Digital Earth: Prism of 2021

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Abstract

The study examines the development of the scientific concept of the Digital Earth in 2021, related technologies, as well as social practices of its use and implementation. The work is of an overview and interdisciplinary nature. Special attention is paid to the possibilities of applying Digital Earth to the analysis of global highly dynamic processes of a socio-technogenic nature, such as the COVID-19 pandemic. Digital Earth is considered in the context of the UN Sustainable Development Program, as well as digital economy and smart city initiatives. The problem of the Vision of the Digital Earth 2030 and various points of view on the aspects of the Digital Earth as a general cultural phenomenon are discussed. An attempt is made to highlight the main trends in the development of the Digital Earth, relevant in 2021.

Keywords

Digital Earth, sustainable development, digital economy, smart city.

1. Introduction

In his famous 1998 speech, which launched the creation of the Digital Earth, U.S. Vice President Albert Gore specifically pointed to 2005 and 2020 as key beacons in the development of Digital Earth. Indeed, in 2005 the first mass service Google Earth was launched, and in 2020 there was a quantum leap in the implementation of the Digital Earth for global governance to prevent new challenges to all civilization: "What we will be able to do in 2005 will look primitive compared to the Digital Earth of the year 2020" [1]. Today we can say that second part of the prediction is coming true. Indeed, since 2020, Digital Earth is attracting growing global attention again. The focus of interest came in its implementation now. First integral "Manual of Digital Earth" was published [2]. Attention was attracted primarily by new global problems and the growing need for a global management infrastructure to prevent crisis and mitigate their consequences. The insolubility of new problems became especially evident against the background of new global management initiatives approved a decade earlier, but which have remained a declaration – among them the list of 17 Sustainable Development Goals approved by the UN was the most telling. The list of problems that began the third decade of the twenty-first century should begin with the COVID-19 pandemic, which clearly demonstrated the limitations of our ideas about the most fundamental factors of human existence.

2. Methodology

This review paper uses mainly comparative and historical analysis methodologies. The concept of the Digital Earth is in a state of changing of scientific paradigm (in terms of theory of scientific revolutions of T. Kuhn [3]), so a dialectical approach is used to unveil internal logic of the development of discipline, as well as the holistic method of analysis by H. Selye [4,5].

3. Materials and Research

Since the publication of Albert Gore's work, the number of scientific publications that contain

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'Digital Earth' has steadily increased (Figure 1). Beginning in 2019, the number of papers is reaching a new level of about 200 per year. This reflects both the general growth of interest in this scientific concept and the sustainability of that interest. More important, however, are the qualitative changes in the structure of publications. More and more often the problems of the Digital Earth are considered not just like geospatial innovations, but in the context of fundamental, urgent and even vital problems of mankind. This has been facilitated, in particular, by the formation of a framework of values in the form of human development goals, formulated in 2015 by the UN General Assembly in the form of 17 Sustainable Development Goals (SDGs) [6]. The growth of interest in the Digital Earth in 2021 was determined by its need to solve practical problems, and there is reason to believe that this is becoming a new trend.

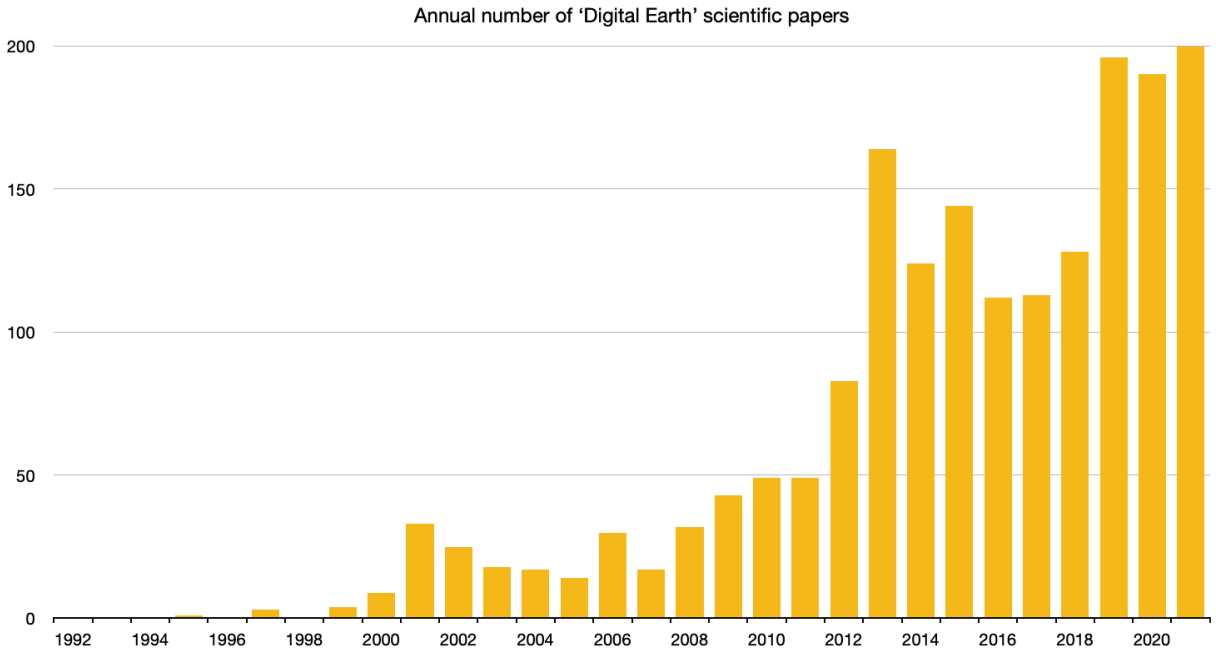

Figure 1: Annual number of scientific publications (books, articles, etc.) worldwide with search phrase 'Digital Earth' according to Springer Nature search data (August 2022)

3.1. 12th International Symposium ISDE: Digital Earth vs. Digital Twins

Symposia and Summits are key scientific events in the field of Digital Earth, held annually by ISDE in different countries on different continents (Figure 2). They play a crucial role in the development of the Digital Earth vision and its worldwide outreach. In 2021 the status of the Digital Earth concept was discussed at the 12th International Symposium on Digital Earth (ISDE12), that was held in Salzburg, Austria in a hybrid (on-cite and online) format from 6 to 8 July, 2021 under the slogan "Digital Earth for Sustainable Societies" [7]. It was organized by the International Society for Digital Earth (ISDE) and hosted by Department of Geoinformatics – Z_GIS (University of Salzburg, Austria) in parallel with the traditional AGIT and GI forum. Number of participants both forums in both modes (online and physically presented) exceeded 700 [8].

As a previous 8 Digital Earth Summit [9], ISDE12 took place in the very challenging situation of the COVID-19 pandemic, which significantly complicated international scientific communications.

In spite of all the obstacles, ISDE12 was a great success. Moreover, the difficult situation facilitated a deep and engaged discussion of humanity's most complex and urgent problems. Naturally, the issues of sustainable development, crisis prevention and, above all, epidemic crises, were in the focus of the participants' attention. Equally important were the issues of ethics, GeoHumanitarian Actions, Data Driven Intelligence, involving young people in the development of the Digital Earth, the problems of Citizen Science, and others. From a scientific point of view, the discussion on the relationship between the concepts of Digital Earth and Digital Twins, which continued at the forum, was of exceptional interest.

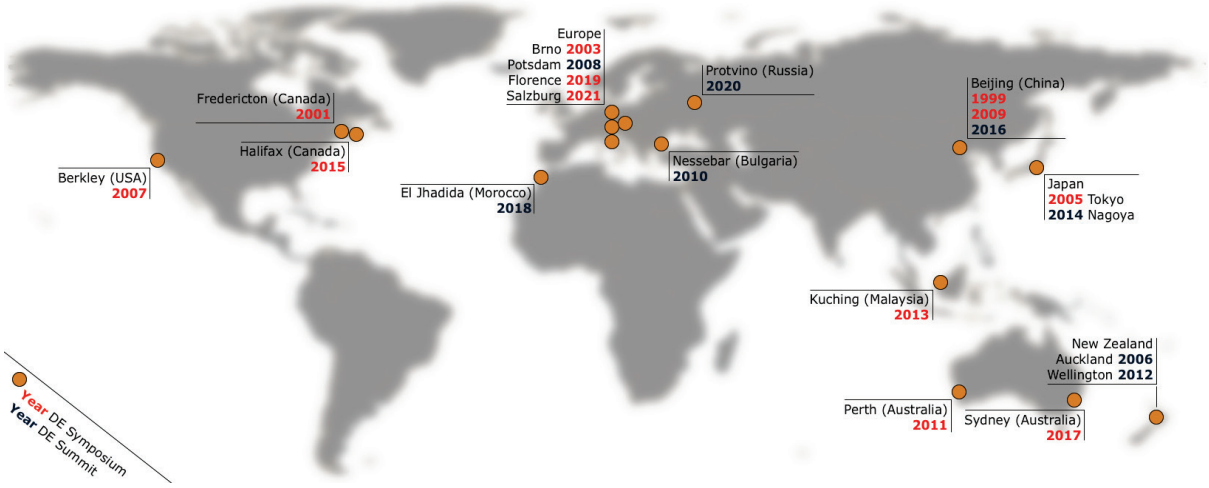

Figure 2: Map of key ISDE scientific events, Symposia ans Summits, since 1999 till 2021

Both concepts address the same set of problems, and their "digital" nature implies the unity of methodological approaches. This raises the natural question of whether the two concepts should independently coexist, either by including one of them in the other or by excluding one of them as duplicating the other.

At present, this debate is far from over. Its results will be significant, as they will give us an opportunity to understand the nature of the digital transformation, digital representation of reality and, accordingly, the scientific significance of the "digit[al]" in its modern sense, significantly changed .

For example, the paper [10] considers the creation of "Digital Twins of the Earth" through the formation of the so-called Digital Ecosystem (DE). In the optics of this approach Digital Twins replace and supersede the concept of Digital Earth, which is emphasized by the use of the same acronym for both Digital Ecosystem and Digital Earth.

Moreover, another term with the same acronym is proposed – Destination Earth (DE). It is described as "a new initiative in Europe to develop such shared infrastructure and data space", aimed at creating "a dynamic, interactive, multi-dimensional, and data intensive replica of the Earth (system), which would enable different user groups (public, scientific, private) to interact with vast amounts of natural and socio-economic information". This description is very close to existing definitions of the Digital Earth and means substituting it with yet another metaphor.

According to another approach, Digital Earth is essentially a " Signless Earth", because it incorporates a vital unsigned component (so-called “zero signs”) into the information model [11]. In other words, Digital Earth is a geospatial information system that no longer uses only signs and that is why it has acquired radically new capabilities.

Such a point of view leads to the necessity of critical revision of a number of fundamental statements of cybernetics, semiotics, information theory – and, in particular, the definition of information, which is currently identified with the signs as the only possible carriers of it. Regardless of the outcome of this discussion, it can be assumed that it is one of the most academically fruitful topics raised by the discussion of the Digital Earth, and in addition addresses the most fundamental problems of worldview significance. It should be noted that the qualifier "digital" loses its scientific meaning due to its constant use and becomes just a metaphor for progress, the semantic load of which is small. It is still unclear how "digital" is Digital Earth and how possible it is to build Digital Twin of anything except very simple devices.

3.2. COVID-19 and Its Global Consequences

The COVID-19 pandemic has become the greatest challenge to humanity since 2020, and possibly for the long period. At the same time, it was a powerful demonstration of how the integration of heterogeneous data on a global scale and in a rich geospatial context can improve our understanding of epidemic processes and provide an effective response to them. Information about epidemic

developments with high spatial and temporal resolutions has shaped a qualitatively new understanding of epidemic processes and has clearly demonstrated the vulnerability of current health concepts. Invaluable global geospatial information about the pandemic was made publicly available by various geoservices, such as the official online service of the World Health Organization (WHO, [12]) and the Johns Hopkins University dashboard [13]. Open geospatial services (dashboards) with integrated data about COVID-19 Pandemic. Left: official service of WHO [12]. Right: dashboard of Johns Hopkins University [13] (Figure 3).

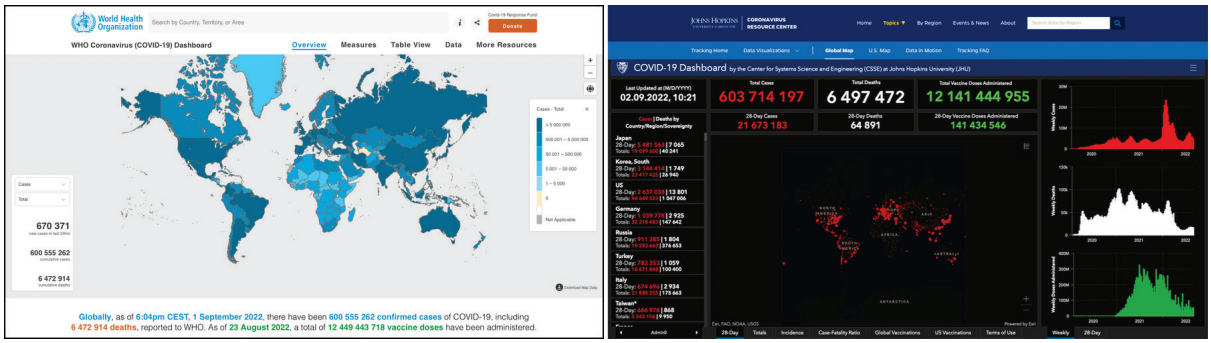

Figure 3: Open geospatial services (dashboards) with integrated data about COVID-19 Pandemic. Left: official service of WHO [12]. Right: dashboard of Johns Hopkins University [13]

Digital Earth has a greater ability to integrate and present epidemic data than any other types of geospatial visualization. This opens up new perspectives in the study and control of epidemic processes. It was shown in [14] that the COVID-19 challenge requires the adoption of a new, more integral and holistic paradigm of thinking. Digital Earth satisfies this requirement and opens up new horizons in interpreting events as well as in forming a new level of situational awareness, which also includes a philosophical dimension. Especially important is the potential of Digital Earth to provide "predictive early warnings and deliver trusted evidence-based prescriptive course of action in real-time at every phase and inter-phase transition of a multi-hazard crisis situation" [14, p. 416]. The study of social aspects of pandemics requires the use of Big Data methods. To a certain extent, the potential of Digital Earth and Big Data in the study of pandemics was demonstrated in [15], which presented the first results of the study of population mobility against the background of COVID-19. The COVID-19 pandemic was far from being complete at the time of preparation of this paper. It can be expected that in the near future there will be the results of new studies performed with the help of Digital Earth and Big Data methodology.

3.3. Digital Earth and Sustainable Development

Digital Earth and Big Data are a vital foundation for responsible global governance to bring the concept of sustainable development to reality. An important step in institutionalizing this global governance environment was the creation of the International Research Center of Big Data for Sustainable Development Goals, CBAS, in Beijing, China, in September 2021 [16]. CBAS was established in just one year – first time it was officially announced by Chinese President Xi Jinping during his speech at the 75th United Nations General Assembly on September 22, 2020. Main goal of the CBAS is implementation of "Transforming our world: the 2030 Agenda for Sustainable Development" [17]. The new center was initially closely integrated with ISDE, and its director is the Honorary President of ISDE, academician Huadong Guo.

Key Missions of CBAS are:

1. Develop SDG data infrastructure and information products;
2. Develop and launch a series of SDG satellites;
3. Provide new knowledge for SDG monitoring and evaluation;
4. Establish a think tank for science, technology, and innovation to promote SDGs;
5. Provide capacity development for SDGs in developing countries.

The first SDG satellite (SDGSAT-1) (Figure 4) was launched on November 5, 2021, two months after the inauguration of CBAS. Its scientific objective is to monitor the spatial and temporal dynamics of 6 SDGs: study the environmental changes and evolution mainly caused by human activities, such as urbanization (SDG 11), human settlement patterns (SDG 2 and SDG 6), energy consumption (SDG 13), and coastal ecology (SDG 14 and SDG 15) [18].

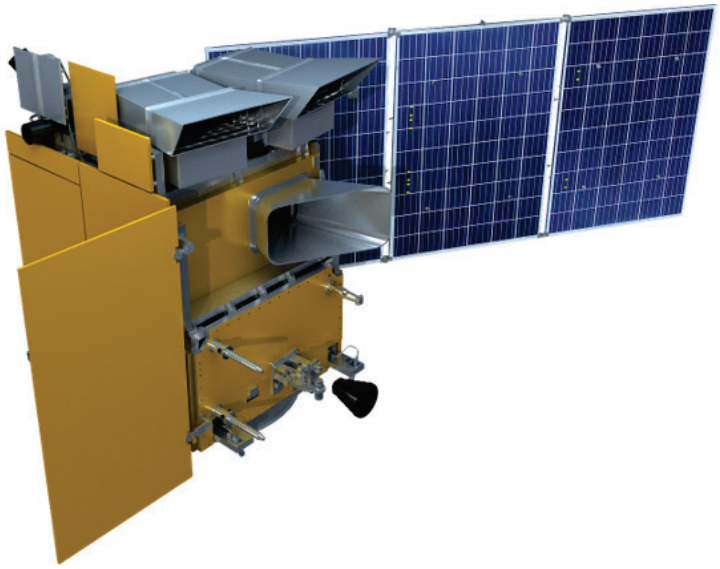

Figure 4: SDGSAT-1 ([18])

The satellite has three sets of payloads: thermal infrared, low-light-level and multi-spectral imagers. Spatial resolution panchromatic/RGB is 10/40 m. SDGSAT-1 was inserted into a sun-synchronous orbit at an altitude of 505 km and an inclination of 97.5 degrees. With an imaging swath of 300 km it allows for a complete survey of the entire surface of the planet every 11 days. First images received by SDGSAT-1 were presented on December, 20, 2021.

4. Conclusions

The year 2021 demonstrated the rapid and versatile development of the Digital Earth concept, primarily in the direction of using it to solve urgent applications. The main ones were overcoming the consequences of the COVID-19 pandemic and integrating the Digital Earth into the monitoring system for key global governance indicators in the framework of the Sustainable Development Goals. The institutionalization of the Digital Earth continues, primarily in the system of UN governance institutions.

However, it can be noted that the main intrigue of Digital Earth continues to be unclear as to the key scientific underpinnings of this undoubtedly revolutionary concept. There is still no current definition of Digital Earth that reflects the evolution of our knowledge over the past decades. The ambiguity of its nature is evident in continuing attempts to metaphorically treat Digital Earth as just another transient technological brand that will be superseded by another marketing form that does not carry any significant scientific content.

The work to define the scientific principles of the Digital Earth will continue in 2022.

5. Acknowledgements

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