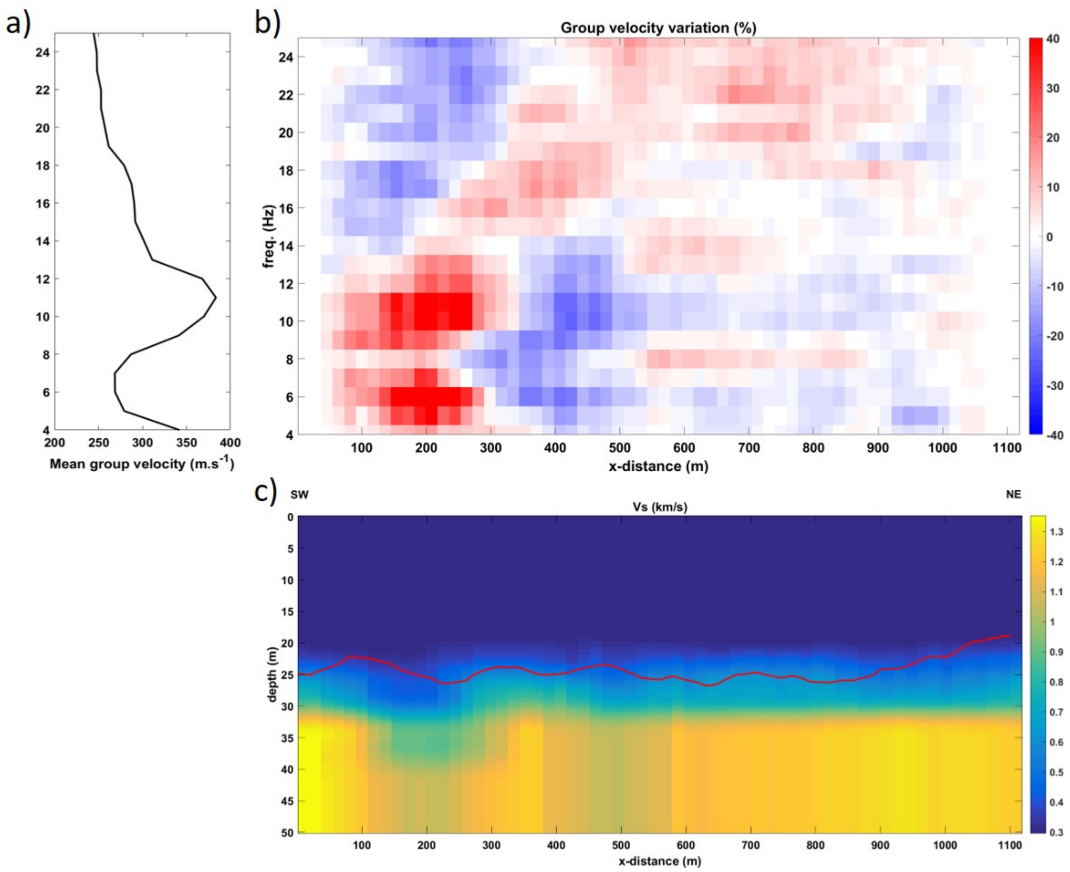

FIG. 2. a) Averaged group velocity curve. b) Group velocity variation compared to mean group velocity shown on a). c) Inverted V_S model along the trench. Red line is the bedrock depth obtained from shear wave source analyses (Isaac and Lawton, 2019).

Application to monitoring

In the MSNoise package, Lecocq et al. (2014) implement the Moving-Window Cross Spectrum analysis (MWCS, first introduced by Ratdomopurbo and Poupinet (1995), also called doublet method). For a detailed theory, lectors can refer to Clarke et al. (2011). Figure 3 shows the average velocity variation observed for all pairs of stations. The analysis is done in the [0.1-1]Hz frequency range, in the [0.5-5]s time window. Figure 3.a shoes the daily velocity variation as well as the smoothed curve (over 40 days). We can clearly see a good correlation between the smoothed curve and the average temperature (Figure 3.b). Figure 3.c shows the daily CO_2 injection, with the periods of injection highlighted in green. They seem to correspond to periods of velocity variation decreasing (Figure 3.a).

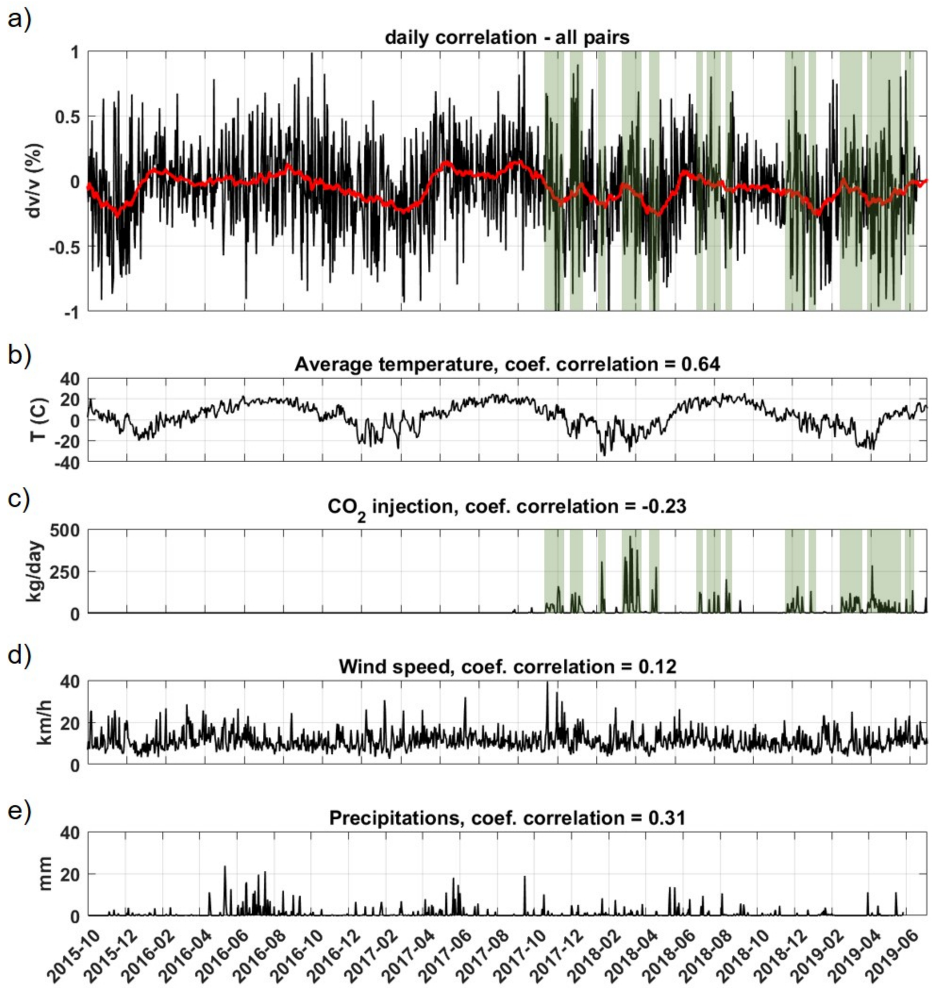

FIG. 3. a) Velocity variation from daily cross correlation. Red curve is the smoothed curve. b) Average daily temperature. c) Daily injection. d) Wind speed at 2m high. e) Rain precipitation.

Conclusions and Future Work

Concerning the imaging of subsurface with ambient noise; the method is already widely attested, especially among the crustal tomography field. The downside part in this study is the shallow depth of investigation due to the frequency range of the used geophones. The V_S model is coherent with other studies done at the Field Research Station. The near surface tomography work can be extended to the June 2019 survey. The 3D part of that experiment will be used to have a 3D Vs model of the subsurface. The trench part of the June 2019 experiment will be used to compare the velocity obtained during winter time (Feb. 2018, this study) and summer time (June 2019, future work) and determine the potential effect of the environmental changes on the near surface conditions.

Concerning the monitoring of CO_2 injection with the ambient noise correlation method, the main challenge at the Field Research Station is the weak amount of CO_2 that is planned to be injected in order to simulate a leakage (Macquet et al. 2019). 500kg/day will induce relatively small plume size (compare to large-scale field) and small variation in elastic parameters. As the use of ambient noise can highly be affected by environmental changes, a very careful analysis of the system is required to fully understand which parameters influences the Green's function reconstruction and so which parameters can be the cause of the observed velocity variation. The 4 years of continuous recording on the broadband stations and several weeks on several denser surveys allow the study of the impact of the environmental changes on the ambient noise correlation method. The effect of the seasonal temperature is clearly visible on the velocity variation curves. We also suspect an effect of the CO_2 injection. Further analysis is required to confirm the first observations and be able to associate observed velocity variation to the correct parameters. Ultimate goal being to determine if whether or not the ambient noise correlation technique can be used to detect leakage of CO2. The monitoring work will be updated with the continuous acquisition on the broadband array. Since June 2019, seismic continuous acquisition was also done on 24 geophones. During that period, the CO_2 injection increases. Monitoring trough ambient noise correlation and trough events detection will be carrying on.

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References

Barmin, M. P., Ritzwoller, M. H., and Levshin, A. L., 2001, A fast and reliable method for surface wave tomography: Pure App. Geophys., 1351–1375.

Clarke, D., Zaccarelli, L., Shapiro, N., and Brenguier, F., 2011, Assessment of resolution and accuracy of the moving window cross spectral technique for monitoring crustal temporal variations using ambient seismic noise: Geophysical Journal International, 186, No. 2, 867–882.

Isaac, J. H., and Lawton, D. C., 2019, Near-surface depth/velocity models at the CaMI Field Station: CREWES Research Report, 31.

Lecocq, T., Caudron, C., and Brenguier, F., 2014, MSNoise, a Python package for monitoring seismic velocity changes using ambient seismic noise: Seismological Research Letters, 85, No. 3, 715–726.

Lehujeur, T., Vergne, J., Schmittbuhl, J., Zigone, D., Le Chenadec, A., and EstOF Team, 2018, Reservoir imaging using ambient noise correlation from a dense seismic network: Journal of Geophysical Research- Solid Earth, 123, No. 8, 6671–6686.

Levshin, A., Yanocskaya, T. B., Lander, A. V., Bukchin, B. G., Barmin, M. P., Ratnikova, L. I., and Its, E. N., 1989, Seismic surface waves in a laterally inhomogeneous earth: edited by V. I. Keilis-Borok, Springer, New York.

Macquet, M., Lawton, D. C., Saeedfar, A., and Osadetz, K. G., 2019, A feasibility study for detection threshold of CO2 at shallow depths at the CaMI field research station, Newell county, Alberta, Canada: Petroleum Geoscience, petgeo2018–135.

Ratdomopurbo, A., and Poupinet, G., 1995, Monitoring a temporal change of seismic velocity in a volcano: Application to the 1992 eruption of Mt. Merapi (Indonesia): Geophysical research letters, 22, No. 7, 775–778.