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A new GPS approach to bridge shallow and deep vertical land motion

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Coastal vertical land motion dominates regional sea-level changes at many locations. GPS sites with continuous observations have been used to study long-term vertical land motion (VLM) in many coastal regions. Many GPS stations are installed on the top of buildings or mounted to concrete pillars and masts that are driven to refusal, typically 2-20 m depth. Thus, GPS measures deep VLM that occurs beneath the building foundation or platform upon which they sit. However, the natural sediment compaction of compressible Holocene deposits, often exacerbated by peat soil oxidation due to surface water drainage, can exceed deep VLM in many low-lying coastal regions. Since GPS does not capture VLM that occurs in the sediment column above the depth of their foundation, the long-term VLM can be underestimated. Therefore, assessment of flooding risk due to subsidence hazards might have been underestimated.

In this study, we introduce a new technique that makes use of the GPS Interferometric Reflectometry (GPS-IR) approach for estimating shallow VLM, and the conventional GPS positioning approach for estimating deep VLM. GPS-IR is used to measure antenna height changes (vertical distance between the phase center of GPS antenna and top of the ground surface) that is attributed to ground surface changes and reflects shallow displacements. Traditional carrier phase positioning software is used to measure the three-dimensional antenna position changes. The vertical component of position changes is attributed to displacement that occurs beneath the structural foundation and reflects deep VLM. Here, we derive total VLM (sum of shallow and deep motion) at a few test GPS stations in the Mississippi Delta, a region that experiences both high rates of sea-level rise and land subsidence. Our results are validated with InSAR measurements and rod surface elevation table and marker horizon records. We show that our technique can provide a better understating of the processes that derive VLM in coastal regions.