

Introduction & Use Cases of Fibre Sensing

Chris Atherton, GÉANT Fibre Sensing Incubator lead

GÉANT Infoshare: NREN Fibre Infrastructure for Sensing 05 Dec 2024



Public (PU)



Welcome.



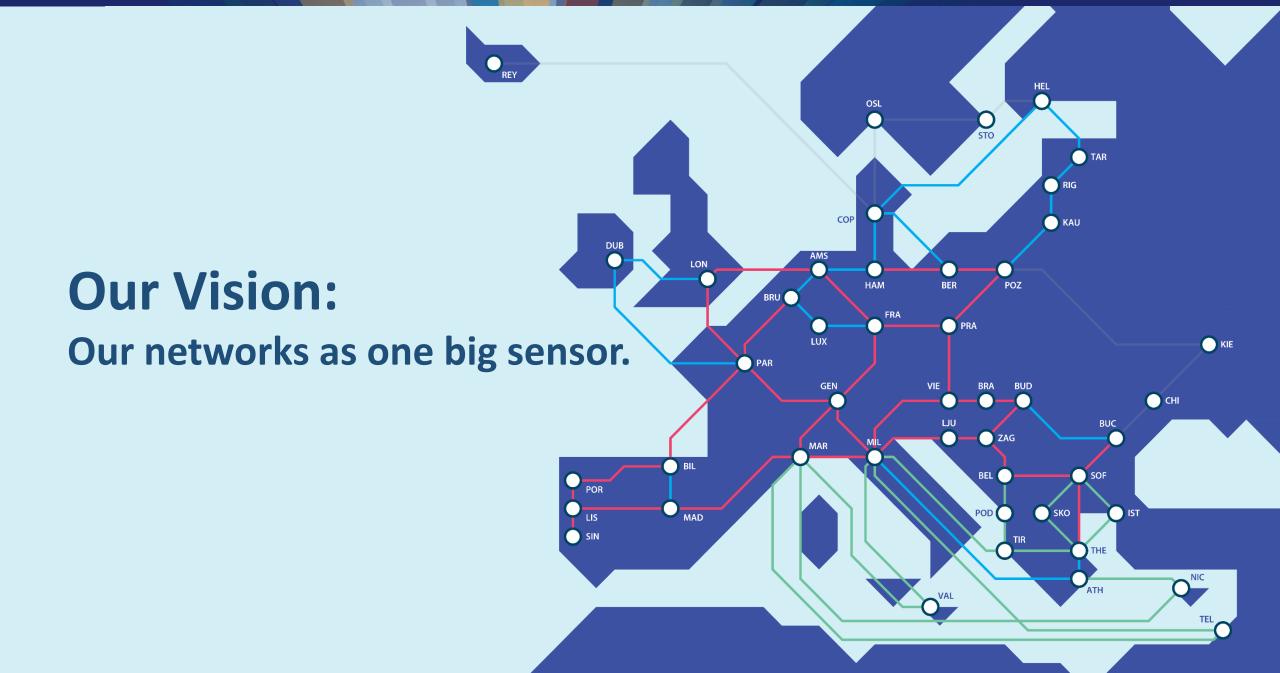
Info share Agenda

- Use Cases of fibre sensing Chris Atherton (GÉANT)
- Fibre Sensing technologies Jan Radil (CESNET)
- Data Acquisition Hannah Mihai (DeiC)
- Q&A



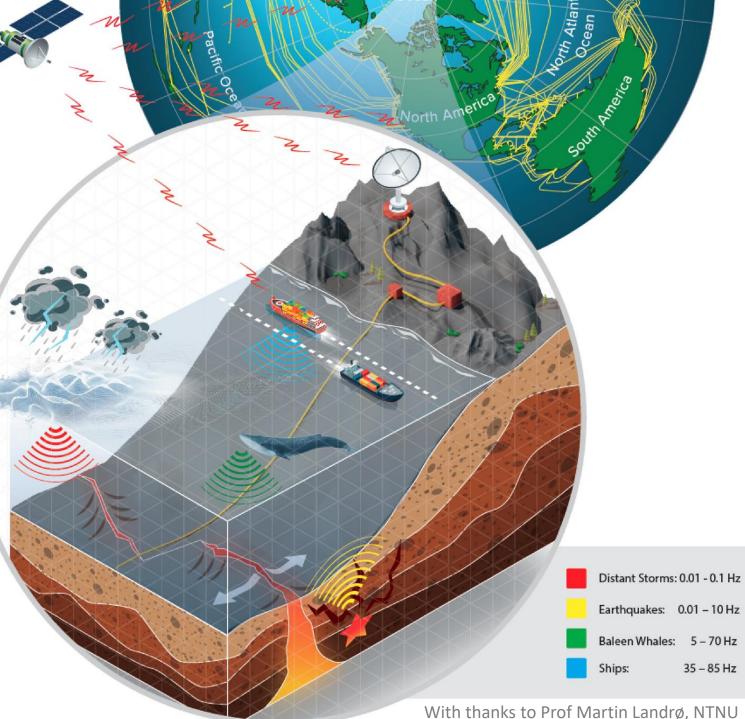
Use cases of fibre Sensing

- The vision
- The three user areas
- Some examples



3 types of users

- Security & operations
- Civil protection
- Scientific Research



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Security & Operations – Cable cuts

- On average 150-200 submarine cable cuts per year. Terrestrially it's assumed more, but there's no real public data source for this.
- Most caused by human interaction (fishing is main issue in submarine cables), 10% by natural forces, abrasion is also a cause in small number of cases.
- Key issues:
 - Disruption
 - Traffic impacts on network from rerouting
 - Delays to other planned work to respond to emergencies
- Protecting the key infrastructure of submarine or terrestrial fibres is in our collective interest.
- Knowing what caused an issue and where can help with decreasing the time to repair.
- Identifying risks and notifying cable operators can prevent cable cuts.
- Trespass Fibre sensing can be used to detect trespass or animal movements on or near a fibre.
- Digging noise or vibrations caused by digging (either humans or machines) can be detected allowing for monitoring and alerting of potential theft or interference.

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Saboteurs Cut Internet Cables in Latest Disruption During Paris Olympics





Red Sea cable cuts' impact was 'severely underestimation and the severely underestimation of t

Network services provider RETN says the February 2024 submarine cable cuts in the Red Sea affected clo Europe-Asia data traffic flow, not the 25% initially reported.



Undersea cable cuts in the Baltic Sea are stoking geopolitical tensions here's what's going on







Start Cable Types × Fiber optic cable × Cable Application × Business × Information

British and French Submarine Communication Cables Cut

Since the explosion of the Nord Stream gas pipeline in September, Europe has witnessed the breaking of submarine communication cables in Norway and the deliberate cutting of railway cables in Germany. The 20 October, the UK submarine fiber optic cable linking the Shetland Islands to Soutland was damaged. At this same time, submarine cables in the south of France also failed, affecting three important lines of communication.

The successive interruptions of infrastructures have raised concerns about the security of communications. The vulnerability of critical energy and communication infrastructure is of great concern.

UK Submarine Cable Outage Leaves Islands Offline

the submarine cable SHEFA-2, connecting the Faroe Islands with mainland Scotland via the Shetland Islands and Orkney, was damaged in two separate incidents leaving most of the islands without internet connection.



Raw Datasets Archived Projects Sponsorship

Home / Analyse / Archived Projects / Mediterranean Fibre Ca..

Mediterranean Fibre Cable Cut - a RIPE NCC Analysis

Analysis by the RIPE NCC Science Group with contributions from Roma Tre University. Editors: Rene Wilhelm, Chris Buckridge

Introduction

On the morning of 30 January 2008, two submarine cables in the Mediterranean Sea were damaged near Alexandria, Egypt. The media reported significant disruptions of Internet and phone traffic in the Middle East and South Asia. About two days later, a third cable was cut, this time in the Persian Gulf, 56 kilometers off the coast of Dubi. In the days that followed more news on other cable outages came in.

The RIPE NCC Science Group has looked at the impact these events had on Internet connectivity by analysing data collected by RIPE NCC Information Services.

Security & Operations – Evidence gathering

Svalbard cable cut 7th Jan 2022.

Investigation dropped due to lack of evidence. Initially believed to be due to human activity. Experts believe an anchor or trawl caused the break.

A Russian Research Vessel / Trawler had ship automatic identification system (AIS) transponder turned on during the time of the cut.

Said vessel on AIS made 107 passes over the spot where the cable was cut in hours leading up to the break.

The cable was buried 2m deep in sediment. Periodically there is significant trawling activity in the area. On that day there were numerous vessels fishing but only the Russian trawlers were crossing the cable.

Fibre sensing can play a part here.



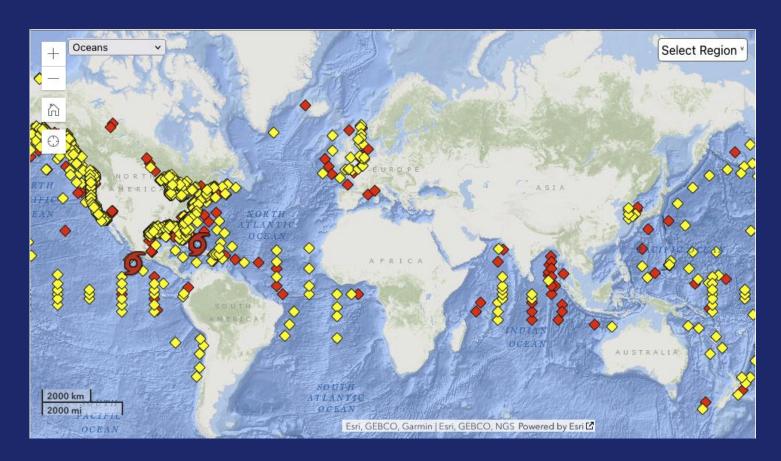
The police images shed light on what happened to the Svalbard cable on the night of January 7, 2022. The outermost layer is a protective coating made of nylon yarn impregnated with tar. It appears to have been peeled off. FOTO: POLITIET

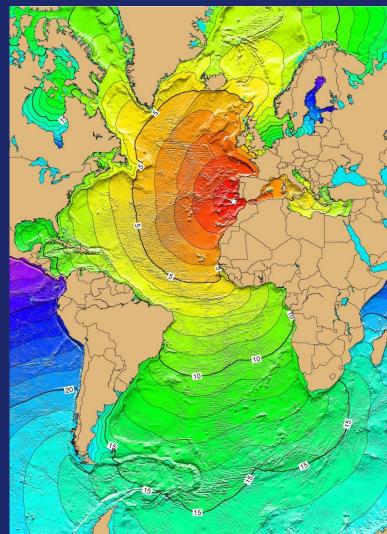
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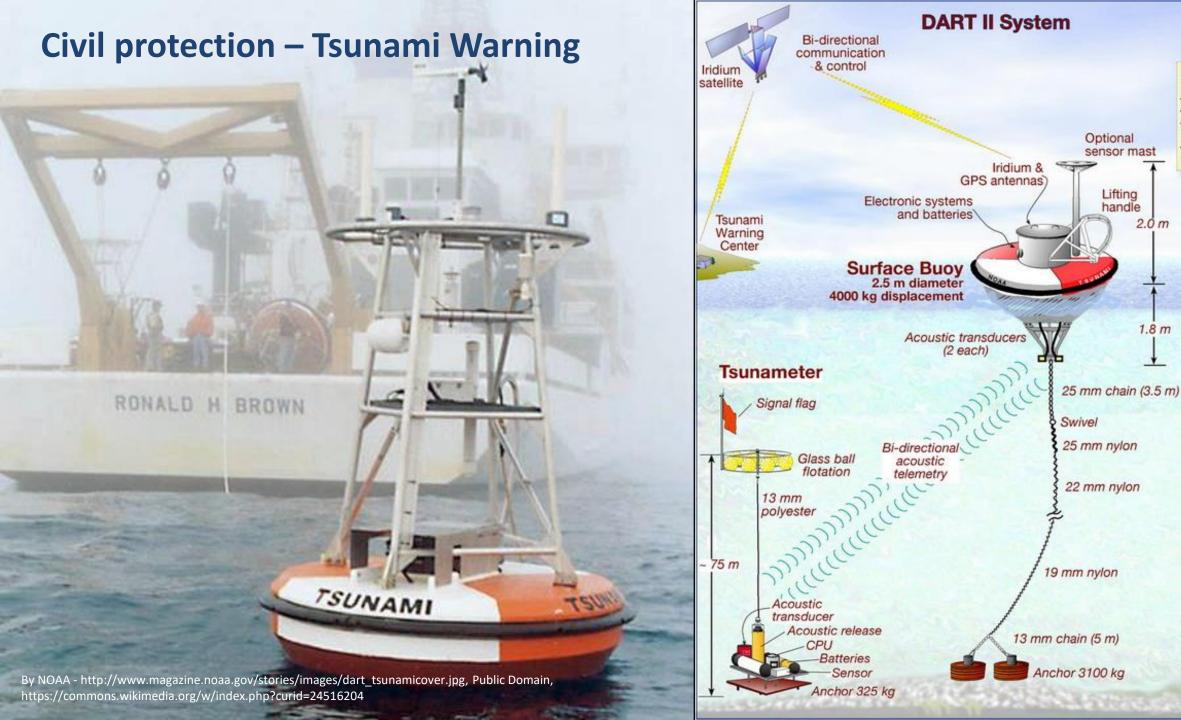
https://www.nrk.no/tromsogfinnmark/this-is-what-thedamaged-svalbard-cable-looked-like-when-it-came-up-fromthe-depths-1.16895904

Civil protection – Tsunami Warning





https://www.ngdc.noaa.gov/hazard/tsu_travel _time_events.shtml



Optional

met sensors

Barometric Pressure Seasurface Temp & Conductivity

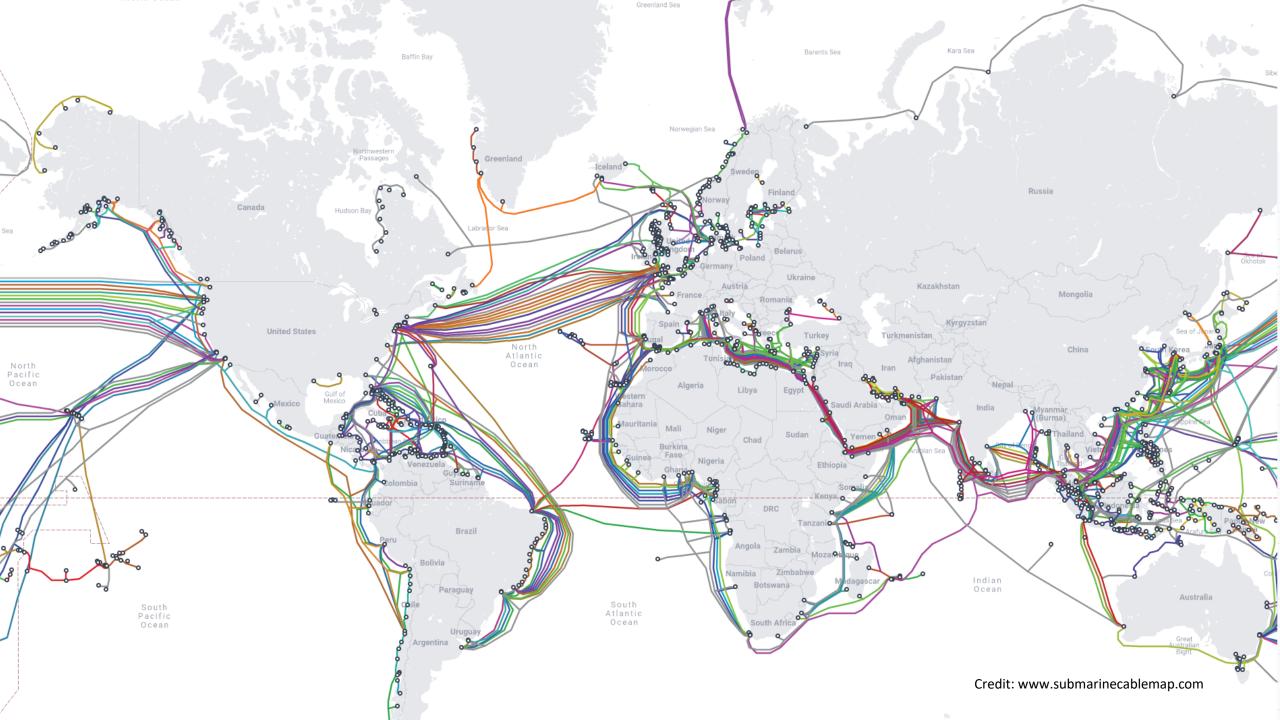
Air Temperature/

Relative Humidity

Wind

-

1000-6000 m

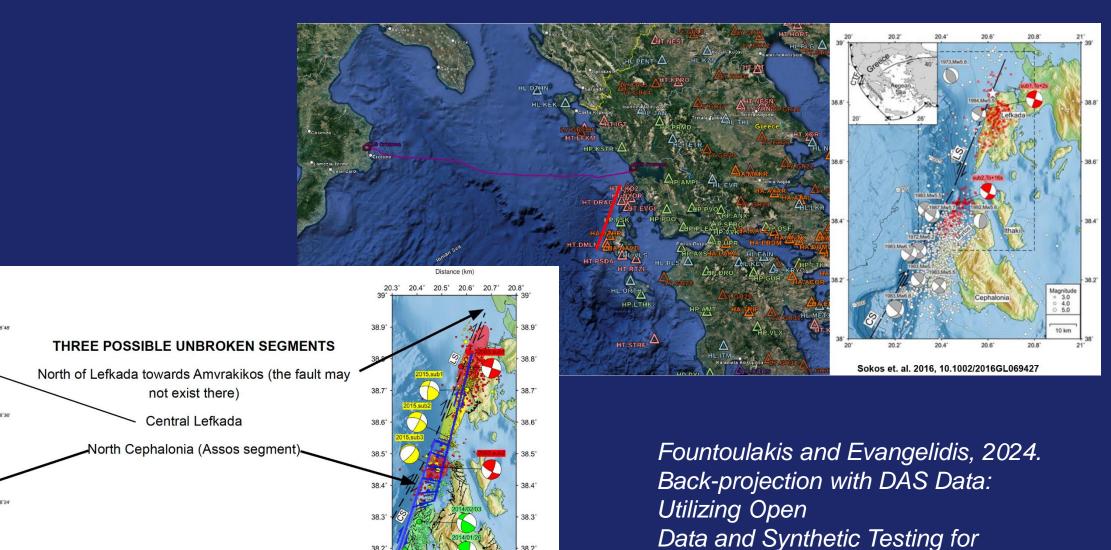


Civil protection - Earthquake monitoring

Ionian Sea

20'24'

0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8



Avallone et. al, 2017 Sci Rep g/10.1038/s41598-017-10431-w Sokos et. al. 2016, GRL,

10.1002/2016GL069427

38.1° 20.3° 20.4

20.5° 20.6° 20.7° 20.8

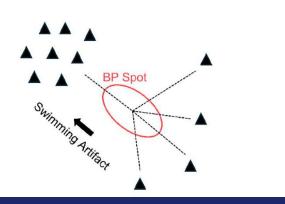
Deployments. SUBMERSE Project

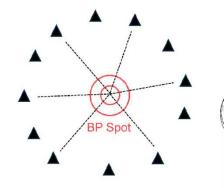
Future

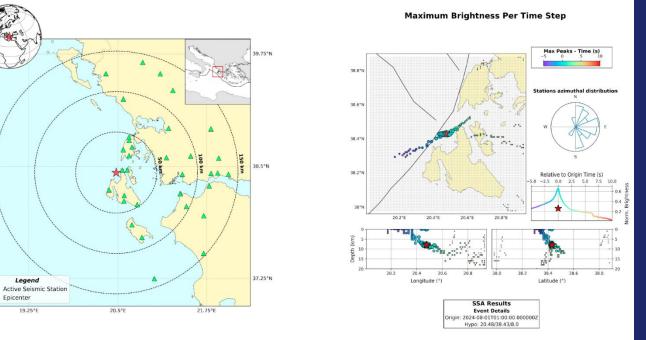
Civil protection - Earthquake monitoring

"When BP executions have missing or insufficient data for some azimuths around the source, the resulting images typically feature poorly defined sources and significant uncertainty"

~swimming artifact~







Fountoulakis and Evangelidis, 2024. Back-projection with DAS Data: Utilizing Open Data and Synthetic Testing for Future Deployments. SUBMERSE Project.

*

Civil protection – Building regulations

Building codes are sets of regulations governing the design, construction, alteration and maintenance of structures. They specify the minimum requirements to adequately safeguard the health, safety and welfare of building occupants.

Some provisions within the International building code standards (from International Code Council (ICC)) are intended to ensure that structures can adequately resist seismic forces during earthquakes. These seismic provisions represent the best available guidance on how structures should be designed and constructed to limit seismic risk.

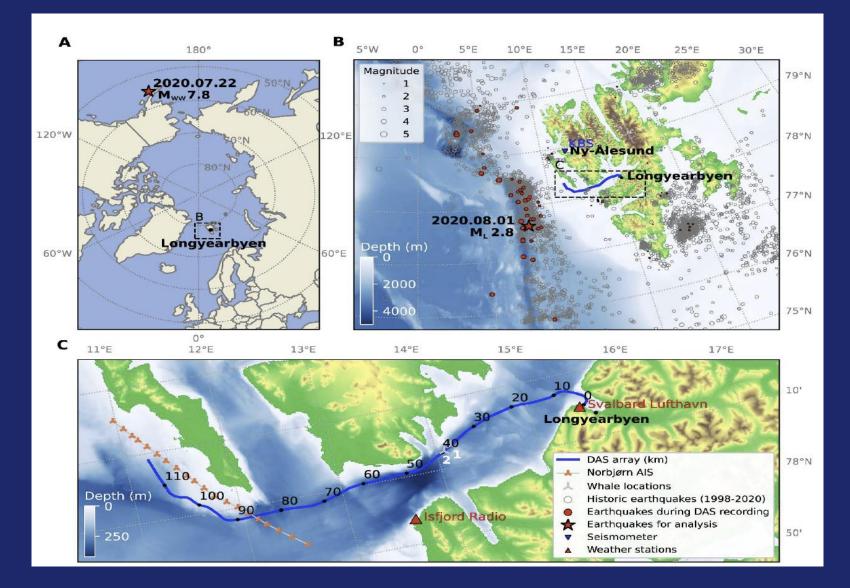
Changes or additions to the seismic provisions come from many different sources, including new research results and documentation of performance in past earthquakes.

Several seismic institutes, whom NRENs already serve with connectivity and services, define the seismic provisions in the building regulations in their respective country.



https://www.fema.gov/emergency-managers/riskmanagement/earthquake/seismic-building-codes

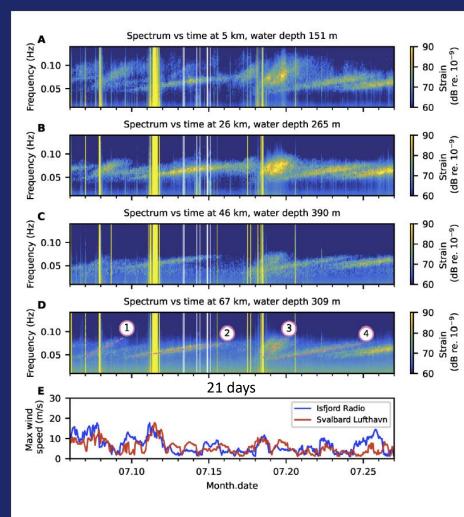
Scientific Research - Seismology

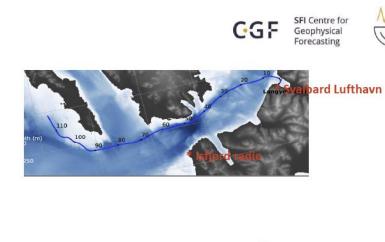


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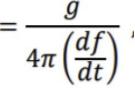
Audio of an earthquake recorded from a submarine fibre using DAS

Scientific Research - Oceanography

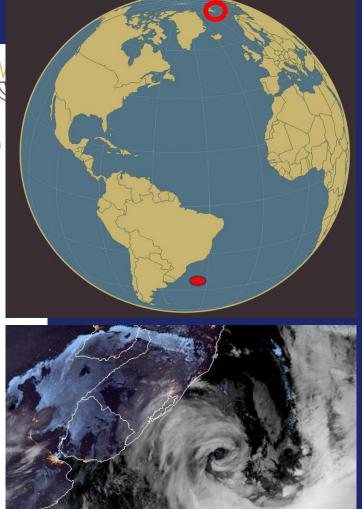




Munk, 1963:



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

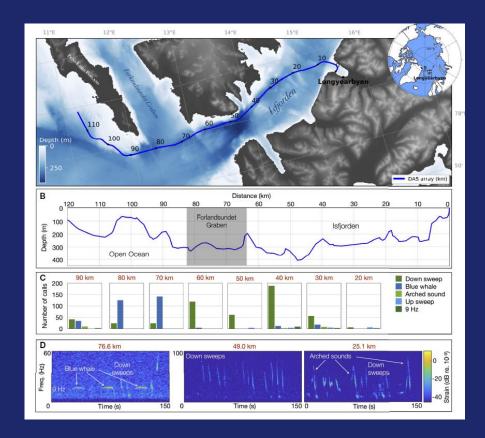


L. Farias. Extratropical cyclone will hit the west and south of Santa Catarina this Tuesday. NOTISUL, 2020

With thanks to Prof Martin Landrø, NTNU https://doi.org/10.1038/s41598-022-23606-x

Scientific Research – Marine biology







Baleen whale vocalizations detected over the 120 km of the Svalbard underwater distributed acoustic sensing (DAS) array

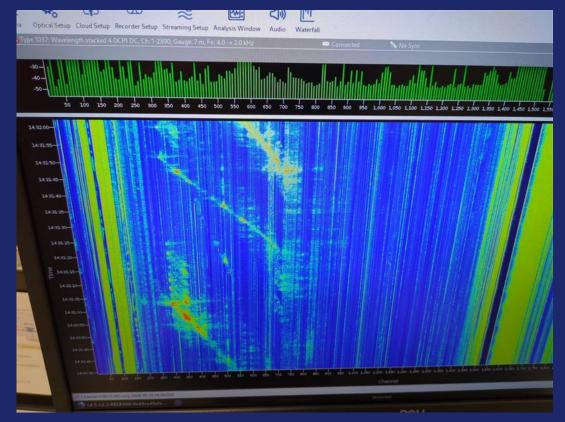
Source: Le' a Bouffaut et al. , Eavesdropping at the Speed of Light: Distributed Acoustic Sensing of Baleen Whales in the Arctic, Frontiers in Marine Science, July 2022

Scientific Research – Sociology / Urban planning

Traffic monitoring is possible with fibre sensing

M. van den Ende, A. Ferrari, A. Sladen and C. Richard, "Next-Generation Traffic Monitoring with Distributed Acoustic Sensing Arrays and Optimum Array Processing," 2021 55th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, USA, 2021, pp. 1104-1108, doi: 10.1109/IEEECONF53345.2021.9723373.

Fontana, Marco and García-Fernández, Ángel F. and Maskell, Simon, Notch Periodogram for Multiple Vehicle Trajectory Estimation with Distributed Acoustic Sensing. Available at SSRN: <u>https://ssrn.com/abstract=4845199</u> or <u>http://dx.doi.org/10.2139/ssrn.4845199</u>



Car travelling along road outside University College Cork.

With thanks to Dónal Cunningham (HEANet) and Dr. Abhinav Gautam of the Tyndall Institute, University College Cork

Scientific Research – Applied sciences

Fibre sensing can also be used for monitoring train or tram health

- Rockfalls Vibrations from falling rocks on or near a fibre can detected.
- Landslides Movement of large volumes of soil, rock, earth generate vibrations which can also be detected on or near a fibre.

•Catenary flashovers: When electrification faults cause a flashover (for example from tree branches too close to overhead power lines), it makes a brief but distinctive noise. Fibre sensing can geolocate the fault saving inspection and repair team's significant time.

•Track condition monitoring: Because fibre sensing can be used to monitor changes over time it can be used to detect performance changes in the rail infrastructure (track condition) or the trains themselves as they pass by or along the fibre.



Now over to the technologies

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