MoST seminar 14.12.2023

SFI Centre for Geophysical Forecasting

DAS technology

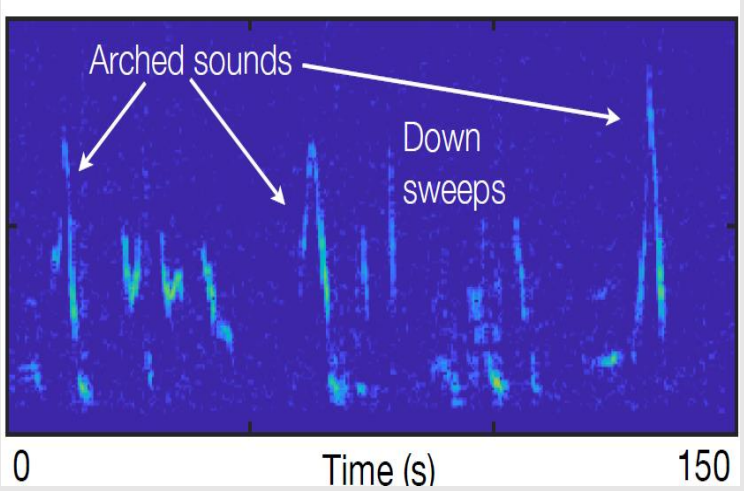
Martin Landrø

SFI Centre for Geophysical Forecasting

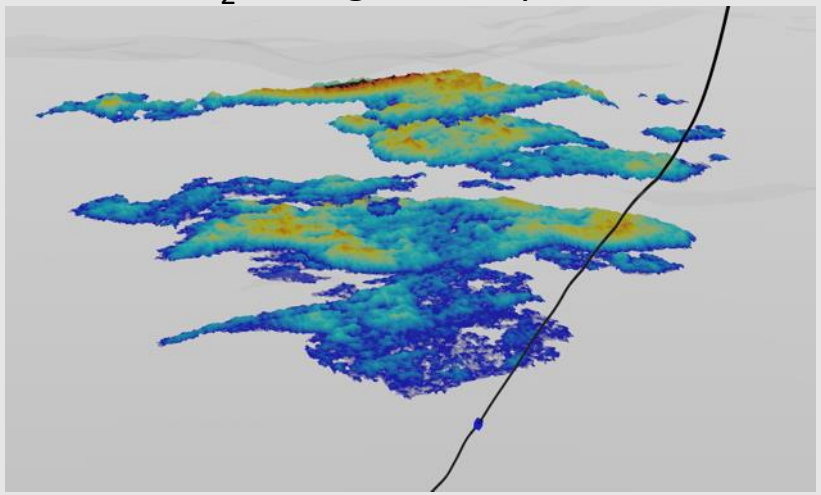
SFI Centre for Geophysical Forecasting

4 Departments at NTNU: IES, IMF, IDI, IGP
12 Industrial Partners: AkerBP, ASN, BaneNOR, CGG, Digital Geology, **Equinor**, NVE, Sikt, Shearwater, Statens Vegvesen, Tampnet, TGS
2 Research Partners: NORSAR and JAMSTEC (Japan)
Total budget (8 years): 210 MNOK (90 NFR; 55 NTNU; 65 Industry+NORSAR)
PhDs and post docs: 24 over 8 years

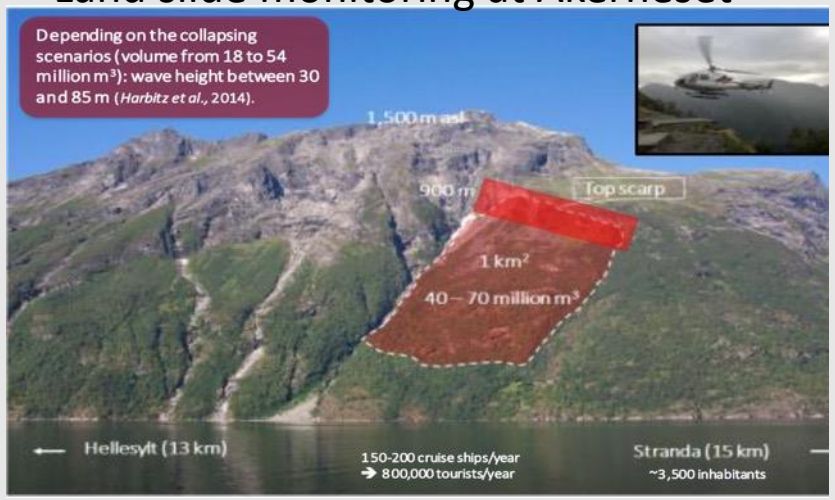
Whale recordings at Svalbard



CO_2 storage at Sleipner



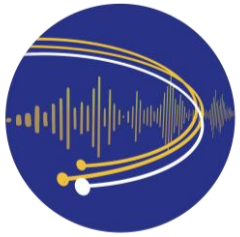
Land slide monitoring at Åkerneset



Our objective is Innovation: Creating new business opportunities, products and services

Work Packages

Double set of workpackage logos: small and large – you find them at CGF teams /General/Templates



WP1

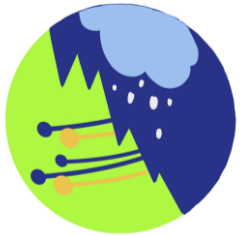
Distributed Acoustic Sensing - DAS

WP2

CO2 and gas / energy storage

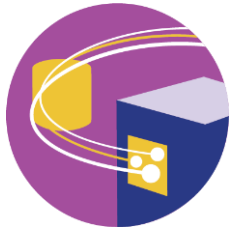
WP3

Monitoring and Forecasting Systems



WP4

Geohazard prediction



WP5

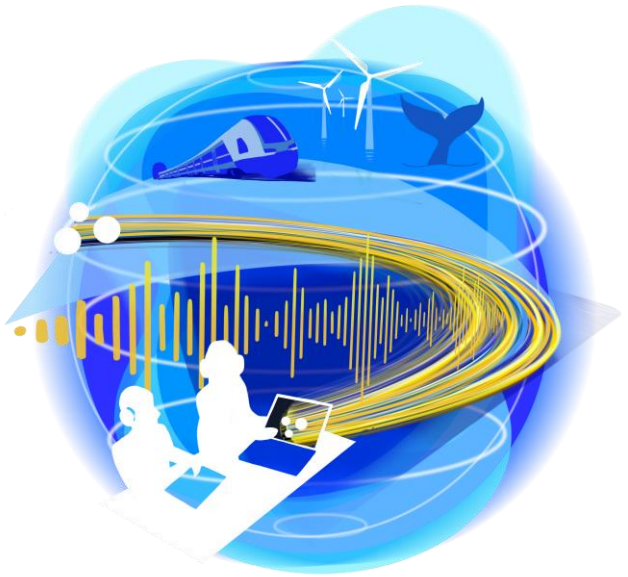
HPC Tools and Techniques for Model-fitting the Subsurface

WP6

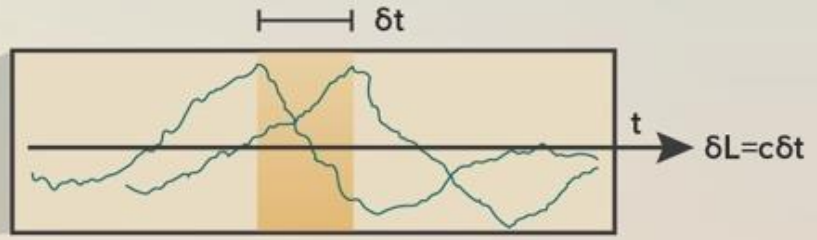
Data Assimilation and Uncertainty Quantification

WP7

Deep earth imaging



How Distributed Acoustic Sensing works with light pulses in a Fibre Optic cable



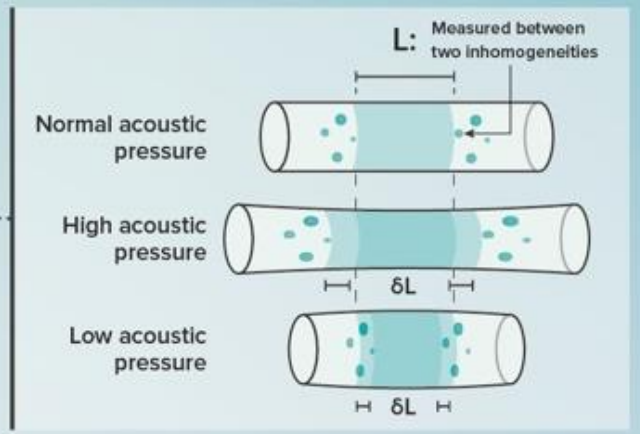
1 Light pulses are injected into a fibre cable at regular intervals

2 Acoustic sources, such as whales, ships and earthquakes, radiate oscillating pressure fields

3 These oscillating pressures stretch and compress the fibre

4 Inhomogeneities in the fibre scatter the light pulses back to the interrogator

5 Variations in backscattered light due to the stretching of the fibre can be tracked at the interrogator to tell us about the acoustic pressure field at points along the fibre



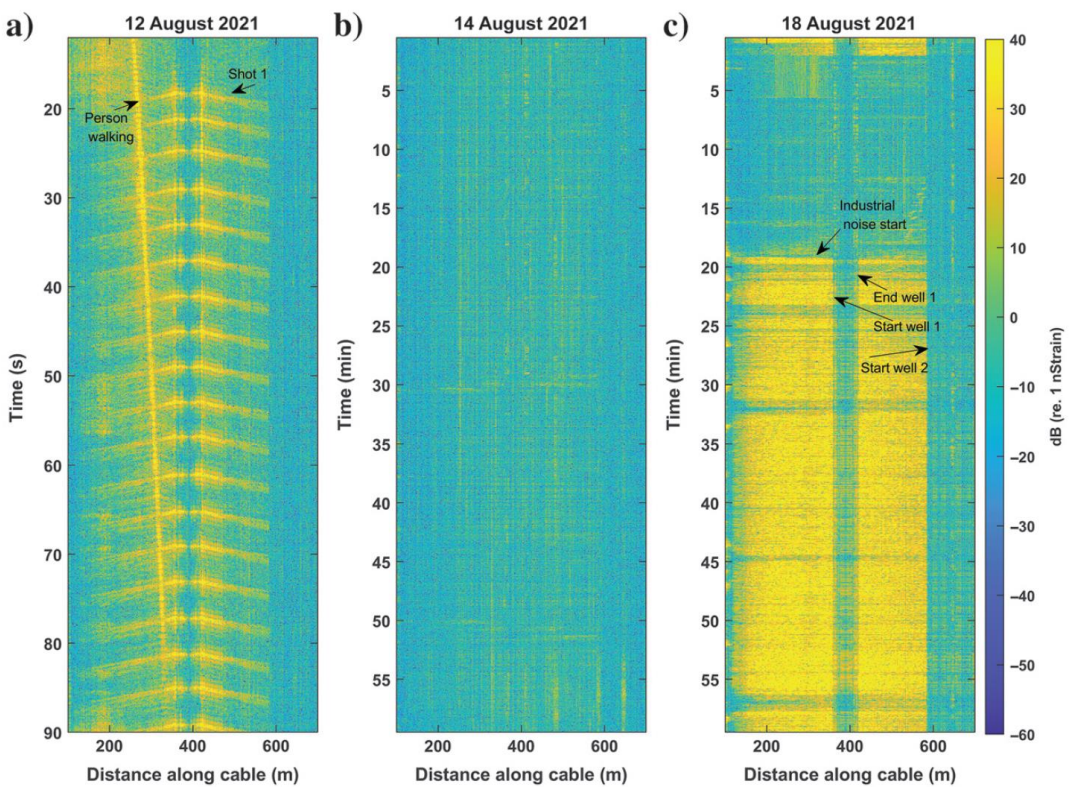
Fibre optic cable

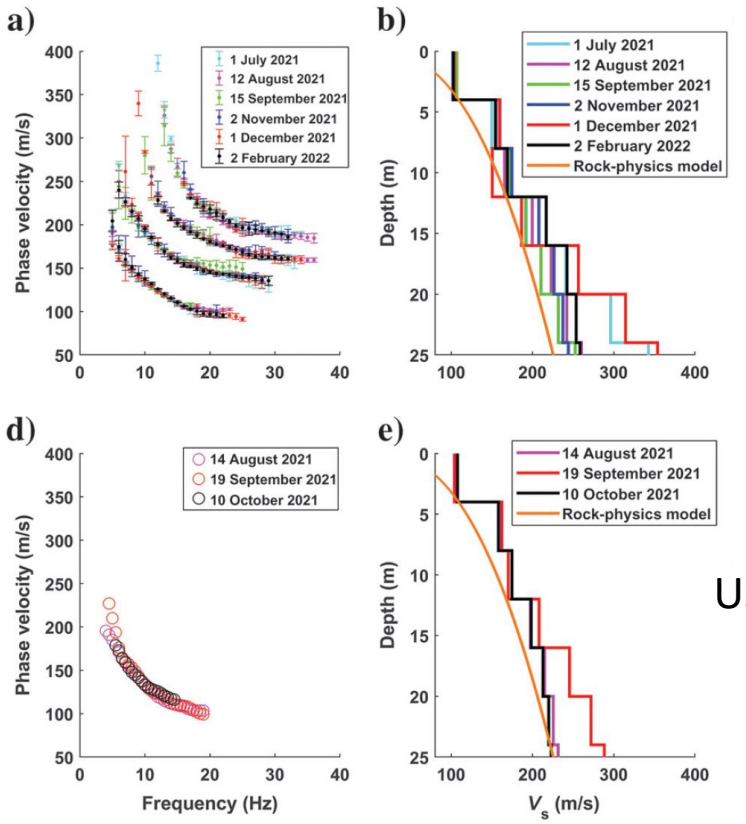
CGF SFI Centre for Geophysical Forecasting

Quick clay monitoring in Rissa, Norway – deployment of fibre – a cooperation with Trøndelag Fylkeskommune, Indre Fosen commune and NorConsult

Rissa – CGF field test site

Monitoring the shear wave velocity during road construction in Rissa



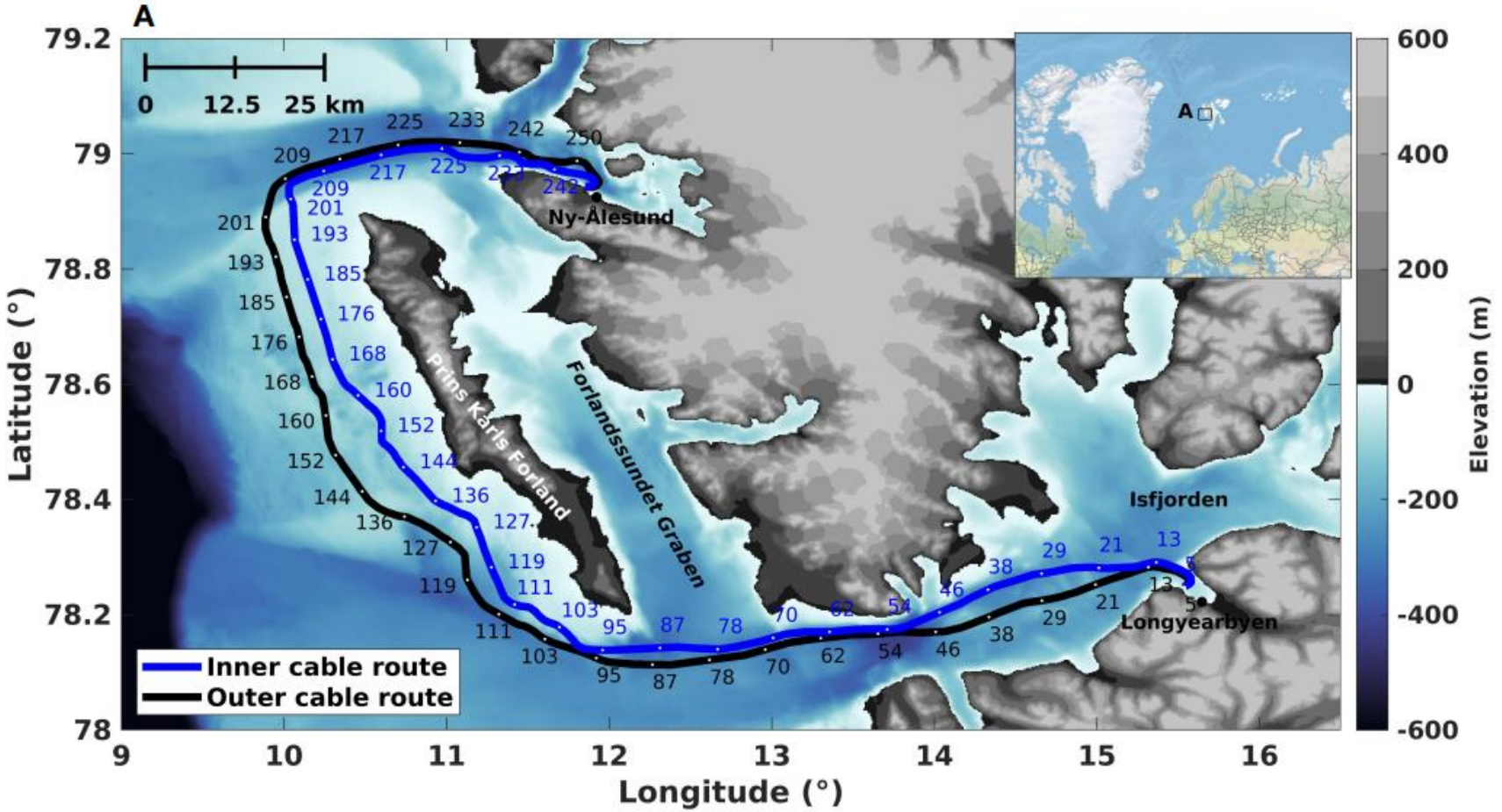


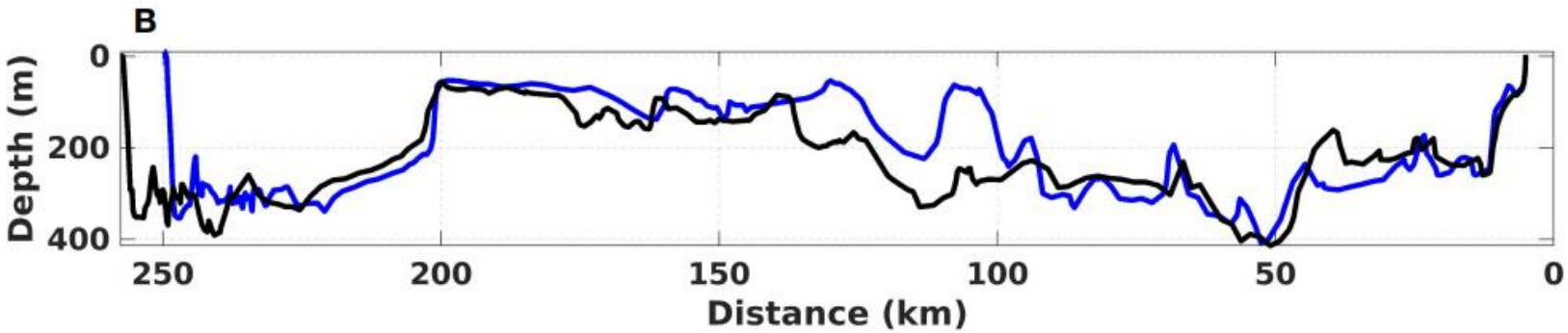
Active hammer shots

Using background noise only

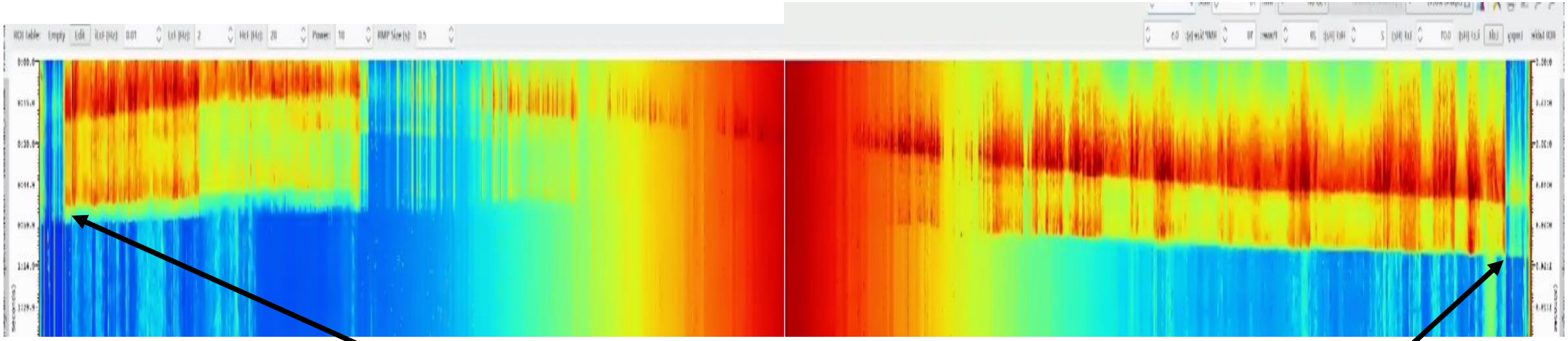
Rørstadbotnen et al., 2023, Quick clay monitoring using distributed acoustic sensing: A case study from Rissa, Norway, Geophysics 88, B267-B283

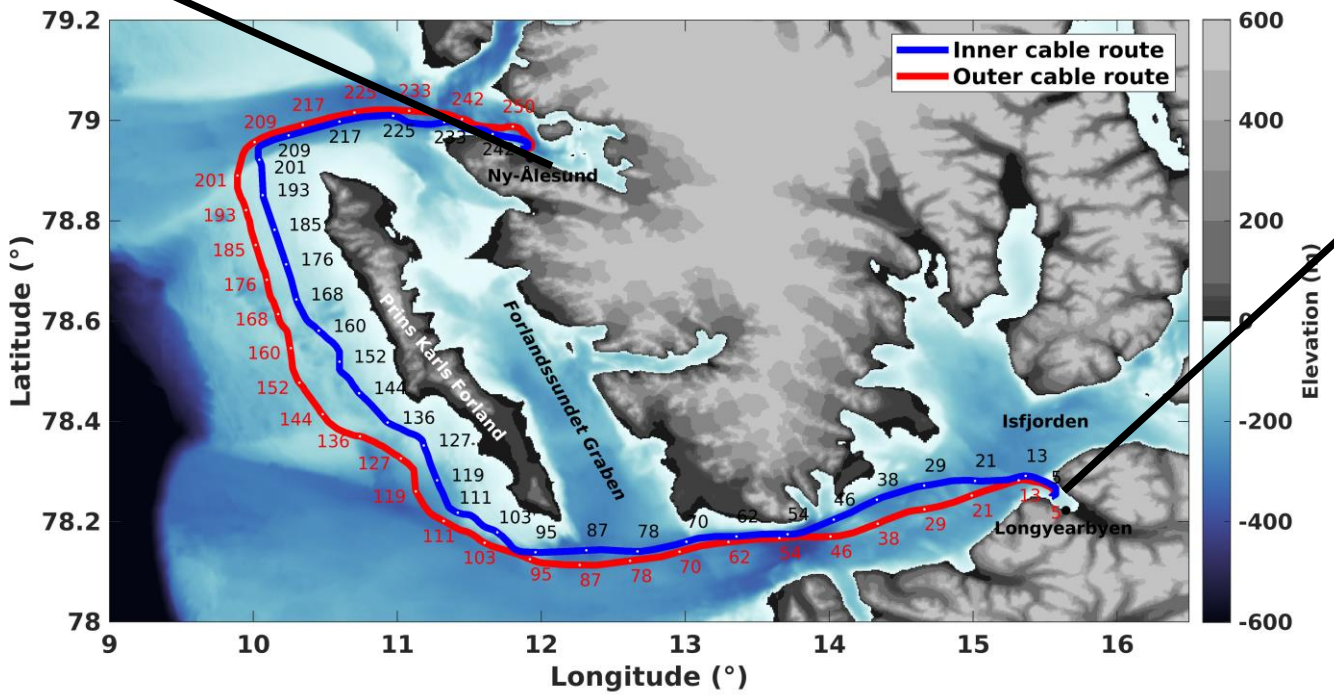
The two fibre optic cables offshore Svalbard





The 2022 CGF Svalbard field campaign: Using 4 interrogators





Cooperation between SIKT, ASN, UIB, NORSAR and NTNU

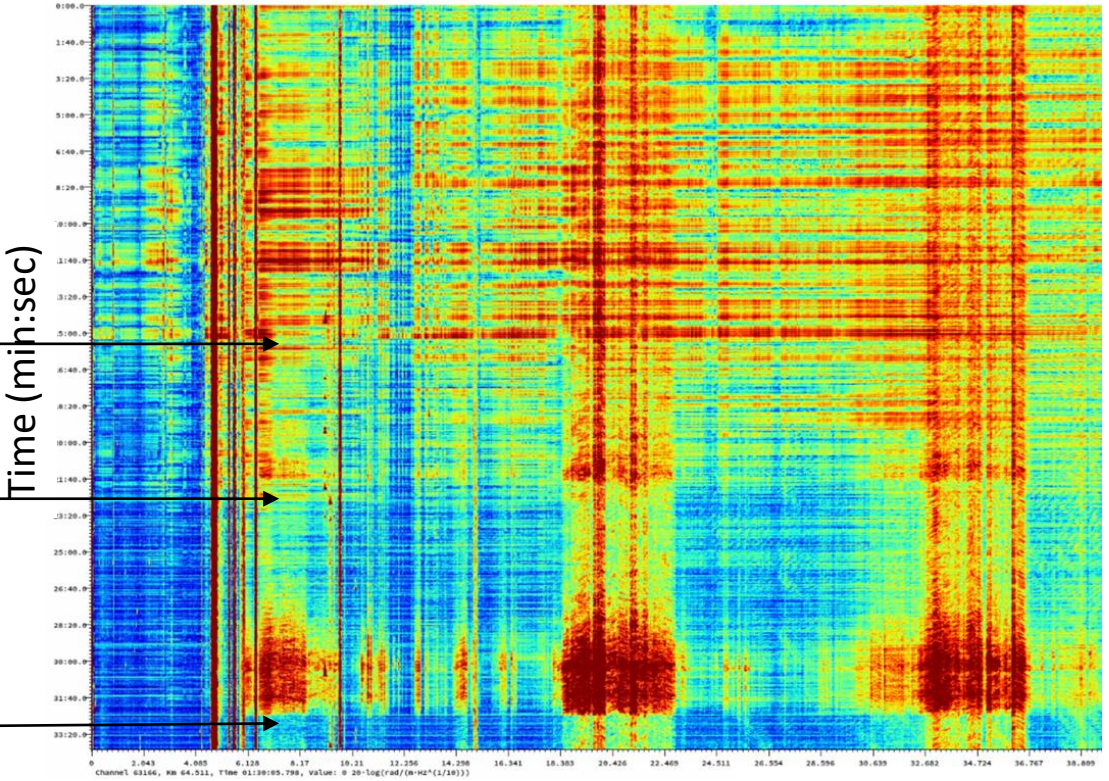
The 6th February earthquake in Turkey – DAS recording offshore Svalbard

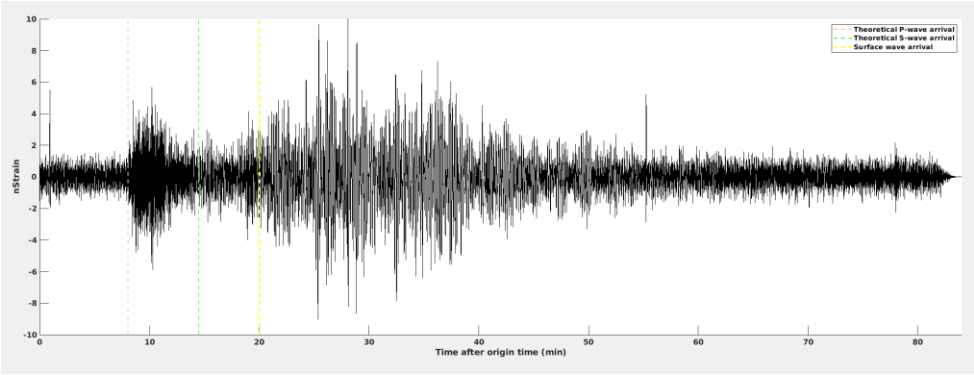
Plot end at 01:56:10

First Surface arrival wave: 01:43:43

First S-arrival (?) 01:40:57

First P-arrival 01:25:42





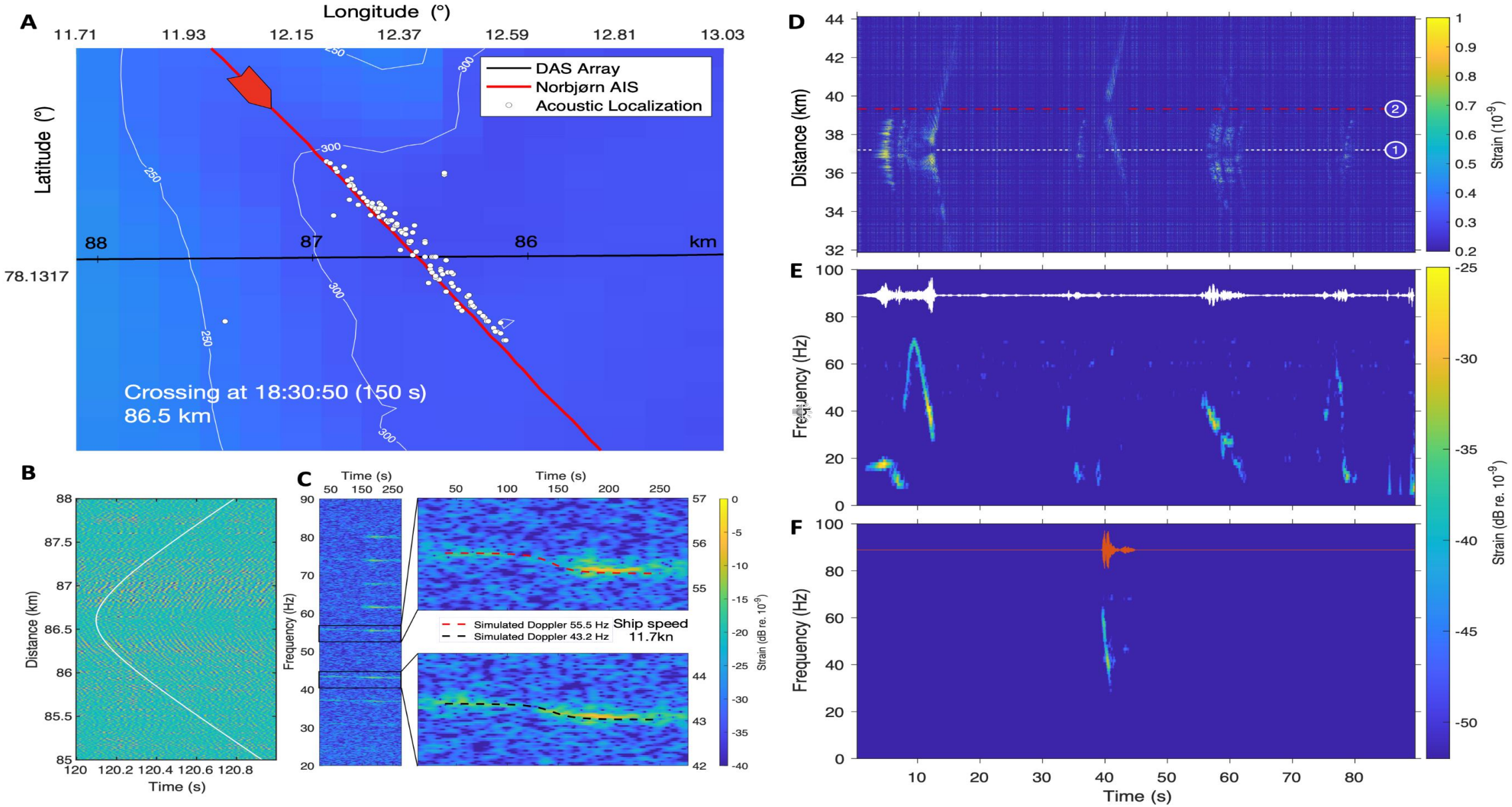
Plot start at 01:24:10

Distance along cable (km)

The magnitude **7.8 earthquake in Turkey and Syria** was clearly observed on the fiber cable going from Longyearbyen to Ny-Ålesun The section shown here is a 60 km portion of the cable located in Kongsfjorden. P-, S-, and surface- waves are clear events in the data and arrive at distinct times. We observe them as nearly flat events 8 min 4 sec, 23 min 22 sec and 26 min 8 sec after the origin time reported by USGS (01:17:35 UTC).

The rough epicentral distance to Svalbard is 4,780 km. If we make the rough assumption that the P-, S- and surface- wave propagated the same distance they have the following velocities: 9.9 km/s, 3.4 km/s and 3.0 km/s.

Sensing whales, storms, ships and earthquakes - Arctic fibre-optic cable



Bouffaut, L. et al., 2022, **Eavesdropping at the speed of light: Distributed acoustic sensing of baleen whales in the Arctic**. Front. Mar. Sci. 9, 901348.

Forskarar bruker fiberkablar for å tjuvlytte til kval

Det er lite forsking på korleis auka aktivitet i Arktis påverkar dyrelivet til havs.
No bruker forskarane fiberkablar for å lære meir om kvalen.

Foto: Jan-Morten Bjørnbakk / Scanpix

Ingeborg Grindheim Slinde
Journalist

Vi rapporterer frå **Tromsø**

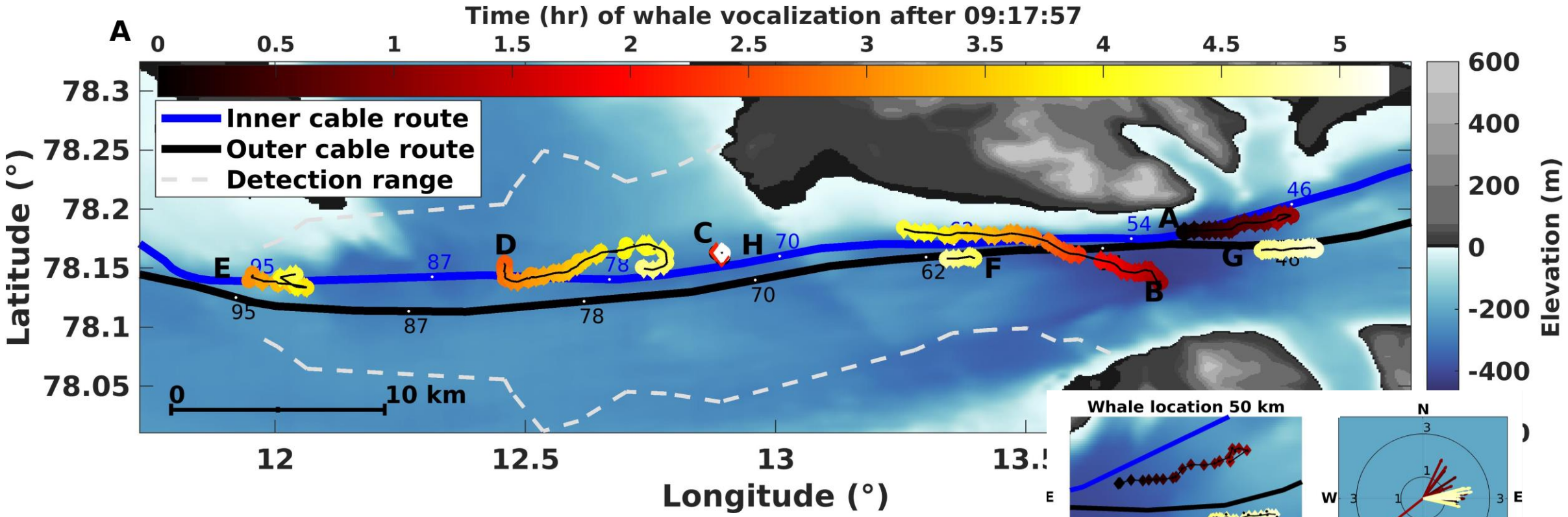
Publisert 19. juli kl. 09:50
Oppdatert 19. juli kl. 10:54

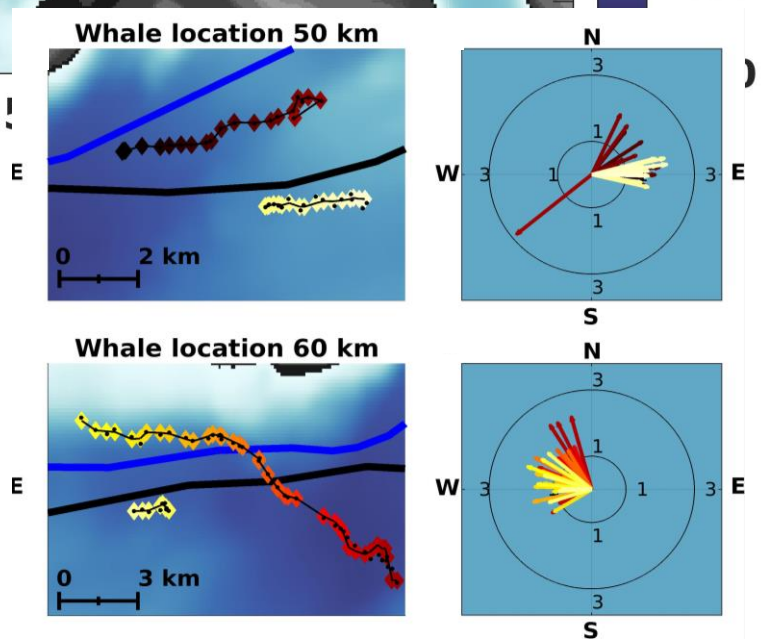
TECH & SCIENCE

Watch: How Scientists Track Ocean Giants

BY ALICE AMELIA THOMAS, ZENGER NEWS ON 7/12/22 AT 10:22 AM EDT

Tracking several fin whales for 5 hours





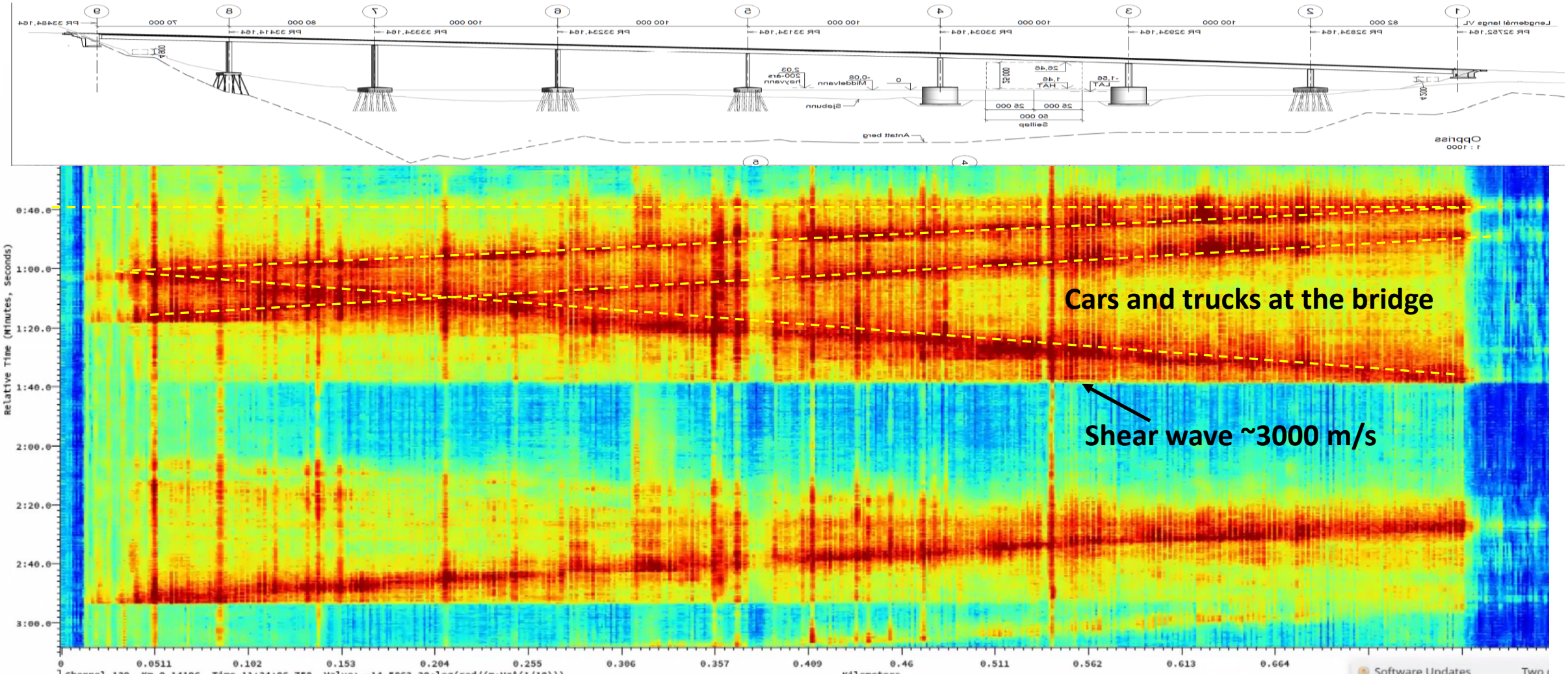
- Detection range from 2.4 km to 9.4 km depending on noise level and cable coupling

Rørstadbotnen, R. et al., 2023, **Simultaneous tracking of multiple whales using two fibre-optic cables in the Arctic**, Front. Mar. Sci. 10, 3389

Tracking fin whales

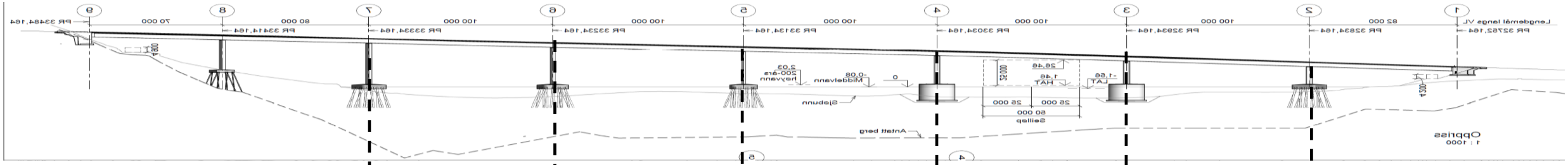
Åstfjordbrua 740 m – a cooperation with Trøndelag Fylkeskommune

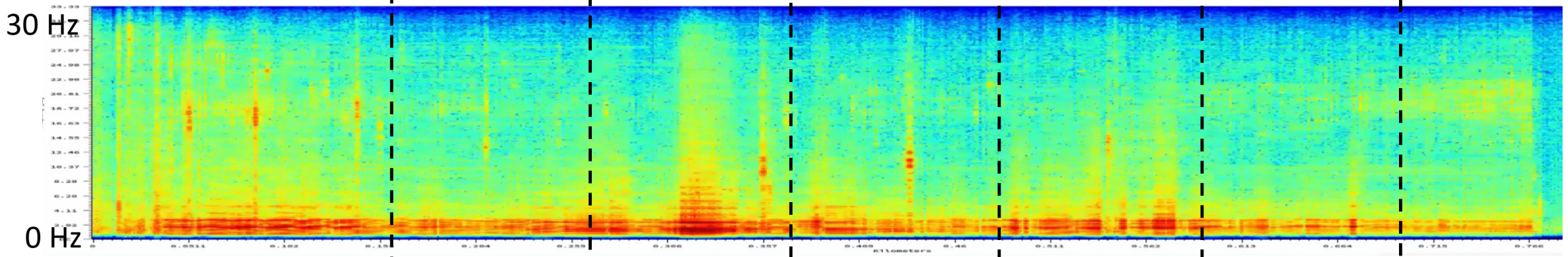
Åstfjordbrua: Examples of trucks meeting at the bridge

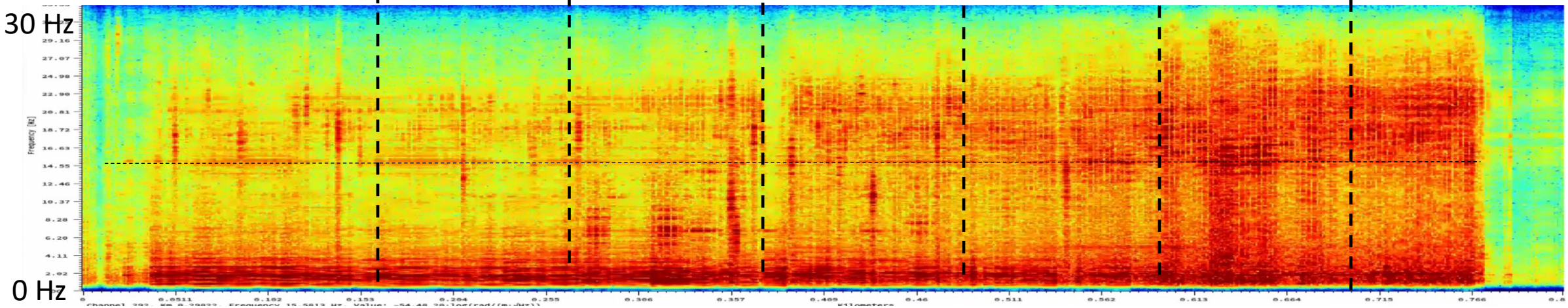


Fx-plot with and without load

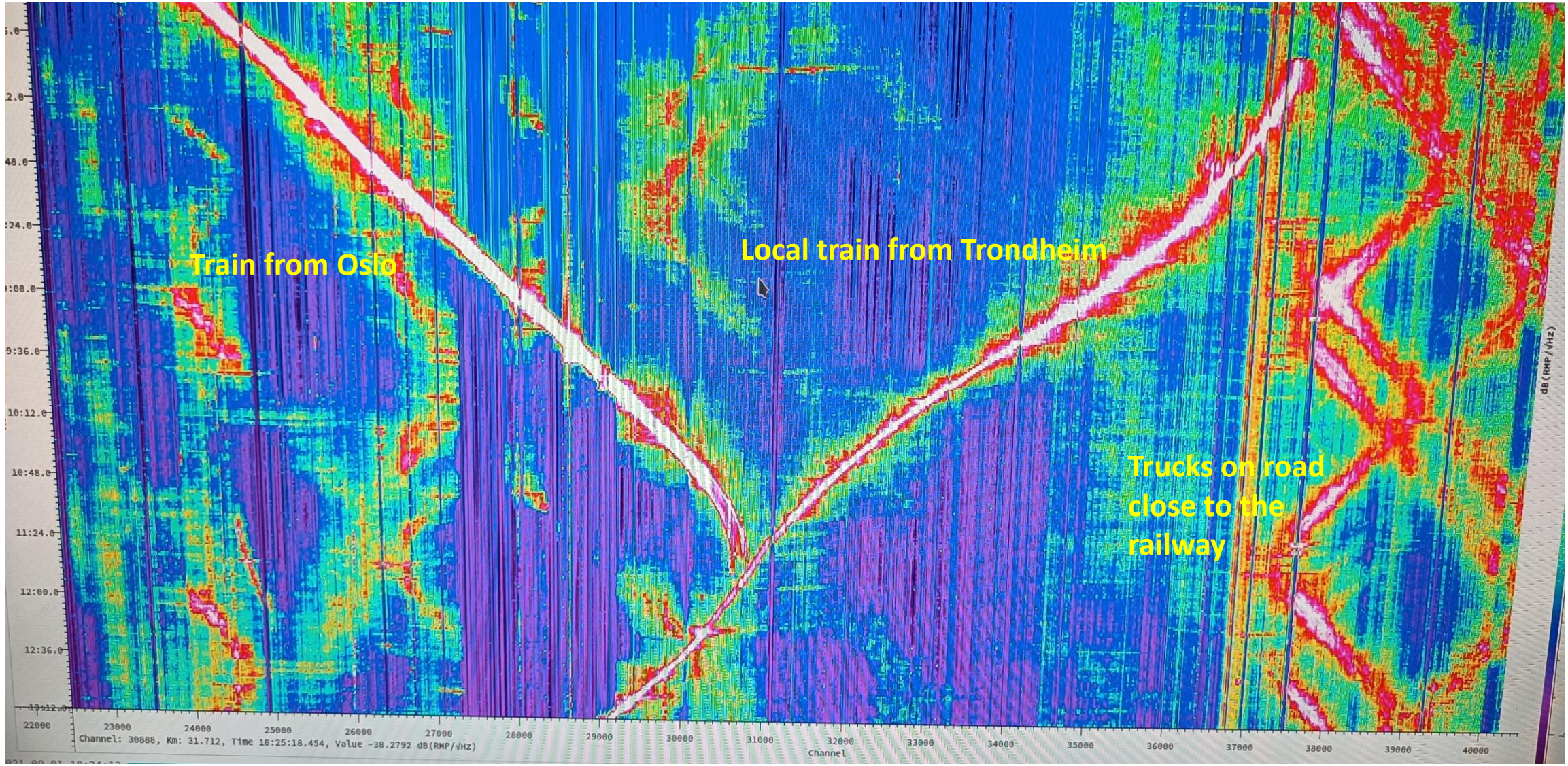
Eigenfrequency for the entire bridge f=c/2L = 3000/1480 = 2 Hz
Between pillars: f=3000/200= 15 Hz, f = 3000/400= 7.5 Hz , ….



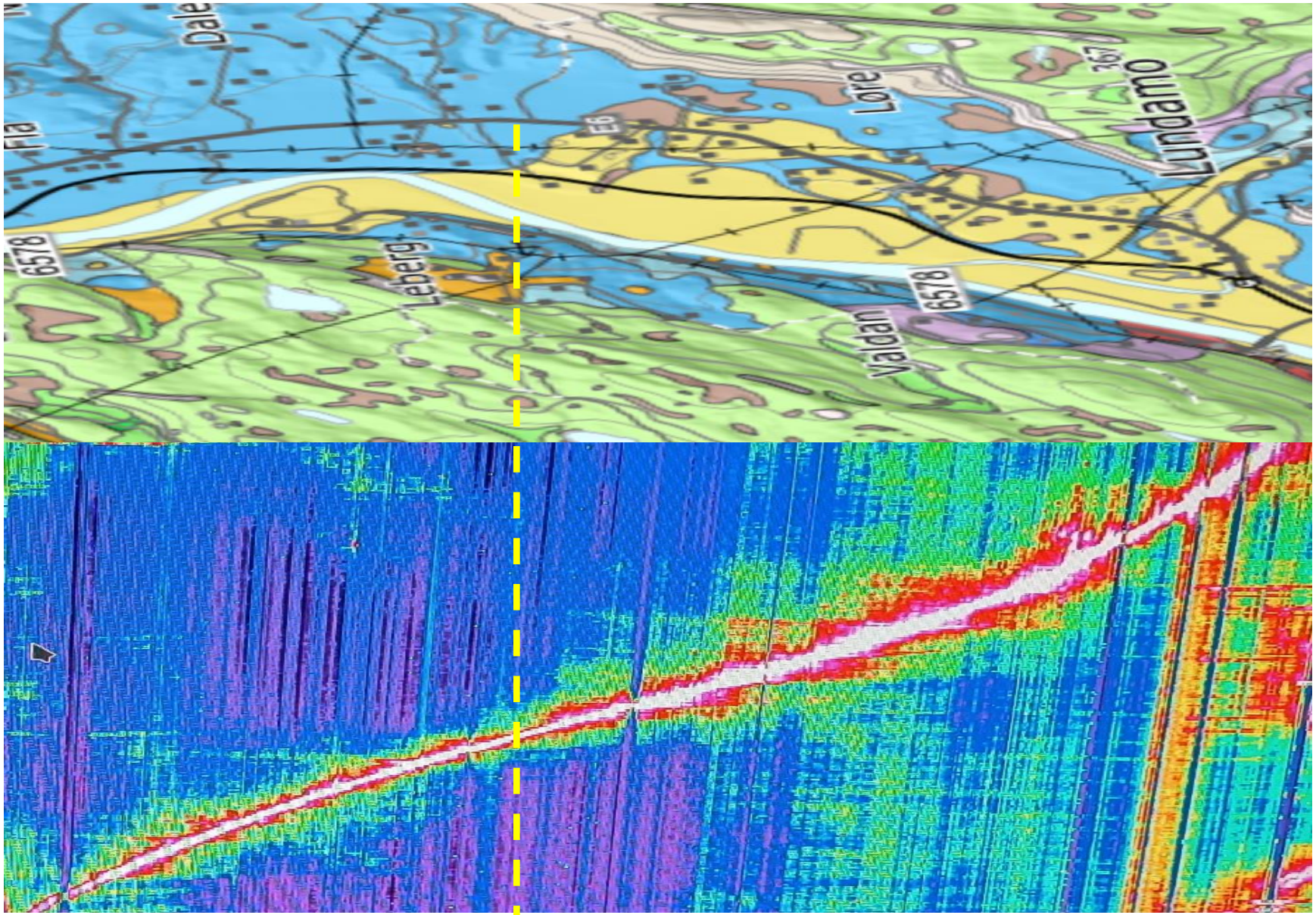




The BaneNor test in September: Two trains passing North of Ler – 1st September at 20:19 – DAS recording between Trondheim and Støren

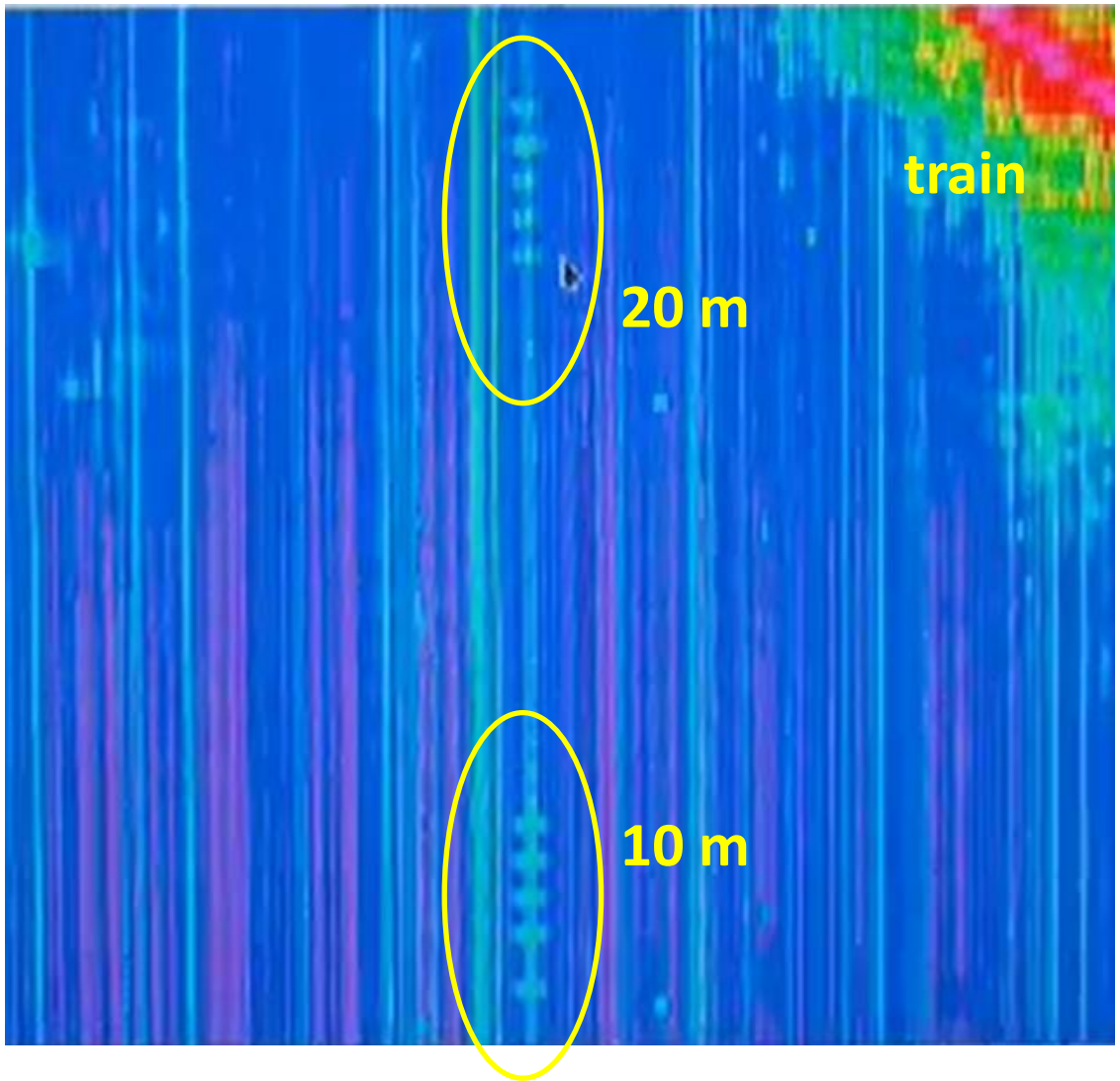


Can we use the train signal for subsurface monitoring?



Clay-fluvial boundary

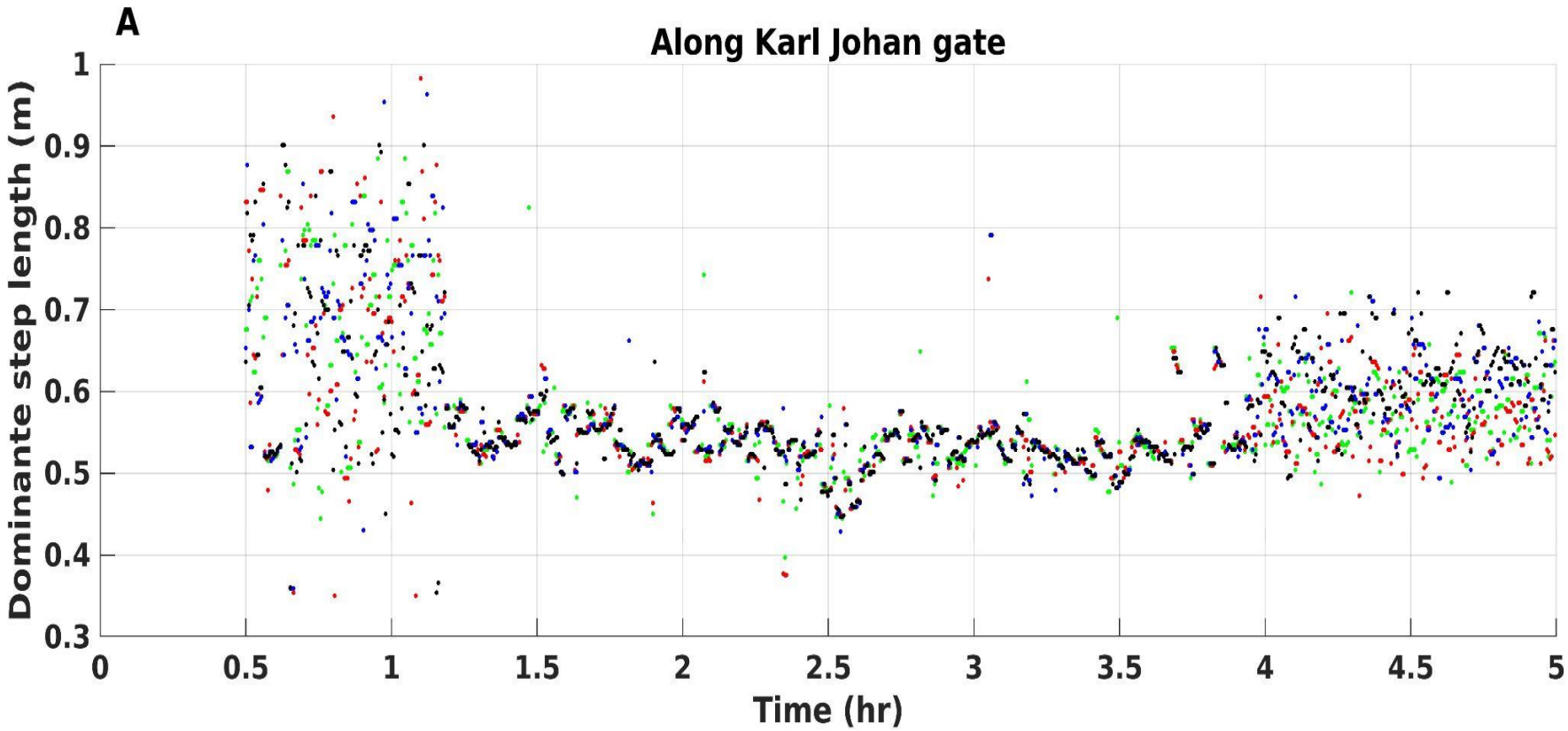
Jumping 20 and 30 m away from railway – and train arriving from South.



Urban monitoring (Oslo; 17th May parade)

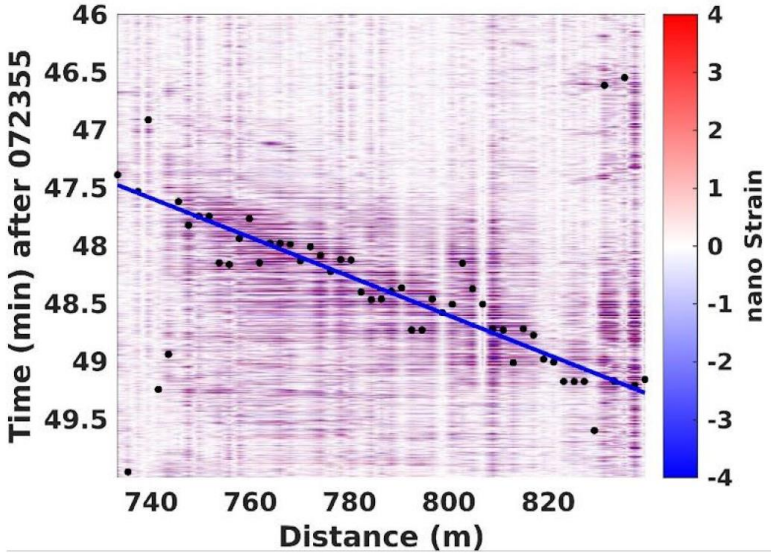
Using fiber optic communication network to monitor urban activity

Robin André Rørstadbotnen[*,a,b], Jo Eidsvik[b,c], Jan Langhammer[a,b], Martin Landrø[a,b], Osman Mohammad Ibrahim[d]



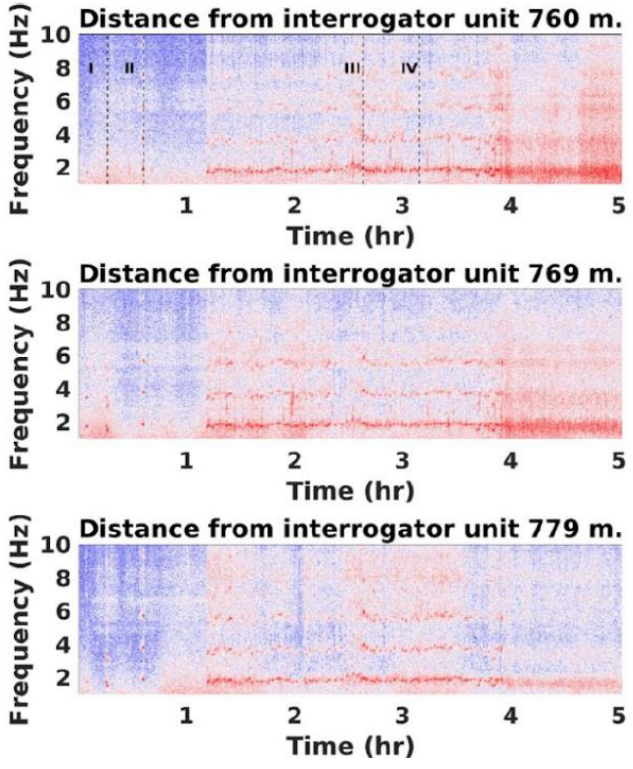
A cooperation between Oslo Municipality and CGF

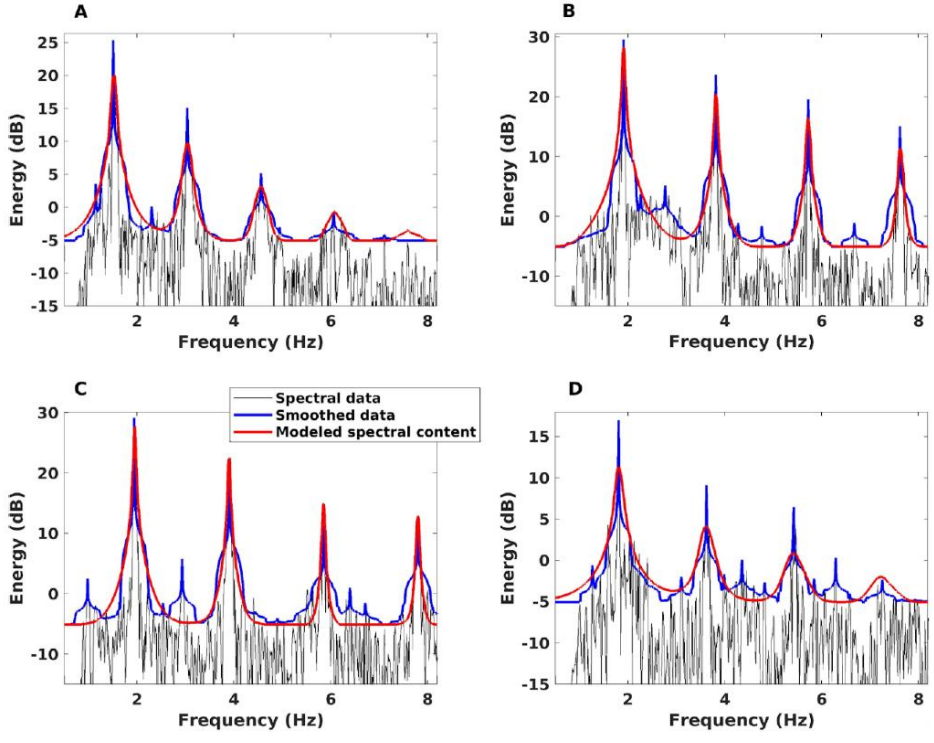
Urban monitoring (Oslo; 17th May parade)



Simple model: $$F_1(t) = W\left[1 + \sum_{n=1}^{N} \sqrt{N}\,\alpha_n \sin\left(n2\pi f_p t + \phi_n\right)\right],$$

Average step length: $l(t) = v/f(t)$

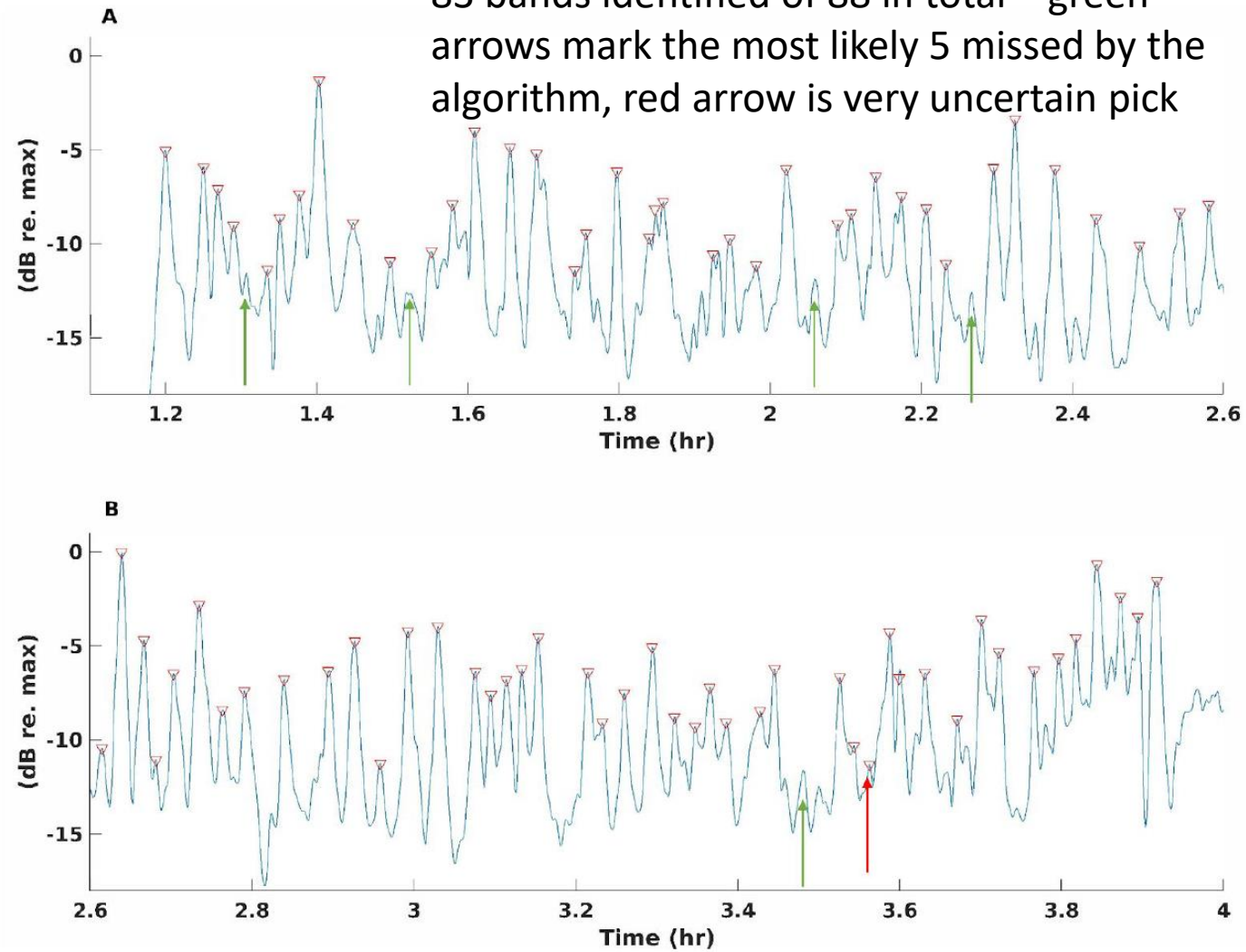




Model
Smoothed data

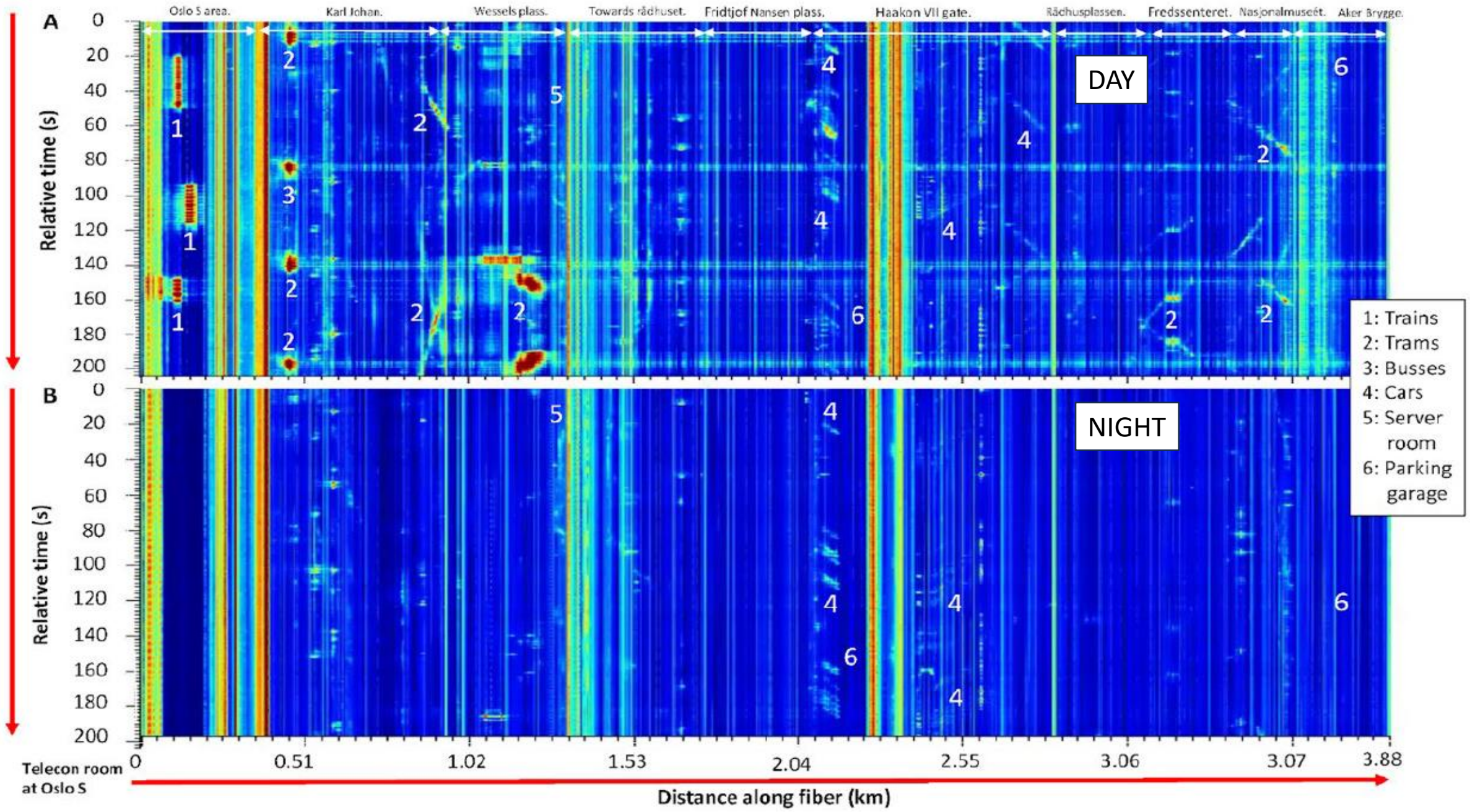
Amplitude analysis to estimate number of bands in the parade

83 bands identified of 88 in total – green arrows mark the most likely 5 missed by the algorithm, red arrow is very uncertain pick



One of the 88 bands that participated in the 2023 17th May parade in Oslo

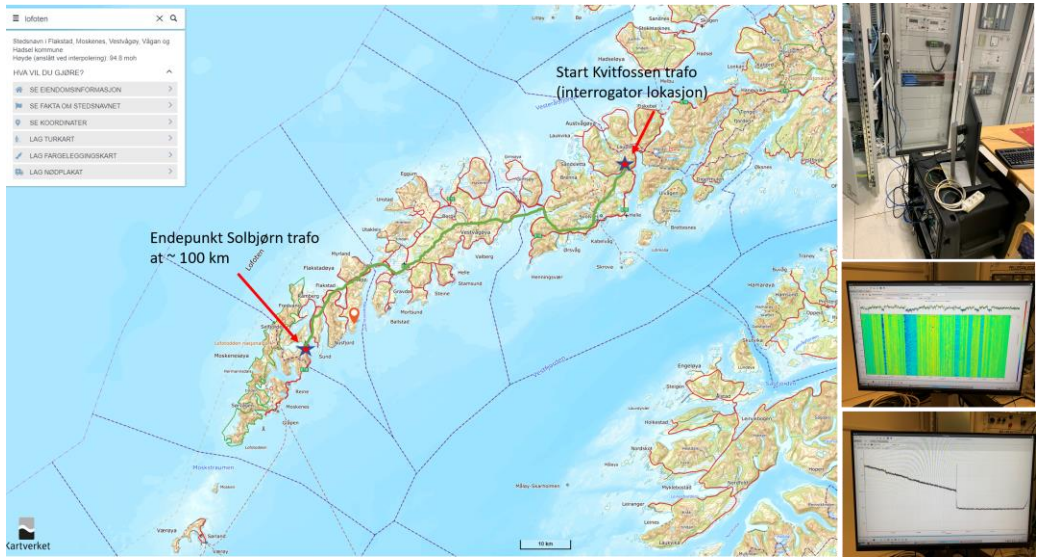
DAS-dat in OSLO – day and night: Trains, Trams, Busses, Cars, Electrical noise



DAS-monitoring of power-line in Lofoten – cooperation between ELMEA and CGF

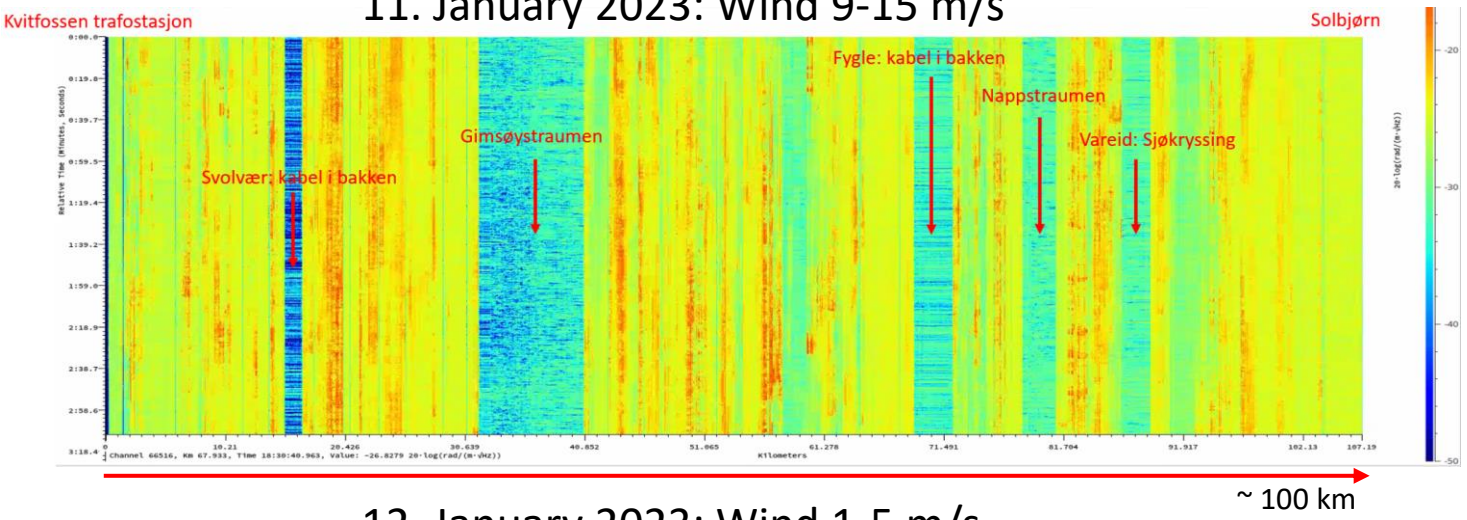
Monitoring of around 100 km:

- ❑ Impact of weather
- ❑ Vibrations of components over time
- ❑ Sabotage and theft
- ❑ Trefall and lightning
- ❑ All activities generating acoustics

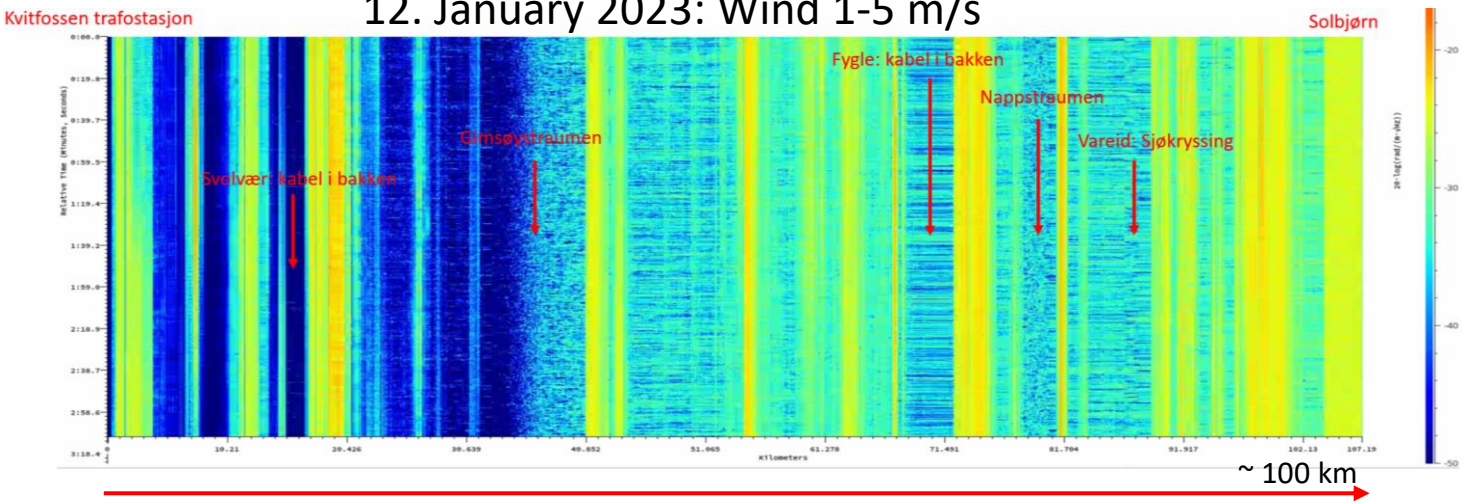


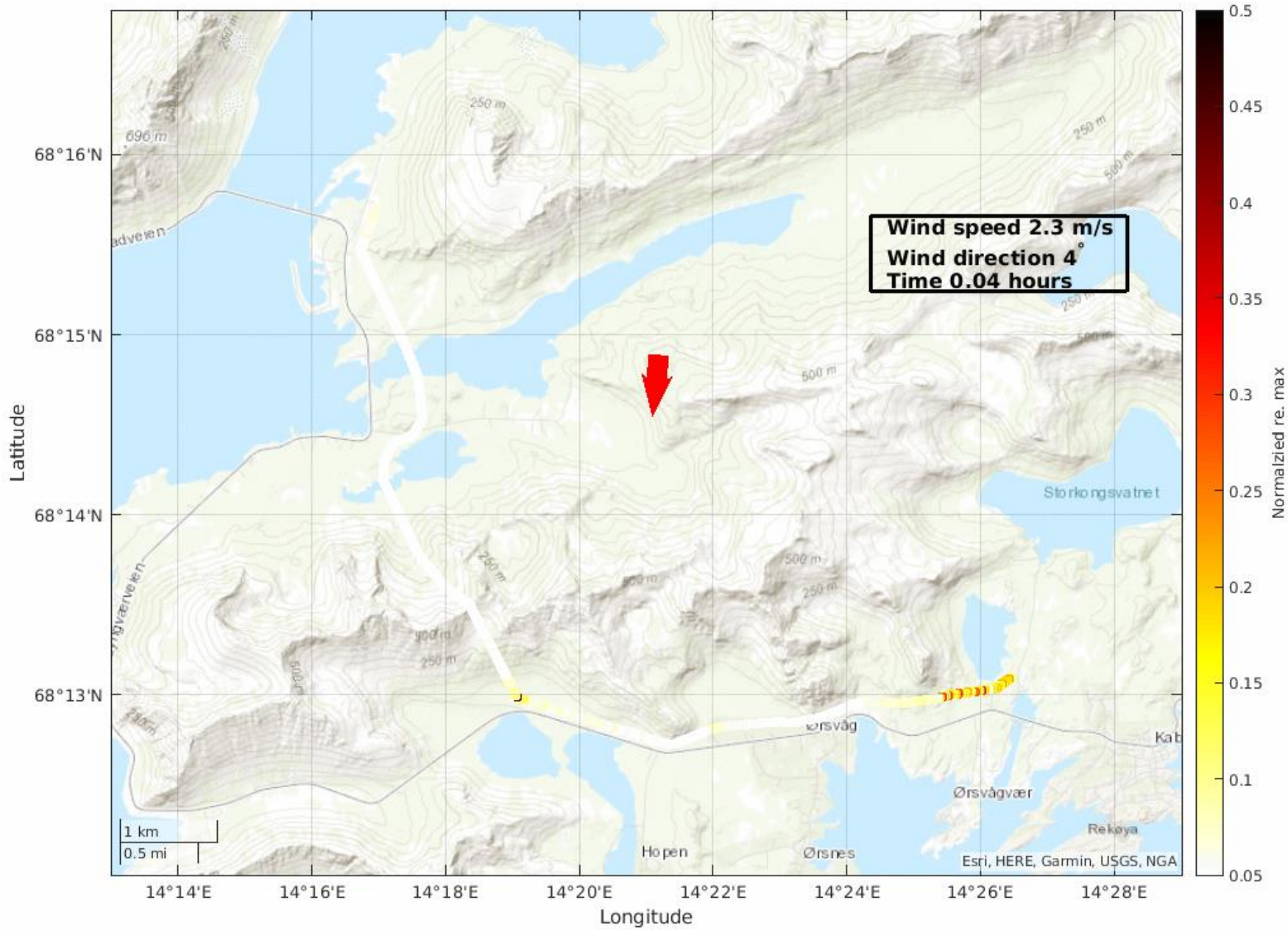
Full line overview, responses to be analyzed in detail

11. January 2023: Wind 9-15 m/s



12. January 2023: Wind 1-5 m/s




Wind speed 2.3 m/s
Wind direction 4°
Time 0.04 hours
68°16'N
68°15'N
68°14'N
68°13'N
Latitude
14°14'E
14°16'E
14°18'E
14°20'E
14°22'E
14°24'E
14°26'E
14°28'E
Longitude
Storkongsvatnet
Ørsvåg
Ørsvågvær
Reköya
Hopen
Ørsnes
1 km
0.5 mi
Esri, HERE, Garmin, USGS, NGA
Normalzied re. max
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05