# ASTER — A New Spaceborne Instrument Which Will Contribute to Thermal Remote Sensing of the Energy and Water Balance Over Land Surfaces

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## ABSTRACT

The Advanced Spaceborne Thermal and Emission Reflection Radiometer (ASTER) is a high-spatial-resolution multispectral imager scheduled to fly in Earth orbit on the first platform of NASA's Earth Observation System (EOS-AM 1) in mid-1998. The instrument will have three bands in the visible and near infrared with 15-m spatial resolution, six bands in the shortwave infrared with 30-m spatial resolution and five bands in the thermal infrared with 90-m spatial resolution. There will be an additional, aft pointing, band in the near infrared with 15-m spatial resolution that will provide same-orbit stereo data when combined with the corresponding nadir viewing band. The ASTER instrument is being built by the Japanese Government based on the scientific requirements of the ASTER science team. This international team of scientists will also be responsible for the development of algorithms for data reduction and analysis. ASTER will be able to address a variety of science objectives identified by the EOS global change program. ASTER will provide surface temperatures and emissivity estimates, surface reflected radiances and digital elevation models at a spatial scale that will allow detailed process studies.

## INTRODUCTION

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a high-spatial-resolution multispectral imager currently scheduled to fly in Earth orbit in mid-1998, on the first platform of NASA's Earth observing System (EOS-AM 1). The instrument will have three bands in the visible and near infrared (VNIR) spectral range (0.5-1.0 μm) with 15-m resolution, six bands in the shortwave infrared (SWIR) spectral range (1.6-2.5 μm) with 30-m spatial resolution, and five bands in the thermal infrared (TIR) spectral range (8-12 μm), with 90-m resolution (Kahle, et al., 1991; Yamaguchi, et al., 1993). An additional backward viewing telescope with a single band in the near infrared with 15-m spatial resolution will provide the capability, when combined with the nadir viewing elements, for same-orbit stereo data.

The instrument is being provided by the Japanese Government under the Ministry of International Trade and Industry (MITI). The ASTER project is implemented through the Earth Resources Satellite Data Analysis Center (ERSDAC) and the Japan Resources Observation System Organization (JAROS), which are nonprofit organizations under the control of MITI. JAROS is responsible for the design and development of the ASTER instrument, which will be carried out the Nippon Electric Company (NEC), the Mitsubishi Electric Corporation (MELCO), Fujitsu, and Hitachi under contracts with JAROS.

The ASTER science team is an international team of Japanese, American, French, and Australian scientists. The team participates in the definition of the scientific requirements for ASTER, in the development of algorithms for data reduction and analysis, and in calibration, validation and mission planning.

## SCIENCE OBJECTIVES

ASTER is the only high-spatial resolution surface imager on EOS-AM 1. As a result, there are a variety of unique science objectives that the instrument will be able to address. The main contributions to the EOS global change studies will be in providing surface temperatures, surface emitted and reflected radiances, and digital elevation models (DEMs) at a spatial scale that will allow detailed surface studies to be conducted.

The multispectral thermal infrared data will provide information to enable separation of the brightness temperature into surface kinetic temperature and land surface spectral emissivity, without having to make such broad assumptions about the surface emissivity which were required in the past when using broadband thermal imaging instruments. The derived land surface temperature data have application s in studies of surface energy and water balance as required by Climate, weather, and biogeochemical models. They can be used to aid in the quantification of evaporation and evapotranspiration, and the interactions between vegetation, soils, and the hydrologic cycle. Temperature data will also be used in the monitoring and analysis of volcanic processes. Day anti night temperature data will be used to estimate thermal inertia as an aid to surface compositional mapping.

The extensive wavelength coverage combined with same-orbit stereo capability will contribute to surface compositional, structural], and geomorphological mapping objectives. The VNIR, SWIR, and TIR bands have all been chosen for use in surface compositional mapping. Soil mapping can contribute to a knowledge of long-term and short-term changes in soil characteristics and quality. The high-spatial-resolution data will contribute to the knowledge of deforestation and land-use change, sea level change, coastal erosion, paleoclimate, and the distribution of mineral resources. These data can also be used to help monitor and understand how episodic processes such as rainfall, runoff, dust storms, earthquakes, and volcanism modify the Earth.

EOS AM-1 will carry two other surface imaging instruments in addition to ASTER. They are the Multi-angle **imaging** Spectro-Radiometer (MIS]<) and the Moderate-Reso lution imaging Spectrometer (M ODIS). 1 ligh-spatial -resolution data from ASTER will be used to study in more detail those quantities and processes such as the surface properties, elements of the surface energy and water balance, and cloud properties that are monitored globally by MODI S and/or MISR at a moderate resolution. Data from MODIS and MISR will be used to help with the atmospheric correction of ASTER data.

## INSTRUMENT DESCRIPTI ON

ASTER will provide data in the three spectral regions using three separate radiometer subsystems. These are the visible and near-infrared (VNIR) subsystem being provided by NEC, the short wavelength infrared (SW] R) subsystem provided by MELCO, and the thermal infrared (TIR) subsystem provided by Fujitsu. The instrument band passes, radiometric accuracies, and radiometric and spatial resolution are given in Table 1. The VNIR includes a separate, single-spectral-band (().76-().86 pm, channel 3B) radiometer inclined backward at an angle of 27.6° to the other sensors to provide a 1 S-m same-orbit stereoscopic imaging capability. A wide dynamic range and multiple gain settings will help ensure. useful data for a variety of investigations.

### TABLE 1. ASTER INSTRUMENT BANDS

| Band | Wavelength range (µm) | Radiometric accuracy | Radiometric resolution | Spatial resolution |
|---|---|---|---|---|
| VNIR | | | | |
| 1 | 0.52- ().60 | ±4% | ≤0.5% | 15111 |
| 2 | 0.63 -0.69 | ±4% | ≤0.5% | 15111 |
| 3 | 0.76- 0.86 | ±4% | ≤0.5% | 15 m |
| SWIR | | | | |
| 4 | 1.60-1.70 | ±4% | ≤0.5% | 30 m |
| 5 | 2.145-2.185 | ±4% | ≤1.3% | 30 m |
| 6 | 2.185-2.225 | ±4% | ≤1.3% | 30 m |
| 7 | 2.235-2.285 | ±4% | ≤1.3% | 30 m |
| 8 | 2.295-2.365 | ±4% | ≤1.0% | 30 m |
| 9 | 2.36-2.43 | ±4% | ≤1.3% | 30 m |
| TIR | | | | |
| 10 | 8.125-8.475 | 1-3K* | ≤0.3K | 90 m |
| 11 | 8.475-8.825 | 1-3K* | ≤0.3K | 90 m |
| 12 | 8.925 -9.275 | 1-3K* | ≤0.3K | 90 m |
| 13 | 10.25- 10.95 | 1-3K* | ≤0.3K | 90 m |
| 14 | 10.95-11.65 | 1-3K* | ≤0.3K | 90 m |

*≤1 K for T = 270-340K

*Stereo* B/H ratio 0.6

The swath width for all three systems is 60 km. The ASTER instrument has a crosstrack pointing capability of ±8.55° for the SWIR and TIR subsystems, and ± 24° for the VNIR subsystem. This gives crosstrack observing ranges on the ground of approximatel y ±136 km and ±343 km respectivel y, ensuring that an y point on the globe wil l be accessible at least once every 16 days for the SWIR and TIR, and once every five days for the VNIR. However, in most instant.cs, all three radiometer systems will image the same 60- km ground swath.

## O1)ICRATIONS

Instrument and spaceci aft resources are allocated to support an 8% average duty cycle, which corresponds to over 700" 60x60 km scenes/day. ASTER data will be acquired and processed according to specific user requirements identifying acquisition time, gain, wavelength region, and data product. in addition, ASTER has the goal of obtaining a cloud-free data set for the entire Earth's land surface by the end of its five-year mission. This global data set will cover all ASTER wavelength regions. Users will be able to request that data products, of local and regional extent, be made from the global data set. The stereo capability will be used to generate high-resolution digital elevations models (DEMS) in selected regions. observations will also include silts involving highly-coord inated field experiments with simultaneous ground and aircraft measurements, targets of opportunity such as volcanoes and major weather events, and observations of clouds on a local to regional scale.

## DATA PRODUCTS

The basic geophysical data products to be produced from AS"]'] ER data are surface emitted and reflected radiance, surface temperature, emissivity and reflectance, and digital elevation models (DEMs). These along with Soil Brightness Index (S131), Perpendicular Vegetation Index (PVI), Normalized Difference Vegetation Index (NDVI), a polar cloud and sca icc map, and auxiliary, intermediate, and browse products are ASTER's standard products that will be ready at launch. It is currentl y planned that most algori thms will be devel oped joi ntl y by American anti Japanese team members. All standard data products will available from the EROS Data Center Land Process Data Active Archive Center (DAAC).

## REFERENCES


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