EOS PM Science Working Group Meeting Minutes

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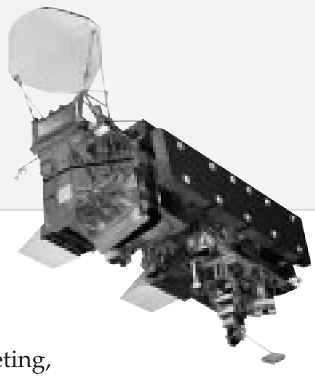

The EOS PM Science Working Group met on October 15, 1999 at Goddard Space Flight Center to discuss a range of topics, with emphasis on validation in the morning and spacecraft maneuvers in the afternoon.

The meeting was chaired by EOS PM Project Scientist Claire Parkinson, who opened with a brief update on the mission, including confirmation that the scheduled launch date is December 21, 2000. She gave short status statements on each of the six EOS PM instruments, with their expected delivery dates to the spacecraft company, TRW. Two of the instruments, the Advanced Microwave Sounding Unit (AMSU) and Clouds and the Earth's Radiant Energy System (CERES), are already delivered, while the other four are scheduled for delivery in the time frame of October-December, 1999.

Parkinson also presented the results of the voting for a new name for EOS PM. Voting was done by e-mail, with a ballot containing 17 candidate names compiled over the previous several months. The voting was done individually within each of the following six groups: the AIRS/AMSU/HSB Science Team, the AMSR-E Science Team, the CERES Science Team, the MODIS Science Team, the PM Project, and the EOS Project Science Office. With equal weight given to the results from each of the six groups, the top vote-getter was "Aqua." Three days after the meeting, NASA Associate Administrator Ghassem Asrar confirmed Aqua as the new name for EOS PM.

The opening remarks from the chairperson were followed by presentations from each of the four science teams, in each case providing a team update and an indication of planned validation activities for EOS PM.

AMSR-E Science Team

The Advanced Microwave Scanning Radiometer-EOS (AMSR-E) Team presentation was made by Elena Lobl, the AMSR-E Team Coordinator. Amongst the improvements mentioned as recently having been made in the AMSR-E algorithms is the addition of convective/stratiform differentiation in the precipitation algorithm, illustrated with results from the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI). Lobl showed a sample TMI North Atlantic sea surface temperature (SST) anomaly image from the period of the September 1999 passages of hurricanes Floyd and Gert. She pointed out the ability of TMI's through-cloud retrievals to show detailed patterns in storm-induced negative SST anomalies.

Lobl also presented results from the Southern Great Plains (SGP) 1999 field campaign in Oklahoma. The results verify the sensitivity of C-band radiometry to soil moisture in the top 2.5 cm of the ground in areas with low vegetation cover.

The AMSR-E Team proposal to do much of their data processing at Marshall Space Flight Center (MSFC), the home base of the AMSR-E Team Leader, through a Science Investigator-led Processing System (SIPS) has been approved, much to the relief of the AMSR-E Team. The team members feel that having control of the processing at MSFC should greatly simplify the data processing effort. The Beta versions of the AMSR-E algorithms were delivered to the Team Leader Science Computing Facility (TLSCF) last year, and the engineering version 1 (V1) is due to the TLSCF by November 1, 1999. The engineering version of the algorithm software is due to the SIPS by March 1, 2000, and the launch version is due by August 1, 2000.

The Japanese are responsible for AMSR-E instrument calibration, but the calibration team includes members from the U.S. AMSR-E Team. Regarding validation, the Japanese and U.S. teams each have validation plans and are working together to merge these into a coordinated plan. Validation analyses will include satellite intercomparisons with TMI and Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSMI) data as well as field data and aircraft campaigns. Lobl showed a post-launch validation timeline, plus a chart of the AMSR-E standard products. She mentioned the interest within the AMSR-E Team to have joint calibration/validation activities with other PM science teams and suggested an intercomparison workshop six months after launch. When questioned about an aircraft experiment scheduled for early 2001, Lobl and AMSR-E-colleague Chris Kummerow responded that the experiment will still be valuable even in the event of a launch delay preventing receipt of AMSR-E data during the aircraft campaign.

AIRS/AMSU/HSB Science Team

The Atmospheric Infrared Sounder (AIRS) Team presentation was made by the AIRS Project Scientist George Aumann. Aumann reported that the AMSU-A on NOAA-15 (equivalent to the PM AMSU) is working well and that the Humidity Sounder for Brazil (HSB) is equivalent to the AMSU-B scheduled to fly on NOAA-L. The AIRS instrument itself has completed vibration testing and is currently in thermal vacuum testing.

There was some discussion at the meeting regarding the goal of global 1-K root-mean-square temperature retrieval accuracy from the AIRS/AMSU/HSB system in 1-km layers in the troposphere. No one disagreed with the statement that this is a key goal, but several in the room were not aware that the 1-K/1-km accuracy level is not a Level-1 requirement. The AIRS instrument would require the addition of wedged filters to reach the 1-K/1-km accuracy level.

Aumann then presented a list of the expected AIRS data products and discussed the status of the AIRS Level 1b Algorithm Theoretical Basis Document (ATBD). The Level 1b algorithms are not being revised at this point, but the ATBD is being augmented to include new test results that, among other things, enable a narrowing of the large error bars appearing in the original ATBD. Aumann showed a signal-to-noise scatter plot containing all 2378 AIRS channels. Some channels are markedly better than others regarding signal-to-noise ratio, and AIRS Team member Joel Susskind explained that, because of the large number of channels on AIRS, the final-product AIRS algorithms will be able to avoid the channels exhibiting the greatest noise. With respect to spectral purity, there are no detectable leaks down to the 0.003 μm level. Below that there are some artifacts in the data, but the integrated out-of-band response is significantly less than the noise. Aumann showed calibration plots and explained that a linearity correction will be applied to improve further the instrument calibration. This was followed by a plot of vertical profiles through the atmosphere of simulated retrieval accuracies for the AIRS/AMSU/HSB suite of instruments.

While processed data for assimilation into forecast models should be available within 3 hours after receipt of telemetry data, Aumann indicated that Level 2 products can lag about 24 hours behind the data downlink. Level 2 performance validation for the AIRS will be based on ground truth radiosondes and ocean buoys. The ground-based validation will involve a large-scale international effort including field locations in the U.S., Australia, Brazil, France, Korea, and China. In closing, Aumann encouraged the PM Science Teams to work together to create combined data products, advocating specifically, as an example, the creation of a consensus EOS PM SST product, in addition to the three or four separate SST products that will be obtained based on the individual instruments. Bruce Barkstrom seconded the need to coordinate, specifically in the determination of cloud-free pixels, but mentioned also that the effort required could be considerable.

MODIS Science Team

The Moderate Resolution Imaging Spectroradiometer (MODIS) Team presentation was made by the MODIS Team Leader Vince Salomonson and the MODIS Project Scientist Bob Murphy. Salomonson began with a brief review of the 36-band MODIS instrument and the key geophysical parameters being obtained from each of the band groupings. The PM MODIS instrument has considerable strengths, including the elimination of some of the problems identified in the Terra MODIS. Some problems do currently exist on the PM MODIS, however, including focal plane misregistration and a series of worrisome and unexplained pixel outages in the 1.2- and 1.6-μm bands.

The calibration strategy for MODIS includes a suite of onboard calibrators (a blackbody, a solar diffuser and solar diffuser stability monitor, and a spectroradiometric calibration assembly), spacecraft maneuvers to view the moon and deep space, and co-registration of bands.

Salomonson indicated that all MODIS Level 1 products will be processed by the Goddard Distributed Active Archive Center (DAAC). Level 2-4 data, for both the Terra MODIS and the PM MODIS, will be processed by the MODIS Adaptive Processing System (MODAPS) and then ingested into the Goddard DAAC for data distribution. In operational readiness tests for Terra, the Goddard DAAC has successfully ingested 100% of the Level 0 and ancillary test data. Although the data processing functionality was demonstrated, sustained operations were not. Salomonson is confident that there will be enough data available to validate the instrument and to produce the Terra at-launch data products. Salomonson expects it to take until about a year after launch before the MODIS Team will be able to produce full global products operationally.

The MODIS Team recently conducted its Mission Operations Science System

(MOSS) version 3 dry run. This was a week-long test in which a 48-hour test data set was processed and distributed through the MOSS system. Two major problems were identified, bringing down the system temporarily, but once the problems were solved, the processing continued.

Regarding validation, Murphy explained that the PM validation efforts are an extension of the Terra plans and will include field experiments, coordinated ground-based networks, and cross-comparison with other sensors, such as the AIRS on PM. The MODIS/AIRS comparisons will involve radiances, SSTs, land surface temperatures, and land surface emissivities. MODIS Level 1 products will be validated in two phases: first, through the use of its on-board calibrators and second through feedback from the science data. Extensive vicarious calibration efforts will include surface-based measurements at key test sites at the White Sands Missile Range in New Mexico, the Railroad Valley Playa in Nevada, and a thermal infrared test site yet to be determined (several are being investigated).

The three MODIS discipline groups—Atmosphere, Land, and Oceans—have their own validation strategies, and Murphy elaborated on each. Validation sites are spread throughout the globe, and several field campaigns for the Terra MODIS are well along in the planning stages. Because the current focus is on the upcoming Terra mission, detailed field campaign planning for the PM mission remains in the future. Both Elena Lobl of the AMSR-E Team and George Aumann of the AIRS/AMSU/HSB Team expressed interest in the MODIS suggestion of an initialization cruise at about six months after launch.

CERES Science Team

The CERES Team presentation was made by the CERES Instrument Working Group Leader Bob Lee and the CERES Team Leader Bruce Barkstrom. Lee reported that the CERES instrument calibration is tied directly to the National Institute of Standards and Technology (NIST) radiance standards. He said the CERES Team has done a very good job of calibrating and characterizing their blackbodies. Instrument data-processing parameters are available at http://lposun.larc.nasa.gov/~jack/task37data.html. This site contains details about the CERES sensor gains, spectral responses, zero-radiance offsets, and ground-to-flight sensor gain stabilities.

Lee presented a physical layout of the CERES instrument. He said the plan is to calibrate CERES by looking at deep space (through spacecraft maneuvers) as well as looking at the onboard blackbodies, solar diffuser, and tungsten lamp. The blackbodies are used for calibrating CERES' total and window channels, while the shortwave channel uses the tungsten lamp. Lee explained that for the TRMM CERES, the team noted a 0.1-0.2 % increase in gain on orbit versus what was measured on the ground. He suspects that twelve days of thermal vacuum were insufficient for full vacuum adaptation. The CERES sensors aboard TRMM were stable to within 0.2 % (0.2 Watts per square meter per steradian) over the first 18 months the satellite was in orbit.

Regarding validation, Barkstrom pointed out that his team has 10 months of TRMM CERES data to work with, making the use of simulated data unnecessary. He plans to store and distribute these data through the Langley TRMM Information System (LaTIS), which is accessible through the EOS Data and Information System (EOSDIS) Data Gateway. Barkstrom said radiation budget data involve a multi-dimensional space including wavelength, space (latitude, longitude, and height), angle, and time. Errors in the data are a strong function of the time and space scales of the data products. Thus, each CERES product faces unique validation challenges. From the standpoint of the CERES investigation, validation is used to remove obvious errors and bound the uncertainties of the fields in the data products. The basic focus of CERES validation remains examination of global consistencies and anomaly patterns. However, the CERES Team also plans to use surface-based measurements, aircraft, and balloon *in situ* data to validate CERES data. Most of the *in situ* data the CERES Team will use come from efforts, such as the Atmospheric Radiation Measurement Program (ARM), that produce data for other investigations as well. Barkstrom provided a list of current sites that CERES plans to use for validation. For each site, CERES will produce time series of footprints with broadband radiances and fluxes, as well as cloud properties. He offered to expand the list if other teams are interested.

The CERES validation schedule will focus on Level 1 radiance and calibration/navigation in the first six months after launch (L + 6 months), the Level 2 Earth Radiation Budget Experiment (ERBE)-like product starting at L + 9 months, the Level 2 cloud properties starting at L + 18 months, the Level 2 surface and atmospheric fluxes starting at L + 36 months, and the Level 3 gridded data and time averages starting at L + 42 months. Barkstrom also noted that CERES plans to produce new Angular Distribution Models from the CERES instruments that operate in Rotating Azimuth Plane scan mode (which samples all directions) for the final CERES data products.

Formation of a Validation Working Group

Following the four science team presentations, Parkinson recommended, and the group approved, the formation of an EOS PM Validation Working Group (named later in the day by Mike Gunson). This group will consist of Elena Lobl and Frank Wentz from the AMSR-E Team, George Aumann and Mike Gunson from the AIRS Team, Tom Charlock and Pat Minnis from the CERES Team, and Wayne Esaias, Michael King, Jeff Morisette, and Kurt Thome from the MODIS Team. The group is tasked with increasing communication about validation plans amongst the EOS PM science teams and facilitating the development of joint validation efforts and the exchange of data. The formation of the Validation Working Group concluded the morning session. Subsequent to the October 15 meeting, Peter Hildebrand of Goddard Space Flight Center (GSFC) agreed to chair the group. Hildebrand is the new Branch Head of GSFC's Microwave Sensors Branch and has considerable experience in validation, obtained during many years at the National Center for Atmospheric Research in Boulder, Colorado. He is new to the EOS program and will bring a fresh perspective to the validation efforts.

Statement for ESDIS

The afternoon session began with a brief discussion of a one-paragraph statement drafted by the PM Project Scientist in response to a request from the Earth Science Data and Information System (ESDIS) for an "EOS PM Long-Term Science Plan for Nominal Observational Modes." The core of the statement is that there should be no intentional significant interruptions of the basic observational mode (providing systematic, global coverage) without prior review and approval by the EOS PM Science Working Group. This draft statement was unanimously adopted, prior to the group's moving on to the main topic of the afternoon session, i.e., spacecraft maneuvers.

Spacecraft Maneuvers

All instruments on the PM spacecraft are intended to make observations of the Earth system. However, the spacecraft has the capability of performing various maneuvers to provide non-Earth views that could be of value in the calibration of the instruments and the analysis of the data. The issue of which maneuvers to have the PM spacecraft perform has been contentious for some time, as the four science teams have conflicting needs, preferences, and concerns, but it was important at this meeting to formulate a maneuver timeline for the first 90 days after launch. Briefly, the basic positions of the four teams are:

(a) The AIRS Team would prefer no maneuvers, because maneuvers are not needed for AIRS, they ensure the absence of Earth-system data during and surrounding the period of the maneuver, and they add a risk factor. The AIRS Team Leader, Mous Chahine, and Project Scientist, George Aumann, confirmed that they do not want the AIRS instrument turned on until after completion of the initial maneuvers. Hence, if maneuvers have to be done, they should be done at the earliest possible date, so as not to delay the opening of the AIRS instrument any longer than necessary.

(b) The CERES Team requires a maneuver to obtain an essential view of deep space for their calibration efforts. Bruce Barkstrom and Bob Lee explained that the CERES Team needs either three constant-pitch-rate maneuvers or two inertial-hold maneuvers, preferably soon after day 30 of the mission. The constant pitch-rate and inertial-hold maneuvers are both classified as pitch maneuvers and involve a flipping over of the spacecraft. The CERES Team would also like a yaw maneuver, which involves a lesser turning of the spacecraft, of no more than 11 degrees and lasting no more than 15 minutes. Lee explained that the team only needs a single yaw maneuver and that it should be done early in the mission.

(c) The MODIS Team also requires a deep-space maneuver, although it cannot take advantage of it until somewhat later in the mission than the CERES Team would prefer. Bob Murphy explained that scheduling the maneuver at day 65 (or as soon thereafter as the moon would be out of the way) would be the appropriate timing for MODIS at this point, based on their current scheduling of MODIS events early in the PM mission. He indicated, however, that it might be possible to accelerate this schedule, and that the MODIS Team members will have a much better handle on this after they obtain MODIS data from the Terra mission. Murphy and Gerry Godden also explained the desire for a series of yaw maneuvers over the course of four days early in the mission, and for small roll maneuvers to view the moon on the order of five times per year throughout the mission. The yaw maneuvers appropriate for MODIS involve 13 orbits on each of two days with the MODIS doors closed and the same sequence on two days with the MODIS doors opened. The desired yaw maneuvers last approximately 5 minutes during each orbit, with incremental turn changes of 2 degrees from orbit to orbit. Each small roll maneuver will last no more than 10 minutes and will roll the spacecraft no more than 20 degrees.

(d) The AMSR-E Team does not require maneuvers, but feels that the team could benefit from a view of deep space. Hence the AMSR-E Team is in favor of a deep-space maneuver, but would prefer to minimize the number and extent of additional maneuvers. Elena Lobl and Chris Kummerow presented the AMSR-E Team position, which is driven in part by the scientific value obtained by the spacecraft maneuvers performed during the TRMM mission, which also contains a microwave radiometer (the TRMM Microwave Imager [TMI]). It is important that both the large reflector and the cold-sky mirror on AMSR-E obtain a view of cold sky during the desired deep-space maneuver.

As the discussion proceeded, George Morrow and Pete Pecori, the PM Project Manager and Deputy Project Manager, respectively, explained several constraining factors. The first and most important regarded the deep-space maneuver and the fact that TRW has only analyzed and agreed to the constant-pitch-rate maneuver, not the inertial-hold maneuver. This quickly ended the discussion of the inertial-hold possibility. Second, Morrow and Pecori explained the importance of having all essential initial testing of the spacecraft and instruments completed by day 90 because of the contractual agreement with TRW. This necessitates both having the AIRS instrument turned on preferably at least 30-40 days prior to day 90 and doing, at least once prior to day 90, each type of maneuver likely to be done at any time during the duration of the mission.

The discussion was aggressive, but there was a shared recognition of the need for a reasonable compromise, and the result was a consensus agreement to the following:

(1) 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. It is possible that the day-55 timing might have to be shifted toward, or to, day 65, if the MODIS Team finds that it cannot make use of a pitch maneuver done as early as day 55. If, on the other hand, the MODIS Team determines that it can accelerate the MODIS schedule to allow the maneuver even earlier than day 55, this would have advantages for the other teams. Bob Murphy has an action item to report back on further MODIS Team analyses of this issue.

(2) 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. Bob Lee of the CERES Team and Gerry Godden of the MODIS Team were given the action item to determine the specifics of the second series of yaw maneuvers, to accommodate both the CERES and MODIS needs. Subsequent to the meeting, Lee and Godden determined that the CERES needs can be met through the MODIS yaw maneuvers.

(3) 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.

All maneuvers should be done during the primary shift of the mission operations team.

Closing and Sub-Groups

Following the agreement on spacecraft maneuvers to be executed during the first 90 days of the mission, marking a major accomplishment for this Science Working Group, Parkinson adjourned the general meeting and had two smaller groups remain an additional 50 minutes. Specifically, Bob Lee and Gerry Godden met with each other and with the mission operations team regarding the yaw maneuvers; and Elena Lobl, Mike Gunson, Bob Murphy, Claire Parkinson, and George Aumann met in the initial meeting of the newly formed EOS PM Validation Working Group. In the latter meeting there was an enthusiastic exchange of ideas on how this group can best encourage and support joint validation and data-exchange efforts amongst the EOS PM Science Teams.