GLOBAL OCEAN MONITORING THROUGH REMOTE SENSING METHODS AND BIG DATA ANALYSIS

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Abstract - In the recent growth of remote sensing techniques with big data analysis, the need for more reliable environmental monitoring of the oceans has been attributed to many research studies. Remote Sensing of Global Oceans (RSGO) offers a wide range of human, biological, marine and oceanographic applications using satellites. The oceanographic data has been collected and processed using different remote sensing satellites in space. A vast number of Ground Monitoring (GO) instruments, both in space and in the atmosphere, provide vast amounts of remote sensing data from across the globe. This paper seeks to create an Intuitive Tile-Based framework using RSGO (ITB-RSGO) for the immediate access and valuable analysis of big data. The raw data has been viewed and roamed through the Internet via a virtual world as tiles, increasing their spatial knowledge, which can be used to tune and pre-load data and optimized indexing for distributed computing. The spatially-focused tile, which incorporates cutting-edge technology, eliminates the disparity between the RSGO and end-users. Compared to the input pictures, the tile array can be transmitted more quickly over the Internet, allowing people to access those resources digitally through its intelligent space distribution capability. This remote sensing platform provides an essential advantage in acquiring complex ocean data and significantly increases the cycle observation, understanding, and prediction ability. The graphical findings demonstrate that the proposed ITB-RSGO is highly accurate, quick and less time-consuming in detecting global ocean changes.

Keywords: Remote sensing, big data, global ocean, image processing, remote sensing satellites.

1 INTRODUCTION

The ocean covers more than three - quarters of the earth's area. Microorganisms provide oxygen to the ocean surface through the process of photosynthesis. The ocean has drained 90 per cent of global warming heat. 90% of international shipping traffic occurs through seas. However, 96% of the ocean is still unexplored and underestimated by human beings [1]. This requires knowing all aspects of the sea and its dynamic links to the earth's climate, soil, snow, water and organisms, including humans. It is crucial that awareness of the planet has to be promoted and the long-term well-being of humanity be ensured and help direct human-environmental governance [2]. Oceanography is changing from an expeditionary scientific field dependent on the ship to a remote observatory approach that facilitates long-term data collecting and provides an immersive ability for studies to be conducted using real-time data transmission.

The Ocean Expeditions Project (OEP) [3], for example, is managing and integrating information from over 850 devices in its several clusters. Devices are put on a wide range of platforms, including airships, independent submarine cars, boots, profilers, inferential mooring cords and boxes for transport planes. Over 200 specific data items from the air-sea interface to the seafloor are measured or extracted from approximately 75 specialist instrument models used in OEP. Data has been obtained and processed at an unparalleled level and pace using multi-source ocean observation [4]. Gartner defines big data[5], which indicates placing the sample characteristics for ocean observation (density, speed, and range). Ocean observation data should also be seen as big standard data, i.e. maritime big data.

This information will be stored, interpreted, analyzed and other items, including visualizations, in native format, extracted, calibrated and processed for quality control [6]. The unique properties of large-scale marine data such as multi-source, long-lived, unpredictable, and incomplete outweigh traditional systems processing and analysis. This condition has created new problems for the existing systems, such as relational database systems and global level infrastructure facilities [7]. Recent investigations concerning big data specifically deal with exploring and making use of those high volumes of data more accurately and reliably [8]. Infrastructure [9], stockpiling [10], analysis [11], security [12], etc., are critical concerns examined in these studies.

The remaining sections of the paper have been systematized as follows: Section 2 describes the associated research on global ocean monitoring using big data and remote sensing methods. Section 3 shows the Intuitive Tile-Based framework using RSGO (ITB-RSGO). Simulation results and related discussion has been provided in Section 4. Section 5 provides the conclusion and an overview which describes possible future studies.

2 RELATED WORKS

In Earth system science [13], Earth observation satellites are a rare source of knowledge to tackle many complex problems. As the spatial data knowledge-gathering technology has evolved continuously, Earth scientists have begun to collect, store and process large amounts of geospatial data set easily to discover various environmental anomalies worldwide [14,15]. There is a steady growth in the number of available, inactive RSGO wireless sensors transmitted into space, with remote sensing users and service providers becoming exposed to problems with data processing [16-18].

Innovative methods to managing, analyzing and distributing remote sensing techniques and services are needed to respond to these challenges [19]. The abundance of remote sensing information revolutionizes the processing, analysis and interpretation of remote sensing data to gain knowledge. [20] In general, remote sensing techniques are used through data access, retrieval analysis, and visual expression. Present practices are not necessary to meet the requirements of a complete application for expertise, focusing on the area of Marine Remote Sensing (MRS). The petabyte-scale repository of MRS data has been publicly accessible from various US government departments, including NASA, the US Geological Survey, NOAA and the European Space Agency [21], in recent years, through the introduction of comprehensive open data policies.

Although researchers can report data from those institutions and their analysis results, the individual who downloads who creates a copy from the server's hard disks poses possible bottlenecks [22,23]. Users will have to download the requested data and apply unique software such as SeaDAS and ENVI, which takes experience and training [24,25] for use. These systems also offer experienced users valuable, high-quality items but are also difficult to map, control, interpret, and communicate changes to the environment [26]. This paper introduces SatANA for online analysis of MRS results, which allows users to experience immediate access, elevated measurement, and vibrant illustration.

The architecture of high-performance computer systems involves developing more heterogeneous systems that can combine resources at various locations [27]. While the overall performance of cloud computing systems in remote sensing applications has been seen to be strong, there remain challenges to the progressive integration of the cloud computing concept into remote sensing studies [28]. The overarching objective must be to simplify the access of distributed data sets from various users.

But the energy demand, still challenging to use in parallel processing platforms or on-board processing situations, is still an ongoing problem. The complete integration of Big Data learning methods into remote sensing techniques would be necessary to address these difficulties. Big data literature in Remote Services primarily emphasizes and finds it a data-intensive computing problem [29] on a large-scale topic in Big Data Computing. A high-performance computing paradigm is usually used to handle big real-time data [30]. In recognition of these issues, this document provides a platform called ITB for the online study of RSGO data that integrates fast data access, high accuracy estimation and vibrant visualization.

3 PROPOSED ITB-RSGO SYSTEM

Enormous base knowledge must be integrated to support organizational acceptance and thoughtful review of RSGO documents as a service resource. This article pre-processes RSGO portraits to a lossless tileset to preserve the original information [31]. The groundbreaking ITB-RSGO architecture has been pursued to gain a high standing emphasis on the array of lossless tiles.

3.1 Lossless Tile Set with Three-Dimensional Responsiveness

The architecture of ITB-RSGO is based on the selection of lossless tiles. In addition, the tiles could be modified by spatial awareness. The principal method of manipulating uncompressed file collection includes separating, resampling and encoding the image and then creating a lossless compact file in a pyramid. Similarly, on both of the two nearest floors of the hierarchy, each tile on the top floor has three lower-level tiles. The rates are reduced so that the tiles are increased. The spatial precision is lower than the original image, and at this point, the optimal quantity is achieved. This technique retains an adequate knowledge of the actual picture of the base pyramid tile, which can be used for mathematical analysis. Thus, the triangular design increases the actual object rendering and zooming volume, allowing tiles to consider their size.

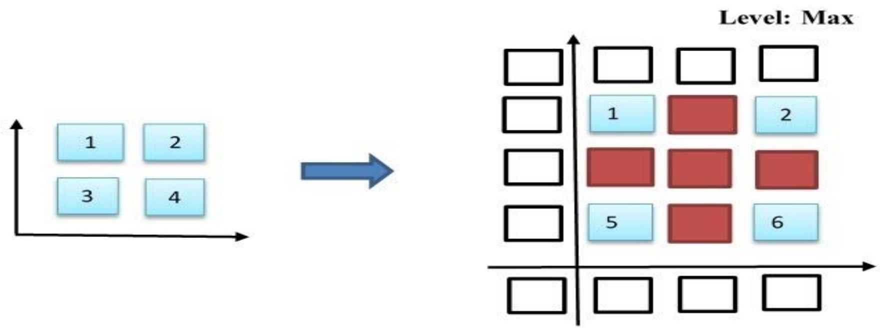


Figure 1 Illustration of pixels between original image and tiles in the proposed ITB-RSGO system

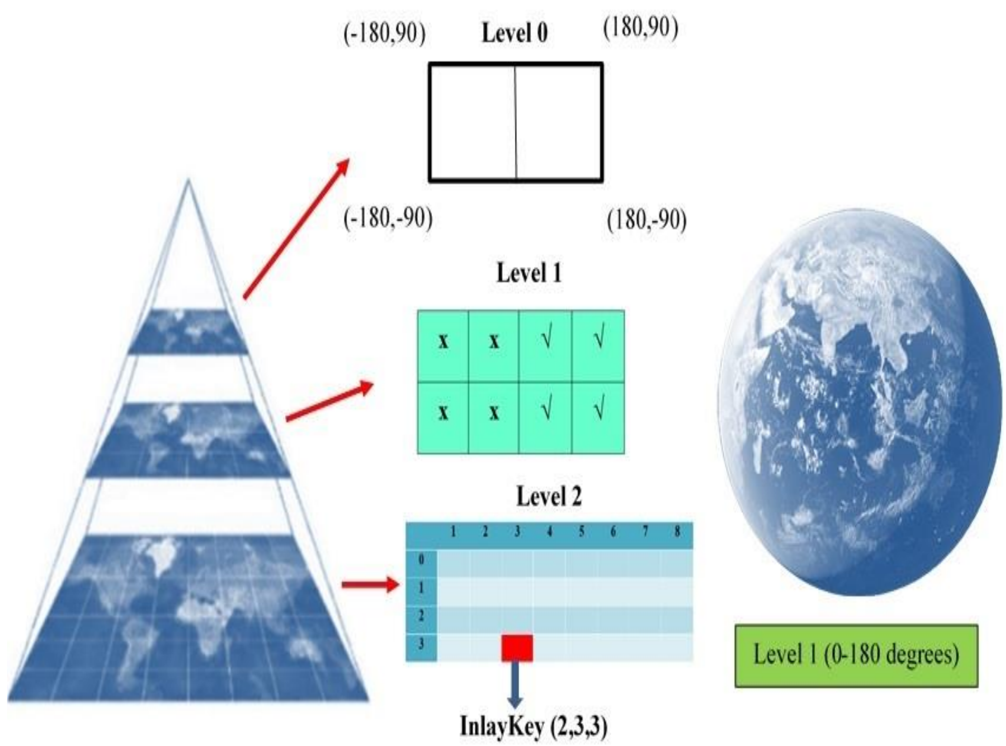


Figure 2 Lossless tile set with three-dimensional perception. TileKey performance used for the proposed ITB-RSGO system.

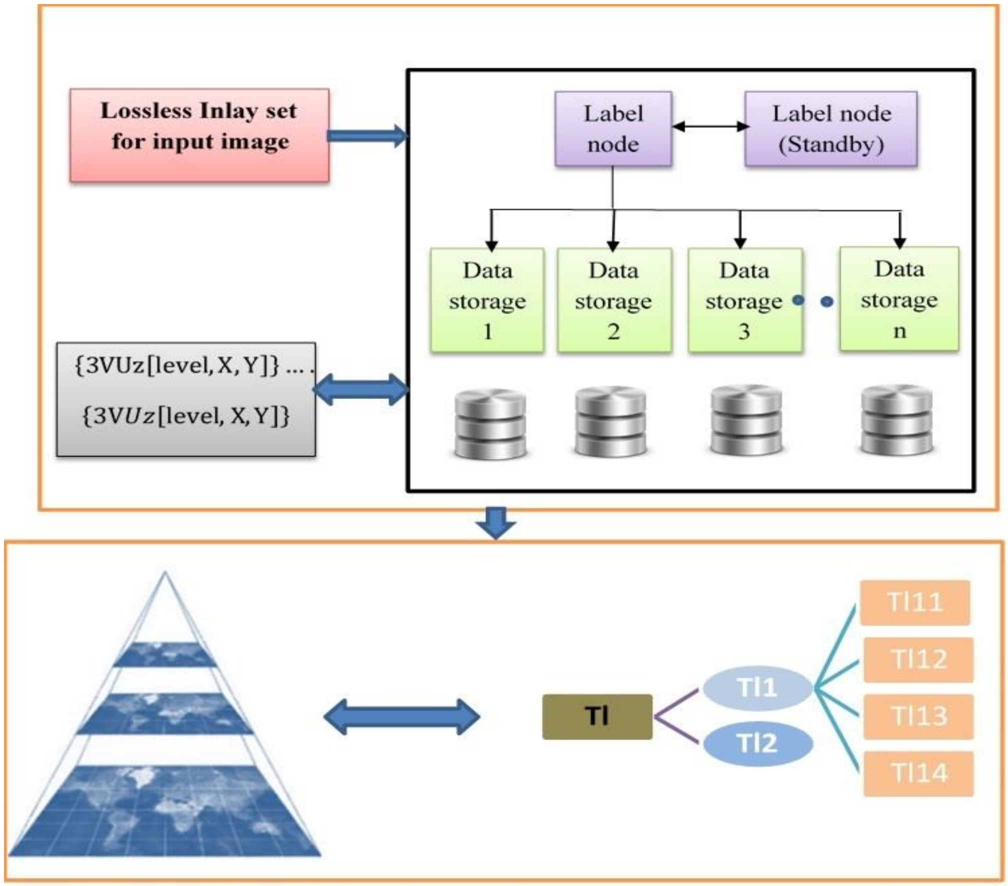


Figure 3 Integrated fusion storing design for the proposed ITB-RSGO system

Fig. 1 shows the pixels between the original image and tiles in the current ITB-RSGO structure. In the form of the ITB-RSGO grouping and segmentation, pixels will be blended. To keep the original pixel, all pixel values should be translated to a broader range. Multiple tiles are included in this package of 256*256 pixels. The temporal degree, accuracy, initial tiles in the nearest neighbourhood, and the sum of tiles in this display sequence has been measured.

In addition, the value of the original representation will be reversed about the undefined pixels of the existing table set (the maroon Pixels in Fig. 1). By entering a different numerical quantity of the actual pixel, a pixel definition will be extracted. A layered image hierarchy is being revised using a rear-tree structure for the new tile array. By contrast, an TileKey approach is an tile in the image hierarchy as a spatial indicator. The original image contains information for spatial context, which is lost during the flooring operation.

Likewise, ITB-RSGO interactive space uses TileKey technology to position tiles without understanding the spaces and as seen in Fig. 2. The virtual world will determine quickly whether the scientists search and matches inside each Tile's URL thread and react to the filename. The perspective factor and the extent of loading tiles have been determined. In comparison to the above approach, designers may connect tile information tools that allow users to display organizational behaviour in placing simulated ITB-RSGO tiles and theoretical tiles.

The 3D-cognizance of the tile has been denoted as

$$3\mathrm{VU_z}[\mathrm{level}, \mathrm{X}, \mathrm{Y}] = \frac{1}{4^{\mathrm{level_{hi}} - \mathrm{level^{ot}}}} \quad (1)$$

Following the consumer's magnification and tilting operations, the structure of the tile has been specified. $3\mathrm{VU_z}[\mathrm{level}, \mathrm{X}, \mathrm{Y}]$ denotes the three-dimensional coefficient for tilting operations of tile about level 0 or 1 or 2. X, Y denotes the corresponding pixel coefficient.

$$3\mathrm{VU_p}[\mathrm{level}, \mathrm{X}, \mathrm{Y}] = \sum_{level_{begin}}^{level_{end}} \frac{1}{4^{\mathrm{level_{hi}} - \mathrm{level^{ot}}}} \quad (2)$$

$3\mathrm{VU_p}[\mathrm{level}, \mathrm{X}, \mathrm{Y}]$ denotes the three-dimensional coefficient for magnification of tile about level 0 or 1 or 2. X, Y denotes the corresponding pixel coefficient. $\mathrm{level_{hi}}$ and $\mathrm{level^{ot}}$ denotes the highest level of the pixel and optimal coefficient value of the pixel, corresponding to the actual image, respectively.

$$3VU_z[\text{level}, X, Y] = 3VU_p[\text{level}, X, Y] + 3VU_z[\text{level}, X, Y] \quad (3)$$

The cumulative 3-D coefficient represents the sum of the 3-D coefficient of titling of the tile operations and the 3-D cofactor for the tile magnification. The higher the coefficient, the lower the surface density. The zooming index is the panning-up. In addition, the total magnification and tilting are the entire tile coefficient. Each tile loaded by the consumer in each picture correlates to its $3VU_z$.

$$3VU_c\left[\text{level} + 1, X_i, Y_j\right] = 3VU_n[\text{level}, X, Y] \quad (4)$$

The relationship between the three-dimensional node and the child tile coefficient has been shown in equation (4). The values for i and j range from 0 to 1. $3VU_c$ is the three-dimensional child coefficient for the level+1. $3VU_c$ is the three-dimensional node coefficient for the given level.

$$3VU_p[\text{level} + 1, X_1, Y_1] = 3VU_c[\text{level}, X, Y]/4 \quad (5)$$

Likewise, the relationship of the three-dimensional coefficient between the tile parent and the non-magnification coefficient has been determined by equation (5). Besides being adequately specified, the ITB-RSGO architecture can simplify the realistic development in the simulation, collection and storing of RSGO data.

3.2 Tile Centred Enactment for ITB-RSGO Framework

Currently, satellite remote sensing consumers face quantity problems as data records exponentially expand. Several tools allow increasingly detailed observations linked to existing databases to create a continuous and exact database and pace as periods between views decrease on an hourly or hourly basis. Flexible storage and quick measurement are therefore essential to visualize the data and calculation output stored. Attempts were made to combine these problems with the above-mentioned geographical tile array and to improve them sensibly.

3.3 Integrated Monitoring Framework and Storage

The ITB-RSGO architecture adopts a system-level management architecture for the organization and provides simulation and programming with a self-settling tile interface. The idea of a hybrid database is used for other experiments. However, the hybrid database has been boosted and offered a more efficient simulation and database maintenance platform through spatial awareness of tiles.

Fig. 3 shows the integrated fusion storing design for the proposed ITB-RSGO system. As discussed in the previous section, when tiles are asked, this design also considers the customers' 3-D coefficient data. The required tiles were found in the lower-left area of Fig. 3. Initially, metadata and hierarchical data for the RSGO image are managed through the object-relationship tables with the pyramid's total structural and projection lengths, line number, column number, spatial size, and statistical image values. Secondly, big tiles are managed using the Distributed File Schema (DFS) decentralized cloud storage system, which provides enhanced storage capacity for extended RSGO files while providing storage compatibility. The central server and various knowledge modules are part of this section. The server data can be saved in tables via the Zone Server and is based on the base layer DFS architecture. Thirdly, it has been processed in real-time and vast volumes of enriched 3D coefficient information for higher efficiency in the storage database. Geo-Hashing allows loading, and the registration process is self-directed from retention management, the TileKey experience in the three-dimensional factor.

3.4 Dynamic Visualization of Proposed ITB-RSGO System

The above method is carried out regardless of the application, but the information question arises from the customer's simulated globe. The demand from the simulated earth is a modern method for data collection and interpretation that can incorporate heterogeneous geo-space data globally. Users may navigate easily around simulated globes by adjusting their viewing angles, locations and investigate and examine geospatial data from multiple viewpoints and at various rates of depth. This method produces geographic coefficients that are registered not only by the processor but also by the digital environment to improve visualization of results. The visual interface is defined as mapping the data to a type that helps scientists to manage the data by knowing what the data include if computers are small.

With regard to marine environment aspect mapping, it is imperative to define a suitable transfer method through which multiple values can be translated into intuitive graphics details. According to its comprehensive remote sensing capability, it is not feasible to replicate small-form adjustments while the transfer mechanism is built to represent the entire picture. For instance, in broad oceanic areas, chlorophyll products are constant, whereas, in low, near-shore areas, abundant changes are seen. However, improvements may not be precisely the same in different vital locations; hence the transition feature must be modified for client conditions appropriately. The RSGO data in the ITB sense is displayed digitally in the form of pyramid tiles. At the same time, the interactive ITB-RSGO globe will dynamically build a transition mechanism to transmit rich details to user-interested regions because of the spatially-aware feature of the tiles.

The image will be processed based on the tile, with a parallel processing solution, until the tiles enter the recipient. Therefore, the simulated environment of ITB-RSGO changes the information continuously, which must be retrieved in the database. Therefore, as the inlay is moved to the user interface, two queues are used for presentation. Another tail is to keep the filling tile line and carry the tiles and set. When the present inlay has never been in storage, the storage list is moved to avoid interruptions in uploading and encoding operations. In the meantime, the space coefficient knowledge is reported by the virtual environment of ITB-RSGO. The client-side only says spatial details upon restarting, as distinct from the server part. This data is placed in memory in a queue owing to economic output and minor concentrations. The framework will construct the transfer method dynamically to configure the optimized image rendering locally based on documented spatial coefficient details.

4 ANALYTICAL RESULTS AND DISCUSSION

4.1 Data Sets

The SatCO2 cloud datacenter collects RSGO information and product from various organizations, generates data with self-developed algorithms, converts and unifies data formats, and uploads the final product for online analytical applications to SatANA hybrid database storage. SatCO2 reportedly includes different tracking data for the last 22 years from seas across China, the Western Pacific Ocean, the Indian Ocean, and the Global Ocean.

4.2 Results for the Proposed ITB-RSGO System

Fig. 4 indicates the surface depth results in RSGO using the 3D coefficient equalization of the suggested ITB-RSGO system. The blue dotted line reflects a simulated awareness in three dimensions that contains an area in Fig.4. The figure illustrates the comprehensive transformation in the clearness of the near-shore seawater. If customers like to zoom in, the three-dimensional coefficient will further be improved, and they have a guide to managing integrated server power. In addition, the ITB-RSGO system caches several tiles to avoid repetitive information requests during the presentation. Although the uncompressed version of the initial results is hierarchical tiles, these tiles can be stored locally. At the same time, it is possible to view the user interface with an uncompressed tile sheet.

Fig. 5 shows the concentration of chlorophyll in an ocean segment over 12 months in 2019, based on the proposed ITB-RSGO system. Fig. 5 indicates an estimated annual chlorophyll concentration in the Bay of Bengal at 5 km from data collection when the storage hub is connected. A plankton bloom event with a complex transitional nature function in the region defined in the red rectangle can be observed from the virtual globe ITB-RSGO. To perform a phytoplankton abnormality test over several months and improve their computational algorithms through traditional analyses, scientists can access several RSGO data over a few years. For all database calculations, users do not mess with their computers' technological influence and the results are shown straight to the user interface. The chlorophyll concentration in July 2019 has been found to be the largest.

Time and velocities of processing with different data sizes compared with the SatANA method for the proposed ITB-RSGO System have been shown in Fig. 6. Fig. 6 (a) shows that the loading time increases exponentially as the data size grows. When comparing processing times for the SatANA paradigm and the proposed ITB system, the latter gave less processing time than the former framework. The reason for the improved performance of ITB-RSGO is attributed to enhanced and optimized space visualization structure. Fig. 6 (b) depicts the speed versus data size of the existing system and the proposed ITB-RSGO system. The rate of these structures increases linearly as the data size grows and becomes saturated as the size of the data approaches 140GB. The speed of the proposed ITB system is higher than the SatANA framework.

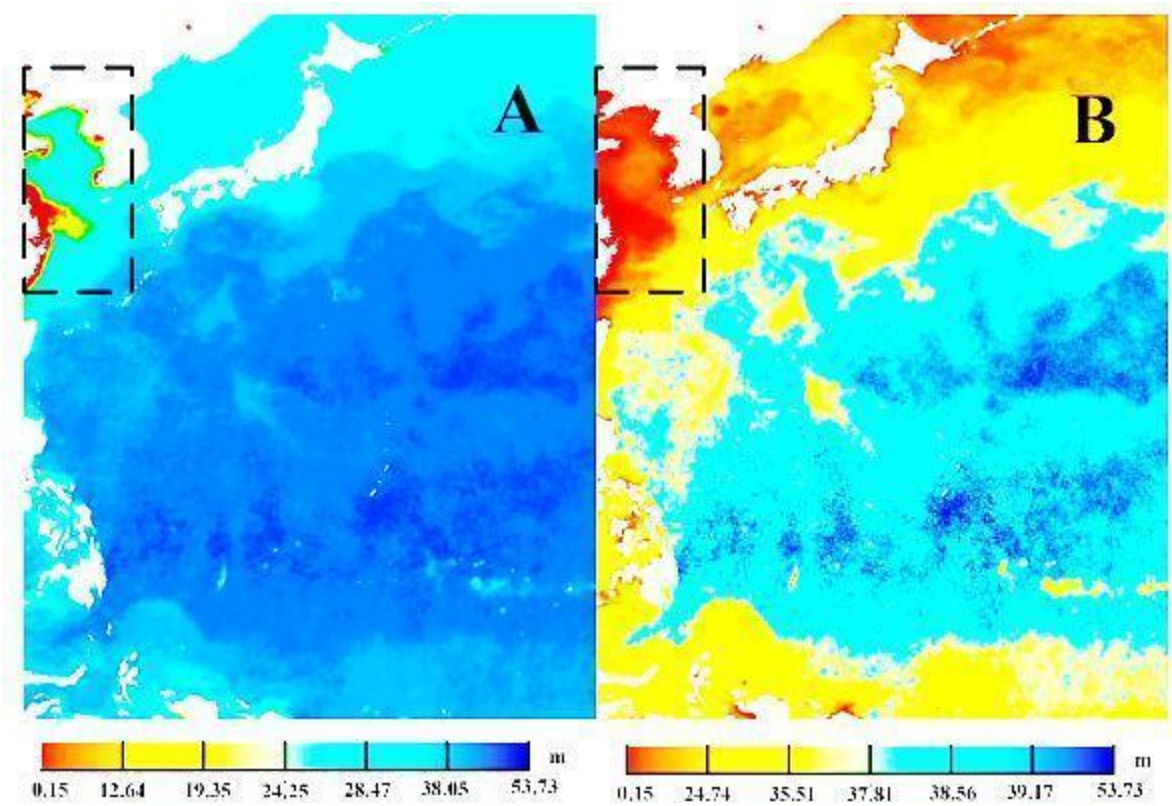


Figure 4 Surface depth results in RSGO using the 3D coefficient equalization of the suggested ITB-RSGO system

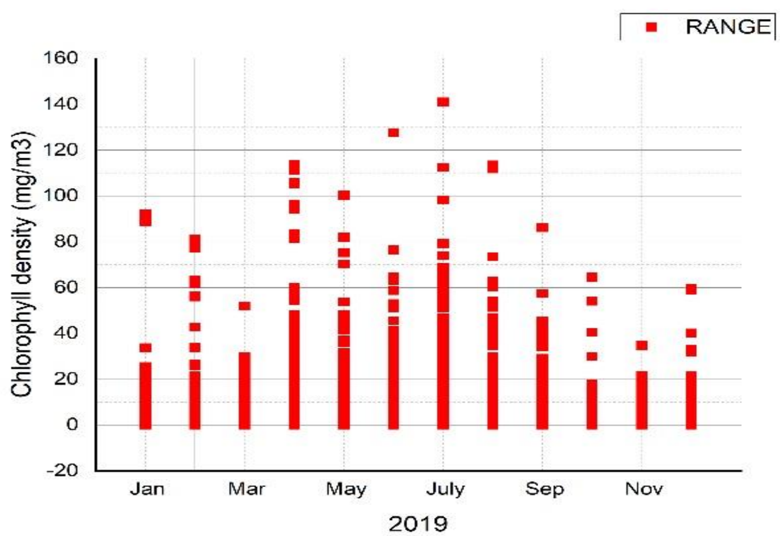
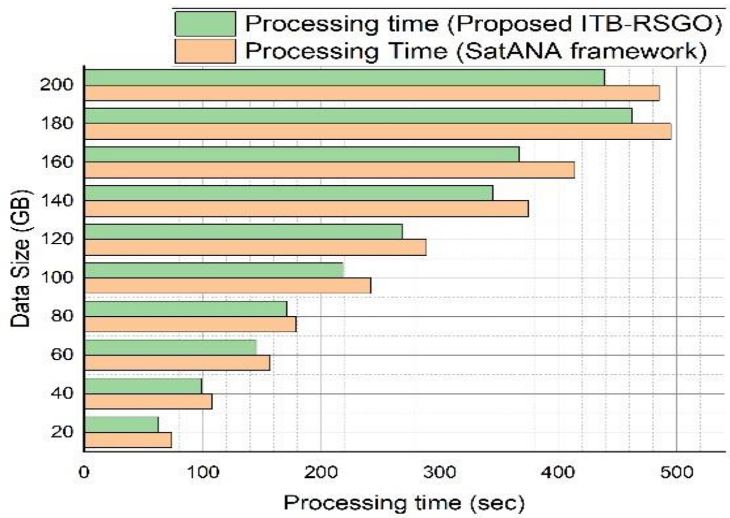
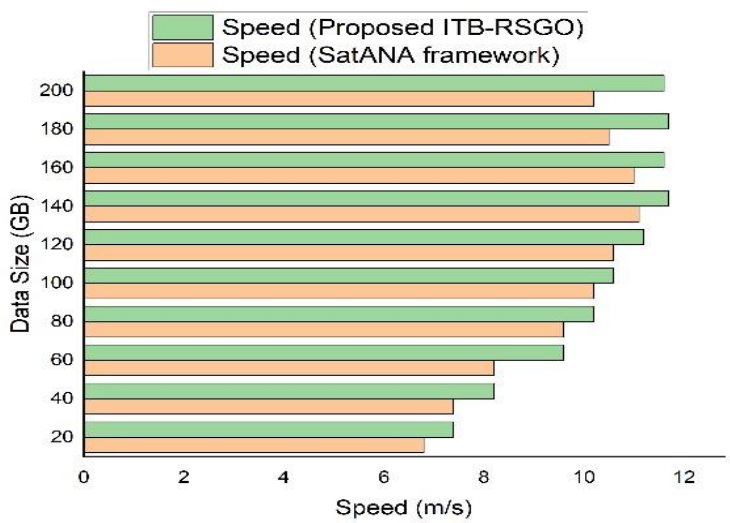


Figure 5 Concentration of chlorophyll in an ocean segment over 12 months in 2019, based on the proposed ITB-RSGO system



(a) Processing time analysis



(b) Speed analysis

Figure 6 Time and velocities of processing with different data sizes compared with the SatANA method for the proposed ITB-RSGO System

5 CONCLUSION

The paper seeks to create an Intuitive Tile-Based framework using RSGO (ITB-RSGO) for the immediate access and valuable analysis of big data. The spatially-focused tile, which incorporates cutting-edge technology, eliminates the disparity between the RSGO and end-users. Compared to the input pictures, the tile array can be transmitted more quickly over the Internet, allowing people to access those resources digitally through its intelligent space distribution capability. This remote sensing platform provides an essential advantage in acquiring complex ocean data and significantly increases the cycle observation, understanding, and prediction ability.

A plankton bloom event with a complex transitional nature function in the region defined in the red rectangle can be observed from the virtual globe ITB-RSGO. To perform a phytoplankton abnormality test over several months and improve their computational algorithms through traditional analyses, scientists can access several RSGO data over a few years. The processing time has been shown to increase exponentially with increasing data size. When comparing processing times for the SatANA paradigm and the proposed ITB system, the latter gave less processing time than the former framework. The reason for the improved performance of ITB-RSGO is attributed to enhanced and optimized space visualization structure. The speed of the proposed ITB system is higher than the SatANA framework.

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