

The Aqua Satellite

The Aqua Satellite Team



Dr. Claire Parkinson



Dr. Steven Platnick



William Guit



Dr. Bruce Wielicki



*Dr. Moustafa
Chahine*



Dr. Roy Spencer



Dr. Michael King



Steve Graham



Dr. Akira Shibata

Profiles For Aqua Satellite Instrument Science Team Leaders



Bruce Wielicki
CERES Science Team Leader

Dr. Wielicki's research has focused on clouds and their role in the Earth's radiative energy balance for over 20 years. He currently serves as Principal-Investigator on the CERES Investigation and as a Co-Investigator on the NASA Cloudsat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) missions. Cloudsat and CALIPSO are centered on cloud studies and will fly in formation with the CERES instrument and other instruments on the Aqua platform.

Earlier, Dr. Wielicki was a Co-investigator on the Earth Radiation Budget Experiment and developed a new Maximum Likelihood Estimation (MLE) method for determination of the cloud condition in each ERBE field of view. This method enabled the development of the first estimates of cloud radiative forcing (CRF) by distinguishing individual observations as clear, partly-cloudy, mostly-cloudy, or overcast. This measurement became a standard of comparison for global climate models. The poor ability of global climate models to reproduce the ERBE cloud radiative forcing measurements was a key element in the designation of the "role of clouds and radiation" as the highest priority of the U.S. Global Change Research Program.

Dr. Wielicki was also a Principal Investigator on the First International Satellite Cloud Climatology Experiment (ISCCP) Regional Experiment (FIRE) and served as FIRE Project Scientist from 1987 to 1994. His research used Landsat satellite data to provide the first definitive validation of the accuracy of satellite derived cloud fractional coverage. More recently, he has demonstrated the surprising non-gaussian distributions of cloud optical depth present in broken boundary layer cloud fields, and has shown the large bias these distributions can cause in global climate model estimates of both solar and thermal infrared fluxes.

Throughout his career, Dr. Wielicki has pursued extensive theoretical radiative transfer studies of the effects of non-planar cloud geometry on the calculation of radiative fluxes, as well as on the retrieval of cloud properties and top of atmosphere radiative fluxes from space-based observations. Dr. Wielicki received his B.S. degree in Applied Math and Engineering Physics from the University of Wisconsin - Madison in 1974 and his Ph.D. degree in Physical Oceanography from Scripps Institution of Oceanography in 1980. He received a NASA Exceptional Scientific Achievement Award in 1992 and the Henry G. Houghton Award from the American Meteorological Society in 1995.

Selected Papers

[Earth's Climate System: A 21st Century Grand Challenge](#)

[Ceres And The S'cool Project \(1997\)](#)

[Clouds and the Earth's Radiant Energy System \(CERES\): An Earth Observing System Experiment](#)

[Clouds and the Earth's Radiant Energy System \(CERES\): algorithm overview](#)

The Aqua Satellite



Moustafa Chahine
AIRS/AMSU/HSB Science Team Leader

Moustafa Chahine was awarded a Ph.D. in Fluid Physics from the University of California at Berkeley in 1960. He is Chief Scientist at the Jet Propulsion Laboratory (JPL), where he has been affiliated for 30 years. From 1978 to 1984, he was Manager of the Division of Earth and Space Sciences at JPL; as such, he was responsible for establishing the Division and managing the diverse activities of its 400 researchers.

For 20 years, Dr. Chahine has been directly involved in remote sensing theory and experiments. His resume reflects roles as Principal Investigator, designer and developer, and analyst in remote-sensing experiments. He developed the Physical Relaxation Method for retrieving atmospheric profiles from radiance observations. Subsequently, he formulated a multispectral approach using infrared and microwave data for remote sensing in the presence of clouds. These data analysis techniques were successfully applied in 1980 to produce the first global distribution of the Earth surface temperature using data from the HIRS/MSU sounders.

Dr. Chahine was integrally involved in the AMTS study, which laid the basis for the current AIRS spectrometer. Dr. Chahine served as a member of the NASA Earth System Sciences Committee (ESSC), which developed the program leading to EOS, and currently is Chairman of the Science Steering Group of a closely related effort, the World Meteorological Organization's Global Energy and Water Cycle Experiment (GEWEX). Dr. Chahine is a Fellow of the American Physical Society and the British Meteorological Society. In 1969, he was awarded the NASA Medal for Exceptional Scientific Achievement and, in 1984, the NASA Outstanding Leadership Medal.

Selected Papers

[Retrieval of mid-tropospheric of CO₂ directly from AIRS measurements \(2009\)](#)

[Application of Atmospheric Infrared Sounder \(AIRS\) data to climate research \(2009\)](#)

[Biases in total precipitable water vapor climatologies from Atmospheric Infrared Sounder and Advanced Microwave Scanning Radiometer \(2007\)](#)

[Three years of hyperspectral data from AIRS : what have we learned. \(2007\)](#)

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Roy Spencer
U.S. AMSR-E Science Team Leader

Dr. Spencer received his B.S. in Atmospheric Sciences from the University of Michigan in 1978 and his M.S. and Ph.D. in Meteorology from the University of Wisconsin in 1980 and 1982. He then continued at the University of Wisconsin through 1984 in the Space Science and Engineering Center as a research scientist. He joined NASA's Marshall Space Flight Center (MSFC) in 1984, where he later became Senior Scientist for Climate Studies. He resigned from NASA in 2001 and joined the University of Alabama in

Huntsville as a Principal Research Scientist. Dr. Spencer has served as Principal Investigator on the Global Precipitation Studies with Nimbus-7 and DMSP SSM/I, and the Advanced Microwave Precipitation Radiometer High Altitude Studies of Precipitation Systems. He has been a member of several science teams: the Tropical Rainfall Measuring Mission (TRMM) Space Station Accommodations Analysis Study Team, Science Steering Group for TRMM, TOVS Pathfinder Working Group, NASA Headquarters Earth Science and Applications Advisory Subcommittee, and two National Research Council study panels.

Since 1992 Dr. Spencer has been the U.S. Team Leader for the Multichannel Imaging Microwave Radiometer (MIMR) team and the follow-on AMSR-E team. In 1994 he became the AMSR-E Science Team leader.

He received the NASA Exceptional Scientific Achievement Medal in 1991, the MSFC Center Director's Commendation in 1989, and the American Meteorological Society's Special Award in 1996.

Selected Papers

[Satellite and Model Evidence Against Substantial Manmade Climate Change](#)

[Global Warming as a Natural Response to Cloud Changes Associated with the Pacific Decadal Oscillation \(PDO\)](#)

[Cloud and Radiation Budget Changes Associated with Tropical Intraseasonal Oscillations](#)

[Potential Biases in Feedback Diagnosis from Observational Data: A Simple Model Demonstration](#)

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Michael King
MODIS Team Leader

Dr. Michael King is Senior Research Associate in the Laboratory for Atmospheric and Space Physics, University of Colorado. He served as Senior Project Scientist of NASA's Earth Observing System (EOS) from 1992 to 2008. He joined Goddard Space Flight Center in January 1978 as a physical scientist, and previously served as Project Scientist of the Earth Radiation Budget Experiment (ERBE) from 1983-1992.

His research experience includes conceiving, developing, and operating multispectral scanning radiometers from a number of aircraft platforms in field experiments ranging from arctic stratus clouds to smoke from the Kuwait oil fires and biomass burning in Brazil and southern Africa. He has lectured on global change on all seven continents.

Earlier, he developed the Cloud Absorption Radiometer for studying the absorption properties of optically thick clouds as well as the bidirectional reflectance properties of many natural surfaces, and is principal investigator of the MODIS Airborne Simulator, an imaging spectrometer that flies onboard the NASA ER-2 aircraft. This instrument has aided immeasurably in the development of atmospheric and land remote sensing algorithms for the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument.

Selected Papers

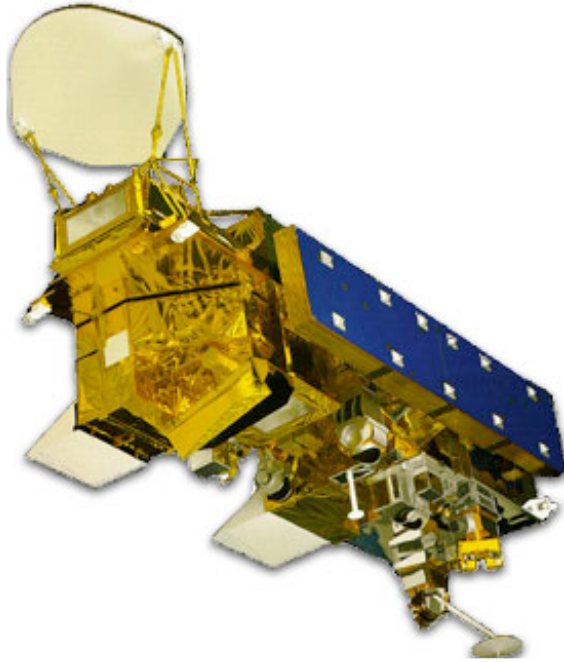
[Evaluation of cirrus cloud properties derived from MODIS data using cloud properties derived from ground-based observations collected at the ARM SGP site.](#)

[Urban aerosols and their interaction with clouds and rainfall: A case study for New York and Houston.](#)

[Observed Land Impacts on Clouds, Water Vapor, and Rainfall at Continental Scales.](#)

[Remote sensing of liquid water and ice cloud optical thickness, and effective radius in the arctic: Application of airborne multispectral MAS data.](#)

Overview Of The The Aqua Satellite

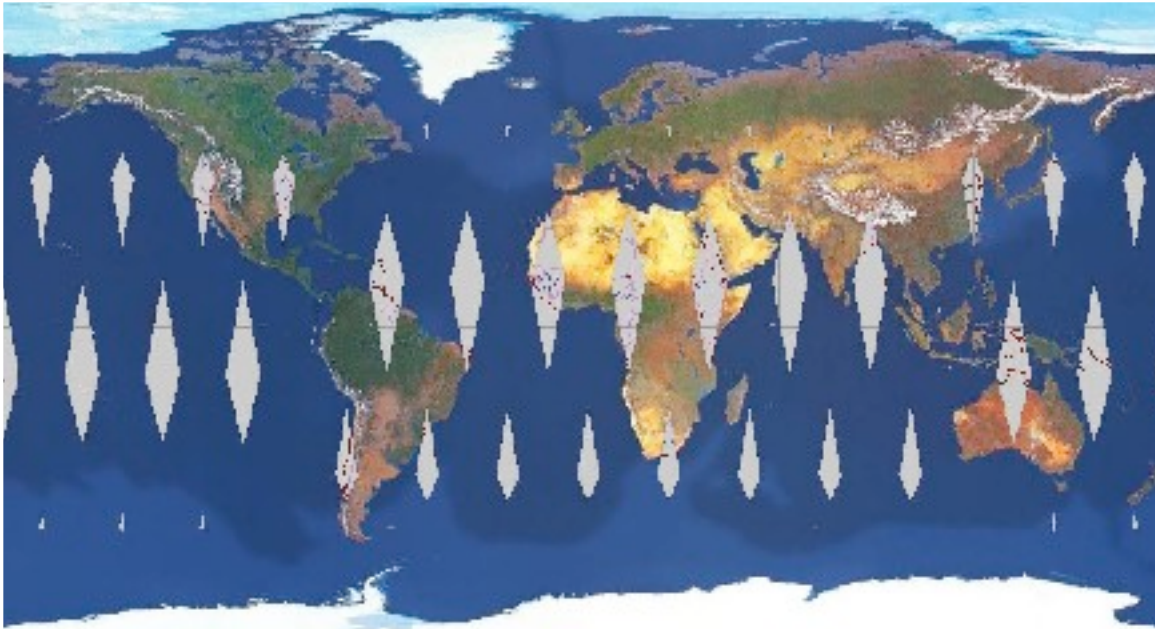


Aqua, Latin for water, is a NASA Earth Science satellite mission named for the large amount of information that the mission will be collecting about the Earth's water cycle, including evaporation from the oceans, water vapor in the atmosphere, clouds, precipitation, soil moisture, sea ice, land ice, and snow cover on the land and ice. Additional variables also being measured by Aqua include radiative energy fluxes, aerosols, vegetation cover on the land, phytoplankton and dissolved organic matter in the oceans, and air, land, and water temperatures.

The Aqua mission is a part of the NASA-centered international Earth Observing System (EOS). Aqua was formerly named EOS PM, signifying its afternoon equatorial crossing time. A timeline of Aqua on-orbit progress through the initial 120 day check-out period can be found [here](#).

Aqua was launched on May 4, 2002, and has six Earth-observing instruments on board, collecting a variety of global data sets. Aqua was the first member launched of a group of satellites termed the Afternoon Constellation, or sometimes the A-Train. The second member to be launched was Aura, in July 2004, the third member was PARASOL, in December 2004, and the fourth and fifth members are CloudSat and CALIPSO, in May 2006. PARASOL exited the A-Train orbit in December 2009. Expected upcoming missions are Glory, a NASA mission due to be launched in 2010, and GCOM-W1, a JAXA mission due to be launched in 2011. After these two missions join, the A-Train will be led by GCOM-W1, followed by Aqua, then CloudSat, CALIPSO, Glory, and, in the rear, Aura.

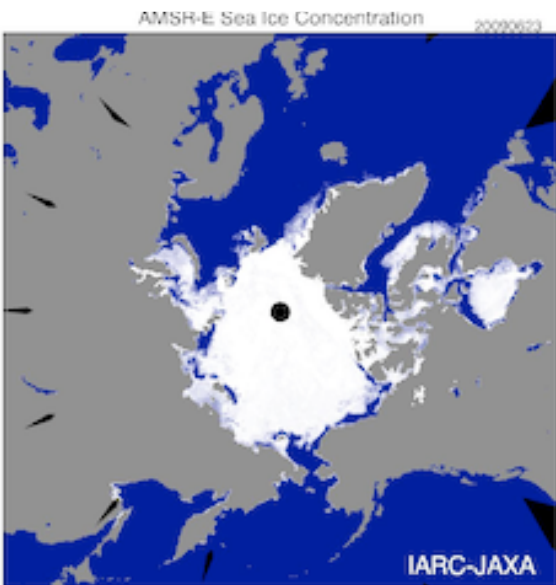
Aqua's Orbit



The Aqua satellite provides coverage that is global between 89.24°N and 89.24°S. In a single day the satellite performs 28 half orbits around the Earth.

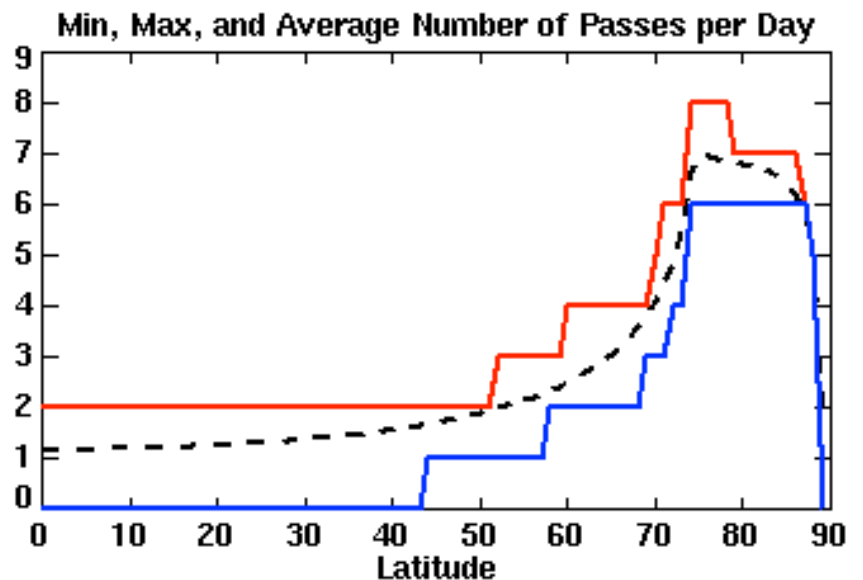
There are several small diamond-shaped areas not covered by the scans, as well as small areas of the north and south pole that are not scanned. These

missing area can be seen in the accompanying diagrams presented here.



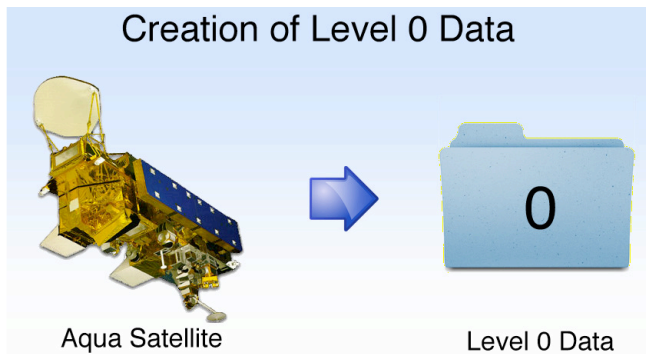
For example, at the equator on a given day, Aqua does not observe certain longitudes that fall between orbits on that day. At other longitudes, where subsequent orbits overlap, Aqua observes that point twice per day. On the average, Aqua observes each longitude at the equator slightly more than once per day.

The Aqua satellite takes about 50 minutes to cover a swath of the planet. Aqua observes a given location on Earth from zero to eight times per day, depending on latitude, longitude, and phase of Aqua's orbit. This figure below shows the minimum, maximum, and average number of times that Aqua observes a location at a given latitude. The average is around one-degree latitude bands.



Aqua Satellite Data Processing

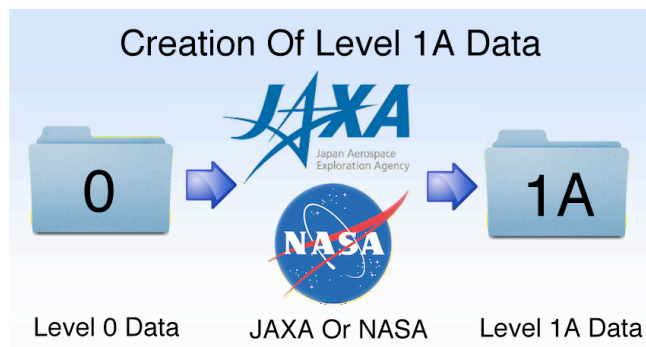
This chapter examines the steps that go into processing the Aqua satellite data. Several data files are produced as the satellite data moves through the processing pipeline. The term “Level” is used to show how far through the pipeline the data has gone. Levels start at zero and go up to four, with each successive layer representing a product that has received more processing. We'll be looking at Level 0 (raw satellite) data to level 2A data.



Level 0 data contains the actual data produced by transmissions from the instruments on the satellite. The data has not been through Quality Assurance, it hasn't been geocoded, etc.

The most recent 4 days of Level 0 data for the Aqua satellite can be downloaded from the University of Wisconsin. Connect via FTP as an anonymous (Guest) user. See the file 00README.txt for additional information.

[Link To University of Wisconsin Aqua Satellite Level 0 Data](#)



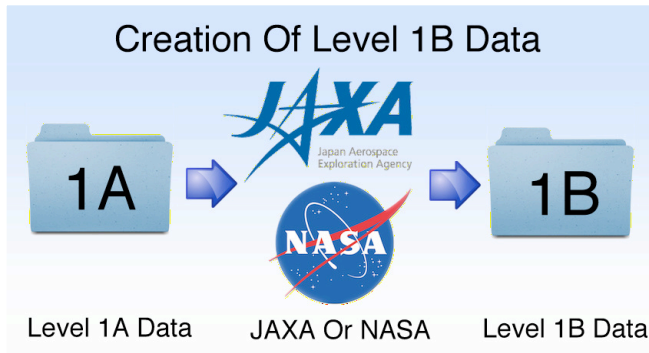
Level 0 AMSR-E data is processed into Level 1A data by the Japan Aerospace Exploration Agency (JAXA). Level 0 AMSU data is processed into Level 1A data by NASA. Like Level 0 data, I consider Level 1A data too low level to use.

AMSU Level 1A data contains geo-located data counts and engineering parameters. I have not been able to find AMSU Level 1A data online for downloading.

For AMSR-E Level 1A data, each half-orbit data granule consists of observation counts, antenna temperature coefficients, offsets for calculating antenna temperatures, calibration temperature counts, land/ocean flags, time, latitude, longitude, and navigation fields in HDF format. The data sampling interval is 2.6 msec for each 1.5-sec scan period for the 6.9-GHz to 36.5-GHz channels, and 1.3 msec for the 89.0-GHz channel. AMSR-E collects 243 data points per scan for the 6.9-GHz to 36.5-GHz channels, and 486 data points for the 89.0-GHz channel. Each swath spans 50 minutes.

AMSU Level 1A data can be downloaded [here](#).

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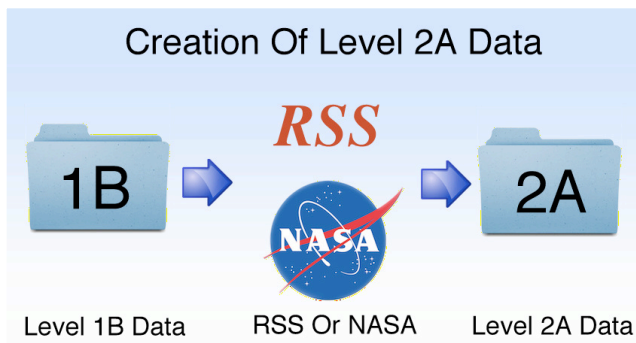
Level 1A AMSR-E data is processed into Level 1B data by the Japan Aerospace Exploration Agency (JAXA). Level 1A AMSU data is processed into Level 1B data by NASA.

The AMSU-A Level 1B data set contains AMSU-A calibrated and geolocated brightness temperatures in degrees Kelvin. This data set is generated from AMSU-A Level 1A digital numbers (DN) and contains 15 microwave channels in the 50 - 90 GHz and 23 - 32 GHz regions of the spectrum. A day's worth of data is divided into 240 scenes, each of 6 minute duration. An AMSU-A scene

contains 30 cross-track footprints in each of 45 along-track scanlines, for a total of $45 \times 30 = 1350$ footprints per scene. The AMSU-A is co-aligned with the AIRS instrument onboard the Aqua platform so that successive blocks of 3×3 AIRS footprints are corresponding to AMSU-A footprint.

The AMSU Level 1B data can be downloaded from the [NASA AIRS data holdings web page](#). A Quick start Guide for this data is [here](#).

AMSR-E Level 1B data is brightness temperature that is transformed from antenna temperature in level 1A by transformation coefficients. The JAXA link to the AMSR-E Level 1B data is a [dead link](#).



Level 2A data is created from Level 1B data by either RSS or NASA. Level 2A data contains derived data and is used to produce various Level 3 and Level 4 data files.

AMSU Level 2A data contains combined data from the AIRS/AMSU/HSB instruments and can be downloaded [here](#).

AMSR-E Level 2A data is brightness temperature that contains derived geophysical variables at the same resolution and location as the Level-1 source data. These

derived data include geophysical quantities for water, water vapor, cloud liquid water, precipitation, sea surface wind speed, sea surface temperature, sea ice concentration, snow water equivalent, and soil moisture.

Recently the AMSR-E/Aqua Level 2A data was determined to have errors in the resampled 89.0 GHz Horizontal (H) fields. Files with data coverage from 19 June 2002 00:29 through 4 November 2004 05:43 are affected. The fields containing bad data are:

- 89.0H_Res.1_TB
- 89.0H_Res.2_TB
- 89.0H_Res.3_TB
- 89.0H_Res.4_TB

AMSR-E Level 2A data can be downloaded [here](#). An online history of the changes made to processing this data can be found [here](#).

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AMSU Data	Available To Public
Data Transmitted From Satellite To Ground	No
Level 0 Data	Partial ¹
Level 1A Data	No
Level 1B Data	Yes
Level 2A Data	Yes

Notes

1 AMSU and AMSR-E Level 0 data is available for a 4 day window from the University of Wisconsin.

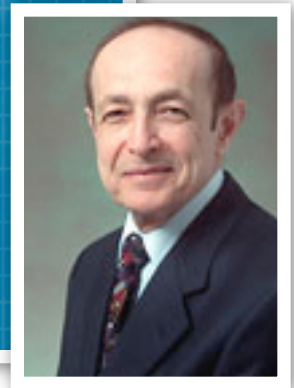
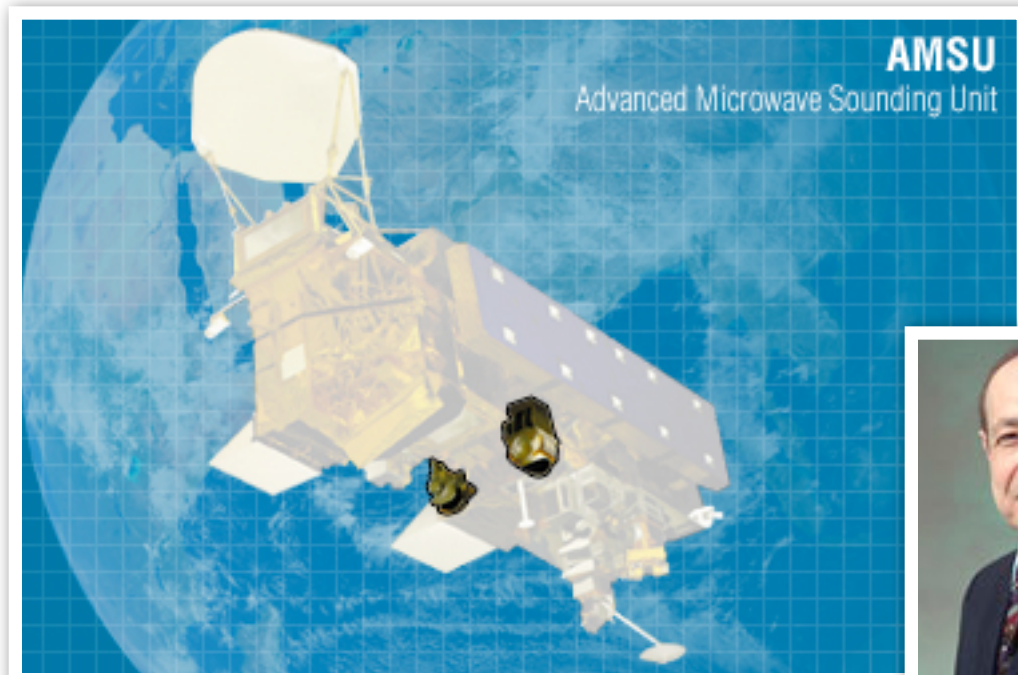
2 Computer source code to read and write various versions of HDF-EOS files is publicly available. However, this code does not actually process climate data.

AMSR-E Data	Available To Public
Data Transmitted From Satellite To Ground	No
Level 0 Data	Partial ¹
Level 1A Data	Yes
Level 1B Data	No
Level 2A Data	Yes

AMSU Computer Code	Available To Public ²
Process Satellite Data To Level 0	No
Process Level 0 To Level 1A	No
Process Level 1A To Level 1B	No
Process Level 1B To Level 2A	No

AMSR-E Computer Code	Available To Public ²
Process Satellite Data To Level 0	No
Process Level 0 To Level 1A	No
Process Level 1A To Level 1B	No
Process Level 1B To Level 2A	No
Process Level 1A To Level 2A	Yes

Advanced Microwave Sounding Unit (AMSU-A)

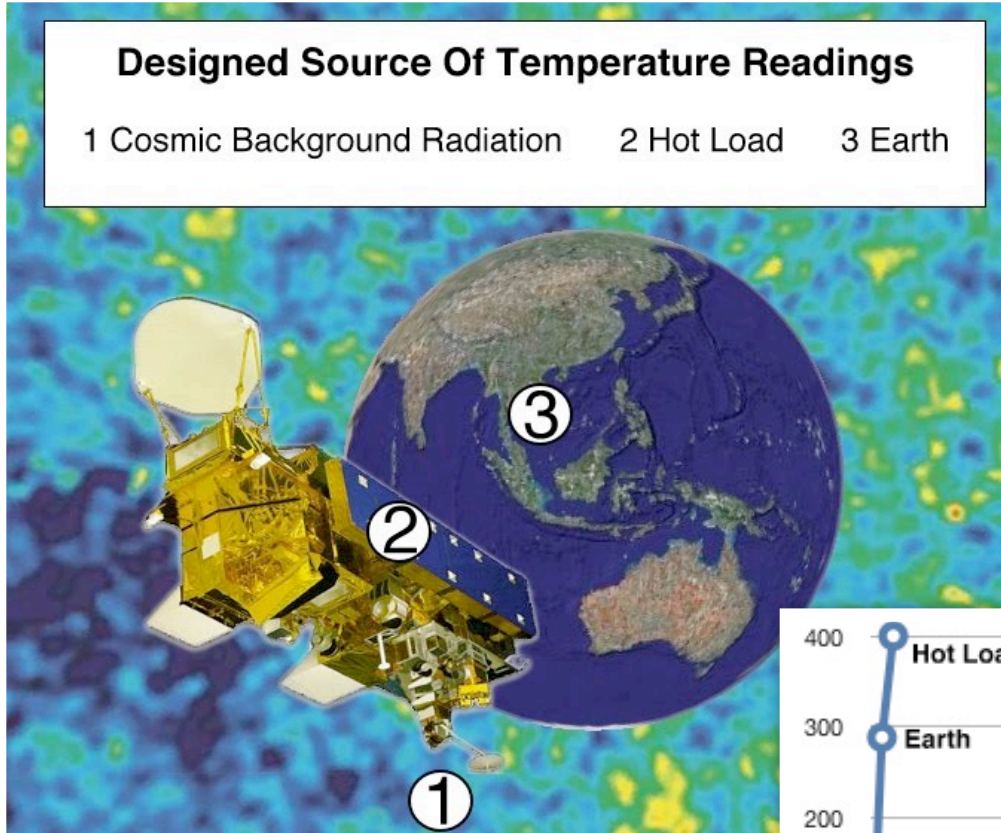


The Advanced Microwave Sounding Unit (AMSU-A), a 15-channel microwave sounder designed primarily to obtain temperature profiles in the upper atmosphere (especially the stratosphere) and to provide a cloud-filtering capability for tropospheric temperature observations. The first AMSU was launched in May 1998 on board the National Oceanic and Atmospheric Administration's (NOAA's) NOAA 15 satellite. The EOS AMSU-A is part of a closely coupled triplet of instruments that include the AIRS and HSB.

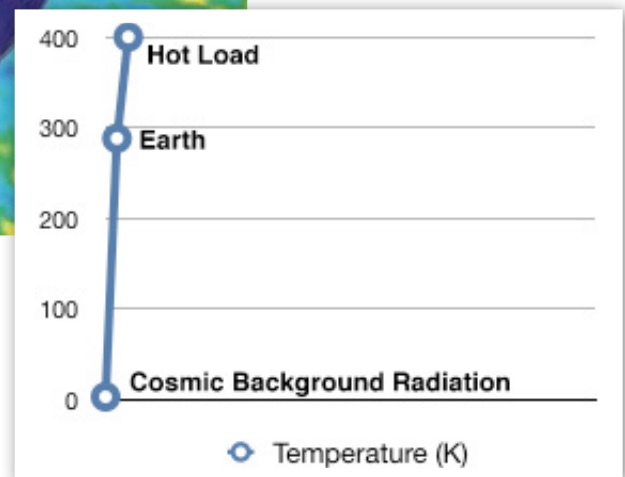
Instrument characteristics

- Passive multi-channel microwave radiometer measuring atmospheric temperature.
- 15 channel microwave sounder with a frequency range of 15-90 GHz.
- Provides atmospheric temperature measurements from the surface up to 40 km.
- On board NOAA K/L/M as well as Aqua.

AMSU Calibration



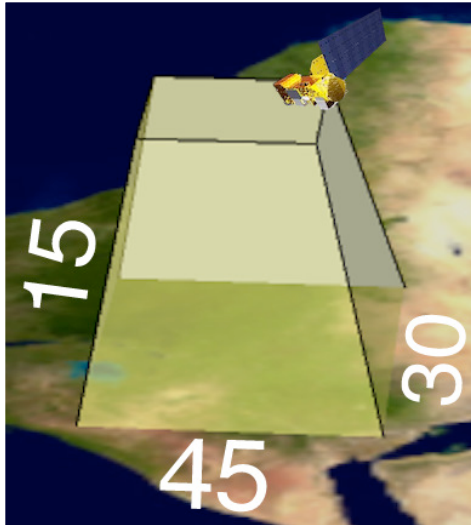
The temperature sensing instruments on the Aqua satellite must be calibrated. For the AMSU calibration, the satellite reads the temperature of the Cosmic Background Radiation (CBR) to calibrate it against a known low temperature value of 2.7 K. A high temperature calibration is done against an onboard "Hot Load" whose temperature is measured by eight precision thermostats.



Calibration is a process that makes instrument readings accurate and useful. Instruments are calibrated against known values so that their readings of unknown values can be considered reliable.

With calibrated values for low and high temperatures available, values read from the Earth are simply scaled between these low and high values to determine the temperature.

AMSU Scanning



A single full scan by the AMSU consists of 45 scan lines. These scan lines are along the path of the satellite as it orbits the Earth. Each scan line has 30 footprints. These footprints are perpendicular to the path of the satellite. Finally, each footprint has 15 channels. These channels measure brightness temperatures at different heights of the atmosphere.

Hardware for the two lowest frequencies is located in one module (AMSU-A2) and that for the remaining thirteen frequencies in the second module (AMSU-A1).

This arrangement puts the two lower atmospheric moisture viewing channels into one module and the oxygen absorption channels into a second common module to ensure commonality of viewing angle independent of any module and/or spacecraft misalignment due to structural or thermal distortions.

Channel Number	Channel Frequency (MHz)	Function
1	23,800	Water Vapor Burden
2	31,400	Surface Temperature
3	50,300	Surface Temperature
4	52,800	Surface Temperature
5	53596115	Tropospheric Temp
6	54,400	Tropospheric Temp
7	54,940	Tropospheric Temp
8	55,500	Tropospheric Temp
9	f0= 57,290.34	Stratospheric Temp
10	f0217	Stratospheric Temp
11	f0322.248	Stratospheric Temp
12	f0322.222	Stratospheric Temp
13	f0322.210	Stratospheric Temp
14	f0322.24.5	Stratospheric Temp
15	89,000	Cloud Top/Snow

The table to the left shows which channels are responsible for measure different parts of the atmosphere.

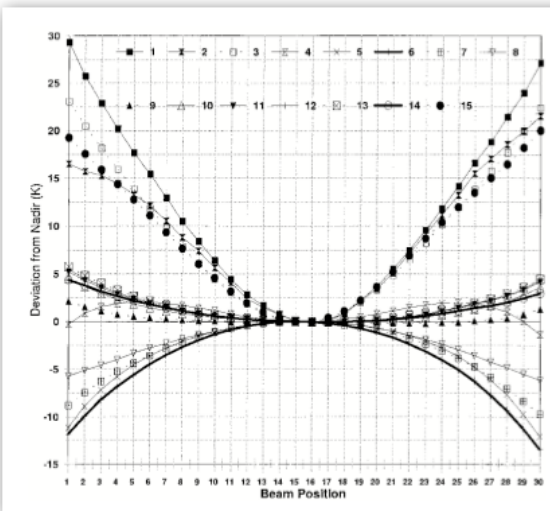
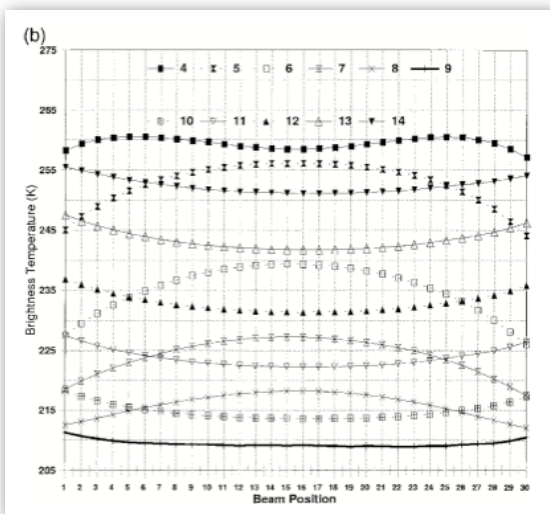
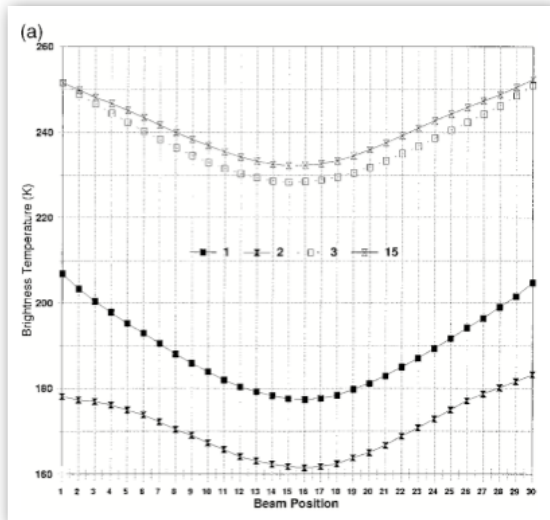


Channel 4 failed in December, 2007 and is not used. Channel 7 on the AMSU has high noise and should not be used.

Channel 7 had too much noise to be considered reliable even before the satellite was launched. Channel 4 failed in December, 2007 and its data is no longer used. Instead, it is synthesized from the other channels. The procedure for doing this is discussed in [AIRS/AMSU/HSB Version 5 Modification of Algorithm to Account for Increased NeDT in AMSU Channel 4](#). The algorithm discussed there requires data not available online. That data is reproduced here:

Channel	NeDTi	Channel	NeDTi
1	0.17	9	0.16
2	0.22	10	0.22
3	0.25	11	0.24
4	0.14	12	0.35
5	0.20	13	0.48
6	0.17	14	0.80
7	0.14	15	0.12
8	0.16		

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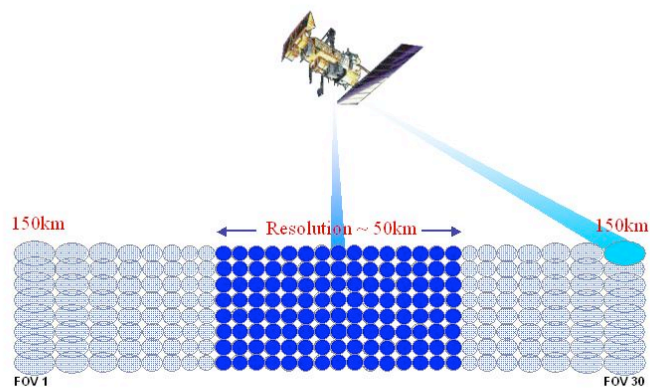


The AMSU scans 30 footprint readings per scan line. Because these readings are done with the satellite in the same position, footprints to the far left and far right will be at different heights in the atmosphere than readings directly below the satellite. A visual example of these offsets is shown in the diagrams to the left. The first diagram shows the offsets for channels 1-3, and 15. The second shows the offsets for the other AMSU channels.

These offsets cause a deviation in the brightness values for each footprint. These deviations are shown in the diagram to the left. The X axis shows the footprint readings. The Y axis shows the variations in brightness that occur at each footprint for each channel.

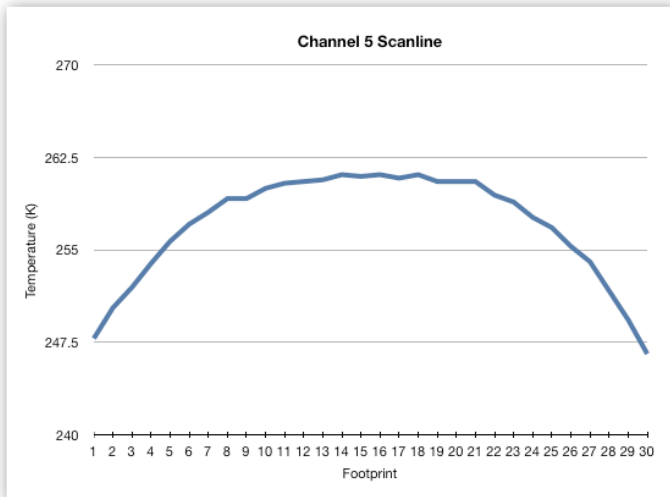
NASA processing of the scans treats these differing values at differing footprints for exactly what they are: brightness measurements at different levels of the atmosphere. NOAA satellites equipped with an AMSU, on the other hand, adjust these values to make them as if they were all measuring the atmosphere at the same depth as footprints 15 and 16.

The scanning resolution of the AMSU changes based on the angle of the scan to the instrument. Scans directly below the instrument have the best resolution and cover the smallest area. Scans at sharper angles to the instrument have poorer resolution and cover a wider area.



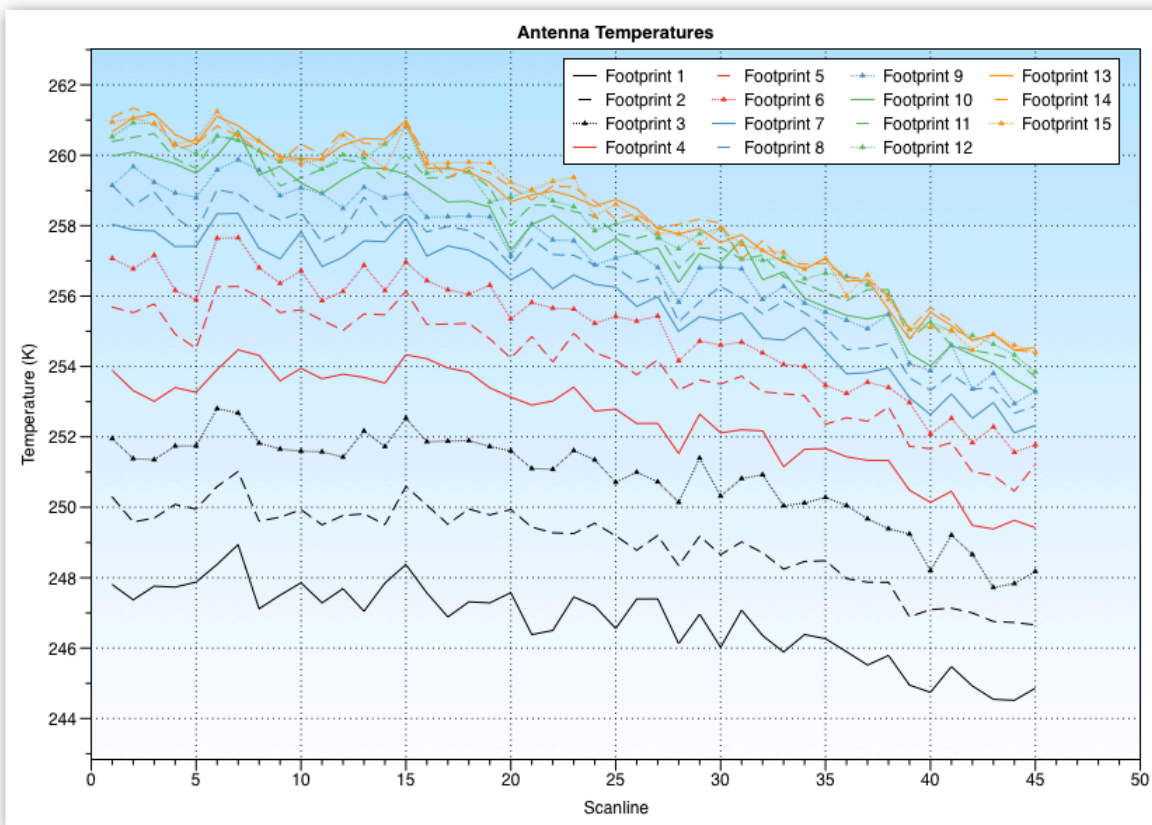
AMSU Scanning Geometry and Resolution

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A sample scan line taken from channel 5 is shown in the diagram to the left. The footprints scan positions further and further away from the satellite. Footprints 15 and 16 are basically scanning directly below the satellite, whereas footprints 1 and 30 are far away from the satellite. The further away from the satellite a footprint is, the larger the error in its temperature measurements.

In the journals, the error difference between footprints 1 and 30 for channel 5 is said to be about -10 K. In practice, it seems the actual difference can be a bit larger. I've seen many differences larger than 50% of the expected difference.



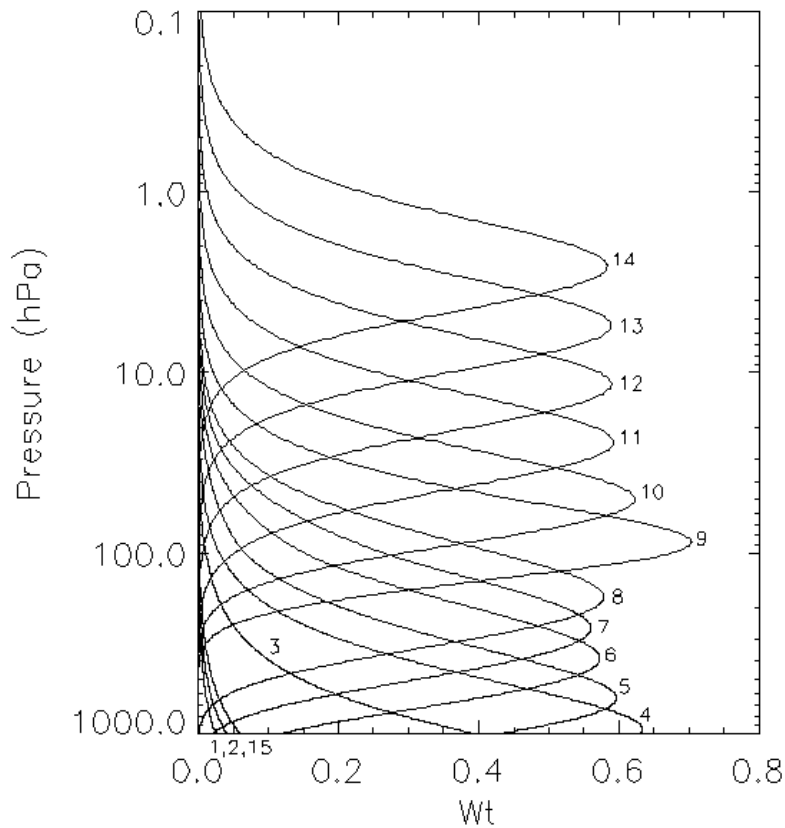
Moreover, it seems the differences are different for different temperatures. The graph to the left shows the readings for footprints 1 through 15 for channel 5 for all 45 scan lines in an actual file. When the temperatures are higher, the differences between footprint 1 and 15 are greater than when the temperatures are lower.

On the left side of the graph, where

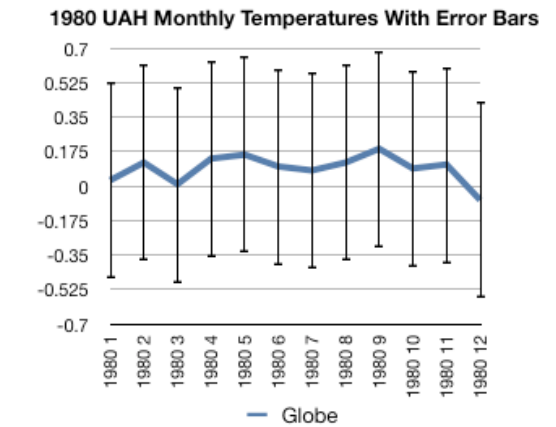
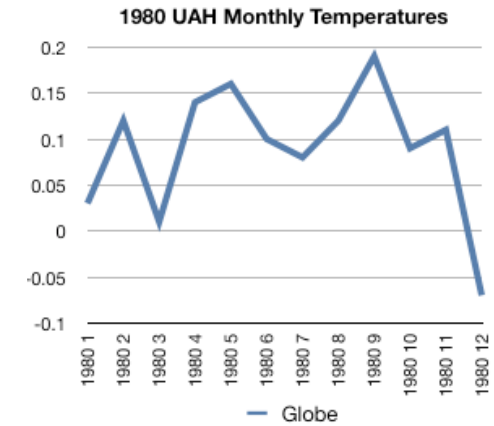
overall temperatures are higher, the difference between footprint 1 and footprint 15 is about 14 K. On the right side of the graph, where overall temperatures are lower, the difference between footprint 1 and footprint 15 is about 10 K. So in this example, higher temperatures produce an error amount that is about 40% higher than the cooler temperatures.

Recalling that each Level 1B AMSU data file contains six minutes of data, the chart above is saying that in those six minutes a temperature drop of between 3 K and 7 K was detected.

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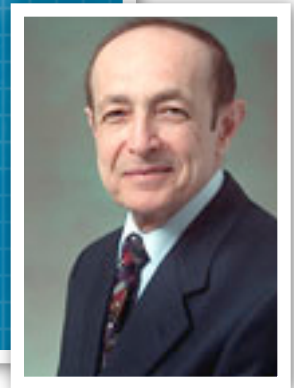
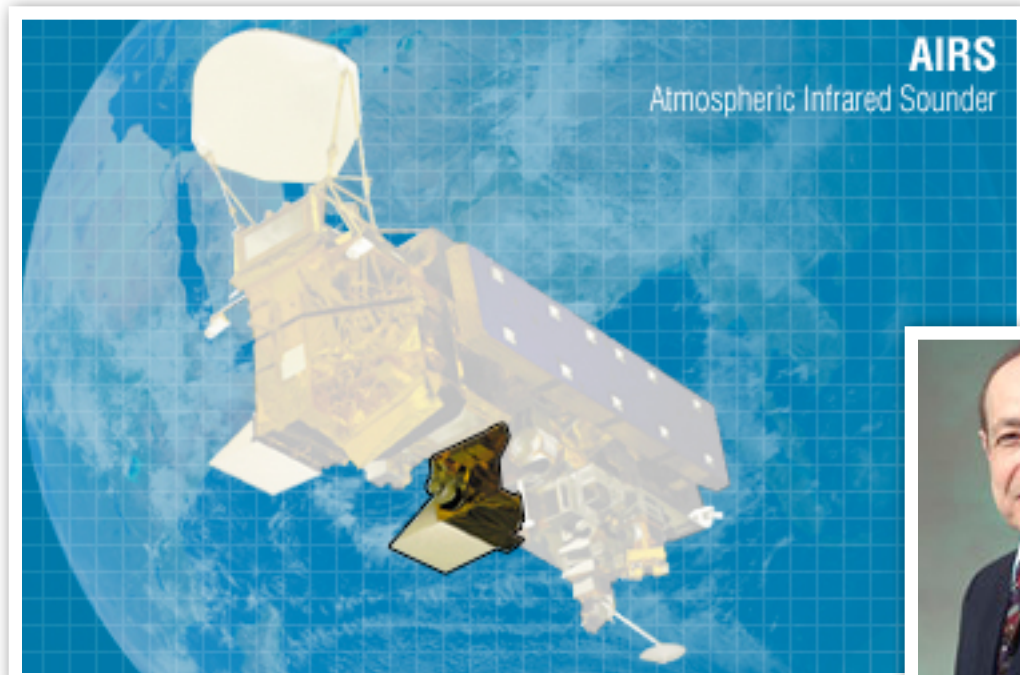
Each channel is multiplied by a weight constant, as shown in the diagram to the left.



The UAH data obtained from the AMSU has a margin of error of ± 0.5 degrees C. This is the margin of error for the absolute temperature, as opposed to the change in temperature over time (called the anomaly). If the error of the absolute temperature is constant, then the anomaly value is useful even though the change is smaller than the margin of error for the absolute temperature reading.

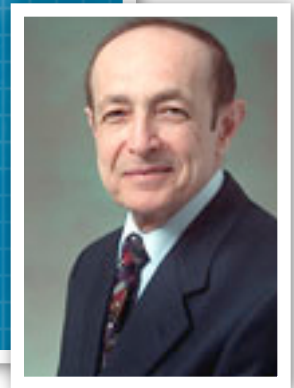
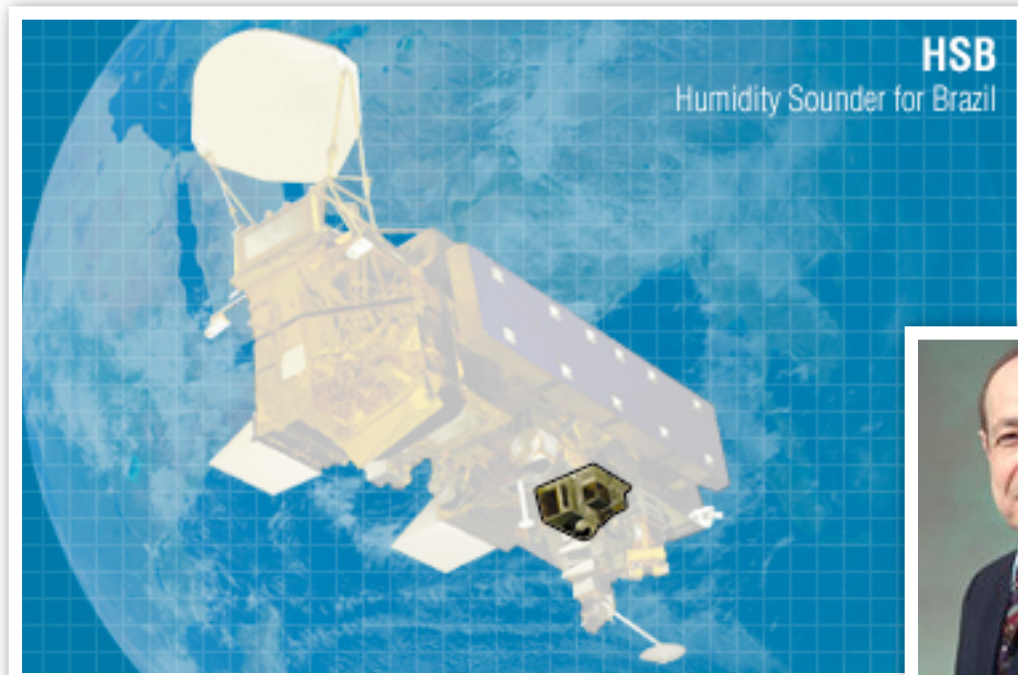
I assume the margin of error is believed to be constant. If it's actually, say, 0.3 in one reading than it's 0.3 in all readings. Otherwise the UAH anomaly data is useless, as the anomaly is significantly smaller than the margin of error.

Atmospheric Infrared Sounder (AIRS)



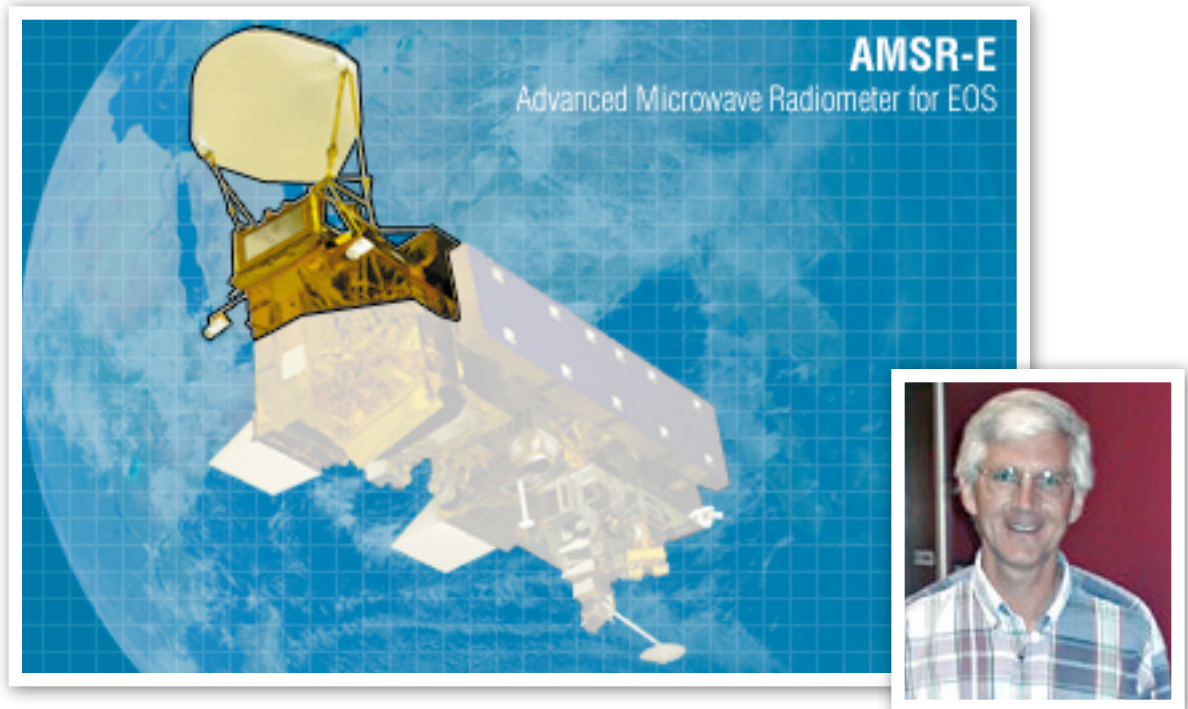
The Atmospheric Infrared Sounder (AIRS), an advanced sounder containing 2378 infrared channels and four visible/near-infrared channels, aimed at obtaining highly accurate temperature profiles within the atmosphere plus a variety of additional Earth/atmosphere products. AIRS will be the highlighted instrument in the AIRS/AMSU-A/HSB triplet centered on measuring accurate temperature and humidity profiles throughout the atmosphere.

Humidity Sounder for Brazil (HSB)



The Humidity Sounder for Brazil (HSB), a 4-channel microwave sounder provided by Brazil aimed at obtaining humidity profiles throughout the atmosphere. The HSB is the instrument in the AIRS/AMSU-A/HSB triplet that allows humidity measurements even under conditions of heavy cloudiness and haze. The HSB provided high quality data until February 2003.

Advanced Microwave Scanning Radiometer for EOS (AMSR-E)

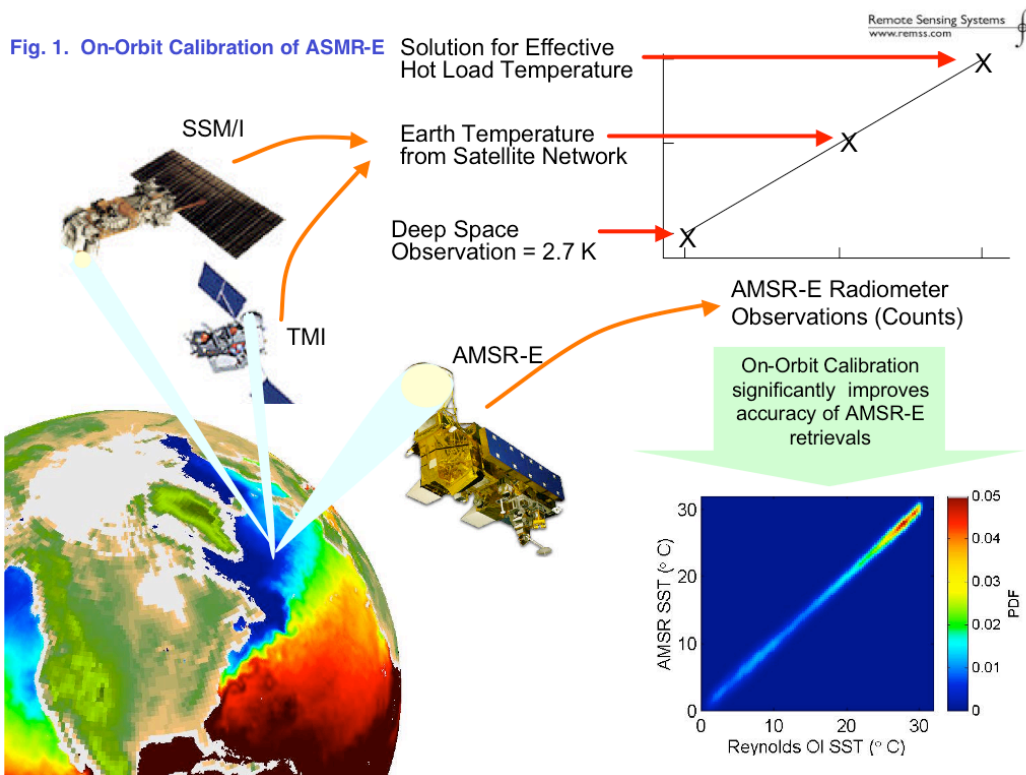


The Advanced Microwave Scanning Radiometer for EOS (AMSR-E) is a twelve-channel, six-frequency, total power passive-microwave radiometer system. It measures brightness temperatures at 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz. Vertically and horizontally polarized measurements are taken at all channels. The Earth-emitted microwave radiation is collected by an offset parabolic reflector 1.6 meters in diameter that scans across the Earth along an imaginary conical surface, maintaining a constant Earth incidence angle of 55° and providing a swath width array of six feedhorns which then carry the radiation to radiometers for measurement. Calibration is accomplished with observations of cosmic background radiation and an on-board warm target. Spatial resolution of the individual measurements varies from 5.4 km at 89.0 GHz to 56 km at 6.9 GHz.

Instrument characteristics

- Passive microwave radiometer, twelve channels, six frequencies, dual polarization, conically scanning.
- Measures precipitation rate, cloud water, water vapor, sea surface winds, sea surface temperature, ice, snow, and soil moisture.
- All-weather measurements of geophysical parameters supporting several global change science and monitoring efforts.
- External cold load reflector and a warm load for calibration.
- Offset parabolic reflector, 1.6 m in diameter, and rotating drum at 40 rpm.
- Multiple feedhorns (6) to cover six bands from 6.9 to 89 GHz with 0.3 to 1.1 K radiometric sensitivity; vertical and horizontal polarization.

AMSR-E Calibration



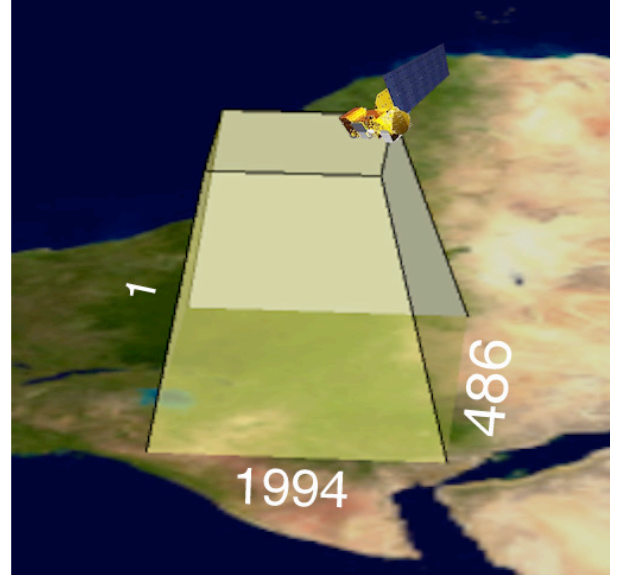
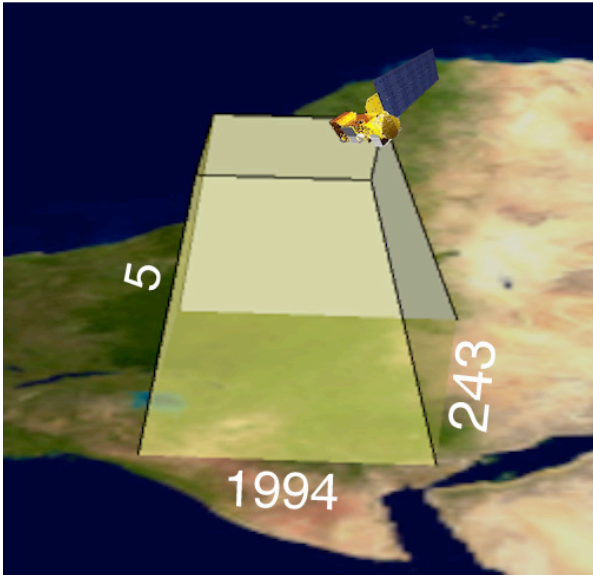
The AMSR-E calibration method takes a reading from Earth and compares it against readings from other satellites measuring the same location and time.

From this additional information, the Earth temperature reading for the Aqua satellite is calibrated. Then based on the temperature of the CBR and the calibrated Earth temperature, the hot load temperature is extrapolated.

Because of this, the calibration of AMSR-E is dependent upon the calibration of these other satellites. These satellites are the TMI and SSM/I satellites. The SSM/I satellite uses the CBR and hot load calibration method that Aqua originally intended to use. The TMI satellite uses statistical analysis and calibration information from the SSM/I satellite.

The end result of this process is the AMSR-E is calibrated without the need for ground-based temperature measurements.

AMSR-E Scanning



The AMSR-E scans at low resolution and at high resolution.

For low resolution, the AMSR-E scans 1994 times in the same direction as the satellite is moving. Each of these 1994 scans contains 243 readings perpendicular to the movement of the satellite (called Footprints), and each of these 243 readings contains 5 channels, each at a different frequency.

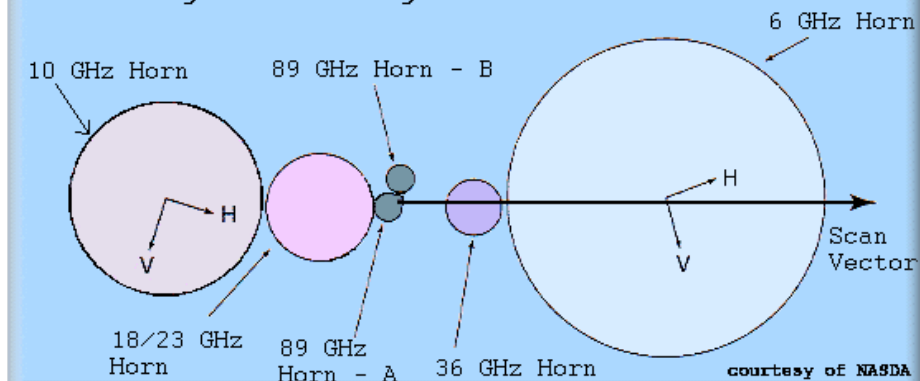
For high resolution scans the AMSR-E scans 1994 times in the same direction as the satellite is moving. Each of these 1994 scans contains 486 readings perpendicular to the movement of the satellite, and each of these 486 readings contains 1 channel at a frequency of 89.0 GHz.

The different frequencies are used to measure different attributes of the Earth, as shown in the table below.

Frequency	Measurement
6.9 GHz	Sea Surface Temperature, Soil Moisture, Vegetation
10.7 GHz	Sea Surface Temperature, Wind Speed
18.7 GHz	Wind Speed, Water Vapor
23.8 GHz	Unknown
36.5 GHz	Cloud Liquid Water
89 GHz	Rain Rate

The Aqua Satellite

Horn Alignment Along Scan

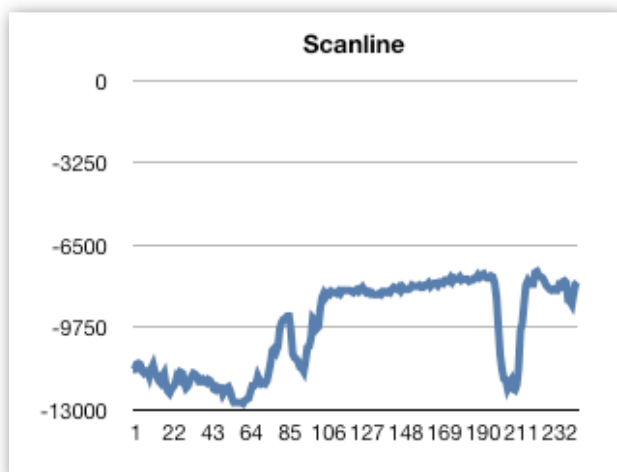


The AMSR-E instrument has 6 channels, or "horns" it uses to collect data from the Earth. A physical description of the horns appears in the image above and their technical specifications, including which data products (Level 1B and/or Level 2A products) their readings appear in, are described in the table below.

AMSR-E Spatial Characteristics of Observations

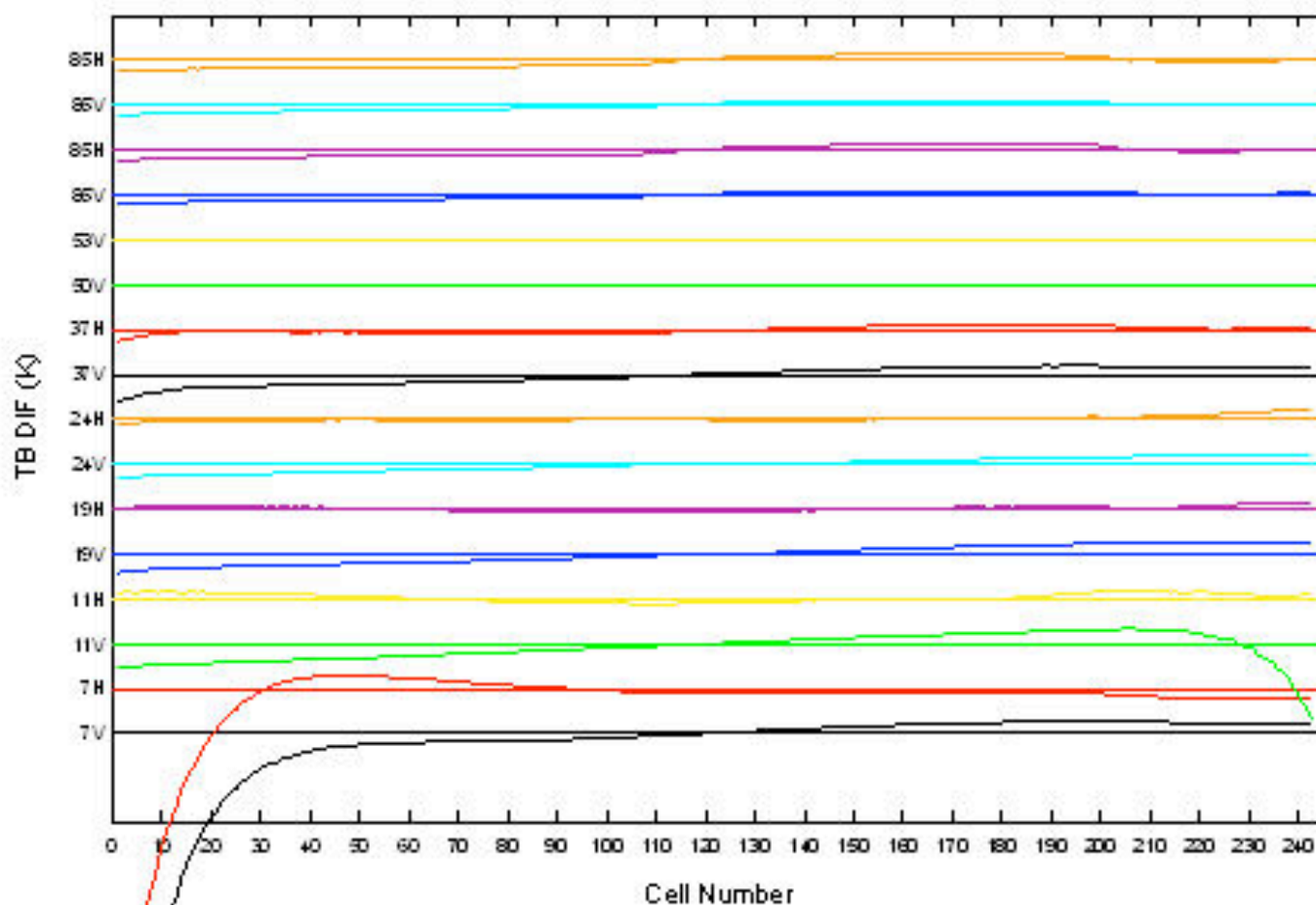
Resolution	Foot print	Mean spatial resolution	89.0 GHz	36.5 GHz	23.8 GHz	18.7 GHz	10.7 GHz	6.9 GHz
1	75 km x 43 km	56 km	•	•	•	•	•	• o
2	51 km x 29 km	38 km	•	•	•	•	• o	
3	27 km x 16 km	21 km	•	•	• o	o		
4	14 km x 8 km	12 km	•	o				
5	6 km x 4 km	5.4 km	o					

- Includes Level-2A (smoothed) data
- o Includes Level 1B (unsmoothed) data at original spatial resolution



The actual data for frequency 36.5, which the cloud liquid water frequency, is shown here. It shows a single scan line. The data is the vertical scan results at resolution 4.

The Aqua Satellite



An Along-scan error is caused by AMSR-E's cold mirror or warm load entering the FOV of the feedhorns, or by the main reflector seeing part of the spacecraft. The RSS performed an analysis of the AMSR-E along-scan error and developed a correction.

In spite of RSS's best efforts to accomplish a robust AMSR-E along-scan temperature correction, users should note that some contamination remains in the 14 pixels at the beginning of each scan line. Users should determine whether to include those pixels based on their specific research application and the effects of the contamination described below.

In early 2007, researchers at NSIDC conducted an along-scan error analysis by examining brightness temperature distributions for each sample position in three different, relatively uniform climatic regions over a sufficiently long time period to eliminate effects from random, transient events. The three regions included a portion of Antarctica, an area of the Indian Ocean south of Australia, and an area of African jungle in the Salonga National Park region of the Democratic Republic of the Congo.

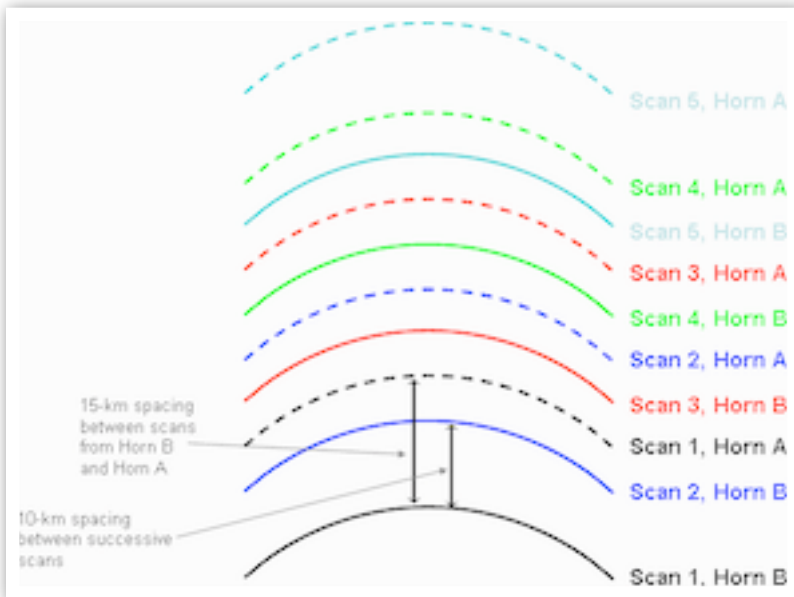
NSIDC concluded that even after the RSS along-scan correction, a significant cold bias remains in brightness temperature measurements in all channels over Antarctic regions from the beginning of each scan line,. There is also some evidence of a cold bias in 7 GHz channels over jungle areas. There does not appear to be a bias in any channels observing ocean areas.

The Aqua Satellite

At the 89 GHz scan resolution, the AMSR-E instrument was originally designed to collect data from the Earth using two "horns", called the A Horn and the B Horn. These horns provided coverage to different areas in a scan and together provided full information for the scan. A diagram of this process is presented here.



On November 11th, 2004 the 89 GHz A Horn of the AMSR-E instrument failed. It no longer provides data. To correct for this, the processing software was modified to use only the 89 GHz B Horn. The A Horn data still appears in the data files as zero value data.



AMSR-E Source Code



The National Snow And Ice Data Center provides to the public all its source code that processes AMSR-E data.

Ordering The Source Code

The source code is stored in 9 folders that NSIDC calls Delivered Algorithm Packages (DAPs). You must order the source code before you download it. This is done by sending off a request to their User Services Department using [this form](#). Just tell them you'd like to download the DAPs and they will give you instructions on how to register and download the DAPS via FTP.

Some of the DAPS also use the [PORT Mathematical Subroutine Library](#).



Recall that the AMSR-E scans detects both the H and V polarization of light. The H and V values are what allows the source code to detect land, rain, wind, and other characteristics. It's the source code that actually detects these characteristics, not the satellite.



You'll see the term TB used throughout the code. This is shorthand for Brightness Temperature.



The data files in the `anc` folder are binary files, so if you want to see what data they contain, you'll need to write a translation program to convert them to ASCII text. See the the Fortran file `ancdata.blk` in the `src/land/level2/common` folder for a description of the data in each data file.

The Code

The code you'll get is written in Fortran and C. There are also data files required by each DAP. Each DAP comes in its own folder and each folder contains a zip file of the source and data files, as well as some read-me files. After you unzip the files, you'll find the source code in the `src` folder and the data files in the `anc` folder.

A walkthrough of the nine DAPs is provided below.

Input File	Level 2A Brightness Temperature File
Output File	Level 2 Land File
Data Produced	Soil Moisture, Vegetation Water Content, Land Surface Temperature, Surface Type
Uses PORT?	Yes
Platform	Linux

L2_Land

Inputs

The source code uses the Level 2A Brightness Temperature file as well as several data files as input. The data files are stored in the `anc` folder that comes with the source.

The Aqua Satellite

Source Code

The source code is located in the `src/land/level2` folder. There are three main groups of source code: C code, Fortran code, and common code located in the `common` folder. The C code is used mainly for QA and I/O purposes. It's the Fortran code that does the real work. The code in the `common` folder is also Fortran code, stored as reusable blocks.

The main file is `amsre_l2main.f`. This file will call all the other code as needed. Overall, the program performs the following processes:

- 1) Ingest ancillary databases and external parameters.
- 2) Ingest AMSR-E Level 2A TB data.
- 3) Grid TB data on EASE-grid projection.
- 4) Export gridded TB data.
- 5) Perform geophysical retrieval.
- 6) Export results/flags as Level 2B land product.

Other source files of note are:

`dobsonv3.f` Compute the dielectric constant of soil as a function of frequency, soil moisture, sand/clay fractions, and surface temperature.

`fmod_pr3ch.f` Compute TB as a function of the 6.9, 10.7, and 18.7 frequencies.

`fmod_regrs.f` Compute vegetation water content and soil moisture as a function of the 10.7, and 18.7 frequencies.

`fmod_tb4ch.f` Compute R squared and Chi values based on the 10.7, and 18.7 frequencies and values calculated in `dobsonv3.f`.

`fmod_tb6ch.f` Compute R squared and Chi values based on the 6.9, 10.7, and 18.7 frequencies and values calculated in `dobsonv3.f`.

Execution

AMSRE_L2MAIN executes with 5 command-line arguments:

```
amsre_l2main.exe INPUT_L2A ANCIL_DIR L2B_DIR GTB_DIR PMC_VER
```

INPUT_L2A: Filename of the input Level 2A data file

ANCIL_DIR: Directory of ancillary databases

L2B_DIR: Directory of output Level 2B data files

GTB_DIR: Directory of gridded TB data files

PMC_VER: Product maturity code and PGE version number



NOTE: This program is designed to execute on big endian machines.

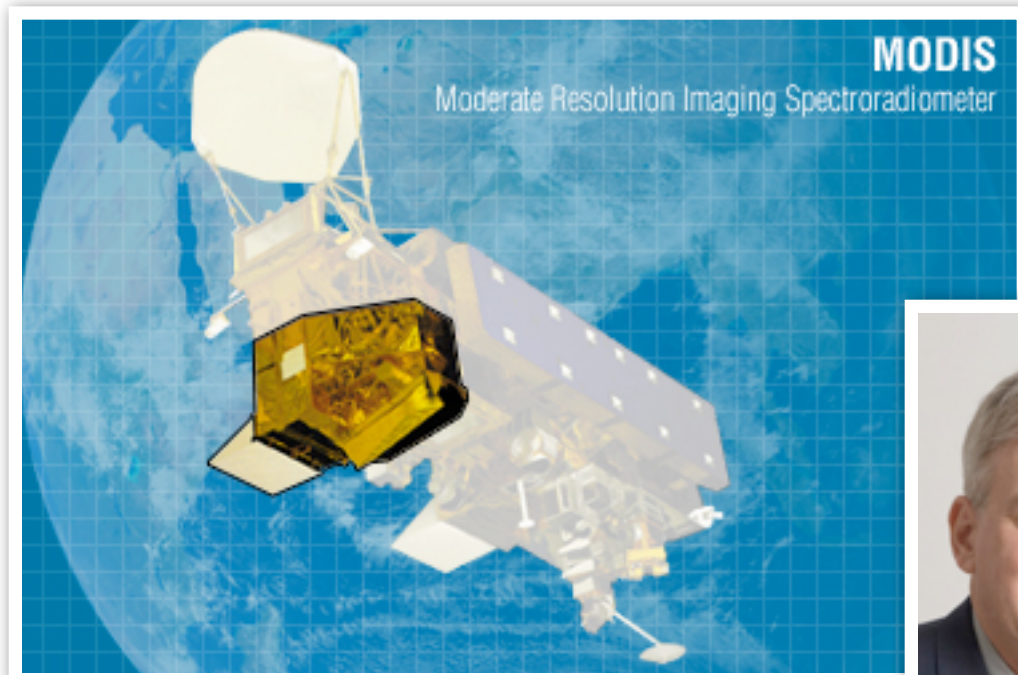
Output

The Level 2B land product contains surface type, surface moisture, land temperature, and vegetation water content information for the Earth.

Additional Information

Useful documentation on the algorithms is available at [AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Params, & QC EASE-Grids](#).

Moderate Resolution Imaging Spectroradiometer (MODIS)

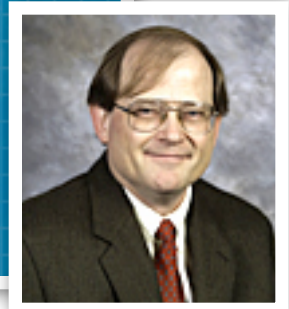
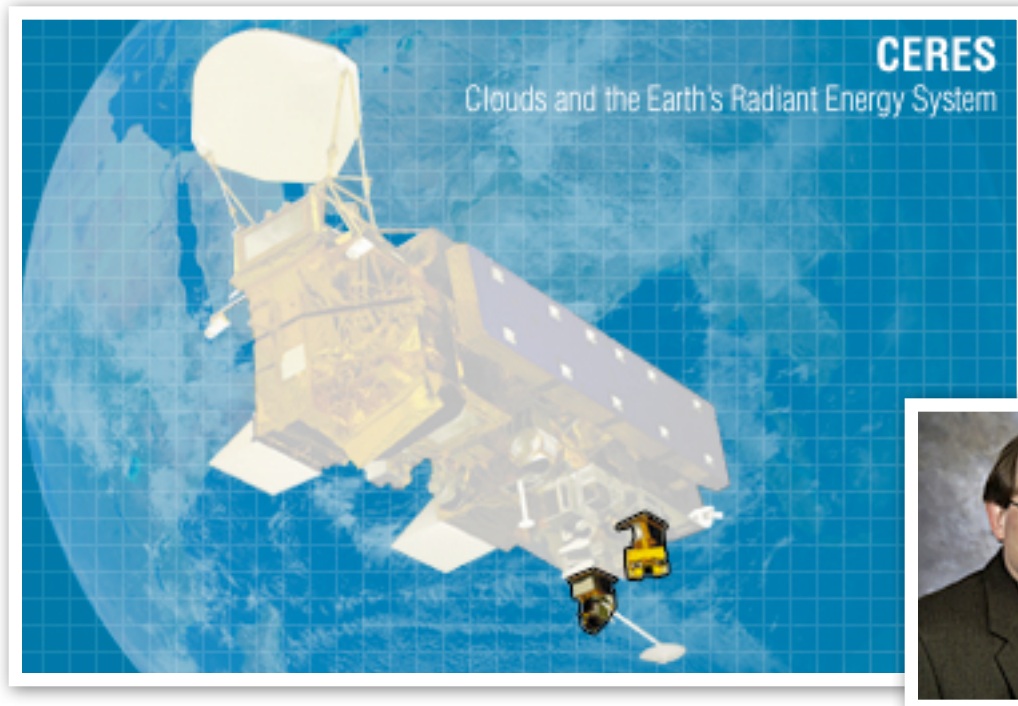


The Moderate Resolution Imaging Spectroradiometer (MODIS), is a 36-band spectroradiometer measuring visible and infrared radiation and obtaining data that are being used to derive products ranging from vegetation, land surface cover, and ocean chlorophyll fluorescence to cloud and aerosol properties, fire occurrence, snow cover on the land, and sea ice cover on the oceans. The first MODIS instrument was launched on board the Terra satellite in December 1999, and the second was launched on Aqua in May 2002.

Instrument characteristics

- Selected for flight on Terra (launched Dec. 1999) and Aqua.
- Medium-resolution, multi-spectral, cross-track scanning radiometer.
- Measures physical properties of the atmosphere, and biological and physical properties of the oceans and land.
- 36 spectral bands—21 within 0.4-3.0 μm ; 15 within 3-14.5 μm .
- Continuous global coverage every 1 to 2 days.
- Signal-to-noise ratios from 900 to 1300 for 1 km ocean color bands at 70° solar zenith angle.
- NEDT's typically < 0.05 K at 300K.
- Absolute irradiance accuracy of 5% for <3 μm and 1% for >3 μm .
- Daylight reflection and day/night emission spectral imaging.

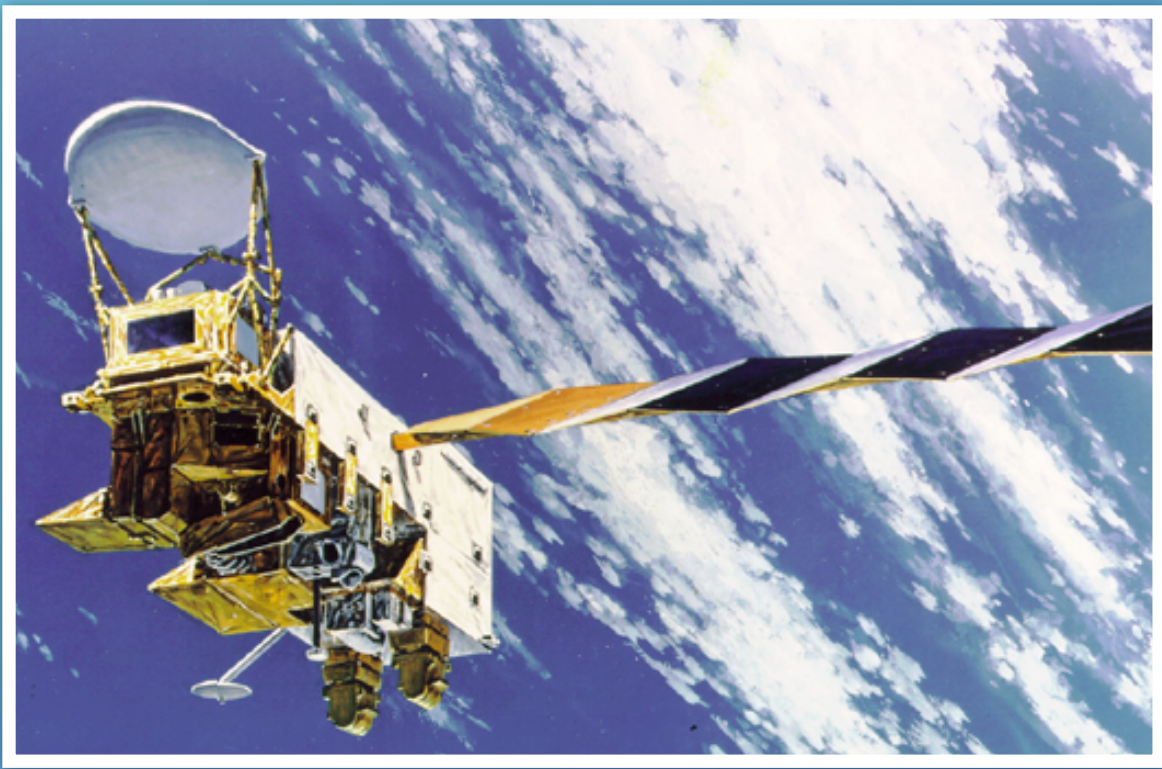
Cloud's and the Earth's Radiant Energy System (CERES)



The Cloud's and the Earth's Radiant Energy System (CERES) is a 3-channel radiometer measuring reflected solar radiation in the 0.3-5 μm wavelength band, emitted terrestrial radiation in the 8-12 μm band, and total radiation from 0.3 μm to beyond 100 μm . These data are being used to measure the Earth's total thermal radiation budget, and, in combination with MODIS data, detailed information about clouds. The first CERES instrument was launched on the Tropical Rainfall Measuring Mission (TRMM) satellite in November 1997; the second and third CERES instruments were launched on the Terra satellite in December 1999; and the fourth and fifth CERES instruments are on board the Aqua satellite.

Instrument characteristics

- Selected for flight on TRMM, Terra, and Aqua.
- Two broadband, scanning radiometers: One cross-track mode, one rotating azimuth plane (bi-axial scanning).
- First instrument (cross-track scanning) is continuing ERBE, TRMM, and Terra measurements and the second (biaxially scanning) is providing angular radiance information to improve the accuracy of angular models used to derive the Earth's radiative balance.
- Single scanner on TRMM mission (launched Nov. 1997)
- Dual scanners on Terra (launched Dec. 1999) and Aqua, and single thereafter.



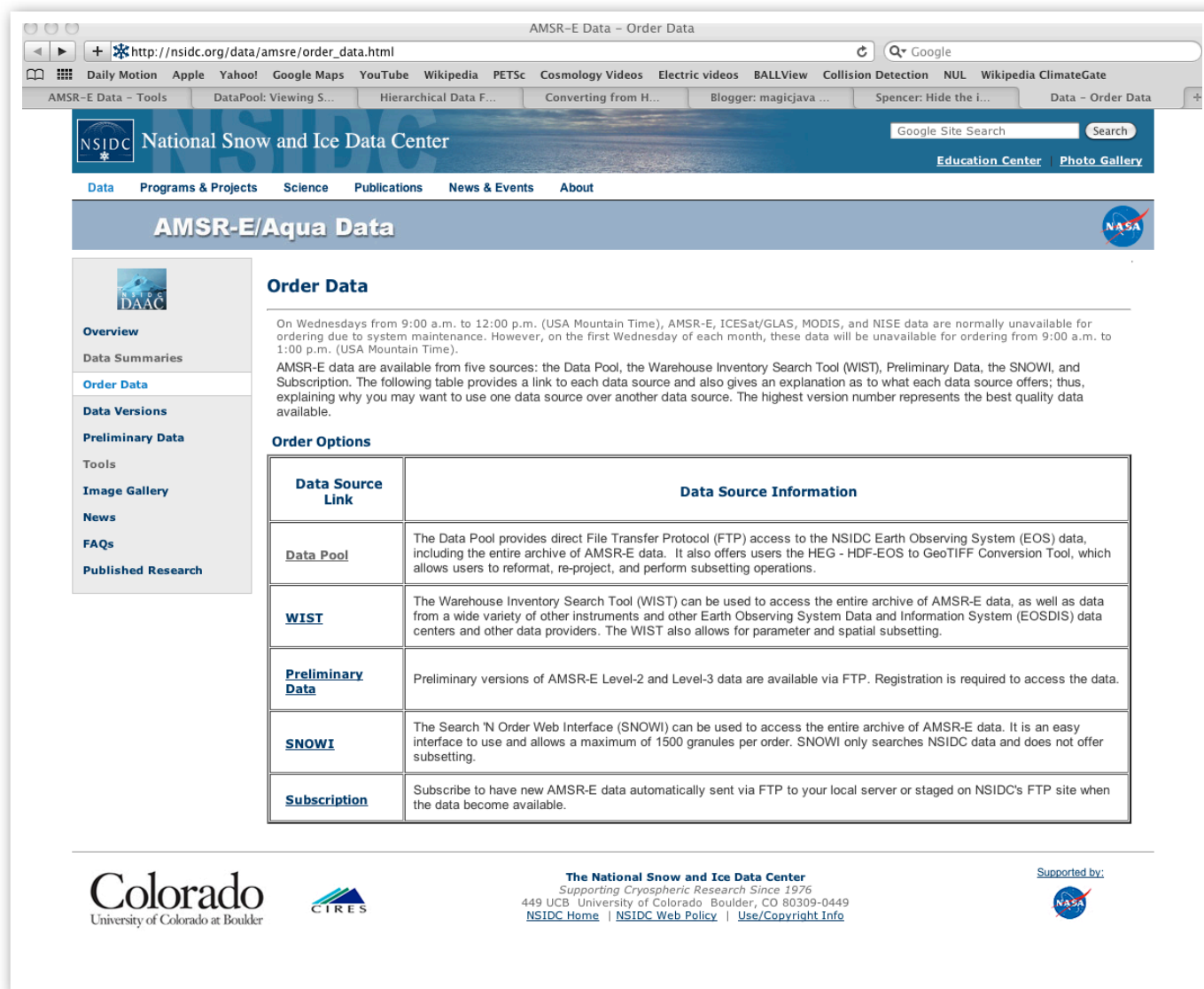
Appendix A

Downloading Data

Downloading Data

Downloading Aqua AMSR-E Data From The National Snow And Ice Data Center

In a browser, open the National Snow and Ice Data Center (NSIDC) AMSR-E Order Form at http://nsidc.org/data/amsre/order_data.html



The screenshot shows a web browser window with the URL http://nsidc.org/data/amsre/order_data.html. The page is titled "AMSR-E Data - Order Data" and features the NSIDC logo and navigation links. The main content area is titled "AMSR-E/Aqua Data" and includes a sidebar with links to Overview, Data Summaries, Order Data, Data Versions, Preliminary Data, Tools, Image Gallery, News, FAQs, and Published Research. The "Order Data" section contains a paragraph about data availability and a table of "Order Options".

Order Data

On Wednesdays from 9:00 a.m. to 12:00 p.m. (USA Mountain Time), AMSR-E, ICESat/GLAS, MODIS, and NISE data are normally unavailable for ordering due to system maintenance. However, on the first Wednesday of each month, these data will be unavailable for ordering from 9:00 a.m. to 1:00 p.m. (USA Mountain Time).


AMSR-E data are available from five sources: the Data Pool, the Warehouse Inventory Search Tool (WIST), Preliminary Data, the SNOWI, and Subscription. The following table provides a link to each data source and also gives an explanation as to what each data source offers; thus, explaining why you may want to use one data source over another data source. The highest version number represents the best quality data available.

Data Source Link	Data Source Information
Data Pool	The Data Pool provides direct File Transfer Protocol (FTP) access to the NSIDC Earth Observing System (EOS) data, including the entire archive of AMSR-E data. It also offers users the HEG - HDF-EOS to GeoTIFF Conversion Tool, which allows users to reformat, re-project, and perform subsetting operations.
WIST	The Warehouse Inventory Search Tool (WIST) can be used to access the entire archive of AMSR-E data, as well as data from a wide variety of other instruments and other Earth Observing System Data and Information System (EOSDIS) data centers and other data providers. The WIST also allows for parameter and spatial subsetting.
Preliminary Data	Preliminary versions of AMSR-E Level-2 and Level-3 data are available via FTP. Registration is required to access the data.
SNOWI	The Search 'N Order Web Interface (SNOWI) can be used to access the entire archive of AMSR-E data. It is an easy interface to use and allows a maximum of 1500 granules per order. SNOWI only searches NSIDC data and does not offer subsetting.
Subscription	Subscribe to have new AMSR-E data automatically sent via FTP to your local server or staged on NSIDC's FTP site when the data become available.

Colorado
University of Colorado at Boulder

CIRES

The National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976
449 UCB University of Colorado Boulder, CO 80309-0449
[NSIDC Home](#) | [NSIDC Web Policy](#) | [Use/Copyright Info](#)

Supported by:


On the Order Data Screen, click the **Data Pool** link.

DataPool: Selecting ESDT...

http://n4eil01u.ecs.nasa.gov:22000/WebAccess/drill?attrib=group&group=AMSA&

Google

AMSRE Data - Tools | Viewing Search Res... | Hierarchical Data F... | Converting from H... | Blogger: magicjava ... | Spencer: Hide the i... | Selecting ESDT...

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Note: Java, Version 6 is required if using the Data Pool map interface. To download, please go to <http://www.java.com/>

Alert: The AMSR-E/Aqua Daily L3 12.5 km Brightness Temperatures, Sea Ice Concentration, & Snow Depth Polar Grids (AE_SI12) product using the V11 algorithm contains an error in the Snow Depth on Sea Ice parameter in data prior to 05 October 2009. Users of this product should use caution when working with the Northern Hemisphere Snow Depth on Sea Ice parameter in data prior to 05 October 2009 until the data have been reprocessed with the V12 algorithm. We apologize for the inconvenience.

Please contact [NSIDC User Services](#) for assistance.

To continue, please select a value for **Data Set** by clicking a link in the table below. Each link in the Data Set column below takes you to a set of Temporal values for which that product is available.

Data Set	Description	Granule Count
AE_5DSno.2	AMSR-E/Aqua level 3 5-day products are of global snow water equivalent on EASE-Grids.	540
AE_DyOcn.2	AMSR-E/Aqua global ocean level 3 daily products are on .25 x .25 degree ascending and descending grids. Products are generated using the level 2B ocean products as input.	2720
AE_DySno.2	AMSR-E/Aqua level 3 daily products are of global snow water equivalent on EASE-grids.	2721
AE_L2A.2	AMSR-E/Aqua global swath brightness temperatures are resampled at resolutions of 56 km, 38 km, 21 km, 12 km, and 5.4 km.	78854
AE_Land.2	AMSR-E/Aqua global swath surface soil moisture and ancillary parameters including surface type, vegetation water content, surface temp., and QC parms are generated from level 2A AMSR-E Tb's spatially resampled to a nominal 25-km equal area earth grid.	78831
AE_Land3.2	AMSR-E/Aqua level 3 global daily surface soil moisture with vegetation water content, surface temp., & Tb's are generated on a nominal 25-km equal area earth grid by time-compositing the level 2B parameters separately for ascending and descending passes.	2721
AE_MoOcn.2	AMSR-E/Aqua global ocean level 3 monthly products are on .25 x .25 degree ascending and descending grids. Products are generated using the level 2B ocean parameters as input.	90
AE_MoSno.2	AMSR-E/Aqua level 3 products are of monthly global snow water equivalent on EASE-Grids.	91
AE_Ocean.2	AMSR-E/Aqua global swath ocean wind speed at 38 and 21 km res., water vapor over ocean at 21 km res., cloud liquid water at 12 km res., and sea surface temperature at 56 and 38 km res. are generated using the Wentz Algorithm and level 2A product.	78854
AE_Rain.2	AMSR-E/Aqua global swath rain rate and rain type products are generated using the level 2A spatially resampled Tb's and the Goddard Profiling Algorithm (GPROF).	78851

On the DataPool screen, click the [AE_L2A.2](#) link. This contains the AMSR-E/Aqua global swath brightness temperatures data.

DataPool: Selecting Date...

http://n4eil01u.ecs.nasa.gov:22000/WebAccess/drill?attrib=esdt&esdt=AE_L2A.2&group=AMSA

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Daily Motion Apple Yahoo! Google Maps YouTube Wikipedia PETSc Cosmology Videos Electric videos BALLView Collision Detection NUL Wikipedia ClimateGate

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Note: Java, Version 6 is required if using the Data Pool map interface. To download, please go to <http://www.java.com/>

Alert: The AMSR-E/Aqua Daily L3 12.5 km Brightness Temperatures, Sea Ice Concentration, & Snow Depth Polar Grids (AE_S12) product using the V11 algorithm contains an error in the Snow Depth on Sea Ice parameter in data prior to 05 October 2009. Users of this product should use caution when working with the Northern Hemisphere Snow Depth on Sea Ice parameter in data prior to 05 October 2009 until the data have been reprocessed with the V12 algorithm. We apologize for the inconvenience.

Please contact [NSIDC User Services](#) for assistance.

Current Search Criteria

You may click on a hyperlinked criterion to go back and resume the drill-down from that point.

Data Group	AMSA
Data Set	AE_L2A.2

The above search criteria would return approximately **79378 granules** which is about **4166144.2 MB** of data.

Your options are:

- [Select a value \(or a range\)](#) for **Date**.
- Skip Temporal and move on to **Time of Day**
- [Get the granules](#) that match the above criteria. **Note:** Search exceeds max. result limit (500 granules). Result set will be truncated.
- [Start a new search](#)

Select a Day, Week or Month

Note: Each count (in red) represents the hits of all granules for that date range (a day is treated as a range as is a week). As such, sums of counts will not add up correctly (e.g., the hits for all of the days of the week will not total the displayed hits for that week).

[2002](#) > [2003](#) > [2004](#) > [2005](#) > [2006](#) > [2007](#) > [2008](#) > [2009](#) > 2010

January
350

	SUN	MON	TUE	WED	THU	FRI	SAT	Weeks of the Year
January						01	02	Week 1
February						30	30	59
March	03	04	05	06	07	08	09	Week 2
April	30	30	31	30	30	30	30	205
May	10	11	12	13	14	15	16	Week 3
June	30	30	30	1				88
July	17	18	19	20	21	22	23	Week 4
August								
September								
October								

Now you're at the data selection screens. This is a group of screens that let you select the date and time of the data you want, as well as spatial and day/night data. NOTE: Daily data can range in size from 1 to 2.5 GB! So you're not going to want to download tons of data at a time. Stick to small date ranges, probably one or two days.

If you're interested in a specific date range. use the calendar at the bottom of the screen.

DataPool: Selecting Time...

http://n4eil01u.ecs.nasa.gov:22000/WebAccess/drill?attrib=date&beginDate=2010-01-12&endDate=2010-01-12&esdt=A

Google

Daily Motion Apple Yahoo! Google Maps YouTube Wikipedia PETSc Cosmology Videos Electric videos BALLView Collision Detection NUL Wikipedia ClimateGate

AMSR-E Data - Tools Viewing Search Res... Hierarchical Data F... Converting from H... Spencer: Hide the i... Selecting Time... Blogger: magicjava ...

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Note: Java, Version 6 is required if using the Data Pool map interface. To download, please go to <http://www.java.com/>

Alert: The AMSR-E/Aqua Daily L3 12.5 km Brightness Temperatures, Sea Ice Concentration, & Snow Depth Polar Grids (AE_S12) product using the V11 algorithm contains an error in the Snow Depth on Sea Ice parameter in data prior to 05 October 2009. Users of this product should use caution when working with the Northern Hemisphere Snow Depth on Sea Ice parameter in data prior to 05 October 2009 until the data have been reprocessed with the V12 algorithm. We apologize for the inconvenience.

Please contact [NSIDC User Services](#) for assistance.

Current Search Criteria

You may click on a hyperlinked criterion to go back and resume the drill-down from that point

Data Group	AMSA
Data Set	AE_L2A.2
Date	2010-01-12 - 2010-01-12

The above search criteria would return approximately **30 granules** which is about **1544.688 MB** of data.

Your options are:

- [Select a value](#) (or a [range](#)) for Time-of-Day.
- Skip Time_of_Day and move on to [Spatial](#)
- [Get the granules](#) that match the above criteria.
- [Start a new search](#)

Select a Time of Day (GMT)
 On the Hour or [On the Half Hour](#)

00:00-01:00 4	01:00-02:00 2	02:00-03:00 2	03:00-04:00 2	04:00-05:00 2	05:00-06:00 3
06:00-07:00 2	07:00-08:00 2	08:00-09:00 2	09:00-10:00 2	10:00-11:00 3	11:00-12:00 2
12:00-13:00 2	13:00-14:00 2	14:00-15:00 3	15:00-16:00 2	16:00-17:00 2	17:00-18:00 2
18:00-19:00 2	19:00-20:00 3	20:00-21:00 2	21:00-22:00 2	22:00-23:00 2	23:00-24:00 3

The next screen let's me you the time of day you're interested in. If you're interested in the entire day and don't want to set any day/night or spatial options you can skip this section.

After you've selected any time options you want, move on to the download screen. You do this by clicking the **Get the granules that match the above criteria** link in the middle of the screen.

DataPool: Viewing Search Results...

http://n4eil01u.ecs.nasa.gov:22000/WebAccess/granule?endDate=2010-01-12&sdt=AE_L2A.2&beginDate=2010-01-12

Google

AMSRE-E Data - Tools DataPool: Viewing S... Hierarchical Data F... Converting from H... Spencer: Hide the i... DataPool: Viewing S... Blogger: magicjava ...

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EOS Data Pool @ NSIDC
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Note: Java, Version 6 is required if using the Data Pool map interface. To download, please go to <http://www.java.com/>

Alert: The AMSR-E/Aqua Daily L3 12.5 km Brightness Temperatures, Sea Ice Concentration, & Snow Depth Polar Grids (AE_S12) product using the V11 algorithm contains an error in the Snow Depth on Sea Ice parameter in data prior to 05 October 2009. Users of this product should use caution when working with the Northern Hemisphere Snow Depth on Sea Ice parameter in data prior to 05 October 2009 until the data have been reprocessed with the V12 algorithm. We apologize for the inconvenience.

Please contact [NSIDC User Services](#) for assistance.

Results for Your Search

Your [search criteria](#) and [results](#) are listed below. If you are not satisfied with your results, you may re-visit your criteria selections by clicking on the links in the Search Criteria table below. You may also [create a new search](#) at any time.

Search Criteria

You may click on a hyperlinked criterion to go back and resume the drill-down from that point

Data Group	AMSA
Data Set	AE_L2A.2
Date	2010-01-12 - 2010-01-12

The above search criteria returned **30 granules** which is about **1544.688 MB** of data.

Results

- 30 AE_L2A.2 granules were found. Average granule size is approximately 51.490 MB.
- The total size of the results set is approximately 1544.688 MB.

Granule	Size (MB)	Date		Time		Day/ Night
		Begin	End	Begin	End	
SC:AE_L2A.2:35160180	52.043	2010-01-11	2010-01-12	23:18:32	00:08:21	NULL
SC:AE_L2A.2:35160505	51.944	2010-01-12	2010-01-12	17:26:12	18:16:04	NULL
SC:AE_L2A.2:35160519						

Now you're at the screen showing the results of the search. At the bottom of this screen is a list of "granules" that matched your search. These granules are the data files to be downloaded. If you look at the top of the Results box at the bottom of the screen, you'll see that the first 10 granules out of 30 granules are being displayed. You'll also see controls for displaying the other granules.

We start downloading by right-clicking the link to each granule and selecting Download. You can see the links to the granules on the left side of the Results box at the bottom of the screen. The first link in this example is named SC:AE_L2A.2:35160180. There's a row for each granule. Download 10, then go to the 2nd screen, download 10 more, then go to the 3rd screen and download the last 10.

Congratulations, you've downloaded your AMSR-E data from NSIDC.

Downloading Aqua AMSR Data From NASA

In a browser, open the NASA AIRS data holdings web page at <http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings>

AIRS
Atmospheric InfraRed Sounder

You are here: [GES DISC Home](#) » [AIRS](#) » Data Holdings

DATA PRODUCTS

The anomaly found in the AVI (Global Forecast System) data that GES DISC receives from NOAA to produce Aqua AIRS Level 2 products has been addressed. The production of level 2 and level 3 products for Aqua AIRS has been resumed.

Register as an AIRS Data User

By registering as an AIRS Data User, you will receive announcements of discovered features and caveats which are directly applicable to your area of research. You will also receive the AIRS Newsletter. For AIRS related questions, please submit to [AskAIRS](#) site.

Click the product name in **Data Product Name** column to see a summary of each data product. To obtain data for a particular product, click on the links for WHOM or Mirador search engines in the **GES DISC Data Access** column. For a complete list of data access options, please see our [DATA ACCESS](#) page.

Version 5

► Announcement for the release of AIRS Version 5.2 Data

AIRS L1B Products (Version 5)

Data Product Name	Description	Spatial Resolution	Temporal Coverage	Average Item Size (Mb)	GES DISC Data Access
AIRIBRAD	AIRS IR geolocated radiances	13.5 km @ nadir	2002-08-30 - present	56	Mirador
AIRVBRAD	AIRS Vis/Near IR geolocated radiances	2.3 km @ nadir	2002-08-30 - present	11	Mirador
AIRABRAD	AMSU-A1 & AMSU-A2 combined, geolocated & calibrated brightness temperatures	45 km @ nadir	2002-05-21 - present	0.6	Mirador
AIRHBRAD	HSB geolocated & calibrated brightness temperatures	13.5 km @ nadir	2002-05-24 - 2003-02-05	1.7	Mirador
AIRIBQAP	AIRS IR quality assurance subset	N/A	2002-08-30 - present	2.4	Mirador
AIRVBQAP	AIRS Vis/Near IR quality assurance subset	N/A	2002-08-30 - present	1.1	Mirador

On the DATA PRODUCTS Screen you'll see a table at the bottom of the screen. On the left-most column you'll see a link that provides the general data product name. The second column describes a subset of the general product data, and the right most column has a link to where the data can be retrieved.

The data you want is the AMSU-A1 & AMSU-A2 combined, geolocated & calibrated brightness temperatures, which is in the 3rd row of the table. To start the process of downloading this data, click the **Mirador** link in the right-most column of the 3rd row.

Mirador Earth Science Data Search Tool

http://mirador.gsfc.nasa.gov/cgi-bin/mirador/homepageAlt.pl?keyword=AIRABRAD

Search DISC
+ Advanced Search + GO

NASA National Aeronautics and Space Administration
Goddard Earth Sciences Data and Information Services Center

+ ATMOS COMPOSITION + HYDROLOGY + A-TRAIN + AIRS + MODELING + NEESPI + PRECIPITATION

+ GES DISC Home
Mirador
+ OVERVIEW
+ HELP CENTER
+ DATA HOLDINGS
+ VIEW CART

Mirador
Data Access Made Simple

IMPORTANT MESSAGE - Atmospheric Infrared Sounder (AIRS) Near-Real Time (NRT): January 09, 2010 - 11:00am The AIRS instrument on the Aqua spacecraft has been turned off because of an instrument anomaly. FOT engineers are currently working the issue but as of this time no ETA for returning the instrument to operations is available. [more info...](#)

You are here: [Keyword Search](#)

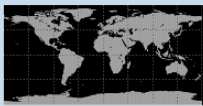
Keyword Projects Science Areas

SEARCH MIRADOR

Keyword: Location:

[Advanced Search](#)

Time Span
From: To:



[Search GES-DISC](#)

Available: [AIRS, OMI, MLS, HIRDLS, TOMS, UARS, TRMM, GLDAS, SORCE, Subsets from A-Train Sensors \(e.g MODIS, AIRS, OMI and MLS\)](#)

What's New: [View GES-DISC Data by NASA Science Area](#) [Search TRMM Orbital data by % missing data](#)

Acknowledgements:
Location Gazetteer data from: [National GeoSpatial Information Agency](#)
Events Gazetteer data from: [Unisys](#), [EPA](#) and [Smithsonian Global Volcanism Program](#)

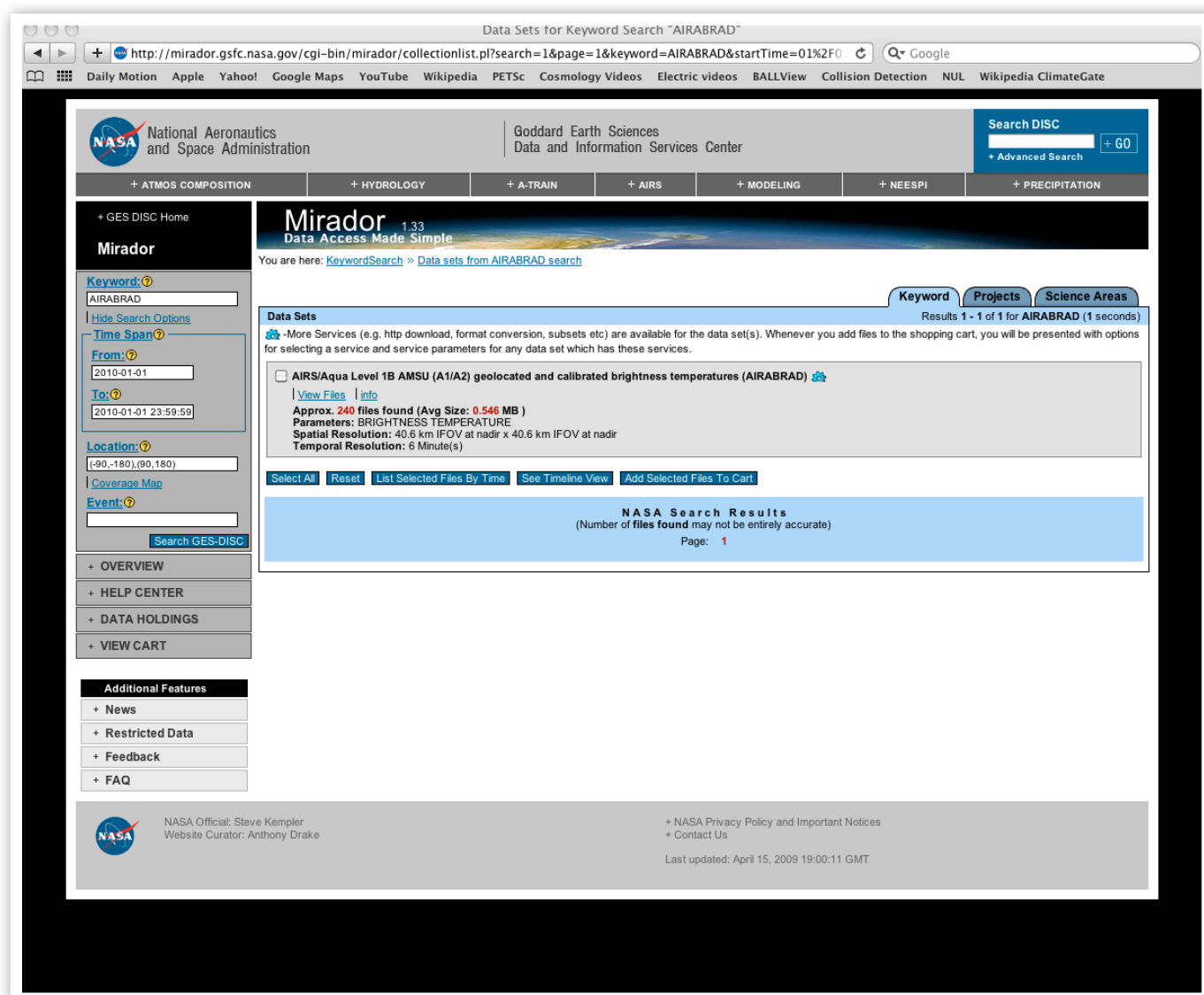
LATEST NEWS
[+ Mirador News Archive](#) [RSS](#)

NASA Official: Steve Kempler
Website Curator: Anthony Drake

+ NASA Privacy Policy and Important Notices
+ Contact Us
Last updated: December 01, 2009 17:20:44 GMT

The second screen lets you specify location and time criteria for the data. For this example, enter a date range of 01/01/2010 (in MM/DD/YYYY format) for the beginning and end ranges. Leaving the location criteria blank so that you get data for the entire planet.

Once the search criteria is entered, click the **Search GES-DISC** button on the form.



The next screen shows the results of the search. This screen is deceptively simple, showing what appears to be only one file. This isn't actually the case. There's actually dozens of files. Where the NSIDC RSS files each contained about 50 minutes of data, the NASA UAH files contain only 6 minutes of data. So you're going to get lots of files to cover just one days worth of data.

To see all the files actually in the results, click the **View Files** link below the result.

File Listing for AIRS/Aqua Level 1B AMSU (A1/A2) geolocated and calibrated brightness temperatures

http://mirador.gsfc.nasa.gov/cgi-bin/mirador/granlist.pl?page=1&dataSet=AIRABRAD&version=005&allversion=005&keyw= Google

Daily Motion Apple Yahoo! Google Maps YouTube Wikipedia PETSc Cosmology Videos Electric videos BALLView Collision Detection NUL Wikipedia ClimateGate

NASA National Aeronautics and Space Administration

Goddard Earth Sciences Data and Information Services Center

Search DISC + Advanced Search + GO

+ ATMOS COMPOSITION + HYDROLOGY + A-TRAIN + AIRS + MODELING + NEESPI + PRECIPITATION

+ GES DISC Home

Mirador

Keyword: AIRABRAD

Hide Search Options

Time Span

From: 2010-01-01

To: 2010-01-01 23:59:59

Location: (-90,-180),(90,180)

Coverage Map

Event:

Search GES-DISC

+ OVERVIEW

+ HELP CENTER

+ DATA HOLDINGS

+ VIEW CART

Additional Features

+ News

+ Restricted Data

+ Feedback

+ FAQ

Mirador 1.33
Data Access Made Simple

You are here: [Keyword Search](#) » [Data sets from AIRABRAD search](#) » [File Listing of AIRABRAD](#)

AIRS remains in standby mode
AIRS remains in standby mode, where it has been since January 9. As a result of the instrument examination, the current outlook is to bring the instrument into Science Mode around January 22. Subsequent calibration checking and adjustment process may take two additional weeks, before science data start flowing again. These are very preliminary estimates that will materialize barring any unexpected anomalies along the recovery process. [more info...](#)

Keyword Projects Science Areas

Results 1 - 15 for AIRABRAD (1 second)

Sort by time: Descending Day/night: All

AIRS/Aqua Level 1B AMSU (A1/A2) geolocated and calibrated brightness temperatures info

The following services are available for the data set(s). Whenever you add files to the shopping cart, you will be presented with options for selecting these services.

Download via HTTP Subset by Channel

Add Selected Files To Cart Add All Files in All Pages To Cart

<input type="checkbox"/> File Names/Descriptive File Names <input checked="" type="checkbox"/> Select All in Page	Start Time
<input checked="" type="checkbox"/> AIRS.2010.01.01.240.L1B.AMSU_Rad.v5.0.0.0.G10005063822.hdf (0.55 MB)	2010-01-01 23:59:24 (Day) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.239.L1B.AMSU_Rad.v5.0.0.0.G10005063912.hdf (0.55 MB)	2010-01-01 23:53:24 (Day) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.238.L1B.AMSU_Rad.v5.0.0.0.G10004083954.hdf (0.55 MB)	2010-01-01 23:47:24 (Day) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.237.L1B.AMSU_Rad.v5.0.0.0.G10004083945.hdf (0.55 MB)	2010-01-01 23:41:24 (Day) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.236.L1B.AMSU_Rad.v5.0.0.0.G10004083936.hdf (0.55 MB)	2010-01-01 23:35:24 (Day) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.235.L1B.AMSU_Rad.v5.0.0.0.G10004083935.hdf (0.55 MB)	2010-01-01 23:29:24 (Day) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.234.L1B.AMSU_Rad.v5.0.0.0.G10004083927.hdf (0.55 MB)	2010-01-01 23:23:24 (Both) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.233.L1B.AMSU_Rad.v5.0.0.0.G10004083926.hdf (0.55 MB)	2010-01-01 23:17:24 (Night) Metadata
Download: HDF (FTP) HDF (HTTP)	
<input checked="" type="checkbox"/> AIRS.2010.01.01.232.L1B.AMSU_Rad.v5.0.0.0.G10004083917.hdf (0.55 MB)	2010-01-01 23:11:24 (Night) Metadata
Download: HDF (FTP) HDF (HTTP)	

This screen lets you pick and choose which files that were part of the search results that you actually want to download. There's two useful buttons on this page, the Add Selected Files To Cart and the Add All Files in All Pages To Cart buttons. This form uses a shopping cart metaphor . You add the files you want to your shopping cart, then download the contents of your shopping cart.

Since this is just a walkthrough, only select one file, the first in the list, for download and ignore the others. This will give you 6 minutes of data for the date you selected. Do this by unselecting all the files except the first and clicking the **Add Selected Files To Cart** button.

The screenshot shows the Mirador web application interface. At the top, there's a NASA logo and the text "National Aeronautics and Space Administration" and "Goddard Earth Sciences Data and Information Services Center". A search bar is on the right. Below the header, there are navigation tabs for various data categories: ATMOS COMPOSITION, HYDROLOGY, A-TRAIN, AIRS, MODELING, NEESPI, and PRECIPITATION. The main content area is titled "Mirador 1.33 Data Access Made Simple". It features a "Service Selection" section with instructions on how to select services. Below this, there's a table with columns for "Data Set", "Selected Service", and "Available Services". The table lists a data set "AIRS/Aqua Level 1B AMSU (A1/A2) geolocated and calibrated brightness temperatures (AIRABRAD.005)" with a "None" selected service and two available services: "Download via HTTP" and "Subset by Channel...". At the bottom, there are buttons for "Continue to Shopping Cart" and "Cancel".

Now you're at the Services Selection screen. Here you can select how you want to download the files (by HTTP or FTP), or further narrow the results to provide only a subset of the channels in the data. Different channels measure different parts of the atmosphere.

For this example all the channels will be downloaded, so you can ignore the channel service. And for this particular search result you only have the option of using HTTP as the download protocol. Select the HTTP option by clicking the **Download via HTTP** link on the right side of the screen. This puts the file in your shopping cart.

Now click the **Continue Shopping** button.

Checkout

http://mirador.gsfc.nasa.gov/cgi-bin/mirador/checkout.pl?caller=ftp_download&page=&dataSet=&keyword=AIRABRAD&loc...

Google

Daily Motion Apple Yahoo! Google Maps YouTube Wikipedia PETSc Cosmology Videos Electric videos BALLView Collision Detection NUL Wikipedia ClimateGate

NASA National Aeronautics and Space Administration

Goddard Earth Sciences Data and Information Services Center

Search DISC + Advanced Search + GO

+ ATMOS COMPOSITION + HYDROLOGY + A-TRAIN + AIRS + MODELING + NEESPI + PRECIPITATION

+ GES DISC Home

Mirador

Keyword: AIRABRAD

Hide Search Options

Time Span

From: 2010-01-01

To: 2010-01-01 23:59:59

Location: [-90,-180],[90,180]

Coverage Map

Event:

Search GES-DISC

+ OVERVIEW

+ HELP CENTER

+ DATA HOLDINGS

+ VIEW CART

Additional Features

+ News

+ Restricted Data

+ Feedback

+ FAQ

Mirador 1.33
Data Access Made Simple

Basic Download More Download Options

Your cart will automatically be emptied when you select any download option unless you choose to keep the items.
☒ Keep items in the cart after selecting a download option

DOWNLOAD DATA (WITH WGET, CURL, ETC.)

URL List (Data) URL List (Metadata) URL List (Data and Metadata)

Instructions:

wget:
Save the list of URLs in one of the above links to your local workstation as myfile.dat
On your command line:
wget -i myfile.dat

a UNIX curl example:
Save the list of URLs in one of the above links to your local workstation as myfile.dat
On your command line:
xargs -n 1 curl -O -u anonymous:curl@example.com < myfile.dat

More Options...

NASA Official: Steve Kempler
Website Curator: Anthony Drake

+ NASA Privacy Policy and Important Notices
+ Contact Us

Last updated: April 15, 2009 19:00:11 GMT

This is where it gets complicated, so pay close attention.

The NASA server doesn't actually download files to your computer. Instead, you have to send a series of commands to the NASA server telling it to give you the files you want. Using the following screens you'll build those commands, copy them to your computer, and then execute them to get the files in your shopping cart.

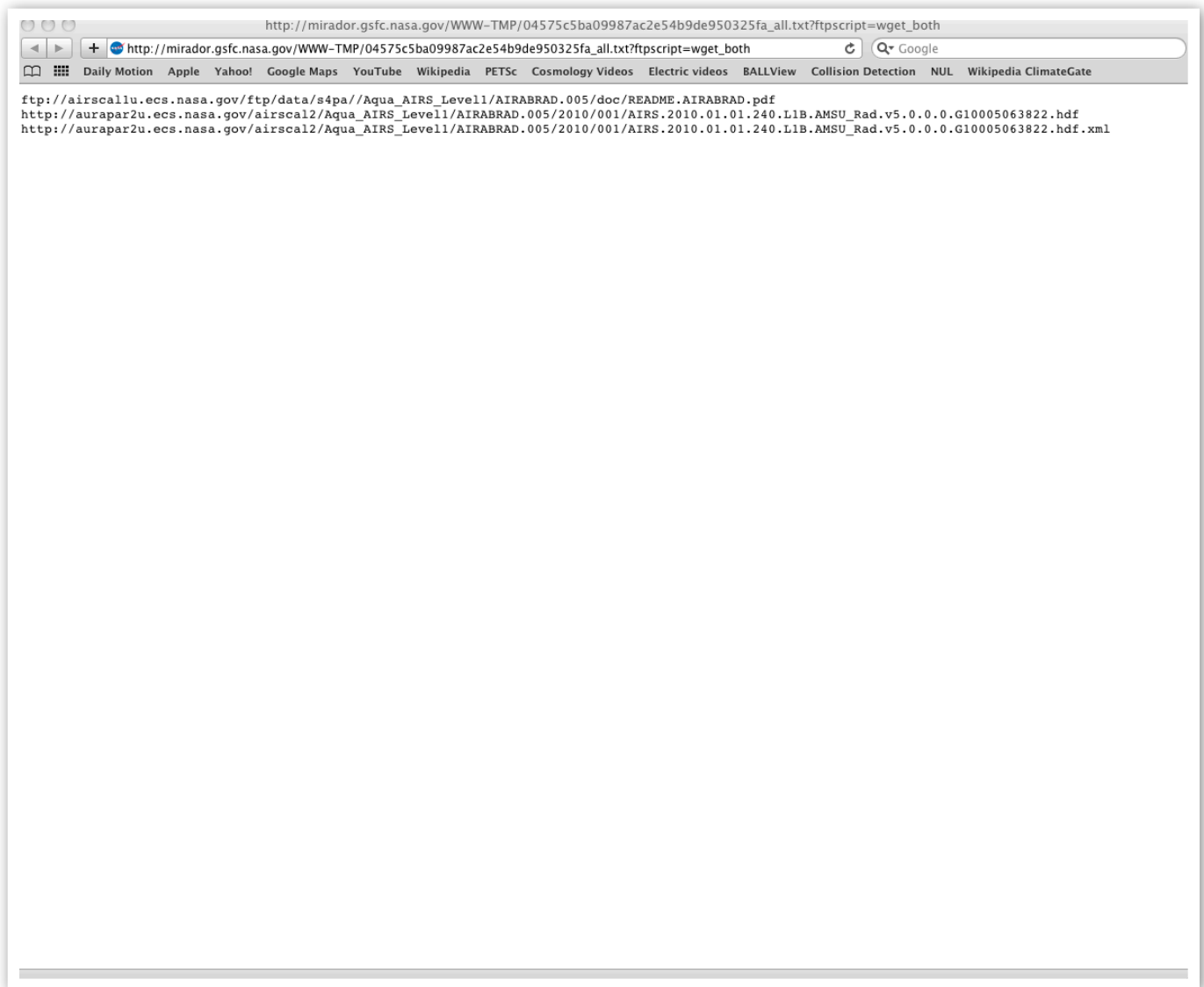
The screen shown above provides three different methods to issue commands to the NASA server to download your results. These methods are 1) A series of wget commands, 2) a series of curl commands, or 3) downloading a Java client to your machine and using that to issue the commands.

Non-technical users will want to use the Java client and follow any instructions it provides. To do that, click the **More Options...** link at the bottom of the page and follow the instructions provided. The rest of this post will discuss using curl to download the files.

The wget and curl methods require a file containing the list of files to be retrieved, and command line instructions needed to download the files in the list. The command lines for wget and curl can be seen in the screen shot above. You'll want to copy and paste one of those command lines after you have the file list on your computer. This example will use curl.

Notice the three buttons at the top of the form, URL List (Data), URL List (Metadata), and URL List (Data and Metadata). Clicking one of these buttons will open a new window containing the file list needed to get the files.

For this walkthrough, download data and metadata, so click that button. The resulting screen is shown below.



This screen shows the file list that need to be used to download the data. Copy and paste this list into a text file.

Now close the browser window containing the file list and go back to the window containing the wget and curl instructions. Copy and paste them to a command line to execute them. This will download the files from your cart to your computer.

A screen shot of a sample terminal session to do all this is shown below.

```
Terminal — bash — 80x24
Last login: Mon Jan 18 07:42:59 on ttys000
[REDACTED] ~ [REDACTED] cd Desktop
[REDACTED] :Desktop [REDACTED] vi myfile.dat
[REDACTED] :Desktop [REDACTED] chmod 777 myfile.dat
[REDACTED] :Desktop [REDACTED] xargs -n 1 curl -O -u anonymous:curl@
example.com < myfile.dat
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload  Total   Spent    Left     Speed
100  590k  100  590k    0     0   486k      0  0:00:01  0:00:01 --:--:--  816k
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload  Total   Spent    Left     Speed
100  558k  100  558k    0     0   547k      0  0:00:01  0:00:01 --:--:--  588k
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload  Total   Spent    Left     Speed
100 31474  100 31474    0     0   111k      0 --:--:-- --:--:-- --:--:--  133k
[REDACTED] :Desktop [REDACTED]
```

The NASA method of getting the data is much more user-hostile than the NSIDC method. There's nothing that can be done about that. But you now know how to get the AMSU raw data.



Appendix B

Viewing Data

Viewing Data

Using HDF-EOS Tools

In a browser, open the National Snow and Ice Data Center (NSIDC) HDF-EOS Tools page at http://nsidc.org/data/hdfeos/hdf_to_ascii.html

Follow the instructions for downloading the HDF Libraries for your system. Once you've downloaded the tools, you'll find the tool `ncdump` is located in the "utilities" folder of the download.

The `ncdump` tool is a command line utility that converts an hdf file to ASCII text. It has several options, the first of which you should learn is the `-H` (upper case H) option. This is the help option that gives you information on all the other options available. These options are:

```
./ncdump [-c|-h|-u] [-v ...] [[-b|-f] [c|f]] [-l len] [-n name] [-d n[,n]] file
[-c] Coordinate variable data and header information
[-h] Header information only, no data
[-u] Replace nonalpha-numeric in names with underscores
[-v var1[,...]] Data for variable(s) ,... only
[-b [c|f]] Brief annotations for C or Fortran indices in data
[-f [c|f]] Full annotations for C or Fortran indices in data
[-l len] Line length maximum in data section (default 80)
[-n name] Name for netCDF (default derived from file name)
[-d n[,n]] Approximate floating-point values with less precision file File name of
input netCDF file
```

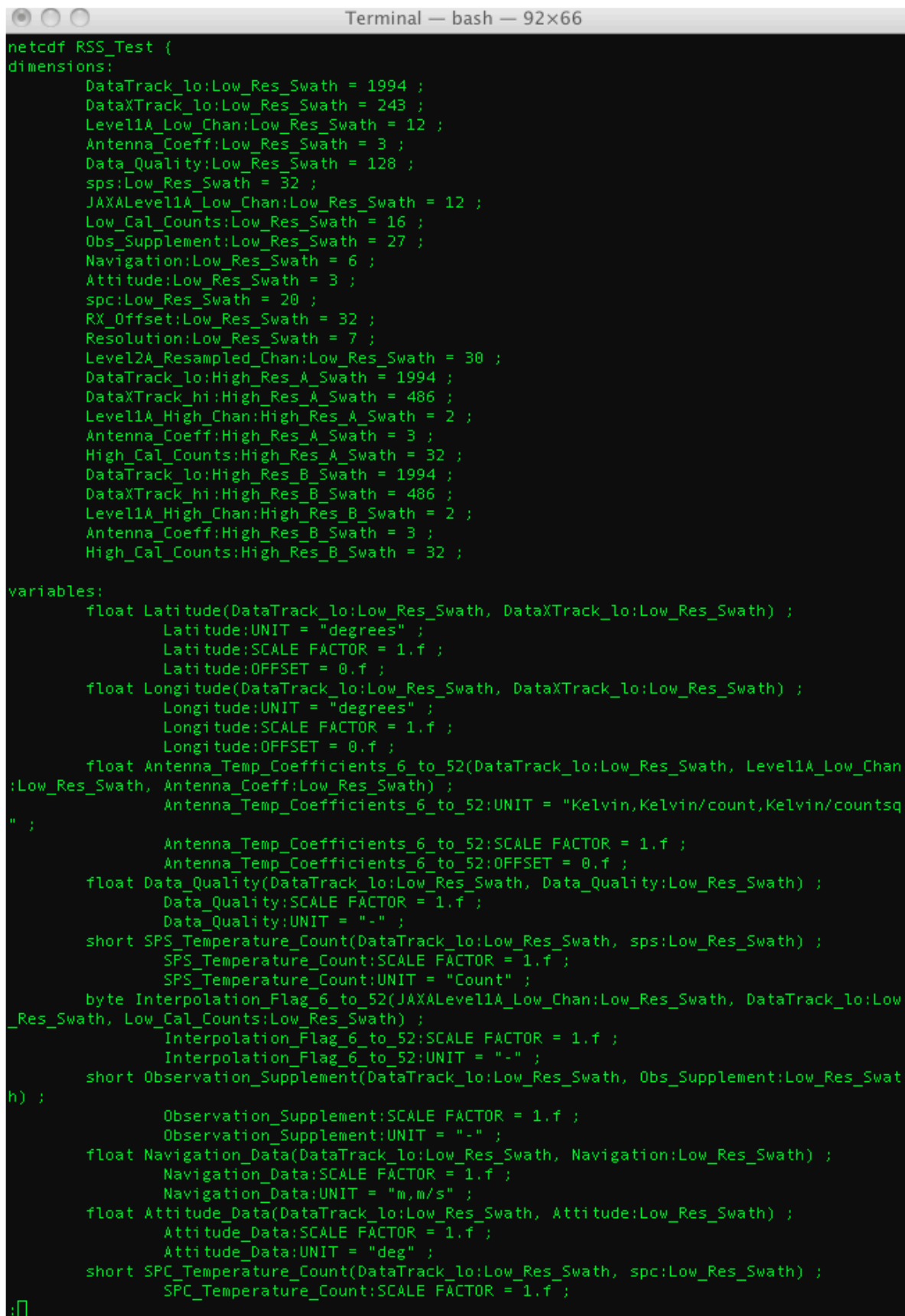
The four variants of `ncdump` we'll discuss are:

```
./ncdump -H
./ncdump -h filename | more
./ncdump -b c filename | more
./ncdump -f c filename | more
```

These commands will show the Help screen, print out headers, print out data with brief descriptions and print out data with full descriptions.

If you want to save the output to disk, replace `| more` with `> output_filename`

The -h (lowercase h) option will extract only header information. So this tells us an HDF file has headers and gives us a way to look at what those headers are. A screenshot is shown below of the output is from running ncdump using this option from a terminal window, like so: `./ncdump -h filename | more`.



```
Terminal — bash — 92x66
netcdf RSS_Test {
dimensions:
    DataTrack_lo:Low_Res_Swath = 1994 ;
    DataXTrack_lo:Low_Res_Swath = 243 ;
    Level1A_Low_Chan:Low_Res_Swath = 12 ;
    Antenna_Coeff:Low_Res_Swath = 3 ;
    Data_Quality:Low_Res_Swath = 128 ;
    sps:Low_Res_Swath = 32 ;
    JAXALevel1A_Low_Chan:Low_Res_Swath = 12 ;
    Low_Cal_Counts:Low_Res_Swath = 16 ;
    Obs_Supplement:Low_Res_Swath = 27 ;
    Navigation:Low_Res_Swath = 6 ;
    Attitude:Low_Res_Swath = 3 ;
    spc:Low_Res_Swath = 20 ;
    RX_Offset:Low_Res_Swath = 32 ;
    Resolution:Low_Res_Swath = 7 ;
    Level2A_Resampled_Chan:Low_Res_Swath = 30 ;
    DataTrack_lo:High_Res_A_Swath = 1994 ;
    DataXTrack_hi:High_Res_A_Swath = 486 ;
    Level1A_High_Chan:High_Res_A_Swath = 2 ;
    Antenna_Coeff:High_Res_A_Swath = 3 ;
    High_Cal_Counts:High_Res_A_Swath = 32 ;
    DataTrack_lo:High_Res_B_Swath = 1994 ;
    DataXTrack_hi:High_Res_B_Swath = 486 ;
    Level1A_High_Chan:High_Res_B_Swath = 2 ;
    Antenna_Coeff:High_Res_B_Swath = 3 ;
    High_Cal_Counts:High_Res_B_Swath = 32 ;

variables:
    float Latitude(DataTrack_lo:Low_Res_Swath, DataXTrack_lo:Low_Res_Swath) ;
        Latitude:UNIT = "degrees" ;
        Latitude:SCALE FACTOR = 1.f ;
        Latitude:OFFSET = 0.f ;
    float Longitude(DataTrack_lo:Low_Res_Swath, DataXTrack_lo:Low_Res_Swath) ;
        Longitude:UNIT = "degrees" ;
        Longitude:SCALE FACTOR = 1.f ;
        Longitude:OFFSET = 0.f ;
    float Antenna_Temp_Coefficients_6_to_52(DataTrack_lo:Low_Res_Swath, Level1A_Low_Chan
;Low_Res_Swath, Antenna_Coeff:Low_Res_Swath) ;
        Antenna_Temp_Coefficients_6_to_52:UNIT = "Kelvin,Kelvin/count,Kelvin/countsq
" ;
        Antenna_Temp_Coefficients_6_to_52:SCALE FACTOR = 1.f ;
        Antenna_Temp_Coefficients_6_to_52:OFFSET = 0.f ;
    float Data_Quality(DataTrack_lo:Low_Res_Swath, Data_Quality:Low_Res_Swath) ;
        Data_Quality:SCALE FACTOR = 1.f ;
        Data_Quality:UNIT = "-" ;
    short SPS_Temperature_Count(DataTrack_lo:Low_Res_Swath, sps:Low_Res_Swath) ;
        SPS_Temperature_Count:SCALE FACTOR = 1.f ;
        SPS_Temperature_Count:UNIT = "Count" ;
    byte Interpolation_Flag_6_to_52(JAXALevel1A_Low_Chan:Low_Res_Swath, DataTrack_lo:Low
_Res_Swath, Low_Cal_Counts:Low_Res_Swath) ;
        Interpolation_Flag_6_to_52:SCALE FACTOR = 1.f ;
        Interpolation_Flag_6_to_52:UNIT = "-" ;
    short Observation_Supplement(DataTrack_lo:Low_Res_Swath, Obs_Supplement:Low_Res_Swat
h) ;
        Observation_Supplement:SCALE FACTOR = 1.f ;
        Observation_Supplement:UNIT = "-" ;
    float Navigation_Data(DataTrack_lo:Low_Res_Swath, Navigation:Low_Res_Swath) ;
        Navigation_Data:SCALE FACTOR = 1.f ;
        Navigation_Data:UNIT = "m,m/s" ;
    float Attitude_Data(DataTrack_lo:Low_Res_Swath, Attitude:Low_Res_Swath) ;
        Attitude_Data:SCALE FACTOR = 1.f ;
        Attitude_Data:UNIT = "deg" ;
    short SPC_Temperature_Count(DataTrack_lo:Low_Res_Swath, spc:Low_Res_Swath) ;
        SPC_Temperature_Count:SCALE FACTOR = 1.f ;
```


The next option we want to look at is `-b`. This provides a brief description for data items that are part of indexes (arrays in C-speak). You need to give this option an `f` or `c` argument. This indicates whether the data should be presented in a Fortran-like or C-like format. A screenshot is shown below of the output is from running `ncdump` using this option from a terminal window, like so:: `./ncdump -b c filename | more`. The first part of the results look a lot like the header results. But scrolling further through the file reveals differences.

```
Terminal — bash — 92x66

"      END_GROUP = INFORMATIONCONTENT\n",
"      END_OBJECT = ADDITIONALATTRIBUTESCONTAINER\n",
"      END_GROUP = ADDITIONALATTRIBUTES\n",
"END_GROUP = INVENTORYMETADATA\n",
"END\n",
" ;

      :MD5_LaLoTb = "9ad88b62690303ba135b97dd8508f87b" ;

data:

Latitude =
// Latitude(0, 0-242)
83.74773 , 83.82304 , 83.8978 , 83.97198 , 84.04556 , 84.11848 ,
84.19074 , 84.26229 , 84.33311 , 84.40313 , 84.47234 , 84.5407 ,
84.60816 , 84.67469 , 84.74023 , 84.80474 , 84.86818 , 84.9305 ,
84.99165 , 85.05157 , 85.11023 , 85.16756 , 85.2235 , 85.27802 ,
85.33104 , 85.38251 , 85.43237 , 85.48055 , 85.52702 , 85.57169 ,
85.61451 , 85.65543 , 85.69438 , 85.73131 , 85.76615 , 85.79886 ,
85.82937 , 85.85764 , 85.88361 , 85.90724 , 85.92849 , 85.94731 ,
85.96367 , 85.97754 , 85.98889 , 85.9977 , 86.00394 , 86.00761 ,
86.0087 , 86.0072 , 86.00313 , 85.99648 , 85.98727 , 85.97552 ,
85.96127 , 85.94451 , 85.9253 , 85.90367 , 85.87967 , 85.85332 ,
85.82469 , 85.79382 , 85.76077 , 85.72559 , 85.68833 , 85.64906 ,
85.60782 , 85.56469 , 85.51971 , 85.47296 , 85.42449 , 85.37435 ,
85.32262 , 85.26934 , 85.21458 , 85.15839 , 85.10082 , 85.04194 ,
84.98179 , 84.92043 , 84.85789 , 84.79425 , 84.72955 , 84.66382 ,
84.59711 , 84.52947 , 84.46094 , 84.39156 , 84.32137 , 84.2504 ,
84.1787 , 84.10629 , 84.03322 , 83.95951 , 83.8852 , 83.81031 ,
83.73488 , 83.65893 , 83.58248 , 83.50558 , 83.42823 , 83.35047 ,
83.27232 , 83.1938 , 83.11494 , 83.03574 , 82.95624 , 82.87645 ,
82.79639 , 82.71609 , 82.63555 , 82.55479 , 82.47383 , 82.39269 ,
82.31138 , 82.22992 , 82.14831 , 82.06657 , 81.98473 , 81.90279 ,
81.82075 , 81.73864 , 81.65646 , 81.57423 , 81.49196 , 81.40966 ,
81.32734 , 81.245 , 81.16267 , 81.08034 , 80.99803 , 80.91575 , 80.8335 ,
80.7513 , 80.66915 , 80.58706 , 80.50504 , 80.4231 , 80.34124 ,
80.25947 , 80.1778 , 80.09624 , 80.01479 , 79.93345 , 79.85224 ,
79.77116 , 79.69023 , 79.60944 , 79.5288 , 79.44832 , 79.368 , 79.28784 ,
79.20786 , 79.12806 , 79.04845 , 78.96902 , 78.88979 , 78.81076 ,
78.73194 , 78.65333 , 78.57493 , 78.49675 , 78.4188 , 78.34107 ,
78.26359 , 78.18633 , 78.10932 , 78.03256 , 77.95605 , 77.8798 ,
77.8038 , 77.72807 , 77.65261 , 77.57742 , 77.50251 , 77.42787 ,
77.35352 , 77.27946 , 77.20569 , 77.13222 , 77.05904 , 76.98616 ,
76.91359 , 76.84133 , 76.76938 , 76.69775 , 76.62643 , 76.55545 ,
76.48479 , 76.41445 , 76.34445 , 76.27479 , 76.20546 , 76.13647 ,
76.06784 , 75.99955 , 75.93161 , 75.86403 , 75.79681 , 75.72993 ,
75.66344 , 75.5973 , 75.53153 , 75.46614 , 75.40112 , 75.33647 ,
75.27221 , 75.20833 , 75.14484 , 75.08173 , 75.01901 , 74.9567 ,
74.89477 , 74.83324 , 74.77211 , 74.71139 , 74.65107 , 74.59116 ,
74.53167 , 74.47258 , 74.41391 , 74.35566 , 74.29783 , 74.24043 ,
74.18344 , 74.12688 , 74.07076 , 74.01506 , 73.9598 , 73.90498 ,
73.85059 , 73.79665 , 73.74314 , 73.69008 , 73.63747 , 73.5853 ,
73.53358 , 73.48232 , 73.43151 , 73.38116 , 73.33127 , 73.28184 ,
73.23286 ,
// Latitude(1, 0-242)
83.83654 , 83.91178 , 83.98647 , 84.06057 , 84.13406 , 84.20689 ,
84.27905 , 84.35049 , 84.42117 , 84.49107 , 84.56014 , 84.62835 ,
84.69564 , 84.76198 , 84.82732 , 84.89162 , 84.95483 , 85.01691 ,
85.07779 , 85.13743 , 85.19577 , 85.25276 , 85.30835 , 85.36248 ,
85.41508 , 85.46611 , 85.5155 , 85.56318 , 85.6091 , 85.65321 ,
85.69542 , 85.73569 , 85.77396 , 85.81015 , 85.84423 , 85.87613 ,
85.90579 , 85.93317 , 85.95821 , 85.98086 , 86.00109 , 86.01885 ,
86.03411 , 86.04684 , 86.05701 , 86.06461 , 86.0696 , 86.07199 ,
86.07178 , 86.06895 , 86.06351 , 86.05549 , 86.04488 , 86.03173 ,
86.01604 , 85.99786 , 85.97722 , 85.95416 , 85.92873 , 85.90096 ,
85.87091 , 85.83863 , 85.80419 , 85.76763 , 85.72901 , 85.6884 ,
```

You can see we're now getting values for the headers we saw previously.

The final ncdump command we're going to cover is -f. This is like -b, but gives full descriptions for the data items. Using the command `./ncdump -f c filename | more` produces the following results:

```
Terminal — bash — 92x66

"      GROUP = INFORMATIONCONTENT\n",
"      CLASS = \"4\"\n",
"      OBJECT = PARAMETERVALUE\n",
"      NUM_VAL = 1\n",
"      CLASS = \"4\"\n",
"      VALUE = \"18\"\n",
"      END_OBJECT = PARAMETERVALUE\n",
"      END_GROUP = INFORMATIONCONTENT\n",
"      END_OBJECT = ADDITIONALATTRIBUTESCONTAINER\n",
"      END_GROUP = ADDITIONALATTRIBUTES\n",
"END_GROUP = INVENTORYMETADATA\n",
"END\n",
" ;

:MD5_LaLoTb = "9ad88b62690303ba135b97dd8508f87b" ;

data:

Latitude =
83.74773 , // Latitude(0,0)
83.82304 , // Latitude(0,1)
83.8978 , // Latitude(0,2)
83.97198 , // Latitude(0,3)
84.04556 , // Latitude(0,4)
84.11848 , // Latitude(0,5)
84.19074 , // Latitude(0,6)
84.26229 , // Latitude(0,7)
84.33311 , // Latitude(0,8)
84.40313 , // Latitude(0,9)
84.47234 , // Latitude(0,10)
84.5407 , // Latitude(0,11)
84.60816 , // Latitude(0,12)
84.67469 , // Latitude(0,13)
84.74023 , // Latitude(0,14)
84.80474 , // Latitude(0,15)
84.86818 , // Latitude(0,16)
84.9305 , // Latitude(0,17)
84.99165 , // Latitude(0,18)
85.05157 , // Latitude(0,19)
85.11023 , // Latitude(0,20)
85.16756 , // Latitude(0,21)
85.2235 , // Latitude(0,22)
85.27802 , // Latitude(0,23)
85.33104 , // Latitude(0,24)
85.38251 , // Latitude(0,25)
85.43237 , // Latitude(0,26)
85.48055 , // Latitude(0,27)
85.52702 , // Latitude(0,28)
85.57169 , // Latitude(0,29)
85.61451 , // Latitude(0,30)
85.65543 , // Latitude(0,31)
85.69438 , // Latitude(0,32)
85.73131 , // Latitude(0,33)
85.76615 , // Latitude(0,34)
85.79886 , // Latitude(0,35)
85.82937 , // Latitude(0,36)
85.85764 , // Latitude(0,37)
85.88361 , // Latitude(0,38)
85.90724 , // Latitude(0,39)
85.92849 , // Latitude(0,40)
85.94731 , // Latitude(0,41)
85.96367 , // Latitude(0,42)
85.97754 , // Latitude(0,43)
85.98889 , // Latitude(0,44)
85.9977 , // Latitude(0,45)
86.00394 , // Latitude(0,46)
86.00761 , // Latitude(0,47)
```

As you can see, every item in an array is commented with its exact location in the array. This kind of output may come in handy during debugging situations.

Using HDView

In a browser, open the HDG Group HDFView page at <http://www.hdfgroup.org/hdf-java-html/hdfview/>

Follow the instructions for downloading HDFView to your system.

The HDFView tool provides a graphical interface to HDF files. It shows both headers and data. You can edit the file and save your edits to disk.

To use this tool, double click on it, and select Open from the File menu. Navigate to the file you want to look at and

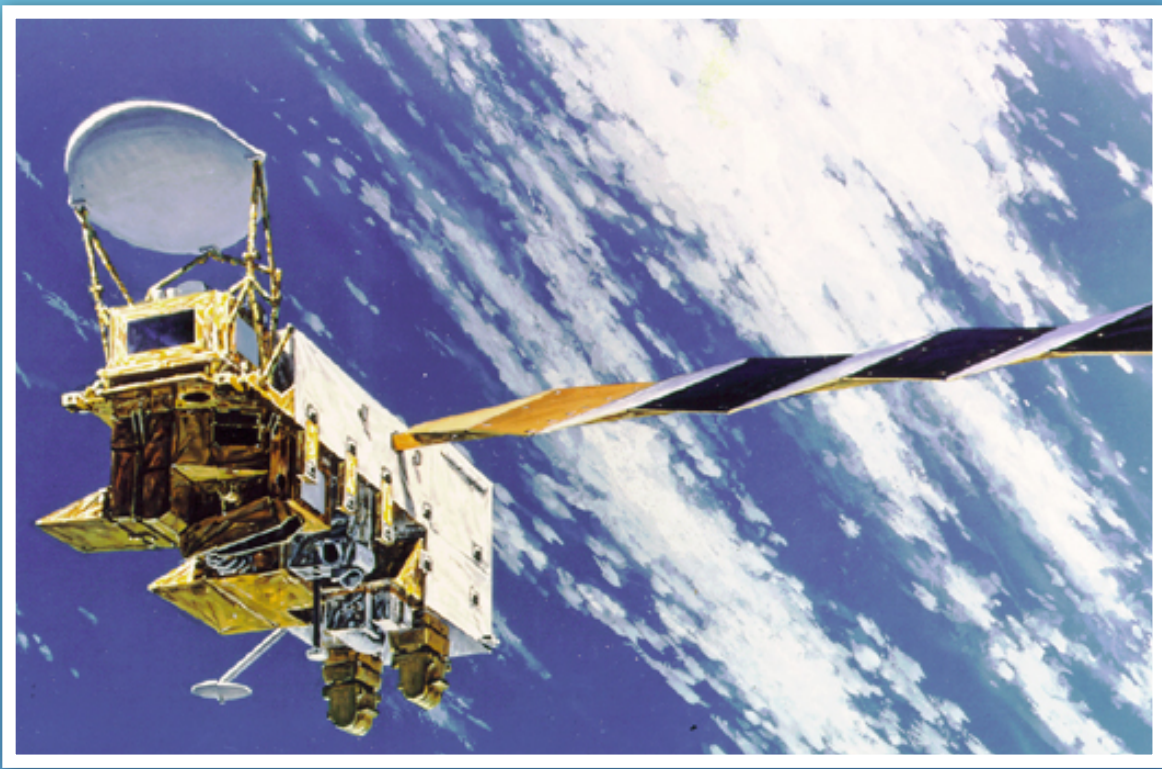
click the Open button. A screen shot of HDFView with a file loaded up is shown below.

On the left side you see a Tree control showing the headers in the file. Double-clicking a header brings up it's edit window in the main window.

If you make edits to the data they can be saved using the **Save** or **Save As** menu items in the **File** menu.

The screenshot shows the HDFView application window. The title bar is 'HDFView'. The menu bar includes 'File', 'Window', 'Tools', and 'Help'. Below the menu bar is a toolbar with icons for file operations. The 'File/URL' field shows '/Applications/UAH_Test.hdf'. On the left is a tree view of the file structure: 'UAH_Test.hdf' contains 'L1B_AMSU', which contains 'Geolocation Fields' (with sub-items 'Latitude', 'Longitude', and 'Time') and 'Data Fields' (with many sub-items like 'scanang', 'satheight', 'satroll', etc.). The main window displays a 'Table' view of the 'Latitude' field. The table has 5 columns (0, 1, 2, 3, 4) and 38 rows (0 to 37). The bottom status bar shows 'Latitude (720, 6)' and '64-bit floating-point, 45 x 30'.

	0	1	2	3	4
0	4.332792...	4.477857...	4.602009...	4.710386...	4.808586...
1	4.811420...	4.957628...	5.082645...	5.191875...	5.290043...
2	5.290013...	5.437305...	5.563138...	5.673037...	5.771915...
3	5.768731...	5.916832...	6.043297...	6.154086...	6.253493...
4	6.246613...	6.396222...	6.523812...	6.634856...	6.735027...
5	6.725202...	6.875630...	7.004102...	7.115830...	7.216378...
6	7.202896...	7.354851...	7.483984...	7.596862...	7.698126...
7	7.680916...	7.834047...	7.964313...	8.077440...	8.178931...
8	8.159197...	8.313165...	8.444093...	8.558193...	8.660463...
9	8.636739...	8.792272...	8.924370...	9.038925...	9.141941...
10	9.114449...	9.271211...	9.404245...	9.519738...	9.623125...
11	9.592308...	9.749933...	9.883904...	9.999932...	10.10396...
12	10.06938...	10.22863...	10.36356...	10.48033...	10.58533...
13	10.54715...	10.70729...	10.84318...	10.96092...	11.06593...
14	11.02395...	11.18572...	11.32234...	11.44110...	11.54693...
15	11.50135...	11.66405...	11.80216...	11.92098...	12.02729...
16	11.97789...	12.14197...	12.28114...	12.40101...	12.50834...
17	12.45463...	12.62032...	12.76021...	12.88110...	12.98868...
18	12.93128...	13.09830...	13.23920...	13.36088...	13.46949...
19	13.40818...	13.57618...	13.71813...	13.84040...	13.94952...
20	13.88400...	14.05343...	14.19647...	14.31986...	14.43007...
21	14.36014...	14.53160...	14.67534...	14.79952...	14.90999...
22	14.83601...	15.00855...	15.15370...	15.27874...	15.38991...
23	15.31222...	15.48545...	15.63201...	15.75769...	15.86981...
24	15.78755...	15.96292...	16.10999...	16.23679...	16.34920...
25	16.26292...	16.43977...	16.58825...	16.71615...	16.82966...
26	16.73816...	16.91645...	17.06577...	17.19463...	17.30871...
27	17.21336...	17.39313...	17.54388...	17.67311...	17.78837...
28	17.68858...	17.86944...	18.02136...	18.15153...	18.26735...
29	18.16329...	18.34566...	18.49875...	18.62986...	18.74666...
30	18.63747...	18.82181...	18.97610...	19.10814...	19.22551...
31	19.11227...	19.29774...	19.45324...	19.58651...	19.70444...
32	19.58601...	19.77383...	19.93019...	20.06418...	20.18338...
33	20.05986...	20.24893...	20.40689...	20.54215...	20.66128...
34	20.53423...	20.72449...	20.88373...	21.01997...	21.14056...
35	21.00794...	21.19979...	21.36027...	21.49752...	21.61830...
36	21.48124...	21.67476...	21.83623...	21.97455...	22.09666...
37	21.95390...	22.14956...	22.31266...	22.45173...	22.57449...

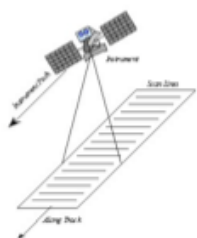


Appendix C

HDF-EOS File Information

HDF-EOS File Information

The HDF file format is NASA's standard file format for storing data from the Earth Observing System (EOS), which is the data gathering system of sensors (mainly satellites) supporting the Global Climate Change Research Program. The Aqua satellite uses a specialized form of HDF called HDF-EOS, which deals specifically with the kinds of data that EOS produces.



Swath: The swath concept for HDF-EOS is based on a typical satellite swath, where an instrument takes a series of scans perpendicular to the ground track of the satellite as it moves along that ground track (see diagram at left). As the AIRS is profiling instrument that scans across the ground track, the data would be a three dimensional array of measurements where two of the dimensions correspond to the standard scanning dimensions (along the ground track and across the ground track), and the third dimension represents a range from the sensor. The "horizontal" dimensions can be handled as normal geographic dimensions, while the third dimensions can be handled as a special "vertical" dimension.

AMSU Major Data Groups

The AMSU Level 1B file is made of four major groups; "Dimensions", "geolocation fields", "Attributes", and "Data fields" with data fields sub-divided into "Per-Granule Data Fields", "Along-Track Data Fields, and "Full Swath Data Fields".

Dimensions: These are HDF-EOS swath dimensions. The names "GeoTrack" and "GeoXTrack" have a special meaning for this document: "GeoTrack" is understood to be the dimension along the path of the spacecraft, and "GeoXTrack" is the dimension across the spacecraft track, starting on the left looking forward along the spacecraft track. There may also be a second across-track dimension "CalXTrack," equivalent to "GeoXTrack," except that "CalXTrack" refers to the number of calibration footprints per scanline. "GeoTrack" is 45 for large-spot products (AMSU-A, Level-2, cloud-cleared AIRS) and 135 for small-spot products (AIRS, Vis/NIR, HSB).

Geolocation Fields: These are all 64-bit floating-point fields that give the location of the data in space and time. If the note before the table specifies that these fields appear once per scanline then they have the single dimension "GeoTrack." Otherwise, they appear once per footprint per scanline and have dimensions "GeoTrack,GeoXTrack."

Attributes: These are scalar or string fields that appear only once per granule (a granule is a file). They are attributes in the HDF-EOS Swath sense.

Per-Granule Data Fields: These are fields that are valid for the entire granule (a granule is a file) but that are not scalars because they have some additional dimension.

Along-Track Data Fields: These are fields that occur once for every scanline. These fields have dimension "GeoTrack" before any "Extra Dimensions." So an "Along-Track Data Field" with "Extra Dimensions" of "None" has dimensions "GeoTrack"; whereas, if the "Extra Dimensions" is "SpaceXTrack (= 4)," then it has dimensions "GeoTrack,SpaceXTrack."

Key Data Fields

Location Data Fields

- Latitude: Boresight geodetic latitude (degrees North, -90->+90), dimension (90,135)
- Longitude: Boresight geodetic longitude (degrees East, -180->+180), dimension (90,135)
- Time: Footprint "shutter" TAI Time: floating-point elapsed seconds since Jan 1, 1993

Per-Granule Data Fields

- center_freq: Channel center frequency (GHz), dimension (15)
- IF_offset_1: Offset of first intermediate frequency stage (MHz) (zero for no mixing), dimension (15)
- IF_offset_2: Offset of second intermediate frequency stage (MHz) (zero for no second mixing), dimension (15)
- Bandwidth: Bandwidth of sum of 1,2 or 4 channels (MHz), dimension (15)
- NeDT: Instrument noise level estimated from warm count scatter (15)

Along-Track Data Fields

- qa_scanline: Bit field for each scanline (bit 0 set if sun glint in scanline; bit 1 set if costal crossing in scanline, bit 2 set if some channels had excessive NeDT estimated), dimension (45)
- qa_channel: Bit field by channel for each scanline (bit 0 set if all space view counts bad; bit 1 set if space view counts marginal; bit 2 set if space view counts could not be smoothed; bit 3 set if all blackbody counts bad; bit 4 set if blackbody counts marginal; bit 5 set if blackbody counts could not be smoothed; bit 6 set if unable to calculate calibration coefficients; bit 7 set if excessive NeDT estimated), dimension (15,45)

Swath Data Fields

- antenna_temp: Calibrated, geolocated channel-by-channel AMSU observed raw antenna temperature (K), dimension (15,30,45)
- brightness_temp: Calibrated, geolocated channel-by-channel AMSU sidelobe-corrected antenna temperature (K), dimension (15,30,45)
- brightness_temp_err: Error estimate for brightness_temp (K), dimension (15,30,45)
- landFrac: Fraction of AMSU footprint that is land (0.0 -> 1.0), dimension (30,45)
- landFrac_err: Error estimate for landFrac, dimension (30,45)

Each AMSU Level 1B data file contains a collection of scans that take place over 6 minutes.

In these 6 minutes, the AMSU scans 45 times in the same direction as the satellite is moving. Each of these 45 scans contains 30 readings perpendicular to the movement of the satellite (called Footprints), and each of these 30 readings contains 15 channels, each at a different height above the Earth's surface.



These values are collected by three different pieces of hardware. Receiver A11 handles channels 6, 7, and 9 through 15. Receiver A12 handles channels 3, 4, 5, and 8. Receiver A2 handles channels 1 and 2.

This gives a total of 20,250 readings in a single Level 1B file. These 20,250 readings are stored as a contiguous block of data in the file that, in the parlance of C programmers, can be read into computer memory as a three dimensional array.

There are actually two sets of this 20,250 piece block of information in the AMSU Level 1B files. The first set is called antenna temperatures and is the raw data in degrees Kelvin as read by the satellite modified by calibration information (specifically, antenna temperatures = calibration coefficient/instrument readings²).

The second set is called brightness temperatures consists of slightly modified antenna data. The brightness temperatures have a companion set of data, 20,250 error estimates called brightness temperature errors that estimate the accuracy of the brightness temperatures.

Either the antenna temperatures or the brightness temperatures can be considered to be the raw data used to create the UAH data.

AMSU Data Quality

There are several fields in the AMSU Level 1B data file that contain the results of Quality Assurance (QA) checks. In fact, much of the file is QA data. These fields tell if various pieces of data in the file can be used with confidence. Here are the important QA fields to check when processing temperature data:

- **State 1** Indicates the state of the AMSU-A1 unit for each scan line. If this value is anything other than 0, the data in the scan line should be rejected.
- **QA Receiver A11 and QA Receiver A12** These flags indicate the quality of the AMSU temperature receivers for each scan line. If either are non-zero, the data in the scan line should be rejected.
- **SATGEO QA, GLINTGEO QA, and MOONGEO QA** These fields contain QA information for each scan line. If a non-zero value is present, the data in the corresponding field should be rejected.
- **FTPTGEO QA, ZENGEO QA, and DEMGEO QA** These are satellite position QA flags and occur for each of the 30 field of view footprints for each of the 45 scan lines. If a non-zero value is present, the data in the corresponding field should be rejected.
- **QA Channel** This is a series of 15 flags indicating the reliability of each channel of the AMSU. Channels with non-zero values should not be used. Recall from [Part 1](#) that channel 7 is always bad.

Pseudocode For Reading Raw AMSU Data

The following pseudocode shows how to process a AMSU Level 1B file, checking for QA errors, and grabbing the temperature data. Recall that temperatures are provided in degrees Kelvin and that channel 7 is always bad.

```
Open File
```

```
Read AMSU Record Into Memory
```

```
Foreach Of The 45 Scanlines
```

```
  If State_1 Not Equal To 0 Then Reject Scanline
```

```
  If QA_Receiver_A11 Not Equal To 0 Then Reject Scanline
```

```
  If QA_Receiver_A12 Not Equal To 0 Then Reject Scanline
```

```
  If SATGEO_QA Not Equal To 0 Then Reject Scanline
```

```
  If GLINTGEO_QA Not Equal To 0 Then Reject Scanline
```

```
  If MOONGEO_QA Not Equal To 0 Then Reject Scanline
```

```
Foreach Of The 30 Footprints
```

```
  If FTPTGEO_QA Not Equal To 0 Then Reject Footprint
```

```
  If ZENGEO_QA Not Equal To 0 Then Reject Footprint
```

```
  If DEMGEO_QA Not Equal To 0 Then Reject Footprint
```

```
Foreach Of The 15 Channels
```

```

If QA_CHANNEL Not Equal To 0 Then Reject Channel

Read Antenna Temperature for this Scanline/Footprint/Channel
Read Brightness Temperature for this Scanline/Footprint/Channel
Read Brightness Temperature Error for this Scanline/Footprint/Channel
End Foreach
End Foreach
End Foreach

```

AMSR-E Scan Information

Each AMSR-E Level 2A data file contains a single scan at low resolution and a single scan at high resolution.

For low resolution, the AMSR-E scans 1994 times in the same direction as the satellite is moving. Each of these 1994 scans contains 243 readings perpendicular to the movement of the satellite (called Footprints), and each of these 243 readings contains 5 channels, each at a different frequency.

This gives a total of 2,422,710 readings in a single Level 2A file. This data has been "smoothed" as part of its processing from Level 1B to Level 2A.

For high resolution scans the AMSR-E scans 1994 times in the same direction as the satellite is moving. Each of these 1994 scans contains 486 readings perpendicular to the movement of the satellite, and each of these 486 readings contains 1 channel at a frequency of 89.0 GHz.

This gives a total of 969,084 readings in a single Level 2A file. This data has not been smoothed. It's in its original Level 1B form.



Both the low resolution and high resolution temperatures are stored in a scaled offset format. To obtain the actual temperature in degrees Kelvin multiply the stored values by 0.01 and add 327.68 to the result.

AMSR-E Data Quality

There are several fields in the AMSR-E Level 2A data file that contain the results of Quality Assurance (QA) checks. These fields tell if various pieces of data in the file can be used with confidence. Here are the important QA fields to check when processing temperature data:

For Low Resolution Scans

- **Scan Quality Flag** A series of 1994 flags indicating the quality of each scan line. If a flag is not zero, the corresponding scan line should be rejected.

- **Channel Quality Flag 6 To 52** A series of 1994 arrays containing 12 flags each. There are two flags for channels 6.9, 10.7, 18.7, 23.8, and 36.5. The last two fields are not used as there is no channel 52. These flags indicate the horizontal and vertical scan validity for each scan footprint. If either flag for a footprint is not zero, the corresponding footprint should be rejected.

For High Resolution Scans

There are two high resolutions scans in the Level 2A file, one for Horn A and one for Horn B. Horn A is broken and its data should be ignored.

- **Scan Quality Flag 89B** A series of 1994 flags indicating the quality of each scan line for Horn B. If a flag is not zero, the corresponding scan line should be rejected.

- **Channel Quality Flag 89B** A series of 1994 arrays containing 2 flags each. These flags indicate the horizontal and vertical scan validity for each scan footprint. If either flag for a footprint is not zero, the corresponding footprint should be rejected.

Pseudocode For Reading Raw AMSR-E Data

The following pseudocode shows how to process a AMSR-E Level 2A file, checking for QA errors, and grabbing the temperature data. Recall that temperatures are provided in scaled offset degrees Kelvin and that Horn A is always bad.

```
Open File
```

```
Read Low Resolution Record Into Memory
```

```
Foreach Of The 1994 Scanlines
```

```
    If Scan Quality Flag Is Not 0 Then Reject Scanline
```

```
    Foreach Of The 5 Footprints
```

```
        If Either Of The Channel Quality Flags Are Not 0 Then Reject Footprint
```

```
        Read Each Of The 243 Footprints For the Channel
```

```
    End Foreach
```

```
End Foreach
```

```
Read High Resolution Horn B Record Into Memory
```

```
Foreach Of The 1994 Scanlines
```

```
    If Scan Quality Flag Is Not 0 Then Reject Scanline
```

```
    If Either Of The Channel Quality Flags Are Not 0 Then Reject Footprint
```

```
    Read Each Of The 486 Footprints For the Channel
```

```
End Foreach
```