Minutes of the Aqua Science Working Group Meeting

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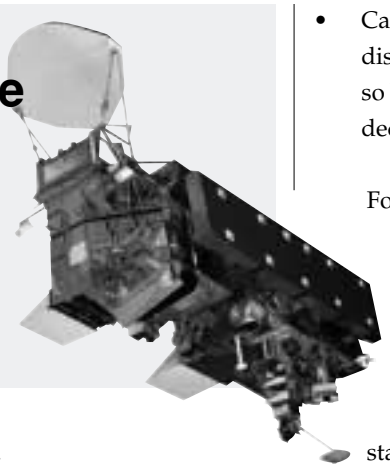

The Aqua Science Working Group met at the Goddard Space Flight Center (GSFC) on April 27, 2000. Claire Parkinson, the Aqua Project Scientist, opened the meeting at 8:30 by welcoming everyone and introducing the new Aqua Outreach Coordinator, Steve Graham, of the EOS Project Science Office.

Parkinson began by stating that considerable progress has been made since the last meeting, which occurred in October 1999. The MODIS, AIRS, HSB, and AMSR-E instruments have all arrived safely at TRW, and those along with the previously ready CERES and AMSU instruments were all mechanically integrated onto the spacecraft between December 15, 1999 and February 1, 2000. Electrical integration of the instruments is now underway. Last fall, the AMSR-E and AIRS/AMSU/HSB Algorithm Theoretical Basis Documents (ATBDs) were updated, and on March 14, 2000 they were defended before a review panel. The NRA for AIRS/AMSU/HSB and AMSR-E Validation has been approved and signed by Ghassem Asrar and is scheduled to be released on May 8, 2000.

Next, a short discussion took place regarding the newly approved minimum success criteria for the Aqua mission. These criteria state that a successful Aqua mission will:

- Achieve a safe launch and on-orbit check-out of the spacecraft and instruments.
- Produce the first high spectral resolution global infrared spectra of the Earth.
- Obtain 1 K/1 km global root-mean-square temperature profile accuracy in the troposphere by 1 year after launch.
- Extend the improved TRMM rainfall characterization to the extra tropics, for a minimum of one year.
- Produce the first global, through-clouds SST daily maps of the ocean, for a minimum of one year.
- Produce large scale global soil moisture distribution for regions with low vegetation.
- Produce calibrated global observations of the Earth's continents and ocean surfaces 150 days after the mission is declared operational.
- Capture and document three seasonal cycles of terrestrial and marine ecosystems and atmospheric and cloud properties.
- Produce three sets of seasonal/annual Earth radiation budget records.
- Produce improved measurements of the diurnal cycle of radiation by combining Aqua measurements with Terra and/or TRMM measurements for months of overlap.
- Produce combined cloud property and radiation balance data to allow improved studies of the clouds in the climate system.
- Capture, process, archive, and distribute Aqua data products, doing so by 150 days after the mission is declared operational.

Following Parkinson's opening remarks, Bruce Barkstrom, the CERES Team Leader, provided an update on the CERES program. Barkstrom began his talk with an overview of the CERES Science Objectives, stating that for climate change analysis, there must be a continuation of the ERBE record of radiative fluxes at the top of the atmosphere (TOA) and that the same analysis techniques performed on the ERBE data must be used for Aqua (as is being done for Terra) and that much of the software is based on the same code for ERBE data. Other objectives include doubling the accuracy of estimates of radiative fluxes at TOA and the Earth's surface, providing the first long-term global estimates of radiative fluxes within the Earth's atmosphere, and providing cloud property estimates consistent with the radiative fluxes from surface to the top of the atmosphere.

Barkstrom then displayed preliminary data/images from the Terra press conference held on April 19, 2000. He noted that within a few days of Level 1B, the CERES team was producing Level 2 data using ERBE angular distribution models, getting about 10% albedos over the ocean, 25% over the Sahara, and 70% on the tops of the highest thunderstorms. In addition, the data are correctly geolocated and the team is reasonably happy with the progress of the instrument.

The CERES S'COOL Project now has over 465 schools in 36 countries providing ground-truth measurements of clouds to assist with the validation of the CERES instrument.

Next, Kory Priestley of the CERES Team presented on the CERES Deep Space Maneuver. He reminded the audience that CERES is two instruments, one predominantly for cross track spatial sampling (Fixed Azimuth Plane Scanning), the other for hemispherical sampling (Rotating Azimuth Plane Scanning). Both CERES instruments can operate in either mode.

Priestley remarked that there is a need to characterize scan dependent offsets, which are extraneous instrument artifacts that impart sample dependent biases on the radiometric measurements. These offsets arise from two sources, electromagnetic signals and micro-strains. Priestley noted that the offsets are very significant and that accurate knowledge of scan dependent offsets at the sub 1-count level is necessary to meet the mission accuracy requirements of 0.5% and 1.0% accuracy for terrestrial and solar energy flows. Globally averaged this roughly corresponds to flux values of 1.2 W/m^2 top of the Atmosphere LW Flux and 2.0 W/m^2 TOA SW Flux. By taking the total channel and subtracting the shortwave channel, it's difficult to meet the error budget; but by doing the pitch-over maneuver, the errors can be removed.

Next, Priestley provided an overview of the lessons learned from TRMM. He noted that ground to on-orbit shifts of approximately 1 count peak-to-peak occurred in all three channels of the CERES PFM instrument; analyses of the collected data indicated that 30-50 repetitions of each combination of elevation and azimuthal angle are necessary; and CERES/TRMM scan dependent offsets have been reduced an order of magnitude from ERBE. As a bottom line, Priestley stated that a significant improvement has been made over ERBE; CERES accuracy requirements are a factor of 2 more stringent than ERBE; offsets are still significant as potential error sources for CERES; and TRMM should only be viewed as a "best case" until the design is validated over several flight models.

Following the TRMM discussion, impacts of Terra omitting and/or delaying its CAMs was discussed. An immediate impact would be that the traceability to ground calibration radiometric scale would be less certain. There would also be a significant impact on validation timeline for the Level-1 data which would then impact all downstream data products.

Priestley concluded his presentation by summarizing the pertinent issues, noting that it is imperative that CERES accurately characterizes their scan dependent offsets in order to achieve their scientific goals and continue the long term dataset. A failure to do this would mean a significant impact to the data validation timeline, a delay in the release of validated data products, more frequent reprocessing, less certain intercalibration with similar instruments, and a degraded ability to monitor long-term climate change.

Vince Salomonson, the MODIS Team Leader, opened his presentation by displaying early images from MODIS-Terra and noted that many of the images are located on the Terra Homepage URL at terra.nasa.gov. In addition, a MODIS poster that was displayed at the Investigators Working Group meeting recently held in Tucson, AZ was also presented. Salomonson walked through a series of images that highlighted many of MODIS' capabilities including sun stimulated fluorescence, natural color imagery, comparisons between AVHRR and MODIS, ocean color, cloud optical thickness, total column water vapor, land composites, sea surface temperature, aerosol optical thickness, and broadband white sky albedo. Salomonson added that one of the things not yet illustrated well is the fire band. There is a large dynamic range on the intensity of fires within a pixel up to 400K, and the team has not yet come up with a good illustration of how well they are doing this. But overall, MODIS is performing "better than spec" providing useful data in several areas.

Pre-launch calibration and characterization was critical to the development and the ultimate use of the MODIS data. Even though very considerable efforts were provided by the MODIS MCST that have improved the performance of the MODIS, there was more that should have been done. The pre-launch test program still was not sufficient to adequately identify and characterize some key sensor problems (focal plane co-registration, ADC/bin-fill non uniformity, mirror side differences). Also, major compromises were made to the Terra-MODIS in order to adhere to an earlier (not achieved) launch schedule including not verifying an electronic cross-talk fix (the problem still persists), and not measuring the RVS of the scan mirror. In addition, fixes of known problems on FM1 may not be made due to similar launch schedule pressures.

The test schedule for Terra operations was too tight and if there are similar assumptions for Aqua, launch readiness will be compromised. The duration of A&E phase was underestimated, as 90 days was not adequate. At L+132, the deep space maneuver had not been conducted, the solar diffuser only finished on L+131, the sensor is not in optimal operational configuration and is still requiring TDRSS support for real-time operations. Salomonson added that a more realistic schedule is needed for Aqua.

The telemetry specification for Level 0 data from Aqua is not finalized.

Salomonson assumes that this will not be significantly different than Terra, but if it is, then Aqua Level 1a software will not be ready for launch. Also, bit flips in the data from the Terra spacecraft caused problems with EDOS and DAAC processing of the data.

Funds for Aqua processing hardware must arrive by L-5 months because the current MODAPS will be unable to support production of both Aqua and Terra products at the required volumes and resources will severely limit testing of Aqua processing.

After a brief break the meeting reconvened with Parkinson summarizing the October 15, 1999 Agreement on the Aqua Spacecraft Maneuvers during the first 90 days after launch. This agreement stated that:

- The deep-space maneuver will be a constant-pitch-rate maneuver done on three consecutive orbits, preferably on day 55 or as soon thereafter as the moon is out of the way.

- A series of yaw maneuvers with the MODIS doors closed will be done on days 26-27, and a second series of yaw maneuvers with the MODIS doors open will be done on days 30-31.

- A small roll maneuver, to enable a view of the moon from the MODIS Space View Port, will be done on day 40 or as soon thereafter as the moon is appropriately positioned.

Dr. Mous Chahine, the AIRS Team Leader, then stated that the deep space maneuver should be removed from the schedule because it will cause a reduction in data quality from the AIRS, which would take considerable time to correct itself. He said that George Morrow has been informed of the AIRS team viewpoint.

Parkinson then turned the floor over to Fran Wasiak of Aqua's Instrument Planning Group to discuss the Integrated Mission Timeline (IMT). The purpose of the IMT is to plan the order of the activities necessary to get the spacecraft to the operational phase of the mission and is intended to be a high-level management tool. The IMT was developed largely from TRW's Orbital Activation Plan and includes information acquired at the October 1999 Science Working Group meeting. A preliminary IMT Review was held on February 29-March 2 and included Aqua Project, TRW, Instrument Operation, and Flight Operation Teams. Inputs from this review are being incorporated and a new version of the IMT is scheduled to be released at the end of May. It will be accessible at the following internet address: ftp://198.118.192.20/pub/fot/leo_timelines/pm

After returning from lunch, Roy Spencer, the AMSR-E Team Leader, offered an update on AMSR-E Validation and Science. A joint AMSR Science Team Meeting will be held in July 2000 in conjunction with the IGARSS meeting in Honolulu, HI.

Validation plans for AMSR rainfall products in FY 2000 include the routine operation of Eureka WSR-88D (doppler radar) and the installation of rain gauge clusters at 2 locations (tbd). In FY 2001, in addition to the routine operations of the WSR-88D, the Wallops Experiment on 3D raincloud structure will occur and will include 2 multi-parameter radars, NASA NPOL radar, NOAA ETL radar, rain gauge and disdrometer network. In FY 2002, an experiment will be conducted in the Sea of Japan which will include the NASA NPOL radar, DC-8 with radiometers, NASDA radars and microphysics aircraft, NASDA ground support, and possibly the ER-2 with radiometers. In FY 2003, a long-term statistics program will start (possibly at Wallops) with the NPOL radar, and in FY 2004 a 60-day Eureka experiment with 2 aircraft is planned.

Validation plans for AMSR ocean products include the utilization of buoys, ships, and satellite radiometers for SST; buoys, satellite radiometers, and NCEP models for surface winds; radiosondes for integrated water vapor; histogram analysis and GOES imagery for integrated cloud water.

Validation plans for AMSR land products include field experiments that will utilize intensive sampling over a 200 x 200 km area diverse in vegetation, climate, and topography, for a 1 month period, employing satellite, airborne, and ground instrumentation. In addition, existing operational networks will be utilized such as the Oklahoma Mesonet, DoE ARM/CART, USDA ARS Micronet, Illinois Climate Network, and sites in Russia, China, and Mongolia. Also, cooperative programs such as GEWEX/GAME, GEWEX/CEOP, GSWP, DAO, NCEP, and ECMWF will be leveraged. Comparisons with other sensors such as the SSM/I and SSM/IS, Aqua's MODIS and AIRS, and SAR will be studied. Field campaigns currently scheduled include Nagaoka, Japan (2000), Southern Great Plains (2001, 2003, 2005), Walnet Creek, IA, Little River Watershed, GA, San Pedro basin, AZ, and Thailand, Tibet, and Mongolia in 2001-02 (with NASDA).

Sea ice validation plans include satellite intercomparisons with SSM/I and SSM/IS and campaigns such as Meltpond 2000 in the Arctic (June/July 2000), and campaigns in Antarctica (August 2001, 2003 out of Punta Arenas) and the Arctic (with

rainfall experiments in 2002 and 2004). Snow cover plans include participation in MODIS field campaigns, AMSR-E sea ice campaigns, and an NSIDC collaboration.

The second half of Spencer's talk dealt with AMSR-E science. It was noted that cloudy SST retrievals from the TRMM microwave imager (TMI) have been demonstrated. Examples included how the TMI shows cold wakes behind hurricanes that AVHRR misses, and how TMI SST's and QuikScat winds show mesoscale modulation of winds by equatorial instability waves. In addition, pointing errors have been found in NOAA K AMSU data (window channel imagery), as evidenced by the continents moving back and forth on the imagery. Aerojet has documentation of measured AMSU pointing errors and NESDIS has documentation of AMSU mounting errors.

Following Spencer's presentation, George Aumann, the AIRS Project Scientist, presented a status update on the AIRS/AMSU/HSB Program. Aumann stated that the instruments are mounted on the spacecraft and mechanical alignment is completed. Detailed on-orbit sequence from launch to launch + 90 days has been developed. In addition, a high level plan for data processing/validation from launch to launch +12 months is being synchronized between the GSFC DAAC and the AIRS science team.

Characterization of the AIRS at spectrometer temperatures of 149K, 155K, and 161K were completed in thermal vacuum testing before shipping. The temperatures were selected based on the predicted range of orbital conditions.

Aumann noted that instrument performance is "on spec" and the radiometric accuracy, after accounting for linearity, scan angle and polarization effects using the thermal vacuum data, is expected to be excellent.

Analysis of test data to determine the spectral response function (SRF) for each detector is almost completed. Part of the SRF determination involves high resolution measurements of the entrance filter for each array at 149K, 155K, and 161K using spare filters at JPL. Ten of the eleven entrance filters have been tested to date.

The AIRS SRFs are critical for the quantitative use of the AIRS data. The SRFs will be made available as part of the AIRS Calibration Report for external users. Aumann said that there are two methods which make the SRF details transparent to the user:

1. If the user prefers his/her own radiative transfer, then the SRF for each of the 2378 spectral channels is given by a prescription (available in tabulated form and as a function call).

2. If the user prefers the AIRS team-provided radiative transfer routine, giving the atmospheric/surface state vector as input to a function call returns the calculated upwelling spectral radiances for each of the 2378 spectral channels as output.

After a short break, EOS Validation Scientist David Starr provided an overview of the 2nd EOS Validation NASA Research Announcement (NRA). This NRA is limited to AIRS and AMSR-E on Aqua, and a few spectroscopic studies supporting Aura and will distribute approximately $2M per year, excluding the Atmospheric Radiation Measurement Radiosonde program. Teams and program managers from NASA Headquarters are expected to participate in the proposal review process and are also expected to organize post-selection workshops to initiate contact with the selected investigators.

The NRA is due to be released on May 8; letters of intent due June 15; proposals due July 13; peer review by mail due September 11; peer review panel will convene September 26-28; and selections will be released on November 1.

An open re-competition for CERES and MODIS is planned, with the possibility of a few additional Terra (ASTER, MOPPIT, and MISR) and maybe IceSat (GLAS) investigations. Current plans are to extend the proposals one year and then have a recompetition with selections by September 1, 2001 (draft NRA by October 2000). Starr wants input from the CERES and MODIS teams so he can develop an effective NRA for the next cycle.

Following Starr's presentation, Aumann offered some thoughts on Aqua platform instrument cross-validation. He noted that validation of a product means certifying that the product measures what it is intended to measure and has a quantifiable accuracy. Comparison of measurements of the same spatial, spectral, and temporal scene from two separate instruments on Aqua does not constitute validation, but may only confirm that data from two instruments are statistically likely to refer to the same quantity.

Aqua instrument cross-validation must be timely. There are significant differences in the maturity of the software of the different instruments. However, after significant bugs are fixed (e.g., L+3 months) every effort should be made to complete some level of cross-validation before the software is officially labeled "validated" (e.g., L+12 months) and available to the outside investigators from the DAAC.

Cross validation will be very useful and

can be done in a timely fashion if limited to simple products (Level 1B) and simple scenes. Cross validation within the first 12 months is not practical for global comparisons and Level 2. After then the comparison of apparently similar named products from different instruments can be a fruitful research effort.

Aumann suggested to have each instrument team evaluate potential areas for cross validation, coming to an agreement on what should be done and when, and present the plan at the September 2000 Aqua Science Working Group Meeting.

The final presentation of the meeting was given by Claire Parkinson and Steve Graham on Aqua outreach. It was noted that for the Terra mission, a set of science fact sheets were prepared that highlighted the science themes of the mission, and these topics were displayed for the group to discuss. It was proposed that the Aqua mission also develop a set of fact sheets highlighting its science. Parkinson and Graham presented the following list of four possible topics:

- The Aqua Mission
- The Water Cycle
- Enhanced Weather Forecasting
- The Earth's Snow and Ice Cover

The group decided that the fact sheets should be written for the water cycle and enhanced weather forecasting first and, upon the recommendation of Larrabee Strow, that one or more of the fact sheets should emphasize new technologies.

Finally, the possibility of performing a "webcast" of the Aqua launch was discussed. The suggestion was well received, and preparations will begin regarding this event. The meeting concluded at 4:00pm. The next scheduled Aqua Science Working Group Meeting is September 12, 2000 at GSFC.