Quarterly EOS Contract Report - Report #57

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Remote Sensing Group (RSG), Optical Sciences Center at the University of Arizona

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Summary:
Work by members of the RSG during the past quarter consisted of Science Team support activities including the attendance at meetings related to MODIS and submission of ATBDs and validation plans. Several members presented papers at the Denver SPIE meeting. The VNIR and SWIR Cross-Calibration Radiometers were used as part of a cross-calibration experiment looking at calibration sources being used for MTPE sensors. The spherical collector for the diffuse-to-global meter was completed and tested and a sensitivity analysis of vicarious calibration over dark targets was completed. The uniformity of the BRF meter was tested with our 40-inch SIS and the system was used to collect a BRF data set during a September campaign to White Sands. A field campaign to Lake Tahoe was also made to collect data in support of dark-target calibration work. Data to evaluate the Cimel TIR radiometer were processed and presented to Cimel.

Task Progress:
P. Slater and E. Zalewski attended the EOS Calibration Meeting at Goddard Space Flight Center on 9 -11 July. Slater summarized the status of the calibration of the ASTER sensor subsystems, reviewed the First Joint Vicarious Calibration Field Campaign, gave a description of solar-radiation-based calibration (SRBC) including results of a recent comparison, made by S. Biggar, of SRBC and lamp-based calibrations of his VNIR radiometer, and lead a discussion on future plans for joint vicarious calibration activities. Biggar, Slater, K. Thome, and Zalewski attended the Denver SPIE meeting August 5-7. Biggar served as session chair for an EOS session and presented a paper on the radiometric cross-calibration of HYDICE. Slater chaired a session on HYDICE characterization and gave a paper on the in-flight radiometric stability of HYDICE. Zalewski gave a paper on the laboratory and on-board calibration of HYDICE. Thome also attended the conference presenting papers on a reflectance-based calibration of HYDICE and on a sensitivity analysis of the ASTER atmospheric correction. Zalewski attended the MCST ATBD IR Audit at Wisconsin on August 28 - 29. Slater and Zalewski attended the MCST ATBD Solar-reflective Audit at Goddard Space Flight Center on September 5 - 6. Biggar attended a MODIS Quarterly Management Review at Goddard Space Flight Center September 18 and 19. Various test results were presented by SBRS with a discussion of

how to interpret the results, if any tests should be redone, and whether it is possible to cancel some further testing. Biggar investigated the scan mirror emissivity problem on MODIS as it relates to the thermal calibration. Slater, Thome, and Zalewski attended a calibration workshop in Toulouse, France September 18-20 where they presented papers on SRBC, the calibration of HYDICE, and the proposed calibration of VEGETATION by reference to SPOT-4, respectively. The three also attended the EUROPTO meeting in Taormina, Italy September 23-26 where Thome presented a paper (with K. Arai of Saga University as first author) on the recent Lunar Lake experiment and results of last year's Lake Tahoe experiment (with R. Parada of RSG as lead author). Slater chaired two sessions on sensor calibration and was co-author of two papers. Thome sent comments to A. Schwarz of JPL regarding the ASTER Product Generation System Test Plan. Thome submitted a revised version of the ATBD for the atmospheric correction of ASTER and a revised version of the validation plan for the atmospheric correction. Slater submitted viewgraphs describing the validation plans, using vicarious calibration, for ASTER- and MODIS-derived top-of-atmosphere (TOA) radiances.

P. Spyak made measurements with the SWIR transfer radiometer using the 40-inch spherical integrating source (SIS). These included measurements to examine stability, repeatability, band-to-band consistency, signal-to-noise ratio, sphere uniformity, sphere drift, and radiometer interactions with the sphere. He also viewed the 6-inch SIS to measure the stability and repeatability. Spyak reduced the in-band bandpass filter data. A few filters are slightly out of specification, but the effect of this is not expected to be significant.

Biggar and Spyak took part in a cross-calibration experiment involving calibration sources for MTPE. E. Nelson prepared the shipping containers for the SWIR CCR. C. Burkhart made a mount for the tripod assembly to hold our 6-inch SIS in front of the SWIR CCR. This allows the SIS to be viewed in a repeatable fashion for use during calibration experiments to monitor the radiometer's operation. A radiance calibration traceable to NIST was performed on the SWIR CCR to characterize the radiometer for the cross-calibration experiment. The estimated error in this calibration is less than 4%. Biggar did a radiance calibration of the VNIR radiometer on 30 July. His estimated uncertainties are less than 3% with respect to a NIST irradiance standard. Biggar and Spyak traveled to Santa Barbara and Pasadena for measurements of the MODIS SIS from August 12-14, the Landsat SIS on August 15, and the MISR SIS on August 17 and 19-21. Both radiometers performed well. Spyak began analyzing the data and will have it fully analyzed when calibration data are provided by SBRS and after the November trip to Japan. Biggar and Spyak sent preliminary results of the cross-calibration experiments to C. Johnson of NIST.

Biggar, S. Recker and Spyak began preparing for the cross-calibration experiment for the ASTER calibration sources that is

now scheduled for November. They obtained an ATA Carnet to ship the CCRs to Japan. Biggar modified the 6-inch SIS shipping case to allow him to ship the docking station for the notebook computer to allow easier GPIB connections. He installed a GPIB card into the docking station for a more reliable connection to the VNIR CCR. Spyak returned the shipping case for the SWIR CCR's tripod that arrived damaged and it has been repaired.

Our blacklab facility was used by representatives from UCLA to characterize the aluminum diffuser for PMIRR (Mars Observer replacement instrument). Biggar modified hardware and software in the blacklab to prepare it for use by the UCLA personnel. In response to problems with the blacklab computer, Biggar and T. Mitchell began modifying the blacklab software to operate on a new Pentium class computer. They have determined how to move a linear stage with the U100 controller via the GPIB interface. There are still some minor difficulties in controlling the Unidex stages in the blacklab through the GPIB interface, but progress has been made. Mitchell derived the center wavelength and bandpass of the blacklab radiometer interference filters using the full-width-half-maximum and moment methods on measured filter data. J. LaMarr and Spyak used the SWIR CCR to calibrate a barium sulfate panel in the SWIR. Spyak ordered a new laser for the blacklab.

Spyak and LaMarr began studying the effects of atmospheric absorption in optical laboratory experiments by performing measurements and analyzing the results. Spyak began a literature search related to this topic. Spyak sent Ultra-Pol (black cloth) samples to J. Young of SBRS for testing. Spyak evacuated the InSb dewar for the Optronic monochromator.

B. Crowther continued work on the diffuse-to-global meter. The spectrometer and motor control program are now working and he linked the Aerotech and the Greenleaf RS-232 libraries. Burkhart completed a rough model of the occultor that Crowther tested for vibration. He conducted three calibration experiments for three different parts of the diffuse/global irradiance meter. The first was a characterization of the angular response of the integrating sphere collector built by Crowther and Burkhart using data collected on Mount Lemmon and at White Sands. Data were collected with three candidate knife edge apertures for the sphere. Crowther determined the average temperature coefficient of the responsivity for the LiCor detector from 300 nm to 1100 nm at intervals of 1 nm. This will be used to correct data from the angular response experiments that are affected by varying temperatures. Crowther collected the data for the spectral calibration of the LI-1800. The sources used were the Optronic monochromator, a HeNe laser, and three atomic line sources. Initial results indicate that the bandpass of the LI-1800 is quite close to the 12-nm figure specified by LiCor. Crowther received repaired stages from Aerotech and ordered an additional fiber optic cable for the LiCor and two travel cases for the diffuse/global equipment. C. Gustafson computed shift and digitization errors in cross-calibration data using the TM imagery

from White Sands from October 1994. She found several 2-km by 2-km areas where there is no change in a calibration coefficient derived from cross-calibration using data that is misregistered by as much as 0.5 km. Several 4-km by 4-km areas were found where the error is less than 1% for the same misregistration and 10-km by 10-km areas where the error is less than 3%. Similar results were obtained using HRV data from the same time period.

Parada adapted software written in France to run on our computer system. He found a bug in the wave-slope modeling in the code and fixed this. He used this code for a sensitivity analysis of the radiance-based approach applied to the Lake Tahoe and open ocean cases. Parada received several improvements of Successive Order code from R. Santer. He completed a first attempt at the calibration of AVIRIS data from June 1995 corresponding to the SeaWiFS wavelengths. Parada summarized the results of this work in a EUROPTO paper that Thome presented.

Spyak defined methods for analyzing the TIR data from the Lunar Lake and Railroad Valley field trip in May. He discussed results and data reductions with M. Sicard and J. Myers. Sicard, Spyak, and Zalewski discussed plans for another field trip to Jornada Experimental Range near Las Cruces, New Mexico. Sicard made preparations for the field campaign that is being organized by ASTER Science Team member, T. Schmugge and is scheduled for September 10-12 with a Landsat-5 overpass on the 11th. Sicard continued to reduce the data from the Lunar Lake/Railroad Valley and earlier Jornada field experiments and presented preliminary results at a meeting held by Cimel on July 26th, in Avignon, France. In the presentation, Sicard showed comparisons with measurements made with an Everest IRT at Jornada of several surfaces. Comparison data from Lunar Lake were also shown. Sicard concluded that the CIMEL is stable for ambient temperatures between 10 and 40 C, the response for the four filters shows good agreement, and the calibration done in the lab is different by 1% in radiance from that determined from field measurements. Sicard suggested that Cimel install an internal blackbody, develop a temperature-controlled box, increase the data acquisition rate, and improve the accuracy of the detector thermometer. Sicard received Jornada ground data and emissivity measurement from Schmugge and Railroad Valley emissivity data from S. Hook. Sicard also received Lunar Lake TIR data from H. Tonooka and the locations of the site used by JPL. Sicard is writing software that accounts for the filter transmittance when computing the responsivity of Cimel TIR radiometer. This will be used to compute new calibration equations for the radiometer. He also developed software to compute the band-integrated transmittance of the system's filters.

P. Nandy began streamlining the ASD data processing routines using IDL. The ASD canned routines (run through a PC system) were evaluated and used to develop software which strips and decodes the header segments of multiple data files. The software also graphs the ASD data in a format similar to that of the PC-based

ASD software. Nandy also developed IDL software to process the header and data from multiple ASD files and compile them into a single file readable by our reflectance-retrieval software, and designed the software to allow the user to select a particular set of ASD data files, convert these to the appropriate format, and then initiate the reflectance-retrieval software.

Nandy tested the BRDF camera's spatial uniformity and overall system performance using the fisheye lens and 40-inch SIS. A variety of look angles, bands, and camera orientations were used. The measurements showed a distribution of circular dark spots with data values approximately 8-9% below the surrounding values from the sphere. From the data, Nandy determined the spots were not due to the SIS or the fisheye lens and further testing with a standard Nikkon 55-mm lens revealed a similar but different pattern of spots. A bright spot was also apparent in the center of all images, with data values up to twice the surrounding values, but tapering off dramatically within a dozen pixels to either side. Nandy sent the camera to Photometrics for cleaning and to pump and bake the detector array. The camera was tested after being returned by Photometrics after servicing. All of the dark-spots disappeared, though the bright white central region is still present. Photometrics personnel suggested this may be due to vignetting through the camera's smaller-than-standard Uniblitz shutter. Nandy further investigated the bright spot found it to be strongly dependant on the camera lens's entrance pupil size. It is brightest for small apertures, while hazy and diffuse for the largest settings. Further testing indicate this is an artifact of the 55-mm lens and the spot is not apparent in the fisheye data. Thome used the camera during a recent White Sands trip in September to collect several sets of data. These data will be used to test several planned data retrieval approaches.

In field-trip related work, LaMarr reviewed what is needed to upgrade the autotracker. He designed a mount for testing the autotracker filter encoding and completed ND filter measurements and out-of-band measurements on spectral filters. Biggar and Crowther replaced the controller board in the Helios data logger. Parada planned and coordinated a field campaign to Lake Tahoe that took place July 21-31. The goal of the campaign was to collect data to validate the use of the Successive Orders radiative transfer code over the lake and the collection of data for the calibration of AVHRR (NOAA-14). C. Curtis, LaMarr, Nelson, Parada, and Thome participated. Thome completed the majority of the processing for the First Joint Vicarious Calibration Campaign at Lunar Lake. To date, predicted radiances at the top of the atmosphere have been determined at 1-nm intervals from 350 to 2500 nm for all data sets from June 1, 2, 3, and 4. The processing was done using both MMR and FieldSpec derived reflectances and for all targets of each data set. This amounts to a total of 66 sets of radiative transfer output at the above wavelengths. Biggar, Crowther, Parada, Spyak, and Thome traveled to White Sands to collect data for several SPOT-2 and -3 calibrations September 4-9.

Mitchell joined the group this month as a PhD. student in Optical Sciences. He has a BS degree in Electrical Engineering (1991) and a good background in physics from Worcester Polytechnic Institute. His Electrical Engineering thesis was RS-232 Fiber-optic Data Link, and his Physics thesis was Radiation Trapping Effects in Erbium-Doped Optical Fibers. For the last 2.5 years he has worked at the USDA-ARS Water Conservation Laboratory in Tucson developing specialized filters and processing software for enhancing airborne videographic imagery, developing image processing software for multi-spectral imagery analysis, and computer networking.

Future Work:
Spyak and Biggar will continue to prepare for a trip to Japan for a cross-calibration experiment. This includes paperwork, equipment testing, software development, further calibration/ characterization of the SWIR and VNIR CCRs, and evacuating the SWIR CCR dewar.

Parada will begin processing the Tahoe '96 data. The data set includes measurements which can be used to confirm the modeling of multiple view angles, retrieve the effective aerosol vertical scale height, and calibrate a large footprint sensor (AVHRR). He will repeat the calibration of the MMR using a lamp-based and SIS-based approach. As part of this, the MMR filter transmittances will be measured again for filters 1-4. The results of this work will be incorporated into a paper summarizing the work and previous results. Parada will update the reflectance uncertainties for use in the sensitivity studies of the reflectance-based method. He will finalize the MMR calibrations using our 40-inch spherical integrating source and additional SRBC and molecular-based calibrations based on band-integrated results.

Nandy and Thome will process the BRF meter data from White Sands. Thome will process the White Sands data for the calibration of SPOT-3. Plans are being made for a November trip to White Sands for a calibration of Landsat-5 and a first test of the diffuse-to-global meter. The trip will also be used for further testing of the BRF meter and to evaluate our surface reflectance retrieval techniques.

Zalewski will be completing the Validation Plans for the TOA Radiances of ASTER and MODIS.

It has been proposed that Biggar and Spyak assist SBRS during the forthcoming calibrations of MODIS in which the 100 cm Spherical Integrating Source (SIS-100) is used. This will restore the tie-in with the August 1996 cross calibration which was lost because of the failure of one of the lamp groups in the SIS-100. The relationship between the absolute calibration of all of the solar reflective bands of MODIS will be re-established with MISR, ASTER, Landsat, SeaWIFs and OCTS. Additional benefits expected are verification of the SNR, the radiometric stability including the ambient-to-vacuum stability of the D1 dichroic, and possibly the

linearity of MODIS. Details regarding the implementation of this proposal will be worked out in coordination with MCST and SBRS.