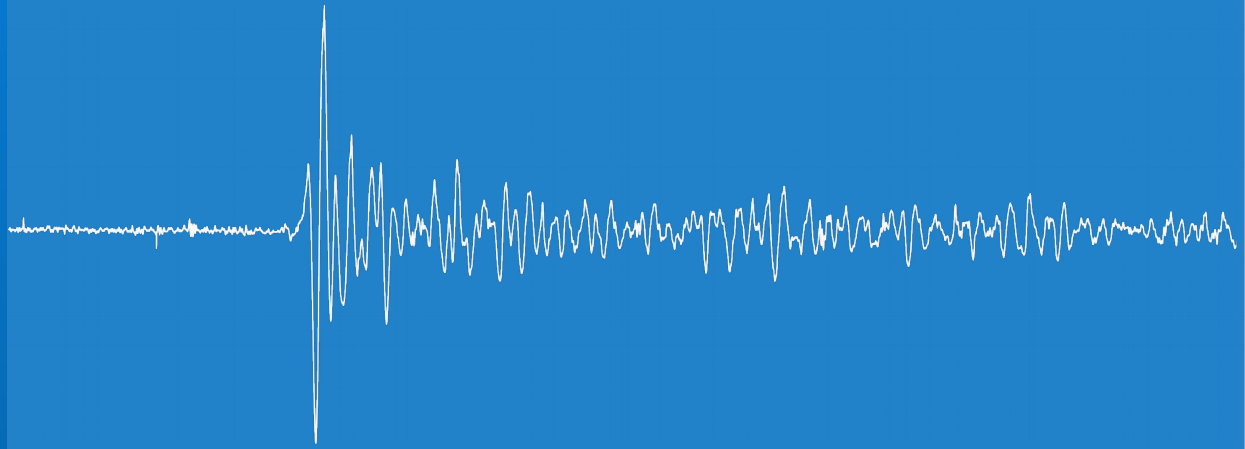
Digitization and analysis of printed seismograms from aftershocks of the Novaya Zemlya explosion on October 27, 1973



Carl Hellesen, Leif KG Persson, Steven Gibbons

Foto: Försvarsmakten/David Gernes

FOI

Hagfors observatory 1969 - 2019

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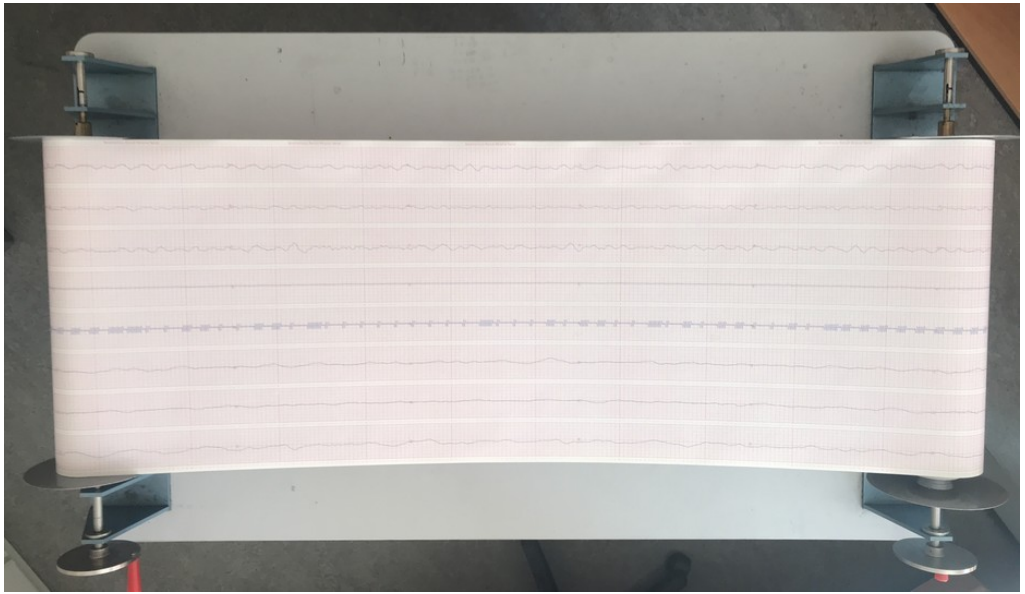
What data are we looking at?

- Printed seismogram plots on paper rolls
  - About 40 cm wide
  - Very high quality prints
- Data between 1969 and 1983 available at the FOI storage
- Three stations in a triangular pattern
  - Äppelbo
  - Hagfors
  - Stöllet
- Plotting was not done continuoulsy
  - Plotting from circular tape memory activated by trigger



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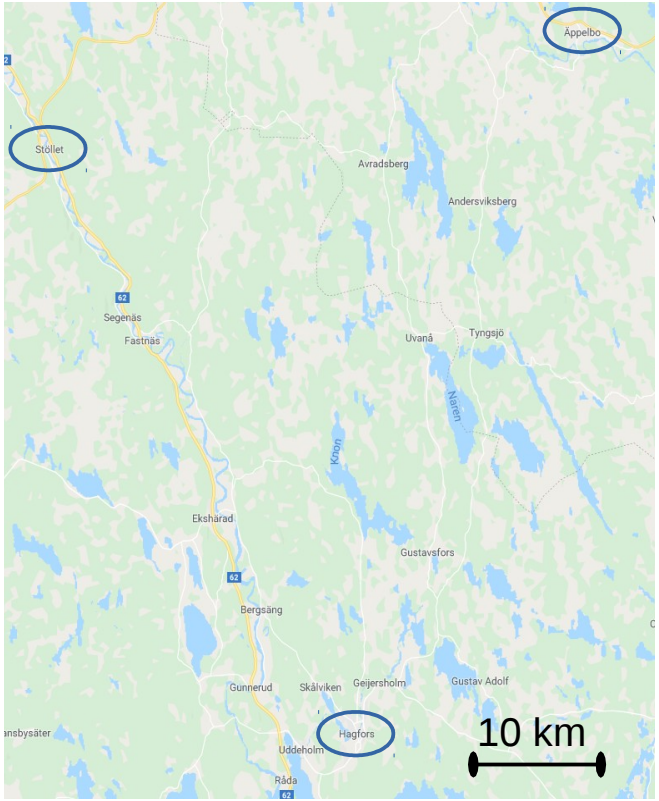

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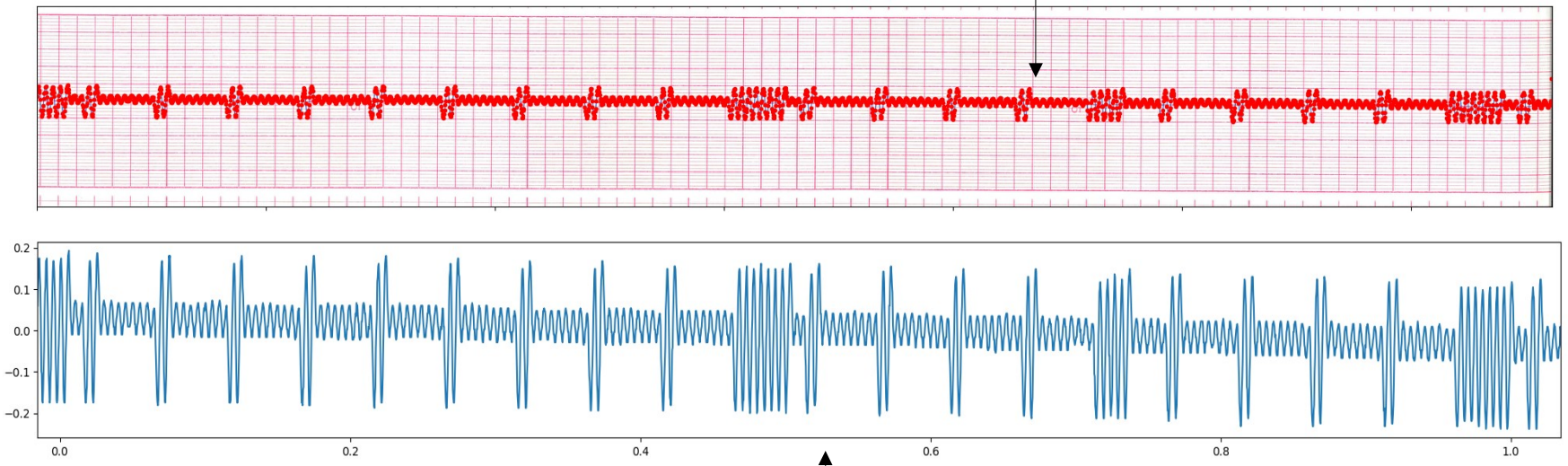
Example of digitization

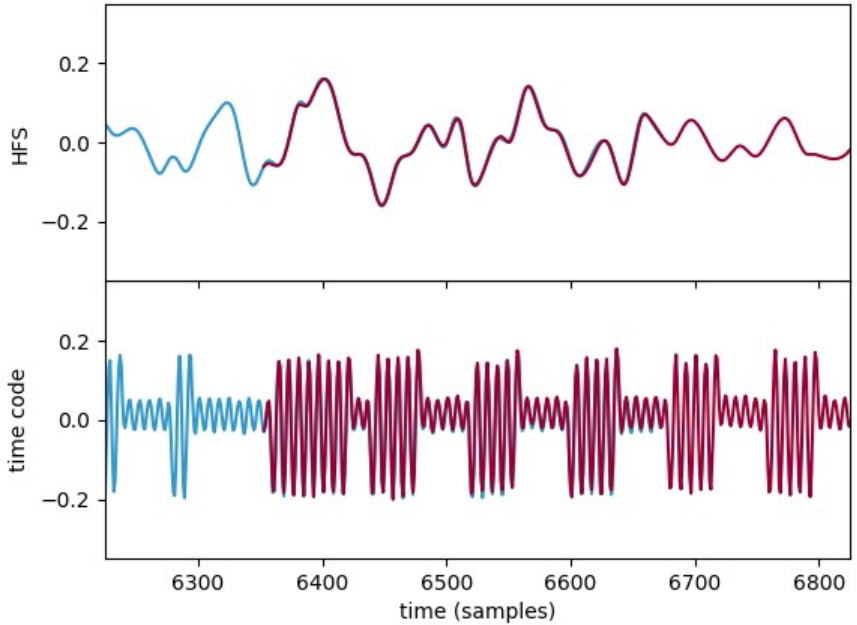
Line is followed by tracing the distance in RGB space from each pixel to the line color



Time code, 10 Hz carrier frequency

Example of digitization

- Several scans are merged into contiguous trace
  - Cross correlate two traces to find overlap
  - Jitter in paper speed an issue, traces can quickly run out of phase
  - Use every 0.1 s clock cycle to phase lock scans
- Identifying jumps between triggered restarts not always trivial
- Fingerprints
- Routines for automatic reading of the time code



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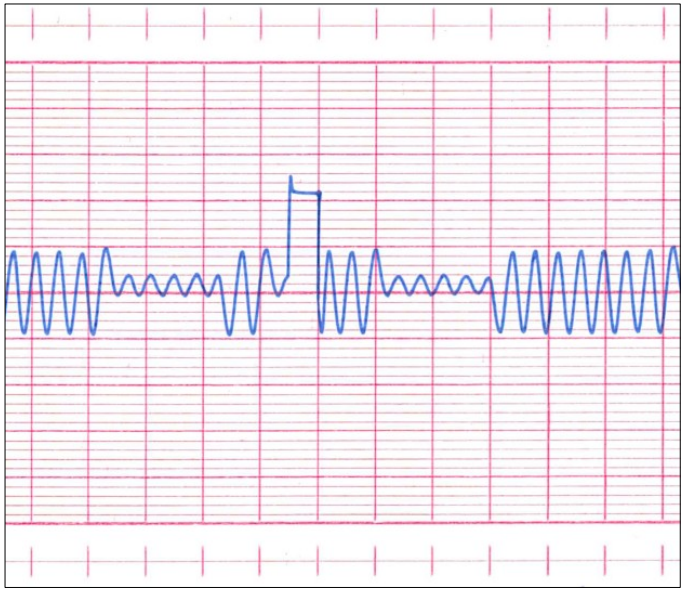
Restart of paper feed



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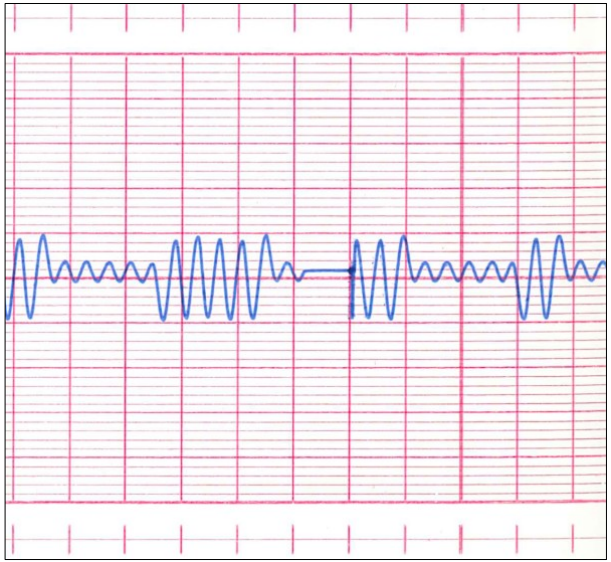
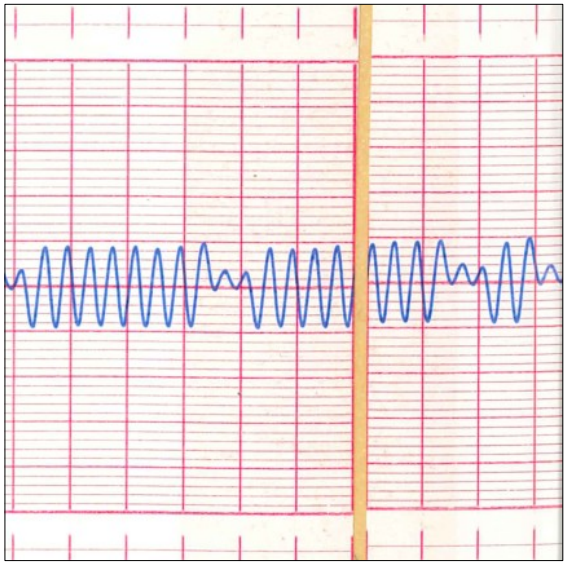


Paper cut and taped



FOI

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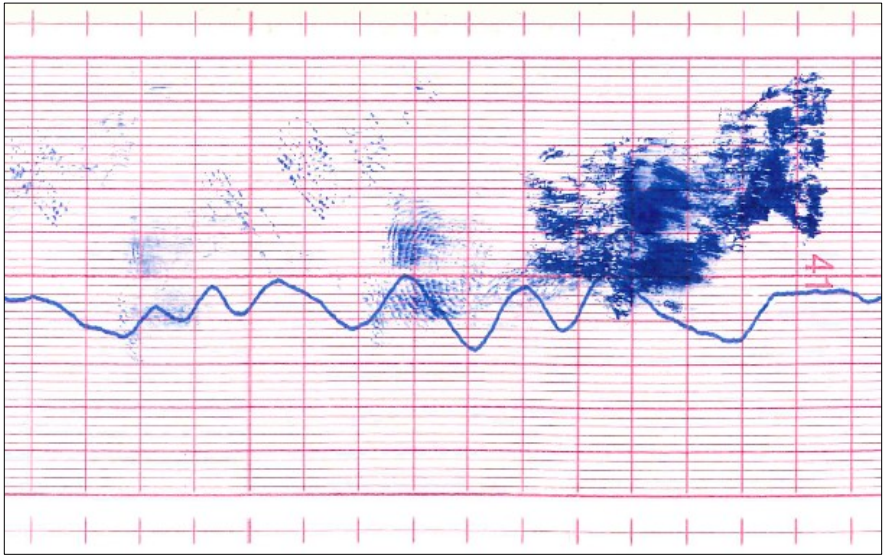

October 27, 1973 Novaya Zemlaya test

- 4 MT hydrogen bomb
  - Southern test site
  - 2200 km distance from Hagfors
- mb = 6.9
  - Resulted in several aftershocks
  - Up to mb = 4.8
  - Very few SP recordings preserved today
- Succesfully digitized printed Hagfors recordings of several aftershocks
  - Weak indications of S waves

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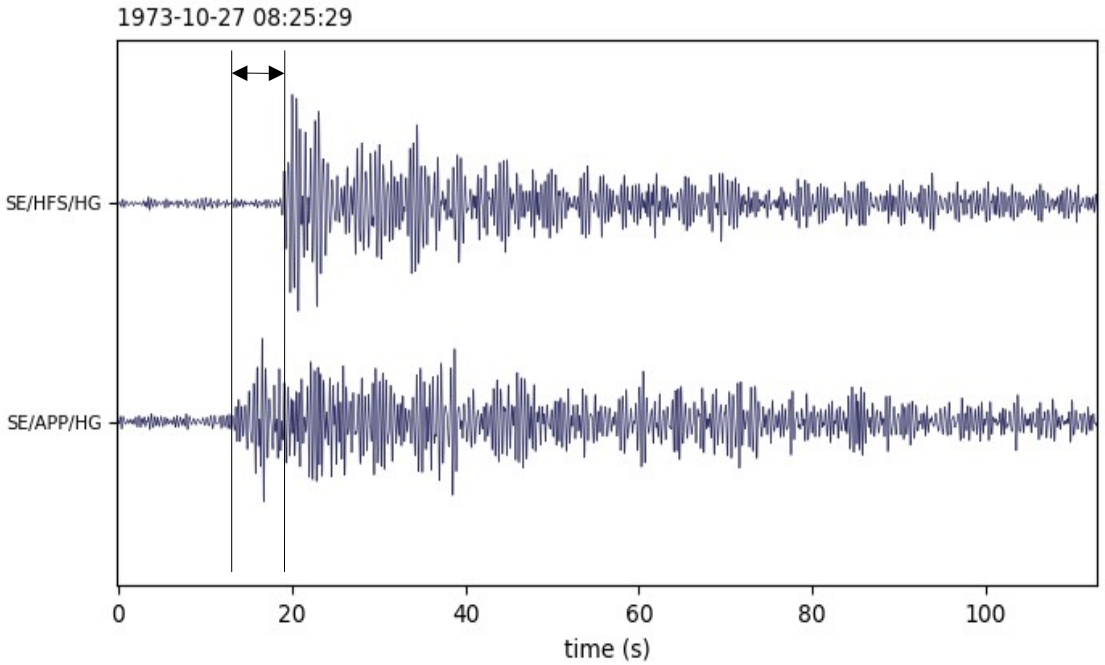

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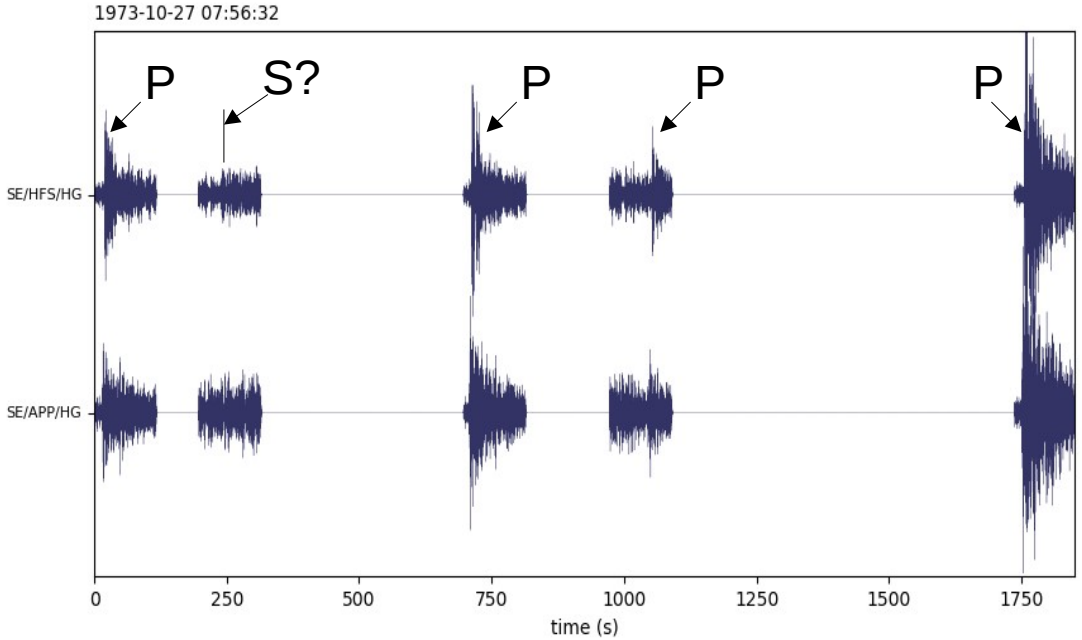
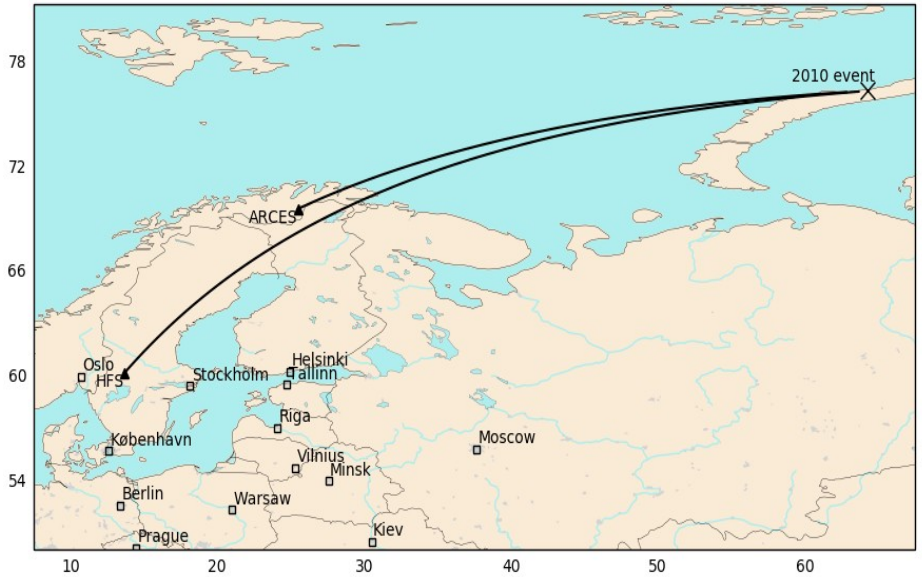


Compare with earthquake Oct 11, 2010

- mb = 4.7
  - Northern Novaya Zemlya
- Hagfors shows clear P wave
  - Only weak signs of S wave
- ARCES shows both P and S waves
- Consistent picture with results from scanned prints
  - … as well as other NZ earthquakes, e.g. in 1986 and 1992



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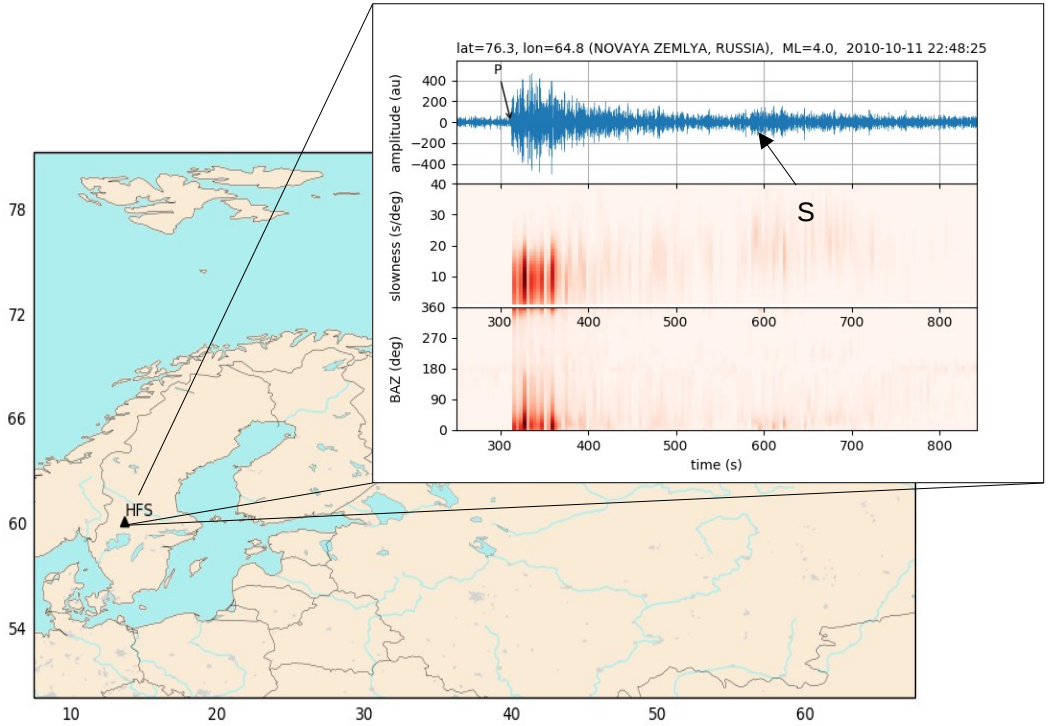

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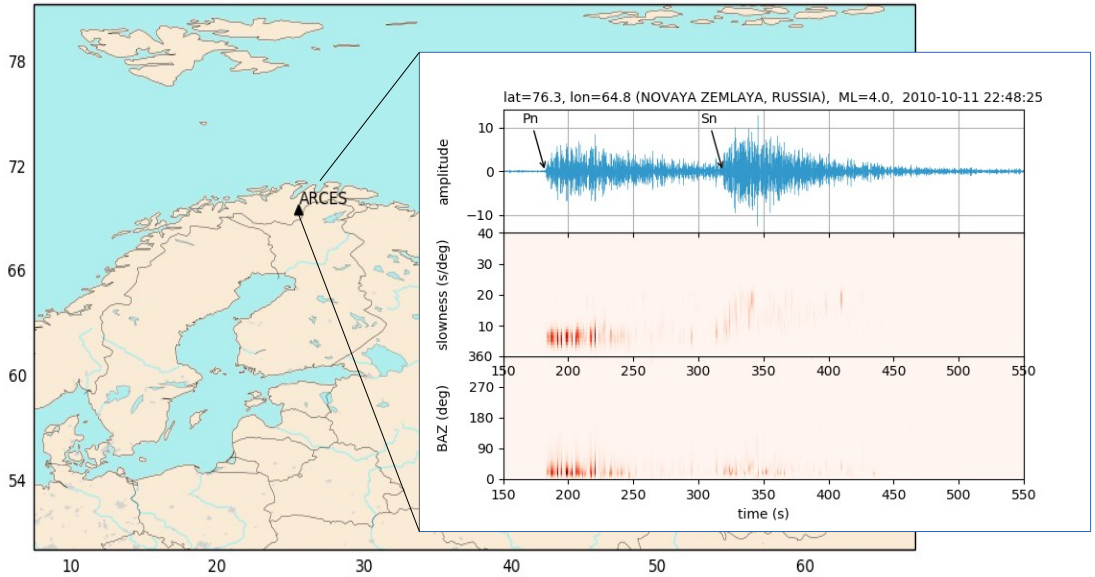

Conclusions

- We have improved the scanning routines of printed seismograms at FOI
  - Attention to detail is important when merging several scans into a contiguous trace

- Application to aftershocks of Oct 27, 1973 hydrogen bomb at Novaya Zemlaya
  - P waves dominate strongly
  - In qualitative agreement with observations from earthquakes at Novaya Zemlaya

Swedish Defence Research Agency

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