

United Nations Educational, Scientific and . Cultural Organization



Hydrological

Programme



UNESCO Land Subsidence International Initiative

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Events

World Water Day 2022 -**Groundwater, Making the** invisible, visible



Groundwater provides almost half of all drinking water worldwide, about 40% of water for irrigated agriculture and about 1/3 of water supply required for industry. It sustains ecosystems, maintains the baseflow of rivers and prevents land subsidence and seawater intrusion. Despite its importance, groundwater is invisible. And out of sight oftentimes also means out of mind.

Through this event that will introduce World Water Day 2022 and the UN World Water Development Report on the theme of groundwater, participants will be able to shape the campaign through suggestions of activities but also get the information and the tools needed to raise awareness of groundwater.

https://www.worldwaterweek.org/event/9726-world-water-day-2022---groundwater-making-theinvisible-visible

New Literature

General, methods

Gazzola, L., Ferronato, G., Frigo, M. et al. A novel methodological approach for land subsidence prediction through data assimilation techniques. Comput Geosci (2021).

https://link.springer.com/article/10.1007/s10596-021-10079-6

With, Pietro as one of the co-authors.

Colombia, Carribean

Gómez, J.F. et al., Vertical Land Motion as a Driver of Coastline Changes on a Deltaic System in the

Colombian Caribbean. Geosciences 2021, 11, 300. https://doi.org/10.3390/geosciences11070300

Egypt, Alexandria

Amr Z. Hamouda et al., Subsidence model of the ancient Alexandria Royal port linked to sea-level rise and natural hazards using integrated geophysical methods, The Egyptian Journal of Aquatic Research, 2021,ISSN 1687-4285 <u>https://doi.org/10.1016/j.ejar.2021.07.003</u>

(https://www.sciencedirect.com/science/article/pii/S1687428521000510)

Abstract: Marine geophysical methods are quite valuable in geoarchaeological investigations and remote seabed classifications due to their capability to cover vast areas in a short time and reveal fine details of the seafloor and subsurface features in unexcavated sites. The present study aimed to reconstruct the depositional history of the uppermost sediment sequence of the ancient Royal port of Alexandria during different historical periods, and point out the impact of the post-glacial eustatic sea-level rises and natural hazards that took place through the last 2000 years. To resolve this riddle, seismic and geomorphologic surveys were conducted by using a sub-bottom profiler and side scan sonar respectively in integration with previous sediment core data, to extrapolate the vertical extent of the strata and monitor the recent seafloor situation. The results of this study confirmed the subsidence of the ancient port mainly as a result of sea-level rises and the 365 AD tsunami. Seismic interpretations suggested a depositional scenario through successive stages from the Royal port's construction until its abandonment, also the detailed analyses of backscatter images showed significant variations on the seafloor geomorphology that took place through the recent years which in turns give prominence to the impact of the short-term winds and storms as well.

Indonesia, Jakarta

Hiroshi Takagi et al., People's perception of land subsidence, floods, and their connection: A note based on recent surveys in a sinking coastal community in Jakarta,

Ocean & Coastal Management, Volume 211, 2021, 105753, ISSN 0964-5691,

https://doi.org/10.1016/j.ocecoaman.2021.105753.

(https://www.sciencedirect.com/science/article/pii/S0964569121002362)

Abstract: Land subsidence has triggered severe coastal floods in Jakarta, whose mechanism has been extensively investigated by researchers and engineers. The government has also recognized this fact, which has partially contributed to the recent announcement that the capital will be relocated to East Kalimantan. However, it is not clear whether ordinary people perceive the progress of land subsidence as their own issue. To ascertain this, a field survey was conducted after a major coastal

flood that took place in December 2017, which revealed that nearly half of the people living in a rapidly sinking coastal community were not aware of the ongoing land subsidence under their own houses. Severe flood and land subsidence were not strongly recognized as interlinked problems by local citizens. Rain-induced flooding is common in the community, and this may explain why a quarter of respondents did not fear the 2017 coastal flood, despite their houses being flooded, in some cases to a depth above their heads. Land subsidence has an adverse effect on flooding. Awareness building programs for normal citizens should be promoted, in order to articulate the significance of stopping groundwater extraction for mitigating land subsidence and the flooding it induces.

Indonesia, Java Central

A Roadmap to address Land Subsidence for Central Java

https://europa.eu/capacity4dev/ecodrr-cca/discussions/roadmap-address-land-subsidence-centraljava

Indonesia, peatlands

Deshmukh, C.S., Julius, D., Desai, A.R. et al. Conservation slows down emission increase from a tropical peatland in Indonesia. Nat. Geosci. (2021). <u>https://doi.org/10.1038/s41561-021-00785-2</u>

https://www.nature.com/articles/s41561-021-00785-2

Iran, Najafabad Plain

K. Shirani et al., Assessment of Land Subsidence in the Najafabad Plain Using the Differential Synthetic Aperture Radar Interferometry (DInSAR) Technique.

https://www.magiran.com/paper/2293626/?lang=en

Italy, Ravenna

Soboyejo, L.A. et al., Different processes affecting long-term Ravenna coastal drainage basins (Italy): implications for water management. Environ Earth Sci 80, 493 (2021). https://doi.org/10.1007/s12665-021-09774-5

Poland, Bogdanka

Guzy, A.; Witkowski, W.T. Land Subsidence Estimation for Aquifer Drainage Induced by Underground Mining. Energies 2021,14, 4658. <u>https://doi.org/10.3390/en14154658</u>

https://www.mdpi.com/1996-1073/14/15/4658/pdf

PR China, Beijing Plane

Zhang, S. et al., Three-Dimensional Surface Displacement of the Eastern Beijing Plain, China, Using Ascending and Descending Sentinel-1A/B Images and Leveling Data. Remote Sens. 2021, 13, 2809. https://doi.org/ 10.3390/rs13142809

https://www.mdpi.com/2072-4292/13/14/2809/pdf

PR China, North China Plain

Guangli Su et al., Spatiotemporal evolution characteristics of land subsidence caused by groundwater depletion in the North China Plain during the past six decades, Journal of Hydrology, 2021, 126678, ISSN 0022-1694,

https://doi.org/10.1016/j.jhydrol.2021.126678.

(https://www.sciencedirect.com/science/article/pii/S0022169421007265)

Abstract: Land subsidence due to groundwater depletion significantly obstructs regional economic and social development, and long-term high-precision monitoring of land subsidence is the prerequisite for solving this problem. Based on precise leveling data covering ~50,000 km since 1952 in the North China Plain (NCP), this study investigated dynamic patterns of land subsidence over three periods—1960–1980s, 1980–1990s, and 1990–2010s—with unprecedented spatial extent and accuracy. The main results were as follows. (1) The extent of the NCP subsidence gradually expanded. In 1960–1980s, subsidence regions mainly located at central and coastal plain, covering ~6,200 km2 with subsidence rates > 20 mm/yr. Over time, the subsidence region gradually expanded westward to the eastern foot of the Taihang Mountains, northward to the south foot of the Yanshan Mountains, and southward to the Shandong Hills. Areas with subsidence rates > 20 mm/yr increased to ~22,800 km2 and ~41,800 km2, respectively, in 1980–1990s and 1990–2010s. (2) The subsidence rate significantly accelerated. Statistics for points with settlement rates > 5 mm/yr showed that the average values in the three periods were 12.2, 17.3, and 26.5 mm/yr, respectively. The subsidence zone covered by the profile line from Dingzhou–Cangzhou showed the most prominent acceleration, and the average settlement rates in the three periods were 16.4, 29.6, and 55.3 mm/yr, respectively. (3) Subsidence in Tianjin was mitigating gradually with rate slowing from 58.2 mm/yr in 1960–1980s to 33.6 mm/yr in 1990–2010s, primarily by limiting groundwater exploitation. (4) By comparing with the variation of groundwater level, we infer that groundwater depletion is mainly responsible for the land subsidence of the NCP. Nowadays, the problem of land subsidence is still very serious in the NCP, requiring further control measures.

PR China, Pingtan Island

Teng, X. et al., Application of a Zoning Methodology for Groundwater Suitability on Islands, a Case Study of Pingtan Island, China. Water 2021, 13, 2000.

https://doi.org/10.3390/w13152000

https://www.mdpi.com/2073-4441/13/15/2000/pdf

PR China, Shenzen

Yufang He et al., Integration of InSAR and LiDAR Technologies for a Detailed Urban Subsidence and Hazard Assessment in Shenzhen, China

Remote Sens. 2021, 13(12), 2366; https://doi.org/10.3390/rs13122366 - 17 Jun 2021

https://www.mdpi.com/2072-4292/13/12/2366

PR China, Wuhan

Qing Ding et al.; Monitoring, analyzing and predicting urban surface subsidence: A case study of Wuhan City, China, International Journal of Applied Earth Observation and Geoinformation, Volume 102, 2021, 102422, ISSN 0303-2434,

https://doi.org/10.1016/j.jag.2021.102422.

(https://www.sciencedirect.com/science/article/pii/S030324342100129X)

Abstract: Wuhan, one of China's megacities with rapid development, is facing serious surface subsidence. In this study, we combined MT-InSAR, geo-detector, and LSTM (Long Short-Term Memory) to achieve the monitoring, analysis, and prediction of surface subsidence in the main urban districts of Wuhan. The effectiveness of MT-InSAR in monitoring surface subsidence was validated against leveling results. During the monitoring period, the maximum subsidence velocity and uplift velocity were -53.3 mm/year and 18.0 mm/year, respectively. We identified six subsidence regions and explored their deformation characteristics. Further, we analyzed the relationship between the surface subsidence and influencing factors using the geo-detector in a quantitative manner. Our study revealed that the distance to soft soils had the greatest explanatory power on the subsidence. However, we also confirmed that subsidence was affected via coupling effects from multiple factors, suggesting a complex reinforcing relationship among influencing factors. The interaction between the distance to soft soils and the distance to karst collapse prone areas had the largest joint explanatory power on subsidence. Further, we constructed a data-driven LSTM model to predict and analyze the subsidence. The results showed that the LSTM model achieved great performance and presented strong universality, suggesting that it can be used for subsidence prediction in large geographic areas.

PR China, Yangtzhe River Belt

Gao, Y., Cao, G., Ni, P. et al. Natural hazard triggered technological risks in the Yangtze River Economic Belt, China. Sci Rep 11, 13842 (2021). <u>https://doi.org/10.1038/s41598-021-93353-y</u>

Spain, Madrid

Sanz Pérez, E. et al.; Identification and Investigation of Subsidence Areas to Mitigate Karstic Risks in Urbanized Areas of Madrid, Spain: A Case Study. Sustainability 2021, 13, 7716. https://doi.org/10.3390/su13147716

https://www.mdpi.com/2071-1050/13/14/7716/pdf

Taiwan

Muhsiung Chang et al., Numerical Assessment on the Influence of Various Factors for Subsidence at the Intersection of Expwy 78 and High Speed Rail of Taiwan

https://www.springerprofessional.de/numerical-assessment-on-the-influence-of-various-factors-forsub/19357858

USA, California, Mojave

On the USGS-website an explanation of InSAR with application for a Mojavo study as example:

https://ca.water.usgs.gov/mojave/inSAR-methods.html

USA, Louisiana

Kenneth R. Olson et al., Mississippi River Delta: Land Subsidence and Coastal Erosion

https://doi.org/10.4236/ojss.2021.113008

Courses

https://www.youtube.com/watch?v=kdC-FsZyobA&ab_channel=RUSCopernicusTraining

RUS-Webinar demo on youtube: Land Subsidence mapping using Sentinel-1. RUS Copernicus

Vietnam, Mekong Delta

Eslami, et al. Projections of salt intrusion in a mega-delta under climatic and anthropogenic stressors. Commun Earth Environ 2, 142 (2021). <u>https://doi.org/10.1038/s43247-021-00208-5</u>

Maps

The Netherlands, Updated subsidence prediction map

Updated land subsidence maps show the effects of climate change and water level management.



A map of the Climate Effect Atlas for forecasting land subsidence until 2100. Scenario high – water level indexation and strong climate change.

<u>https://www.deltares.nl/en/news/updated-land-subsidence-maps-show-the-effects-of-climate-change-and-water-level-management/</u>

USA, Arizona

Where the land subsides most The Sulphur Springs Valley south of Willcox Basin has the most dramatic subsidence in Arizona, with some areas dropping about 6 inches a year. In that area, the most subsidence has occurred in the area of Cochise Stronghold and Dragoon roads which has had a fissure open up several times in recent years. The area where a major crack recently closed a stretch of U.S. 191 - about 4 miles from where the earlier fissure occurred - has had extensive land subsidence, but not as much. Time Period of Analysis: 4/15/2019 to 4/16/2021 Total land subsidence in the Willcox and Kansas Settlement areas, Cochise County, based on satellite data. 186 Robbs Rd Araberger R Rosenbark Rd Kito zav Rel 81 Sulfur Springs Ro Barker Ranch Rd 30 Puntos Eastland Rd 191 181 Legend Total land subsidence Greater 40 cm (15.7 in) Subsidence feature 25-40 cm (9.8-15.7 in) Hardrock 15-25 cm (5.9-9.8 in) Earth fissures 10-15 cm (3.9-5.9 in) Highways and interstates 6-10 cm (2.4-3.9 in) Interstate 4-6 cm (1.6-2.4 in) US 2-4 cm (0.8-1.6 in) State Roads 1-2 cm (0.4-0.8 in) DETAIL AREA 0-1 cm (0-0.4 in) Railway Miles 15 12 6 9 3 7/28/21 SOURCE: Arizona Departemt of Water Resources ARIZONA DAILY STAR

https://bloximages.chicago2.vip.townnews.com/tucson.com/content/tncms/assets/v3/editorial/6/e 9/6e97d25e-ef14-11eb-8249-f3b5384590ce/610064de1c698.pdf.pdf

USA, California



This map shows areas of subsidence in California. Areas colored in purple and magenta have seen the greatest amount of subsidence. Natural gas pipelines are in black.

https://www.eurekalert.org/multimedia/716648

Mining activities

Yury Derbin et al., Thermo-fluid–mechanical numerical simulations of surface subsidence at the site of underground coal gasification in:

Quarterly Journal of Engineering Geology and Hydrogeology (2021) qjegh2020-106.

https://doi.org/10.1144/qjegh2020-106

https://pubs.geoscienceworld.org/qjegh/article-abstract/doi/10.1144/qjegh2020-106/600738/Thermo-fluid-mechanical-numerical-simulations-of?redirectedFrom=fulltext

Estimation of Mining-Induced Horizontal Strain Tensor of Land Surface Applying InSAR

https://www.mdpi.com/2075-163X/11/7/788/pdf

PR China, Northwest China

Wang Yajing et al., Spatial Variability of Soil Moisture in Mining Subsidence Area of Northwest China

https://assets.researchsquare.com/files/rs-678820/v1 covered.pdf

PR China, Shanxi Province

Zhiyu Yi et al., Long-term Landsat monitoring of mining subsidence based on spatiotemporal variations in soil moisture: A case study of Shanxi Province, China, in: International Journal of Applied Earth Observation and Geoinformation, Volume 102, 2021, 102447, ISSN 0303-2434, <u>https://doi.org/10.1016/j.jag.2021.102447</u>.

(https://www.sciencedirect.com/science/article/pii/S0303243421001549)

Abstract: Ground subsidence caused by mining activities has extensively and chronically affected people living near mining areas. Remote sensing images provide temporally and spatially continuous observations of surface natural resources. In order to accurately understand and continuously observe subsidence areas, this study investigated the spatiotemporal dynamics of mining subsidence using long-term Landsat time-series. The study area was a typical mining region in Shanxi Province, China, with a long history of mining activity. Landsat images from 1986 to 2019, as well as reference data, were used to construct inter-annual time-series trajectories of soil moisture, which were derived from spatial normalizations of the soil moisture monitoring index(SSMMI). The LandTrendr algorithm on the Google Earth Engine platform was then used to extract the subsidence areas and their spatiotemporal dynamics. The results indicate that (i)the map of the spatial distributions of mining subsidence had an overall accuracy of 83.8% and indicate that areas that underwent subsidence were mainly concentrated in mining cites(including Taiyuan, Lvliang, and Linfen); (ii)subsidence

PR China, methods

Zhao, G. et al., An Adaptive Offset-Tracking Method Based on Deformation Gradients and Image

Noises for Mining Deformation Monitoring.

Remote Sens. 2021, 13, 2958.

https://doi.org/10.3390/rs13152958

https://www.mdpi.com/2072-4292/13/15/2958/pdf

PR China, Xuzhou

Zhao, J., Huang, Y., Tang, T. et al. Reclamation of coal mining subsidence based on people's esthetic preference. Int. J. Environ. Sci. Technol. (2021). <u>https://doi.org/10.1007/s13762-021-03544-3</u>

Modelling

In Water Resources Research:

Sandro Andrés et al., Multirate mass transfer approach for double-porosity poroelasticity in fractured media.

https://doi.org/10.1029/2021WR029804

Under preview in: Stochastic Environmental Research and Risk Assessment:

Sunil Kumar et al.,

Land Subsidence Prediction using Recurrent Neural Networks

DOI:

10.21203/rs.3.rs-278247/v1

https://www.researchsquare.com/article/rs-278247/v1

Monitoring

General, methods

Amer, R.; Xue, Z.; Hashimoto, T.; Nagata, T. Distributed Fiber Optic Strain Sensing for Geomechanical Monitoring: Insights from Field Measurements of Ground Surface Deformation. Geosciences 2021, 11, 285. <u>https://doi.org/10.3390/geosciences11070285</u>

AGU

Evolving the Geodetic Infrastructure

"I just can't imagine waking up one morning and saying, oh, the GPS constellation isn't working anymore," said Michelle Sneed, a USGS hydrologist who was part of the committee that authored the NASEM report. One area that Sneed monitors is the San Joaquin Valley, an agriculture region in central California that has changed dramatically because of groundwater pumping for irrigation. From 1925 to 1977, the land surface in this area subsided about 9 meters because of compaction. Sneed and colleagues used continuous GPS and InSAR to assess land subsidence in the west central San Joaquin Valley and explored potential risks to the California Aqueduct.

https://eos.org/articles/evolving-the-geodetic-infrastructure

The Netherlands, Zegveld

The soil in the Netherlands consists largely of peat. These areas are subject to subsidence through oxidation and compaction. As a result, peat meadows are increasingly wet, which decreases the carrying capacity of the land for an increasingly longer period of the year. Subsidence causes damage to buildings and infrastructure. Peat oxidation also causes the emission of CO2, among other things and thus contributes to warming the climate. Under certain circumstances, the oxidation of peat also releases the greenhouse gas methane (CH4) and nitrous oxide (N2O).

Trials are being carried out by the Deltares foundation where soil subsidence and the respective measures are being tested. SHORE was requested to acquire UAV LiDAR data and provide advice during a multi-year monitoring campaign of the Zegveld Peat Innovation Centre.



From the Press Dead Sea

Dead Sea shrinking causes exposed for the first time.

https://www.plenglish.com/index.php?o=rn&id=69997&SEO=dead-sea-shrinking-causes-exposed-for-the-first-time

General, Peat drainage

Agricultural short-term usage leads to peatland degradation with millennia-lasting consequences!

https://www.openaccessgovernment.org/agricultural-short-term-usage-leads-to-peatlanddegradation-with-millennia-lasting-consequences/114592/

Australia, Queensland

Farmer welcomes CSG wells onto property despite neighbours' fears of subsidence'

https://www.abc.net.au/news/2021-07-02/farmer-supports-coal-seam-gas-despiteopposition/100251792

Indonesia

"Climate-induced Disasters and Indonesian Politics" by Aninda Dewayanti and Neo Hui Yun Rebecca

https://www.iseas.edu.sg/articles-commentaries/iseas-perspective/2021-98-climate-induceddisasters-and-indonesian-politics-by-aninda-dewayanti-and-neo-hui-yun-rebecca/

Iran, General

Land Subsidence Destroys Iran's Society.

https://www.iranfocus.com/en/life-in-iran/47255-land-subsidence-destroys-irans-society/

Iran, Tehran

Tehran Ground Subsidence is a slow and silent Ticking Bomb.

https://www.intel-lab.net/post/tehran-ground-subsidence-is-a-slow-and-silent-ticking-bomb

Ireland, general

How ground subsidence affects the safety of buildings

https://www.rte.ie/brainstorm/2021/0706/1233423-ground-subsidence-buildings-urban-rural/



USA, Louisiana

The Biloxi-Chitimacha-Choctaw tribe is losing homes to erosion on the Gulf Coast



Since the 1950s, Isle de Jean Charles, LA, has lost 98 percent of its land to subsidence and saltwater intrusion.

https://www.sunherald.com/news/local/article252661948.html

Videos

USA, California

Delta Mendota Canal Subsidence

https://www.youtube.com/watch?v=hFCm0tU-5Ls&ab_channel=RichardAnderson

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