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Subterranean CO_2 dynamics are driven by air pressure fluctuations in two semi-arid grassland in SE Spain

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Many studies have focused on shallow soil CO_2 dynamics but have neglected deeper soil layers. This fact is remarkable because the vadose zone (unsaturated zone extending between the ground surface and the water table) can contain highly CO_2-enriched air in its pores, cracks and fissures. Here, we examine the relationship among variations in subterranean CO_2 molar fraction, water content, temperature and atmospheric pressure over three years within a vertical profile (at 0.15, 0.5 and 1.5 m depths) in two semi-arid grasslands located in SE Spain. We used the continuous wavelet transform analysis to describe the temporal variability, explore the spectral properties and investigate the cause-effect relationship between CO_2 molar fraction and other variables. Our results show that CO_2 dynamics strongly depend on changes on atmospheric pressure, which is appreciable over a wide range of frequencies with clear semidiurnal, diurnal, synoptic and monthly oscillations. Differences in such differences were also found between the two ecosystems, and might be related to their proximity to the coast and their differing fraction of vegetation cover. Additionally, weak daily dependencies were found regarding soil temperature and soil water content at 0.15 m.

Pressure changes substantially controlled the direction and magnitude of CO_2 content (with daily fluctuations of up to 1500 ppm CO_2), suggesting the importance of subterranean storage and non-diffusive gas transport, processes that can invalidate the flux-gradient approach. Such processes are especially important in ecosystems with high interconnectivity between the unsaturated porous media and the atmosphere.