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Land observation from geosynchronous earth orbit (LOGEO): Mission concept and preliminary engineering analysis

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Abstract

We propose an Earth-observation mission Land Observation from Geosynchronous Earth Orbit (LOGEO) to place two spin-scan-stabilized 500-m resolution 9-band VNIR–SWIR imagers in a near-geosynchronous inclined orbit, allowing 15 min observations with a full range of daily sun angles and 30° variations in view angle. LOGEO drifts westward at about 4° per day, providing geostationary-style coverage for all points on the globe eight times per year. This unique imaging geometry allows accurate retrievals of daily changes in surface bidirectional reflectance, which in turn enhances direct retrieval of biophysical properties, as well as long term and consistent land surface parameters for modeling studies that seek to understand the Earth system and its interactions. For studies of climate and environmental dynamics, LOGEO provides accurate observations of atmospheric aerosols, clouds, as well as other atmospheric constituents across a diverse number of spatial and temporal scales. This collection of land, atmospheric, and climate data products are directly applicable to seven of the nine GEOSS societal benefits areas, providing great opportunities for international collaboration. We also present an overview of LOGEO's systems architecture, as well as top-level design-trade studies and orbital scenarios.

1. Introduction

The Land Observation from Geosynchronous Earth Orbit (LOGEO) mission is built on the concept of acquiring systematic measurements of spectral and bidirectional characteristics of the solar radiation reflected by the Earth/atmosphere system. This platform incorporates two identical imagers with a 12-h offset between equatorial crossing times to provide full global coverage up to eight times per year. This capability opens up new perspectives for discriminating atmospheric constituents (e.g. CO_2, H_2O, O_2, O_3, CO, NO, clouds and dust) and surface biophysical parameters (e.g. vegetation cover, vegetation index, leaf area index, and surface albedo) at levels of accuracy that existing geostationary sensors (e.g. GOES and MSG) have not been able to achieve thus far.

Our main emphasis is on the development of a moderate resolution (0.5–1.0 km) land-imaging platform that can directly address the science goals established by NASA, as well as ecosystem, carbon, hydrological, and mesoscale modeling communities. This paper addresses the need to establish technical and scientific priorities for streamlining and optimizing remote sensing platforms by specifically exploring instrument design characteristics, orbital scenarios, and identifying appropriate subsystem requirements. We also propose a comprehensive suite of land-surface–atmosphere products

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that promote environmental research, operational applications (e.g. weather and climate dynamics), and overall scientific discovery.

Our design emphasizes two major technical elements: LOGEO's imaging geometry and instrument characteristics. LOGEO's overall systems architecture is also presented in this paper, as well as top-level design-trade studies and orbital scenarios, and a survey of different subsystem technologies, readiness to manage the orbiter in an operational context.

This paper discusses how LOGEO's spatial, spectral, bidirectional sampling, and temporal scales can be optimized for studies focusing on biodiversity and land-use change, as well as natural hazards, disasters, and security response applications. We also present a comparison between LOGEO's instrument platform, orbital configuration, and bidirectional sampling scenarios against other known instrument platforms (i.e. MODIS, GOES, and POLDER).

2. Mission overview

Departing slightly from normal geosynchronous height, LOGEO drifts westward at about 4° per day, providing geostationary-style coverage for all points on the globe eight times per year (Fig. 1). This capability allows measurements of multiple series of full diurnal cycles, which in turn enables a complete view of daily phenomena for all land surface biomes (e.g. tropical rainforest, urban areas, or croplands) across different seasons.

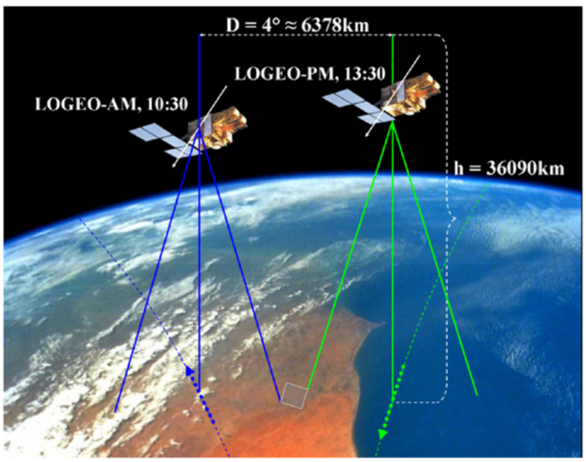

Fig. 1. LOGEO drifts westward at about 4° per day, providing geostationary-style coverage for all points on the globe eight times per year.

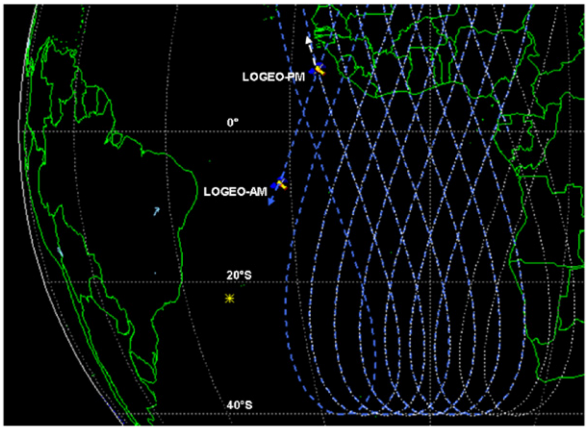

Fig. 2. LOGEO incorporates two sensors: LOGEO-AM, which crosses the equator in the morning when cloud cover is at a minimum and its view of the surface is least obstructed, and LOGEO-PM, which crosses the equator in the afternoon to observe the daily variability of surface features.

This orbit path ensures that each point on the Earth is viewed from a wide range of both sun and view angles during a day and achieves observations across regions that cannot be seen by geostationary imagers. With an orbital inclination angle of 40°, LOGEO's subsatellite point moves in a figure-eight-shaped daily circuit ranging from 40° north to 40° degrees south latitude. Similar to current moderate resolution platforms (e.g. EOS-MODIS), LOGEO incorporates two identical imagers, but with a 12-h offset between equatorial periods to provide full global coverage eight times per year (Fig. 2).

This configuration allows us to look at every square kilometer under the sensors' footprint every 15 min and enhances LOGEO's geolocation capabilities by reducing resampling errors during image geo-referencing and co-registration routines. Combining observations from both imagers also satisfies numerous requests from ecosystem, carbon, hydrological, and mesoscale modeling communities to assimilate on a 1-km or finer global grid to further resolve and characterize land surface properties and to produce estimates of water, energy, and momentum balance exchanges at regional to continental scales with quantifiable uncertainty.

3. Science objectives

How is the global Earth system changing? What are the primary forcings of the Earth system? What changes are occurring in global land cover and land use, and what are their causes? How will future changes in atmospheric composition affect ozone, climate, and global air