MONITORING AND ANALYSIS OF GEODESIC DEFORMATIONS USING GIS

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Abstract

This in the article geodetic deformations observation and GIS technologies in analysis opportunities research The study used GNSS measurements, InSAR radar data and geoinformation systems integrated analysis based on land surface sink and shift processes Deformation maps, 3D models and time analysis results based on sink speed, direction and danger zones evaluated. Obtained results deformation processes remotely to monitor them, spatial and time in sizes forecast for practical basis creates.

Keywords: Geodesic deformation, GIS, GNSS, InSAR, subsidence, displacement, monitoring, dynamic analysis, artificial companion information, risk zones.

Introduction

Last ten in years geodesy, geoinformatics and remote probing technologies intense developed, natural and man-made processes in real time in mode observation opportunities **is** expanding. Including land **surface a dwarf, a shift and deformation changes determination and monitoring** issue geodetic of research the most current from directions to one became. In the earth 's crust happened to be such changes human activity, land under of the waters level, mine digging to take, earthquakes, or of buildings weight as a result come comes out. Their early to be determined and analysis **buildings security, infrastructure stability and natural danger in the analysis** incomparable importance profession will reach.

Geodetic deformations when land surface different at points happened to be sinking, shifting, vertical or horizontal in the direction tremors as a result harvest to be geometric changes This is understood. changes **traditional geodetic measurements,** that is leveling, triangulation, GNSS observations using determination possible. But only point measurements with limitation deformation of processes **spatial scale** complete does not illuminate. Therefore, today 's on the day **Geoinformation systems (GIS)** and **remote probing (RS)** technologies

combined approach deformations observation the most effective from the methods one as confession is being done.

GIS technologies using **measurement, analysis and visualization processes are unified information in the environment done** This **is** deformation processes time according to observation, spatial dynamics modeling and motion vectors mapping opportunity In particular, **InSAR (Interferometric Synthetic Aperture Radar**) technology radar artificial companion from images using millimeters level land changes determination opportunity This gives method with GIS integration through **deformation zones** determined, **dangerous regions** is determined and change by speed (mm / year) **classification maps** is created.

Uzbekistan in the area, especially **Fergana valley, Tashkent region** and **Surkhandarya mountainous zones** geodynamic in terms of activity with separated This is in the regions natural geological conditions, seismic activity, and land under of the waters ascent as a result **sink and shift processes** is being observed. From this outside, mining, land under communication networks, and transport infrastructure with related anthropogenic factors are also deformational processes For example, Fergana in the valley 2018–2024 between take visited observations as a result some industry in the regions **up to 5–8 mm per year sediments** record This situations **InSAR data and GNSS observations** based on determined they are between high the presence of correlation ($R^2 \approx 0.96$) approved.

GIS technologies advantages is that they deformation information **many source analysis possible gives.** Geodesic measurements, artificial companion images, geological sections, and meteorological data to a single platform placed, **many multilayer** Perform deformation analysis This method is through deformation process **reasons, speed and direction** is determined and time sequence based on **trend analysis** is executed. With this together, **3D and 4D deformation** using **models** (e.g. ArcScene, QGIS 3D, Global Mapper) of processes spatial and time according to dynamics interactive in the form visualization will be done.

Today on the day world on a scale deformations observation for **European Space Agency Agency's Sentinel-1, NASA's NISAR, Landsat-8/9, TerraSAR -X** such as artificial companion systems active are being used. Their high spatial (10–30 m) and temporary (6–12 days) accuracy monitoring regular take to go opportunity is creating. This technologies GIS systems with when integrated, **digital deformation bases** takes shape and they are connected to real- time monitoring systems As a result, dangerous regions about **early warning systems** create possible It will be.

Uzbekistan Republic The President's "Earth Resources " in management digital technologies current to grow " about " decisions, as well as " Geodesy, Cartography and land cadastre system digitization Strategy (2023–2030)" documents based on GIS within **deformation monitoring** system create priority from directions one as This is defined as scientific research for **local geodetic monitoring networks** formation, **artificial companion information automatic again work developing algorithms,** and **deformation GIS modules of analysis improvement** requirement will reach.

This attitude with this The main purpose of the research is **geodetic deformations GIS technologies using observation and their time according to dynamic analysis done increase,** as well as sinking, sliding and other land changes **remotely standing control to do scientific and methodological from developing** the **basics** The research consists of results not only scientific, maybe practical also important in terms of divided into **buildings security, infrastructure stability, engineering-geological design** in the processes wide application possible [1-10].

Results and discussion

Research results this shows that the geodesic deformations GIS technologies using observation land on the surface happened happening sinking, sliding and other deformation of processes spatial and temporary dynamics in determining high accuracy and reliability gives. Learned in the area take visited geodetic observations, GNSS measurements and InSAR radar data analysis as a result deformation of processes nature, speed and them to the surface bringer factors identified and their GIS environment through visual analysis done increased. Research area along placed geodetic stations 2020–2024 using between regular measurements take GNSS data analysis as a result some at points annual sink speed 4–6 millimeters organization reached, some in places and this indicator from 8 millimeters increased record Such deformations mainly land under of the waters movement, man-made loads, geological of layers compression and climate changes with related that is was determined. Some at the stations horizontal shift directions it is determined that actions in the region tectonic of lines direction with up to 90 percent compatibility GNSS observations showed time When analyzed by, 2021–2023 between deformation processes relatively activated record was done, this in the period in the region one how many times lower amplitude earthquake vibrations observed with explained.

Radar artificial companion information based on take InSAR analyses performed using GNSS observations complementary main source Sentinel-1 is an artificial satellite. companion by received C- band information interferometric again developed the Persistent Scatterer Interferometry (PSI) algorithm using deformation maps created. This on maps every one pixel for annual change speed in millimeters expressed. Obtained to the results according to the area northeast in part average sink speed 5–7 mm/ year, some local in the ovens and up to 10 mm/ year enough South sector and relatively stable change, change speed 2 mm/ year Radar phases time according to When analyzing the dynamics, deformation processes seasonal to the character has that is determined. Spring and summer in the seasons sink speed increase, fall and in winter relatively stabilized This situation was observed. land under of the waters level change, rain amount seasonal change and soil humidity with GNSS measurements of InSAR data with when compared, their compatibility level 95–97 percent organization did, this and radar- based monitoring high accuracy confirms.

Received all data GIS environment – ArcGIS Pro and QGIS programs using integrated. GNSS and InSAR data georeferenced to a single base without placed and interpolation Surfaces – Kriging and IDW methods based on continuous deformation fields created. Each monitoring period for sink values based on spatial distribution maps was compiled. Results analysis this showed that deformation processes uneven distributed some, some in zones sink process year during stable, some in places and sharp variable color Based on GIS created timely time series one of the point change graph showing the deformation speed trend and determine cyclical characteristics opportunity For example, some points in 2022 speed sharp increased, this in the period oil spill out of the norm more than was and land under of the waters movement increased. Also, precipitation speed with land under water level between correlation The coefficient is r = 0.87, which is strong statistic connection indicates.

GIS environment deformation processes spatial modeling for comfortable environment Created. 3D deformation model based on “TIN” (Triangulated Irregular Network) relief model built and he drowned depth, direction and speed spatial in a way reflection Based on the 3D model determined lowest relief points sink hearths as This is marked. fireplaces around analyzed structures, transportation networks and communication infrastructures located regions with on top of each other to fall This is the deformation of processes man-made factors with directly connection proved. Based on GIS The created 3D model is

transferred to the “Dynamic Deformation Map” system connected, new artificial companion information when it arrives automatic to the updated monitoring map This approach is real- time. in mode deformations observation opportunity gave. Research to the results according to, deformation processes danger to the level looking at three to the category isolated. Low risk zones (0–3 mm/ year) natural sink processes column was stable geological into layers right arrived. Middle dangerous zones (3–6 mm/ year) seasonal changes and man-made downloads with related mainly industry enterprises, construction fields and around irrigation areas located. High dangerous zones (>6 mm / year) strong sink or shift processes record built, structures for dangerous regions organization GIS environment through created danger maps colored gradients with expressed, red color is high dangerous, yellow medium, green and stable zones stated. To the calculations according to research 18 percent of the area high dangerous, 36 percent middle dangerous, 46 percent and stable from zones consists of happened The results of this analysis are based on high dangerous monitoring frequency in the regions increase, every three per month information updated to go necessity marked.

Based on GIS deformations time according to modeling is also performed increased. Using the “Temporal Animation” module monthly changes based on dynamic maps These maps were created through deformation processes seasonal vibration obvious seen : spring and summer in the months sink processes activated, autumn and in winter and slowed down. This information based on deformation future development tendency forecast for prophecy A model was developed based on GIS. created regression model 2025–2028 using for sink probability forecast was done, the results according to some in the regions sink 10–15 percent of the zones expansion probability This forecast is available. man-made activity intensified in the regions danger level increase shows.

Received results scientific and practical point of view from the point of view high importance has divided, geodesic deformations using GIS observation traditional geodetic to measurements relatively one how much advantages First, GIS - based monitoring deformations wide spatial in scope assessment opportunity creates. Secondly, time series analysis through of changes dynamics Third, GIS data base artificial companion information based on automatic updated Fourth, the use of GNSS and InSAR data integration accuracy up to ±2 mm Finally, GIS models using dangerous zones identified, structures and infrastructures for warning systems are developed. So Thus, an integrated GIS–GNSS–InSAR approach deformation processes complex evaluate them time and space analysis in

dimensions and dangerous zones early in determining the most effective method as oneself justified. Research results Uzbekistan mountain, mining and urbanization process high was in the regions, in particular Fergana valley, Tashkent, Samarkand and Surkhandarya in the regions current to be possible was scientific and practical methodical the basis creates [11-17].

Conclusion

Research results this showed that the geodesic deformations GIS technologies using observation land on the surface happened happening sink and shift processes in determining high accuracy GNSS measurements, InSAR artificial companion information and GIS integration based on deformation of processes spatiotemporal dynamics determined, settled speed, direction and danger zones mapped. Retrieved results deformations mainly land under of the waters change, man -made downloads and geological conditions with connection showed. In a GIS environment created 3D and dynamic maps using dangerous regions clear marked and forecast models through their future development trend evaluated. Integrated GIS–GNSS–InSAR approach geodetic monitoring efficiency increasing, constructions security, infrastructure stability and natural danger in the analysis important scientific and practical tool as oneself justified.

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