SAND2021-11576C

Sandia National Laboratories

Distributed acoustic sensing of seasonally variable environmental processes in the Beaufort Sea, Alaska



Michael G. Baker

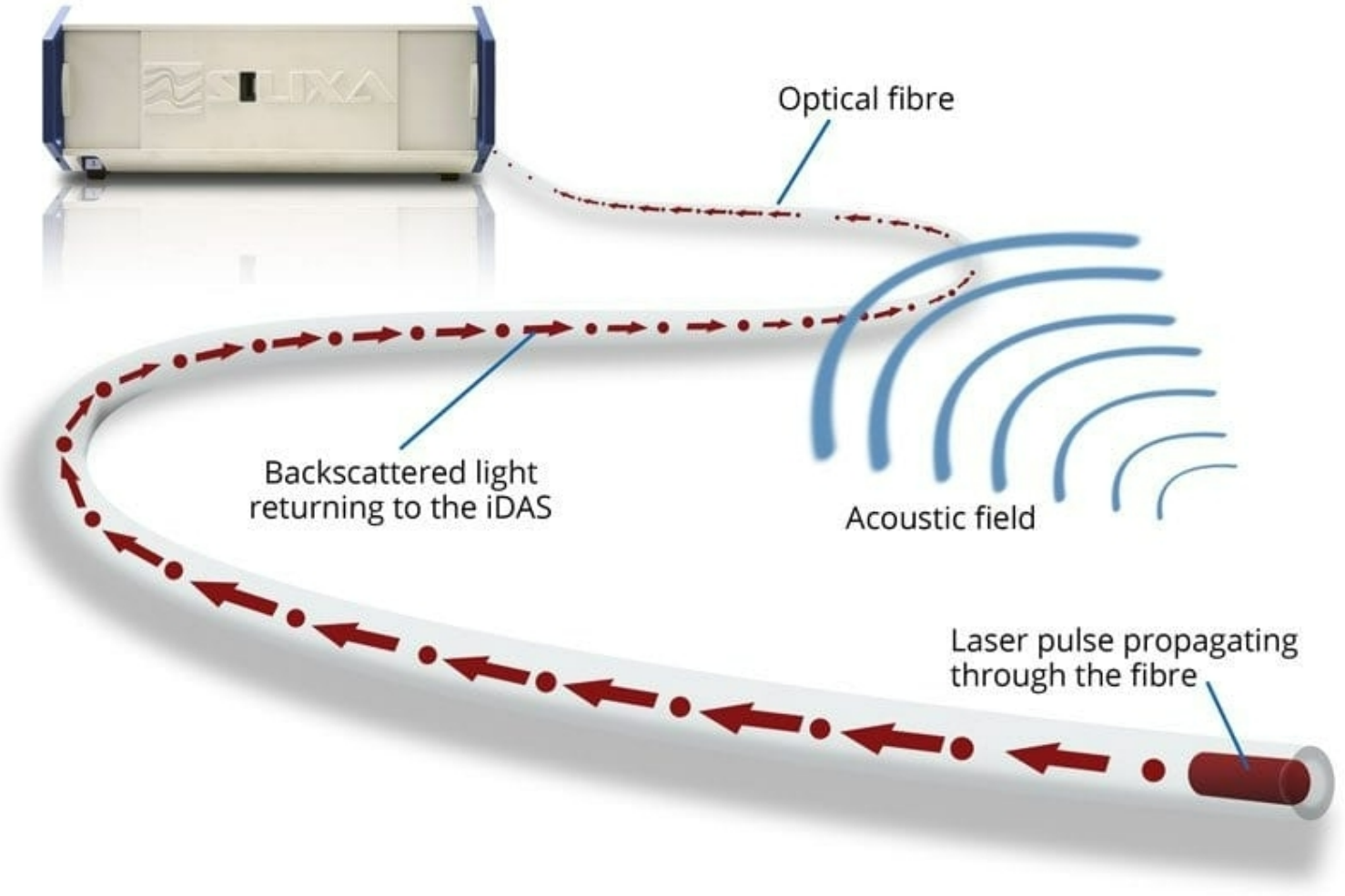
Postdoctoral Researcher
Geophysics Department
Sandia National Laboratories

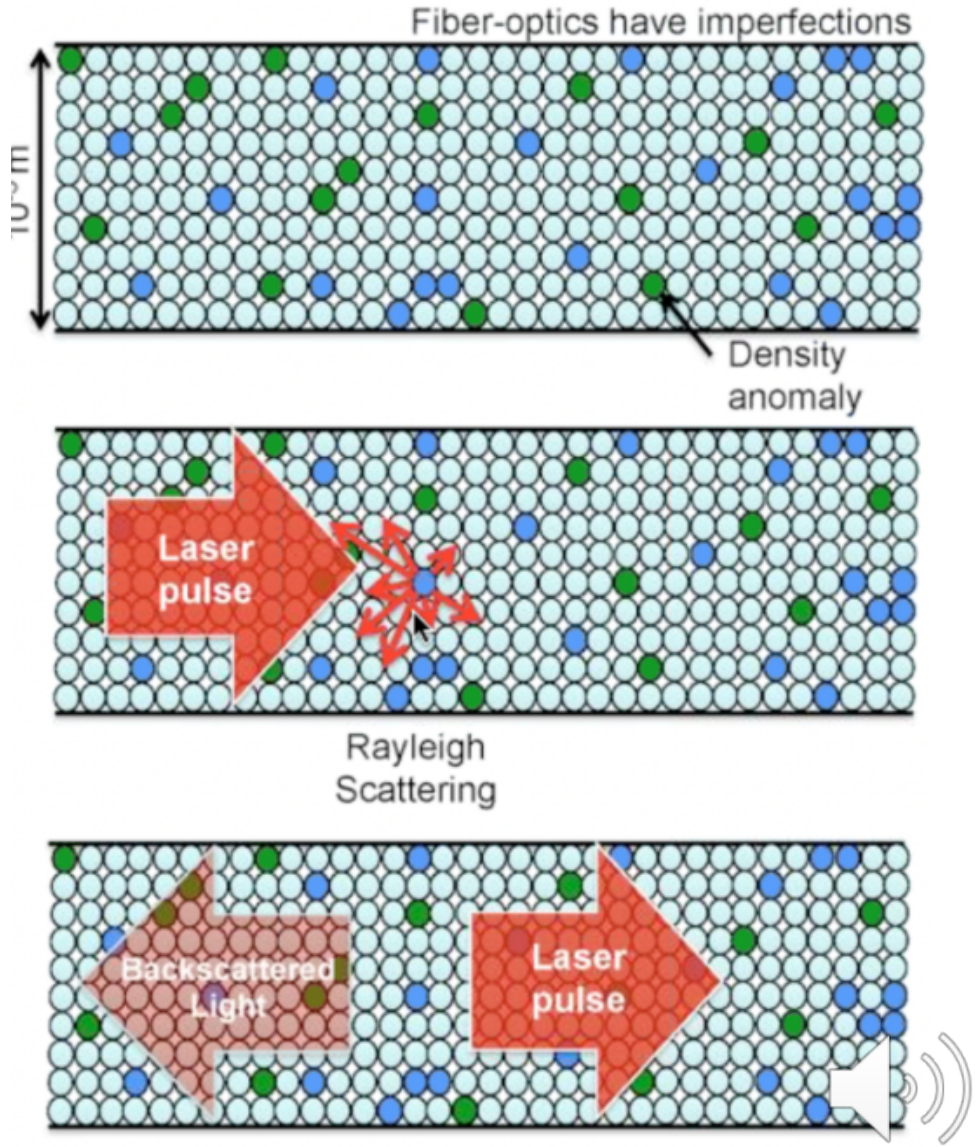
U.S. DEPARTMENT OF ENERGY | NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Distributed Acoustic Sensing (Briefly)





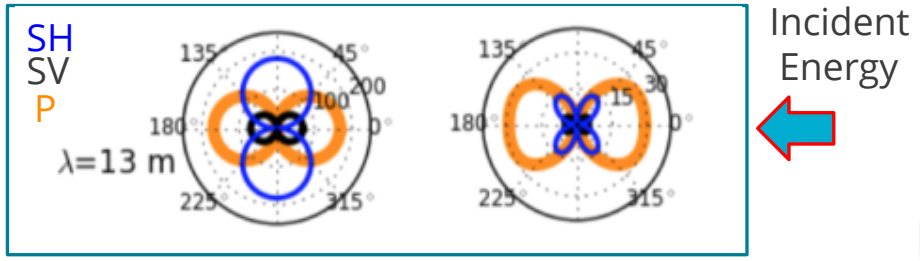
Distributed Acoustic Sensing (Briefly)

Pros

- High spatial resolution : 1 – 10 m typical for seismology
- Large bandwidth : 0.01 Hz – 100 kHz
- Large aperture : up to ~50 km
- Works with *ad hoc* networks or existing telecom ”dark” fiber infrastructure
- Robust against environmental hazards
- Low degree of error for channel position and bearing (compared to OBS)
- Logistically simple, since only the fiber termination needs to be accessible

Cons

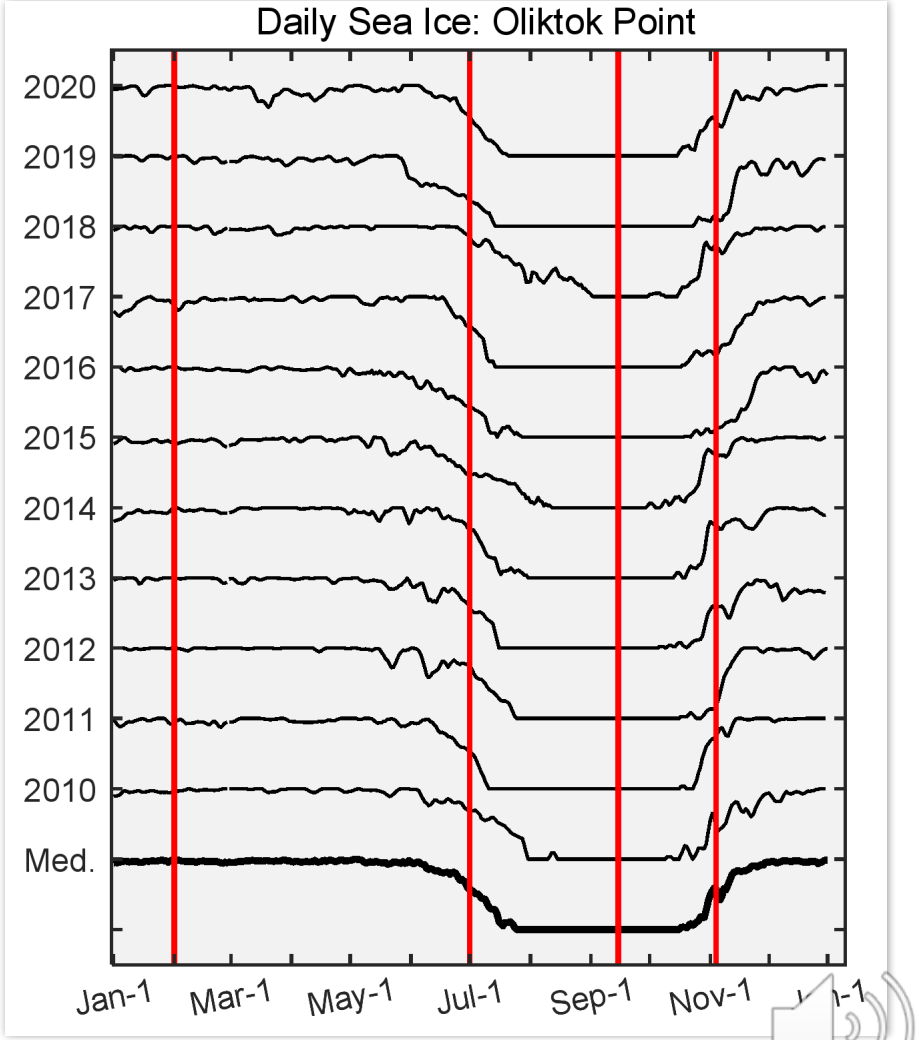
- Sensitive only to axial strain i.e., functions as an array of 1-D seismometers
- Wave-type-dependent sensitivity nodes
- Power hungry : ~200 W
- Storage hungry : ~3.2 TB/day
- Confined to within 50 km of coast
- DAS unit cost : $100k or more



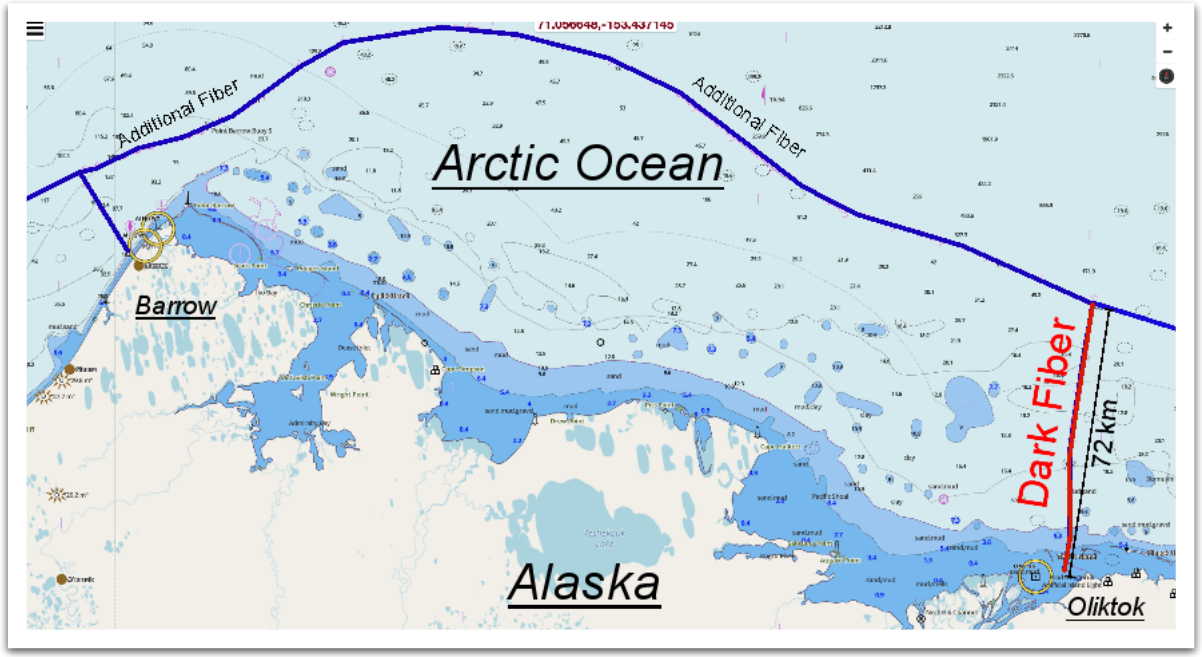
1-C Horizontal Seismometer DAS

CODAS : Cryosphere/Ocean Distributed Acoustic Sensing

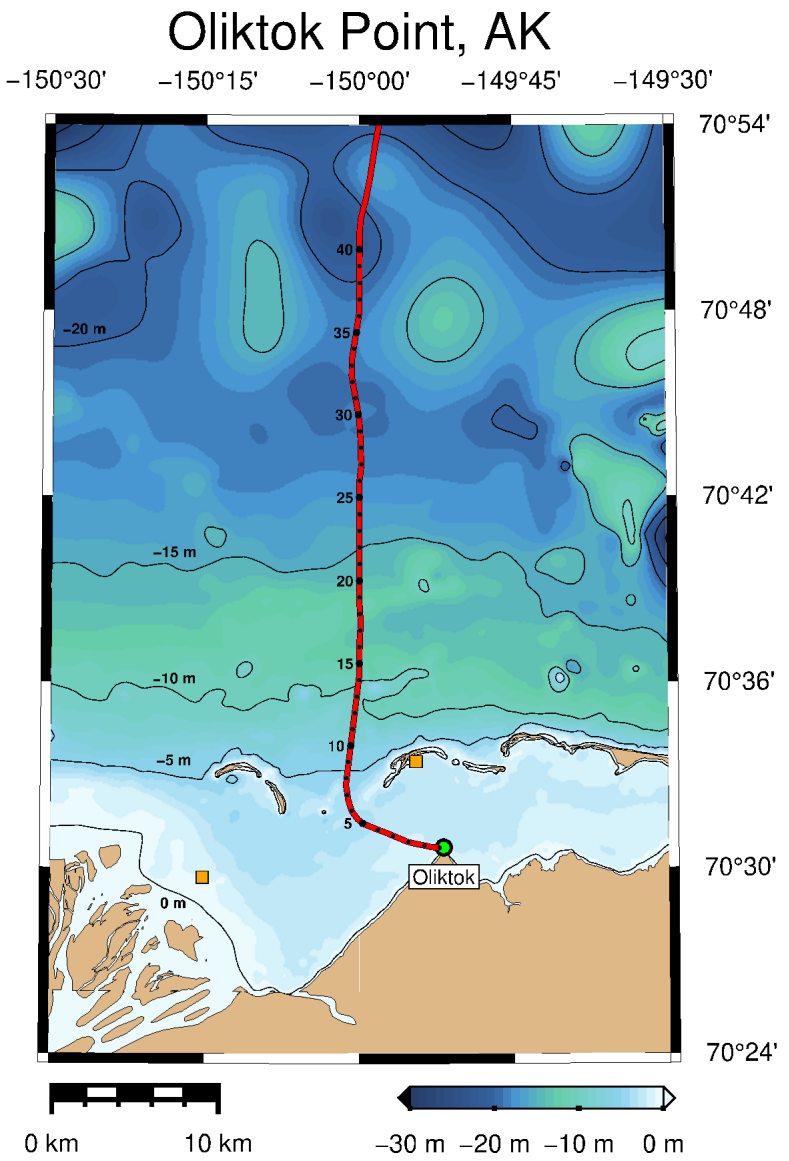
- **Goal** : Observe & characterize a plethora of seismoacoustic signals touching on environmental processes and national security goals in the Arctic
  - Sea ice extent/formation/breakup/thickness
  - Wave height, current intensity, storm intensity
  - Anthropomorphic signals like ships, machinery, etc.
  - Biogenic signals like whale and seal vocalizations
- First ever **seafloor** deployment of DAS to a polar coastal environment
- First ever **multi-seasonal** deployment of seafloor DAS to any coastal environment
  - CODAS : Eight 1-week-long data collects in each of the Arctic “seasons.”
- Unprecedented spatial and temporal resolutions for environmental seismoacoustics
  - 40 km array aperture
  - 2 m “sensor” spacing
  - 1000 Hz sampling rate
  - Long period limit >300 s



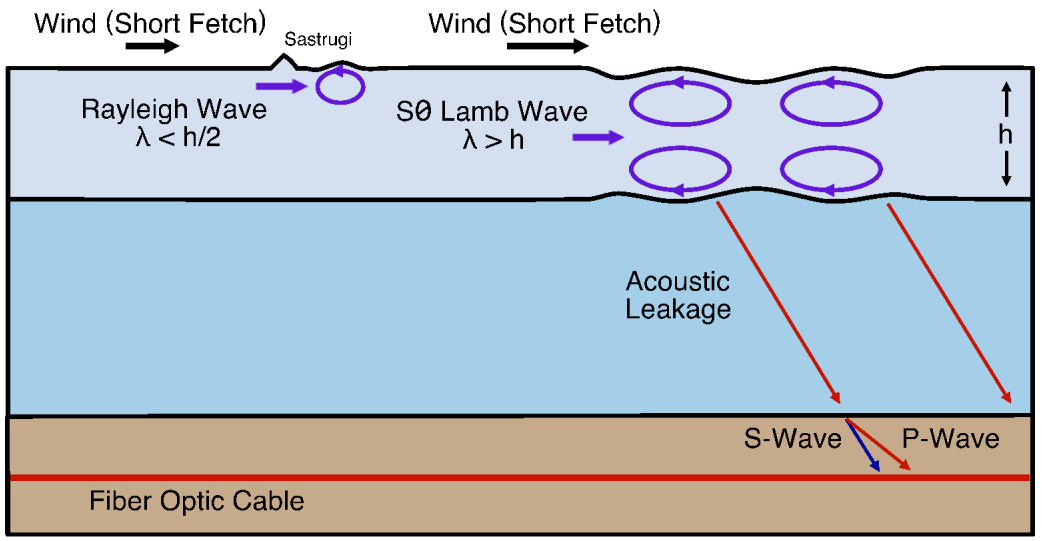
CODAS : Cryosphere/Ocean Distributed Acoustic Sensing

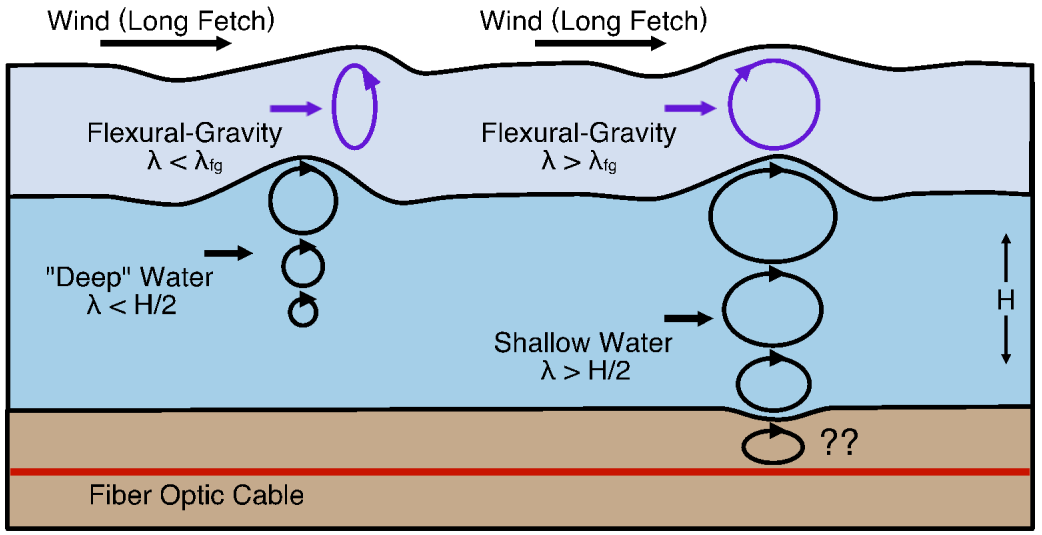


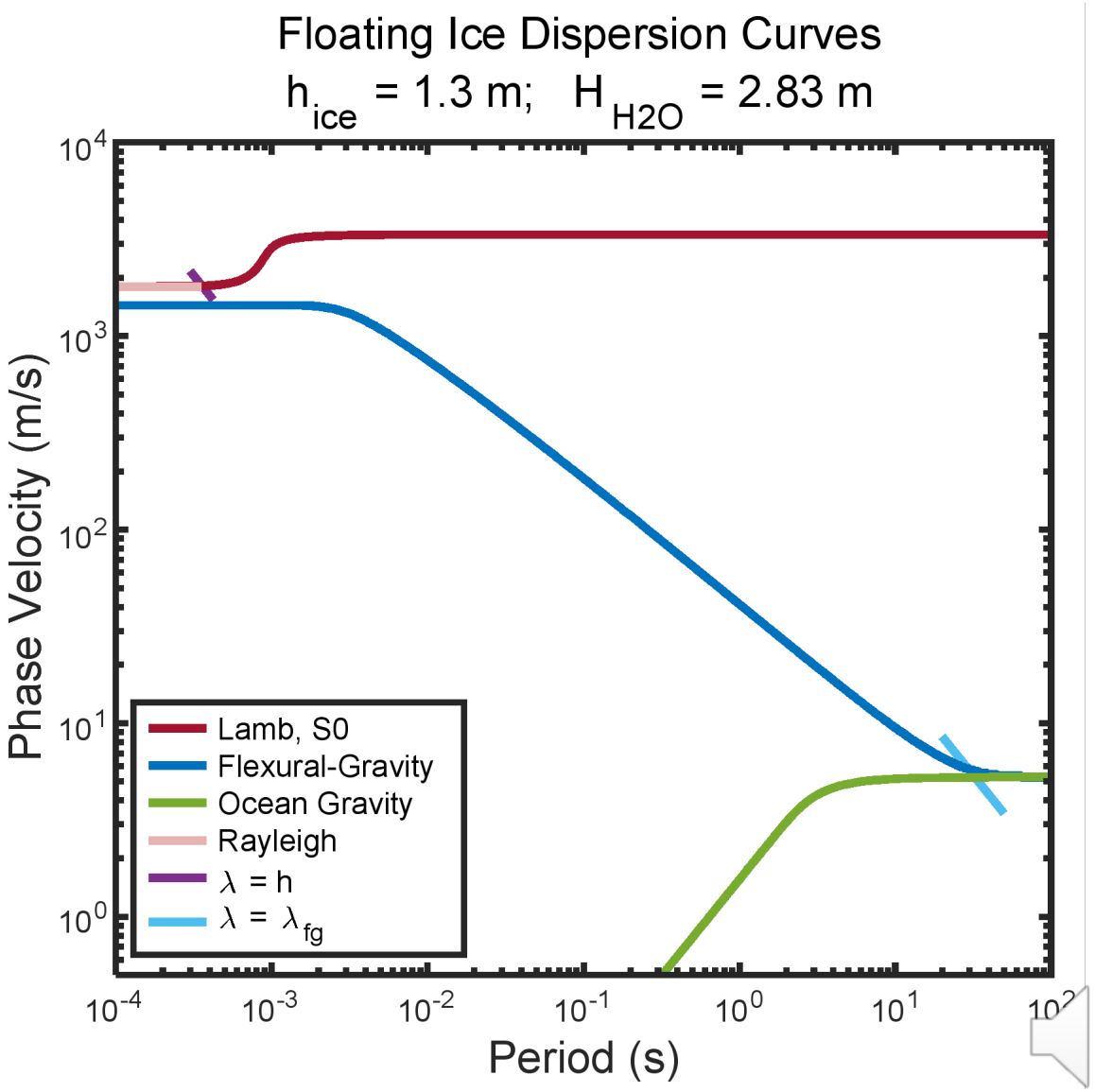
- Dark Fiber section is only a small part of a 2,500 km network owned by Quintillion (eventually London to Tokyo)
- An optical amplifier at 42 km from shore is the maximum distance for this DAS deployment
- This 42 km stretch is best describes as a shallow shelf (0-20 m depth)



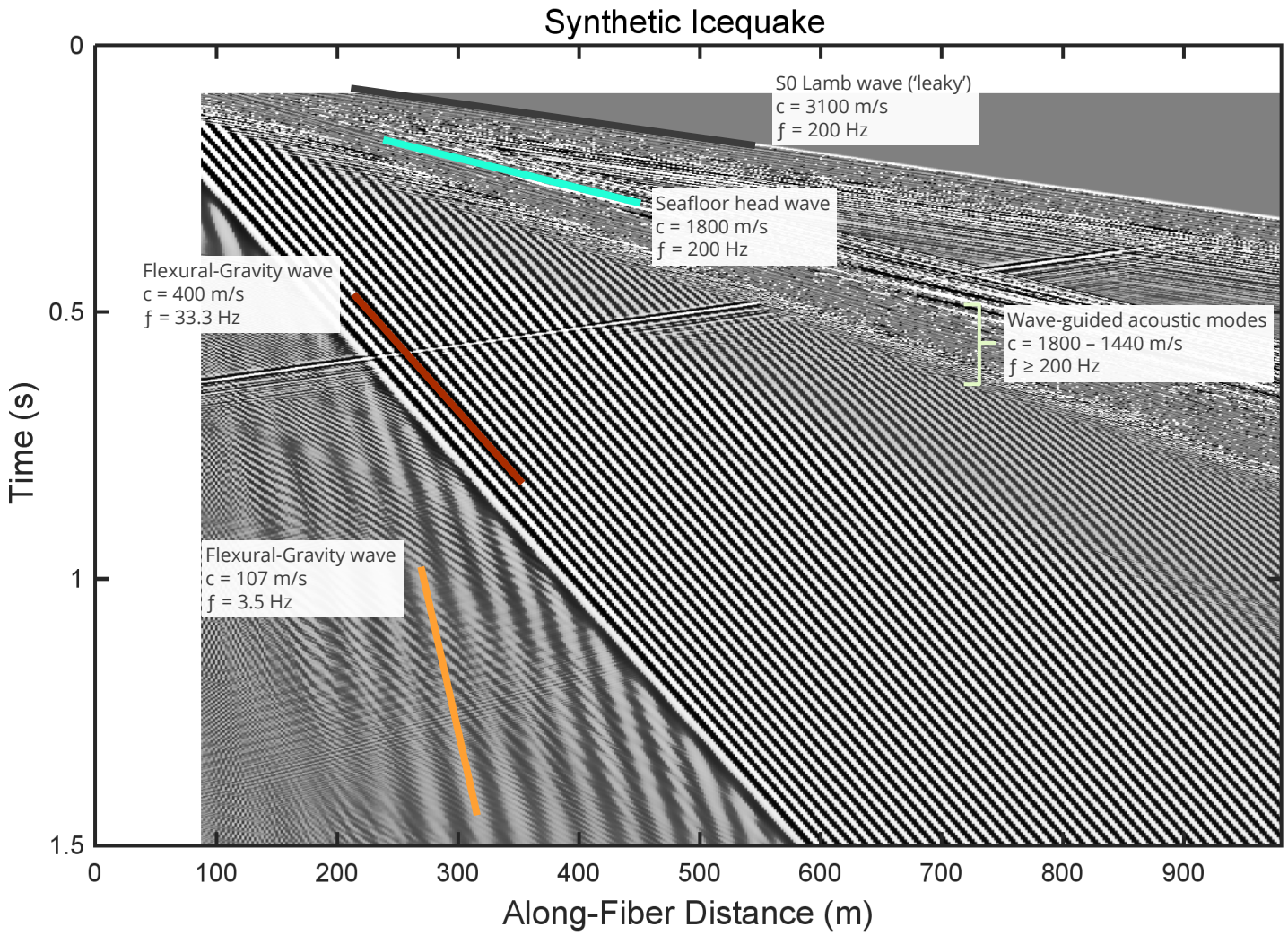
Waves in Floating Ice (Briefly)

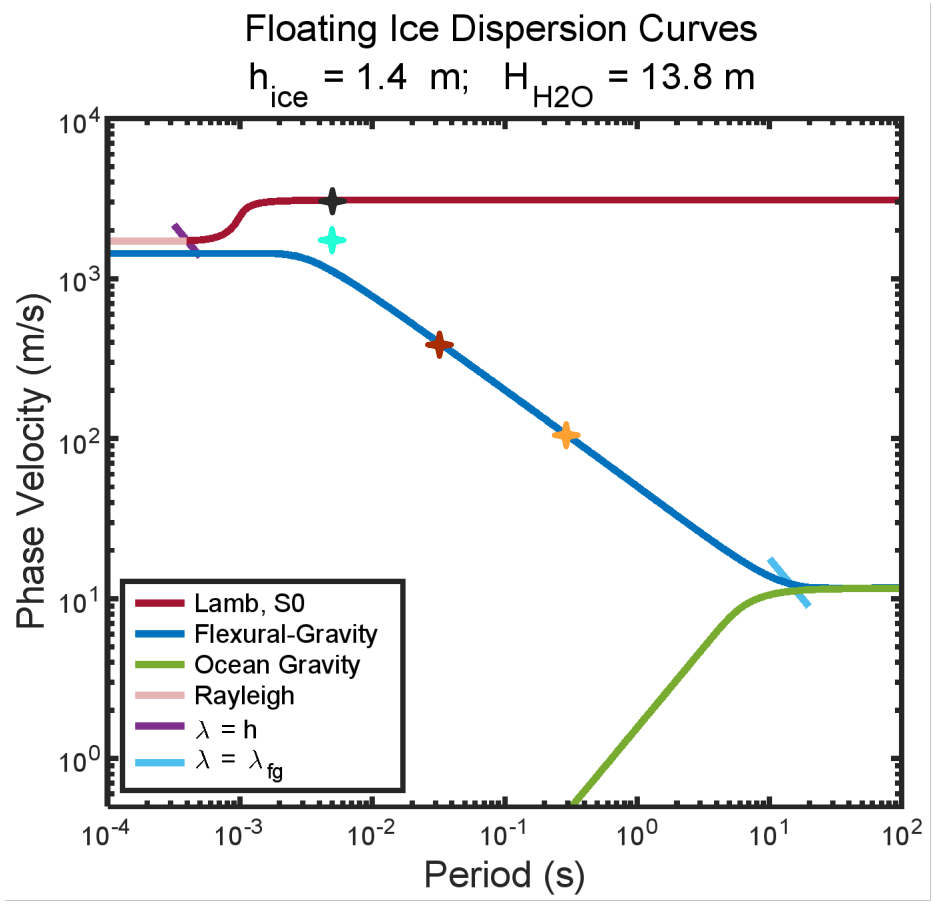






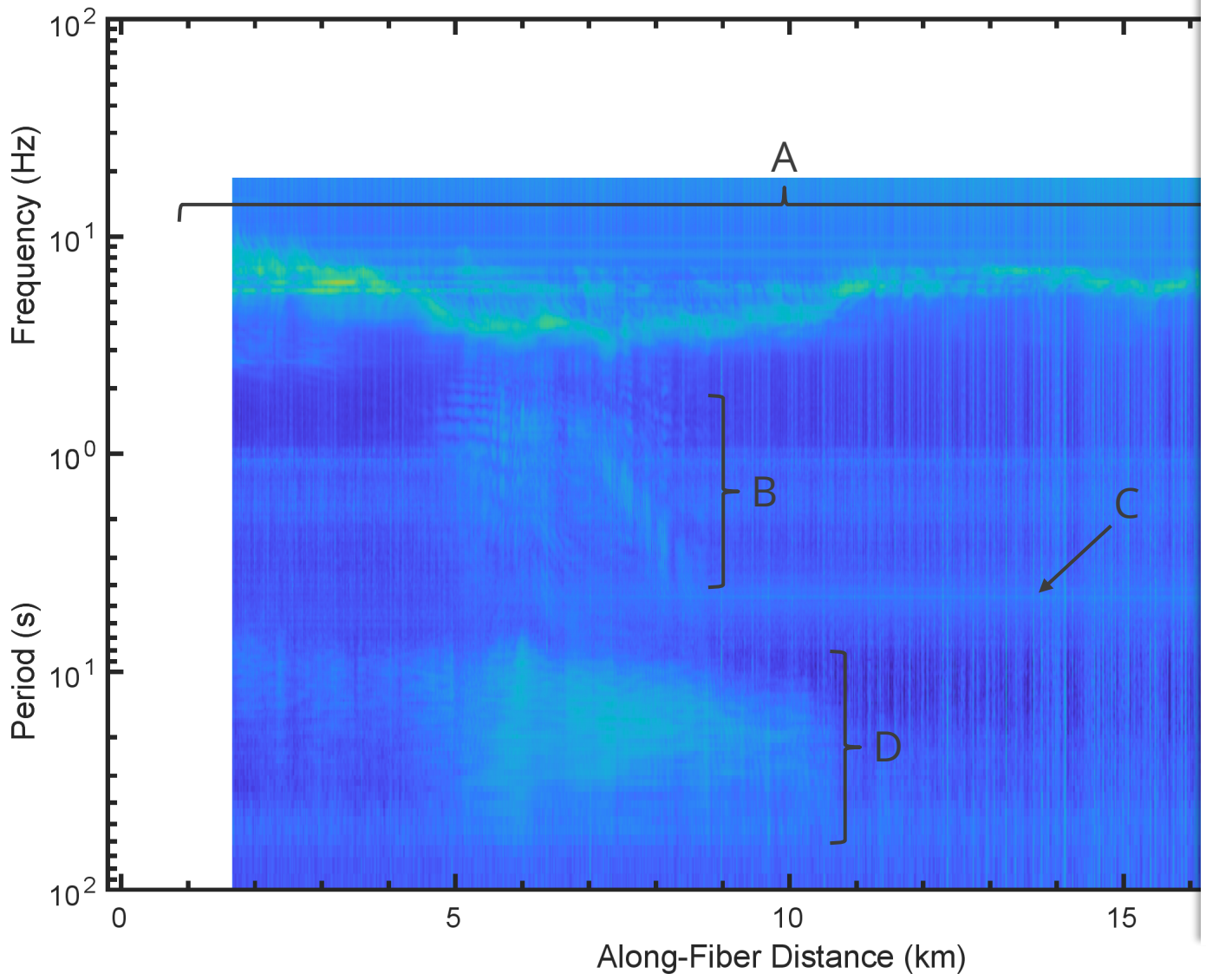
Waves in Floating Ice (Briefly)

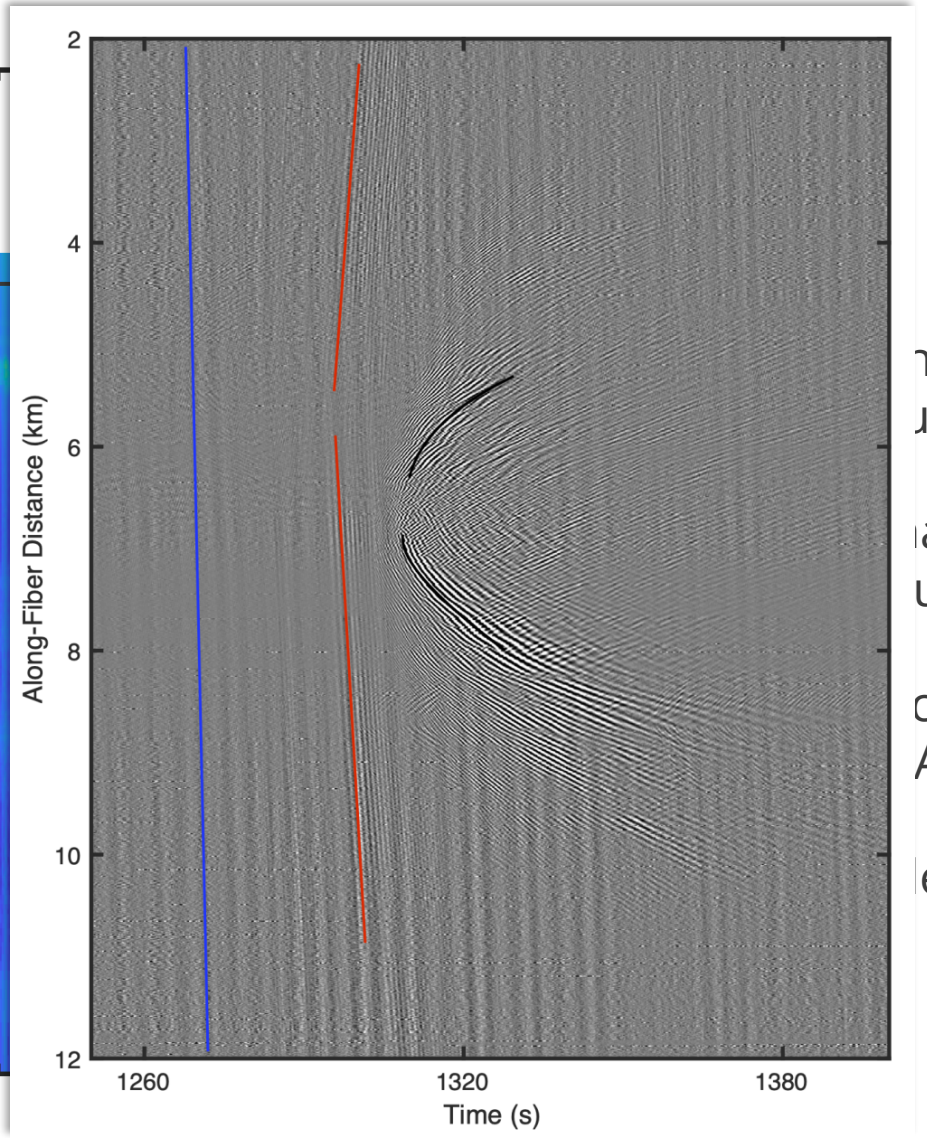




Inversion of floating flexural plate dispersion curves may yield ice & water layer thicknesses

Environmental Signals – Winter, 2021





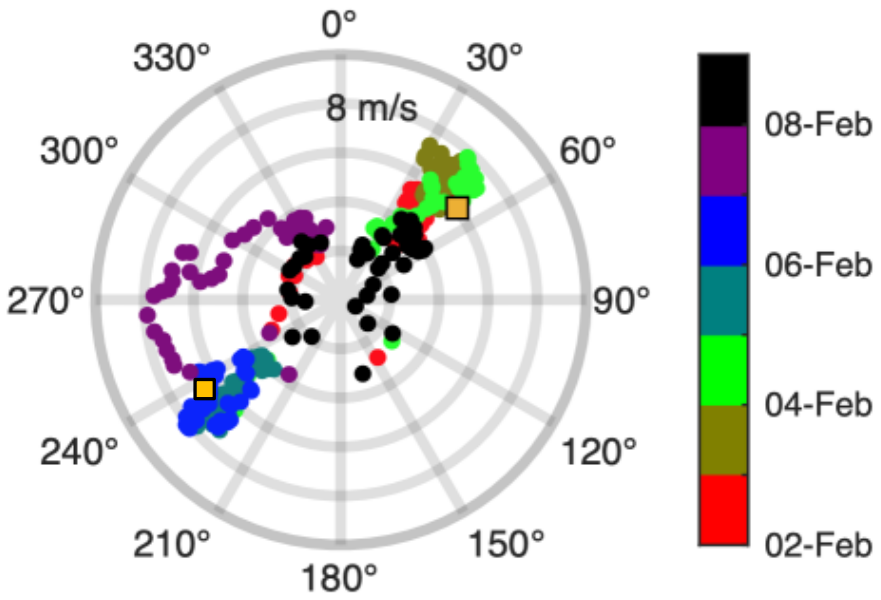
nal,
ure

al,
uake

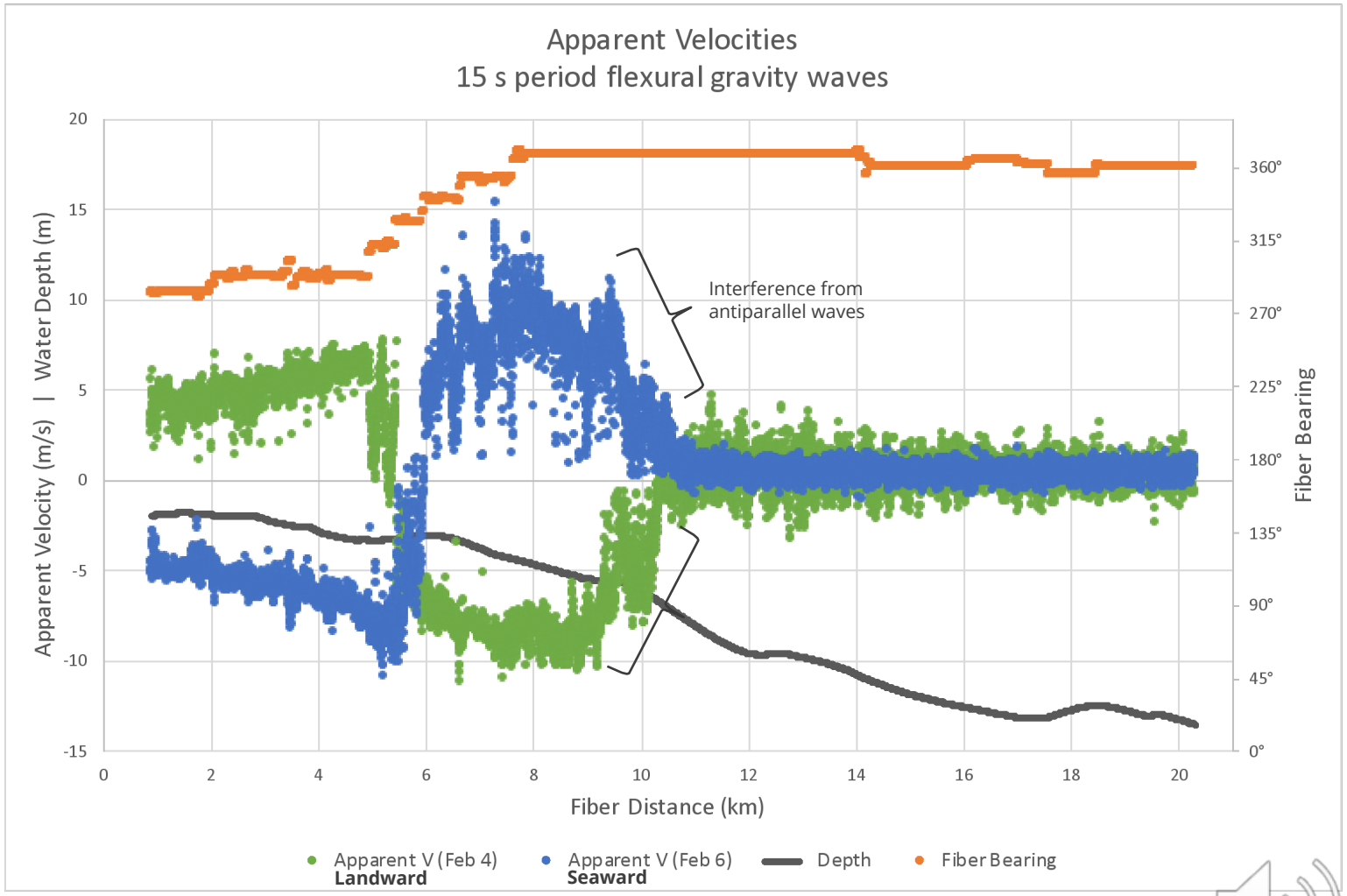
croseism
AK

lexural-

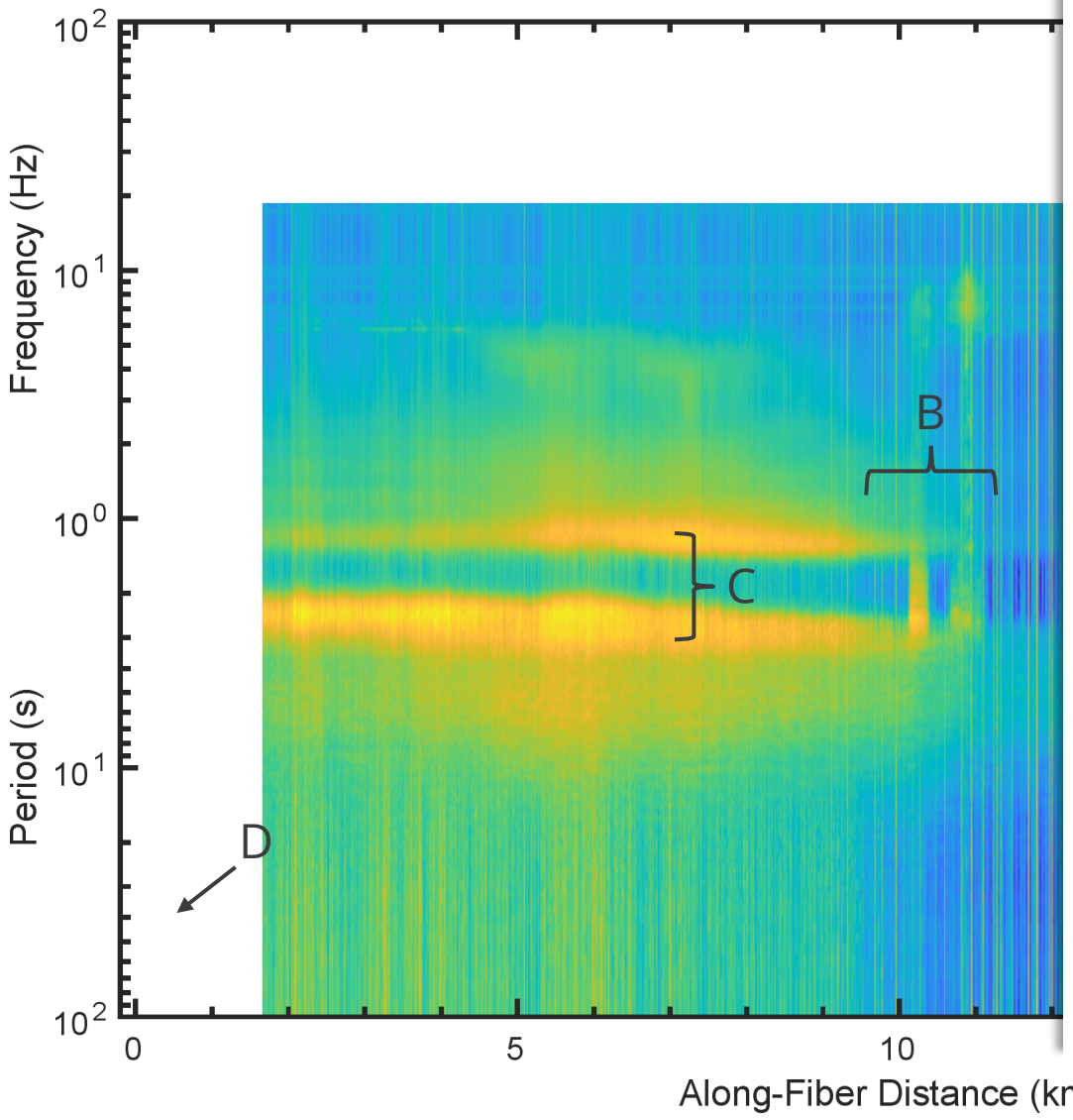
Environmental Signals – Winter, 2021

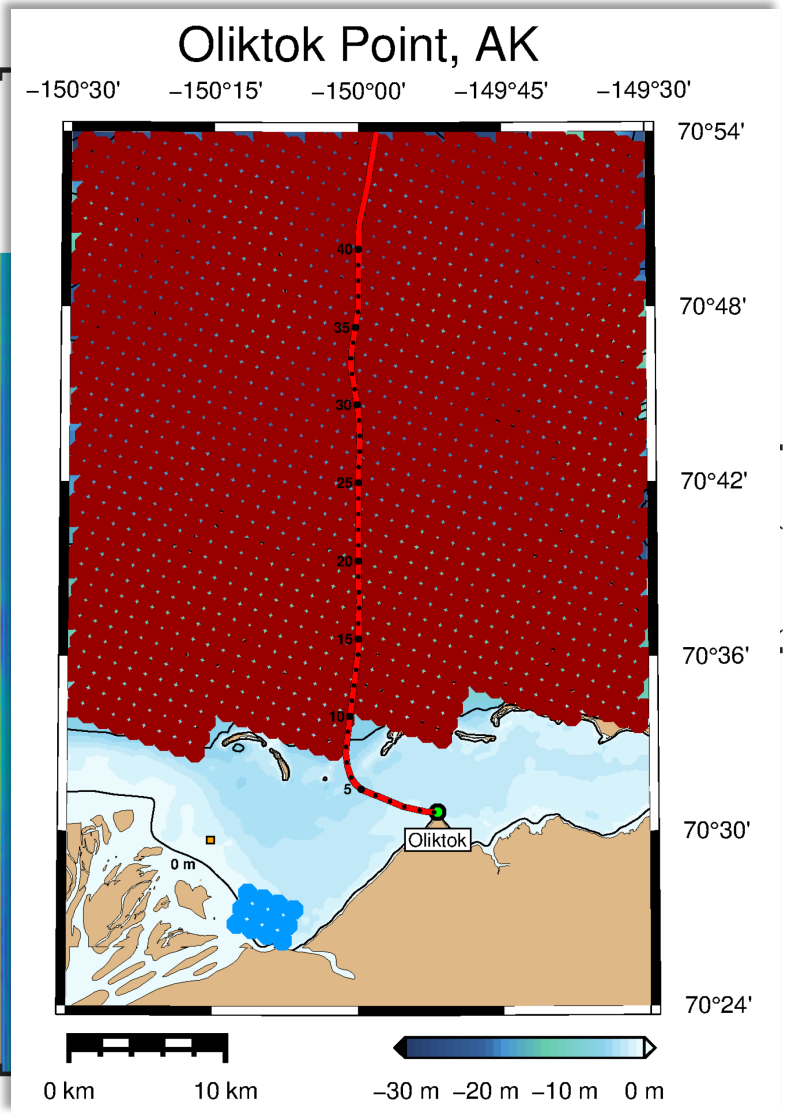


- Sustained winds generate parallel-propagating flexural-gravity wave energy.
- Coherent F-G waves not observed beyond 10 km fiber distance, i.e., beyond barrier islands. Cause yet unknown!



Environmental Signals – Spring, 2021





July 9, 2021
0800–0900 UTC

A) Persistent signal, unknown nature

B) Sea ice edge (~10 km), ice-ice, ice-water noise

C) Peaks: 1.2 & 2.4 s, Possible shallow-water microseisms

D) HDD conduit exit, poor fiber coupling

Acknowledgements

- CODAS Team Members:
  - Robert E. Abbott (Principle Investigator)
  - Kyle Jones (Project Manager (and Photographer))
  - Michael G. Baker
  - William T. O'Rourke
  - Leiph A. Preston

- CODAS is funded by SNL's Lab-Directed Research and Development (LDRD)

LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

- All CODAS data collected with a (SNL-owned) Silixa iDAS™.

SILIXA sense the difference

- CODAS fiber access provided by Quintillion, LLC

QUINTILLION


Questions?