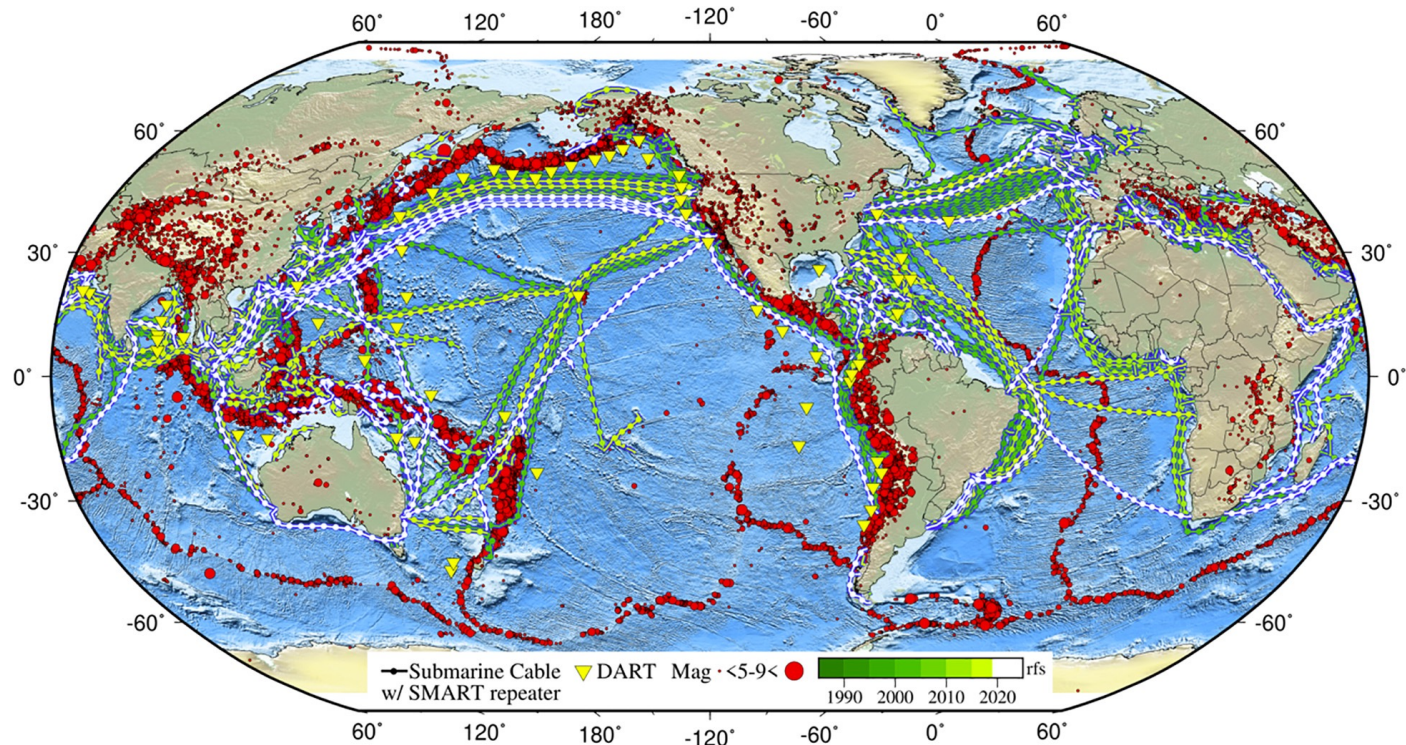


Trans-Oceanic Distributed Fiber Sensing

Zhongwen Zhan (Caltech)



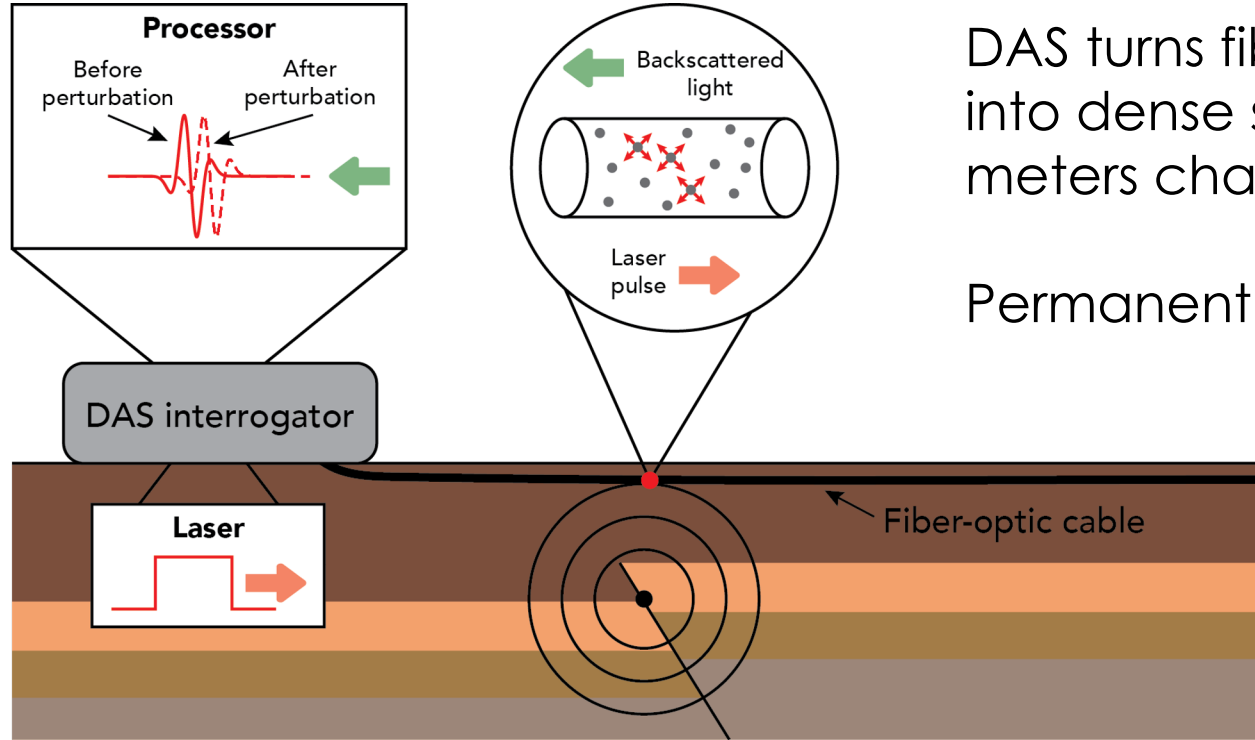
What is different?

Fiber infrastructure as platform

vs.

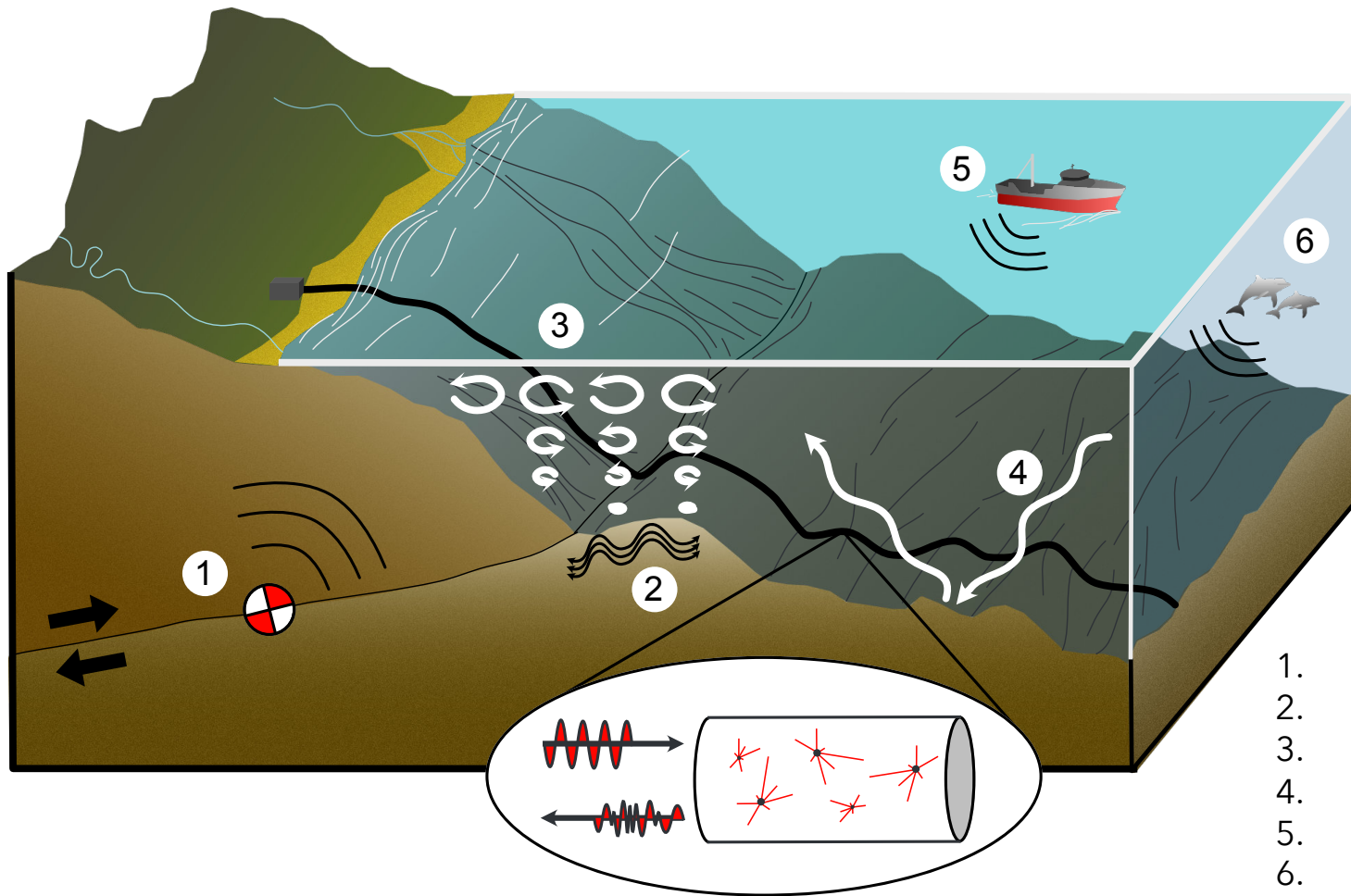
Fiber infrastructure as sensors

Distributed **A**coustic **S**ensors (DAS)



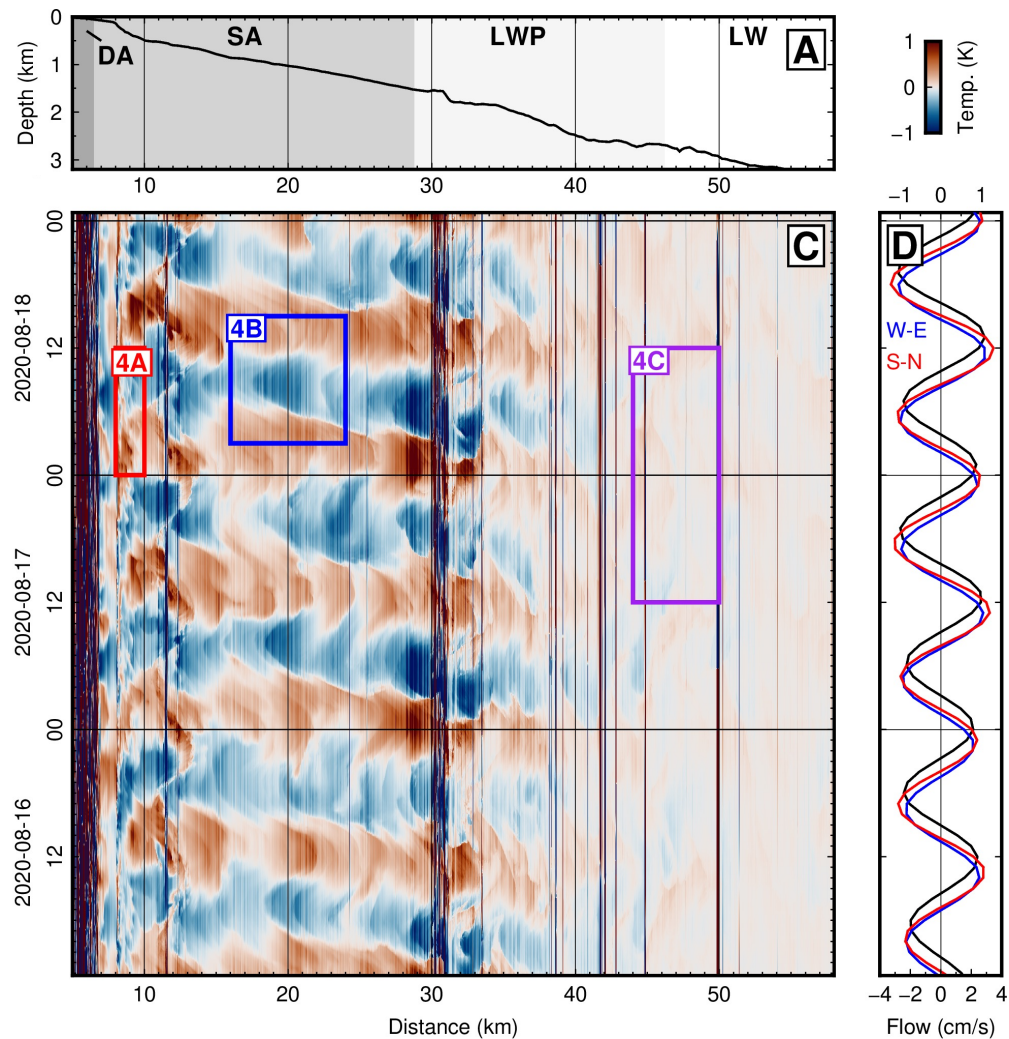
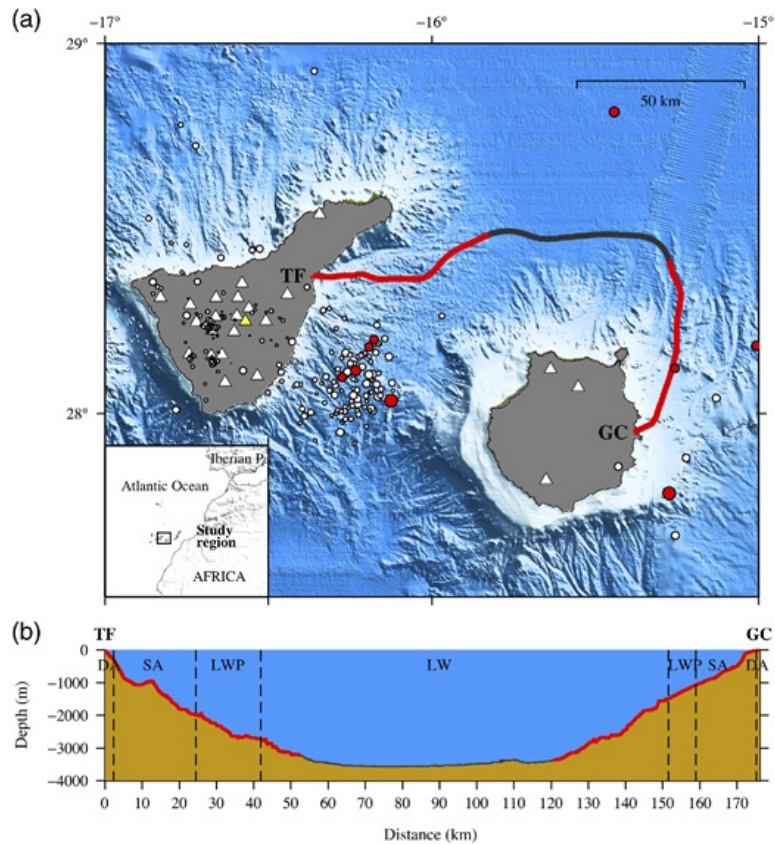
DAS turns fiber-optic cables into dense seismic arrays with meters channel spacing.

Permanent & continuous.



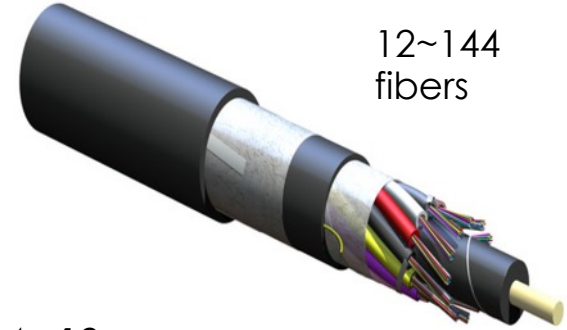
1. Earthquakes
2. Ambient seismic noise
3. Surface gravity waves
4. Internal gravity waves
5. Anthropogenic noise
6. Marine mammal vocalizations

Nonlinear internal tides at Gran Canaria

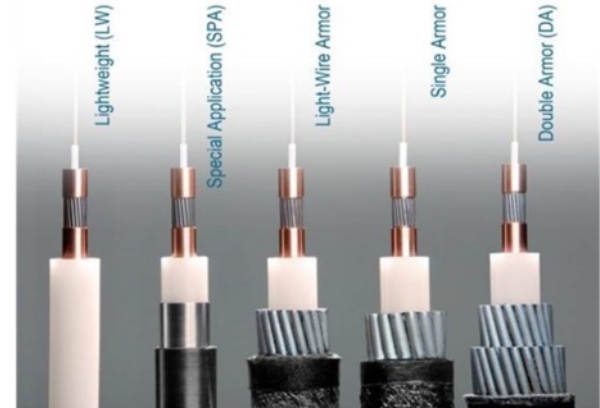


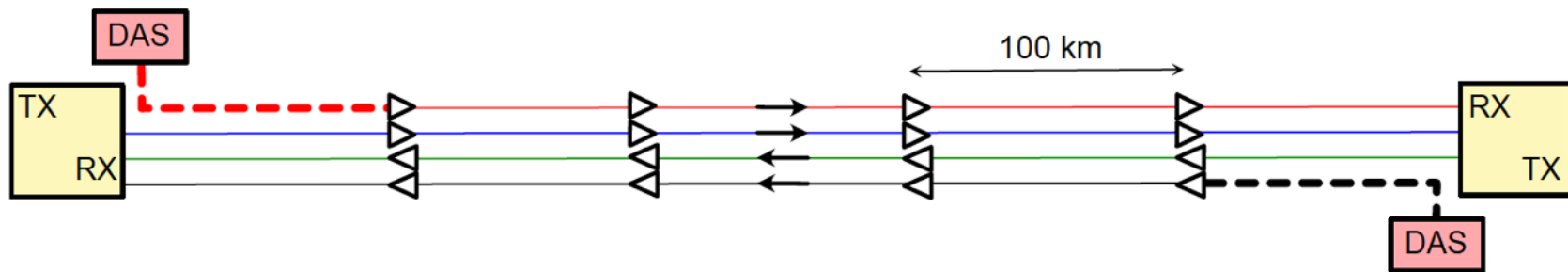
Long-haul telecom cables are different ...

- Very expensive and busy infrastructure
- Heavily regulated and secured
- DAS range too short (up to 100km)

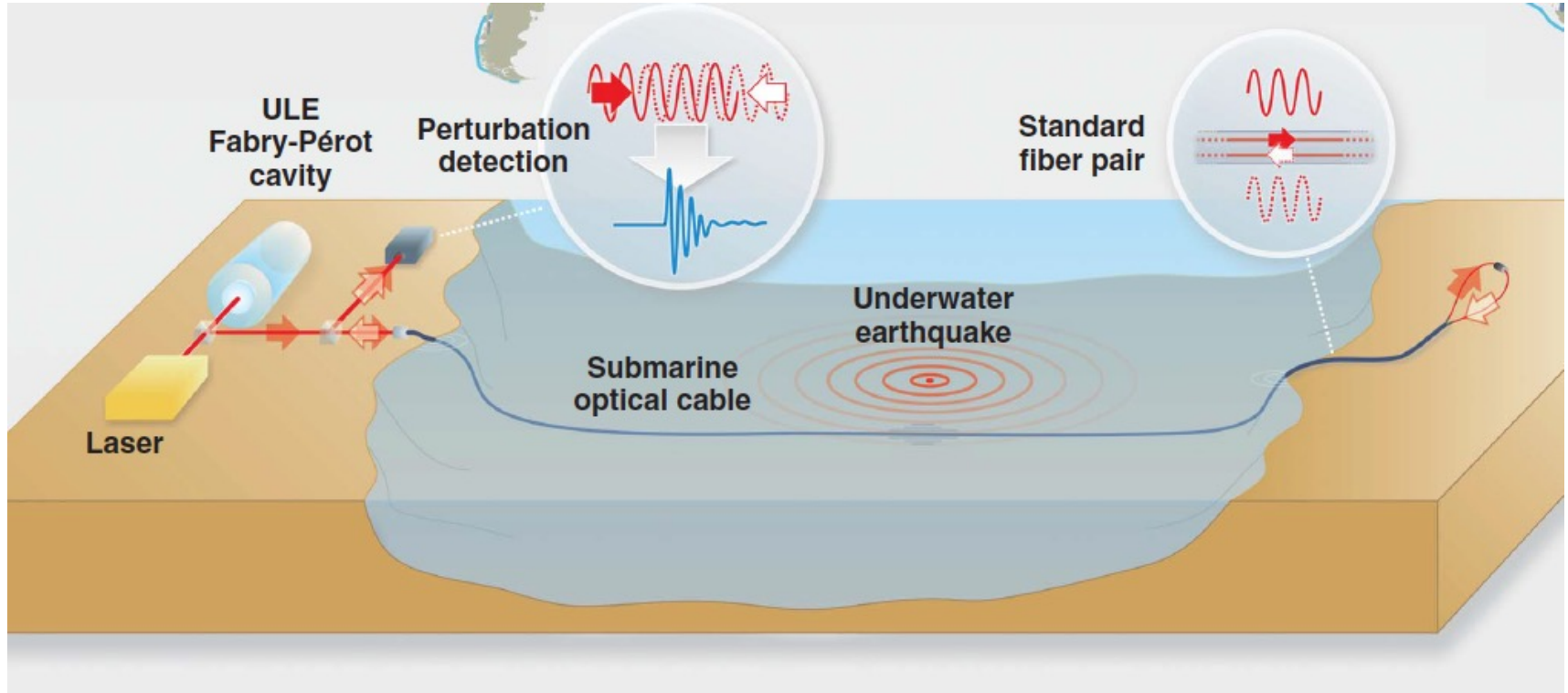


4 ~12
fibers

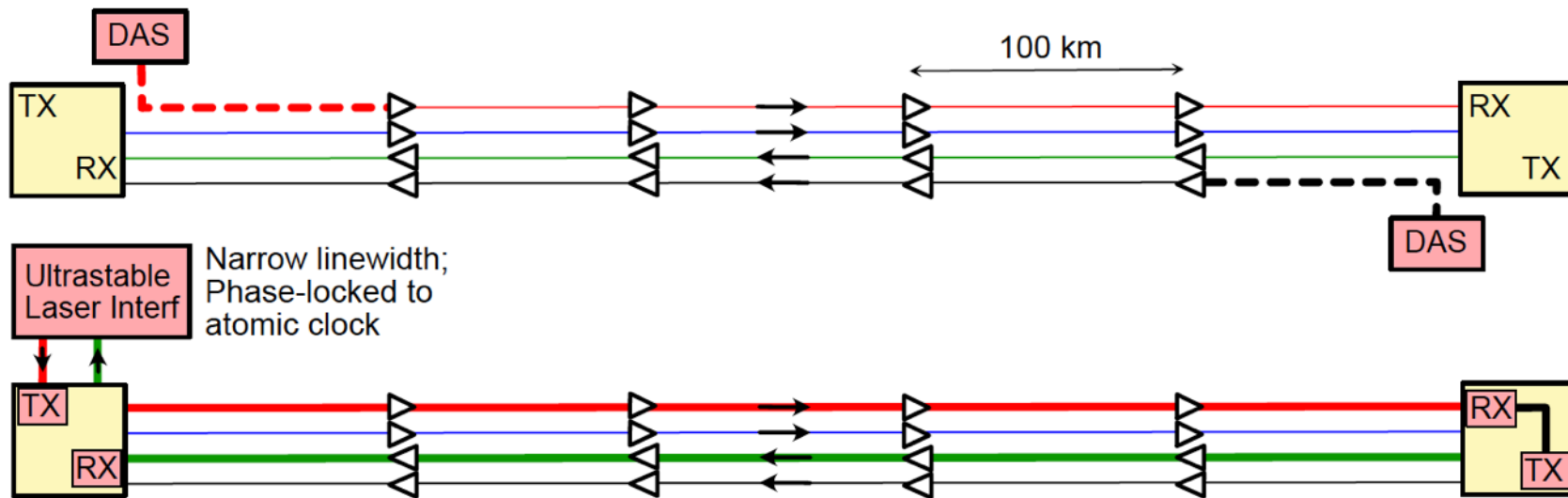




Ultra-stable laser interferometry

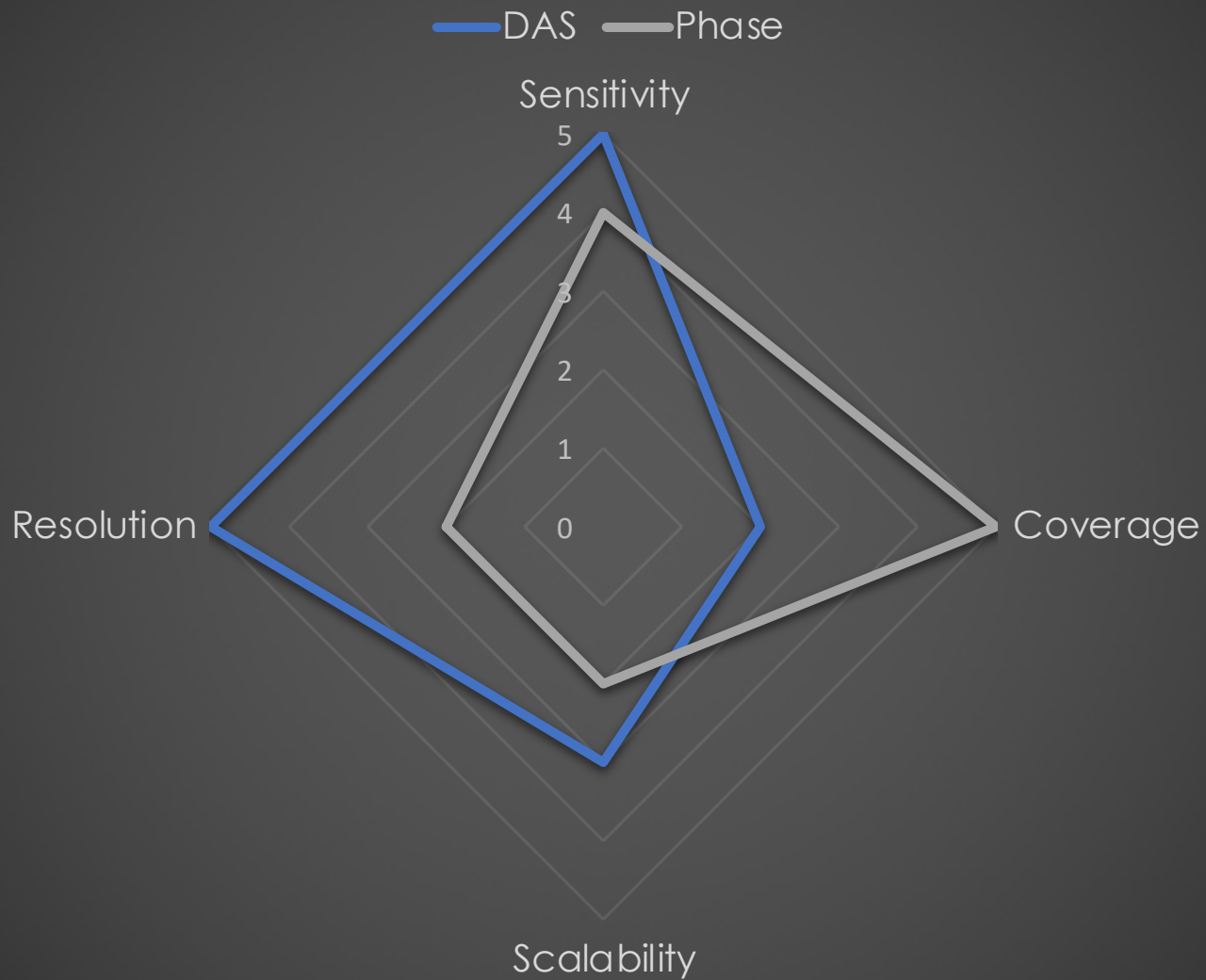


Marra et al., 2018



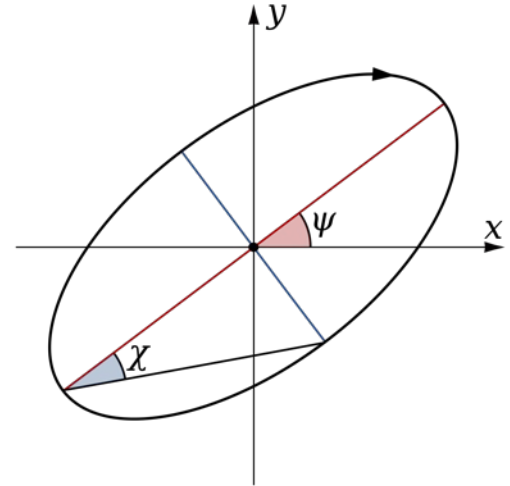
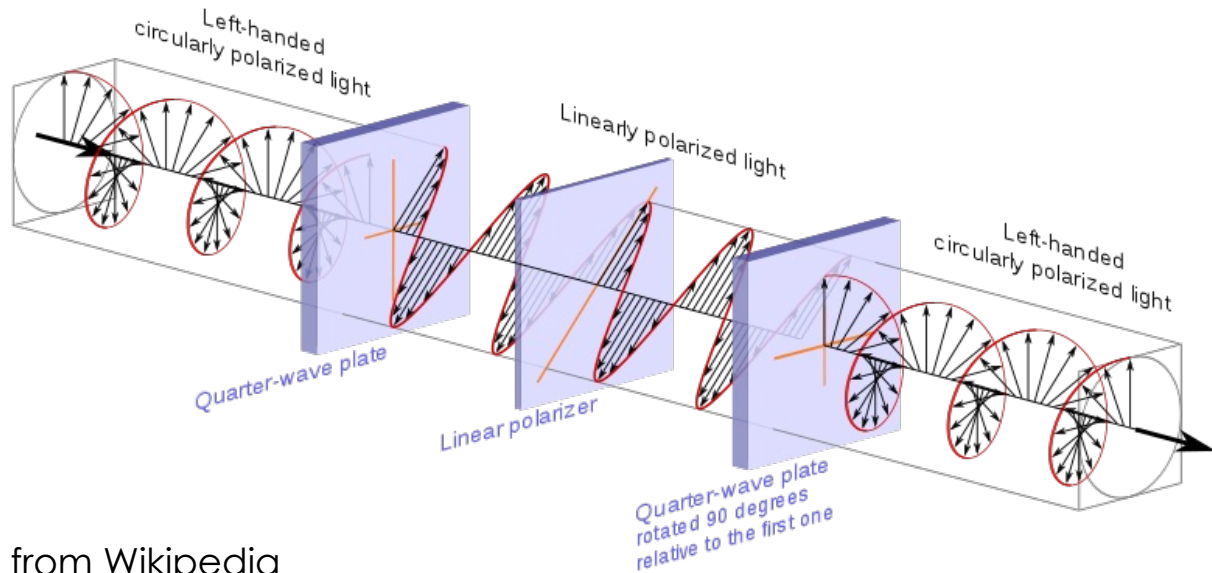
State-of-the-art Telecom laser linewidth: 5kHz - 10kHz

Laser linewidth used in Marra et al. (2018): 1Hz (out of 200THz)!



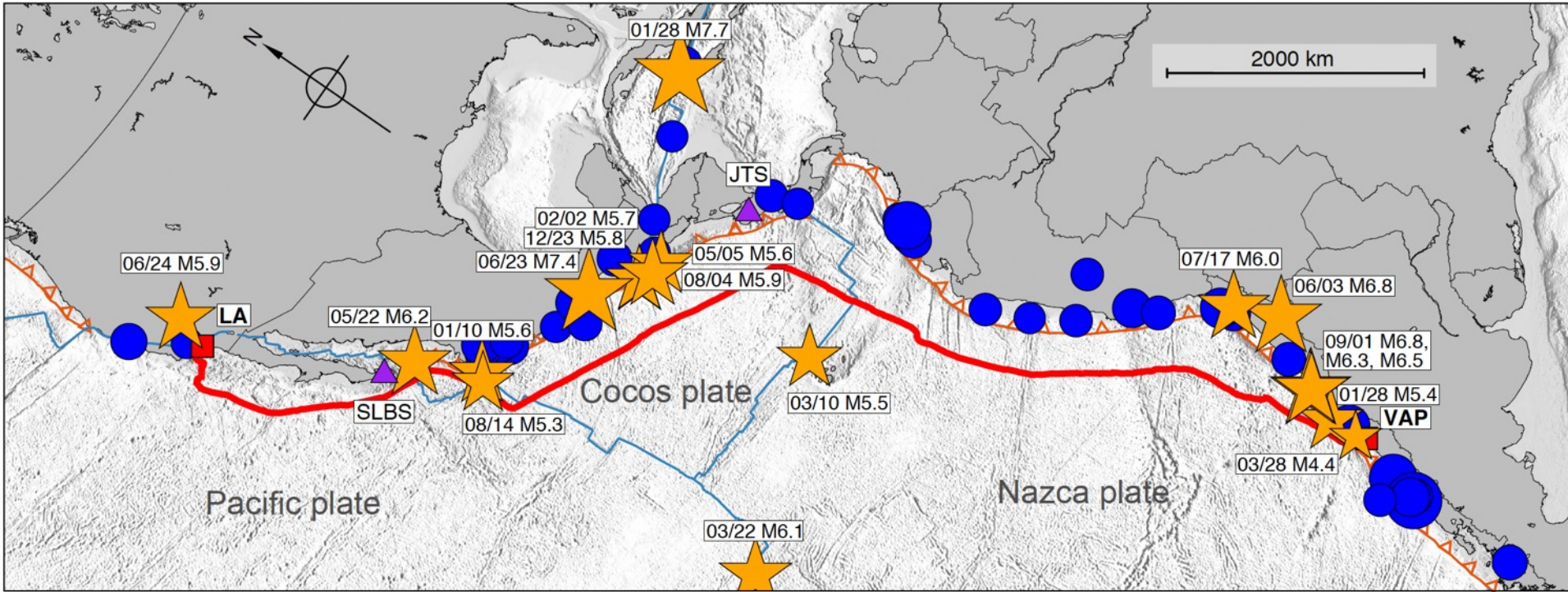
Sensing by state of polarization

- Telecom requires measurements of polarization to restore it
- Principles: stress to fiber causes change in polarization

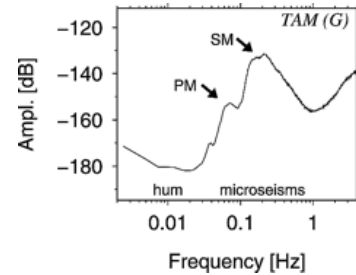
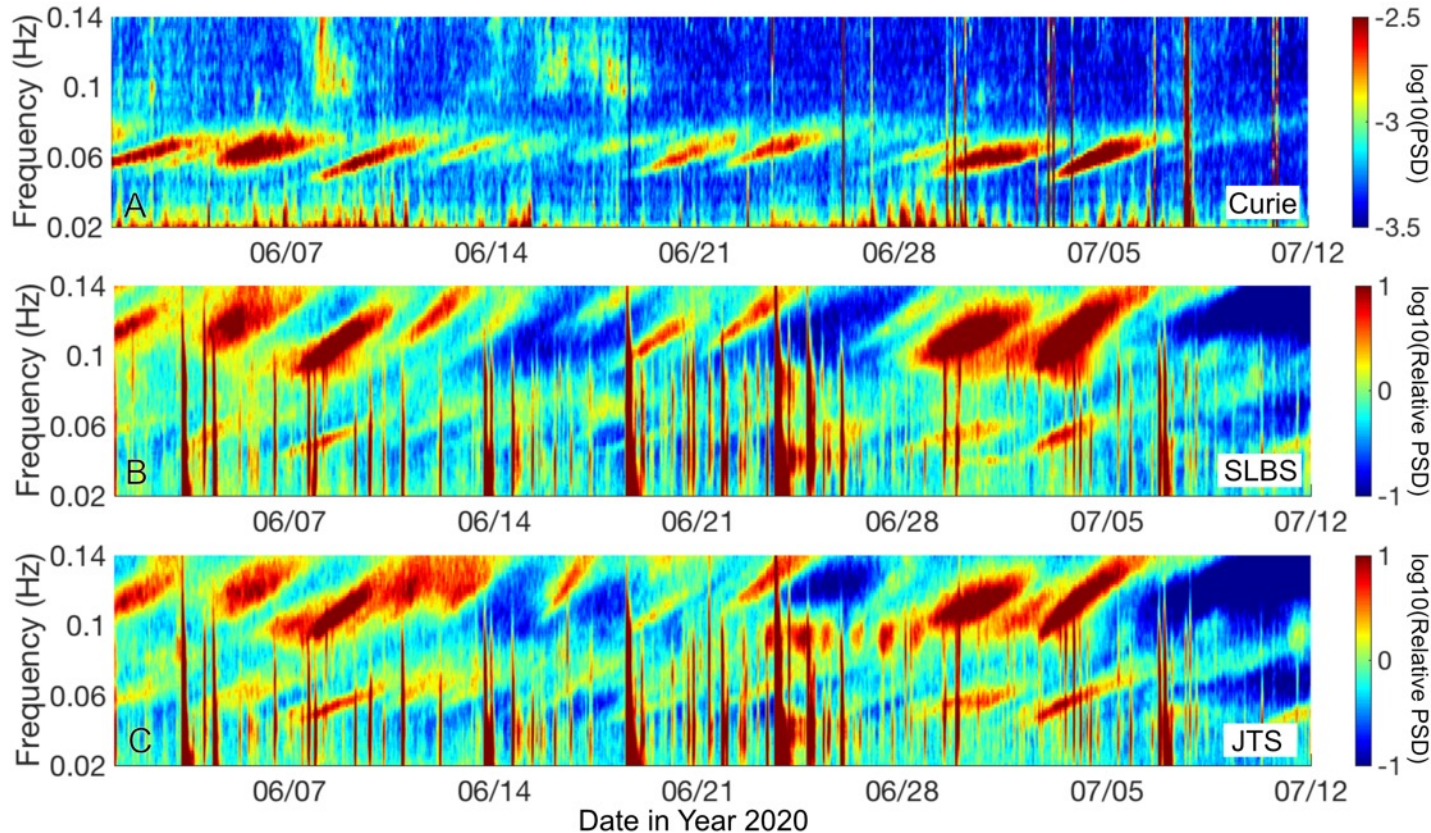


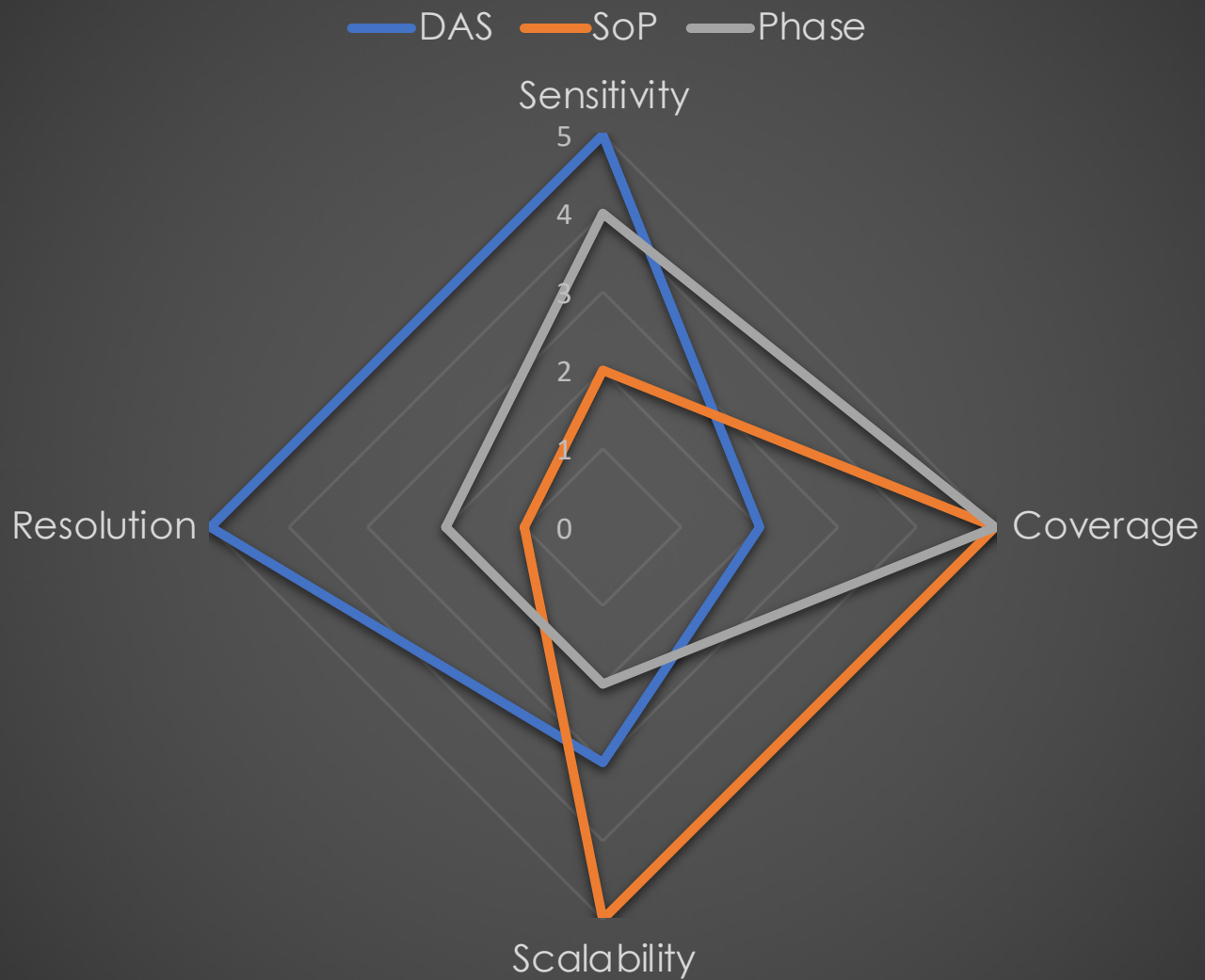
from Wikipedia

A 10,000-km fiber optic cable, Curie, by Google from Los Angeles to Chile

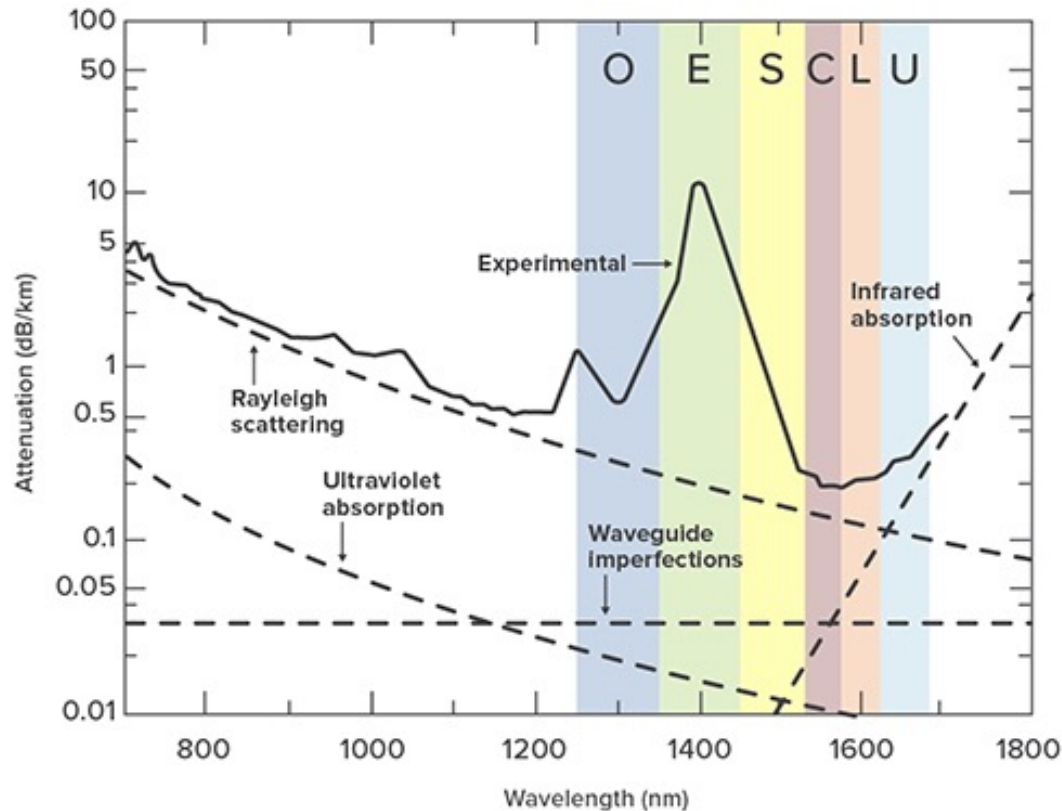


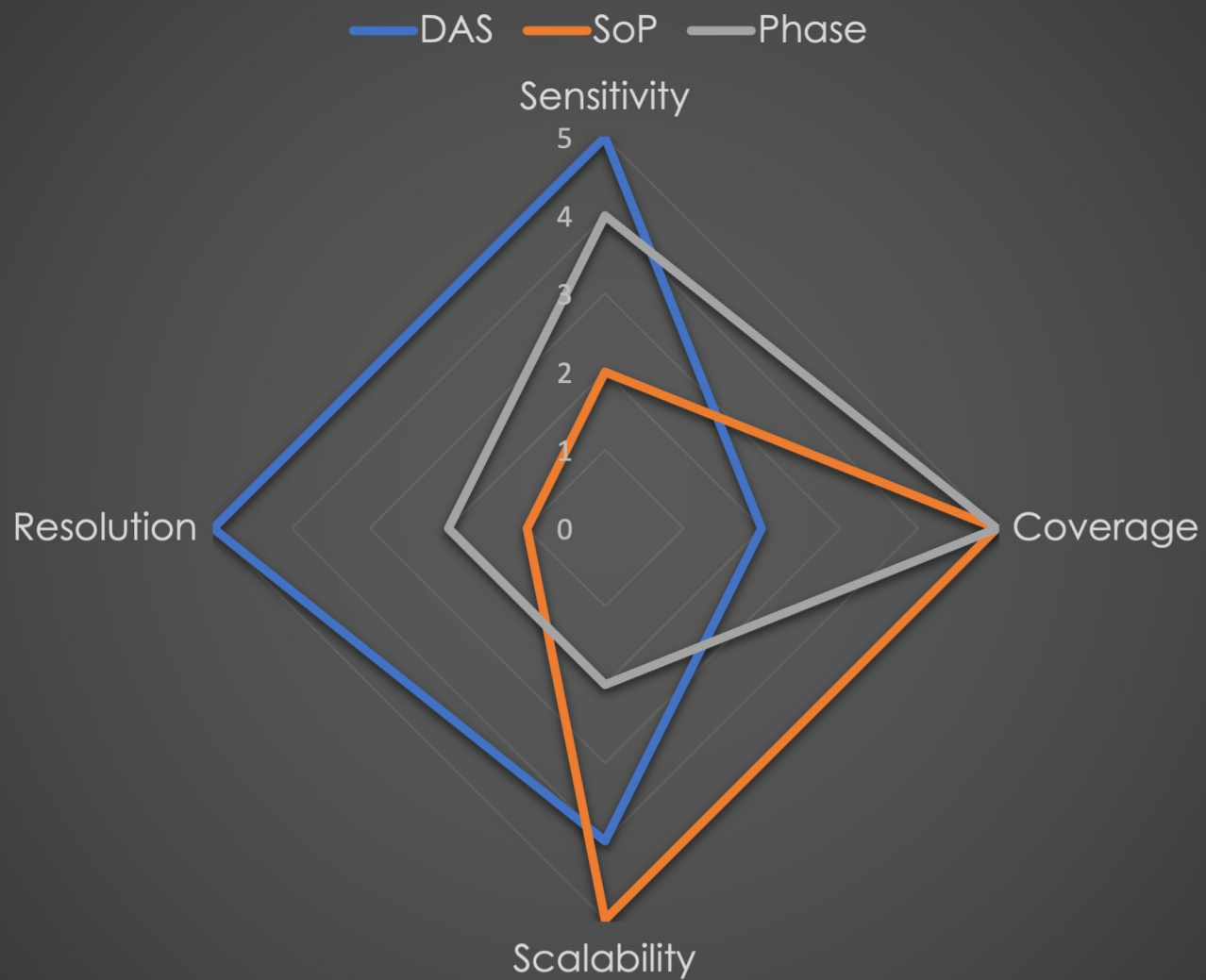
SoP detection of ocean swells

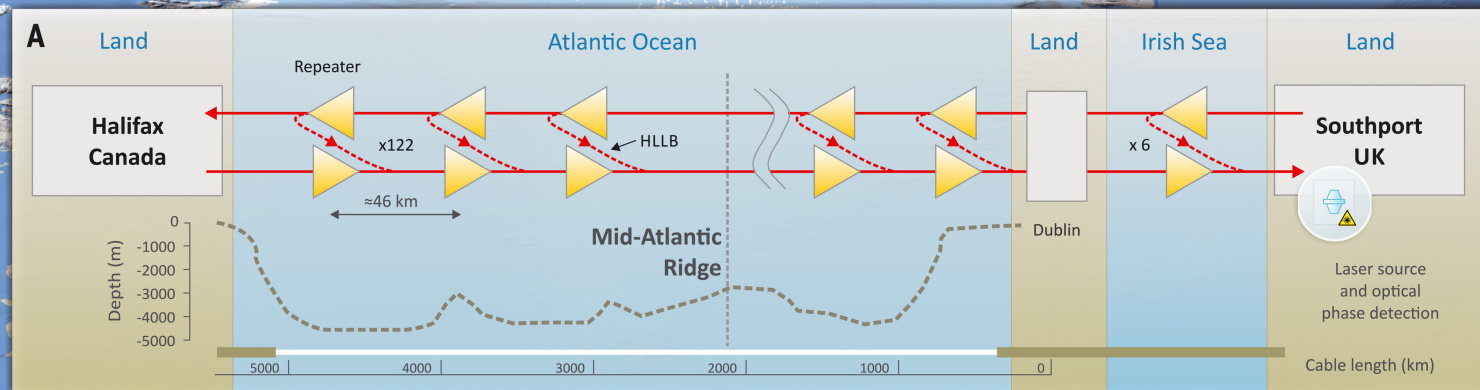




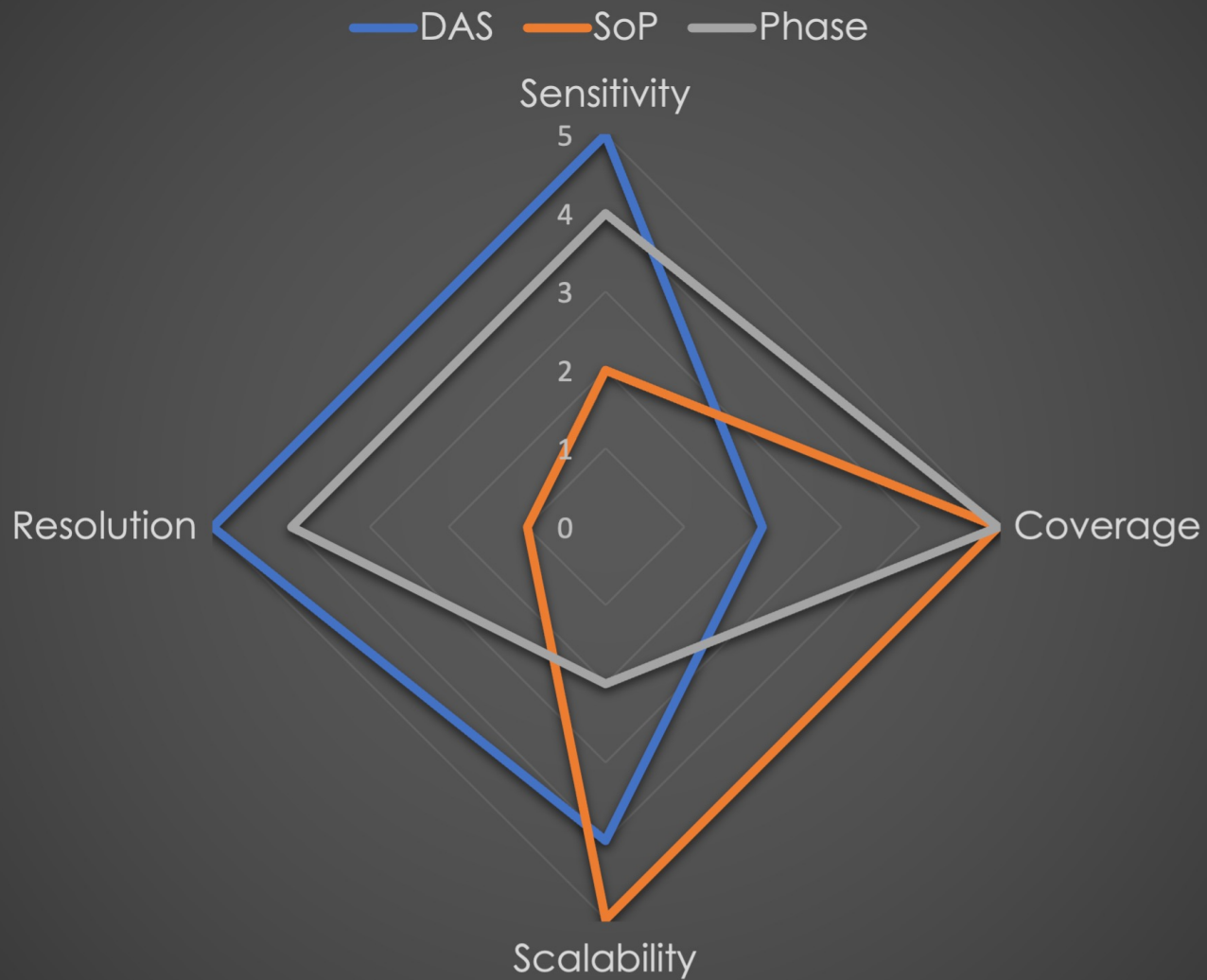
L-band DAS co-exists with telecom

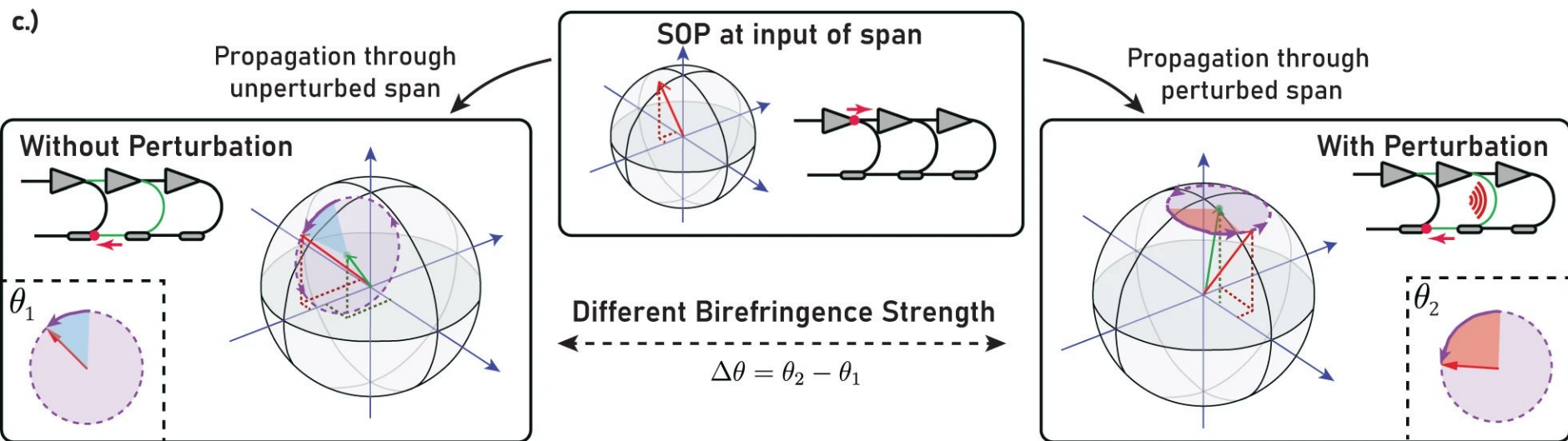
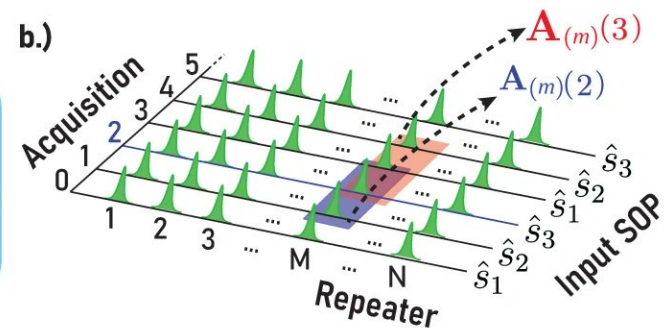
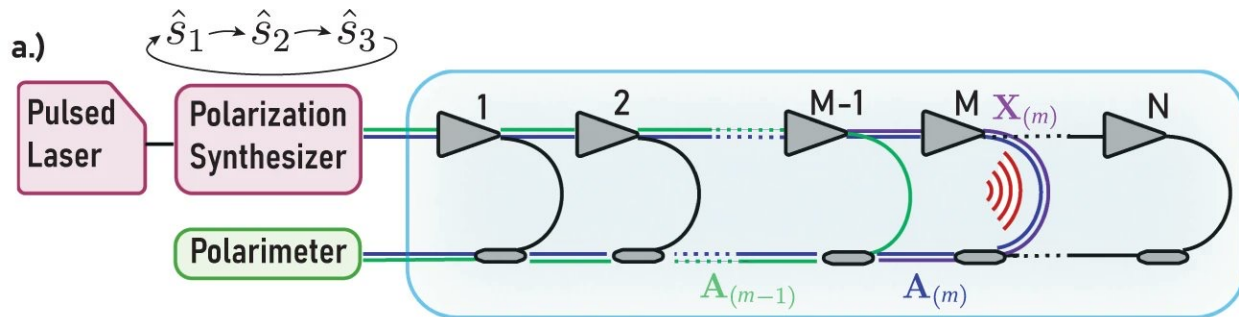


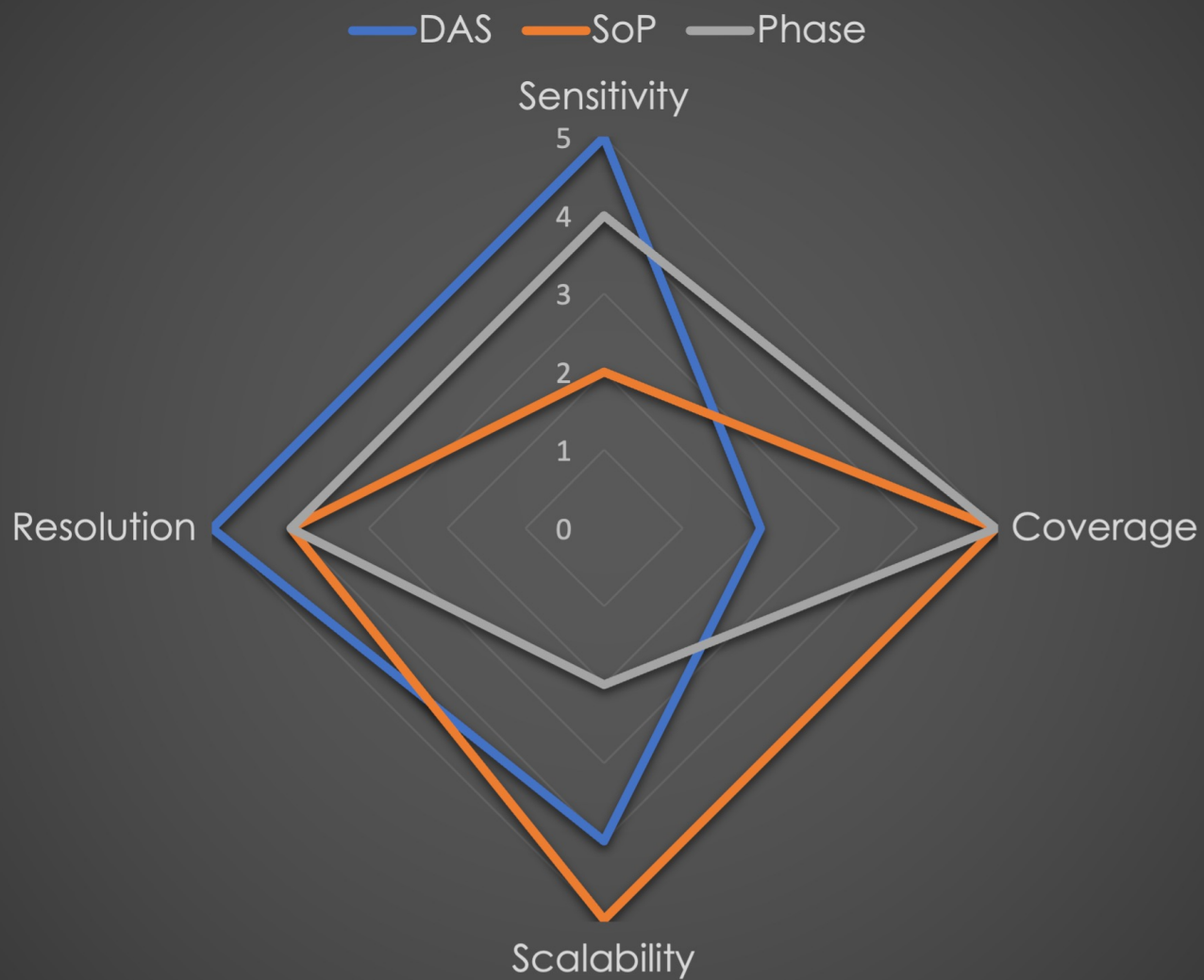




Marra et al., 2022







Submarine fiber sensing for geoscience

- Multiple emerging submarine fiber sensing technologies: DAS, Phase, Polarization, and maybe more?
- **Fiber sensing technologies are progressing quickly!!**
- Benefit both submarine geophysics and oceanography
- A cocktail solution are necessary for the best outcome
- **Almost all fiber sensing technologies are developed jointly by academia and the telecom industry.**

Thank you! Questions?