The LASUGEO project: monitoring LAnd SUbsidence caused by Groundwater exploitation through gEOdetic measurements.

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In the last decades, rapid urbanization, global climate change and uncontrolled anthropogenic transformations of the territory caused a relevant increase in geo-hazards events with huge economic and social consequences. The dramatic increase of these events with environmental degradation highlights the importance of improving ground monitoring and natural resources management with a continuous exchange of knowledge between the scientific community and authorities in charge of environmental risk management. Since the late 1990s, SAR (Synthetic Aperture Radar) data allow measuring slow-moving ground deformations. In the last decades, the use of spaceborne InSAR (Interferometric SAR) has increased significantly thanks to the availability of large-area coverage, millimetre precision, high spatial/temporal data resolution and good cost-benefit. For the last 3 decades, the development of Multi-Temporal Interferometric SAR techniques (MT-InSAR), commonly grouped into PSI-like (Persistent Scatterers Interferometry) and SBAS-like (Small BAseline Subset) algorithms, has changed the way radar images can be exploited for geohazard monitoring (natural gas extraction, mining activities, groundwater overexploitation, karst or landslides processes, etc.). Most of the subsidence bowls mapped by the PSI technique in Belgium have been related to strong fluctuations of an aquifer implying at the surface ground deformations (Declercq et al., 2017; 2021). Besides, the recent dry years are related to ground stability problems in large areas of Flanders. Land subsidence poses significant problems. The most affected regions lie on compressible loose sediments. Any change in the piezometric heads modifies the pore pressure, which may induce consolidation if the geological formations are compressible. Geomechanical aspects are fully coupled to groundwater flow equations. If groundwater levels and pressures are restored, a partial rebound (uplift) corresponding to the elastic part of the geological formations is observed. Consolidation and elastic rebound processes occur in confined and unconfined conditions. The most sensitive parts of the concerned aquifers contain clay, loam or peat lenses but consolidation may occur mostly in the underlying and overlying layers that are often less permeable and more compressible than the aquifer itself. In this case, it is largely a delayed process occurring as far as the pore pressure variation slowly propagates in the low permeability (aquitard) layers. We propose to confront the results of the PSinSAR technique data with hydrogeological groundwater models and two other geodetic techniques: GNSS and gravimetry. LASUGEO focusses on ground deformations in different areas in Belgium: the deep aquifer system of western Flanders, the

Tertiary aquifer system in Central Flanders, the Antwerp area, the Leuven area and the Brussels Region.

The possible groundwater overexploitation needs to be established through a transient hydrogeological model considering all the stress factors applied to the aquifers. The estimated compaction in the subsiding bowls will be compared with 1D geomechanical model results. The latter will be performed using geotechnical effective stresses as deduced from the pore pressure distribution from the hydrogeological model (Dassargues et al., 1989). These different steps will be done by the partners of the LASUGEO project that are involved in the different case study areas.

References

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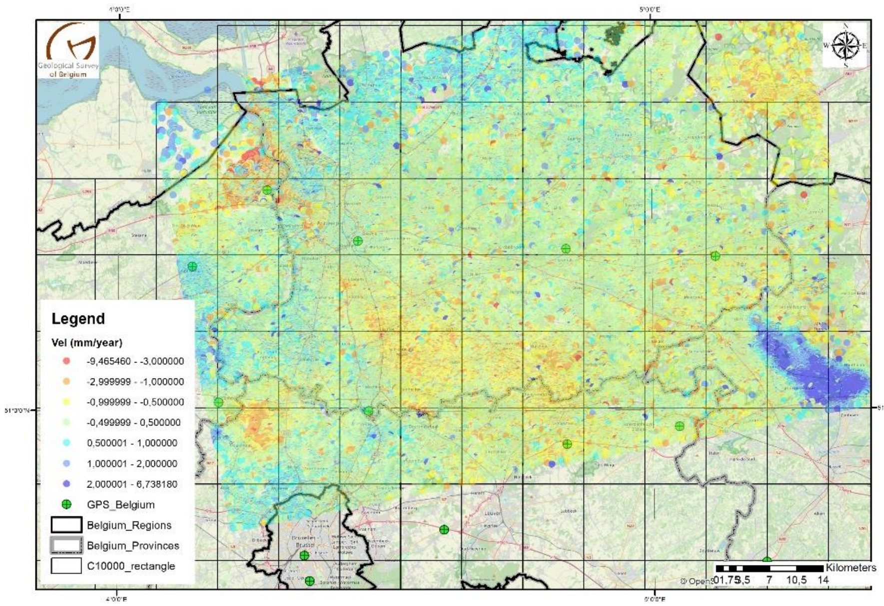

Figure. PSInSAR data showing the average LOS velocities (in mm/year) from Sentinel-1A ascending scenes (2016-2020) covering a large area in Flanders (between Brussels and Antwerp). Red colours indicate land subsidence areas while the blue colours indicate uplifting ground deformations. Green circles are the GNSS stations located in that area.