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SATELLITE-BASED ASSESSMENT OF SINKHOLE HAZARD OCCURRENCE

Abstract

Karst subsidence or localized cover collapse sinkholes are severe hazards found worldwide. Karst are areas characterized by carbonate (limestone and dolomite) and evaporate (salt, gypsum, and anhydrite) rocks. Furthermore, sinkholes formations are associated with both geomorphological variations and changes in the hydrological conditions. Although sinkholes are challenging to predict, karst areas are more susceptible and conducive to the formation of cover collapse sinkholes. Seasonal soil moisture and precipitation conditions collected from satellite-based sensors and remote sensing algorithms can potentially investigate incipient failure factors that initiate a sinkhole. This novel advancement in research examined hydrologic factors contributing to the triggering of sinkholes obtained from several National Aeronautics and Space Administration (NASA) Earth Science satellite-based missions. Satellite data provides near-real-time spatial and temporal correlations that can be used to evaluate sinkhole formation mechanisms. Data analysis was performed using: (i) time-series precipitation conditions from the Global Precipitation Measurement (GPM) mission with Integrated Multi-satellite Retrievals (IMERG) for GPM; (ii) the NASA Soil Moisture Active Passive (SMAP) satellite mission, and the National Climate Assessment - Land Data Assimilation System (NCA-LDAS), which produces high-quality fields of land surface states (e.g., soil moisture); and (iii) the vegetation greenness from the Landsat Surface Reflectance-derived Normalized Difference Vegetation Index (NDVI). This study found that the volumetric water content for two-thirds of the studied sinkholes occurred in the wet season and a three-year high in root zone moisture content. The findings of extracting the cumulative precipitation from the peak of one wetting season to the next examined over three years yielded that two-thirds of the sinkholes occurred during the period of highest precipitation. In addition, the vegetation indices greater than 0.25 concurred with levels that would indicate water infiltration into the subsurface. Therefore, remote sensing data examination of volumetric soil moisture content, localized precipitation, and vegetation indices demonstrated a significant correlation between sinkhole occurrence and soil surface conditions. This research offers opportunities to develop sinkhole susceptibility and a predictive analytics approach to gain insights into the evolution of sinkholes from satellite-based hydrologic data.

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