Intelligent Observation Strategies for Geosynchronous Remote Sensing for Natural Hazards

Abstract

Geosynchronous satellites (orbiting in the same motion period as the Earth) offer a unique vantage point for monitoring environmental factors, and for those in the geostationary orbit (satellite, equatorial orbit, 35.7 km above the surface) 24 hour imaging is possible. This paper describes the GeoCAPE mission to address coastal and air pollution events in geostationary orbit, complementing similar initiatives by the South Korea in Asia, and by ESA in Europe, effectively offering coverage of the northern hemisphere. Commercial communication satellites are envisioned to provide a platform for instruments capable of viewing the GOES-West instruments. The Temporally Emission Monitoring of Pollution (TEMPOM) satellite was implemented to monitor pollution covering most of North America, by high spatial resolution from geostationary orbit. The NASA Earth Venture instruments will take advantage of a GEO host spacecraft to improve emission inventories, monitor population exposure, and enable effective emergency control strategies for reducing emissions and minimizing their impact on the environment.

This paper addresses the results of a NASA study to explore observation strategies to fully exploit both the unique observing viewpoint and new technologies enabling the rapid acquisition and development of geographic data products sufficiently to understand natural hazards and supporting the disaster management lifecycle.

Study Objectives

The goal of the GEO-CAPE observations optimization feasibility study was to research options for an overall observing strategy to maximize the ocean science return. The study identified key scientific benefits such as improved time and quality of observations, and computed costs and benefits of potential strategies. Specifically:

- Examine and develop needed analysis driving ocean instrument operations concepts
- Determine ways to optimize observations with respect to cloud avoidance
- Describe the high-cost/benefit tradeoff for candidate observation strategies

Instrument Scheduling Environment Assumptions

The GOES-16/17 and 8/9 Level 1 Input Environments (GOLDEN) were the candidate environment concepts for the study.

Cloud Forecast Scheduling Concepts

Cloud detection is employed to determine if cloud threshold is met; if so, observation is downlinked; if not, observed data is deleted to reduce data handling costs. Onboard Cloud Detection Algorithms

- EO-1 onboard Cloud Detection
  - The Hyperion sensor is on the left. The resulting product masks clouds (orange) and identifies non-cloudy (blue) and ice covered surface (pink), and was processed using the EO-1 onboard cloud detection algorithm.
  - Hyperion Scene size: 361.6k scanline length (pixels)* 12 bands.
  - Time to process cloud detection: 0.6 s (0.172 s) with level 1 compiler optimization.
  - Scaling the instrument scene size to the FR dimensions would require ~3 s to process (with no optimization), compared to the 1 s required to acquire the scene.

Onboard Processing of Cloud Detection to Only Downlink Orange scenes

- Time to process cloud detection code: 0.6 s (0.172 s)
- Orange scenes uplinked to the ground, with Cloud Thresholds
- Orange scenes uplinked to the ground
- Orange scenes are not archived, and inbound cloud detection is employed to determine if cloud threshold is met; if so, observation is downlinked; if not, observed data is deleted to reduce data handling costs.

Key Findings

Hazard and weather operations concepts are still evolving. While offering 24/7 monitoring at high resolution, data handling may be a cost driver to mitigate with onboard processing. GSFC’s GEO-CAPE Observations Simulation demonstrated the feasibility and benefits for several intelligent observation strategies:

-Daily (4x/day) Cloud detection scheduling: cloud threshold settings and forecast constraints:
- Marginal scene handling
- Onboard processing all cloud detection to only downlink observations that crossed threshold, thus reduce data handling costs.
- Cost-effective onboard processing available with 2015 technology

The emerging Internet of Things (IoT) technology provides an opportunity to develop pay-as-you-go products to be readily accessible by a user’s smartphone or other small appliance.

References