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Monitoring the evolution of the near-surface seismic structure due to tectonic, atmospheric, and hydrological effects.

The Earth's near-surface is a buffer zone between the solid and fluid Earth and it responds at various scale to geodynamics. It is greatly affected by shallow geohydrology because seismic velocities respond similarly to pore pressure fluctuations below the water table. We present such analysis from a 20-year California-wide survey of changes in seismic velocities in the upper 200m depth and inferred changes in pore pressure. We find that the downpours of atmospheric rivers and the multi-year droughts modulate the hydrological signature in seismic velocities. Over 20 years, southern California has been the most sensitive to these effects, with a progressive increase of at least 2-3% in seismic velocities. In cases of excessive groundwater drawdown, either from the lack of recharge or from anthropogenic over-use, the land subsidence observed from remote sensing coincides with areas of significant increases in seismic velocities. While this occurs in California, we discuss the particularly strong effects in Mexico City during a 25-year survey that exhibits large annual rates of up to 0.8%/year. This work highlights the opportunities to monitor groundwater resources but also changes in site conditions for future ground-motion predictions in seismically active regions. The near surface also responds to earthquakes over a range of time scale. In Parkfield, a 22-year study shows the various impacts of earthquake damage, slow dynamics, environmental modulations, and additional signals that indicate the tectonic loading of the fault. Areal strain in Parkfield using GNSS data indicates a shallow shear strain loading and expansion. We find that the long-term increase in dv/v is rather related to the shear strain loading than the shallow dilation. We interpret that either there is a surface slow creep and a recoupling that is not measured by GNSS, or that the observed dv/v is more sensitive to the shear strain than the dilatational strain.