Revealing the signature of ground frost in continuous seismic data with machine learning

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Abstract

We study how ground frost affects the ambient seismic wavefield recorded by a three-component broadband sensor. By applying machine learning algorithms on continuous seismic data, we can retrieve the seismic signature of the continuous freeze and thaw process at the surface of the ground. The retrieved signature reveals that the presence of ground frost imprints the amplitude of the ambient seismic wavefield, and the energy ratio between horizontal and vertical components (H/V). A regression model can even predict diurnal freeze and thaw patterns based on the seismic data. Thus, we assume that slight changes in the physical properties of the frozen surface, such as the thickness, alter the seismic wavefield. Models of the subsurface with different properties of the ground frost agree with the observations from the field. The penetration depth of the ground frost, the temperature of the frozen ground, and the presence of different modes in the wavefield determine how the seismic wavefield is changing. The findings of this study show the potential of a single seismic station for monitoring frozen bodies near the surface, such as permafrosts.

Revealing the signature of ground frost in continuous seismograms with machine learning

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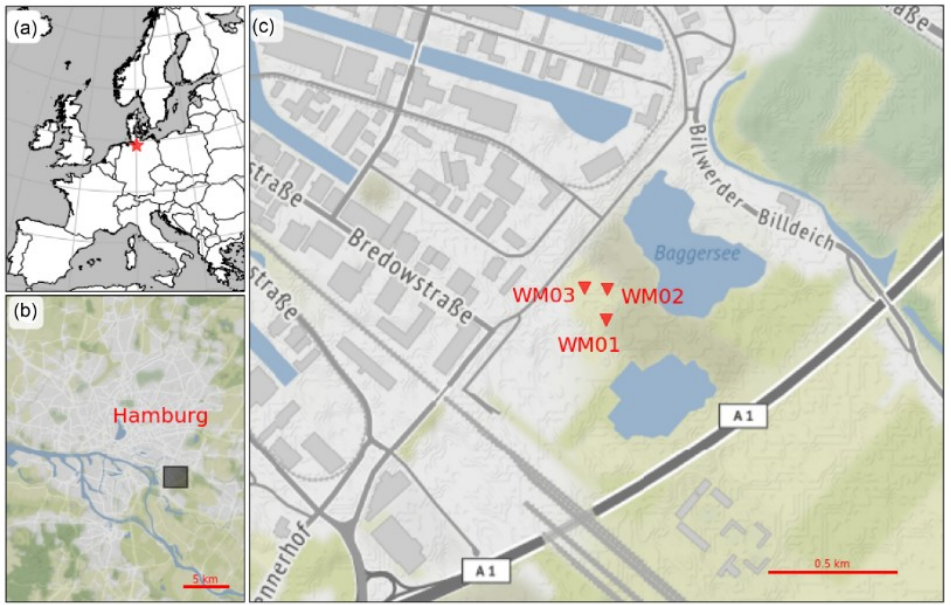
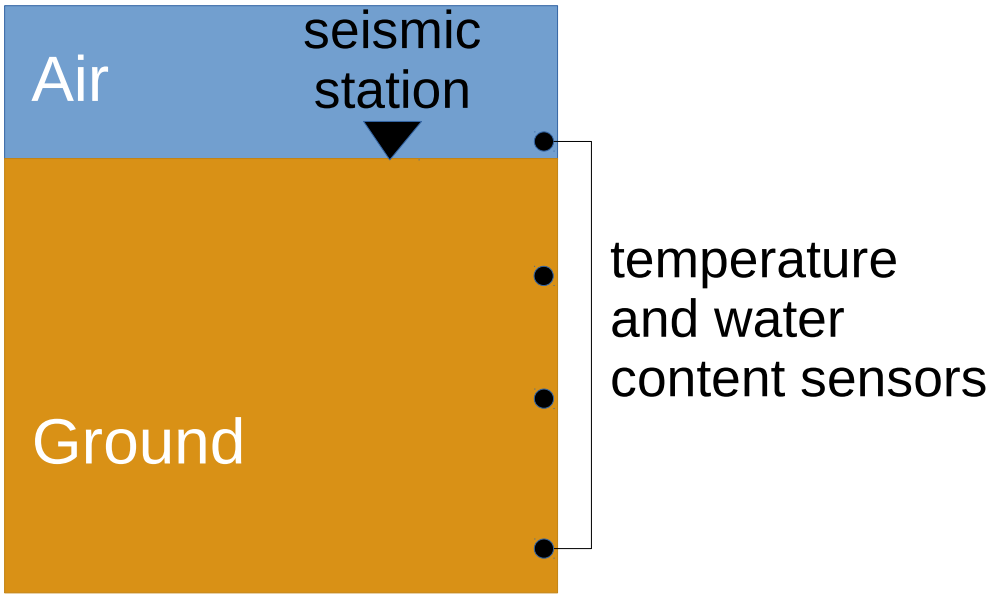
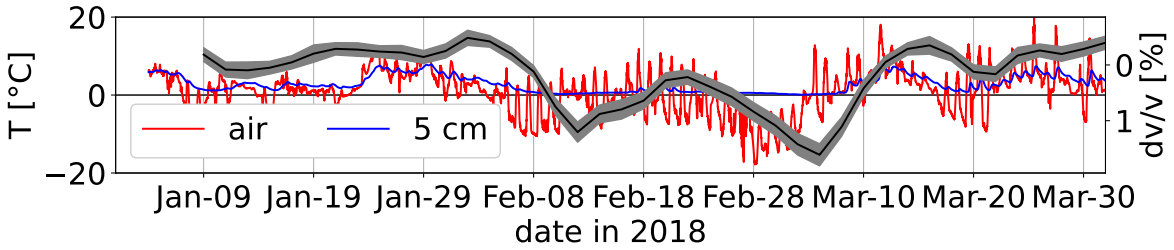
Monitoring the near subsurface with seismology in an urban environment





Unsupervised learning reveals seismic signature of centimeter thick ground frost



- dv/v tracks freezing and thawing on centimeter scale

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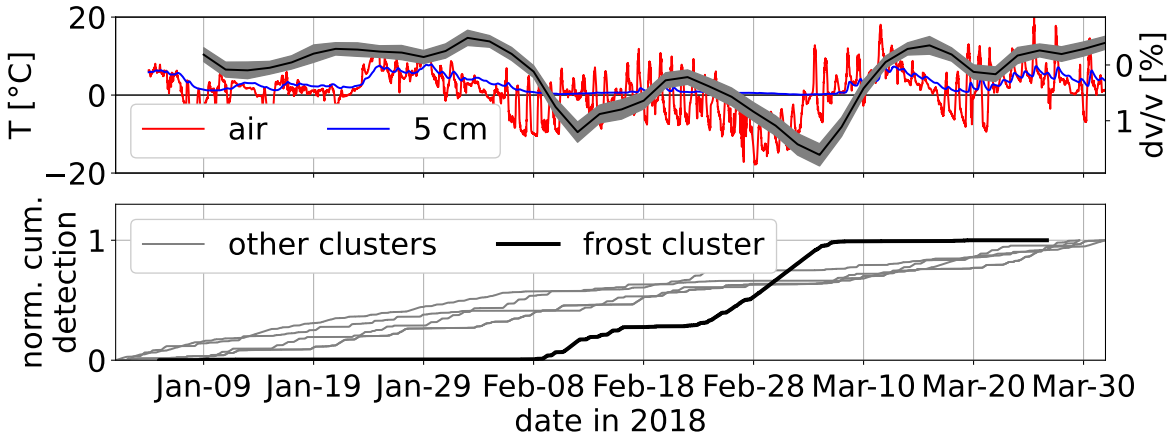

- dv/v tracks freezing and thawing on centimeter scale
- pattern during ground frost in seismograms

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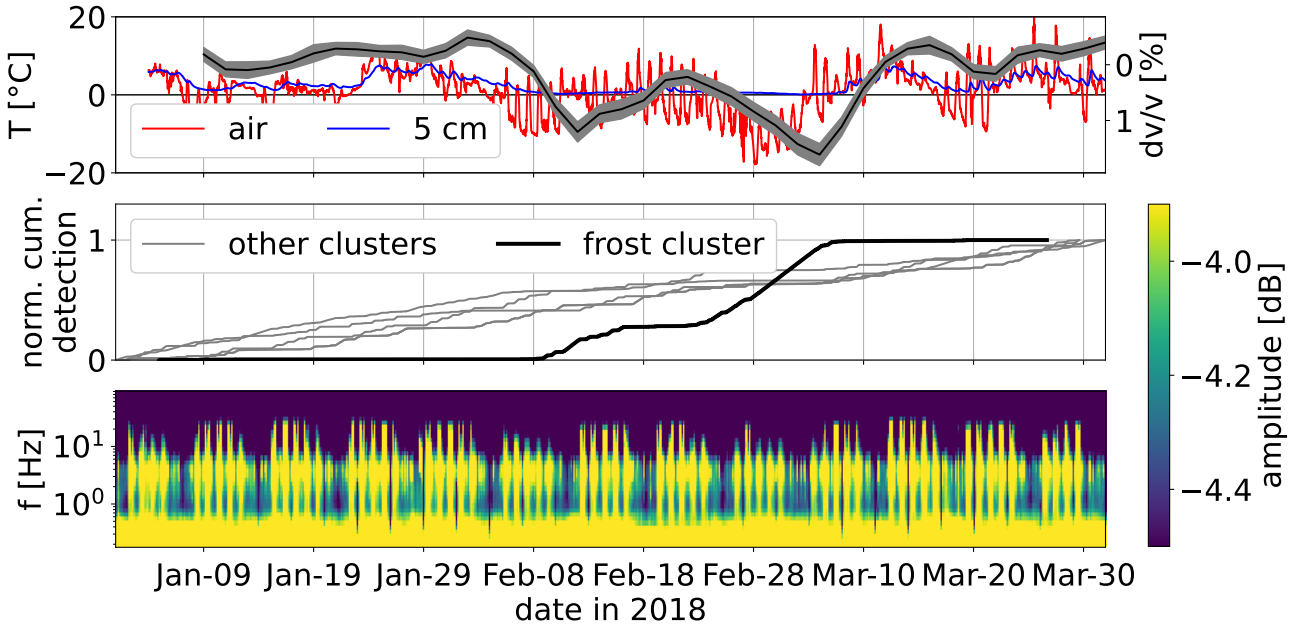

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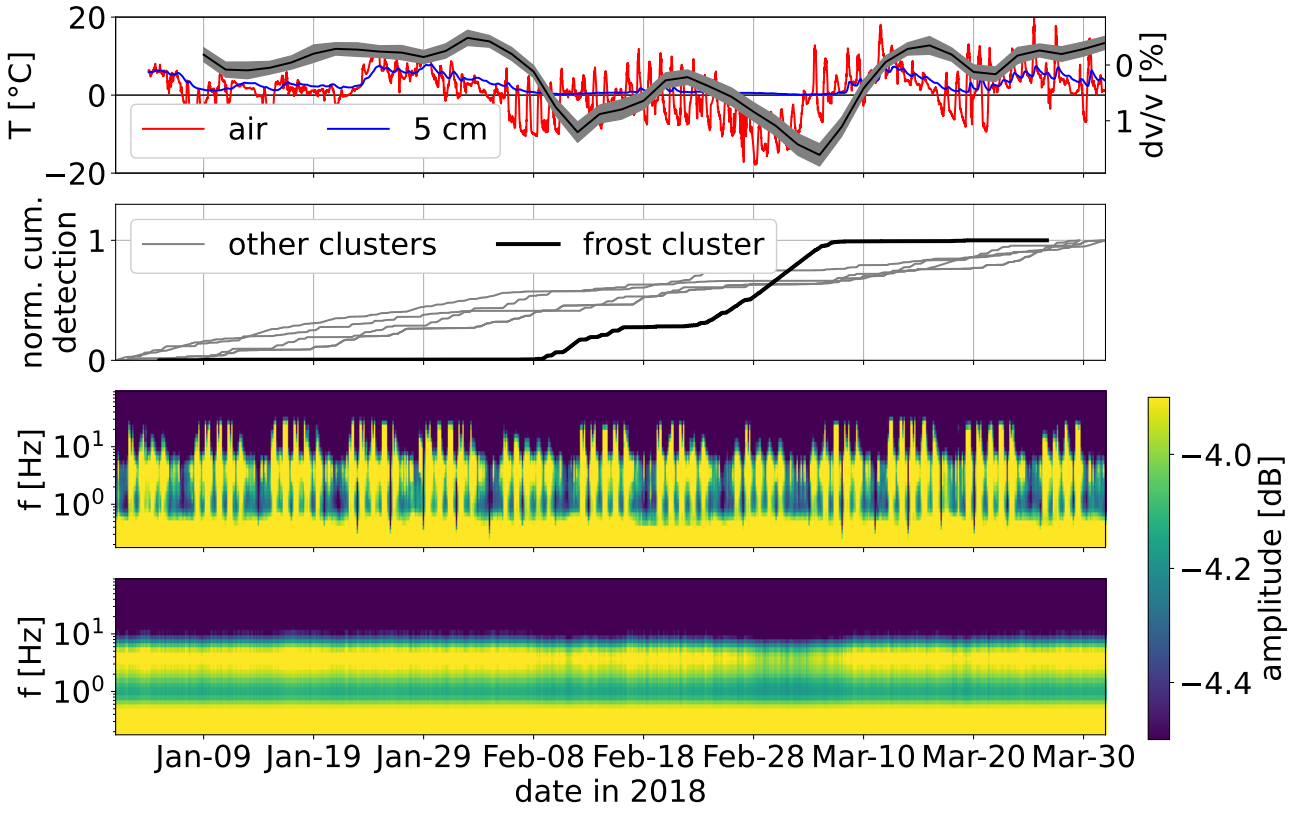

- dv/v tracks freezing and thawing on centimeter scale
- pattern during ground frost in seismograms
- decrease of amplitude and H/V due to ground frost

What are the implications?

1. Leverage the potential of 3C-Seismometers for permafrost monitoring with machine learning
2. How does a surface freezing effect surface wave modes? → interpretation of dv/v more complicated?

Want to chat about it in-person or virtually?
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