Minutes of the Aqua Science Working Group Meeting

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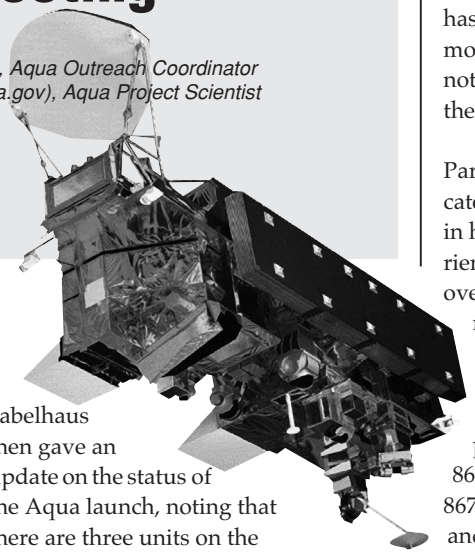

The Aqua Science Working Group met at the Goddard Space Flight Center (GSFC) on February 8, 2001, chaired by Claire Parkinson, the Aqua Project Scientist. Parkinson opened the meeting at 8:30 a.m. with a welcome and the announcement that George Morrow, the Aqua Project Manager, will be leaving the Aqua project on February 9 and will be replaced by Phil Sabelhaus. Parkinson elaborated on the critical work performed by Project Managers and thanked Morrow for all he has done to ensure that the mission will reach the objectives laid out by the scientists. Morrow then explained that he has greatly enjoyed working on the Aqua mission but has decided to take a job with Jackson and Tull, a private aerospace company, as Vice President for their Aerospace division. He thanked everyone for working with him and noted that he will be present at Vandenberg Air Force Base with many others to watch the launch of Aqua.

Morrow then introduced Phil Sabelhaus as the incoming Aqua Project Manager. Sabelhaus offered a brief history of his involvement with NASA Earth Science missions, including Project Manager of TOMS/EP, TOMS on ADEOS, GOES, Landsat, Aura, and VCL. He is happy to have the opportunity to be involved with the Aqua mission, especially at this critical and exciting stage, and is committed to the mission's success.

Sabelhaus then gave an update on the status of the Aqua launch, noting that there are three units on the spacecraft that are currently causing concerns: the Formatter Multiplexer Unit/Solid State Recorder (FMU/SSR), the transponder, and the transponder interface electronics (TIE). The Aqua TIE will be removed from the spacecraft and sent back to B. F. Goodrich for inspection, because a similar Aura TIE has recently failed vibration testing. The system Comprehensive Performance Test (CPT), scheduled to start February 8, was delayed to allow time to complete the procedure dry runs; the current estimated start date is February 14. [*Editors note: The Dry Run System CPT was successfully completed on March 6. No new significant hardware issues were identified.*] Additional problems include paint cracking on the Earth shade on AIRS and excess oil in the CERES deployment mechanisms. The latter problem is being addressed by placing the deployment mechanisms in a thermal chamber at an elevated temperature in order to bake out the excess oil.

Sabelhaus noted that the Delta Launch Manifest is filling up and is crowded in the June/July timeframe with Jason/TIMED, MAP, Genesis, Geolite, and GPS. The latest word is that the Flight Planning Board meets on February 8 and will likely slip Jason/TIMED to August. Meanwhile, a commercial Boeing launch called Earthwatch is sliding into the October slot. ICESat has a December slot and Iridium has moved to March 2002. If Aqua does not launch in September/October 2001, then it will likely be early 2002.

Parkinson thanked Sabelhaus and indicated that the Aqua mission is fortunate in having someone of Sabelhaus's experience and caliber available for taking over the Project Manager's job. She then mentioned that Volume 2 of the EOS Data Products Handbook is now available and copies can be obtained from lee_mcgrier@sesda.com or by phoning Lee McGrier at (301) 867-2037 or Steve Graham at (301) 867-2036. In addition, the AMSR-E logo and brochure have been printed and are being distributed.

Following Parkinson's comments, Ramesh Kakar, the Aqua Program Scientist at NASA Headquarters, spoke about the recompetition of the Terra and Aqua science teams. The present science team contracts run out on December 21, 2001, and Procurement may or may not allow contract extensions beyond that date. A new NASA Research Announcement (NRA) for recompeting the team efforts is under development, with Jim Dodge and Jack Kaye (both of NASA Headquarters) working on it. It is expected that the new NRA will recognize three broad categories: algorithm maintenance, science data analysis, and forward compatibility. Kakar noted that the sum of funding in the three categories would approximate the available funding in the science team funding line.

It is not clear at this time if separate NRAs will be needed for the two platforms or if one will suffice. It is possible that an NRA for Terra will be released this summer and the new NRA for Aqua (concentrating on AIRS/AMSU-A/HSB

and AMSR-E) could appear approximately one year after launch. Rather than going into more detail, Kakar deferred to Jack Kaye, who was at the afternoon session to expand upon these issues.

Next, Kakar offered an introduction to the NASA Earth Science Enterprise Research Strategy (2000-2010), noting that it should be a guiding strategy for the next decade and that it is based on the following five questions:

- How is the global Earth system changing?
- What are the primary forcings of the Earth system?
- How does the Earth system respond to natural and human-induced changes?
- What are the consequences of changes in the Earth system for human civilization?
- How well can we predict future changes in the Earth system?

Under these primary questions, there are 23 additional questions focusing on specific research areas. Kakar pointed out that 6 of the 23 questions concern the global water cycle. Lastly, Kakar reviewed the current missions and launch schedule.

"First Light Images" and Science Team Presentations

Next, Parkinson explained the importance for NASA public relations of getting good "first images" to show publicly a few months after launch and mentioned that Bruce Barkstrom and Vince Salomonson, the CERES and MODIS Team Leaders, respectively, have been through this process in 2000 with the Terra spacecraft.

CERES Team

Barkstrom then relayed his experience with first light images from Terra and offered thoughts on possible first light images from Aqua. Barkstrom noted that it is not premature to start now preparing for the first Aqua press conference. The audience to keep in mind when preparing images is the general public. Word charts and bar charts should be avoided, and the images should be kept simple.

The Aqua Working Group, or its spokesperson, needs to decide on the main Aqua story to present during the press conference. At the Terra press conference, the main story centered on atmospheric aerosols. It would be helpful to have movies and animations detailing the concepts, as opposed to still images.

Barkstrom noted that moderately acceptable formats are global images with recognizable features (geography) that are visually interesting. He posed the question of whether or not the U.S. should be in the center of the visuals. Also, Barkstrom praised the MISR team as having done the best preparations for the Terra press conference. Their work is a good model to follow for the Aqua press conference, with video sequences and well-rehearsed responses.

The Public Affairs Offices at NASA Headquarters and GSFC will have the primary responsibility for orchestrating the press conference. It is anticipated that we will use the services of the GSFC Scientific Visualization Studio and Earth Observatory team and should begin two to three months prior to the first press conference rehearsal in order to perfect the image formats and color scales. Based on the Terra experience, it will probably require about three iterations before the images are suitable. Also, the teams should expect to do a complete rehearsal at an IWG prior to the press conference.

MODIS Team

Parkinson then introduced Vince Salomonson, the MODIS Science Team Leader, to present initial results from the Terra MODIS and thoughts on possible first light images from Aqua. Salomonson noted that MODIS is performing well in terms of spatial, spectral, radiometric, geometric, and quantization performance. All major systems are working, the focal planes and bands are well registered and are performing (overall) better than specifications, and calibration looks good. Also, noise and other factors have been identified and reduced, leading to a useful state for scientific use. Finally, studies are continuing to further optimize Level 1B data. Salomonson also noted that there are 5 MODIS direct readout stations in the U.S., and 25 stations or more are expected to be in place worldwide soon.

Regarding Level 1B improvement areas, the following Terra MODIS characteristics have been fixed or improved on the Aqua MODIS:

- radiance versus scan-angle response for the thermal emissive bands;
- optical cross-talk from band 31 (11 μm) into bands 32 (12.0 μm) through 36 (14.3 μm);
- electronic cross-talk amongst bands 5-7 and bands 20-26; and
- non-uniform digital count bin-fill factors, particularly for bands 31-36.

Salomonson showed a chart summarizing the operational characteristics of the Terra MODIS since "first light" in February 2000. Several problems have been stabilized starting in the fall of 2000. The MODIS Characterization Support Team is now looking at making quantified estimates of the overall uncertainty in the Level 1 product. Preliminary estimates show that the uncertainty is being reduced with time and has reached planned levels for Bands 4 and 5. In

the thermal infrared bands (particularly the sea surface temperature bands at 11 and 12 μm) the performance has not reached adequate levels but is improving as more efforts continue to reduce the various uncertainty factors.

Commenting on the overall status of the science products, Salomonson said that ~40 products are currently in development. Most of the products have been released in Beta format for examination by the scientific community, starting in the fall of 2000. Work continues on all the products to get them to the point where they can be considered routinely useful for scientific or applications studies. It is suggested that anyone wishing to employ the MODIS products should communicate with the appropriate MODIS Science Team member to ascertain the utility of the product or, at least, should pay careful attention to the quality "flags" on the products. Additionally, the MODIS Web pages contain much useful material on quality assurance and validation efforts for the products. In general, use by the scientific community is encouraged so as to obtain feedback and hasten validation.

MODIS-associated data processing systems (i.e., the GSFC DAAC and the MODIS Adaptive Processing System [MODAPS]) reached stable global production in fall 2000 and are consistently ingesting, processing, archiving, and distributing data. The data systems are resource-constrained and efficiencies in hardware, systems, software, algorithms, and even products are being evaluated. While hopeful for additional resources, all avenues are being pursued for producing consistent, timely data sets. A goal is to produce a consistent, one-year data set starting sometime in 2001. This effort may begin in June 2001, using the best performing algorithms available at that time. It will cover the period from November 2000 to November 2001.

Regarding production status, EDOS is working well and reorders of Level 0 data by the GSFC DAAC are approximately 1%. The DAAC is processing Terra at 2X on Silicon Graphics Origin 2000s, and is expected to reach 3X with the addition of the remaining Aqua hardware and installation of the S4P on the Origins to support reprocessing. MODAPS is shipping 300 GB per day to the DAACs, and 167 TB of MODIS products have been archived at the GSFC, EROS Data Center, and National Snow and Ice Data Center DAACs.

A MODIS User Survey was conducted at the Fall 2000 AGU meeting. The goal of the survey was to address whether or not MODIS data distribution is lower than it should be. Roughly 350 people from fields ranging from education (K-12 and college introductory remote sensing courses) to atmospheric and oceanographic research participated in the survey. The reasons for not ordering MODIS data can be grouped into four categories:

1. Data Maturity - Several people indicated that they would wait for more mature data products because of resource limitations. (This is typical for new data products.)

2. Data Access - Several people had experienced difficulties with ordering data and have not tried again. (Information needs to be distributed regarding the improvements in data access.)

3. Data Subsetting (spatial, temporal and parameter) - The transfer of large data files is difficult. Several users would find the data more manageable if vertical profiles of selected parameters for specified geographical regions were available. (Subsetting/data mining efforts are taking place.)

4. Data Formats - Some users expressed concern about the data only being available in HDF-EOS format. (Use of data format translators is being considered.)

Salomonson commented on the near-term challenges facing the science team, including work to improve the Level 1B products, to optimize the use of the products by the scientific community, and to maximize the publication and oral presentation of recent results. The team is working to find and implement efficiencies in the processing, reprocessing, archiving, and distribution of the data.

Lastly, Salomonson commented on first light images from Aqua. The present understanding is that first light for MODIS will occur 39 days after launch, versus 68 days after the launch of Terra. In the Terra MODIS case, needed outgassing/purging did not occur sufficiently, and actions were necessary to eliminate icing on the radiative cooler in August 2000. The current perception is that the Aqua MODIS schedule is too fast, and MODIS first light should probably occur closer to 50 days after launch. However, the MODIS Science Team is ready to work with the Project to better understand the plans and tradeoffs. Salomonson mentioned the importance of using common words rather than scientific terms at the "first light" press conference and of having a central theme.

AIRS/AMSU-A/HSB Team

After a short break, George Aumann, the AIRS Project Scientist, offered a status update on the AIRS/AMSU-A/HSB program. The AIRS/AMSU-A/HSB instruments have been integrated on the Aqua satellite at TRW for the last six months, and many of the comprehensive performance tests (all with spectrometer and detectors at ambient temperature) have been completed. AMSU-A and HSB time code issues in the packets are currently being resolved. The pre-thermal vacuum scan mirror inspection is scheduled for February 18. The thermal vacuum test itself will allow testing of AIRS detectors at the in-orbit temperature of 60 K.

Regarding software status, AIRS Product Generation Software (PGS) version 2.1 has been delivered to the GSFC DAAC, and version 2.1.5 (the last pre-launch PGS delivery) will have the final interfaces frozen, plus additional Quality Assurance indicators. Level 1B software has been revised based on data from the Lockheed Martin thermal vacuum chamber and has been documented in the Level 1B Algorithm Theoretical Basis Document version 2.2i.

Global simulated software has been used for software development, incorporating real instrument noise and spectral characteristics. The global data field has been based on National Centers for Environmental Prediction (NCEP) Aviation forecasts including multi-layer clouds, liquid water, surface emissivity, and surface temperature. A "golden day" exercise was completed over the period January 22-25, 2001. This exercise involved testing the data flow, display, retrieval and analysis software. The team is currently analyzing the data.

Regarding validation activities, the AIRS team is working towards the original schedule of DAAC delivery of validated PGS by Launch + 12 months. Validation support teams will be integrated into the plan as soon as the teams are officially selected.

Aumann reiterated the challenge set forth by James Baker of NOAA and Dan Goldin of NASA to demonstrate AIRS data assimilation impact by Launch + 12 months. To that effect, a workshop was held on December 6, 2000, and was attended by representatives of NCEP, the European Centre for Medium-Range Weather Forecasts, the UK Met. Office, the Canadian Meteorological Center, and the GSFC Data Assimilation Office (DAO). The operational data link via NOAA's National Environmental Satellite Data and Information Service is in place and is currently producing daily AIRS/AMSU-A/HSB "data" using the NCEP Aviation forecast model. The current data assimilation uses only Level 1B, cloud-free data. The AIRS science team will assist with cloud-free identification, cloud-cleared radiance utilization, and the forward and tangent model. The next workshop is scheduled for May 2001.

Some initial thoughts on possible first light images from AIRS/AMSU-A/HSB presented by Aumann include:

- animation of a global map going from the top of the atmosphere to the surface to illustrate global temperature soundings;
- animation of global maps of several days of total water from AMSU to illustrate water transport; and
- animation of several days of global images from an upper tropospheric sounding channel to illustrate "water wind."

A special section in the Journal of Geophysical Research with first results from AIRS/AMSU-A/HSB is being planned, with refereed papers from each AIRS Science Team member. The papers would be submitted at Launch + 12 months, but will be in print no sooner than 10-12 months after submission.

AMSR-E Teams

Following Aumann, Elena Lobl presented on behalf of Roy Spencer, the U.S. AMSR-E Science Team Leader. Lobl noted that the AMSR-E Science Investigator-led Processing System (SIPS) should be ready for the Mission Operations Science Systems-2 test. Lobl then described a passive-microwave rainfall mystery, wherein various estimates of tropical ocean rainfall change during El Niño Southern Oscillation (ENSO) (+10% during the warm phase) are at least double those inferred from surface energy and atmospheric radiation balance considerations. Possible explanations for these differences include rainfall efficiency and changes in drop size distribution. The TRMM radar actually shows a rainfall decrease during the warm phase, perhaps due to changes in drop size distribution.

Regarding AMSR-E first light images, Lobl noted that AMSR-E has a strong heritage and thus the only new measurements to be highlighted are the highest spatial resolution passive-microwave data yet in the extratropics (the TRMM Microwave Imager has similar resolution in the tropics) and the highest 6 GHz resolution yet (50 km vs. SMMR's 120 km). Possible first light images include extratropical imagery of rain systems over the land and ocean, sea ice, soil moisture, snow cover, oceanic wind fields near deep low pressure systems, global imagery of sea surface temperature (even through clouds), and improved spatial sampling of rainfall.

After Lobl, Yasuyuki Ito, the ADEOS-II Science Project Manager at the Earth Observation Research Center (EORC) of the National Space Development Agency of Japan (NASDA), presented a status update on ADEOS-II and AMSR-E/Aqua, plus thoughts on possible first light images. Ito began with a brief overview of the Earth observation satellite programs of Japan, including a breakdown of the organization of the Office of Earth Observation Systems.

Next, Ito provided a status update on the ADEOS-II program. The ADEOS-II system Proto-Flight Test was completed in December 2000, and the satellite will be stored by the end of March 2001. Functional tests and additional tests on the satellite's sensors will be conducted, with a Post Qualification Review to be held by the end of March 2001, aiming towards a February 2002 launch target.

The AMSR-E flight instrument is undergoing a systems test aboard the Aqua spacecraft at TRW, while the Level 1 data processing system is undergoing its first mission simulation test. The second mission simulation test will be conducted from April to July 2001. Also, the Level 2 and 3 data processing system

is in the manufacturing and test phase.

Regarding data distribution for ADEOS-II and AMSR-E, the Earth Observation Center (EOC) will be the receiving, archiving, processing, and distributing center while the EORC will serve as the algorithm development and calibration/validation center. Validated Level 1 and Level 2 data will be available at the EOC 12 months after launch, but PI's will have access to the non-validated data before their public release. NASDA and NASA will implement catalog, browse, and order interoperability for the ADEOS-II phase.

Ito noted that geophysical products from the Global Imager (GLI) on ADEOS-II will include aerosol parameters, cloud parameters, chlorophyll-a, colored dissolved organic matter, suspended solid weight, sea surface temperature, vegetation index, and snow grain size and impurities. Additionally, the SeaWinds sensor will measure sea surface wind vectors, while the Polarization and Directionality of the Earth's Reflectances (POLDER) will measure clouds and aerosol parameters, and the Improved Limb Atmospheric Spectrometer II (ILAS-II) will measure ozone and HNO_3. The geophysical products from AMSR on ADEOS-II and AMSR-E on Aqua include cloud water, water vapor, precipitation, sea surface wind speed, sea surface temperature, sea ice, snow depth, and soil moisture.

There was an AMSR PI meeting in Kyoto, Japan from October 30 to November 1, 2000 and a joint U.S./Japan AMSR/AMSR-E, team meeting held in conjunction with an International Geoscience and Remote Sensing Symposium in Honolulu in July 2000. Currently, an AMSR/AMSR-E PI meeting is tentatively planned for the November 2001 to January 2002 time frame.

Ito suggested, as possible first light images from AMSR-E, a selection of high-resolution Level 1B images and Level 3 images on water vapor, sea surface temperature, and other variables, and, if feasible, animations using Level 1B and/or Level 2 data.

Discussion

Following Ito's presentation, Parkinson led a brief general discussion on Aqua first light images, including possibilities for highlighting, such as improved resolution, morning/afternoon contrasts, and the full hydrological cycle. Barkstrom noted that we need to move beyond highlighting high-resolution images and show how these data can affect people's lives. He also mentioned that it would be helpful to stress the combination of instruments and their technical differences. Bruce Wielicki of the CERES Team added that the images should focus on a common theme, such as the water cycle. Aumann mentioned that television weather forecasters are now claiming a 5-day accuracy and that there is a large public awareness of this, leading to the suggestion that maybe we should highlight the impact that Aqua will have on weather forecasting. It was also noted that many of the topics could be the same as those in the upcoming Aqua Science Writers' Guide.

Validation

Following the general discussion, Peter Hildebrand, the Aqua Deputy Project Scientist for Validation, presented a summary of the Aqua Validation Working Group meeting held at GSFC on February 7, 2001. In attendance at the February 7 meeting were approximately 20 participants from the MODIS, CERES, AIRS, and AMSR science teams. At the meeting, validation plans for each Aqua instrument were reported on by instrument team representatives. In summary:

- Vince Salomonson reported the MODIS Team's scheduled comparisons with other satellites, ground measurements and science campaigns, and models. Specific to MODIS-Land (see http://modarch.gsfc.nasa.gov/MODIS/), there will be a strong emphasis on piggyback validation activities with AERONET and FLUXNET. MODIS-Ocean will conduct an AVHRR pathfinder/MODIS comparison, conduct cruises with a marine interferometer, and utilize the MODIS Ocean Buoy. MODIS-Atmosphere will utilize land validation sites and field campaigns such as ARM, AERONET, FIRE-ACE, and SAFARI.

- Bruce Wielicki reported on the CERES Team's calibration and validation efforts for the Terra CERES and the TRMM CERES. Most CERES validation makes use of long-term validation sites such as ARM, BSRN, and AERONET sites for clouds, aerosols, and surface radiative fluxes. Current CERES field plans include the CERES ARM Validation Experiment (CAVE), the Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS), scheduled for July 12 - August 1, 2001, and the CERES Ocean Validation Experiment (COVE). The CERES field validation plans are detailed on the CERES Web site at http://www-cave.larc.nasa.gov/cave/.

- Eric Fetzer explained that on-orbit validations for the AIRS Team will focus strongly on operational rawinsondes and dedicated radiosondes at times of overpass, plus observations of the marine surface state from buoys. Soundings will come from ARM-CART validation sites, Brazil, and Australia. Fetzer noted that the full validation plan is on the AIRS Web site, http://www-airs.jpl.nasa.gov/.

- Elena Lobl noted the AMSR-E Web site at http://wwwghcc.msfc.nasa.gov/AMSR/. AMSR-E ocean product validation will utilize buoy, radiosonde, and satellite observations. Sea ice product validation will

use ship and aircraft campaigns, as well as MODIS and Landsat observations. Rainfall products will be validated through several field campaigns using a ground X-band radar and data from the Eureka and the Kwajelein radars, plus comparisons with the TRMM Precipitation Radar and the TRMM Microwave Imager. Snow products will be validated on 25-km grid, regional, and river basin scales using aircraft observations. Soil product validation will utilize many land surface hydrology experiments around the globe, modeling and data assimilation, and comparisons with AIRS and MODIS.

Hildebrand noted that common themes surrounding Aqua validation plans include the upcoming announcement concerning the pending Aqua validation proposals and the expected recompetition of the science team efforts. The next steps for the Aqua Validation Working Group will be to evaluate the common validation needs and to develop common calibration/validation venues. The next meeting will take place on August 1, 2001, the day before the next Aqua Science Working Group meeting.

During the validation discussion, Wielicki pointed out the need to sort out the definitions of beta versus provisional versus validated data products. Salomonson agreed, adding that it is probably an issue most appropriately addressed by the EOS Investigators' Working Group.

Formation Flying of the EOS Afternoon Satellites

After the lunch break, the meeting reconvened at 1:30 p.m. with Parkinson introducing the next set of three talks, all centered on the issue of formation flying of the afternoon satellites Aqua, PICASSO, CloudSat, PARASOL, and Aura. The first speaker in the group, Mark Schoeberl, the Aura Project Scientist, began by noting that there is considerable interest in the formation-flying concept at NASA Headquarters and that his term for the afternoon satellite formation is the "A-Train", with Aqua at the lead and Aura at the tail. He showed an impressive animation of the A-Train in orbit and mentioned several important complementarities amongst the instruments on the five A-Train satellites.

Schoeberl then introduced Rich Macintosh and asked him to review formation flying requirements and the Aqua requirements for initial orbit phasing. Formation flying of Aqua with Aura requires that both spacecraft must maintain a ground track on the World Reference System (WRS) using frequent burns (once every three months) to counteract atmospheric drag. A ground track control of ±20 km results in minor variations in spacecraft separation of ±43 seconds along-track. The largest effect on the spacecraft separation over time is from the difference in ascending node mean local time (MLT) between the two orbit planes. While both spacecraft maintain their ground tracks, separation will change gradually as the MLT changes.

Both spacecraft must perform occasional inclination maneuvers to control MLT drift so minimum desired separation (on the order of 15 minutes) is not violated. The Aqua MLT is allowed to range from 1:30 p.m. to 1:45 p.m., while the Aura MLT is allowed to range from 1:30 p.m. to 2:00 p.m. Aqua and Aura must agree on desired MLT ranges to maintain separation; this implies an agreement on the frequency of inclination maneuvers. Smaller MLT range implies smaller, more frequent inclination burns—1 or 2 per year versus 1 or 2 over the lifetime of the mission.

Macintosh noted that, during the ascent phase, Aqua will perform maneuvers to synchronize with the WRS, and could normally synchronize with any WRS path since it is the first spacecraft in the afternoon constellation. However, initial orbit phasing relative to the morning constellation must be considered to avoid ground station conflicts with those spacecraft. Aqua will need to time the ascent maneuvers so that after it reaches its final orbit position, it will not fly over the polar ground stations at the same time as other spacecraft. The preliminary Aqua ascent plan to 705 km consists of four maneuvers to be completed by day 14. The synodic period between spacecraft at 695 km and 705 km is 32 days; this is the maximum time we would have to wait for proper initial phasing before starting ascent maneuvers.

If Aqua is required to phase with the morning constellation, the time needed to perform the ascent to mission altitude could increase significantly depending on the initial phasing at launch. The best-case scenario has an initial phasing at launch that allows the final desired position to be achieved with no changes to the nominal maneuver plan. The worst-case scenario has an initial phasing at launch that requires a delay of one synodic period before starting the ascent. In the latter case, 32 days would be added to the 9-day maneuver period, for a total of 41 days. However, from the Terra experience, this would not necessarily preclude instrument operation during the ascent period.

Wayne Esaias, the MODIS-Ocean Group leader, offered the suggestion that in addition to formation flying of the A-Train we should look into the possibility of having the daytime path of the Aqua MODIS match the previous or next nighttime path of the Terra MODIS.

The next speaker, Bruce Wielicki from the CERES Team, continued with the formation-flying theme by elaborating on the synergisms of the train. Wielicki reiterated that the A-Train consists of Aqua, PICASSO, CloudSat, PARASOL, and Aura, with Aqua leading the train. The nominal plan for the others is to precess across the Aqua-MODIS scanning path.

Wielicki explained that together, PICASSO, CloudSat, and Aqua will allow studies of cloud feedbacks in the climate system in ways never before possible. These studies would involve processes in atmospheric state, cloud physics, cloud optics, and top of atmosphere, surface, and atmospheric radiative heating profiles. Additionally, formation flying will be useful for cloud validation with CloudSat and PICASSO. Variables include cloud amount, cloud top height, cloud physical thickness, cloud base, cloud visible optical depth, cloud infrared spectral emissivity, cloud liquid water path, cloud ice water path, cloud particle phase, and cloud particle size.

The A-Train will also facilitate aerosol validation. The vertical locations of aerosol layers are critical for source region back-trajectories, and the locations of cloud/aerosol in the same vertical layers are critical for indirect aerosol forcing. MODIS can obtain good aerosol data over dark surfaces, but the A-Train will allow us to obtain such data also over snow, ice, and all other surfaces. The optimal scenario is to combine PICASSO with MODIS and PARASOL. Wielicki noted that precession across the MODIS swath would help verify causes/physics of angle dependent aerosol cloud properties from passive imagers providing global climate data.

Next, Graeme Stephens of Colorado State University presented on CloudSat and the afternoon constellation. He reiterated that the combination of constellation observations well exceeds the sum of the individual parts and explained that part of his purpose in speaking at this meeting is to convince Aqua scientists of the importance of CloudSat contributions. The CloudSat team has developed optimized retrieval methods that combine heterogeneous (multi-sensor) information derived from the constellation. This, however, requires availability of the data. A critical issue thus becomes the exchange of data and how quickly and at what cost the CloudSat researchers will be able to obtain appropriate subsets of Level 1 data from the other missions.

Stephens elaborated on how information from one sensor can enhance the products derived from others, with the possibility of development of new products and an opening of the possibilities for addressing new science.

Stephens then spoke briefly on the CloudSat mission, noting that it will include the first 94 GHz spaceborne radar system. A unique feature is that the radar is extremely sensitive and has a wide dynamic range. It sees the majority of clouds, from thin cirrus clouds to deep convective clouds producing heavy precipitation. The CloudSat science objectives are to:

- measure the vertical structure of clouds and quantify their ice and water content,
- predict clouds and precipitation,
- improve weather prediction and clarify climatic processes,
- improve cloud information from other satellite systems (particularly Aqua),
- investigate the effects of aerosols on clouds and precipitation, and
- investigate the utility of the 94 GHz radar for observing precipitation in the context of cloud properties from space.

Stephens then commented on two formation-flying scenarios. The original scenario involved CloudSat in formation with PICASSO-CENA (and more loosely with Aqua) to provide essentially instantaneous lidar/radar views of the atmosphere. The current scenario involves CloudSat flying in a tight formation with Aqua, aligning CloudSat radar with nadir pixels of MODIS. The combination of Aqua and CloudSat data enhances the science of both missions.

Stephens then presented some examples of CloudSat synergy with MODIS, CERES, and AMSR. He noted that MODIS optical depth provides independent information that more tightly constrains the relation between the power returned from radar and the water and ice content of the radar volume, thus improving retrievals.

Finally, Stephens stressed the importance of coordinating CloudSat and Aqua validation efforts, noting also that the need exists to establish a data flow dialog and subsequent plan of action among members of the constellation instrument teams.

Recompetition

Following Stephens, Jack Kaye from NASA Headquarters spoke on the plans in development for dealing with the upcoming expiration of science team contracts. This will involve a separation of the science efforts into two main categories. First, the Core Instrument Team Activities, including algorithm maintenance and key aspects of data product validation, will be covered under an appropriate, somewhat restricted solicitation. This will maintain the continuity and heritage to insure high quality data products for release to the broad science community. It is expected that support for these activities will decrease over time as the processing algorithms stabilize and the initial validation studies prove successful. Both Terra and Aqua instrument team activities will likely be covered in one solicitation.

Second, an NRA will be released to solicit from the Earth sciences community long-term, multi-platform, multi-instrument Science Data Analysis investigations. Investigations will be sought that address questions relating to discipline areas and key science themes rather than addressing single instrument data sets. It is expected that support for these investigations will

increase over time as the data products from the EOS platforms reach appropriate stages of maturity. Researchers will be allowed to use alternative algorithms from those used in the standard products, although the funding here will not be for new algorithm development.

With these two types of solicitations, the goal is to fund activities that carry the EOS project through transitions from pre-launch initial algorithm development, to post-launch algorithm refinement and stability, to initial validation studies, and finally to broader validation studies and uses of the data products to address and answer important scientific questions. The intention is to shift funding dollars more and more from algorithm development and maintenance to scientific analysis.

Data Processing

Following Kaye, Bruce Barkstrom, representing Chris Justice and the Science Working Group on Data (SWGD), presented on Terra and Aqua data processing issues, beginning with an overview of a workshop held on June 1-2, 2000, at GSFC. The June 2000 workshop was called to evaluate how well the EOS Data and Information System (EOSDIS) supports current and upcoming EOS missions, to determine how requirements have changed, and to recommend solutions to meet evolving needs.

The participants at the June 2000 workshop discussed the then current operating status of EOSDIS, in particular the lower than expected throughput and how it should be addressed. They noted that the February 1996 baseline sizing used to implement EOSDIS is not adequate to support current science data needs. Because that baseline was established before the algorithms were developed and could be run in the production environment, it did not have a clear empirical basis. Terra instrument team representatives presented revised system sizing estimates based on current experience and improved understanding of the EOS production environment.

Barkstrom noted that the instrument teams have made considerable improvements and efficiencies to codes and algorithms. However, increased hardware capacity is needed above the 1996 baseline to generate the higher-order geophysical data products already committed for Terra and planned Aqua science. Provisional cost estimates suggest that a much-desired three-fold increase in production capacity at the DAACs and SIPS could be obtained with a cost of approximately 7% of the annual ESDIS budget.

Aqua Integrated Mission Timeline

After Barkstrom, Fran Wasiak of the Aqua Instrument Planning Group presented an update on the Aqua Integrated Mission Timeline (IMT). The third IMT review was held on October 17, 2000, and was attended by representatives from the Aqua project, TRW, Instrument Operations Teams, and the Flight Operations Team (FOT). The current version of the IMT is based on all the IMT reviews (March, July, and October 2000). Some adjustments in the Aqua maneuver plan are to move the MODIS yaw maneuver from days 26-27 and 30-31 to days 32-33 and 37-38 and add a CERES yaw maneuver on day 41. One important maneuver that has not changed is the deep-space pitch maneuver scheduled for day 55. Plans call to baseline the IMT in March or April 2001.

Assumptions guiding the IMT team include:

- Activities, in general, are scheduled to occur during the FOT prime shift.
- Per FOT direction, only one EOS Polar Ground Network pass is used per orbit.
- Instruments use only Alaska and Svalbard ground stations. Spacecraft bus uses Alaska, Svalbard, and Wallops. McMurdo is not available for use.
- TDRSS is assumed to be available as scheduled. The Project has requested nearly continuous coverage for the first three hours after launch and two 20-minute TDRSS contacts per orbit thereafter.
- Timeline is based on the nominal plan and does not account for contingencies.
- Scheduling of the MODIS roll maneuver does not yet account for moon phase.
- Instrument scheduling is based on results of the last IMT review as well as continuing information exchange with Instrument Operations Teams and TRW, the Aqua spacecraft developer.

Issues surrounding instrument commanding during the first two weeks include the fact that spacecraft and AMSR-E RunUp activities occupy most of the first two weeks. Teams still have the option to schedule benign activities with their instruments during this period if they choose to do so, and MODIS may choose to perform transition to the ON state earlier than day 15 now that AMSR-E RunUp has been shortened.

It is the AIRS Team's preference not to perform deep-space constant pitch maneuvers, and the current IMT assumes no pitch maneuvers for the scheduling of AIRS activities, despite the planned pitch maneuver on day 55. Under some scenarios, AIRS would not complete its activation checkout until after the Launch-plus-90-days threshold. Hence, AIRS has provided a preliminary alternate plan of activities that needs to be implemented into the Baseline.

The slip in the MODIS yaw maneuvers is primarily because the MODIS Team has elected to wait until day 15 to begin the outgassing procedure and prefers 14 days of outgassing rather than the earlier scheduled 11 days. MODIS activities

remain in the same order, slipping the first set of yaw maneuvers to days 32-33. The second set of MODIS yaw maneuvers no longer needs to be delayed for CERES, and MODIS may opt to perform both sets of yaw maneuvers on four consecutive days.

The new review version of the IMT is to be released on March 30, while the Baseline IMT is to be released two weeks before Mission Rehearsal #1. Finally, the Product Development Tracking Tool has been proposed for IMT Change Request submittal.

Outreach

Steve Cole of the EOS Science News and Information Team at GSFC gave the last formal presentation of the day. The EOS Science News and Information Team supports media outreach efforts of all EOS missions and researchers. Cole noted that this is a critical time in the planning for media activities related to the launch of Aqua. Input from the Aqua Science Working Group on the key stories that the media and public should know about Aqua and its science needs to be given soon so it can be used to develop various media materials, including a "Science Writers' Guide to Aqua."

Science Writers' Guide topics should highlight key advantages of Aqua, either from its new instruments or from the usefulness of its data in combination with other data, including data from Terra. An initial list of possible Aqua research highlights was presented. Topics included: improvements in weather forecasting, sea-ice monitoring, snow-cover mapping and runoff estimates, complete ocean color coverage, diurnal cycles of clouds and solar radiation, surface heat budget of the ocean, acceleration of the hydrological cycle, insight into atmospheric water processes, mapping wildfire hazards, and soil moisture content. Comments on this list and suggestions of specific

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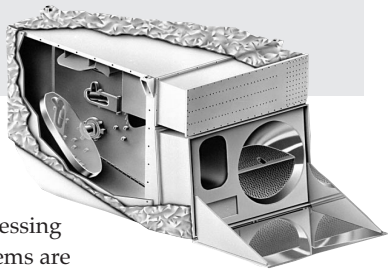
MODIS Science Team Meeting

— Rebecca Lindsey (rlindsey@pop900.gsfc.nasa.gov), SSAI

MODIS SCIENCE TEAM MEETING, January 24 and 25, 2001
MODLAND Validation Workshop, January 22 and 23, 2001
MODIS Ocean Team Meeting, January 23 and 26, 2001
MODIS Characterization Support Team Meeting, January 23, 2001
MODIS Atmosphere Group Meeting, January 23, 2001
MODIS Land Group Meeting, January 26, 2001



The MODIS Science Team Meeting and affiliated meetings convened in Columbia, MD, January 22-26, 2001. This article summarizes the activities of the two-day plenary session on January 24 and 25. Please see the "Meetings" section of the MODIS home page (http://modis.gsfc.nasa.gov) for the complete meeting minutes for this meeting, as well as other MODIS-related meetings for which minutes are available.

Vincent Salomonson, MODIS Science Team leader, began the meeting by emphasizing the MODIS team's commitment to aligning its efforts with the Earth Science Enterprise's research strategy. He expressed his enthusiasm about the early results coming from the team. MODIS' major instrument systems work, the spectral bands are properly located, signal to noise ratios are good, and the gains appear to be stable. Data processing is stabilizing and products are being produced and archived. The calibration and characterization efforts overcame several challenges this first year after launch. Many of the MODIS products have been released including some Level 3 (L3) products from every discipline group, and the team is working toward improving product quality through instrument characterizations and validation.

Salomonson concluded the talk with a summary of challenges that the team would be addressing in the future: reaching a stable instrument characterization state, ensuring data processing systems are efficient and that they are able to supply sufficient power to process and reprocess data, determining how to support MODIS Direct Readout users, and preparing for Aqua.

Terra Status

Paul Ondrus gave a brief history of Terra since launch. The high points are that all major systems are working within specs, the craft is producing enough power, it is collecting all science data, and it is satisfying pointing requirements. The biggest challenge has been managing the solid state recorder. Terra makes 4.8 TB of data each month; in one year, Terra has doubled the amount of Earth science data available to the scientific community. Ondrus reported that the deep space maneuver is still being negotiated with the Project and the other instrument teams.

MODIS Status

Bruce Guenther, MODIS Characterization Support Team Leader, gave a brief summary of instrument status, starting with the year's highlights, among them MODIS' successful activation and command operation. MODIS L1B data were the first Terra data to be publicly released; the solid-state recorder delivered 22.9 TB of data in 2000. The past

Validation investigations

Both EOS Validation investigators and MODLAND PIs made presentations. There were also presentations from MISR (Brugge), the Scientific Data purchase (Pagnuti), and NASDA's GLI team (Honda). Presentations are available online (URL 1). Based on the presentations and discussions from break-out sessions, the meeting arrived at several conclusions. In general, there is no set definition for what it means for a product to be "validated." That is, validation activities are incremental, with incremental stages including:

- exploring products at a few well-instrumented sites;
- incorporating multiple sites with similar measurements;
- developing a globally representative network and incremental goals;
- checking and refining products to be on target – "unbiased";
- estimating product uncertainty at pilot sites;
- comparing initial results with theoretical error bars;
- estimating product uncertainty with global representation, and
- inferring the impact of uncertainty on products' use.

The ultimate driver should be the utility of products for addressing science and application questions. Current activities are addressing the early stages in this incremental structure.

From the experience gained during the first year of MODIS data collection, there is a clear need for a close coupling between external validation investigators and the science team. This interaction between several investigators and the science team could provide expanded opportunities for validation activities including:

1. additional sites with the same investigators;
2. additional sites with additional investigators (using protocols and methods already developed);
3. network of sites with global representation; and
4. integration with end user feedback.

Summary

Validation campaigns have been undertaken for each of the MODLAND products. They represent a significant amount of work and dedicated resources. Results are starting to come in. Validation activities in 2001 will benefit from stable MODIS data. As activities continue, emphasis will be placed on standardizing measurement techniques through protocols. MODLAND will continue to focus on the EOS Land Validation Core Sites and to interact with international partners through the CEOS, WGCV-LPV.

Acknowledgments

Thanks to Nazmi El Saleous, Robert Wolfe and David Roy for their MODIS production and QA input at the meeting and Rebecca Lindsey for help in preparing this report.

Related URLs:
1. MODIS Land Team Validation Annual Review Meeting, 2000: http://modis-land.gsfc.nasa.gov/val/modland_val_mtg_2001.html

2. CEOS Working Group on Cal/Val – Land Product Validation subgroup: http://modis-land.gsfc.nasa.gov/val/modland_val_mtg_2001.html

3. MODLAND Production http://modland.nascom.nasa.gov/prod/

4. MODLAND Science Quality Flag http://modland.nascom.nasa.gov/QA_WWW/release.html

5. EDC DAAC's MODIS Reprojection Tool: http://edc.usgs.gov/programs/sddm/modisdist/index.shtml

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Minutes of the Aqua Science Working Group Meeting

researchers active in these areas were requested of all meeting attendees.

Lastly, Parkinson led a brief discussion on whether to attempt to produce a special Aqua issue of a professional journal. Salomonson commented that the Terra special issue of the IEEE Transactions on Geoscience and Remote Sensing was useful and a corresponding issue could be equally useful for Aqua. One suggestion was to emphasize AIRS/AMSU-A/HSB and AMSR-E, with briefer discussions regarding MODIS and CERES, both of which are included in the IEEE special issue on Terra. It was decided that a special Aqua issue should be pursued.

The date for the next meeting of the Aqua Science Working Group was set for Thursday, August 2, 2001 at GSFC.