AMSR-E Instrument Description

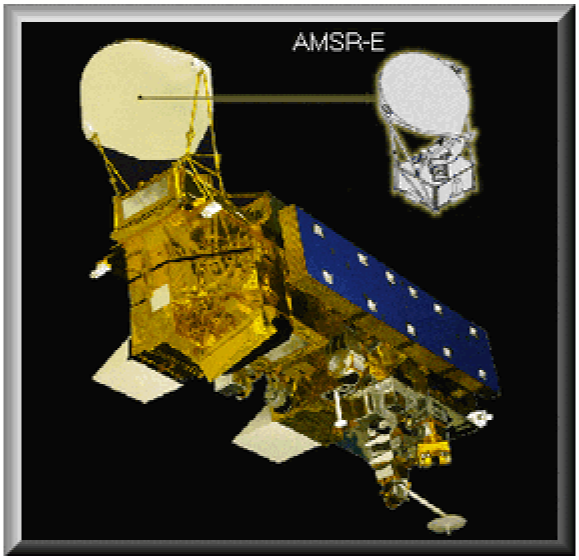

Figure 1. AMSR-E Instrument Image Courtesy of NASA

Sensor or Instrument Description

The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) is a twelve-channel, six-frequency, passive-microwave radiometer system. It measures horizontally and vertically polarized brightness temperatures at 6.9 GHz, 10.7 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, and 89.0 GHz. Spatial resolution of the individual measurements varies from 5.4 km at 89 GHz to 56 km at 6.9 GHz. AMSR-E overpass times are near 1:30 a.m. (ascending) and 1:30 p.m. (descending) local time at the equator.

AMSR-E is developed and provided by the Japan Aerospace Exploration Agency (JAXA, Contractor: Mitsubishi Electric Corporation) with close cooperation of U.S. and Japanese scientists. AMSR-E was modified for Aqua from the design used for AMSR, which is onboard the Japanese ADEOS-2 satellite.

Table 1. Selected Physical Characteristics of AMSR-E

Mass	324 ± 15 kg
Size of Sensor Unit	1.95 x 1.5 x 2.2 m (stowed) 1.95 x 1.7 x 2.4 m (deployed)
Size of Control Unit	0.8 x 1.0 x 0.6 m
Power	350 ± 35 W
Thermal Operating Range	-5° C to 40° C
Stability	80 arcsec/sec/axis for roll and pitch; N/A for yaw
Pointing Accuracy	600 arcsec/axis for roll and pitch; N/A for yaw

AMSR-E improves upon past microwave radiometers. The spatial resolution of AMSR-E data doubles that of Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I) data. Also, AMSR-E combines into one sensor all the channels that SMMR and SSM/I had individually. The following table compares operating characteristics of AMSR-E with previous sensors:

Table 2. Comparative Operating Characteristics of SMMR, SSM/I, and AMSR

Parameter	SMMR (Nimbus-7)	SSM/I (DMSP-F08,F10,F11,F13)	AMSR-E (Aqua)	AMSR (ADEOS-II)
Time Period	1978 to 1987	1987 to Present	Beginning 2001	Beginning 2002
Frequencies (GHz)	6.6, 10.7, 18, 21, 37	19.3, 22.3, 36.5, 85.5	6.9, 10.7, 18.7, 23.8, 36.5, 89.0	6.9, 10.65, 18.7, 23.8, 36.5, 89.0, 50.3, 52.8
Sample Footprint Sizes (km):	148 x 95 (6.6 GHz) 27 x 18 (37 GHz)	37 x 28 (37 GHz) 15 x 13 (85.5 GHz)	74 x 43 (6.9 GHz) 14 x 8 (36.5 GHz) 6 x 4 (89.0 GHz)	74 x 43 (6.9 GHz) 14 x 8 (36.5 GHz) 6 x 4 (89.0 GHz)

Key Variables

The AMSR-E instrument measures geophysical variables related to the earth's water cycle, including: precipitation rate, cloud water, water vapor, sea surface winds, sea surface temperature, sea ice concentration, snow water equivalent, and soil moisture.

Principles of Operation

AMSR-E uses an offset parabolic reflector, 1.6 m in diameter, to focus Earth-emmitted microwave radiation into an array of six feedhorns, which then feed the radiation to the detectors. Figure 2. shows the alignment of the feedhorns.

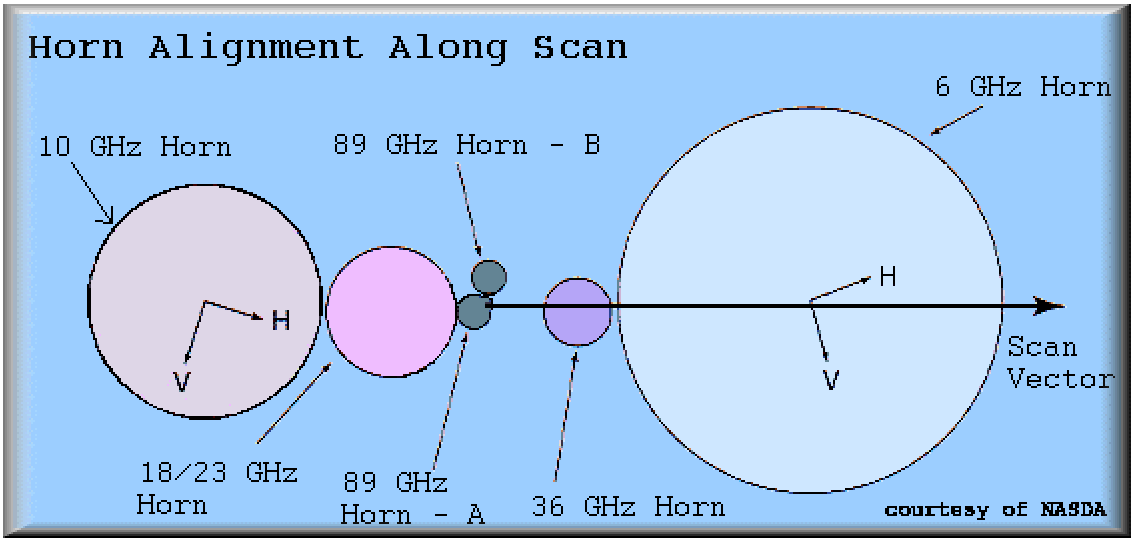

Figure 2. Feedhorn Alignment Along Scan

The reflector and feedhorn arrays are mounted on a drum that contains the radiometers, digital data subsystem, mechanical scanning subsystem, and power subsystem. The reflector/feed/drum assembly is rotated about the axis of the drum by a coaxically-mounted bearing and power transfer assembly. All data, commands, timing and electronic signals, and power pass through the assembly on slip ring connectors to the rotating assembly.

A cold load (cold-sky mirror) reflector and warm load (high-temperature source) are mounted on a transfer assembly shaft that do not rotate with the drum assembly. The loads are positioned off-axis such that they pass between the feedhorn array and the parabolic reflector, hiding it once per scan. The cold load reflector reflects cold-sky radiation into the feedhorn array. Both loads also serve as calibration references for the instrument.

The following table lists the pertinent performance characteristics of AMSR-E.

Table 3. AMSR-E Performance Characteristics

Polarization	Horizontal and vertical					
Incidence angle	55°					
Cross-polarization	Less than -20 dB					
Swath	1445 km					
Dynamic Range (K)	2.7 to 340					
Precision	1 K (1)					
Quantifying Bit Number	12-bit	10-bit				
Center Frequency (GHz)	6.925	10.65	18.7	23.8	36.5	89.0
Bandwidth (MHz)	350	100	200	400	1000	3000
Sensitivity (K)	0.3	0.6				1.1
Mean Spatial Resolution (km)	56	38	21	24	12	5.4
IFOV (km)	74 x 43	51 x 30	27 x 16	31 x 18	14 x 8	6 x 4
Sampling Interval (km)	10 x 10					5 x 5
Integration Time (msec)	2.6					1.3

Main Beam Efficiency (%)	95.3	95.0	96.3	96.4	95.3	96.0
Beamwidth (degrees)	2.2	1.4	0.8	0.9	0.4	0.18

Sensor or Instrument Measurement Geometry

The AMSR-E instrument rotates continuously about an axis parallel to the Aqua satellite at 40 rpm. At an altitude of 705 km, it measures the upwelling scene brightness temperatures over an angular sector of ± 61° about the sub-satellite track, resulting in a swath width of 1445 km. AMSR-E records active scene measurements at equal intervals of 10 km (5 km for the 89 GHz channels) along the scan. The reflector is fixed at a 47.4 degree half-cone angle, which results in an Earth incidence angle of 55°.

Manufacturer of Sensor or Instrument

AMSR-E is developed and provided by the Japan Aerospace Exploration Agency (JAXA, Contractor: Mitsubishi Electric Corporation) with close cooperation of U.S. and Japanese scientists.

Calibration

AMSR-E's calibration system has a cold mirror that provides a clear view of deep space (a known temperature of 2.7 K) and a hot reference load that acts as a blackbody emitter; its temperature is measured by eight precision thermistors. After launch, large thermal gradients due to solar heating developed within the hot load, making it difficult to determine from the thermistor readings the average effective temperature, or the temperature the radiometer sees. The hot load temperature is not uniform or constant, and empirical calibration methods must be employed. See the following documents for further details:

- AMSR-E/Aqua L1A Raw Observation Counts
- AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperatures (Tb)

Accuracy Budget

The radiometer calibration accuracy budget, exclusive of antenna pattern correction effects, is composed of three major contributors: warm load reference error, cold load reference error, and non-linearities and errors with radiometer electronics. The total sensor bias error ranges from 0.66 K at 100 K to 0.68 K at 250 K.

The following factors contribute to the warm load reference error:

- Accuracy of the platinum resistance thermistors (PRTs), measured by the manufacturer, on the order of ±0.1 K
- Temperature gradient over the load area
- Load-feedhorn coupling errors inherent in the system design
- Reflections from the feedhorn caused by receiver electronics

The RMS error from all four of these factors is estimated to be ± 0.5 K.

The cold load reference error is primarily caused by coupling between the cold sky reflector and the feedhorn. Total error is estimated to be ±0.5 K. Other factors include the reflections from the feedhorn caused by receiver electronics and the resistive losses of the cold sky reflector itself. An estimate of this error can be as high as ±0.62 K.

The main factor responsible for non-linearity in radiometer electronics is imperfections in the square-law detector. This non-linearity results in an error that is easily estimated during the thermal vacuum calibration testing. (On SSM/I this error was ±0.4 K.) The receiver's electronics produce a gain drift due to the temperature variation over one orbit, depending on the design of the receiver and overall design of the sensor. The drift can be as much as ±0.24 K for a temperature variation of less than 10°C over one orbit.

Science Data Flow

Under normal operating conditions, Remote Sensing Systems (RSS) in Santa Rosa, California, receives Level-1A data from JAXA via the NASA Jet Propulsion Laboratory (JPL) Physical Oceanography Distributed Active Archive Center (PODAAC). RSS generates a Level-2A resampled brightness temperature product and transmits it via ftp to the Global Hydrology Climate Center (GHCC) AMSR-E Science Investigator-led Processing System (SIPS). The AMSR-E SIPS team processes the Level-2A data into Level-2B swath products and then into Level-3 daily, 5-day, weekly, and monthly gridded products. The Level-2A, -2B, -3 products, associated metadata, production histories, quality assurance files, ancillary files, and Delivery Algorithm Packages (DAPs) are tranferred to the National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC) for archival and distribution to users.

List of Acronyms

The following acronyms are used in this document:

- **AMSR-E:** Advanced Microwave Scanning Radiometer - Earth Observing System
- **DAAC:** Distributed Active Archive Center
- **DAP:** Delivery Algorithm Package
- **EOS:** Earth Observing System
- **EOSDIS:** EOS Data and Information System
- **GHCC:** Global Hydrology Climate Center
- **JAXA:** Japan Aerospace Exploration Agency
- **JPL:** Jet Propulsion Laboratory
- **NASA:** National Aeronautics and Space Administration
- **PODAAC:** Physical Oceanography Distributed Active Archive Center
- **PRT:** Platinum Resistance Thermistor

- **RSS:** Remote Sensing Systems
- **SIPS:** Science Investigator-led Processing System
- **SMMR:** Scanning Multichannel Microwave Radiometer
- **SSM/I:** Special Sensor Microwave/Imager

References

Lobl, E. 2001. Joint Advanced Microwave Scanning Radiometer (AMSR) Science Team meeting. *Earth Observer* 13(3): 3-9.