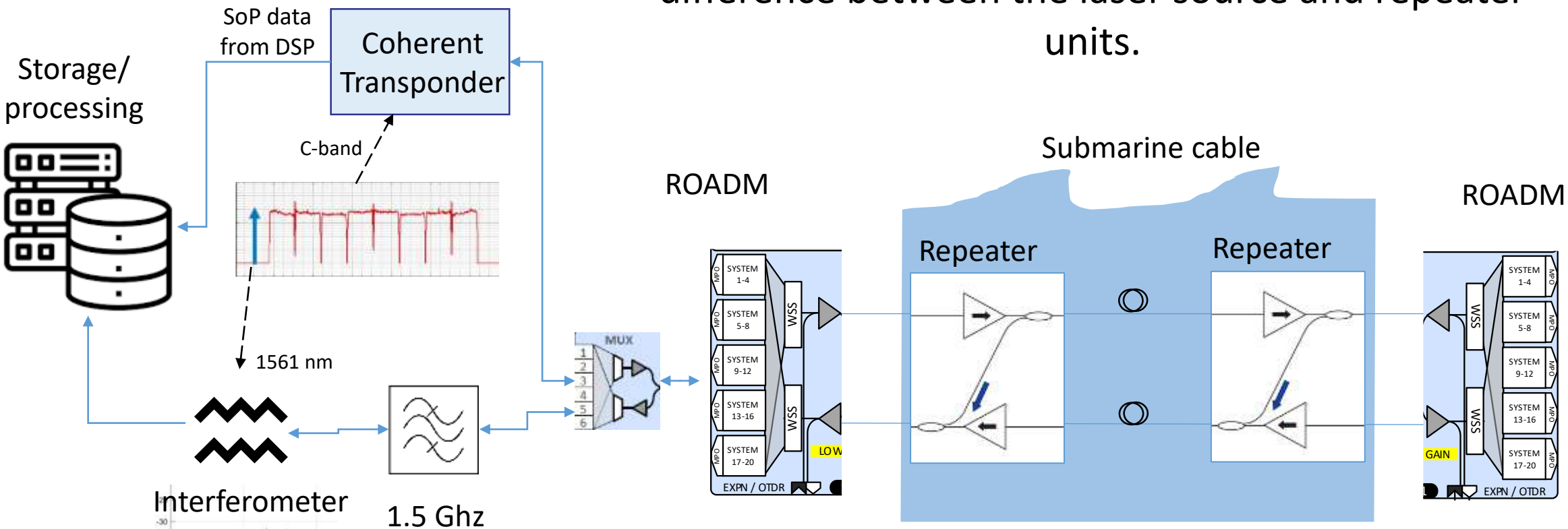
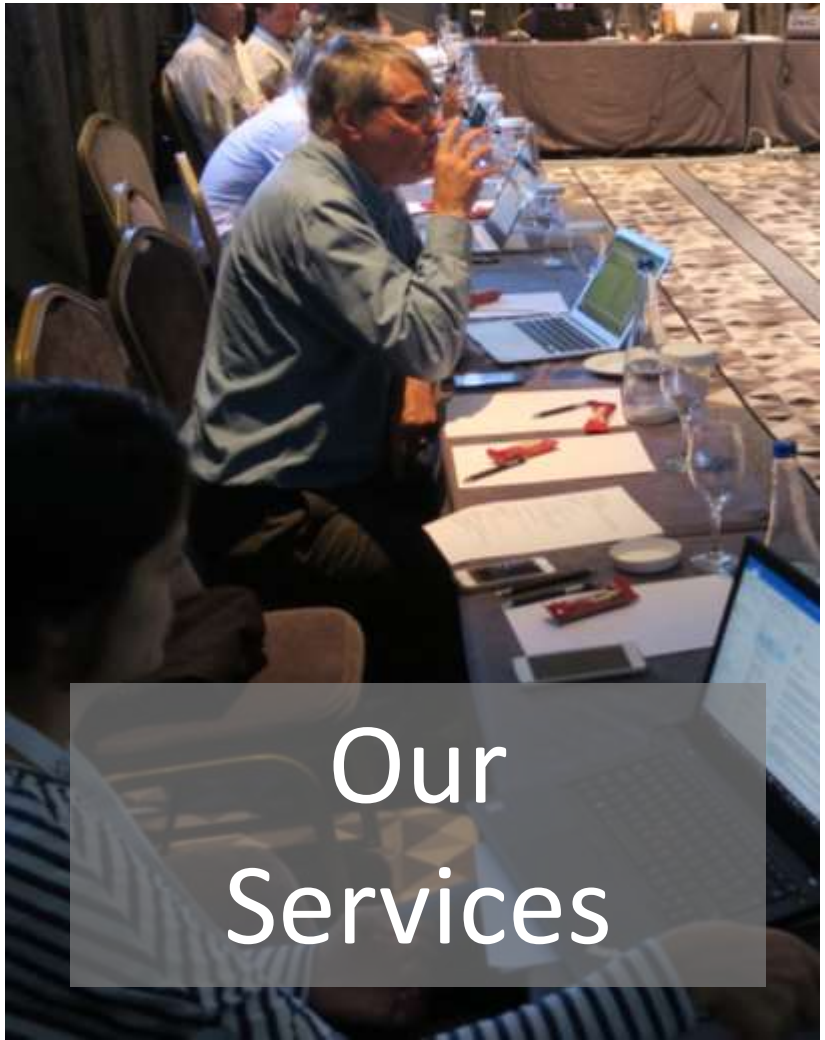
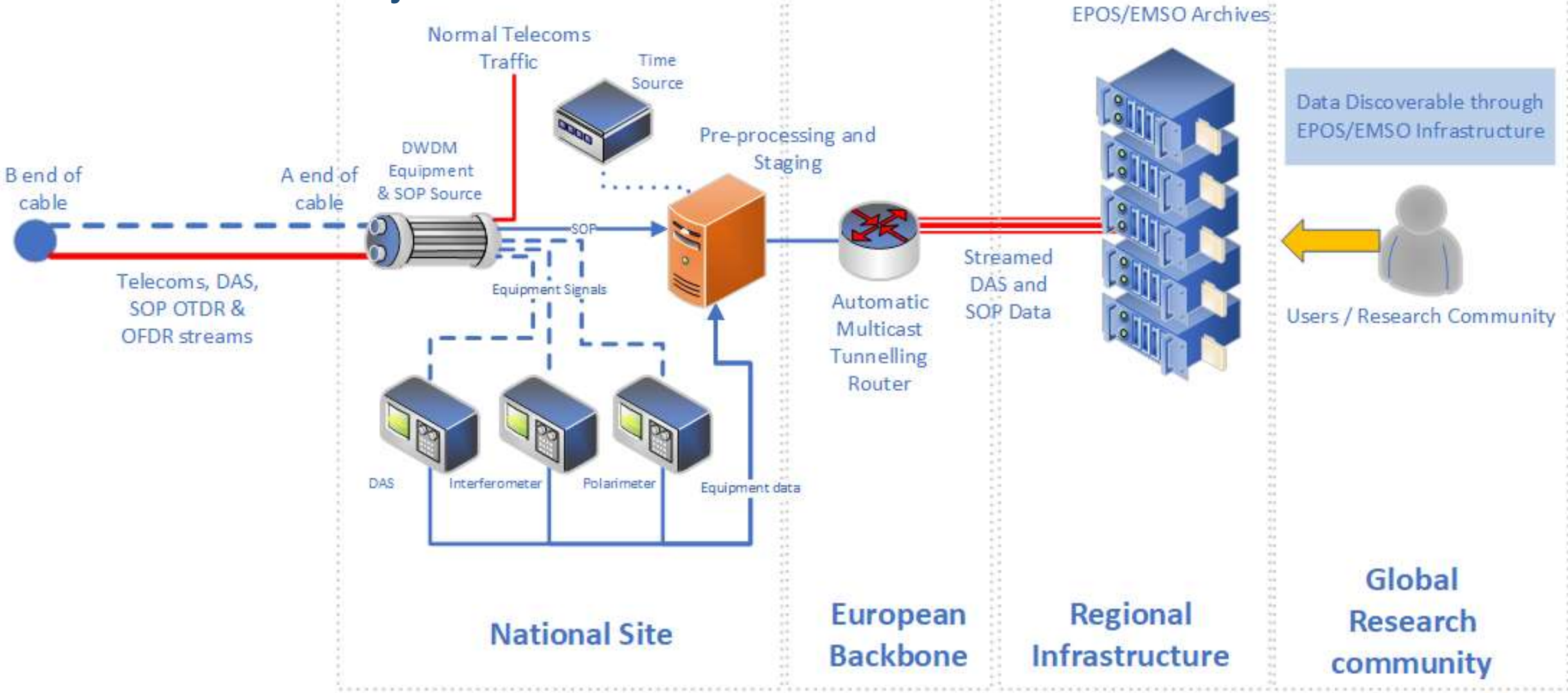



Figure adapted from Marra, G. et al., 2022.

# SOP and DAS – New services we can offer to researchers?

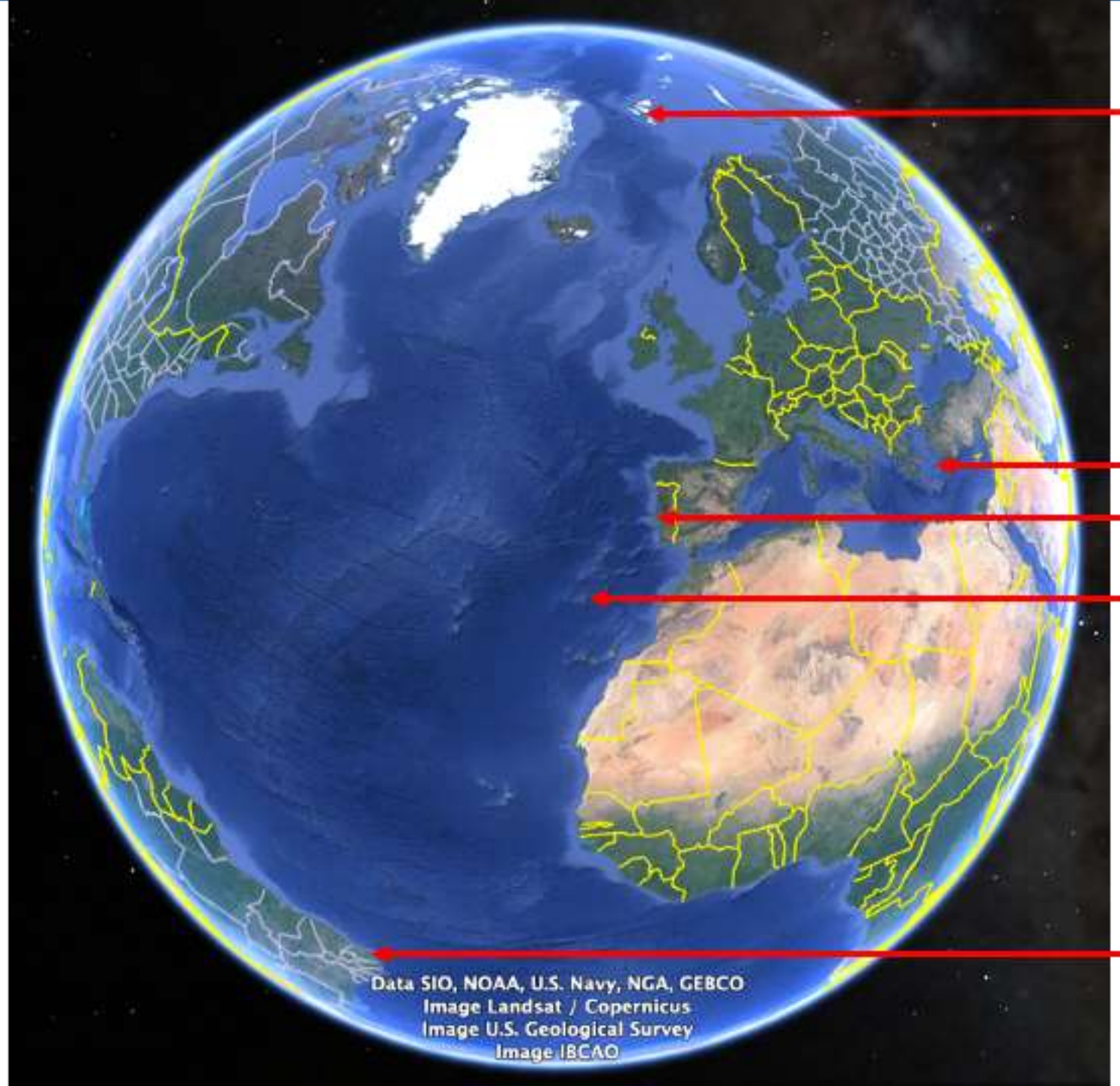
# SUBMERSE Project



# Indicative Site Locations

Primary sites would have both DAS, SOP and SOP OTDR

Secondary sites would not have all experiments



# My challenge to you

# Thank You

Any questions?

www.geant.org


As part of the GÉANT 2020 Framework Partnership Agreement (FPA), the project receives funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 856726 (GN4-3).