

IMPLEMENTATION OF THE LAND, ATMOSPHERE NEAR REAL-TIME CAPABILITY FOR EOS (LANCE)

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ABSTRACT

The past decade has seen a rapid increase in availability and usage of near real-time data from satellite sensors. Applications have demonstrated the utility of timely data in a number of areas ranging from numerical weather prediction and forecasting, to monitoring of natural hazards, disaster relief, agriculture and homeland security. As applications mature, the need to transition from prototypes to operational capabilities presents an opportunity to improve current near real-time systems and inform future capabilities. This paper presents NASA's effort to implement a near real-time capability for land and atmosphere data acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS), Atmospheric Infrared Sounder (AIRS), Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-E), Microwave Limb Sounder (MLS) and Ozone Monitoring Instrument (OMI) instruments on the Terra, Aqua, and Aura satellites.

Index Terms— Real time systems, Satellite applications

1. INTRODUCTION

NASA's Earth Observing System Data and Information System (EOSDIS) provides a wealth of data and products supporting scientific research of the atmosphere, oceans, and land. The Earth Observing System (EOS) instruments onboard Terra, Aqua and Aura satellites make global measurements daily which are processed into higher-level "standard" products within 8 to 40 hours of observation and then made available to users, primarily earth science researchers. However applications users, operational agencies, and even researchers desire EOS products in near real-time to support research and applications, including numerical weather and climate prediction and forecasting, monitoring of natural hazards, ecological/invasive species, agriculture, air quality, disaster relief and homeland security. These users often need data much sooner than routine science processing allows, usually within 3 hours, and are willing to trade science product quality for timely access. In response to this need, NASA developed the Land, Atmosphere Near Real-time Capability for EOS (LANCE).

2. ORIGINS OF LANCE

The EOSDIS was not originally designed to provide data with sufficient latency to satisfy the requirements for near real-time

users. In 2002, a joint initiative between NASA, National Oceanic and Atmospheric Administration (NOAA), and the Department of Defense (DoD) was undertaken to provide data from EOS instruments in near real-time—within three hours of satellite observation—to NOAA's operational users. Following the large wildfires in Montana in 2001, the U.S. Forest Service (USFS) asked for routine and timely delivery of MODIS fire data. In response to this request and with partial support from the USFS, the MODIS Land Rapid Response system was developed [1]. This system, which tapped into the Level 1 data feed from the NASA–NOAA system, provided easy-to-view imagery highlighting active fires. This system was subsequently developed to provide imagery that would enable flood, agriculture, and air quality monitoring. As the EOS processing and products have matured, there has been growing interest from other NASA data users to access data in near real-time. As the NASA–NOAA system aged and the demand for near real-time data increased and broadened across Earth science application areas, the NASA Earth Science Division (ESD) decided to implement a near real-time capability within the EOSDIS.

Building on the existing EOSDIS capabilities, NASA's Earth Science Division sponsored the development of LANCE (lance.nasa.gov). LANCE consists of special processing elements, co-located with selected EOSDIS data centers and processing facilities. These elements process expedited data from the EOS Data and Operations System (EDOS) using optimized science algorithms to provide data in near real-time. The Flight, Research and Analysis, and Applied Sciences Programs within NASA's ESD jointly sponsor the LANCE system development.

3. LANCE ARCHITECTURE

The LANCE architecture leverages existing near real-time satellite data processing systems that are managed by the Earth Science Data and Information System (ESDIS) Project at Goddard Space Flight Center (GSFC). Near real-time data are currently available for MODIS, OMI, AIRS, MLS, and AMSR-E. Each LANCE element distributes data directly to end-users to reduce latency. LANCE maintains a central website to facilitate easy access to data and user services. Each element also plans to implement redundant network, power and server infrastructure to ensure high availability of data and services.

LANCE is a part of the EOS ground system (See Figure 1) and all LANCE data originates from Terra-, Aqua-, or Aura-based

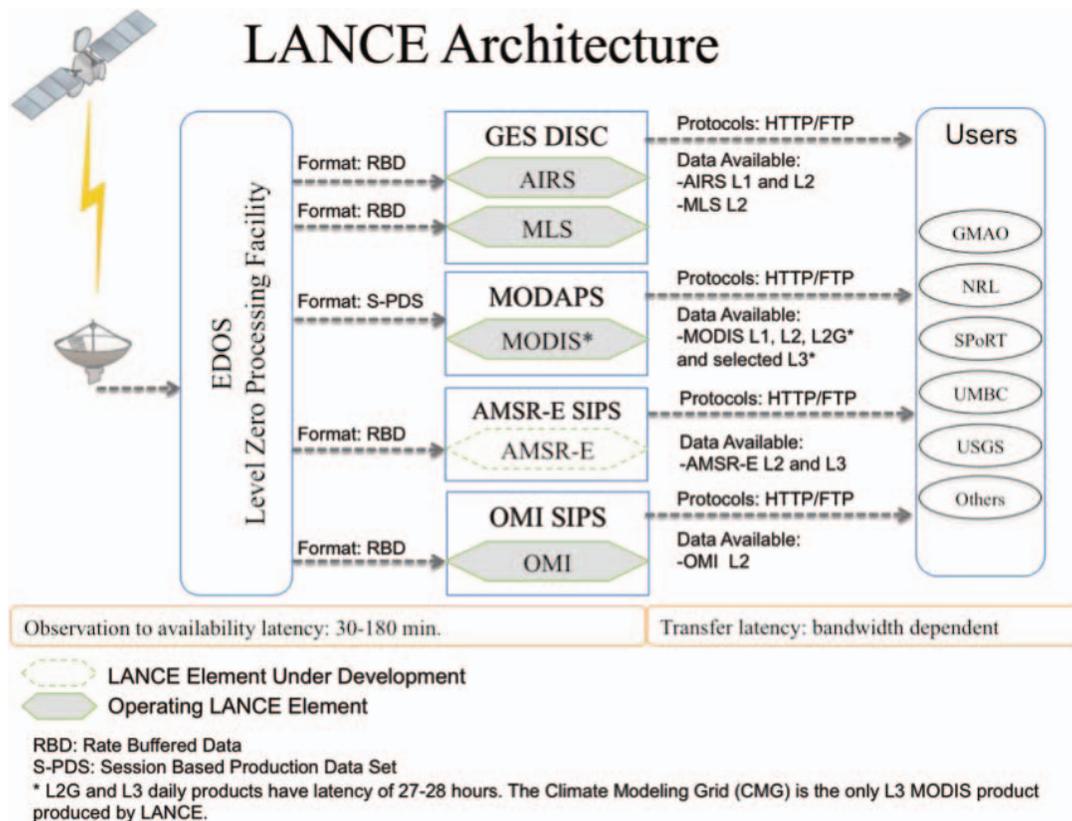


Figure 1: Simplified end-to-end flow of data from instruments to users. The four LANCE elements at the GSFC Earth Sciences Data and Information Services Center (GES DISC), the OMI Science Investigator-led Processing System (SIPS), AMSR-E SIPS, and the MODIS Adaptive Processing System (MODAPS) are supplied with rate-buffered data and/or session-based production datasets from the EDOS as soon as they are downlinked from satellites and transmitted from ground stations, generally within 30 minutes to two hours after observation. Each element then processes raw data into higher-level products before they are made available to users.

instruments. Terra instrument data are downlinked to White Sands, New Mexico via the Tracking Data Relay Satellite System (TDRSS). Aqua and Aura instrument data are downlinked to the Polar Ground Stations (PGS) in Norway and Alaska. Data from all three spacecraft are processed by EDOS to Level 0 and distributed to LANCE elements for higher-level product generation, generally within 30 minutes to two hours after observation. Each element then processes raw data into higher-level products before they are made available to users.

4. LANCE PRODUCTS

Building on a significant investment by NASA in developing science algorithms and products, LANCE creates products that have a demonstrated utility for applications requiring near real-time data. From lower level data products such as calibrated geolocated radiances to higher-level products such as sea ice extent, snow cover, and cloud cover, users have integrated LANCE data into forecast models and decision support systems. Table 1 shows the current near real-time product categories by instrument.

4.1 Example: Expediting MODIS Products

A number of changes have been made to the standard processing approach to expedite the availability of input data sets for near real-time MODIS products. First, the entrained Terra attitude and ephemeris data are used as opposed to the Flight Dynamics System (FDS) product for standard processing. Second, the rate-buffered Ground Based Attitude Determination (GBAD) Aqua attitude and ephemeris data are used, as opposed to the 24-hour Flight Dynamics product for standard processing. Third, certain Level 2 (L2) codes have modified production rules to relax the requirements for ancillary data products. Science team members ensure the highest achievable quality is met within the latency requirements by developing or reviewing all modifications to the standard processing software. All LANCE products have similar science team involvement.

Instrument	Product Categories	Average Latency
AIRS	Radiances, Temperature and Moisture Profiles, Clouds and Trace Gases	75 – 140 minutes
AMSR-E	Brightness Temperatures, Soil Moisture, Rain Rate, Ocean Products	80 - 135 minutes
MLS	Ozone, Temperature	75 – 140 minutes
MODIS	Radiances, Cloud/Aerosols, Water Vapor, Fire, Snow Cover, Sea Ice, Land Surface Reflectance, Land Surface Temperature	90 – 145 minutes Latency excludes L2G and L3
OMI	Ozone, Sulfur Dioxide, Aerosols	100 – 165 minutes

Table 1: LANCE Product Categories and Latency

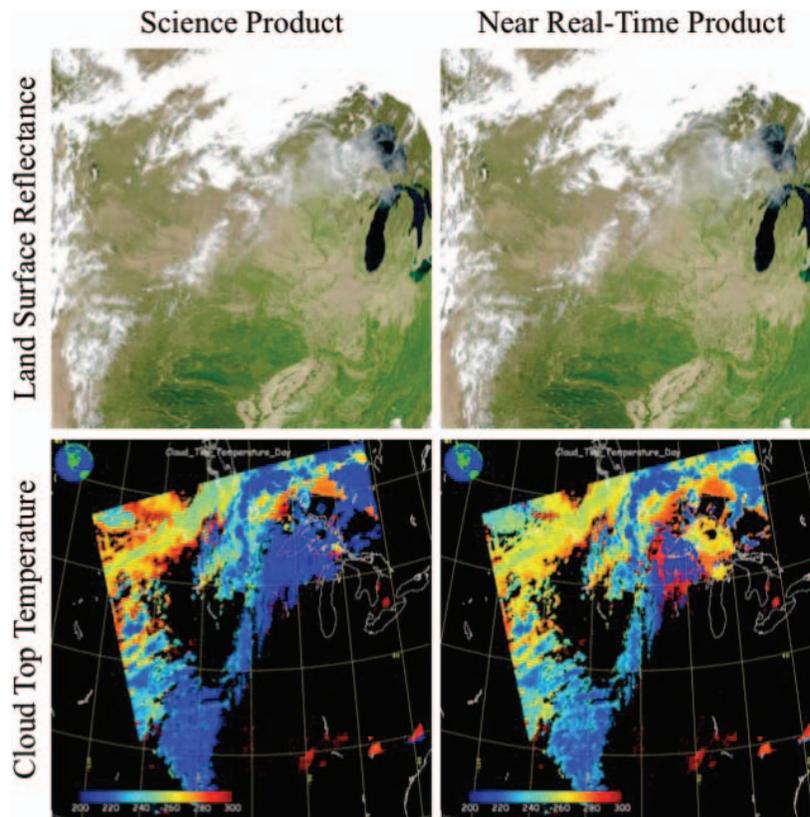


Figure 2: Examples of side-by-side comparisons of the standard and near-real time products. The first example shows a Land Surface Reflectance granule over the Midwest. There appears to be no difference between the products. However, under close examination the near-real time view shows slightly more haze west of the Great Lakes. In contrast, the second side-by-side comparison is for Cloud Top Temperature for the same granule and there are very obvious differences in the region west of the Great Lakes. This is as a result of the sensitivity of this product to the Global Data Assimilation System ancillary data.

4.2 Product Quality

LANCE products are extensively tested and compared with science products before being made available to users. Continuing with the MODIS example from the previous section, Figure 2 compares selected MODIS near real-time and science products.

Characterizations of the differences between science and near real-time products reveal some minor differences, but overall the agreement is high. While every effort is made to create high quality near real-time products, science quality products should be used when latency is not a primary concern.

4.3 Access

Timely, easy and reliable access to near real-time data is required by application users for decision support systems and field campaigns. LANCE has developed system-wide requirements that ensure users can rely on near real-time products. Access to LANCE products is primarily through FTP and subscription services that push data to users systems. In keeping with NASA's Data and Information Policy, all LANCE data are provided without a period of exclusive access and free of charge; however data supplied by international partners or other agencies may be restricted by a Memorandum of Understanding with those organizations.

5. CONCLUSION

The LANCE system has proved a success by satisfying the growing needs of the applications and operational communities for land and atmosphere data in near real-time. NASA's Earth Sciences Division was able to leverage existing science research capabilities to provide the near real-time community with products and imagery that support monitoring of disasters in a timely manner.

Building on the earlier efforts to provide MODIS near real-time data, LANCE has grown to include products from four additional instruments in less than two years. Although based on a distinct set of instruments, each with its own special processing requirements, LANCE was designed as a collaborating system of common practices. Through the use of a central web portal LANCE presents the user community with a common point of access while providing autonomy for the individual elements to develop. The ESDIS Project continues to improve the LANCE system as it goes into operations and use the experience gained through practice to seek adjustments to improve the quality and performance of the system. NASA is establishing a LANCE User Working Group to steer the development of the system and create a forum for sharing ideas and experiences that are expected to further improve the LANCE capabilities.

6. REFERENCES

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