

Research on Surface Deformation Analysis and Prevention Methods in Landslide Areas

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Abstract: *A landslide occurred near the village of Baige, Polo Township, Jianga County, Tibet, causing the Jinsha River to cut off its flow and forming a weir. Sentinel-1, Landsat8 data were collected to analyse the impact of the weir formed by the landslide on the upstream villages and towns, and the MT-InSAR technique was applied to obtain the movement characteristics of the landslide body before the landslide occurred. The results showed that the Baige landslide had already been significantly slipping before the disaster occurred, and the average rate of change of the Baige landslide front was obtained according to the PS-InSAR results, and two suspected landslides were found in the southwest and north of the landslide. PS-InSAR can discriminate the landslide in advance and make regular observation of the active landslide suspected landslide to provide early warning before the disaster occurred.*

Keywords: Baige Landslide; Sentinel-1; PS-InSAR

1. INTRODUCTION

Due to the complex topography of China, the uneven distribution of rainfall in the north and south regions, and the increasing human activities (such as groundwater, mineral resources development and urban construction), China has become one of the most frequent and hazardous countries in the world in terms of geological hazards. The mountainous and hilly areas of southwest, northwest, north, central and north China, as well as the Loess Plateau, have complex geological conditions and a large number of landslides occur each year. Monitoring the surface deformation in the study area is a common method to monitor landslide events. With the increase of available Synthetic Aperture Radar (SAR) data and the development of Interferometric SAR (InSAR), remote sensing technology has been widely applied in the study of geological hazards such as surface collapse, landslide, volcanic eruption, earthquake, mudslide and urban surface subsidence at home and abroad. Compared with field measurement methods, remote sensing technology has the advantages of large range, all-day, all-weather, high accuracy, high temporal and spatial resolution, the ability to monitor areas inaccessible to personnel, and low monitoring cost. Nowadays, InSAR technology tends to be mature and widely applied to identify and monitor potential landslide areas on a large scale. Time is an important category in the history of philosophy and has always been a hot spot for philosophers. Since the early natural philosophy of ancient Greece, philosophers have been discussing the problem of time, but the thinking about time at that time was still mainly related to the original. During the period of German classical philosophy, Kant turned the problem of time to the study of the epistemology of time, and he called time the innate condition of perceptual intuition, the innate form of cognition. Marx, on the other hand, based his discussion of time on the materialist conception of history and externalized time as a space for human development. He believed that time, in a subjective sense, is the social time that is closely related to the practical movement of human beings, and its main characteristic is that it will change with the change of social development. Marx's idea of free time encompasses not only human activity but also social activity.[1]

In the mid-18th century, the Industrial Revolution began in Britain. Industrial reforms rapidly changed the face of production in all sectors of industry, and in the 1840s, machine-based industrial production replaced traditional handicraft production, and Britain became known as the "factory of the world" Subsequently, the Industrial Revolution swept across Europe.

The acceleration of the process of the Industrial Revolution was likewise accompanied by the development of capitalism, which first took hold in the several countries in Europe took root and in turn used capitalism to accumulate wealth and establish bourgeois states. The Industrial Revolution not only brought the bourgeoisie to the center of the stage of history, but also enabled the proletariat to play an important role in world history. In the course of the ensuing capitalist economic development, along with the strengthening of the bourgeoisie's dominance, the conflicts with the proletariat intensified. The living and production conditions of the working class deteriorated, the gap between the rich and the poor between the bourgeoisie and the proletariat became wider and wider, and the workers' movement and the pro-democracy movement were on the rise. The economic crises from 1825 onwards not only inflicted heavy injuries on the working class, but also exposed the inherent defects of the

capitalist system. In the successive workers' uprisings, the resistance of the working class against the bourgeoisie went from spontaneous to conscious, and the proletariat began to emerge as an independent political force.

2. LITERATURE REVIEW

InSAR technology has been one of the most commonly used remote sensing techniques since the 20th century. It is a space-to-earth observation technique combining traditional SAR technology with interferometric technology. It mainly includes Differential InSAR (D-InSAR) measurement technique, Permanent/Persistent Scatterer InSAR (PS-InSAR) measurement technique, Small Baseline Subset InSAR (SBAS-InSAR) and other derived InSAR techniques. Today, InSAR techniques tend to be mature and widely used for the identification and monitoring of potential landslide areas on a large scale.

2.1 D-InSAR

D-InSAR is developed from the traditional InSAR and uses SAR data acquired at different times in the same area for differential interference processing. the differential processing removes the common quantities (flat earth effect, topographic phase and atmospheric delay, etc.) from the two observed phases to obtain the deformation phase and thus surface deformation information. In 1989, Gabriel A. K. et al. first used the D-InSAR technique to detect surface deformation in the Imperial Valley region of California, USA, using image data from Seasat, the first radar satellite launched by NASA in 1978. the results showed that differential interferometric SAR could monitor surface deformation movements of less than 1 cm over a large area of 50 km.

2.2 MT-InSAR

MT-inSAR sequences are represented by PS-InSAR and SBAS-InSAR (Lanari et al., 2004, 2007; Lin Hui et al., 2017). the two methods are more suitable for monitoring long-term slowly accumulating deformation landslides and can obtain information on slope activity patterns. Among them, PS-InSAR is based on the processing of Persistent Scatter points, a discrete point set composed of highly coherent image elements, to model the phase and solve the deformation of PS points. Ferretti et al. (2000) used PS-InSAR to extract landslide displacement rates and demonstrated its ability to detect millimetre precision displacements.

Methods	Contributors	Scope	Advantages	Disadvantages
DInSAR	Gabriel(1989); Massonnet (1993); Massonnet&Rabaute(1993); Zebker(1994); Wegmüller(1998)	Large scale; volcanoes, earthquakes; mines, landslides, oil and gas fields, glaciers, permafrost and urban surfaces	Wide coverage area and less data required. Low cost, wide application, monitoring accuracy in the centimetre to decimetre range.	Vulnerable to atmospheric effects; Requires spatial and temporal baselines; Not suitable for slow deformation; Time-series data not available.
PSInSAR	Ferretti(2000)	Mining subsidence, urban infrastructure, landslides, seismic deformation	Accuracy to millimetre and sub-millimetre levels. Suitable for monitoring urban areas. The contribution of atmospheric effects to the phase can be accurately estimated and eliminated.	Large amount of data, low computational efficiency, need to select optimal master image; Not suitable for large scale monitoring applications and linear deformation model assumptions
SBASInSAR	Berardino(2002)	Volcanoes, mines, permafrost, cities, fault sliding landslides surface deformation	Less image requirements than PS-InSAR, more efficient operations, ability to extract non-linear deformations	Difficult and costly selection of high coherence points. Some limitations in application extension
TCPInSAR	Zhang(2011)	Slow landslide investigations. Subsidence along the HSR	No phase de-entanglement required. Low demand for SAR images.	No DEM to match high resolution SAR data
GBInSAR	Tarchi(1999)	Volcanoes; reservoir dams; bridges; mine slopes; deep surface landslides	Low time de-correlation; High temporal resolution for high accuracy monitoring; Low external influence; short sampling period	Atmospheric phase correction models are not yet well established; Only applicable to single known landslides

3. OVERVIEW OF THE STUDY AREA

The Jinsha River landslide is located on the western side of the Jinsha River at the junction of Baiyu County, Ganzi Prefecture, Sichuan and Jiangda County, Changdu City, Tibet. It is a rocky landslide, blocking the main stream of the Jinsha River and forming a weir, approximately 5, 600m long, over 70m high and 200m wide.

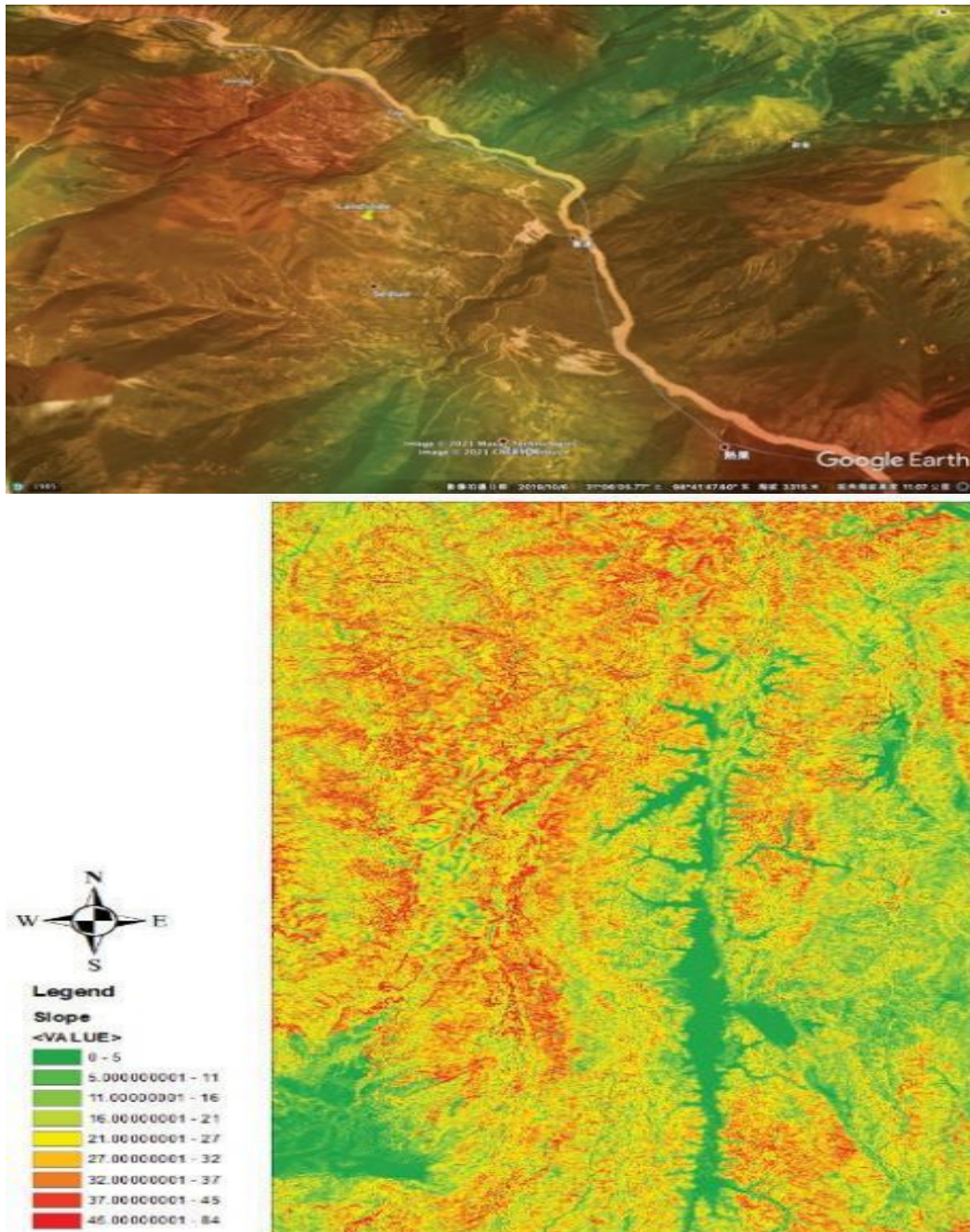


4. GEOMORPHOLOGY

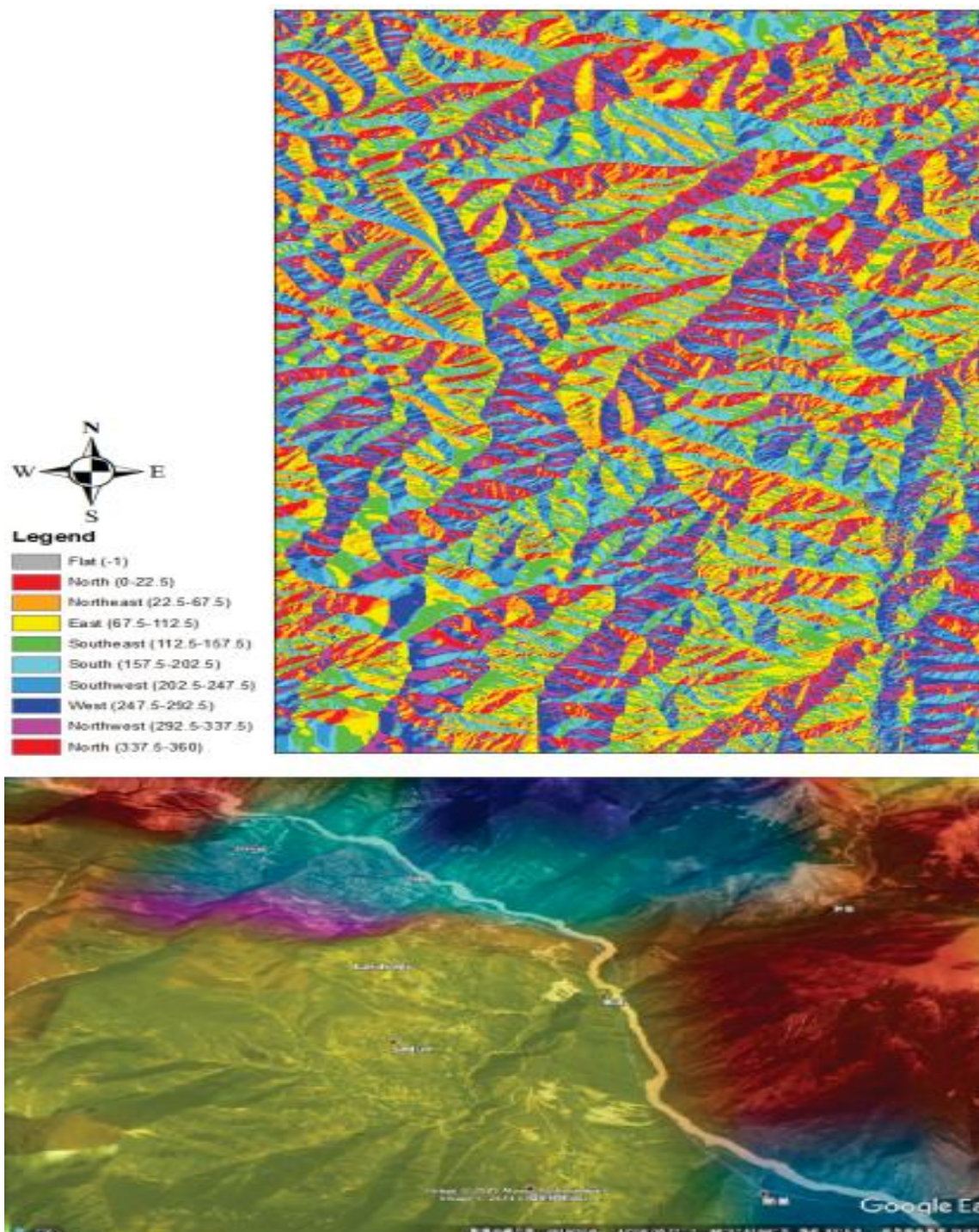
Under the capitalist system of employment, the working class can only obtain real freedom and its survival by raising wages and reducing labor hours. Marx pointed out In the Wages, Prices and Profits, Marx argues that "a time is the space for human development." [2] This fully demonstrates that Marx's idea of free time is closely linked to the emancipation of the working class, and in the macro perspective, this correlation can also be magnified to the development and emancipation of the whole human race.

Marx had studied time in relation to it since his youth, and in his doctoral thesis, the Through a study of the natural philosophies of Democritus and Epicurus, it is suggested "the sensibility of man takes the shape of the embodied time is the existential reflection of itself in the world of sensibility." [3] In this period, Marx understood time as the perceptual perception of human beings, a category belonging to the activity of human thinking. In his next study of the capitalist economy and the system of employment, Marx puts forward a series of economic categories such as "labor time," "free time," "an alienation of labor," and so on. In his description of these categories, he expressed the philosophical aim of eliminating alienation and realizing the free and comprehensive development of human beings.

Marx wrote in the Philosophical Manuscripts of Economics of 1844: "The more the worker produces, the less he can consume; the more value he creates, the less valuable and inferior he is; the more perfect the worker's product is, the more deformed the worker is; the more civilized the object created by the worker is, the more barbaric the worker is; the more powerful the labor, the more impotent the worker is; the more skillful the labor, the more stupid the worker is, and the more the worker becomes a natural person. the more stupid the worker becomes, the more he becomes a slave of nature"! "His labor is not voluntary labor, but forced compulsory labor"! These descriptions by Marx can show to some extent that the labor of the worker is not a conscious and self-willed labor, but the capitalist has forcibly appropriated the labor time of the worker and turned it into a means of preserving his own existence. In the Economic Manuscripts of 1861 - 1863, Marx sublimated time to "time is in fact the active existence of man, it is not only the measure of his life, but also the space of his development." [4] In his continuous research on the theory of surplus value, Marx discussed in detail the alienation of human beings and labor, and the free time enjoyed by workers in addition to the socially necessary labor time will inevitably increase with the abundance of material resources.



The landslide area is located in the east Tibetan Hengduan Mountains and the valley of the Jinsha River basin, and is a typical tectonic erosion landform. the area where the landslide is located is a V-shaped valley of the Jinsha River, with a deep cut and steep banks. the landslide is located on the right bank of the Jinsha River, with an overall slope of 91° and a steeper bank slope, with an average slope of about 50° - 65° . the back edge of the landslide is a north-south oriented ridge that gradually decreases in elevation from south to north, with the mountain becoming progressively narrower. the front edge of the landslide is the concave bank of the Jinsha River, with a water level of 2880 m. the river has a strong lateral erosion effect.

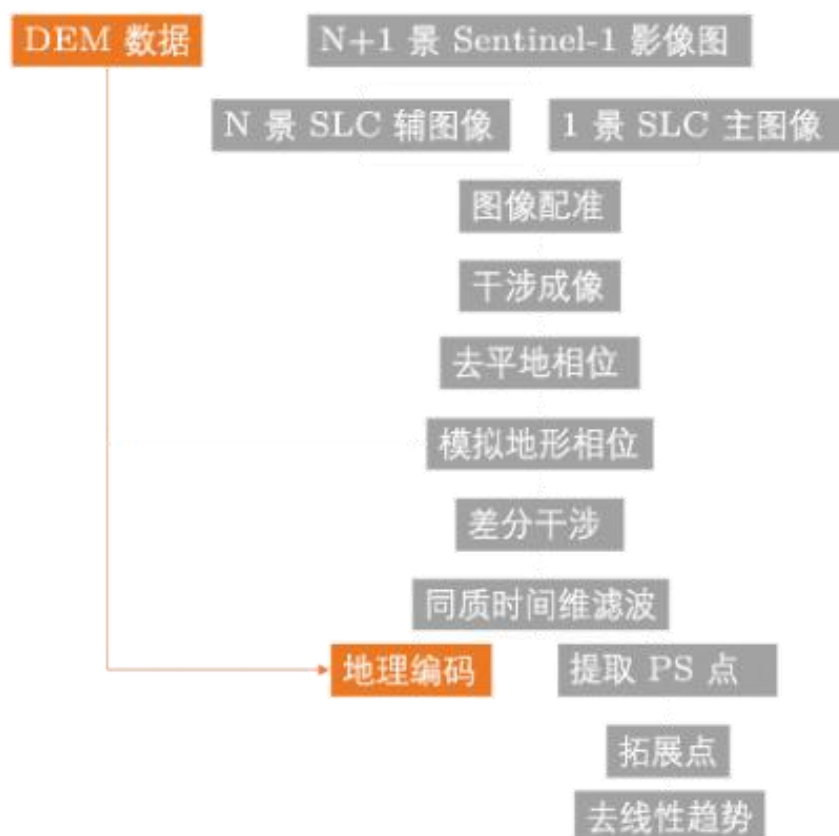


4.1 Experimental data

The data used for this experiment is Sentinel-1A data. the Sentinel-1A satellite is an Earth observation satellite of the European Space Agency's Copernicus programme (GMES), operating in C-band and providing uninterrupted imagery under a wide range of meteorological conditions, with a revisit period of 12 days, ensuring a rich source of data and free downloadable resources, which allows the data to be used without excessive restrictions. In addition to this, the data has a high resolution, which allows it to meet most surface monitoring research needs. It has therefore been favoured by many InSAR research fields. For this experiment, 54 scenes of Sentinel-1A data were selected, covering the period 2016 to 2018.

4.2 Technical Routes

Marx threw himself into the revolutionary movement of 1848-1849, and after the failure of the revolution, analyzed in depth about the reasons why the revolution took place. The failure of this revolution fully demonstrated that the representatives of the advanced productive forces of society and the prime creators of social wealth were mainly the working class, which was better suited than the peasant class to be the vanguard of the revolution. In this context, Marx revealed the means by which capitalists exploit workers by discussing the theory of surplus value and pointed out that the essence of capitalists is to pursue the maximum surplus value, thus realizing capital accumulation.

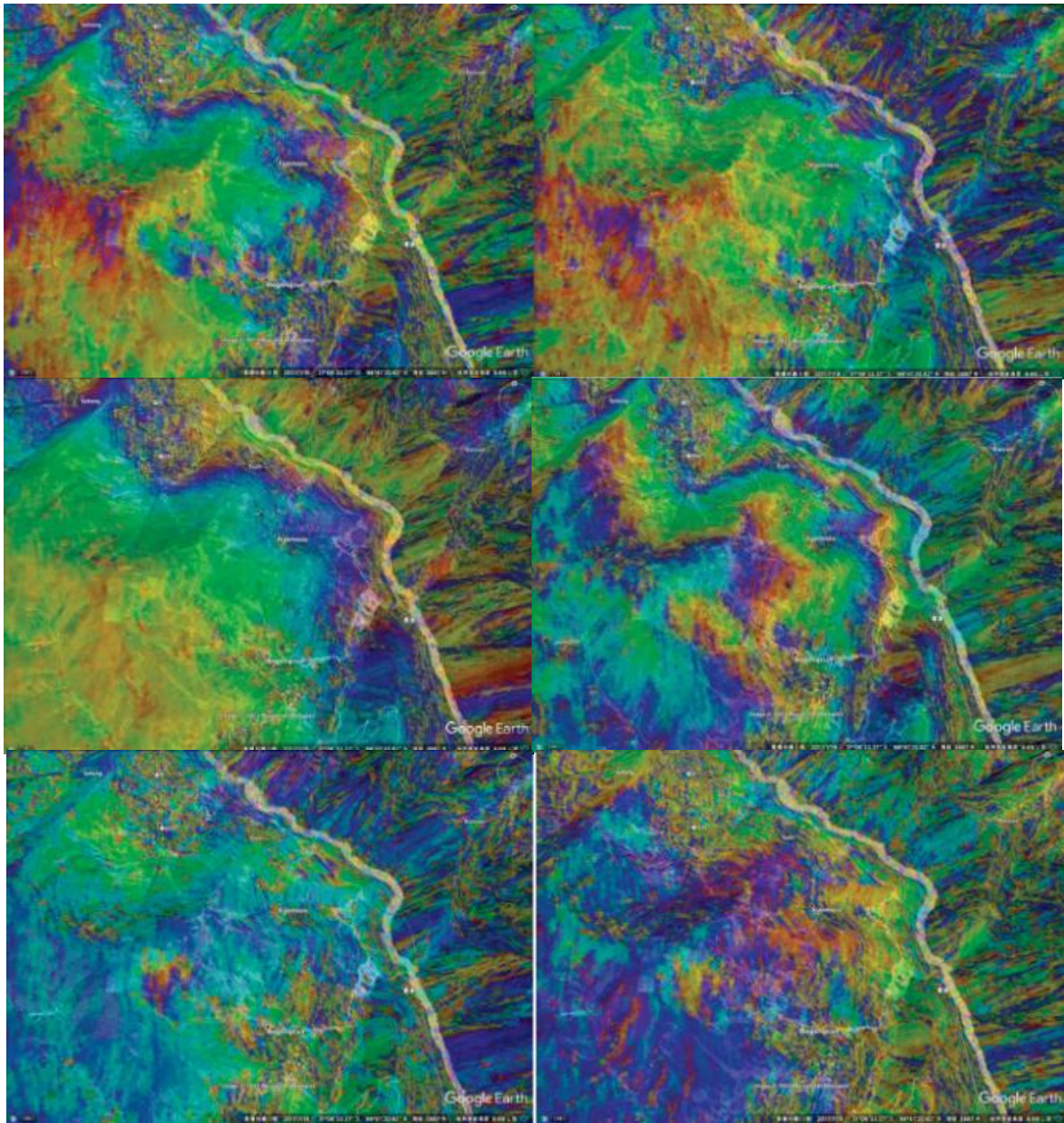


4.3 Data Processing Process

N-1 interferograms and differential interferograms were obtained by removing the flat earth phase and topographic phase from the interferometric phase with the aid of DEM differential interference processing. the PS points were selected for comparison according to the double threshold method of coherence coefficient and amplitude deviation and the amplitude deviation method, and a suitable method was selected for further processing. A system of model equations is developed for all PS points of the interferogram, and the mean deformation rate, elevation error, and atmospheric phase parameters are solved. After removing the above phases from the differential phase, the PS points are re-extracted and the above steps are repeated for deformation inversion. the main steps of the MT- InSAR data processing process are described below.

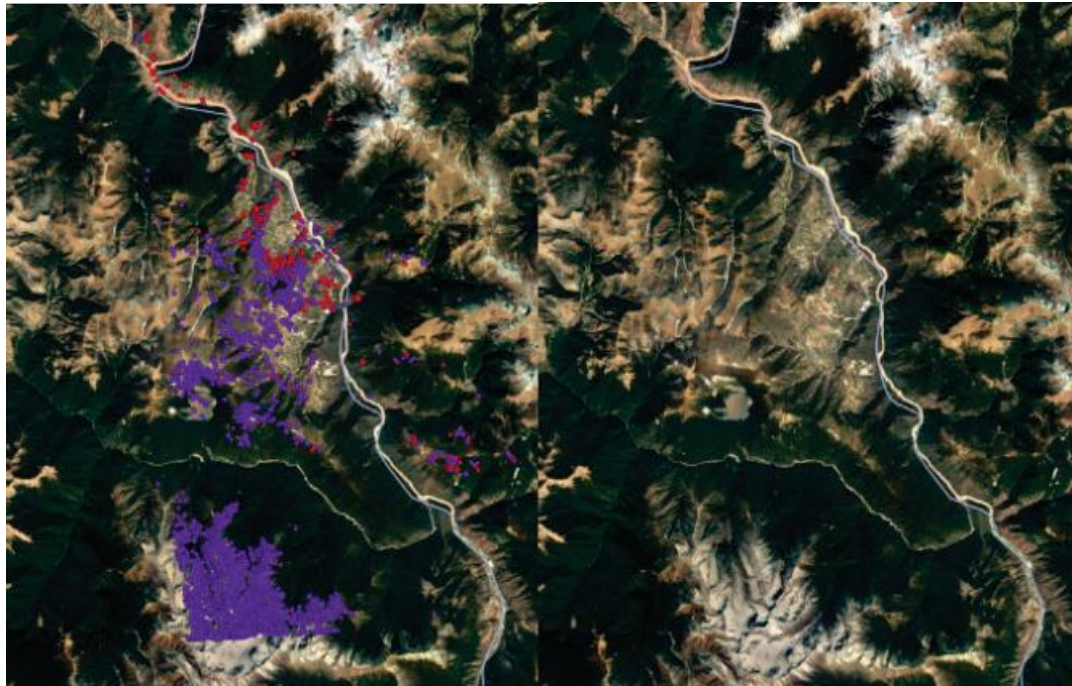
4.4 Selection of Differential Interference

The precision orbital data from the Sentinel-1 satellite can simulate the flat earth phase in the test area to obtain the deflattened interferometric phase. the DEM data is sampled under the image coordinate system and an amplitude image simulated by the reference DEM is generated, which contains only the topographic phase in the simulated amplitude image to achieve the purpose of eliminating the topographic phase. To make the data representation more intuitive, several of these differential interferograms were selected for geocoding and presented on Google Earth.



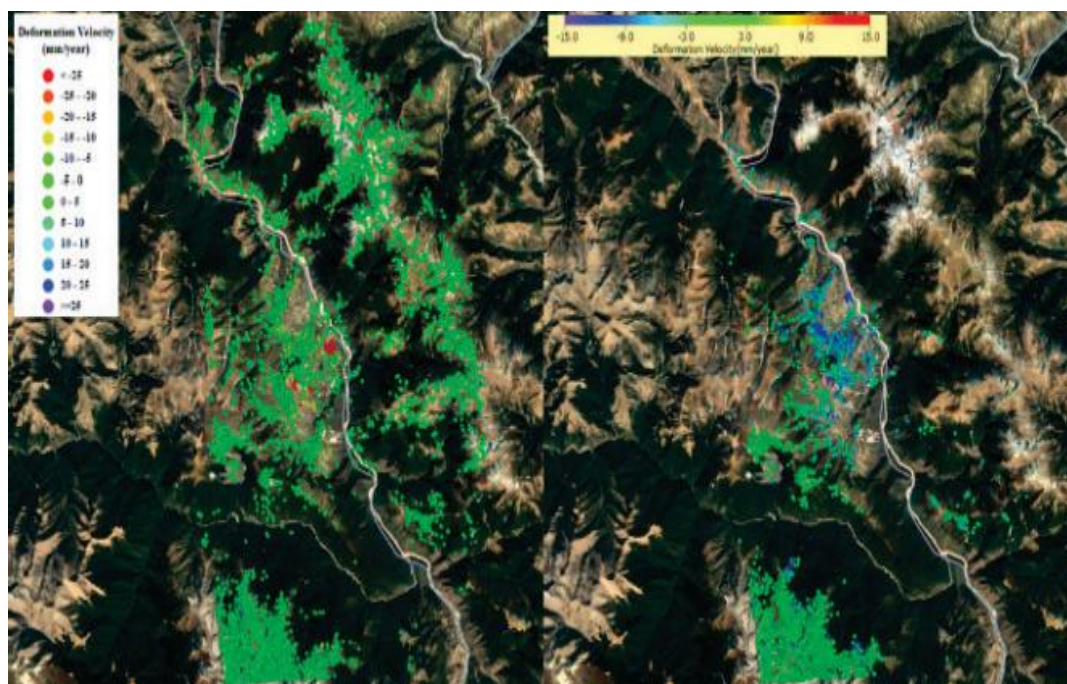
4.5 PS Points Selection

The permanent scatterer method selects interferometric phases from a set of time-series SAR images that have relatively stable scattering properties, are less affected by temporal and spatial decoherence, and have a high signal- to-noise ratio and high coherence. PS points are usually hard ground points, such as artificial buildings, exposed rocks, etc. PS points are characterised by both strong scattering and stability, i. e. strong amplitude in SAR images and consistently strong amplitude information or stable phase in different time series of SAR images. the PS points provide reliable phase information that can be used to infer the deformation information and DEM information of the time series in the region.



4.6 MT-InSAR Timing Modelling

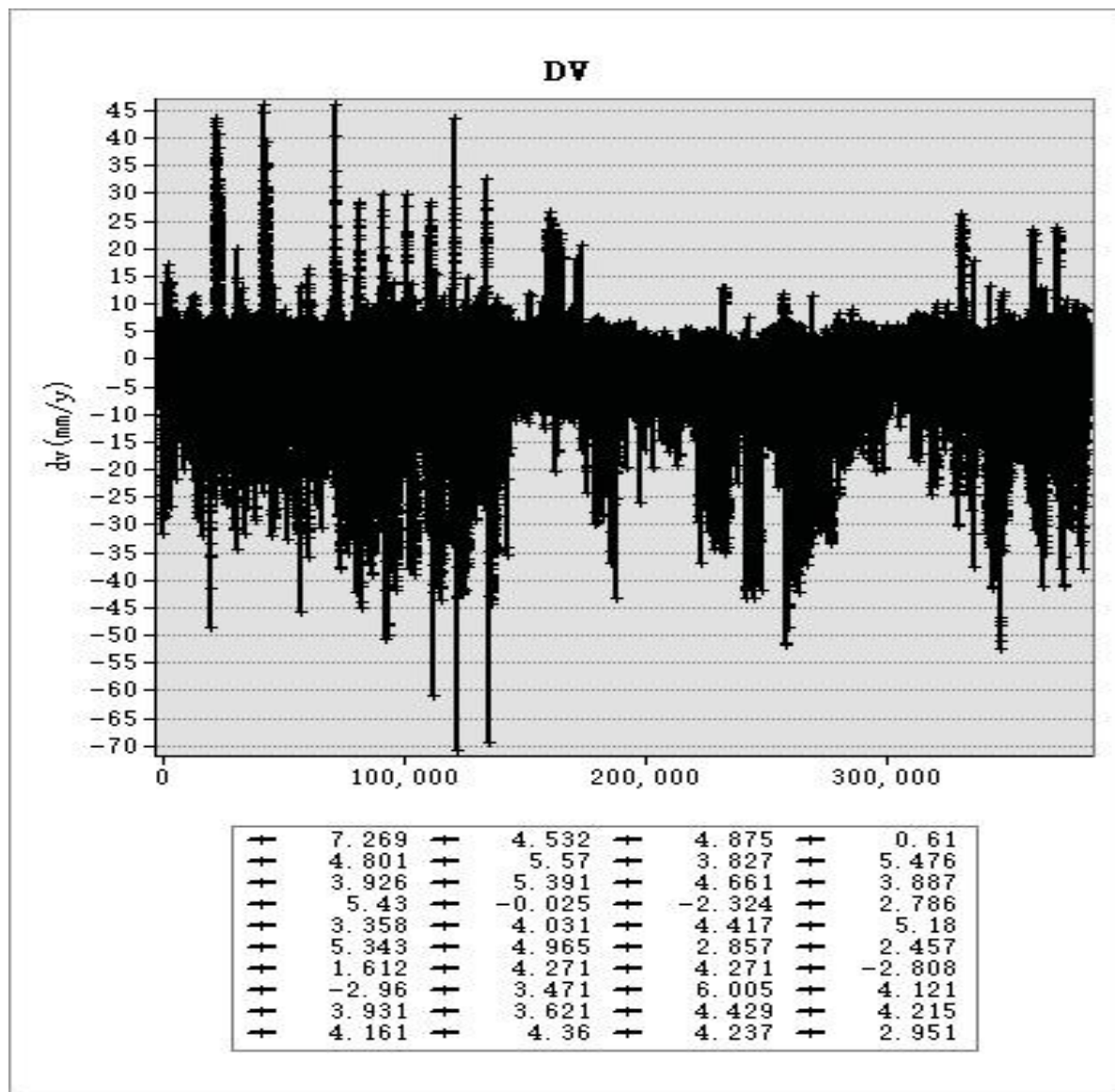
After extracting the PS points in the study area, the phase information of the PS points includes linear deformation, non-linear deformation, and elevation error information. A Delaunay triangular network is created from the PS points and a phase difference model is established. The model is solved to obtain the incremental deformation rate and the incremental elevation error, etc. The deformation rate and elevation error are obtained by integrating the incremental values. After removing the above phase information, the interferometric phase includes the non-linear deformation phase and the atmospheric delay phase. The non-linear deformation phase is obtained by eliminating the atmospheric delay phase using high pass filtering in time and low pass filtering in space. Finally, the deformation information is geocoded to obtain a linear average rate map and a time series cumulative map for the study area.



5. ANALYSIS OF RESULTS

5.1 Landslide Deformation Analysis

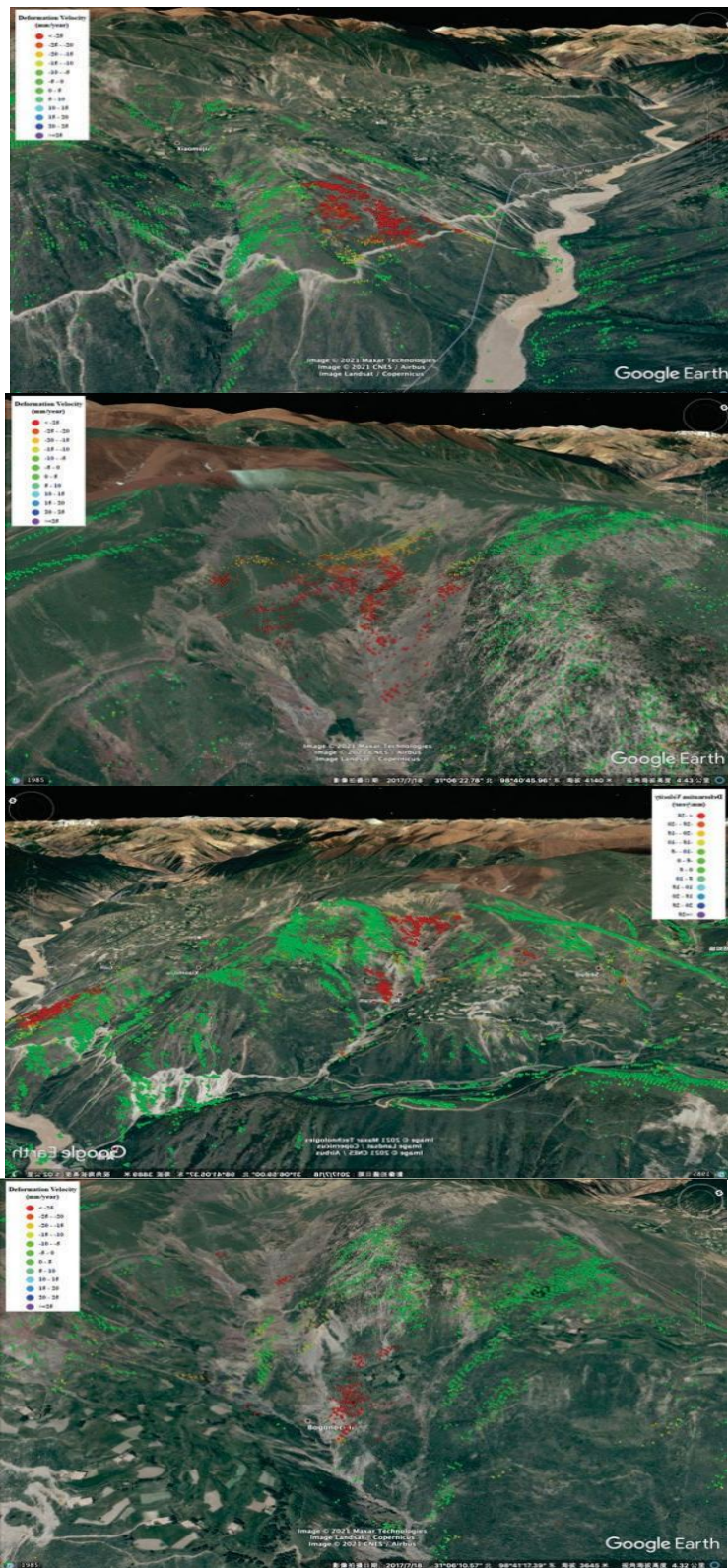
Liu Ben mentions in his relation to labor and space-time, "In labor practice, the relation between time and space is the relation between subject and object. Time, as the active existence of human beings, can only acquire its own reality in practical activities. Labor time itself exists only as a subject, only in the form of activity." Space is the existing living environment of human beings, which belongs to the category of static; time is the process of human beings' active transformation of the existing environment, which is the category of dynamic. In practical activities, time, as the active existence of human beings, is inseparable from human development. "Marx's ideas on free time show that free time is a necessary condition for the emancipation of every human being."



Based on the 54 scenes of elevated track sentinel-1 data obtained covering the Baige landslide, the MT-insar technique was applied to process and remove most of the topography-related phases from the DEM elevation data to obtain the mean deformation rate map and rate distribution map around the Baige landslide.

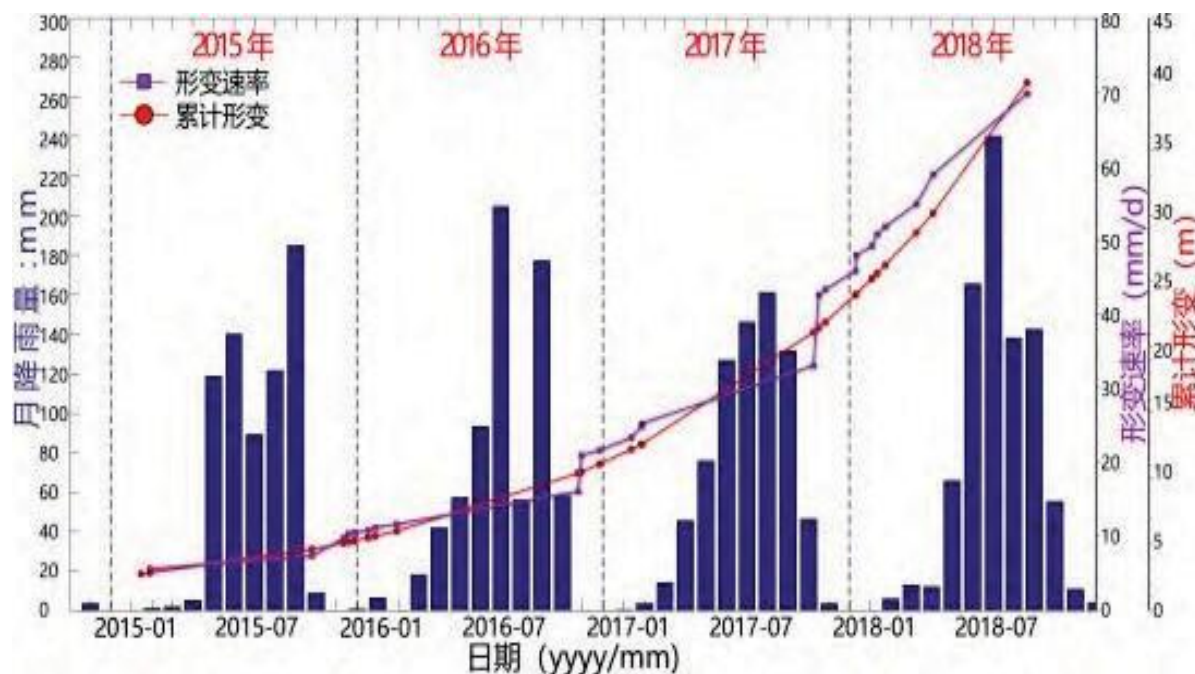
The average deformation rate in most of the study area is below 5 mm/y, indicating that the monitored area is generally stable, but there are three active landslides with deformation rates exceeding 25 mm/y. The images reflect the distribution of deformation rates, with most points ranging from 0 to +5mm/y in the positive direction, with the

maximum exceeding 45mm/y, and most points ranging from -20 to 0 in the negative direction, with the minimum approaching -70mm/y.



5.2 Rainfall Analysis

To analyse the relationship between deformation and precipitation, annual, monthly and daily rainfall data were collected from the nearest GMS station to the Baig landslide in Dege County (98.567°E, 31.733°N). the deformation rate, cumulative deformation and rainfall data are shown in Fig.



The cumulative deformation variables from 2015 to 2017 were small, while in 2018 The cumulative deformation variables were large and the deformation rate gradually increased. the correlation coefficient between rainfall and cumulative deformation was 0.88, indicating that the deformation is highly correlated with rainfall, but the landslide may also be influenced by other internal and external factors.

6. CONCLUSION

This study provided a framing analysis of the coverage of President Xi Jinping by Global Times in the year before two international opinion polls, and specifically analyzed the extent of the coverage, news sources, frame usage and the valence of high - frequency words. By analyzing and comparing the articles in two periods, the study discussed the problems of Global Times in shaping the media image of Chinese national leader, including almost unchanged coverage extent, and news sources usage strategies, and the continuing positive portrait under the duty performance frame and governing belief frame. The results imply that Chinese newspaper aiming at international audience, like the Global Times, are sluggish in response to the changing international environment. It may limit the influence of the Chinese media, not necessarily effective at maintaining a good image of Chinese national leaders among the international public.

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