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Noise-based Ballistic Body-wave Passive Seismic Monitoring

Florent Brenguier (1), Roméo Courbis (1,2), Aurélien Mordret (3), Xander Campman (4), Pierre Boué (1), Malgorzata Chmiel (2), Tomoya Takano (5), Thomas Lecocq (6), Wim Van der Veen (7), and Dan Hollis (2)

(1) Univ. Grenoble Alpes, ISTerre, France, (2) Sisprobe, France, (3) MIT, US, (4) Shell, The Netherlands, (5) Tohoku Univ., Solid Earth Physics Laboratory, Japan, (6) Royal Observatory of Belgium, (7) Nederlandse Aardolie Maatschappij, The Netherlands

Unveiling the mechanisms of earthquake and volcanic eruption preparation requires improving our ability to monitor the rock mass response to transient stress perturbations at depth. The standard passive monitoring seismic interferometry technique based on coda-waves is very stable but suffers from limited spatial resolution. In order to overcome this limitation, we propose a complementary, novel, passive seismic monitoring approach based on detecting weak temporal changes of velocities of ballistic waves recovered from seismic noise correlations. This new technique requires dense arrays of seismic sensors in order to circumvent the bias linked to the intrinsic high sensitivity of ballistic waves recovered from noise correlations to changes in the noise source properties. In this work we use a dense network of 417 seismometers in the Groningen area of the Netherlands, one of Europe's largest gas fields. Over the course of 1 month our results show a 1.5 % velocity increase of the P-wave refracted at the basement of the 700 m thick sedimentary cover. We interpret this unexpected high value of velocity increase for the refracted wave as being induced by the swings in groundwater charge and discharge in a carbonate layer with water conductive fracture networks at 700 m depth. We also observe a 0.25 % velocity decrease for the direct P-wave travelling in the near-surface sediments but conclude that it might be partially biased by changes in time in the noise source properties. The perspective of applying this new technique to detect localized continuous variations of stress perturbations at a few kilometers depth paves the way for improved in situ earthquake, volcano and producing reservoir monitoring.