MODIS/VIIRS Joint Science Team Meeting
May 13-16, 2008
BWI Hilton

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First Plenary Session (May 14)

Welcome

Vince Salomonson—MODIS Science Team Leader
Jim Gleason—NPP Project Scientist

All attendees were welcomed to the first meeting combining both the MODIS and VIIRS Science Teams. Having a combined meeting was deemed a logical step because the Visible Infrared Imager Radiometer Suite (VIIRS) is an instrument that will continue most of the measurement and dataset capabilities of the Moderate Resolution Imaging Spectroradiometer (MODIS), and there are several people that are on both teams. Salomonson provided an overview of the agenda and emphasized the importance of ongoing engagement and support from the MODIS community as progress continues with the definition of VIIRS characteristics and objectives.

Outlook from Senior Headquarters

Jack Kaye—Associate Director for Research, Earth Science Division, NASA Headquarters

Dr. Kaye provided an overview of NASA Earth science programs. The programs are doing well in providing data for the Earth science community. Fourteen missions are flying, and many of these are in the extended phase. The next senior review of extended missions is to be in 2009. Launches coming up include the Ocean Surface Topography from Space Mission (OSTM) and the Orbiting Carbon Observatory (OCO). Airborne platforms are continuing, and NASA HQ is looking at other kinds of supporting field work. Dr. Bontempi organized a shipboard campaign. The Uninhabited Aerial Vehicle Synthetic Aperature Radar (UAV-SAR) is coming along. Modeling work is progressing. The recent Intergovernmental Panel on Climate Change (IPCC) assessment reflects what NASA programs are enabling.

Changes in headquarters staffing have occurred since the last meeting, and Kaye reported that a strong, stable team is in place for the future. The 2009 budget included funding for the decadal survey missions. The National Oceanic and Atmospheric Administration (NOAA) received funding to bring back de-manifested sensors on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP). NOAA also has money to support climate data records.

In terms of new research, the MODIS science team was selected through the Research Opportunities in Space and Earth Science (ROSES) 2007. Proposals for ROSES 2008 are coming in. New research areas for new sensors and new applications are upcoming.

On an interagency level: NASA contributes to 3 administration-level programs: the U.S. Climate Change Science Program (CCSP), the ocean initiative, and the intergovernmental Group on Earth Observation (GEO) effort. The CCSP assessment is due out in May. A

unified synthesis product is upcoming. Within the ocean initiative, the ocean research strategy was released. NASA was asked to lead out in two research areas. NASA is also collaborating with NOAA and United States Geological Survey (USGS). The NOAA collaboration involves developing climate data records. In terms of climate, the IPCC tended to change their away from science to more emphasis on impacts and adaptations.

Questions:

Where do systematic measurements fit into priorities at Headquarters?
The changes in NPOESS came along well into decadal survey. The budget initiative is for the decadal survey, but should also cover some systematic measurements with new instruments. Questions about the quality of measurements will have to be addressed. The decadal survey gave responsibility to NOAA for longer-term measurements. International partnerships will become important.

Is the positive wedge in the latest budget for Earth science at the expense of space science?
Yes. The science mission budget is revenue neutral.

What is the prospect for mission continuation during senior review?
It is hard to turn something off if it is working. Nothing was taken offline in the last science review. The review will look at the state of the spacecraft. Headquarters will also want continuity to capitalize on its investment. The agency is on the line for decadal survey missions.

In terms of mission science review preparation, how should we plan for budgets?
Headquarters will discuss lessons learned from the last senior review, but will the review likely be similar to last review. Headquarters probably won't ask for contingencies. Headquarters doesn't like to pull back money, but sometimes it is necessary. In the past, Headquarters has tried to wall off research and not let problems on flight programs impinge on research. This year, the problems spread. The research community has been slower to obligate funds, which makes it look like you don't need more funds.

Headquarters' Views on the combined MODIS/VIIRS Science Team

Paula Bontempi—MODIS Program Scientist

Dr. Bontempi provided an overview of challenges and successes for the MODIS science team since the last meeting. The organization at Headquarters has changed since the last science team meeting. The fiscal year 2008 budget operating plan may undergo revisions. The science team may have to submit impact assessments related to potential mission cuts. Headquarters is exercising the fourth year option for the MODIS science team leader for fiscal year 2007. During the Earth Observing System (EOS) recompete, 322 proposals were received. Most of these were for integrated science data analysis. Of the 322 proposals, 122 proposals were selected supported at $26 million per year. Not all proposals were fully funded.

The challenge for future research has always been to reap the full research benefits of MODIS combined with other sensors. The science team needs to start to migrate data products to core production for climate data records. The science team is also looking at new products. The focus is on utilizing MODIS to create new understanding of Earth and on feeding information into decision support systems. The science team should think about the continuity of products and evolution. How does MODIS fit into the changing world, the changing system? A sub-goal of NASA's strategic goal 3 is to use Earth-orbiting satellites to study global change and climate.

NASA will undertake another strategic plan in 2009. For Earth science, the last strategic plan was in 2003. The science team should make sure that MODIS and MODIS-type observations are blended into the science plan. NASA is changing from mission-oriented teams to measurement-oriented teams. The decadal survey was released in January 2007. Headquarters is now implementing some mission concept studies as recommended in the decadal survey. Headquarters will also be looking for merged data products, new products, and linkages to NPP VIIRS in the future.

Dr. Bontempi provided an overview of missions that are being formulated or are nearing implementation. The budget chart reflects how the decadal survey will be implemented. The science team should weigh what new measurements are needed and which of these can feed into future missions. There are opportunities for small missions that could be gap fillers or novel new missions.

The mission extension senior review will occur in April 2009. All Earth science missions are up for review except the Ocean Surface Topography from Space Mission and the Orbiting Carbon Observatory, assuming that both of these missions launch successfully.

Dr. Bontempi discussed upcoming issues for the MODIS science team. In the past, the push has been for more interdisciplinary algorithm development and research. Now, it is time to think about the importance and utility of the algorithms and decide which to transition to core production. The science team should establish a process for data product and algorithm reviews. Monthly disciplinary teleconferences may be necessary to coordinate with the MODIS Characterization Support Team and the previous MODIS Science team. Dr. Bontempi will create a plan for a review of data products and algorithms that will involve the community. Dr. Bontempi welcomed suggestions.

The science team will continue to evolve measurement streams to shift towards earth system data records.

Questions:
Where are we on research to operations?
NASA and NOAA and perhaps USGS meet regularly to work out research and operations issues. Dr. Bontempi was not sure what the plan for transition is, but reported that the agencies were still talking about issues. Initially, the agencies focused on oceanography.

When will details of venture class solicitation be clear?
The idea is to have small scale missions to give the community opportunities to propose new things. Dr. Bontempi does not know what the cost cap means, but notes that it will have to be considered soon. The solicitation is an avenue for more frequent access to space. It is also a training ground for new principle investigators and new project leads.

The measures program is concerned with long-term data records. It is funded for 15 million dollars per year. Focused on time series for observations, it is an opportunity for principle investigators to work on time series observations. It doesn't provide a comprehensive continuity for all observations the science team is interested in, and it will not meet the need for all data records.

Headquarters' Views on the combined MODIS/VIIRS Science Team

Diane Wickland—NPP Program Scientist

Dr. Wickland offered background for the NPOESS Preparatory Project (NPP). The NPP is a "bridge mission" between EOS missions and NPOESS to provide continuity for systematic measurements. Terra, Aqua, and Aura continuity is partly addressed by the NPP mission. NPP will provide operational data for weather forecasting and science research. It is not planned to do everything that MODIS does. Dr. Wickland provided an overview of the products that will continue and those at risk. NPP will help compare NPOESS and MODIS by overlapping both missions. Dr. Wickland presented a list of NPP science team members.
Time series data products will serve a variety of science disciplines. The NPP launch was re-baselined to June 2010, and the budget has been reprofiled. The Ozone Mapping and Profiler Suite Limb (OMPS) sensor was restored, and a Clouds and the Earth's Radiant Energy System (CERES) instrument was added. Product Evaluation and Test Elements (PEATEs) were asked to scope potential data production options.

The NPP science team needs to evaluate the quality and character of environmental data records. Dr. Wickland would like a concise summary of environmental data records in the next six months.

In the near term, NASA's role in NPP calibration and the validation of science-quality environmental data records will be determined. Headquarters is considering what will happen to the NPP science team after launch. Funding expires six months after launch, which is probably not enough time to evaluate products.

Dr. Wickland provided an overview of goals for the NPP science team for this meeting. She requested that the team talk about earth science data records, concerns about near-term implementation, and long-term priorities and needs of the science community in the case that NASA is not the agency producing long-term data.

Aqua and Terra MODIS Status

Vince Salomonson-MODIS Science Team Leader and Jack Xiong-MODIS Project Scientist

Both MODIS instruments are performing nominally. Terra MODIS has been in operation for more than eight years and Aqua MODIS has been in operation for 6 years. Both instruments have seem some changes in the reflectance of the optics and the solar panels that amount to about 40% since launch for the Terra MODIS and about 20% for the Aqua MODIS at the shortest wavelength channel (412nm). However, these changes have been accommodated well and both instruments are meeting calibration and characterization specifications. Dr. Salomonson provided an overview of status of noisy detectors. On Terra, the principal noise problems are in bands 5, 6, 7. On Aqua, band 6 is basically not operable. No trend from aging has been detected. Terra and Aqua MODIS spectral characterization results and spatial characterizations results were given. Aqua has a known misregistration of about 0.3 pixel between bands on the cold focal plane assembly (FPA) and warm FPA, but this has not proved to be a problem although there are some recent results that indicate if an adjustment in software is made to accommodate this misregistration, results can be improved.. For future work, the science team will be studying calibration consistency between Terra and Aqua MODIS and cross-sensor calibration of MODIS with other sensors.

MODIS data production and archiving are done through distributed systems. The Land Collection 5 is almost done and when this is completed all of Collection 5 will have been completed for both the Terra and Aqua MODIS data products.

The number of refereed, technical MODIS-related publications continues to grow and is presently proceeding at a rate well over one refereed publication/day. The total for all years is over 2000 publications with over 300 in 2008 (as of the end of June 2008). Dr. Salomonson listed the original panel of people who helped define the MODIS instruments and the original science team that was responsible in large part for the development and production of MODIS data products. MODIS' success is a great credit to those members of the Science Team and their colleagues for their expertise, dedication and perseverance over many years.

In the future, a new collection ("Collection 6") is coming up and is already underway for Level 1 data. The entire science team needs to feed into the reprocessing process. The Headquarters Senior review of the Aqua and Terra missions (as noted previously) is coming up in 2009 and much will depend on demonstrating the continued health of the MODIS instruments along with the documented and demonstrated use of the MODIS data products for science and applications. As reflected in this meeting there is great anticipation for the future given that the NPP and NPOESS missions are emerging on which the VIIRS instrument will continue much of the MODIS capabilities. With these missions and the use of the products that will be forthcoming from the VIIRS instruments, the importance of reprocessing in maintaining and improving the quality of these products needs to be kept in mind.

CALIPSO and MODIS Observations of Changes in Aerosols near Clouds

Jim Coakley—Oregon State University

There is still much to learn about Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data. Changes in aerosols near clouds influence direct radiative forcing. It is the biggest uncertainty in climate change. Dr. Coakley began to study changes in aerosols near clouds to learn about the indirect aerosol effect. The current IPCC report uses only models. Little observational evidence has been incorporated into models to date. Aerosols are responding to clouds; clouds have an indirect effect on aerosol forcing. MODIS and CALIPSO coincident observations are valuable in studying the effect.

Aerosol indirect radiative forcing causes the droplet radius to go down as optical depth goes up. Reanalysis shows an increase in cloud cover with increased aerosol burdens. What are aerosols doing in the vicinity of clouds? Aerosol burdens are going up, and aerosols are getting larger as they approach the clouds in the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) and MODIS measurements. Data from the Indian Ocean Experiment (INDOEX) shows that relative humidity increases 3% near clouds. The rise in relative humidity swells the particles, which increases reflectivity and the aerosol burden. There appears to be no change in the number of particles near clouds. The increase in relative humidity increases the backscatter of aerosols by 50 percent. A comparison of a cloud-free swath with a cloudy swath shows a rise in scattering near the cloud edge because of the change in relative humidity. Dr. Coakley used a cloud-free swath as a baseline to compare to conditions near the cloud edge. Clouds reflect light into the clear sky column, which scatters light into the instrument. Eighty percent of scattering that goes back into the instrument comes from Raleigh scattering, which makes particles look smaller than they are. Aerosols are increasing near clouds because the particles are growing and because of this illumination effect. The scattering issue can be corrected by combining lidar and MODIS. CALIPSO LIDAR is not affected by the illumination problem and can be used to correct MODIS retrievals.

Dr. Coakley compared observations from NASA's Aerosol Robotic Network (AERONET) sun photometers with MODIS data to validate optical depth. MODIS data were used to validate CALIPSO data by collocating MODIS and CALIPSO observations and comparing average measurements of optical depth. CALIPSO optical depths underestimate MODIS optical depths, which in turn underestimate AERONET measurements. CALIPSO is about 14% below AERONET measurements for large optical depths, but measurements of particle size come from CALIPSO. MODIS' measure of particle size is not clean, but it can separate small aerosols from coarse aerosols. It would be nice to separate particle size with CALIPSO. CALIPSO and MODIS are poorly correlated.

The Atmospheres Team PEATE: Status and Issues

Bryan Baum—University of Wisconsin and VIIRS Atmospheres Science Discipline Co-Leader

Dr. Baum outlined the NPOESS Preparatory Project's science goals and the need to access algorithms for environmental data records. In developing long-term data records, it is important to track the needs of the user communities and pay attention to details like orbital drift, calibration, trace gases changes, spectral shifts, improvements in radiation transfer (RT) models, changes in ancillary data, sampling, and sensor-specific issues. Several different cloud climatologies exist. One, PATMOS-x (Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Atmospheres Extended) covers about 28 years from 1981 through 2007. The time series is stable from instrument to instrument with no discernable trend. The High Resolution Infrared Sounder (HIRS) record covers 1978-2002. It is fairly stable, but there is a step change with the launch of HIRS3. It is possible to improve cloud and aerosol products by comparing CALIOP and Aqua MODIS data. Protocols are being developed for comparing instrument parameters. Showed CALIOP-MODIS matches for cloud height difference.

A significant issue for the transition from EOS to NPP is that heritage algorithms are not static. NPOESS algorithms are static. Comparisons are going to be tricky. The MODIS cloud-top code is old.

The product evaluation and test element provides a possible way to transition from EOS to NPP. The low earth orbiter cloud algorithm test-bed is a fast way to produce matchup files. PEATE processing times are provided. Overall, it takes about 9 hours to process a month of data.

AIRS compared to MODIS brightness temperature showed that MODIS is a little brighter than AIRS. This comparison and adjustment provides a way to monitor infrared (IR) band calibration over time.

MODIS collection 5 cloud top pressures were shown. The product is missing some high clouds. Calibration with CALIOP improves the algorithm.

MODIS code transition to the atmosphere PEATE is progressing. Dr. Baum wants to put all algorithms through the PEATE to be able to compare MODIS algorithms with VIIRS algorithms. The PEATE is useful in refining products. Climate data records will require several passes through the PEATE.

The Land Discipline Overview: MODIS/VIIRS

Chris Justice—University of Maryland and VIIRS and MODIS Land Discipline Leader

In 2006, the land team started to expand to embrace other observations in the move from missions to measurements. The last VIIRS meeting was at the National Climate Data Center (NCDC) in February 2008 and was focused on validation planning. MODIS land data are well-established and used, and there has been a large uptake by the international community. MODIS is providing a major contribution to GEOSS and is setting a global standard for data quality, validation, product and instrument information, and data availability. Collection 5 reprocessing of land products finished in May 2008. Collection 6 processing is in the planning stage. MODIS is being used in disaster management

activities and by operational users. The land community continues to get increased user feedback on standard products. The user community expects continuity with VIIRS data. The land direct readout community is growing and a land focus group is self organizing around MODIS. Outside of the science team, the land community needs more information about the VIIRS instrument and what science products can be expected. The land part of the VIIRS Science Team has good communication with NOAA and the IPO. The land group evaluation of the proposed VIIRS environmental data records is continuing. Instrument overlap with MODIS will be essential.

The Ocean Overview: Ocean color

Chuck McClain—NASA Goddard and VIIRS and MODIS Ocean Discipline Leader

Dr. McClain highlighted new science from the ocean community. Dr. Mike Behrenfeld developed a new product for fluorescence line height (FLH). The FLH and chlorophyll products are not too different. Fluorescence yield compared to dust deposition shows a correlation between dust and ocean color. It provides a new tool to look at ecosystem structure. Yesterday's session of the science team meeting focused on calibration issues. The ocean group has worked to improve MODIS ocean color data, starting with Aqua and moving on to Terra. There are significant differences between the two instruments. The ocean team tried to eliminate scan artifacts from retrievals. Efforts were successful with Aqua, but Terra still has problems. The ocean team used SeaWiFS to characterize Terra data. The characterization brings Terra's response in line with expectations.

The VIIRS ocean team has focused on the sensor's performance over the last year and a half. Dr. McClain listed the ocean biology processing group's data sets and mission support activities. The ocean group is planning to reprocess ocean products and is considering a revision of aerosols models. A robust ocean color web site is being maintained. The web-based forum is used to communicate with community. The ocean color site is distributing an increasing amount of data.

The Ocean Overview: Sea Surface Temperature

Bob Evans—University of Miami

Dr. Evans provided an overview of the status of sea surface temperature (SST) products and continuity with VIIRS. He described ongoing work on the MODIS SST product, which uses Aqua and Terra match ups versus time by latitude band. There are a relatively small number of retrievals per 25 kilometer pixel over the full mission. Quality tests are improving. Past quality tests rejected more high-temperature pixels. The ocean team is working to correct Terra mirror side offset issues. MODIS SST measurements are being compared with National Institutes of Standards and Technology (NIST) standards and related satellite measurements done with other instruments. The Marine-Atmosphere Emitted Radiance Interferometer had been deployed on a cruise ship and research vessels through December 2007. The team is comparing VIIRS and MODIS SST algorithms and will later use instrument tests to compare the VIIRS instrument to MODIS.

Second Plenary Session (May 15)

VIIRS Status

Bruce Guenther, NOAA/Integrated Program Office (IPO)

Dr Guenther provided an update on VIIRS and calibration and validation planning. The VIIRS management structure was shown and discussed. The organization is different than what the NASA team is accustomed to in that there is a principle contractor with a science advisory team. The Integration Program Office (IPO) calibration and validation (cal/val) funded activity is led by user community experts. User experts recruit their own teams and develop plans. Dr. Guenther provided the cal/val schedule in a handout. Cal/val activities are proceeding on schedule. A senior science review was held to bring together scientists and engineers. VIIRS appears to be an effective sensor, but recommendations for improvements were provided. One recommendation was to limit specification compliance to fields of view within 45 degrees of nadir. Edge scan performance should not drive the schedule or cost. The review provided recommendations for flight unit one testing. VIIRS sensor performance was compared to MODIS and SeaWiFS. VIIRS has a reduced bandset compared to MODIS. Dr. Guenther described the noise in VIIRS reflected solar and thermal emissive bands. The sensor builder acquired a significant amount of data on the engineering development unit (EDU) and insight into the pre-testing performance of flight unit 1 (FU1). However, the sensor builder has not been able to process sensor test data as quickly as desired. Northrop Grumman Space Technology (NGST) will build a calibration team that includes a core government team. A number of IPO projects have been funded. NIST is working on developing new test fixtures, most likely for flight unit two. Dr. Guenther discussed known issues on flight unit one. Optical cross-talk is occurring in the visible and near infrared integrated filter assembly (IFA). The problem will impact ocean color and likely aerosol optical thickness (AOT). Dr. Guenther asked for feedback on 1.268 micron band, which saturates at 130 W/m2/sr/micron. The specification is different, and perhaps unrealistic. The polarization characteristics of VIIRS are within specification for polarization factor but not for polarization uncertainty. However, the overall polarization responsivity has been more extensively characterized for VIIRS than for MODIS. The fire product is not part of VIIRS. Recommendations for changes to the flight unit-2 (FU2) sensor design changes are required in July. Dr. Guenther requested that those recommendations be sent to him from each science discipline group.

Satellite Imagery for Monitoring and Understanding Harmful Algal Blooms (HABs)

Rick Stumpf of NOAA/National Ocean Survey

The first bloom observed in satellite data was from the Coastal Zone Color Scanner (CZCS) in 1978. Harmful algal blooms (HABs) are toxic, noxious, or nuisance blooms. Harmful blooms kill fish and impact shellfish, tourism, and human health, and cause financial losses. A bloom is defined as an increase in the concentration of the organism. The species does not have to achieve high biomass to be harmful. Many HABs cannot be

detected. HABs occur globally. Red tides are not always toxic. Colored blooms have a high biomass and are visible. It is possible to identify bloom as a HAB or non-HAB through their relationship with other species, temperatures, etc. To identify a bloom, factors to consider include brightness, chlorophyll change, specific optical characteristics, and seasonal or climatic associations. Non-colored blooms may be linked to circulation. The start of satellite remote sensing of HABs occurred with detection of a red tide off Florida in 1978. An anomaly in chlorophyll is used to identify new blooms. From the optical side, backscatter compared to absorption can help identify some species. Detection of harmful blooms can be improved by considering meteorological conditions. Visible imagery can identify some blooms and locations. The correlation between chlorophyll and temperature can be used to identify a bloom. Optics don't always work, but sea surface temperature data can help identify candidate areas where blooms can occur. For more sophisticated optics, the spectral shape may be used. If a bloom changes the color of water, optical techniques may be used to identify it. If it does not, physical forcing correlations may help identify a bloom. Dr. Stumpf listed HABs identified with optics or remote sensing.

DAAC reports: LPDAAC

Tom Maiersperger—Land Processes DAAC-U. S. Geological Survey

The Land Processes Distributed Active Archive Center (LPDAAC) is part of the Earth Observing System Data Information System (EOSDIS), and is located at the United States Geological Survey Earth Resources Observation and Science (USGS EROS). The LP DAAC archives and distributes ASTER and MODIS products. Dr. Maiersperger diagramed the structure of the DAAC within EOS. The historic trend in user demand is increasing. The LP DAAC has distributed 30 million products to date. It routinely distributed 1 million science granules per month in early 2008. The EOSDIS is evolving with new goals. It will be re-architecturing the EOSDIS Core System (ECS) to simplify. The LP DAAC is moving towards maintaining an online archive. The data pool contained a 1-year rolling archive. The LP DAAC is currently expanding the data pool with collection 5. This move will improve access. The LP DAAC is supporting faster MODIS Collection 5 reprocessing by ingesting data more quickly through a number of access methods. The EOS data gateway is transitioning to ECHO/WIST, the general user interface (WIST) for the middleware between Data Partners and Client Partners (ECHO). Other access methods include the LP DAAC data pool, the Global Visualization Viewer (GloVis), a spatial subscription service, and a machine-to-machine gateway. MRTWeb is a new access tool, built on the MODIS Reprojection Tool (MRT), available in 2008. It adapts and integrates two familiar tools, GloVis and MRT (processing tool). The tool allows projecting and mosaicing. Dr. Maiersperger showed a diagram of the backend architecture for MRTWeb. A new user working group was established. The group recommended that the DAAC pursue new data holdings that make up and extend the land remote sensing record; facilitate meetings between USGS and NASA to develop a long-term MODIS and ASTER archive; and expand the visibility of alternative data access methods. A number of LP DAAC outreach events are coming up at many different venues. The LP DAAC's top 10 products were listed.

DAAC reports: MODAPS/LAADS/MrDC

Ed Masuoka—NASA Goddard

The Level 1 and Atmosphere Archive and Distribution System (LAADS) added a level 2 browser for atmospheres. It also offers a level 3 browser. Distribution statistics for LAADS were given. LAADS is distributing about 3 TB of data per day, or 400,000 files per day to the public. Distribution is possible because files are online. Distribution tends to be even between Aqua and Terra. The number of orders by type was shown. A post-processing example of MODIS VI of Korea was shown. All MODIS Level 1B data will be available online by September to free up production on demand. The MODIS Data Processing System (MODAPS) production is finishing collection 5 (C5). The end of C5 will drop the X-rate, which will free up bandwidth to serve data to public. MODAPS is starting atmosphere C5.1 reprocessing. At the end of the year, MODAPS will begin science testing for collection 6. Collection 6 land and atmosphere processing rates were discussed.

DAAC reports: NSIDC

Ruth Duerr—National Snow and Ice Data Center (NSIDC)

An overview of the National Snow and Ice Data Center (NSIDC) was provided. NSIDC's mission is to contribute to cryospheric science, manage data, and disseminate information. NSIDC deals with snow, ice, and permafrost. It is located at the University of Colorado. NSIDC had a copy of the Earth Observing System Data Information System (EOSDIS) Core System (ECS), and is re-architecting the ECS data system. NSIDC is moving toward an online archive. All collection 5 and some collection 4 products are available online now. Trends in orders for MODIS data products are increasing. The number of distinct MODIS users is also increasing. The number of granules ordered increased this year. Users only recently switched to collection 5. NSIDC has other MODIS-based products in addition to core products, including surface morphology and snow grain size of Antarctica, a blended snow product, and MODIS-enhanced radar. NSIDC is offering new web services with a map-server interface to the mosaic of Antarctica. A MODIS interactive subsetting toolkit was developed to provide easier access to MODIS data over specific stations. All improvements were based on user requests.

VIIRS Pre-Launch Calibration Status

VIIRS Performance Status

H. Oudrari - SSAI

Refer to talks from Wednesday's session for details. The objective of the presentation was to present VIIRS sensor performance to subject matter experts. The results are not meant to be the sensor-performance sell-off. Testing is still ongoing. The testing schedule was

shown. Phases 1-3 of testing have been completed. Pre-thermal vacuum testing will start on August 1, thermal vacuum (TV) testing starts in December 2008. VIIRS bands and products were compared to bands and products from MODIS. VIIRS sensor hardware incorporates a modular approach, a diagram of which was shown. All VIIRS bands meet signal to noise ratio (SNR), noise equivalent delta radiance (NEdL), and noise equivalent delta temperature (NEdT) specifications. All bands meet the dynamic range and transition requirements except 3. All reflective and thermal emissive bands meet the response versus scan (RVS) characterization uncertainty. Stray light rejection (SLR), light coming in from off-nadir, causes contamination of radiance. SLR shows non-compliance for 4 bands. A waiver is proposed to relax SLR requirements. An impact assessment needs to be done using MODIS and or synthetic data to determine how the SLR non-compliance will affect environmental data records (EDRs). The near field response, the amount of radiation coming into sensor from bright targets, is not in compliance for many bands. A waiver was proposed for limiting radiance values for bright targets. Ghosting is observed for many short-wave and near infrared (SWIR and NIR) and long-wave infrared (LWIR) bands. An assessment of the impact on EDRs is ongoing. A VIIRS polarization analysis is ongoing, but preliminary results show compliance. All VIIRS bands meet band to band registration specifications for intra M-bands and intra I-bands. Dynamic crosstalk, scanning from bright to dark targets, leads to signal contamination in other bands. An overview of crosstalk observations was given. The static electric crosstalk specification is tight and is not met for all VIIRS bands. Details were provided. Based on engineering development unit (EDU) crosstalk analysis, crosstalk specifications are being reviewed to make them consistent, realistic, and specific to each crosstalk type. Based on ambient test rests, flight unit 1 (FU-1) optical crosstalk is significant for many visible near infrared (VisNIR) bands. Four major VIIRS issues include: thermal emissive calibration not meeting spec for 3 bands; reflective band uniformity showing noncompliance for many bands; and ghosting occurring in FU1 emissive bands. The impact on EDRs is still to be completed. Transition noise and non-linearity are leading to non-compliances. Ten other NPP VIIRS instrument issues were listed.

VIIRS FU-1 Pre-launch Calibration and Characterization

Jack Xiong—NASA/Goddard MODIS Project Scientist and NPP Instrument Calibration Support Team (NICST) Leader

All NPP instrument calibration support team (NICST) reports and memos are available from Northrop Grumman Space Technology's e-rooms. The objective of VIIRS ambient radiometric calibration and characterization (RC-01) was given. All detectors meet the noise ratio (SNR) and noise equivalent delta temperature (SNR/NEdT) requirements. Most spectral bands are meeting the dynamic range requirements, and most dual gain bands meet requirements. Reflective solar band (RSB) gains and signal to noise ratios (SNR) were shown. Measured SNR for all VIIRS RSB bands meet specified requirements at typical radiance (Ltyp). Thermal emissive band (TEB) gains and NEdTs were shown. A few detectors failed SNR/NEdT in run3. A summary of the dynamic range compliance was shown. Band M8 did not meet the dynamic range requirement. There is concern about the impact of SIS 100 stability on radiometric calibration. Better

characterization of the SIS monitor is needed. The thermal vacuum test will provide final results.

The response versus scan-angle characterization was summarized. The reflective solar band (RSB) and thermal emissive band (TEB) response versus scan angle (RVS) characterizations meet requirements. RSB RVS and TEB RVS for all detectors were shown. RVS results and issues were summarized. The SIS monitor performance in RSB testing was not satisfactory. The SIS monitor correction versus drifting correction was shown.

FU1 VIIRS Polarization insensitivity for VisNIR bands
The purpose of the test is to examine the sensitivity of the sensor to polarized light. The first test used a polarized source assembly (PSA) as the polarized light source, the second used a polarizer sheet as polarized light source. The PSA test was affected by the non-uniformity of the light source, which was not an issue with the polarizer sheet. Algorithms for polarization were shown. Charts of test results were shown (see presentation slides on the MODIS web site). All FU-1 VIIRS insensitivity test data are analyzed, and the polarization parameters are derived from the desired data. The derived polarization factors from all tests satisfy the VIIRS specification for the polarization factor.

FP-12: RSB Stray-Light Rejection
The radiance from earth and/or clouds outside the sensor's field of view (FOV) will be the main source of stray light. The functional performance characterization test FP-12 simulated stray light sources comparable to on-orbit conditions. Test data were used for the evaluation of temporal SLR performance against specifications. A 1000 Watt studio lamp was placed 120 inches away from VIIRS, and the telescope was locked at 3 different scan angles. Sensor responses from all positions were summed and scaled. Invalid data were obtained in the initial run. A second run was conducted. Many M bands do not meet the original requirements. The evaluation and approval of waiver request for new requirements is underway. New specifications proposed in the waiver were listed. Preliminary results of the tests were shown. Band M11 has the largest scattering response.

For near field response, the functional performance characterization test FP-14 was conducted to evaluate the ability of the sensor to measure the radiance from a region of the Earth that differs from adjacent scenes. The preliminary results show that bands M4, 12, 13 and 16 are noncompliant. Ghosting signals were found in the thermal emissive bands (TEB). An overview of the FP-14 test was given. A ghosting signal was observed in bands M12-M13, and M15-M16. A two dimensional ghosting profile was shown. A waiver has been requested, and new requirements were listed. The root cause of ghosting is known. NGST sensor data record (SDR) modeling results suggest no substantial impact in the emissive band SDR for sea surface temperature (SST).

All presentation charts are available online.

Spatial Performance
Spatial performance consists of 4 tests. The specifications were detailed. All bands align well, including the I and M bands. Charts detail the results. The instrument meets specifications. The measurements agree with the engineering design unit (EDU), and are also within specification. Changes due to on-orbit conditions (gravity release, temperatures) are expected.

Third Plenary Session, May 16, 2008

Using MODIS and POLDER data to develop a generalized approach for correction of the BRDF effect

Eric Vermote, University of Maryland

Dr. Vermote discussed the use of MODIS and POLDER data to develop a generalized approach for correction of the bidirectional reflectance distribution function (BRDF) effect. The purpose of the research is to account for directional effects in the AVHRR and MODIS long-term record. The presentation showed that directional effects on reflectance time series data can be accounted for with simple linear models. Data from the Polarization and directionality of the Earth's reflectances (POLDER) instrument flying on the Advanced Earth Observation satellite (ADEOS), a French/Japanese satellite, have been used to define the approach towards a generic bidirectional reflectance distribution function (BRDF). Dr. Vermote tested this approach on daily MODIS surface reflectance data at the climate modeling grid (CMG) scale and developed a new approach to BRDF inversion. This new approach allows the reflectance to vary slowly within the time interval. The new approach brought improvements over classical inversion with a greater reduction in noise. A further decrease in noise was obtained by allowing the volume and roughness BRDF parameters to vary as a function of the normalized difference vegetation index (NDVI). NDVI values after the new BRDF correction were improved by a factor of 2 for most land cover types. The correction could be applied to other time series data sets, and the volume and roughness coefficients could be used for other applications. Dr. Vermote intends to use the approach in the long-term data record (LTDR) project to correct MODIS and AVHRR surface reflectance time series for the BRDF effect.
Discipline Summary report: Atmospheres
Michael King—University of Colorado and MODIS Atmosphere Discipline Leader and VIIRS Atmospheres Discipline Co-Leader

The atmosphere group had 14 science presentations. New uses of MODIS data are increasing with other data sources like CALIPSO. The atmosphere group discussed differences between MODIS and VIIRS. The group also discussed needs and plans for collection 6. A highly popular application of MODIS data is the use of polar vector wind data on operational meteorological centers worldwide. MODIS makes multiple passes of the polar regions, and can provide frequent vector wind data. VIIRS won't have the capability to monitor vector winds. Another science deficiency is cloud top pressures, which is highly ambiguous compared to MODIS. In that regard, the VIIRS capability is

similar to AVHRR, a step backwards from MODIS. GOES-R will be comparable to MODIS, but geosynchronous. These two omissions have science consequences.

The Collection 6 wish list for reprocessing was shown. Collection 5.1 reprocessing will start soon to update both Terra and Aqua with Deep Blue and cloud top properties.

Discipline Summary report: Land

Chris Justice—University of Maryland and VIIRS and MODIS Land Discipline Leader

NPP VIIRS issues were discussed in the land group. The current focus of the team is on land environmental data record (EDR) evaluation and NASA Earth science data record (ESDR) generation. Plans are being made for algorithm testing and product validation. Dr. Justice highlighted recommendations for improvements to the follow-on VIIRS instrument of importance for land science, the capacity for fire characterization. The entire science team should prioritize the recommended changes across disciplines and work with NASA management to secure the necessary improvements in VIIRS for extending the MODIS data record.

A higher resolution land-water mask continues to be needed for MODIS and VIIRS. The land team discussed the process for developing and reviewing algorithm theoretical basis documents (ATBD) for new standard products. Collection 5 (C5) reprocessing is now complete, and PI web sites need to be updated with C5 user guides and validation status. Some changes have resulted from the most recent EOS recompete. Vegetation cover change is a discontinued product. The vegetation index (VI) and leaf area index (LAI) products will not be part of a Collection 6 reprocessing. Issues of C5/C6 dependencies have yet to be resolved. The C5 products are now being used for product inter-comparison. In this regard and for land product validation, international partnerships are important. A comparison between MODIS, the Atmospheric Infrared Sounder (AIRS), and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) revealed errors in the version 5 Land Surface Temperature product, which will now be updated. The community now needs time to evaluate C5 and what is being proposed for C6.

Land science results presented during the meeting included the green-up of the Amazon forest in the dry season, showing the resilience of the rainforest to climate anomalies and drought and the correlation between MODIS net primary production (NPP) and inverted carbon dioxide interannual growth rates.. A new data set for MODIS evapotranspiration is planned for release. A new land measurement portal has been developed which highlights moderate resolution data and products for land studies and includes information about the major land product suites, products, international coordination, and upcoming meetings.

Discipline Summary report: Ocean

Bob Evan—University of Miami

The ocean breakout sessions included a number of science presentations covering a wide scope of work, much of which will not be possible with VIIRS. The team also discussed VIIRS. New science includes adaptation or extension of aerosol models used in ocean color processing to improve data from coastal areas. The range of ocean color data is being extended by including models. The process relies on the range of channels available on MODIS. The team discussed how harmful algal blooms are investigated. A new product will provide the capability to record fluorescence line height (FLH). Calibration and validation were discussed in the breakout. The ocean group defined ocean biogeochemistry issues and recommendations for VIIRS. In the near term, the team would like to improve VIIRS sensor performance and attributes, specifically optical crosstalk and characterization data quality. On-board calibration with on orbit maneuvers is needed. The thermal vacuum test data is necessary to access other recommendations. For flight unit 2, the ocean color group would like a remanufactured integrated filter assembly (IFA), dual gains in band M6, sea surface temperature (SST) and fires bands, and two times higher signal to noise ratios (SNRs) in bands M8 and M10. In the long term, VIRRS 2, the team wants to add additional bands: FLH bands, a UV band, a 510 nm band for turbid water chlorophyll, and split the 4 micron band into 3.95 and 4.05 bands. Processing and reprocessing will be needed with current generation algorithms. The team is gearing up for new science thrusts for the ocean geochemistry program. New missions and international sensors hope to focus on coastal regimes, science theme refinement, habitats, and multi-disciplinary science. Additional list of VIIRS FU2 recommendations was provided.

HQ Response

Paula Bontempi—MODIS Program Scientist

Overlapping requirements for VIIRS-2 are emerging from the science team disciplines. Where might we encounter gaps in time series data records? The measurement streams will continue to evolve through the MODIS science team. The EOS recompete will occur in 2009 or 2010. The idea in the mission to measurements theory is to ensure a seamless time series. How do we support success of MODIS? One success is the blending of science teams between instruments and disciplines. Do we need to move towards Terra and Aqua science team meetings? Should the next interdisciplinary science team meeting be held in 6 months? The evolution of efforts from missions to measurements will have to incorporate NPOESS and other future missions. Systematic observations from current sensors are key to climate and Earth system research. The science team needs to look at gaps in systematic observations versus new observations needed for possible new missions.

Algorithms should be reviewed to plan for new or alternative EOS algorithms. For current products, principle investigators should provide a justification for the utility of each algorithm and plan for the transition to core production. Data product documentation and regular reviews are needed. New algorithms or data products would follow a similar pattern for review. Dr. Bontempi will develop a more formal plan.

The Headquarters Mission extension Senior review is coming up in 2009. There has been tremendous progress in science, particularly in interdisciplinary and intersensor science. If science is newsworthy, suggest it for NASA science update or press release, etc. The DAACs are reaching wide communities. Each discipline should coordinate by teleconference for algorithm reviews.

Diane Wickland—NPP Project Scientist

Dr. Wickland was impressed with the progress in science and data distribution. The community is acquiring knowledge about what VIIRS can and can't do, and what can be improved. A plan is needed for how to bring those issues forward. It is helpful to headquarters to know from the science team what is needed for VIIRS. Dr. Wickland would like to work with Dr. Bontempi on the issue of Earth Science data records, and involve the broader user community (modelers, applications users).

Closing Remarks/Plans for future

James Butler—NASA/Goddard-NPP Deputy Project Scientist for Instruments and Calibration

Dr. Butler was impressed with the high quality of data that MODIS produces. On day two of the meeting, the VIIRS instrument was discussed. NICST has processed a lot of data on VIIRS. The pre-thermal vacuum and thermal vacuum testing is next, a critical time for instrument. Dr. Butler suggested a tighter relationship between NICST and the science team to discuss the impact of the tests rests on science. Input about improvements to VIIRS FU2 to better enable NASA science should be emailed to Jim Gleason. An NPP science team meeting is tentatively scheduled for March 09.

Vince Salomonson—MODIS Science Team Leader

MODIS has matured. Collection 6 will be done with input from the science team. As already noted, the NASA Headquarters Senior Review of extended missions is coming up. Dr. Salomonson requested that information for the review be sent to him. The NPP science team meeting has been scheduled for next spring, and a multi-sensor or multidiscipline meeting may be held towards the end of the year or in 2009.

Atmospheres Breakout, May 14

Aerosol Optical Properties

Potential Aerosol Absorption Measurements by MODIS and its Effects on the Aerosol Radiative Forcing

Vanderlei Martins, University of Maryland Baltimore County (UMBC), Lorraine Remer, Goddard Space Flight Center (GSFC), Hong-Bin Yu, UMBC, and Charles Ichoku, University of Maryland-College Park (UMCP)

Absorption measurements typically require bright well-known surface properties. Approaches include using MODIS ocean sun glint 2.1 micron BRF characterization plus GLORY aerosol scattering properties. An alternative approach with MODIS Land short wave broad spectral range critical reflectance (following Kaufman) was described. The technique uses multiple wavelength measurements to separate signatures of organics, dust, and black carbon pollution aerosols.

Figures of particle absorption efficiency vs. wavelength were shown. Fine dust particles dominate at UV wavelengths but have a very small signature at visible/infrared wavelengths. The critical absorption method works by using two images with clear and dirty days, and the same geometry and surface (16 days prior). The technique compares the path radiance in the clean image with the radiance in the dirty image to distinguish dust and smoke components.

Discussion: (1) The technique requires very similar geometry and surface features. (2) Rayleigh illumination also works; a bright surface isn't necessary.

Bluing of Aerosols near Clouds; Results from a Simple Model and MODIS Observations

Alexander Marshak, Robert Cahalan, Goddard Space Flight Center, Tamas Várnai, Guoyong Wen, UMBC, James A. Coakley Jr., Oregon State University, Lorraine A. Remer, Goddard Space Flight Center, and Norman G. Loeb, Langley Research Center

Case studies and statistical long-term analyses of near cloud aerosol properties were shown. Aerosol optical depth tends to increase near clouds (positively correlated with cloud amount). Possible explanations include real microphysics (hydroscopic aerosols, higher particle number from new particle creation, other in-cloud processes) or artificial remote sensing effects (extra illumination from clouds, scene cloud contamination).

The researchers hope to distinguish given that (1) adjacency effect should increase fine mode (blue response) while (2) cloud contamination should increase coarse mode. Statistical observations were shown using years of ocean data. The researchers expected that the angstrom exponent increases with aerosol optical thickness while more sub-pixel

clouds mean larger aerosol optical thickness (AOT). Meanwhile, three dimensional cloud illumination effects decrease AOT rather than increase it.

The researchers concluded that molecular scattering is a key source for brightness enhancements as cloud adjacency effect increases Angstrom exponent. Thick clouds are found to have strong blue wavelength adjacency effect.

Using Airborne High Spectral Resolution Lidar Data to Evaluate Combined Active/Passive Retrievals of Aerosol Extinction Profiles

Richard Ferrare, Sharon Burton, Chris Hostetler, John Hair, Mike Obland, Ray Rogers, Anthony Cook, David Harper, NASA Langley Research Center, and Lorraine Remer, GSFC

The researchers stressed the need to relate Lidar backscatter ratios to local extinction. The technique is to constrain with MODIS or other column AOT measurement assuming constant lidar ratio with altitude. The method uses Langley airborne high spectral resolution lidar (HSRL) to spectrally separate the returns from aerosol and Rayleigh backscatter while constraining retrieval with satellite measured AOD.

An aerosol extinction profile with altitude and studies of vertical variability of lidar ratio was shown. It is very sensitive to aerosol type, particularly for stratified aerosol layers of different types.

CALIPSO track often coincides with MODIS sun glint regions but the researchers were able to combine HSRL flight aerosol retrievals with Aqua/Terra MODIS over land, and PARASOL + Terra + Aqua over water. The researchers are still exploring cases where there are differences with MODIS AOT retrievals (Aqua over water is 20-30% lower). There is better agreement over land.

Discussion: (1)Is there any information on Angstrom exponent differences - No, the researchers hadn't looked yet. (2) Were there any implicit assumptions about aerosol single scatter in CALIPSO? - Yes, the Lidar ratio depends on the aerosol model type.

A Progress Report on Combining MODIS and CALIPSO Aerosol Data for Direct Radiative Effect Studies

Jens Redemann and Qin Zhang, Bay Area Environ. Research Institute, John Livingston, SRI International, Philip Russell, NASA Ames Research Center, and Mark Vaughan, NASA Langley Research Center

In cloud edge aerosol retrievals, the key concern is distinguishing real aerosol swelling versus other radiative scattering effects. The researchers examined co-located CALIPSO/MODIS scenes and compared the CALIPSO cloud mask with MODIS. Both misidentify aerosols as cloud. The MOD04 algorithm does correct this misidentification.

A one month data intercomparison of Aqua MODIS and CALIPSO was shown for ocean only. The experience from comparisons was that: (1) the first comparison was bad with no correlation and 30 percent bias; (2) when all the quality flags were applied to improve the correlation, only 5 percent of the samples were left; (3) the data only compared well under severely cloud-free conditions; (4) zonal means show the largest differences above 30 degrees North (April 2007); (5) there are cloud screening biases that impact results < 1% sampling; and (6) Aqua MODIS AOD is typically 20 percent higher over the ocean above 20 degrees North

Discussion: (1) Jim Coakley offered to show some really clear areas; (2) Suggested that maybe we should start with satellite data and ask what it tells you, rather than the other way around. (3) What's the cause of the latitudinal dependence? - Guessing cloud contamination or built in models, but not known.

Cloud Radiative and Microphysical Properties

"Adiabatic" Marine Stratus Using MODIS Imagery

James Coakley, William Tahnk, A. M. Schuetz, and C. R. Hayes, Oregon State University

The goal is to use MODIS imagery to determine whether marine stratus behave like adiabatic clouds. In partly cloudy box scenes, MODIS Cloud Optical Thickness (COT) is too small and Cloud Effective Radius (CER) is too large. A lot of retrievals get done on sub-pixel clouds because MODIS overestimates cloudy pixels.

An adiabatic relationship among cloud properties would be expected, but the researchers found no correlation of CER or COT with cloud top height, possibly because lifting condensation level keeps changing (moving cloud bottom). It is mysterious that based on photon diffusion lengths, 3.7 micron CER should be larger, but aren't. The researchers recommended that the science team look at delta-log-radius versus delta-log-tau to reduce other effects.

Discussion: (1) Limiting sample to more vertical view angles may improve comparison?; (2) How can CALIPSO help? – CALIPSO could help to filter pixels contaminated with cirrus

Overlaying Absorbing Aerosol Layers on Stratocumulus Cloud Layers and the Retrieval of their Properties using MODIS

Eric Wilcox, Goddard Space Flight Center, Harshvardhan, Purdue University, and Steve Platnick, Goddard Space Flight Center

It is significant that biomass burning (black carbon) aerosol has a very low albedo and introduces a bias in retrieved cloud optical thickness if an absorbing aerosol layer is present above cloud.

Comparisons of MODIS COT with AMSR-E were shown. The researchers found a bias in MODIS when OMI Aerosol index was less than 1, but saw no systematic bias in CER. The low bias in MODIS COT is expected for black carbon overlaying low clouds, and it tends to increase with increasing COT.

The MODIS Level 3 Near-IR Water Vapor and Cirrus Reflectance Data Products and the Modeling Needs

Bo-Cai Gao and Rong-Rong Li, Naval Research Laboratory

The researchers discussed the eight-year time series of MODIS measurements showing morning/afternoon differences using WV global one degree time series. Deviations from the eight-year climatology are due to the 2001-2002 El Nino. The eight-year cirrus climatology shows a clear signature of severe China weather in January 2008, El Nino / La Nina differences, and Tibet plateau Aqua-Terra cirrus differences in April.

VIIRS and SGLI will no longer carry near-IR WV channels. Thermal WV measurements are too temperature sensitive to provide comparable WV retrievals.

WV and cirrus global products are now suitable for modelers to use. Signatures of volcanic ash can also be seen using the cirrus band.

Discussion: (1) How do you know that the 1.38 channel is not seeing high altitude surface ice? --- Always have bright surface thin atmosphere problem. (2) How difficult is it to intercompare Terra/Aqua data from several hours apart?

Ice Cloud Retrievals using the 1.38-µm Water Vapor Band

Kerry Meyer and Steven Platnick, Goddard Space Flight Center, Ping Yang, Texas A&M University, and Bo-Cai Gao, Naval Research Laboratory

The goal is to improve MOD06 retrievals when thin cirrus is present. The researchers demonstrated how to use the 1.38 channel to improve information from the cloud mask product. Multi-pixel analysis separates cirrus and non-cirrus pixels using the .66 and 1.38 bands. The technique restores low optical thickness cirrus pixels marked as clear by the cloud mask product.

Details of the forward radiative code (DISORT + multi-layer clouds + Rayleigh scheme) were also presented with an assessment of the method for single and multi-layer cloud cases. Cases are found to be very sensitive to cloud microphysics. The plans are to include more real-world models and additional uncertainty analysis. MOD06_L2 Collection 6 is proposed to include a thin cirrus retrieval.

Discussion: It is not surprising that MOD06 misses thin cloud cases with current cloud mask.

Lessons learned from Study of Ice Clouds and Dust Aerosols using MODIS and POLDER Observations

Ping Yang, Gang Hong, Zhibo Zhang, Myoun-Myoung Cho, Qian Feng, Andrew Dessler, Texas A&M University, Bryan Baum, CIMSS, University of Wisconsin, and Jérôme Riedi, Université des Sciences et Technologies de Lille, France

The researchers presented a radiative forcing study of Terra MODIS data versus a CAM model. The forcing sensitivity to RT parameterizations and sensitivity of lidar backscatter and depolarization to assumed cloud type were shown. The researchers varied the cloud phase and cloud top pressure to simulate optical depth retrievals.

The effect of dust particle shapes on phase function and a simulated Deep Blue retrieval were also shown. Polarization details had little effect on retrievals.

In an inter-comparison of MODIS and POLDER data (with 20km footprint, assumed drop size), the POLDER average optical thickness was found to be 40 percent less than MODIS due to a poor bulk scattering model and asymmetry factor modeling.

Discussion: Are there any plans to do scattering models for volcanic ash? It is possible to do that with good index of refraction data.

Atmosphere Breakout, May 15, 2008

Cloud Radiative and Microphysical Properties (continued)

Evaluating and Improving the MODIS Cloud Top Height, Mask, and Reflectance Retrievals as part of the Atmospheric PEATE

Robert Holz, Steve Ackerman, Fred Nagel, Steen Dutcher, Paul Menzel, CIMSS, Steven Platnick, GSFC, and Bryan Baum, CIMSS

The iterative process that the Wisconsin PEATE uses to evaluate products was described. Cloud top height difference histograms for MODIS versus CALIPSO were shown. Comparisons found that MODIS overestimates the height of marine stratus clouds and underestimates the height for high clouds.

Global maps of MODIS-CALIPSO heights for Aug 2006 and Feb 2007 were shown. Multi-level clouds don't explain the entire bias. The researchers also found an issue when MODIS uses Window Brightness Temperature instead of CO2 slicing. Four possible options were tested to improve the algorithm with good success. MODIS L3 research cloud products that makes use of a new gridding/aggregation system were also shown.

The Impact of Missing Absorption Channels on Infrared-based Cloud Property Estimation from VIIRS Relative to MODIS

Andrew Heidinger and Michael Pavolonis, NOAA, and Sebastien Berthier, SSEC, University of Wisconsin

Derived cloud emissivity from the four available VIIRS channels was presented. The researchers showed the results of their analysis using a subset of MODIS bands for a case with known CALIPSO data, demonstrating the impact on the single-pixel solution space by including an additional MODIS absorption channel.

They predicted that the lack of absorption channels will lead to much greater uncertainty in cloud height. They expect that VIIRS cloud height climatology will be more like AVHRR than MODIS.

Discussion: Point made that using CRIS when available may improve the climatology. --- It will be difficult to implement operationally

Level-3 Gridded Atmosphere Products

Spatial and Temporal Distribution of Clouds as Observed by MODIS Onboard the Terra and Aqua Satellites

Michael King, LASP, University of Colorado, Steven Platnick, Goddard Space Flight Center, Paul Hubanks, Science, Systems and Applications, Inc., Paul Menzel and Steven Ackerman, CIMSS, University of Wisconsin

The collection five Level 3 (L3) cloud climatology was summarized including mean cloud fraction maps and zonal time series (with improved night cloud identification). The researchers demonstrated that Aqua finds greater cloudiness than Terra over land, but not ocean. Separate climatologies for ice and water phases were shown with cloud top pressure maps.

Global monthly cloud optical thickness maps and effective radius climatologies are also available via the modis-atmos L3 site. The impact of new clear sky restoral on COT/CER histograms in C5 was discussed. Status and planning for C5.1 and C6 were discussed.

Discussion: What is the minimum COT measured by MODIS? Detection level is about 0.3, but retrievals often not be successful for very thin clouds.

Ground-based Measurements and Validation

Mists of Absorption Anomaly by Solar Flux Radiometers

Si-Chee Tsay, Goddard Space Flight Center, and Q. Ji, University of Maryland College Park, GSFC

The researchers addressed the issue of why the absorption measurement anomaly is still important, and what it means in terms of understanding climate change. Surface instruments are key in relating surface forcing to satellite measurements. Few people are working on thermopile technology: Eppley, Kipp & Zonen, Yankee, etc.

The diurnal behavior of cloud cover distributions from surface measurements was shown. There is a way to make pyranometers into better climate-quality instruments. The researchers plan to test at ARM site(s).

Comment: Is there a quantum effect involved here?

Data Use, Assimilation & Interdisciplinary Science Investigations

The Gridded Cloud Object Data and Evaluation of ECMWF Operational Analysis and Re-analysis Data

Kuan-Man Xu and Zach Eitzen, NASA Langley Research Center

The nature of "cloud objects" and "deep-convective cloud objects" in models was discussed. Both optically thin and deep clouds must be modeled correctly in the tropical convective system. Gridded cloud objects with thin and deep clouds were shown using PDF's of TOA albedo that depend on thin and deep grid footprints.

The use of cloud object models in vertical columns in ECMWF model parameterizations based on ratios of deep and thin coverage was discussed. PDFs of TOA radiative fluxes from the models with dependency on SST were shown. The researchers plan to use Aqua CERES to further confirm model findings.

Atmosphere Breakout, May 16

Need and Plans for Collection 6

Michael King, Steve Platnick, et al.

Chris Moeller discussed planned L1B changes, particularly fill values for dead detectors and dead subframes. New A0/A2 strategy based on AIRS intercomparisons will improve Aqua radiances for very cold scenes using B31, B32. Terra adjustments will be made in all thermal bands, but are small except in B24, B25, B27 and B28. Dr. Moeller also

discussed B8 and B9 calibration changes that can impact the Deep Blue algorithm. RVS adjustments will also be made to remove "sawtooth" radiance signatures.

Discussion: Platnick asked about Aqua cold/warm focal plane registration issues. It was suggested that developers should first demonstrate feasibility of applying such corrections to their products.

Regarding the C6 wish list (not complete):

Suggested Cloud Mask improvements include: dust detection, angle-dependent 0.86 micron and 1.38 micron thresholds, spatial coherence tests, etc. Rich Frey maintains the master list of possible changes.

Cloud Top Properties: The discussion focused on discrete temperature values inferred from profiles and fixing height retrieval values. The team needs clarity about the current algorithm and will discuss plans. The team would like to move to 1km retrievals using new and efficient code. Concerns were expressed about the product file size and detector noise.

Cloud Optical Properties: Focus on multilayer flags and new radiative transfer tables. The 250m cloud mask should possibly be used for QA. The team discussed how to treat optical properties of ice clouds consistently with albedo assumptions. Delta transmittance for ice clouds may be removed.

Aerosols: Reprocessing C5.1 for Deep Blue was described. Researchers hope to extend Deep Blue to vegetated surfaces in C6 and move to 1km product. Lorraine's team is working on making more retrievals possible over sun glint regions.

Level-3: There will be additional SDS parameters to integrate.

Ocean Breakout, May 14

PI Briefing

M. Behrenfeld—Oregon State University

A poster on fluorescence work was presented. Processing was generally described. The quantum yield can be measured globally with the fluorescence algorithm. More information is available on the ocean productivity web site, linked from the Ocean Color web site.

Refinement and Maintenance of the MODIS Chlorophyll Algorithm: Ensuring Continuity of a Long-term Satellite Data Record of Chlorophyll
H. Feng—University of New Hampshire

The MODIS chlorophyll algorithm is being refined and maintained to ensure continuity. Feng discussed cross validation of MOIDS aerosol properties over the US East coast using AERONET. AERONET sun photometer in Martha's Vineyard was compared to Aqua MODIS ocean color water leaving radiance. Middle wavelengths performed well, but aerosol optical depth was overestimated and MODIS angstrom coefficient (531) was underestimated. Water leaving radiance is underestimated. MODIS atmosphere (MODIS-ATM) and MODIS ocean color were compared to AERONET measurements. Oceanic AERONET sites and land sites close to the ocean were used in the study. Only MODIS-ATM pixels over the ocean were used. Charts comparing each AERONET site with MODIS ocean color (OC) and MODIS ATM were shown. Both MODIS measurements are correlated. MODIS-OC candidate aerosol models mismatch AERONET and MODIS-ATM models in the US northeast coastal region.

High Performance Liquid Chromatography (HPLC) Pigment Analysis at Horn Point Laboratory (HPL)

C. Thomas—University of Maryland

An overview of quality assurance and quality control procedures was provided along with a progress report for 2008. Dr Thomas described information that the lab needs from principle investigators. Samples of daily quality control measurements were provided. Control charts are graphed when feasible. This year, the lab will be analyzing 3700 pigment samples for the NASA ocean color team. The lab needs principle investigators to submit duplicate filters (at least 5%), and a completed, corrected sample information form.

Beyond Chlorophyll: Ocean color ESDRs and new products

S. Maritorena—University of California at Santa Barbara

Chlorophyll is the historical product derived from ocean color observations and the product should continue to be produced. More bio-optical and biogeochemical variables are now measured at sea, and satellite products for these measurements should be

developed and validated. Dr. Maritorena listed new products being produced, their link to biogeochemistry measurements, and the associated algorithm. New products are merging MODIS, MERIS, and SeaWiFS to improve spatial and temporal coverage. Matchups are being done to validate merged products. A new product is the Kd(UV), which uses products from Global Spectral Model (GSM) models to predict Kd. Another new product is the particle size distribution based on MODIS. Associated products include total biovolume, partitioned biovolumes, and partitioned number concentration. Dr. Maritorena is also developing the GSM model.

MODIS & VIIRS Calibration & Validation Proposal Overview

C. McClain—NASA/Goddard

Dr. McClain proposed to work on MODIS data to improve the calibration of MODIS Aqua and Terra to improve agreement with the Sea-viewing Wide Field of view Sensor (SeaWiFS). Beginning with Aqua MODIS, high resolution data were implemented for the coastal community, and then aerosol corrections were implemented. Work on Terra began after Aqua was completed. Dr. McClain proposed to maintain the SeaWiFS Data Analysis System (SeaDAS) and the SeaWiFS Bio-optical Archive and Storage System (SeaBAS). Product quality will be tested, and principle investigators will assist in implementation and testing. The Chesapeake Bay is being used as a test site. Dr. McClain proposed to work with CALIPSO and Glory teams to improve atmospheric corrections for ocean retrievals.

For VIIRS, Dr. McClain is reviewing operational algorithms and tracking tests to understand how the instrument functions. Testing data needs to be robust enough for post-launch calibration. Dr. McClain listed publications related to MODIS and VIIRS over the last year.

Enhancements to the water-leaving radiance algorithm: Case II waters BRDF and polarized upwelling radiance distribution
Kenneth Voss—University of Miami

Dr. Voss planned to collect data in more coastal regions to measure upwelling radiance distribution. Data from Monterrey Bay and the Chesapeake Bay will be considered. The goal is to get to the f/Q. The instrument, Nurads, will determine the angular correction to Q, but there isn't a way to measure f to get to total f/Q. Dr. Voss will take simultaneous measurements with 3 Nurads instruments to get the full polarization. Three data sets have already been collected, and Dr. Voss started modeling with these data for comparisons. Preliminary results for one case were shown for clear water off Hawaii. Dr. Voss is building a new instrument for ONR that gets much cleaner polarization measurements.

Brief progress report for Ocean Color remote sensing and other works

M. Wang

Proposed works are focused on refining MODIS algorithms for sun glint. Dr. Wang presented 4 posters in the 2008 carbon cycle and ecosystems workshop. Dr. Wang has been working on short wave infrared (SWIR) method improvements, evaluations and validations. Near infrared (NIR)-SWIR data processing is being compared with standard data processing for chlorophyll-a. The goal is to develop applications for SWIR. Blue-green algae blooms in Lake Taihu contaminated drinking water for millions. The bloom was visible in MODIS true color, chlorophyll-a, and nLw.

PI Briefing

W. Gregg

In a previous EOS proposal, Dr. Gregg was funded to assimilate SeaWiFS data into a three-dimensional global ocean model. Assimilated model chlorophyll and SeaWiFS chlorophyll match fairly well. When results were compared to data, assimilation performed better than in-situ and satellite data. This has multiple applications to ocean color. Do errors (gaps) add up to a bias? A comparison of assimilation and data in regions where data were available showed that gaps add up to a bias of about 8 percent. Bias is regional to polar regions. To fill a gap between MODIS and VIIRS, 150 ship observations will be needed per year. Dr. Watson is now funded to assimilate water-leaving radiances.

Cal Val Office

S. Hooker

The calibration and validation office is preparing for the next NASA coastal mission. The cal/val office posted a plan on the ocean color web site. Dr. Hooker showed results for SeaHARRE-4 Pig uncertainties. New technology for calibration and validation is being developed. Rapidly descending rocket-shaped instruments were used previously. Kite-shaped instruments better suited to coastal areas are being developed and tested in shallow waters. A significantly smaller free-falling radiometer is also being developed. Smaller boats are necessary in coastal areas, so smaller instruments are needed. Dr. Hooker provided an overview of an above-water system for validation (OSPREY). Platforms will be useful for above-water radiance to fill in holes and gaps in SeaBAS. Instrumentation was deployed in an Antarctic cruise.

OC reprocessing

Brian Franz

Dr. Franz discussed plans for reprocessing. Data from the entire suite of ocean sensors will be reprocessed including MODIS, SeaWiFS, OCTS, CZCS and the following suites: OC, PAR, CLCT, FLH, POC, ZEU, IOP. The plan is to finish reprocessing by the end of 2008. Reprocessing should improve the accuracy of products, reduce artifacts, improve agreement between sensors, and update formats and documentation. Previous reprocessing brought Aqua MODIS data into the system and matched it to SeaWiFS. Terra MODIS data were processed in the forward stream starting in January 2007. Terra data has been characterized. SeaWiFS data are deviating from the understood model of

degradation for the instrument. The differences are probably related to orbital drift into a new thermal regime. To correct for calibration, a "mini-reprocessing" of SeaWiFS data began in July 2007. No other sensors were reprocessed, so there is a larger gap between SeaWiFS and Aqua. The gap will be corrected. Calibration updates to calibrations for SeaWiFS, MODIS, MODIST, and vicarious calibration have been planned. Bandpass corrections may be done by redefining band centers. The ocean color chlorophyll algorithms will be rederived. A new aerosol model suite based on AERONET size distributions will be implemented. The speckling around cloud edges observed in SeaWiFS data is probably stray light near cloud edges. Improved masking may remove the speckling effect. Other considerations include flag and masks, nLw model, f/Q corrections, and Gordon BRDF correction for diffuse transmittance. For legacy missions, vicarious calibration will be updated.

Discussion

What does the 2009 mission extension for terra and aqua entail? The mission extension will probably not be different from previous extensions. It is a formal proposal process.

After pigment round robins, problems with data processed at CHORES were discovered. CHORES is trying to find a way to correct pigments for data processed there. Data is flowing in quickly in terms of new data sets. The range of chlorophylls should be reconstituted quickly and recover dynamic range quickly. Unique geographic data will still be missing.

What is the role of the VIIRS science team? The team is small. The solicitation called for an evaluation of the operational products and their appropriateness for climate science research. The team will examine algorithms used across disciplines during the pre-launch period and evaluate data quality during the post-launch period. Reprocessing won't be enabled for climate data records. There may be a plan for reprocessing in terms of budgeting. The algorithms are already locked in, but the science team may be able to make small changes.

Ocean Breakout, May 15

NPP Science Data Segment update Ocean PEATE status and plans

Fred Patt

Dr. Patt is the technical lead on the Ocean PEATE, product and evaluation of environmental data records. The science data segment is a distributed network of systems. The SDS Level 1 requirements were designed with the assumption that operational IDPS will not require reprocessing. The Ocean PEATE will acquire VIIRS products and assess the quality of environmental data records to determine if they are useful for research or could work as climate data records. Suggestions for improvements should be sent to the science data office. All VIIRS ocean products will be acquired from

IDPS. The testing and evaluation of algorithm changes will require regenerating the product time series in the mini-IDPS. A data flow diagram for IDPS VIIRS ocean environmental data records was shown. Evaluations of VIIRS products proposed for Level-1 onboard calibration and vicarious calibration, Level-2 matchup analyses and residual detector and scan dependence, and Level 3 sensor cross comparisons, algorithm comparisons, and temporal anomaly evaluations. No Level-3 products will be coming out of IDPS. The ocean PEATE is implementing software to process VIIRS level 2data to level 3 products. The ocean PEATE will depend on the current NASA Ocean Data Processing System. The ocean PEATE gap analysis was described. The data processing system is scheduled to be running by December, and full mission capacity should be reached within 12 months. The existing data system will support PEATE. Evaluation methods and tools have been established. Additional development efforts leverage existing software.

Orbit maneuver update

Fred Patt

Jim Butler, NPP deputy project scientist, is coordinating instrument requests for calibration maneuvers. All instrument requests are being reviewed. NPOESS will not perform calibration maneuvers. A diagram of possible maneuvers shown. Three maneuvers have been proposed for VIIRS: lunar roll, solar diffuser yaw, and a deep space pitch maneuver. The moon is the most reliable calibration source. Lunar calibration provided unprecedented stability for SeaWiFS. MODIS performs monthly roll maneuvers to maintain a 55 degree phase for operational calibration. VIIRS is closer to MODIS. On average, no lunar views will be available for three months of the year. All environmental data records that use the VIIRS reflected solar bands would benefit from lunar calibration. A diagram of VIIRS lunar view was shown. Yaw maneuvers would characterize the solar diffuser BRF and SD screen transmission. The yaw maneuvers later in the mission will characterize SD degradation. Deep space pitch maneuvers will characterize thermal emissive band system-level response versus scan angle. A comprehensive program of calibration maneuvers that have a substantial heritage has been proposed.

VIIRS OC evaluations/issues

Kevin Turpie

A crosstalk analysis shows that crosstalk consists of calibration error and spatial effect. Ideally, uniformly gray scenes would have no crosstalk. The equation for crosstalk was given. The analysis of effects based on algorithm sensitivity analysis was shown (see charts in presentation). Cross talk was simulated in an open ocean scene. The simulation modeled the impact of cross talk on the scene if MODIS saw cross talk equal to cross talk observed in VIIRS. The results and the impact to NPP products were shown. What can be done for ocean color? Suggestions include: hardware fix, post-launch mitigation, or vicarious calibration. Achieving a climate quality record of ocean bio-optics is perhaps not impossible, but NASA does not yet have plans to address or support a path forward. Simulations suggest that the impact to water-leaving radiance is detrimental, causing

errors that exceed performance criteria, but some mitigation may be possible. Other instrument concerns include a dual gain band switch anomaly. Dr. Turpie does not believe that the problem will seriously impact ocean color performance. Near field response tests show good NFR compared with heritage sensors. Stray tests showed possible anomalies. Dr Turpies supports NASA's recommendation for another test. The impact on ocean color is unclear. Polarization response characterization shows results that are better than those observed for the engineering design unit or MODIS. An end-to-end system level calibration is recommended to demonstrate that the calibrator works. The test was not done with MODIS, but the problem was fixed on orbit with a moveable screen. Since the VIIRS screen is fixed, on-orbit adjustment will be more difficult. The gain convergence for a decade of SeaWiFS vicarious calibration was shown. Vicarious calibration experiment results were described, and issues were listed by critical area. The SSPR contractor expects expert users to modify products to achieve the quality level needed for science applications. For instrument design, the main issues are spectral coverage, which presents a high risk to ocean color. Cross talk will impact accuracy and precision. In terms of instrument knowledge, there are a number of issues that present a medium risk. Maneuvers have not been approved, but are likely to be approved, and this poses a medium risk to mission success. Vicarious calibration poses a high risk to mission success because there is no infrastructure or team support and no mechanism to distribute calibration information. There is no support for calibration analysis, which poses a high risk to mission success. Every orbit will have a new calibration. A record of calibration data was requested. Product analysis and improvement are high risk. Upgrades and fixes are likely to be difficult to integrate into the system because of the cost and impact to the processing speed. Reprocessing is not supported, and this also poses a high risk to mission success.

Open discussion

The ocean science team discussed ocean biogeochemistry issues. The community is concerned about the continuity of SeaWiFS-MODIS product quality and global time series. The community will need to balance between VIIRS, international missions, and decadal survey missions. This balance may burden the community. Future science plan calls for research into the carbon cycle, habitats, and other new measurements. The ocean community is dealing with difficult problems in terms of new missions, plus NPOESS, and should do advanced planning to be prepared for the new burden.

The ocean science team listed their requests for VIIRS flight unit two and other attributes that might be required for future VIIRS missions. The team was asked to identify science being done with MODIS that should be continued with VIIRS as well as gaps that VIIRS might fill. What products will be lost in the transition to VIIRS, and what impact will that have on NASA science? The team was asked to create a list of necessary science products. NPOESS was supposed to produce climate data. The science team ought to push for a higher signal to noise SWIR band. The team could also recommend that reprocessing be done. It is not NASA's role to do reprocessing. Operational agencies

were tasked to do reprocessing. If NASA takes on a bigger role for NPP or NPOESS, other science will take a hit. The science team was asked to prioritize research needs.

Ocean breakout, May 16

Science team highlights were shown to discuss work or products that won't be possible with VIIRS. The group discussed suggestions for improvements for the next VIIRS instrument to continue ocean observations. A list of issues and suggestions was presented. To continue SeaWiFS-MODIS product quality, the VIIRS sensor performance must be improved. Optical crosstalk and characterization data quality needs to improve. Recommend changes for flight unit 2 include: a remanufactured IFA; dual gains in band M6; a sea surface temperature and fire band; two times higher SNRs in bands M8 and M10 for coastal waters. Recommendations for VIIRS-2 include: FLH bands, UV band, 510 nm band, split 4 micron band into 2 bands (night-time SST-4). Other issues include: reprocessing, balance between other missions in future. New science thrusts for the future are: coastal regimes, habitats, multi-disciplinary science associated with ACE and GeoCAPE.

The science team suggested that onboard calibration be recommended. Reprocessing for climate data record quality is a requirement. Funding is required to keep current product algorithms up to date. Are there any products missing from the portfolio? The ocean team will prioritize their recommendations for VIIRS 2 via email and send the results to Jim Gleason.

Land Breakout, May 14

VIIRS algorithms and issues

Overview and objectives for VIIRS Land

Chris Justice—University of Maryland

The agenda for the land breakout sessions was reviewed. An email list will be compiled for the merged MODIS + VIIRS land team. A review of who is funded to do what for MODIS and VIIRS was made. Each PI gave a brief statement summarizing their funded work for both MODIS and VIIRS. This was in place of the scheduled "Tour de table" session on Thursday.

Chris Justice provided the following overview. He reported that the focus of VIIRS land science team work has been on evaluation of VIIRS Environmental Data Records (EDRs). A summary and set of recommendations coming out of this work should be sent to NASA Headquarters in about 6 months. Some proposals to develop Earth Science Data Records (ESDRs) have been accepted, to be run in Product Evaluation and Test Elements (PEATEs) for comparison to EDRs produced by Northrop Grumman Space Technology (NGST)/ Interface Data Processing Segment (IDPS). The PEATEs are working on scoping for ESDR product generation. It is assumed that production, quality assurance (QA), and validation of ESDRs is to be funded through the next VIIRS Science Team competition.

Justice highlighted the objectives of this breakout session, which would cover: the Land Science Team (ST) PIs planning for VIIRS, what is needed to produce Earth Science Data Records (ESDRs), and an overview of land processing facility (Land PEATE).

VIIRS Land Update

Robert Wolfe—NASA/Goddard

The NPOESS Preparatory Project (NPP) Flight Unit 1 (FU1) is almost ready for thermal vacuum testing. No hardware changes are expected. Testing is expected to be complete by end of 2008. A workaround is to be implemented for thermal focus variation. Crosstalk will stay as-is, but little effect on land products is expected. Only a small risk exists from final characterization in thermal vacuum testing. More details will be given at the VIIRS Sensor Data Records (SDR) workshop in January 2009.

For NPP Flight Unit 2 (FU2), changes will be made to fix cross-talk and thermal focus. A fix for fire band saturation is needed. (This is not fixed for FU1.) The Land PEATE is on track to be useful by the end of this year. Science Team members are already interacting with Land PEATE (obtaining and testing code.)

With respect to evaluation, LDOPE tools are becoming available for VIIRS data. MODIS algorithms are being compared with NGST VIIRS algorithms. Diagnostic Data Records (DDRs) produced at the Land PEATE are a first cut at Earth Science Data Records/

Climate Data Records (ESDRs/ CDRs), but high-quality input is needed for these products.

With respect to algorithms, NGST is not making many algorithm changes based on Science Team suggestions. Albedo algorithm now planned is lower-quality than the MODIS algorithm (BPSA will be the default VIIRS albedo algorithm).
The group discussed algorithm limitations. NGST has limited funding for NPP algorithm changes. Bob Murphy indicated that at present, the primary focus of the Integration Program Office (IPO) is to get the satellite in operation, as opposed to performing more algorithm development and testing now. We expect for there to be more development of algorithms post-launch. Bob Murphy requests suggestions from the Science Team for algorithm tests and demonstrations of algorithm change results.

Robert Wolfe continued his presentation, saying that some progress has been made on the fire algorithm at NGST. As far as interagency collaboration, interagency meetings with NOAA occur 1-3 times per month (These meetings will be combined with the MODIS/VIIRS Science Team meetings. Her wondered if NGST should also be invited? Department of Defense is also engaged, but less with land than with other products. An opportunity for NOAA funding for Climate Data Records (CDRs) is expected by the end of the year.

Calibration/validation (cal/val) discussions have begun, and funding for cal/val activity may be forthcoming. Surface reflectance should be prioritized for cal/val before downstream products, instead of later as originally scheduled. We would like to have a list and schedule of planned algorithm changes from NGST, along with more timely test results, so Science Team members aren't working with old algorithms when new ones are available.

Most instrument issues have been resolved.

VIIRS EDR Land Products Round Table Status Report: Surface Reflectance/ AOT

Eric Vermote—University of Maryland and Alexei Lyasputin-University of Maryland GEST

Vermote reported that tests have been conducted of the effects of instrument issues on surface reflectance. The impact of crosstalk on surface reflectance and vegetation index does not lead to violation of the NPP specifications. (The Vegetation Index specification is fairly loose, allowing for up to 20% error.)

Surface reflectance is expected to be a good product. Ocean aerosols in the NGST algorithms are converging towards MODIS. NGST is working with the Science Team on the land surface reflectance algorithm, incorporating the MODIS Collection 5 (C5) aerosols. Cloud shadow algorithm improvements are likely to become part of the operational system. Justice said that VIIRS Surface Reflectance is expected to be similar

to that from MODIS C5. Bonnie Reed (from IPO) reported that Surface Reflectance is a retained Intermediate Product (IP) which will to be sent to Science Data Segment (SDS), but won't be archived in Comprehensive Large Array-data Stewardship System (CLASS). Justice added that we might get this into the PEATE, but this is a gap in the system as of now.

Alexei Lyasputin said that as of now, the NGST VIIRS algorithms are similar to MODIS C4. We need to know the NGST schedule for algorithm testing and changes. Right now most aerosol testing is over ocean. Alfredo Huete is watching the potential impacts of differences between MODIS and VIIRS surface reflectances on vegetation index.

VIIRS EDR Land Products Round Table Status Report: Albedo

Crystal Schaaf

The heritage MODIS albedo algorithm produces periodic albedo and Bidirectional Reflectance Distribution Function (BRDF) over land every 500 meters, every 8 days (with a 16-day window). Periodic BRDF is combined with instantaneous observations for daily albedo.

The VIIRS albedo algorithm produces broad-band instantaneous albedo only (no spectral albedos.) Two albedo retrieval methods are included, a MODIS heritage algorithm for dark pixels, and the method developed by Shunlin Liang with AVHRR heritage for bright pixels. The bright pixel method is the primary method over all surfaces.

Modelers want spectral albedo data. Spectral BRDF is another retained IP for VIIRS, which would need to be acquired via the Land PEATE. This product is not available for sea ice. VIIRS albedos are now produced at 1 km resolution and evaluated at 4 km resolution. The VIIRS sea ice albedo spec has been relaxed to require values that are only correct to within 30%.

VIIRS EDR Land Products Round Table Status Report: Sea Ice

Dorothy Hall/ Jim Maslanik

Dorothy Hall reported that she is contributing modestly to the VIIRS sea ice algorithm development, although she is not funded to do this. Jim Maslanik reported that the heritage ice age algorithm distinguishes new/young, one-year, and multi-year ice. The current algorithm only distinguishes new/young ice from all other ice. Confusion occurs between new/young and low concentration (incomplete cover) ice in ice concentration determination, which negatively impacts the ice age results. This may not cause specification violations because new ice cover is limited in area. The Ice Age algorithm relies too much on energy balance modeling where not all parameters are available. Albedo can change a lot with snow depth, which is set to a climatological value in the VIIRS algorithm. It was questioned whether the NGST exclusion conditions for ice age are applied too broadly. There is also a need to archive the ice concentration IP.

Currently, sea ice albedo is retrieved only for ice concentrations of 100%. An attempt is being made to get results at lower ice concentrations. The sea ice albedo spec of 30% error is much looser than what is achievable.

VIIRS ice surface temperature data is generally expected to be good.

VIIRS EDR Land Products Round Table Status Report: Fire

Ivan Csiszar—University of Maryland

The VIIRS active fire product is an ARP (Applications Related Product.) The VIIRS instrument status is good for fire, except for the band M15 saturation issue. FU1 tests higher than expected for saturation. It is unknown whether this will be true after launch too. (This is subject of an impact study.)

The VIIRS algorithm is currently based on MODIS V4. The VIIRS build 1.5 code yields a high number of false alarms over hot bright surfaces, possibly due to code alterations (worse than VIIRS build 1.4 and MODIS C5.) NGST and the IPO have little incentive for algorithm enhancements beyond spec, and it is hard to update the specs. VIIRS chain tests contain bad data in the SDRs, which produce false-alarm fires. There are also issues with the land/sea mask.

It has been recommended to modify the product structure to include fire mask and FRP. NGST has proposed these changes, and the science team has submitted feedback. Csiszar discussed Direct Broadcast issues. These issues mostly came from user community feedback. We need fire code independent of IDPS, since fire is a frequently used product. There is also a need for an unaggregated product, in order to obtain better resolution and more sensitivity. The Direct Broadcast users also want to ensure that the system is ready at launch.

In terms of CDR issues, we have no way to improve the algorithms beyond specs. There is also no CMG equivalent and no reprocessing. The product definition for CDRs is suboptimal. (A multi-resolution approach is needed.)
For validation, the use of simultaneous high-resolution observations and the inclusion of the FRP approach are suggested. Use of airborne data, HyspIRI, and possibly international data is suggested.

Planned work includes CDR definition in conjunction with C5/C6 MODIS, FRP improvements, validation including FRP; separate algorithms for direct broadcast and climate data records.

VIIRS EDR Land Products Round Table Status Report: Land Cover

Mark Friedl—Boston University

Feedback is being provided to NGST regarding Surface Type algorithm issues. The main concerns for land cover are improvement of the training data set used for classification

and the prototype data sets for use in algorithm tests (working with Land PEATE.) There is a question as to which downstream algorithms depend on the surface type algorithms.

VIIRS EDR Land Products Round Table Status Report: LST

Bob Yu-Northrup

Yu described the primary land surface temperature (LST) issues. One is directional effect on LST results, which affects validation and LST CDR applications, including data assimilation. Also, the VIIRS LST algorithm includes three formulas, separate dual split window algorithms for day and night, and a backup single split window formula for sun glint areas. This creates an issue because the three formulas are inconsistent. There are also discontinuities at land surface type transitions. There are only 17 land surface types included, which is insufficient to cover all emissivity variation. There is also an issue with noise in the longwave IR bands.

Louis Giglio said that the land surface temperature algorithm won't work correctly under fire conditions. "No fire" should be an exclusion condition in the specs, or implicit. Yu replied that the upper limit of the surface temperature range cuts off fire conditions.

Land PEATE Update

Alice Isaacman/ Ed Masuoka—NASA/Goddard

Masuoka described the division of labor at the Land PEATE. Robert Wolfe does geolocation, gridding, and software integration, Alice Isaacman leads a team in charge of software development, Sadashiva Devadiga is in charge of QA, and he (Masuoka) is responsible for hardware, security, and administrative tasks.

Land PEATE supports the NPP Land Science Team in assessing the utility of NPP EDRs for climate. Land PEATE builds on the MODIS approach for Science Team support, product generation, and QA. VIIRS land and CERES aerosol algorithms will be run at Land PEATE for NPP. Land PEATE interacts with many other data providers and users, including calibration. They feed back changes to IDPS.

Land PEATE obtains retained IPs from NPP Science Investigator-led Processing System (NSIPS, most data from SD3E (IDPS). It is also possible to obtain archived data from CLASS. If the Science Team and Land PEATE suggest algorithm changes, they can be tested on a mini-IDPS system, then forwarded to the NPP Project Science Office, then to the NPOESS IPO for possible inclusion in IDPS. It is also possible that algorithm changes could be made through more informal means.

Louis Giglio asked how easy it is to transfer code to IDPS from Land PEATE. The answer was that it's done at the mini-IDPS relatively easily, with little change to the algorithm science code. Any new code would have to be incorporated into the IDPS framework and would take more work.

Masuoka reported that Land PEATE includes MODAPS software for processing and distribution. It uses open source software on a scalable system, which now consists of 16

servers. VIIRS Science and Operational software can be run on this system, along with algorithm improvements made by the Science Team. The system is expected to be enlarged to 120 servers by launch, with 600 GB storage, and capable of data processing at least a 10x rate.

Important schedule elements include:
September 2008—Power upgrade installed for servers for C6 + Land PEATE,
October 2008—More storage and 40 more servers will be installed,
December 2008—Network bandwidth to be increased,
March 2009—Launch-ready build of Land PEATE (Build 3),
June 2009—Thread tests (ingest, validation plans and demonstration, supporting calibration),
Jan 2010—Simulate 1 day of NPP data processing.

Isaacman reported that her team is performing software integration of operational code from the IPO. Version 1.4 of the NPP code was obtained one year ago and integrated. Land PEATE is currently integrating Version 1.5 science and operational code. This is done for AOT, cloud mask, fire, and land surface reflectance, and is expected to be complete by the end of the summer of 2008. Land PEATE expects to have code available for Raw Data Records (RDR) and SDR, geolocation, gridding, and granulation sometime in June-July 08. (Gridding and granulation need a code wrapper.)

Land PEATE can run chains of VIIRS data processing. Land PEATE also produces Diagnostic Data Records (DDRs), which are distinct data products from those produced by IDPS. Level 3 DDRs are being produced for more direct comparison of MODIS and VIIRS products. This work is complete for most land algorithms, and in progress for albedo, surface temperature, and snow cover. Test data with VIIRS geometry (from MODIS L2G) are also available. Science Team members will have access to test results. Land PEATE software now runs with the HDF4 data format for software re-use purposes. Land PEATE will put IDPS data into a 5-minute granule format (time aggregation) and convert HDF5 to HDF4. This software development, including a GUI for the aggregation, is in progress.

A comparison of NPP proxy surface reflectance to MODIS data was shown. The NPP proxy data has a bowtie deletion (to be removed by reprojection), and also some bad data results due to overcorrection. Comparison of fire mask results to MODIS shows false positives in NPP v1.5 that don't show in NPP v1.4 or the original science algorithm. Wolfe said that the albedo and vegetation index are being produced as 16-day products rather than 8-day products for comparison to MODIS heritage products. Mark Friedl asked if the VIIRS algorithms were running globally or just on particular tiles at Land PEATE. Wolfe answered that they intend to follow the MODIS science testing approach (16-day global, plus time series of some tiles). They still need to figure out whether running a year of data globally is feasible.

VIIRS Land Validation Planning

Chris Justice-University of Maryland

A workshop was held in Asheville, NC, to outline VIIRS validation plans. Many of the current validation plans came out of this workshop. The data sets selected for initial validation focus were land surface temperature, vegetation index, surface reflectance, surface albedo, fire, and surface type.

AERONET was identified as an important validation resource. The Land Science Team should to interact with the VIIRS atmosphere validation effort to emphasize the significance of AERONET.

Crystal Schaaf has a plan for albedo validation based on Baseline Surface Radiation Network (BSRN). Justice reported that a fire campaign is planned for 2009. No ASTER coincidence will be available for VIIRS fire validation. Discussion of land surface type validation has been limited so far. Justice solicited feedback on validation and noted that validation planning is at a relatively early stage. He emphasizes the need to set priorities and seek funding.

Alfredo Huete expressed that Fluxnet is a primary data set for vegetation index validation, and that AERONET is secondary for that purpose. Justice thought there was not enough money available to fund Fluxnet through the VIIRS validation program, and they would need to discuss that further.

John Townshend asked how does this plan interact with international work and GEOSS, for example, international AERONET and Fluxnet sites? Jeff Morisette responded that through Committee on Earth Observation Satellites (CEOS), AERONET was also requested for VIIRS atmosphere validation, and he thought they should also push Fluxnet through this channel. Bob Murphy added that the IPO has funded Jeff Privette for IPO requirements validation. That is constrained by budget, and is mostly confined to evaluating whether the EDRs meet specifications. NASA would probably want more refined validation with a larger scope. Justice said that they should go to NASA with plans for further validation.

Recommendations for NASA's VIIRS Land (ESDR) Products

Chris Justice-University of Maryland

NASA is starting to develop ESDRs (distinct from EDRs.) There is no Vegetation Continuous Fields (VCF) EDR produced for VIIRS by the IDPS. Another issue is there is a need for a better land/water mask for MODIS and VIIRS. Justice noted that Vegetation Cover Change (VCC) is no longer funded for MODIS or VIIRS, and wondered if that was a big data gap? The answer was that VCF has more users, so that's being continued. Users want a continuous record of some kind into the VIIRS period.

Wolfe said that he thinks what is meant by the "core system" (which is to be used to keep some algorithms running with less Science Team involvement) is MODAPS and Land PEATE, but they need clarification on this point. MODIS Leaf Area Index (LAI),

Fraction of Absorbed Photosynthetically Active Radiation (FPAR), and Vegetation Index (VI) could keep running without programming support for algorithms, but the team members would need to decide if they want to keep running without QA and validation? Giglio wondered what NGST is obligated to deliver for water mask? Bonnie Reed said that land/water information is just carried as a flag in the cloud mask. IDPS will begin by using the MODIS mask for the 1st year, then use a mask made from VIIRS data after that. Justice said the land/water mask would remain an issue.

MODIS Land Session Part I

MODIS Status and Overview

Chris Justice-University of Maryland

We're moving into a situation where the main concern with MODIS is instrument performance, since the algorithms have become more stable. Collection 5 (C5) represented a major improvement over Collection 4. We need to solicit feedback from the community about Collection 6 (C6) in a more active way, although funding limitations make it harder to attend meetings and do other outreach activities.

NASA Headquarters wants to see evidence of scientific advantages to justify producing C6. No C6 Vegetation Index (VI) is funded, so what happens to VI when C5 surface reflectance is no longer produced? Similarly, there is no C6 LAI, and that may affect downstream products. It is necessary to evaluate the effects of these dependencies. It seems that the DAAC system for data distribution is working well.

MODIS C5 Processing Status

Barbara DeShong-SAIC

C5 forward processing began on January 1, 2007. Few issues have been encountered, and the leading edge of processing is usually kept within 2 days of real time. Some delay in Gross Primary Production (GPP) processing occurred due to a change in late look Montana data. This is expected to be caught up by late June 2008.

C5 reprocessing for Terra began September 3, 2006, and Aqua C5 reprocessing started on May 4, 2007. Collection 5 reprocessing is nearly complete except for land surface temperature. Various cleanup tasks need to be done, and should be completed by June 2008:

+ Reprocessing of L2G lites for Terra 2004 for LPDAAC (they didn't get them),
+ Reprocessing of MODHDFSR 2000-274 through 2001-184 due to erroneous data deletion,
+ 64 days of LST need to be reprocessed to fix inconsistencies due to processing on separate machines during time period overlaps,
+ Reprocessing of three 16-day periods when maneuvers caused geolocation errors. There will probably be more maneuvers to process,
+ Reprocessing of 153 days of CERES L1B data, which were mistakenly deleted.

MODIS C4/C5 LST Status Report and Proposed Processing Plan

Zhengming Wan-University of California Santa Barbara

This presentation is a proposal for C6 processing as well as a C4/C5 status report.

MODIS land surface temperature (LST) should only be retrieved for clear-sky conditions. The quality of LST thus depends on the quality of the cloud mask. The MODIS cloud mask (MOD35) is generally of sufficient quality for this purpose. Major refinements have been made to the Collection 5 LST algorithm, for example, combined Terra and Aqua data in the day/night algorithm, a leak correction was made for band 35, and cloud contamination was removed in C5 Level 3 LST. (This has not been done for the C5 Level 2 LST yet.)

Wan showed C4 vs C5 LST comparisons. Differences between C4 and C5 include different spatial distributions due to cloud mask differences, and V5 LST data has more retrievals in Greenland, so the global mean LST is lower.

Testing of a radiance-based approach to validation was conducted. Radiance-based validation results were compared to temperature-based validation. Radiance-based measurements were better at representing the spatial variability of LSTs than temperature-based validation, especially during the day. National Centers for Environmental Prediction (NCEP) atmospheric profiles must be used carefully in radiance-based validation. Radiance-based validation is more uncertain in wet conditions, and doesn't work well if the atmosphere isn't realistically represented in the radiative transfer model. Radiance-based validation includes emissivity measurements. Sometimes radiance-based and temperature-based measurements don't match well.

In daytime bare-soil cases, the assumption contained in the LST algorithm that the difference between surface and air temperatures is less than 16 K is violated, so error increases in LST results. This explains the fact that the worst results found in surface temperature validation, with errors of around 3 K, were for deserts. Emissivity uncertainties also increase LST errors in desert regions. Day/night LSTs may be higher than split-window LSTs in these cases by 1-2 K. Some improvements have been made in the C5 LST algorithm from C4, but issues remain. The error in C5 day-night LSTs in desert areas needs to be investigated further. The day-night algorithm results are bound by the results from the split-window algorithm, so errors in the split-window LST propagate. There have also been cloud mask changes between C4 and C5.

A substantial quantity of validation data is available for C5 LSTs, but less validation has been conducted for the emissivities retrieved by the C5 day/night algorithm.

Proposed C6 updates include removing cloud contamination from Level 2 LST, updating split window LUT (increase range of surface temperature minus air temperature, increase

overlap in sub-ranges to reduce dependency on input meteorological data uncertainty, making minor changes in emissivity values, and other changes based on community input

Land C6 Proposal Summary

Robert Wolfe-NASA/Goddard

Wolfe presented the MODIS land Collection 6 (C6) draft time line:

May 2008: Define Level 1 C6 changes
June 2008: Define land C6 changes and develop straw man plan
June-July 2008: Period for community comment and review of C6 plan
July-December 2008: Science tests of Collection 5 atmosphere and land algorithms run on C6 Level 1 data
September to December 2008: Land C6 algorithm delivery
October 2008 – June 2009: Land C6 science testing
January 2009: Collection 6 Level 1 processing begins
July 2009: Begin Land C6 processing
July 2010: Anticipated completion of Land C6 processing

If C5 Land algorithms run with C6 Level 1 output, C5 L1 processing does not have to continue. The main schedule issue is getting the C6 software integrated and conducting science testing. A C6 science testing plan is in the works.

Wolfe sent out a questionnaire regarding changes for Collection 6 to Science Team members, and has compiled a document summarizing Science Team responses. NASA Headquarters is interested in whether the scientific value of those changes justify producing a C6.

A summary of C6 changes suggested for each algorithm was given. Changes to Vegetation Index and LAI/FPAR are funding dependent. Algorithms downstream of Surface Reflectance will be affected by changes to that algorithm. Downstream algorithms could also be affected by changes to the atmosphere algorithms, such as aerosols, and this isn't mentioned in the document.

It would be desirable to use one cloud mask consistently through all products, instead of some products using MOD09 and others using MOD35. All products should use Level 2G surface reflectance data as input. The 1-kilometer products may be eliminated if equivalent 500m products are available.

Changes are also planned to Level 1B processing, including changes to the handling of dead detectors and polarization effects. There may also be a new land/water mask and a 500m or finer terrain model available.

A new alternate atmospheric correction algorithm developed by Alexei Lyasputin may be implemented. A question arose as to whether Science Team members who have had

proposals accepted that include new algorithms will have to go through an Algorithm Theoretical Basis Document (ATBD) approval process. Testing of the new algorithms can be done by MODAPS.

Land Breakout, May 15

MODLand Session Part 2

Tour de table: PI Summary of Planned Research

(PI summaries were given Wednesday.)

The response to the 2005 Amazon drought

Alfredo Huete-University of Arizona

Measurements are made of seasonal cycle of vegetation greenness (MODIS EVI) in the Amazon. These measurements show increasing photosynthetic activity in the dry season and decreasing photosynthesis during the wet season. This pattern holds only for forest areas, not disturbed areas, which show the reverse pattern. An illustration was shown of new leaf growth on trees in the Amazon forest during the dry season, which is attributed to increased sunlight availability under drier conditions.

Carbon dioxide uptake data from eddy-covariance flux towers was shown to correlate with MODIS vegetation index. This comparison should be valid since the footprints of the towers are about same size as MODIS pixels. This correspondence is demonstrated for locations in Southeast Asia as well as in the Amazon.

During the 2005 Amazon drought, conditions were very dry in the western Amazon (not the area where the flux towers are located.) Fires and atmospheric aerosol levels increased in the drought area that year, since dry disturbed areas catch fire easily. However, the forest became greener during this period due to extra sun, which may happen as long as subsurface water is still available to the forest. Older forest is more resilient to drought (greens up more in dry conditions) than younger forest, due to deeper roots. Secondary forest exhibits of pattern of decreased green in dry season before increasing. The reason for this pattern in secondary forests is an open question.

Alexei Lyasputin wondered if cloud contamination of vegetation signals affecting these results. Huete said they are conducting the validation with ground-based flux towers in order to address this. Murphy wondered if forestry researchers in the Amazon had seen this effect. Huete said that they are more interested in wood accumulation than in phenology, and that his results were still controversial. Vermote asked about the uncertainty of the flux tower observations. Huete said that tower researchers are generally confident that their accuracy is sufficient to corroborate the MODIS results.

Mapping land surface radiation budget from MODIS

Shunlin Liang-University of Maryland

The talk was introduced with an outline of the Earth radiation budget. The radiation budget components are well known on an average basis, but there is spatial and temporal variation that is not well characterized. The net radiation budget at a location includes shortwave and longwave components. Net shortwave radiation is affected by the quantity of incoming solar radiation at the surface and by the surface albedo. The net longwave radiation balance is a function of downward longwave radiation emitted by the atmosphere, surface skin temperature, and surface emissivity. Measurements were shown demonstrating a decrease in solar radiation at the surface until 1999 in Europe, then an increase after that. This pattern had been attributed to recent efforts to reduce air pollution in Europe, but a similar pattern also occurred in China, where air pollution is worsening. According to a recent publication, increased concentration of aerosols in the atmosphere are increasing the amount of diffuse radiation reaching the surface, in turn affecting the global radiation budget. A review of current solar radiation data sets shows that their resolution is too low to address questions about the geographic and temporal variation of the surface radiation budget.

A flowchart was shown illustrating methods for derivation of shortwave and longwave radiation budget components from MODIS data under clear and cloudy conditions. A new algorithm is available for estimating photosynthetically active radiation (PAR), similar to the method used for estimating shortwave radiation. A correspondence was shown between cloud cover and PAR distribution, and validation via ground-based measurements was demonstrated. Temporal scaling of the MODIS data may be done by combining them with GOES data. This helps compensate for the limited frequency of Terra and Aqua overpasses, especially at relatively low latitudes. The PAR product has been generated over North America for 3 years. The patterns seen in these results are not surprising. This data will go to the DAAC.

Some issues with the MODIS radiation balance measurements were described. Spatial and temporal filling of albedo data gaps is needed to obtain the shortwave radiation budget for all times and locations. The downward longwave radiation calculation was originally attempted with atmospheric profiles, but too many errors were introduced. Instead, longwave radiation is derived directly from top-of-atmosphere radiances directly. Two methods were demonstrated to work well for deriving upward longwave fluxes, the temperature-emissivity method and a hybrid method using a neural network. An improved method was described for obtaining net radiation in cloudy conditions, but was not described in detail.

The MODIS radiation budget data were compared to analogous data from CERES. The comparison showed similar spatial patterns in radiation budget components, but the MODIS data were more detailed due to their higher resolution. The MODIS surface radiation budget algorithms are now ready for global production.

Lyasputin asked what problems with the atmospheric profiles caused errors in the longwave radiation measurements. Liang responded that MODIS atmospheric profiles are not detailed enough to limit error in the radiation calculation, and there are also inaccuracies in the cloud mask.

Integrated monitoring of carbon and water dynamics from MODIS

Maosheng Zhao

The MODIS gross primary productivity (GPP) algorithm is based on the Monteith radiative transfer equation, expressing GPP as the product of absorbed photosynthetically- active radiation (PAR) and a photosynthetic efficiency. It was assumed that 45% of the solar radiation is PAR. Photosynthetic efficiency is limited by temperature and water availability. In cloudy conditions, PAR is underestimated. Gap-filling is used to address this. Net primary productivity (NPP) can also be derived. Global NPP anomalies were shown from 2000 through 2006. A correlation was demonstrated between the inverse of atmospheric CO2 levels and NPP. NPP anomalies are also correlated with El Nino.

A new data product has been developed in order to quantify plant transpiration and soil evaporation. Vegetation cover fraction is obtained by normalizing enhanced vegetation index (EVI) by the spread between maximum and minimum EVI observed in a location. This information is combined with MODIS leaf area index, land cover, albedo, EVI, and non-MODIS meteorological data in order to obtain get evapo-transpiration. Results for validation of these evapotranspiration measurements were shown for a set of mostly-U.S. sites. The results of this validation indicate an error of about 25 watts per square meter. A map of mean annual evapotranspiration values derived from MODIS was shown. Evapotranspiration results were compared to precipitation and GPP distributions, showing similar patterns in all the data sets.

MODIS NPP data are now used to estimate crop yields and study the global carbon cycle. MODIS GPP may have some utility in the study of biodiversity, as shown by two examples. Annual GPP was shown to be correlated with richness of bird species, up to a saturation point, then bird species numbers declined with GPP above the saturation point. MODIS GPP was also tested as a proxy for plant biodiversity.

MODIS Burned Area Status and Validation

Luigi Boschetti

Burned area identification from MODIS data started production with MODIS Collection 5. This product was developed along with the MODIS active fire products, and has carbon cycle, aerosol, natural resource, and land cover/ land use change research applications.

The burn scar detection algorithm uses departures from expected BRDF trends over time in order to identify burned areas. The algorithm is automated, pixel-based, and operates

on 500 meter gridded daily MODIS surface reflectance data. If observed reflectance and BRDF are significantly different from projected values, the pixel is flagged as a potential burned area. Further tests are performed on such pixels to refine burn scar identification. Burn scar detection became part of the standard MODIS data processing with Collection 5. The results are being examined and algorithm changes are being tested in order to make improvements for Collection 6.

The detection of burn scars was compared to the MODIS active fires product in different regions. More active fire was detected per burnt area in more densely vegetated areas. This might be due to the presence of smaller fires in those regions that don't produce detectable burn scars. The pattern of burnt area and active fires was a good match.

Validation of the burnt area algorithm was performed using a combination of Landsat ETM+ and SAFNet in-situ data in southern Africa. Comparison of MODIS to Landsat burned area shows a correlation between the results with some scatter. A product inter-comparison was also conducted. Data from L3JRC, SPOT VEGETATION, and GLOBCARBON were obtained for the same period and region as the MODIS validation and compared to Landsat. Burned area was significantly under-detected in the L3JRC data, while the Globcarbon data didn't contain as many underestimations. MODIS data showed the best correlation to Landsat, but some under-detection still occurred.

Validation plans include performing validation for a range of representative conditions, including problem areas such as high forest cover, high LAI, and croplands. Work is in progress with international partners.

Planned improvements for Collection 6 are to reduce under-detections, fix coding errors, improve cloud and aerosol masking and the land water mask, introduce active fire MODIS data into the burn scar detection algorithm to refine the burnt area product. Wolfe asked how including Aqua data in the retrievals helped in burn scar detection. Boschetti said they need Aqua to help obtain more retrievals in frequently-cloudy areas, but differences are modest when there are few clouds.

Directional difference of satellite land surface temperature observed from GOES-8 and GOES-10 Imagery

Bob Yu

Directional differences in land surface temperature (LST) values would affect validation, climate data record (CDR) production, modeling, and data assimilation. Directional effects happen due to geometry, because at different angles more sunlit or shaded area, or more tree crown or soil background area, is in the field of view. The combination of these factors in different proportions results in different LST values. A model shows that apparent LST does change with direction. This effect is seen in AVHRR data due to satellite orbital changes, and also in GOES data validated against SURFRAD in-situ data. Differences also occur between GOES-East and GOES-West land surface temperatures at the same location and time due to the difference in viewing angles between the two satellites. Directional differences in average apparent LST can be up to about 3 K,

varying seasonally and diurnally. These differences are more significant in daytime, when solar radiation interacts differently with different surfaces, than at night.

These effects are large relative to VIIRS requirements, and can't be ignored. VIIRS LST should provide information to help correct for this effect after launch, but we need to work on development of this correction now. A method using the combination of two GOES and 2 polar-orbiting data points per ground location was suggested for inter-calibration. It is unknown whether LST varies with azimuth angle.

Comparison of MODIS LST with the ASTER North American Emissivity Database

Simon Hook—Jet Propulsion Laboratory

A comparison was made between the emissivity and LST products from MODIS Aqua, AIRS, and ASTER. The algorithms for the three instruments were different: the MODIS algorithm was stratified by land cover class and day/night conditions; the Aqua algorithm used a multi-spectral method; and the ASTER method used a calibration curve. The data from the instruments differ in their spatial resolutions and their availability, since AIRS is only on Aqua and Aster is only on Terra, while MODIS is on both satellites. ASTER data for any point on the Earth's surface is available only once per 16 days. In compensation, a 16-day gridded product is made from the ASTER data from clear sky pixels. The resolution of ASTER is high enough that validation can be done with field geology. The agreement between the ASTER and field emissivity data is usually good to within 0.5%, except for water, where there is a 2-3 % bias in the ASTER algorithm. The data from AIRS shows a similar pattern to ASTER, except in areas of low emissivity.

When ASTER emissivity results were compared to MODIS Collection 4 emissivities, agreement was also good except for low emissivity areas. MODIS Collection 5 emissivity results did not compare as well to ASTER, especially in barren areas. This occurred because all barren areas are forced to have a single emissivity value, which is unrealistic. Other land classes do not exhibit this problem, as their emissivities are more uniformly high. The differences between Collection 5 and Collection 4 emissivities can be up to 10%, producing a cold bias in MODIS LSTs in bare areas. The conclusion was drawn that the stratification by land cover classes in the MODIS Collection 5 algorithm is not helpful.

Wolfe noted that the comparison of AIRS and MODIS results is complicated by cloud clearing. He wondered if the differences between MODIS Collection 4 and Collection 5 be due to the removal of cold cloud pixels in Collection 5. Hook said that needs further investigation.

MODIS Validation

Jeff Morisette—NASA/Goddard

Validation of land Collection 5 products is generally moving to stage 2 or 3. Some land products are now listed as validated to Stage 1 that are actually farther along, so this should be updated. They would like to conduct MODIS/VIIRS intercomparison studies during the period that MODIS and VIIRS overlap (assuming that happens). Other multi-product intercomparison projects are being conducted now, and methods developed through these projects will be applicable to MODIS/VIIRS intercomparison.

Other validation needs are seasonality/ temporal variation validation in order to quantify error in the temporal dimension, definition of land product accuracy requirements (ASIC3 workshop did this for calibration), coordination with NPOESS IPO on validation infrastructure needs, maintenance of core sites and data networks, maintenance of land product accuracy statements (statement of level 1/2/3 validation and supporting material.) This information would be more visible and helpful if it was integrated with data access on the Web.

A meeting was held in Asheville, NC, in order to begin to define VIIRS calibration/validation (cal/val) requirements. An NPP cal/val peer review will occur May 21, 2008. One possible action is for NASA to make an addendum to the NPP cal/val plan.

CEOS contribution- QA4E

A QA framework for Earth observation workshop was held. The results of this workshop generally attempt to be generic across all products and sensors/ sensor types, so the framework is very high-level. Appendices will be developed for subgroups, which will include reflectance, albedo, and biophysical parameters. More specific information could be included in these appendices. Justice pointed out that there is a need for more international partnerships in order to compensate for resource limitations. MODIS Collection 5 validation information should be updated on Web sites if possible.

The Land Portal Overview

Tres Montano

The Land Measurements Portal is a Web site that is intended to be a single place to get data from multiple sources, including internationally, or products generated by particular research groups. It is a portal, not a server, which means that it contains links to data sources rather than data storage. Audience members were encouraged to submit information on their data products in order to make them more available. The Land Measurements Portal will also have sections for current news and meeting schedules. Audience members are invited to contribute news and meeting notices.

The data products listings on the portal will be divided into four product groups: vegetation parameters (vegetation index, GPP, NPP, LAI/FPAR, phenology), land cover/land use change (land cover classification, land cover change, fire), surface radiation budget (surface reflectance, LST, emissivity, albedo, BRDF), and land hydrosphere (snow, hydrology). Sea ice may end up as a separate category. The

following metadata are specified for each data set: spatial coverage, spatial resolution, temporal resolution, archive dates, development institution, and funding agencies. Links will be provided to a product description, validation information if available, and multiple data sources if available for each listed data set. There will also be a page for each sensor, with product lists. Products will be cross-referenced with similar products with similar resolutions.

The URL for the Land Measurements Portal is:
http://landportal.geog.umd.edu/portal/portal_login.php

Login: betauser
Password: vDcKX2

More information from the user community is desired: corrections, more sources, new products, and feedback.

MODIS Land C6 Processing Proposals: Continued Discussion

Chris Justice—University of Maryland

Land Science Team members are asked to watch for email regarding MODIS Collection 6 (C6), since there is a need to continue formulating a plan and schedule for the C6 processing. There is still an issue regarding whether C6 data will be usable as input to those of the algorithms that won't be updated to a C6 version.

Privette asked if data from the Collection 5 (C5) algorithms that have not been updated be called C6 if C6 data are used as input? Justice said that those data would still be labeled as C5, but we need to be aware of dependencies on C6 upstream products. We need to get the word out about C6, as well as any use of C6 data in C5 algorithms, including by updating the Web sites. Could the upcoming meeting in Montana be a forum for more validation discussion?

Ranga Myneni asked what to call the output of C5 algorithms run with C6 input? Justice said that first, they need to see if the C5 algorithms will run with C6 data. Then, they should address that question. Shunlin Liang sais they would like more feedback from the community on the Collection 5 results before we start C6 processing. Justice said that C6 processing is not starting until next year. They also need to be able to provide justification for production of a C6. Wolfe pointed out that C5 production need to keep going in order to avoid gaps in time series.

Mark Friedl said that the land/water mask for C6 needs to be improved. Justice agreed it was an important problem, and they'd like to resolve it. Terry Harman said the MODIS land cover classification includes water as a class. Shouldn’t that data set be the source of the land/water mask? Friedl said that distinguishing between land and water in the vicinity of shallow water bodies is difficult, and is not always done correctly in the MODIS algorithms. Justice thought it should be possible to generate a better land/water

mask than what we have now with MODIS data. Alexei Lyasputin said they have an algorithm with internal dynamic land/water/snow classification. This information is generated at 1km resolution now, but finer resolution is needed for land applications. Wolfe said that international groups are working on improving digital elevation models (DEMs). It should be possible to derive a better land/water mask from a DEM.

Masuoka asked whether, in conducting C6 testing, would we test more than one change at a time and whether testing should be open to the community and users as it reaches more readiness for C6. Justice said community involvement is a good idea, but it takes time. There is a tension between community involvement and schedule. The National Snow and Ice Data Center representative suggested that the DAACs could serve the test data to interested people.

Some discussion of the timing issues with forward processing and reprocessing followed. Wolfe said it is probably not a good idea to combine the C5 land algorithms with C6 Level 1 data. They will keep C5 forward processing going through the completion of C6. He asked if they should plan a C6 workshop before we start C6 processing, and Justice said it was a good idea to engage the community, but that the effort we'll be able to make on this will depend on funding. The DAACs could help with community engagement.

Jeff Morisette said that people get criticized for using “old” collections. We need to explain that using the “old” data is OK. A workshop could help with getting the word out about the new collection. Justice said that some products are more ready for updates than others. The planned schedule for C6 may be too aggressive. Shunlin Liang asked if C6 will be the last MODIS reprocessing. Justice said he thinks they are getting to the point of diminishing returns, but the team will need to revisit this issue and re-evaluate. There is a lag between product availability and knowledge among the user base. Some products are ending with C5. Others will probably end with C6. Some products may continue into a Collection 7. Harman thought that if the Level 1B changes that anything downstream should be called Collection 6. Justice though it would depend on the magnitude of changes in the products.

MODIS LST Solutions Subgroup

This session was a discussion of land surface temperature algorithm issues among the developers of those algorithms. This subgroup will develop recommendations that will be presented at the Friday morning plenary.

Land breakout, May 16

MODIS LST subgroup- summary of actions

It would be possible to use the Collection 4 (C4) LST algorithm with modifications for use of this algorithm with Collection 5 (C5) data. However, the C5 algorithm also has some improvements that we don't want to lose by going back to the C4 algorithm.

Zhengming Wan made the following recommendations. In response to user community requests, they should keep MODIS C4 LST products in production with modifications to the code to use C5 inputs. They could run tests and make a decision on this within one month. If the modified code can make LST products similar to the old Collection 4 results, that code should be used to process the MODIS data since Jan 1, 2007, parallel to the current C5 forward processing. Keep both C4 and C5 data in the archive. Remove cloud contamination by a similar method to the C4 post-processing.

He also recommended they adjust the C5 code to fix the problem of high emissivity areas being represented incorrectly. They need to make a small adjustment to the day/night algorithm in the current C5 PGE16. Testing on this could be complete within 6 months. They would do another C5 reprocessing with the new code if the test shows it works. All these issues would be fixed in C6.

Justice pointed out that it creates a problem of two parallel data sets, leaving it to the user to figure out which data set to use. Sadashiva Devadiga said they should make sure an explanation of this is available to users. Wolfe said that version revisions (such as C4, versus C4.1) should be incorporated into the version ID for granules.

Collection 6 planning

Justice reported that the plan for Collection 6 (C6) is to start processing in 2009 and finish in 2010. We'd like to get the community involved in testing but we also don't want to overburden people. It would be a good idea to have a workshop and do outreach, but the Montana meeting may be too late for C6 discussions.

Alfredo Huete and Ranga Myneni are going to check the Vegetation Index and LAI/FPAR results on an ongoing basis, but this processing will be shifted more to just the core system rather than having the PIs give a lot of focus to maintaining these algorithms. Wolfe asked for more input from the science team on scheduling for C6 in order to make the schedule more realistic.

VIIRS issues

Chris Justice presented a slide on VIIRS issues for review. The current focus is on land EDR evaluation and Land PEATE ESDR generation.

A draft of the algorithm status was presented for updating by the science team.
VIIRS EDRs that may be useful for science include:
+ Surface Reflectance,
+ Top of the canopy (TOC) Normalized Difference Vegetation Index (NDVI),

+ Land Surface Temperature (LST). Zhengming Wan has questions about some aspects of the VIIRS LST EDR. Simon Hook thinks there should be a separate LST ESDR, Snow Cover, although no fractional snow cover will be available,
+ Ice extent, sea ice concentration. This IP needs to be archived, and the sea ice age algorithm needs some improvement,
+ Land surface type, which will be used by the U.S weather service in their models.

They expect to work with the contractor to improve some of these algorithms, but other VIIRS operational algorithms will not be suitable for our needs at all. We need to decide which algorithms are in which category. Crystal Schaaf expressed the opinion that VIIRS surface albedo EDR is not going to be a good product, since it provides no spectral information and no information on underlying surface characteristics.

Justice said the ESDRs now in development were LST, albedo, composited NDVI and EVI (Enhanced Vegetation Index), fire (science Team members are in consultation with the NPOESS IPO on the fire algorithms), sea ice concentration, and leaf area index (LAI).

They agreed they should find some way of continuing the Vegetation Continuous Fields record, which is in high demand. They hope that we will have chance for more product improvements once the instrument is stabilized. Stability of the instrument and products are necessary preconditions for validation. Chris Justice hopes this will be more of a focus of the next round of proposals for post-2011. However, we should start planning for possible algorithm improvements now.

Hassan Ouaidrai said there are better algorithms for LST. The current VIIRS LST EDR isn't meeting precision requirements. He wondered how can they make the case to the IPO to use better algorithms? How could they fix this post-launch? Bob Murphy suggested using the Pathfinder approach and try to have this done at the project science level. He said they should start working this through the bureaucracy.

Bob Yu said that since some of the LST data are produced using a split window algorithm and others are produced with a dual split window algorithm, continuity is compromised. Bob Yu and Jeff Privette are publishing paper showing that the split window algorithm is the better approach.

Heather Kilcoyne (IPO representative) asked for better communication between the Science Team and the IPO on LST. Simon Hook said they would like to look at the test results from the IPO.

Chris Justice summarized the recommendations for VIIRS Flight Unit 2, which will be in lockdown in 3 months: improve VNIR IFA, address optical crosstalk, improve VNIR read out integrated circuit to address static electrical crosstalk, improve saturation handling for single bands (for example, in aggregation) (for fire), improve testing of near field and far field stray light VIIRS response. These are the most important issues from the land point of view, which will be raised to the IPO.

A concern was raised regarding whether band I5 has a smaller footprint than the other bands. Hassan Ouaidrai will look into this issue.

Additional Flight Unit issues with respect to fire include M13 crosstalk. M13 requires a 'squarer' point spread function, and the M13 calibration range should be increased, full resolution.

Crystal Schaaf said that we've gone back to AVHRR-type algorithms with VIIRS albedo. Complaints were raised by others about some of the VIIRS specifications that were loosened. Heather Kilcoyne responded that this is an operational instrument, and it's configured to meet those needs. Justice said that they need to be at the table as NASA in order to express our interest in climate observations. There may be a chance that science and operational products will eventually converge. Jeff Morisette asked if they will have validation information in time to make suggestions for FU2? The answer was no, but maybe for unit 3.

Plenary Recommendations

Chris Justice

For NPP, the current focus of the Land Science Team is on evaluation of the NPP EDRs. Some ESDRs are now in development, and some of the EDRs can meet some science needs. An assessment of VIIRS EDR adequacy should be sent to NASA HQ in about 6 months. There is also a need to test data flow now to get improvements back to the IPO. Concerns were also raised about the Land PEATE budget for post launch.

The list of land priorities for FU2 discussed in the breakout session was shown again.

MODIS update:
Some ATBDs for new algorithms to be included in MODIS processing are pending. The approval process includes review by the community, a decision to include the new algorithm, incorporation into MODAPS and MODAPS production. A 250m land/water mask is needed (preferably dynamic), C5 reprocessing has been completed (kudos to MODAPS). They need to update the MODIS land Web sites, by including C5 user guides and validation status.

Production of Vegetation Cover Change has been discontinued. VI and LAI won't be produced for C6. They still need to resolve how data produced by the C5 algorithms with some C6 inputs will be treated.

Summary of Science Team presentations:
For MODIS C5 data, community product intercomparisons are underway between MODIS, ASTER, and AIRS. For example, LST and emissivity results were examined, and errors were found in the C5 results. International calibration/validation intercomparisons are underway through projects like QA4E and CEOS. An example of

validation of the MODIS burned area product through comparison with Landsat was shown. The Land C6 straw man timeline was shown, but this timeline is now in question, since there is a need for more time for the community to evaluate C5 results, examine C6 plans, and examine the results of C6 tests. An example of MODIS product improvement by the Science Team is the BRDF gap-filled product and validation of albedo.

Some examples of Amazon forest greenup during the dry season and drought periods from Alfredo Huete's presentation were shown. Maosheng Zhao and Steve Running's group in Montana have shown a relationship between MODIS NPP and carbon dioxide uptake, and are producing a new evapotranspiration data set from MODIS data. Finally, the Land Measurement Portal Web site is under development. This site will combine links for access to multiple instruments' products. Information on validation, upcoming meetings and other news, and international coordination will also be included on the site.

MCST Meeting, May 13

Instrument and Performance Status

(SDSM) operating normally. The Aqua MODIS SD/SDSM continues to operate on a regular basis. The Black Body (BB) temperatures on both instruments have remained stable. The instrument and warm Focal Plane Assembly (FPA) temperatures have drifted <3K over 8.5 years for Terra, and <1.5K over 6 years for Aqua. The temperature controlled FPA on Terra have remained stable, while on Aqua, loss of cooler margin is an area of future concern for maintaining short-term stability.

Instrument Operations (IOT) Status

Roy Yi (MCST/STG)

The major Terra spacecraft event since the last Science Team Meeting (STM) was the Solid State Recorder (SSR DMU) swap in June 2007. The result is an increase in available supersets – from 32 to 33, and a small increase in data storage for MODIS. The current configuration is considered to be the limit of "no loss" operations. Three occurrences of Science Formatter Equipment (SFE) anomalies coincident with spacecraft passage through the South Atlantic Anomaly (SAA) have occurred in recent months, resulting in short periods of data loss. Since launch, Terra MODIS has performed 562 SD/SDSM, 63 BB, 265 SRCA, 55 Electronics, and 78 Lunar on-orbit calibration activities.

Aqua MODIS experienced an SSR anomaly on December 2, 2007, resulting in data loss. Currently the SSR is not operating in a nominal configuration, but regular data collection has resumed and a software fix is in place to correct for the hardware error. Since launch, Aqua MODIS has performed 364 SD/SDSM, 23 BB, 139 SRCA, 35 Electronics, and 53 Lunar on-orbit calibration activities.

Vince Solomonson asked, given current state of operations, what the projected lifetime for the instruments is. Xiong thought that for Terra MODIS, it would be about 5 years, except for bands 8 & 9, which have shown significant degradation. For Aqua, it is at least 6 years, but an outgas operation will be needed to restore cooler margin for cold focal plane assemblies. Enough fuel remains for end of life spacecraft maneuvers.

Level 1B Status

James Kuyper (MCST/SAIC)

The L1B code has been relatively stable, with only 7 changes since end of 2004 (4 for Terra, and 3 for Aqua). Nearly monthly Look-up Table (LUT) updates are implemented in the MODIS forward processing. Additional LUTs are generated, tested, and delivered to the Ocean Biology Processing Group (OBPG). Preparations for Collection 6 have begun. The L1B group works closely with the calibration group to develop and implement the proposed changes. Two issues requiring code changes (fill values for

inoperable detectors and subframe QA) have been developed, implemented and are undergoing testing. A third issue (instances of space view (SV) DN =0) is still undergoing analysis, before a decision can be made on implementation strategy.

Thermal Emissive Bands (TEB) Performance

Aisheng Wu (MCST/SSAI)

The Thermal Emissive Bands (TEB) performance has been very stable both short-term and long-term since launch for both Terra and Aqua MODIS. Excluding configuration changes and instrument reset events, the long-term response trends and noise performance are relatively stable. As the TEB calibration is performed on a scan-by-scan basis, any long-term trend in sensor response will not impact the calibration significantly. The BB performance on both Terra and Aqua has been excellent. The short-term variation in any of the 12 individual BB thermistors is on the order of 25 mK for Terra and 15 mK for Aqua. Terra MODIS currently has 25 noisy detectors and 1 inoperable detector out of a total 160 TEB detectors (no QA changes since the last Science Team Meeting). Aqua MODIS currently has 3 noisy detectors and 1 inoperable detector (1 new noisy detector since last Science Team Meeting, B29 D2).

Chris Moeller pointed out that Terra Band 34 has had a number of noisy detectors since launch, and he wondered if that was a detector or electronics issue? Aisheng said it was a detector issue.

Reflective Solar Bands (RSB) Performance

Hongda Chen (MCST/SSAI)

Overall, the Reflective Solar Band (RSB) calibration has performed well since the last STM. No new noisy or inoperable RSB detectors. The Terra Solar Diffuser door has remained in a fixed open position (with screen in place) since July 2003, resulting in an increased degradation rate of the SD especially at shorter wavelengths (e.g. Band 8). The response for Terra Band 8 has decreased about 42% (mirror side 1) and 47% (mirror side 2) over the instrument lifetime and Aqua Band 8 has decreased about 20%. Mirror side differences exist on Terra particularly at the shorter wavelength bands (as high as 15% for Band 8). On Aqua, the mirror side differences are less than 1.5% for all RSB bands. The lunar response trending is consistent with the long-term trends observed using the SD/SDSM, and is useful data for deriving the Response Versus Scan Angle (RVS).

Spatial & Spectral Performance

Jack Xiong (NASA/GSFC) & Jason Choi (MCST/SSAI)

The Spectroradiometric Calibration Assembly (SRCA) provides measurements to perform spatial and spectral characterization of MODIS. The spectral mode is able to track only the VIS and NIR bands. The center wavelength and bandwidth on-orbit changes are less than 0.5 nm, except for bands 1 & 19 which have large bandwidths (50 nm). Both Terra and Aqua spectral performance is stable on-orbit. The spatial performance on both instruments has remained stable. The Terra Band-to-Band

Registration (BBR) meets specifications except along-scan between Band 30 and Band 32. On Aqua, there is a known problem with BBR between the cold FPA bands and warm FPA bands. All MTF parameters continue to exceed design requirements.

Concerns and Special Issues

Jack Xiong (NASA/GSFC)

Several concerns and special issues were discussed. (1) Terra MODIS has a known large mirror side difference whose effect became noticeable in L1B reflectance/radiance starting from 2003 for the shortest wavelength bands (Band 8 and 9). The difference is time, season, angle-of-incidence, and latitude dependent. The largest impact will be on science data products using Terra bands 8 and 9. Time-dependent polarization parameters are needed as a potential method of reducing the observed impacts of the mirror side difference. Thus far, no mirror side difference has been observed for Aqua MODIS.

(2) The typical RSB calibration consists of an SD/SDSM operation with a screened and open measurement requiring a total of 6 door movements. Currently the Aqua SD/SDSM calibrations are performed on a tri-weekly basis. At the current rate, Aqua will reach the projected number of lifetime door movements in 2.9 years. To preserve the number of door movements in anticipation of Aqua continued operation beyond the design lifetime, it is proposed that the SD/SDSM activities be changed to a screened operation on the same schedule of tri-weekly and the open operation every 6 weeks. Using this proposed usage, Aqua will reach the projected number of lifetime door movements in 4.4 years. There is no door movement issue on Terra as the door has been fixed in the screen position since an anomaly in 2003.

(3) A decrease in the Aqua cooler margin has gradually reduced the ability to control the Cold Focal Plane Assembly (CFPA) temperature at 83K. Any impact is expected to be small, as the operational TEB on-orbit calibration is on a scan-by-scan basis. The impact of the continuous increase in CFPA temperature variations needs to be evaluated. Several options are available to mitigate the issue: set the CFPA to a higher operational temperature (85K) or perform an outgas procedure. Terra MODIS CFPA temperatures remain well controlled. (4) The calibration consistency between Terra and Aqua MODIS is an issue that needs to be addressed. There are a number of factors that impact the calibration and much information is needed to make the two instrument lifetime data sets consistent.

Collection 6 Issues

Introduction & Proposed QA and TEB Changes

Brian Wenny (MCST/SSAI)

A list of issues/concerns to consider addressing in a Collection 6 was compiled by MCST based on discussions from the last MODIS Science Team meeting as well as from the bi-weekly MODIS sensor Working Group teleconferences.

Proposed QA Changes:
1) Replace Interpolation with fill values for inoperable detectors.

Interpolation for inoperable detectors was implemented at the beginning of the mission. The land team suggested we revisit this decision and instead use a fill value in the L1B product so it is transparent to the users that the detector is inoperable. The code changes have been implemented and a 'golden tile' set of test data produced and is available for the science disciplines to test their algorithms.

2) QA flag on subframe level

Currently QA flags are set for noisy/inoperable behavior on a detector basis. Terra Band 2 Detectors 29 & 30 subframe 1 have a known crosstalk problem. A proposed L1B code change will allow QA flags to be set at a subframe level for bands 1-7. The code changes are complete and a test QA LUT prepared. Several granules of test data have been produced. In Collection 6, subframe 1 of Terra Band 2 detectors 29 & 30 will be flagged as noisy for the user's information. There is expected to be no impact on the L1B product due to the new QA flag.

Proposed TEB changes
1) A0/A2 Update Strategy

The strategy used to derive the nonlinear and offset calibration coefficients was revisited. Ideally pre-launch measurements would be used but due to the configuration/electronics changed for Terra and the gain change for Band 31 & 32 for Aqua, suitable pre-launch measurements are not available. In addition a cold scene bias in brightness temperature has been observed in Aqua MODIS-AIRS intercomparisons for Bands 31 & 32 data. For Aqua the proposed change is to use A0=0 and A2 derived from on-orbit BB cool down activity data as opposed to the current method of using on-orbit BB warm-up activity data. Several test data sets were produced and analyzed. Application of the Collection 6 coefficients revealed little to no impact on retrievals at typical scene temperatures and also eliminated the cold scene bias (~1.5K at 200K scenes) in the Aqua MODIS-AIRS intercomparison. For Terra, Collection 6 A0/A2 coefficients will be derived from BB cool down as opposed to BB warm up activities. A limited data set was produced and analyzed. The largest impacts were observed in Bands 24, 27, 28, and 30. Differences were small for all bands at their typical scene temperature (±0.2K), but could be as large as 1K at low scene temperatures (band dependent). Further analysis is planned and additional data will be produced and provided to the science disciplines to test.

Bill Barnes wondered why MCST thought that cool-down data would have better agreement to pre-launch? Wenny answered that cool down is a passive activity of the BB; thermistors embedded in the BB response time may be more accurate during passive process. Analysis of Aqua data (except for bands 31 & 32) shows that cool-down closer to prelaunch than warm-up.

Proposed RSB Changes

Junqiang Sun (MCST/SSAI)

Two main Reflective Solar bands (RSB) issues are to be addressed in Collection 6, a correction for detector bias in the SD m1 and a detector dependent Response versus Scan Angle (RVS). Differences in detector response are not fully captured by the current m1 algorithm and have slowly increased throughout the lifetime of the instruments. The effect is both band and angle of incidence (AOI) dependent. For example, on Terra Band 8 the difference amongst detectors was initially small at launch (~±0.5%), and has increased to about ±2% in the most recent measurements. A method was proposed using Earth View (EV) radiance detector difference trending at the AOI of the SD to derive the m1 correction factor. The result from applying this technique reduces the detector bias to about ±0.5% with no trend over instrument lifetime.
The degradation rate and mirror side differences on Terra have made derivation of RVS from on-orbit measurements a challenge. Currently the RVS is band dependent in Collection 5. An approach to derive a detector dependent RVS is proposed. For mirror side 1, detector dependent RVS is determined with a linear approximation from SD and lunar m1 data. For mirror side 2, detector dependent RVS is derived from EV, lunar and SRCA dn mirror side ratios. The detector differences are band and AOI dependent and have increased with time. Band 8 has the largest RVS detector difference which has increase over time to ~3% at the AOI of the SV. Band 9, 3, and 10 currently have RVS detector differences of about 1.5%, 1.2%, and 0.8%, respectively, at the AOI of the SV. A comparison of Collection 6 (detector averaged) RVS and Collection 5 agree well, however application of the detector bias m1 correction and detector dependent RVS greatly reduce the EV radiance detector difference which indicates improvement in the L1B product quality.

Science Discipline Presentations

Terra/Aqua Band 1 and 2 Calibration Evaluation Over Libyan Desert Site
Eric Vermote (University of Maryland)

The Land product Normalized Difference Vegetation Index (NDVI) is derived using Band 1 & 2 data. The surface reflectance trends (BRDF-corrected) of a Libyan Desert site using Bands 1 & 2 from both Terra and Aqua were analyzed. The NDVI comparison between Terra and Aqua showed differences that have increased with time between the two instruments. The Terra NDVI has increased with time, and the Aqua NDVI has decreased with time. A similar trend is observed in both Band 1 and 2 surface reflectance. These systematic differences are unexplained at this time and show that Terra and Aqua are less and less comparable with time. Further analysis is needed in collaboration with MCST to investigate the cause of these differences.

MODIS Geolocation Status
Robert Wolfe (NASA/GSFC)

Several changes have been made to the Collection 5 Geolocation: incorporation of new ancillary data, updated ground control points based on GeoCover Landsat 7 products, a new flag identifying times near/after maneuvers, and a Terra northern/southern

hemisphere difference correction. Collection 5 results for Terra are excellent: RMS error is better than accuracy goal, and sun angle fit corrects for N/S hemisphere differences. For Aqua, the RMS error is better than goal in track direction but slightly larger than goal in scan direction (although still better than specification). Handling of geolocation during/after spacecraft maneuvers has been re-examined and several changes have been implemented to improve the geolocation accuracy during these periods.

A number of improvements are planned for inclusion in Collection 6: 1) Updated error analysis, 2) Incorporation of new ancillary data, 3) Updated ground control points, 4) Improved maneuver handling, 5) Compute 500m geolocation and provide in the form of 8-bit offsets from a bilinear interpolation of the 1km data, 6) Enhanced 1km terrain correction, 7) Develop and implement algorithm to remove the AMRS-E jitter from the along-scan mirror motion of Aqua MODIS, 8) Write spacecraft temperature to geolocation product, 9) Write solar elevation correction to geolocation product, 10) Add a scan SDS reporting the quality and type of the ephemeris/attitude data used, and 11) Correct the setting of attitQua when EA source is 'MODIS Packet' (relevant to Direct Broadcast only).

AIRS - MODIS TEB Global Comparisons

Chris Moeller (University of Wisconsin)

An earlier work investigating comparisons between Aqua MODIS and AIRS found a radiance bias between the two instruments (Bands 34-36) that could largely be removed by shifting the MODIS relative spectral response (RSR). The initial study used two days of global measurements and recently this analysis has been extended to process global comparison over the entire Aqua mission. A pattern was noticed in the long term trend – season and hemisphere dependent. Several possible explanations for this behavior have been investigated – MODIS spectral characterization error, MODIS out-of-band filter leaks, and MODIS optical or electronic crosstalk. Applying spectral shifts to the MODIS RSR (Band 34: -15nm; Band 35: -15.5nm; Band 36: -20.2nm) does appear to remove the differences seen in the long term trend. The large spectral shift required is a concern though. Out of band leaks have also been investigated with no firm conclusions as yet. The AIRS data set has been a useful resource for investigating Aqua MODIS performance; however, without a physical basis for the observed performance anomalies (radiance bias) few conclusions can be drawn.

MODIS-Terra cross-calibration for ocean color bands

Ewa Kwiatkowska (NASA/OBPG)

Terra MODIS has a known mirror side difference issue at short wavelength bands which has made deriving Ocean Color products problematic. Collaborative efforts with MCST have identified RVS and polarization as having the largest impact on the data. A vicarious approach using cross-calibration with SeaWiFS was developed to characterize on-orbit Terra RVS and polarization sensitivity. Time-dependent polarization correction

coefficients were derived and applied to the data to determine the impact on the water-leaving radiance (Lwn) product. The results show significant improvement in agreement between Terra and Aqua MODIS Lwn over the mission lifetime.