A wavelet-based method to map swelling clays coupling the ground displacement and the surface soil moisture acquired by Sentinel-1 and SMOS satellites. Application at a gas storage site in Southwestern France (Lussagnet)

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Authors: André Burnol1, Hideo Aochi1, Daniel Raucoules1, Fernanda M. L. Veloso1, Fifamè N. Koudogbo2, Pierre Chiquet3 and Christophe Maisons4, (1)BRGM, DRP, Orléans, France, (2)TRE ALTAMIRA S.L.U, Barcelona, Spain, Barcelona, Spain, (3)TEREGA, Pau, France, (4)MAGNITUDE, Sainte-Tulle, France

Acquisitions of the Sentinel-1 satellite are processed and comprehensively analyzed to investigate the ground displacement during a three-year period above two gas storage sites (Lussagnet and Izaute) in Southwestern France (Figure 1). Despite quite low vertical displacements (between 4 and 8 mm) compared to the noise level, the cyclic motion reflects the seasonal variations due to charge and discharge during summer and winter periods, respectively. A simplified mechanical model can explain these displacements at both storage sites. Nonetheless, despite a general consistency, some features in the Lussagnet case that cannot be explained by the reservoir pressure variations are further investigated. The 10-day SMOS surface soil moisture (SSM) products for descending overpasses between 18 October 2014 and 26 October 2017 in the grid cell of the studied zone (Figure 1) are used to calculate the average of the median, minimum and maximum SSM values for each Sentinel-1 period (12 days). Using the cross wavelet transform (XWT), we show there is an uplift in the Lussagnet zone that contrasts both in phase and period with the seasonal deformation due to the gas exploitation and that is related both to the rainfall and to the surface soil moisture. This work reveals the combination of two different processes driving the ground displacement with the same order of magnitude (about 6 mm), namely the pressure variation of a deep gas reservoir and the swelling/shrinking of the shallow subsurface. As a perspective, the same method coupling both satellite acquisitions (Sentinel-1 and SMOS) may be generalized to improve the global French shrink/swell hazard evaluation based on the 1:50 000 geological map.