Investigation of Land Subsidence in Eastern Thrace (Turkey) using Multi Temporal InSAR

Tohid Nozadkhalili, Semih Ergintav2, Ziyadin Cakir1, Ugur Dogan3, and Thomas R. Walter4

1Istanbul Technical University, Graduate School, Geology, Turkey (nozadkhalil18@itu.edu.tr)
2Bogazici University
3Yildiz Technical University
4Helmholtz Centre Potsdam - GFZ

Westward migration of M>7 earthquakes along North Anatolian fault with the latest one, Izmit 1999 event, led focus of studies to the seismic gap in the main Marmara fault. For this purpose, the coastal ranges of the Marmara Sea, mainly Istanbul megacity, are renowned for earthquake and ground motion hazards, associated with faulting, landslides and sediment compaction processes. Ground motion associated with man-made activities, however, have been barely studied. The Thrace region of Turkey, some 50 km to the North of the Marmara Sea, expresses pronounced ground motions affecting large areas. We use the Persistent InSAR technique to monitor the Marmara region using Sentinel-1 satellites' TOPSAR data between 2014 and 2020. Results for both ascending (T131 and T58) and descending (T36) tracks reveals 10 mm/yr rate of subsidence in the Thrace region of Turkey, affecting an area ~15400km² with dimensions of ~110 km by ~140 km. There are two plausible mechanisms for this deformation; (1) excessive pumping of groundwater for agricultural purposes, or (2) natural gas extraction activities taking place in the region. To better understand the observed deformation source, as a first step, we model potential gas extraction by volume change. No piezometric data are available for this region for the time being. Thick sediments including sandstone, reefal carbonates, amongst others, are aimed for gas exploration in the Thrace basin for more than half century. Depth of gas extraction wells and sediment thickness is compiled from previous studies to compare the subsided area with sediment and well depth variations.

We use the Poly3D boundary element method to model the surface. Poly3D uses planar triangular elements of constant model to model displacement's source. Using triangular elements provides models with complex and smooth 3D surfaces avoiding overlaps or gaps, and hence allowing one to construct realistic models. Poly3dinv inverse model applies a fast non-negative/non-positive least squares solver to optimize the solution. We construct a surface enveloping tips of the wells and use it to produce deformation at surface due by allowing opening on it. Small residuals between the observation and model based on opening suggests that deformation is likely caused by natural gas extraction.