

# **Subsidence associated with oil extraction, measured from time series analysis of Sentinel-1 data: case study of the Patos-Marinza oil field, Albania**

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The Patos-Marinza oil field in central Albania (40.71°N, 19.61°E) is one of the largest onshore oil fields in Europe. More than 7 million oil barrels are extracted per year from the Messinian sandstone formations of the Durrës Basin in the Peri-Adriatic Depression by the Bankers Petroleum Ltd. which has been operating the field since 2004.

In this study, we take advantage of the new Sentinel-1 radar images acquired every 6 to 12 d over Albania to measure the surface displacement in the Myzeqeja plain and in the Patos-Marinza oil field. Images from ascending and descending tracks covering the area are processed through a radar interferometry (InSAR) time series analysis over the 2014 to 2018 time span, providing consistent average line-of-sight velocity maps and displacement time series.

The regional deformation field exhibits a slow subsidence of the basin relative to the highlands (at rates of 2.5 mm yr<sup>-1</sup>) that we interpret as a combination of natural and human-induced compaction. This broad picture is complicated by a strong local subsidence signal with rates as high as 15 mm yr<sup>-1</sup> that spatially correlates with the oil field and is maximal in the zone holding most of the operating wells, where enhanced oil recovery techniques are used. The spatial correlation between the maximum subsidence area and the active wells, as seen from optical images, argues in favor of surface deformation induced by oil extraction. This deformation is well reproduced by elastic models mimicking the compaction using planar negative tensile (closing) dislocations. Such modeling provides a first-order estimation of the volumetric deflation rate in the oil reservoir and suggests that concurrent injection activity has been conducted in the central part of the field where small uplift is observed. This new evidence of significant strain associated with the oil field operations raises the question of the potential impact of these operations on the local seismicity.

**Mots-Clés :** Subsidence, InSAR, Sentinel-1, oil and gas, induced seismicity and deformation, Albania