Available online at www.sciencedirect.com
ScienceDirect
Advances in Space Research 57 (2016) 110–126
ADVANCES IN SPACE RESEARCH (a COSPAR publication)
www.elsevier.com/locate/asr

# Advancements in medium and high resolution Earth observation for land-surface imaging: Evolutions, future trends and contributions to sustainable development

Yashon O. Ouma

*Space Technology and Geoinformatics, Department of Civil and Structural Engineering, School of Engineering, Moi University, Eldoret, Kenya*

Received 25 April 2015; received in revised form 24 October 2015; accepted 26 October 2015
Available online 31 October 2015

**Abstract**

Technologies for imaging the surface of the Earth, through satellite based Earth observations (EO) have enormously evolved over the past 50 years. The trends are likely to evolve further as the user community increases and their awareness and demands for EO data also increases. In this review paper, a development trend on EO imaging systems is presented with the objective of deriving the evolving patterns for the EO user community. From the review and analysis of medium-to-high resolution EO-based land-surface sensor missions, it is observed that there is a predictive pattern in the EO evolution trends such that every 10–15 years, more sophisticated EO imaging systems with application specific capabilities are seen to emerge. Such new systems, as determined in this review, are likely to comprise of agile and small payload-mass EO land surface imaging satellites with the ability for high velocity data transmission and huge volumes of spatial, spectral, temporal and radiometric resolution data. This availability of data will magnify the phenomenon of "Big Data" in Earth observation. Because of the "Big Data" issue, new computing and processing platforms such as telegeoprocessing and grid-computing are expected to be incorporated in EO data processing and distribution networks. In general, it is observed that the demand for EO is growing exponentially as the application and cost-benefits are being recognized in support of resource management.


*Keywords:* Earth observation (EO) trends; Sustainable development; EO Big Data; Grid-computing; Telegeoprocessing; Value-added geoinformation

## 1. Introduction

For the past 50 year, satellite based observations have provided effective ways of monitoring the planet, thus aiding in the exploitation and management of Earth's resources. In essence, Earth observation (EO) data and data products are significant in making of reliable and informed monitoring and management decisions in different areas such as: agriculture sustainability, climate change, Earth system science, human health and epidemiology, energy management, biodiversity and ecosystem studies and water resources management (GEO 2009).

From global to local footprints, geoinformation derived from Earth observations are now significantly contributing towards the study of Earth systems. Understanding the interactions and variations of Earth systems – comprising of the geosphere, biosphere, hydrosphere, cryosphere and the atmosphere, is quite critical in protecting the global environment and in return enhancing the wellbeing of human health, safety and welfare. It is now agreeable that Earth observation technology from space is most suitable for providing a global, repetitive and continuous data coverage for the Earth's surface and for understanding the Earth system. In brief, EO data products are now being used for the effective study and analysis of short-to-long-term interactions, changes and variations on the planet as depicted in Fig. 1.

*E-mail address:* yashon_o@hotmail.com

http://dx.doi.org/10.1016/j.asr.2015.10.038
0273-1177/

Earth observation in general comprises of the measuring technologies and platforms, and refers to the passive and active observation or remote sensing of the Earth from space borne sensors. A continuous review and analysis of the availability of Earth observation data, the societal benefits (e.g. Fritz et al., 2008), and the inference of the future perspectives in terms of data types and modes of acquisition and accessibility is important to the EO user community especially in Earth systems representation and modeling. In addition to active and passive EO data, Earth observation supporting systems such as telecommunication data relaying satellites and Global Navigation Satellite Systems (GNSS) continue to contribute to the broader perspective of Earth observation and geoinformation.

Since the launch of SPUTNIK-1 in 1957 as the first Earth artificial Earth orbiting satellite for gravity field measurements, which was followed by Earth observation reconnaissance CORONA satellite in 1959 (McDonald, 1995), Earth observation satellites have continued to monitor the global environment. Data from EO satellites have been used to effectively demonstrate the inherent fragility of the Earth system and the exposure of the system to rapidly growing human-induced stresses.

In terms of the application of EO, it can be recognized that much has not only changed in terms of the mainstay application of satellite-based military and defense surveillance, but also when it comes to EO applications in civilian use (private industry, governments and academia), a lot has since changed with regards to the acquisition and processing techniques, applications, and in general the community user base has equally increased. In light of the developments in EO, this paper presents an analytical overview on the socio-economic benefits or societal benefits of EO to sustainable development, that has stimulated the tremendous interest and growth in Earth observation, and looks at the different eras of satellite remote sensing in terms of sensor resolutions and applications for land-surface imaging, with the view of inferring the future imaging system demands and data access and processing requirements.

Despite advancements in EO technologies, major hurdles on issues to do with awareness and system maturity to capacity building, investment levels and cultural barriers between the supplier and user communities still remains (Tatem et al., 2008). The remainder of this paper is organized as follows. Section 2 highlights the benefits of Earth observation and motivates on the need for providing value-added and intelligent EO based geoinformation in support of sustainable development. Section 3 provides an overview on the evolutions, the future trends in Earth observation systems for medium and high-resolution land-surface imaging, the EO system mass-payloads and the emerging issue of EO Big Data. Section 4 presents an outlook on the future of EO data acquisition design capabilities and advancements in data access and processing technology and Section 5 is finally on the conclusions and recommendations.

## 2. Earth observation for geoinformation: opportunities and challenges

### 2.1. Benefits of Earth observation

The synoptic view through satellite imagery offers the most appropriate method for quick, economical and

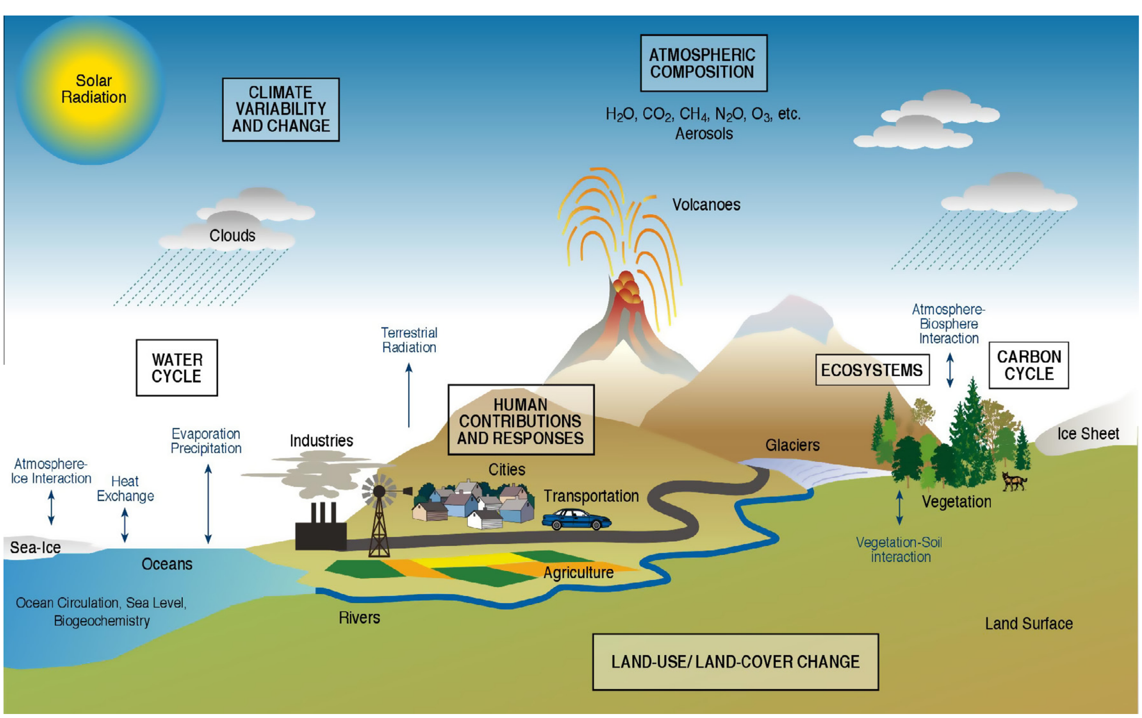


Fig. 1. Components of and interactions within the Earth system. (Image Courtesy of NASA: Geophysical Dynamics Laboratory).