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ACRF Instrumentation Status: New, Current, and Future

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Summary

The purpose of this report is to provide a concise but comprehensive overview of Atmospheric Radiation Measurement Program Climate Research Facility instrumentation status. The report is divided into four sections: (1) new instrumentation in the process of being acquired and deployed, (2) existing instrumentation and progress on improvements or upgrades, (3) proposed future instrumentation, and (4) Small Business Innovation Research instrument development. New information is highlighted in blue text.

Contents

1 New Instrumentation

1.1 90/150 GHz Microwave Radiometer

Mentor: Maria Cadeddu, Argonne National Laboratory

The need for greater sensitivity (and therefore higher frequency) microwave channels to more accurately measure liquid water paths in thin clouds than the current 23.8/31.4 GHz instruments permit has been extensively discussed. Based on a technical evaluation of three proposals submitted for evaluation, Radiometer Physics, GmbH (RPG) (http://www.radiometer-physics.de) has been selected as the supplier with an option to purchase a second instrument (Engineering Change Order [ECO]-00491). RPG has supplied a similar instrument to the University of Munich. The first instrument has been ordered. Following acceptance testing at SGP, the instrument will be deployed to NSA-Barrow. Once the first instrument is accepted a second instrument will be ordered. The second instrument will be deployed with the ARM Mobile Facility (AMF) to Germany in 2007.

STATUS – Maria Cadeddu and Thomas Rose (RPG) installed the radiometer at the SGP guest instrument facility on 18 October for evaluation and acceptance testing prior to deployment at the NSA Barrow site later this year.

1.2 Micro-Pulse Lidar

Mentor: Rich Coulter, Argonne National Laboratory

1.2.1 New Micro-Pulse Lidars

Four new Micro-Pulse Lidars (MPLs) (type-4b-YAG) have been ordered (ECO-00577). Combined with the upgrades described below, this will permit a new (or like new) MPL and an older type MPL to be deployed at each site (SGP-Central Facility [CF], NSA-Barrow, Tropical Western Pacific [TWP]-Darwin, TWP-Manus, TWP-Nauru, and AMF). The new type-4b models will use a Photonics YAG laser with a shorter pulse width to achieve a minimum detection height of ~90 m rather than the 150-300 m detection height of the YLF laser in the earlier type-4b models. The new systems will all have the ability to measure depolarization.

STATUS – All four new MPLs have been delivered to SGP and have completed acceptance testing. New MPLs are now operational at SGP, NSA (Barrow), and TWP (Darwin); a new MPL has been shipped to Nauru for installation in late November.

1.2.2 Upgrade Earlier Type-4 Micro-Pulse Lidars

Because the LiteCycles laser is no longer supported, the type-4 acquired in 2004 will be upgraded to a 4b, which involves engineering modifications in addition to replacing the laser; the 4b-YLF models acquired in 2005 will be upgraded to 4b-YAG by replacing the laser only. These systems all have the ability to measure depolarization.

STATUS – Two of three upgraded systems have been delivered to SGP but were returned for re-collimation of the optics. The laser for the remaining system exhibited low output power and was returned to the laser manufacturer for examination/reworking; following its delivery to SGP, its pump diode failed during acceptance testing. Once acceptance testing is successfully completed, one of these MPLs will be sent to the AMF (Niamey) and one to TWP (Manus Island); the remaining system will serve as a spare.

1.3 Radar Wind Profiler

Mentor: Rich Coulter, Argonne National Laboratory

A 4-panel 1290 MHz RWP has been ordered from Vaisala for the 2007 AMF deployment in Germany. An operating frequency of 1290 MHz was selected to match EU and other global frequency allocations for boundary layer radar profilers. Delivery is scheduled for September 2006 (ECO-00513). In July the FAA denied a request for a license to operate the new RWP at the SGP for testing prior to the AMF deployment to Germany in April 2007. The new RWP is in storage at SGP awaiting shipment to Germany.

1.4 Infrared Sky Imager

Mentor: Vic Morris, Pacific Northwest National Laboratory

An IR sky imager from Blue Sky Imaging (http://www.aas.org/career/bluesky.html) was deployed at SGP in September 2005 to provide nighttime cloud cover measurements (ECO-00429). Problems with moisture infiltration of the imager necessitated its return to the manufacturer for repair/revision in October 2005. The unit was returned to SGP in late June and returned to service in August.

September 2006 – The new heaters appear to prevent moisture accumulation inside the instrument. The images look reasonable compared with the TSI images. The manufacturer is improving the software and image masking parameters. Verification of the cloud fraction algorithms remains to be done.

1.5 Cloud Condensation Nuclei Counter for Southern Great Plains

Mentor: John Ogren and Anne Jefferson, National Oceanic and Atmospheric Administration/Earth System Research Laboratory/Global Monitoring Division

A CCN counter has been included in the AOS for the AMF. A CCN counter for SGP is planned for FY 2006. See http://www.dropletmeasurement.com/ (ECO-00565)

September 2006 – In September Anne Jefferson installed the CCN counter at SGP. Data are available from the Archive.

1.6 Add Multi-Filter Radiometers to Cessna 206 (In-situ Aerosol Profiling aircraft)

Currently, spectral albedo measurements are only possible at the SGP central facility using downward facing Multi-Filter Radiometers (MFR) on the 25-m level of the 60-m tower over a wheat field, and on a 10-m tower over the adjoining pasture. By adding a MFR to the Cessna 206 used for the In-situ Aerosol Profile (IAP), routine measurements of surface spectral albedo could be acquired over a broader area around the SGP central facility (ECO-00584).

STATUS – Discussions continue regarding where on the aircraft to mount the sensor head.

1.7 Hot Plate Total Precipitation Sensor

Mentor: Mark Ivey, Sandia National Laboratory

This is a new sensor developed by Roy Rasmussen at National Center for Atmospheric Research and commercialized by Yankee Environmental Systems. It offers the promise of accurate snowfall measurements without the need of an expensive World Meteorological Organization (WMO)-standard double fence inter-comparison reference shield or troublesome WMO-standard Geonor weighing precipitation gauge. It also offers the promise of handling under-catchment due to winds. One Total Precipitation Sensor (TPS) was acquired for deployment at Barrow in November 2005. The instrument will be deployed in close proximity to a double fence inter-comparison reference and Geonor gauge deployed by the National Oceanic and Atmospheric Administration (NOAA) Climate Reference Network (CRN). If the first sensor compares well with the CRN measurements, a second TPS could be acquired for mounting on the 40-m tower at Barrow to discriminate between blowing and falling snow. Budget cuts at NOAA have caused CRN to defer plans to install a station at Atqasuk; therefore acquisition of a second TPS for Atqasuk may be desirable if the first unit proves successful at Barrow. (EWO-11696).

September 2006 – The instrument has been installed on a piling near the Barrow CRN station. Data collection has been initiated; data ingest development is in progress.

STATUS – Broken fiber optic lines between the Great White shelter and the TPS have delayed progress.

1.8 DigiCORA-III for Manus, Nauru

Mentor: Barry Lesht, Argonne National Laboratory

The digiCORA is the ground station for the Vaisala balloon borne sounding system. In FY 2003-2004 new digiCORA-III systems were acquired and deployed at SGP-CF, NSA-Barrow, and AMF as the primary ground station for those sites. For reliability and compatibility reasons it is necessary to replace the digiCORA-II systems at Manus and Nauru with the new digiCORA-III systems (ECO-00598).

September 2006 – The new digiCORA-III units have been received. Once Barry configures them they will be shipped to the TWP for installation.

2 Existing Instrumentation

This section describes the current status of the existing instrumentation, including any upgrades planned or in progress. The information is abstracted primarily from the Instrument Mentor Monthly Summary reports (available from the instrument web pages) and from ECO status updates.

2.1 Atmospherically Emitted Radiance Interferometer

Mentor: Dave Turner, Space Science and Engineering Center, University of Wisconsin

SGP – One OS/2-based AERI that cannot be upgraded and one AERI upgraded to Windows XP and rapid sampling are both operating nominally.

NSA – One upgraded extended-range (ER) AERI operating nominally; one ER-AERI out of service due to a failed laser in the Bomem interferometer. Radio-frequency interference has been observed in the NSA AERI systems.

TWP – The interferometer in the Darwin AERI failed shortly after it was upgraded to Windows XP and rapid sampling; it will be returned to the U.S. for repair. The Nauru AERI will be upgraded using the upgrade components initially intended for Darwin.

AMF – This OS/2-based AERI is operating nominally.

Spare – The OS/2-based spare AERI at the University of Wisconsin Space Science and Engineering Center (SSEC) needs to have the aging laser replaced in its interferometer before it could be sent to Darwin as a replacement.

2.1.1 Windows and Rapid-Sampling Upgrade

Migration of the AERI software from OS/2 Warp to Windows XP and related computer hardware modernization to enable rapid sampling of the IR spectrum at 10-s intervals was begun in FY 2004 (ECO-00286). In FY 2005, 2 AERI systems were upgraded and installed at NSA-Barrow and SGP-CF. In 2006 the AERI systems at Darwin, Nauru, and the second system at Barrow were to be upgraded in the field. Due to the failure of the second Barrow system it will not be upgraded until after the other AERI systems have been upgraded. The AERI deployed with the AMF will be upgraded following the completion of the Niamey deployment then redeployed with the ARMF to Germany.

STATUS – The upgraded electronics, Windows XP computer, and software were installed in the AERI at Darwin in September. Unfortunately, the interferometer failed shortly after the upgrade. The upgrade components will be used instead to upgrade the AERI on Nauru. The Darwin AERI will be returned to SSEC for disassembly and the interferometer sent to Bomem for repair; it is expected to be out of service for an extended period.

2.2 Aerosol Observing System

Mentor: John Ogren and Anne Jefferson, National Oceanic and Atmospheric Administration/Earth System Research Laboratory/Global Monitoring Division

All AOS instruments are now operating nominally.

2.2.1 Reconfigure Southern Great Plains Aerosol Observing System

The AOS at SGP will be reconfigured to have similar components and data acquisition system as the aerosol systems for AMF, NSA, and the IAP aircraft measurements over the SGP (ECO-00569). This work is scheduled for FY 2007.

2.3 Balloon-Borne Sound System

Mentor: Barry Lesht, Argonne National Laboratory

Radiosonde data recovery was nominal during the month, with Niamey reporting 125 soundings of 120 scheduled (104% recovery), NSA 54/60 (90%), SGP 117/120 (98%), and TWP/C2 (Nauru) 57/60 (95%). Apparently there were data transfer problems from TWP/C1 (Manus) after 9/22, but based on the data available, TWP/C1 had 43/44 (98%) recovery. The 5 extra soundings at Niamey appeared to result from the operators starting a second sounding after the scheduled sounding terminated early. In all cases the early termination was due to the balloon bursting prematurely.

With the installation of new software at NSA and SGP we have begun doing formal ground checks as part of our pre-launch radiosonde preparation. To conduct the ground check, the operator inserts the radiosonde sensor into a sealed chamber that contains a reference-grade thermometer and a molecular sieve desiccant. The process is almost completely automated: the ground station reads the radiosonde values, obtains readings when conditions have stabilized, records these readings, and prompts the operator to enter the reference values of RH (assumed to be 0%) and temperature (read from a digital display on the ground check set).

2.3.1 Make Atmospheric Radiation Measurement Program-Barrow Soundings Available to the Global Telecommunication System

August 2006 – Barry has received a WMO station identifier (70270) for the ACRF Barrow site from NOAA/NWS. Having a permanent station ID for Barrow will facilitate transmittal of Barrow soundings to the GTS. Brian Ermold repaired the SGP GTS transmittal so that data messages are no longer incomplete.

2.4 Broadband Radiometers (SIRS, SKYRAD, GNDRAD, BRS)

Mentor: Tom Stoffel, National Renewable Energy Laboratory

Nothing to report.

2.4.1 Pyrgeometer Calibration Improvements

Tom Stoffel and Ibrahim Reda have initiated an investigation into the source of the bias in the ACRF pyrgeometer blackbody calibration system. Once the source of the bias is determined and corrected a careful validation of the system and a comparison of pyrgreometers calibrated with this and other systems will be conducted (ECO-00559).

At blackbody temperatures less than -20°C, the Dow Corning 200 fluid viscosity increases, which inhibits mixing and results in a temperature gradient of 1.5 to 2.0°C from the base to the top of the hemispherical blackbody. A new set of fluid dispersion manifolds (perforated annuli) has been developed to reduce the temperature gradients in the blackbody. Additionally, a replacement fluid with better low-temperature (viscosity) characteristics has been identified. Two five-gallon containers of this fluid will be acquired for evaluation at NREL. Pyrgeometers calibrated using the new manifold and fluid will be compared with pyrgeometers having calibrations traceable to the World Infrared Standard Group (WISG) and with pyrgeometers calibrated by NOAA/GMD.

Publication:

Reda, I, J Hickey, T Stoffel, J Grobner, and A Andreas. 2006. “Calibrating pyrgeometers outdoors without the need to know the reference value of the atmospheric long wave irradiance.” *Journal of Atmospheric and Solar-Terrestrial Physics* Vol. 68(12), pp. 1416-1424; NREL Report No. JA-560-39391.

2.4.2 Radiometer Calibration Facility Data Acquisition System Replacement (deferred to FY 2007)

The data acquisition system in the Radiometer Calibration Facility (RCF) used for annual Broadband Outdoor Radiometer Calibration (BORCAL) activities is over ten years old and needs to be updated. NREL has recently replaced their BORCAL data acquisition system using internal funds. The SGP system should be a duplicate of the NREL system for software compatibility and performance assurance.

2.5 Carbon Dioxide Flux System

Mentor: Marc Fischer, Lawrence Berkeley National Laboratory

The Carbon Dioxide Flux System instruments at 4, 25, and 60 m on the SGP-CF tower are operating nominally. In September, the heat flux plate that was damaged by rodents was replaced.

2.6 Carbon Monoxide System (CO)

Mentor: Sébastien Biraud, Lawrence Berkeley National Laboratory

The CO system was operating nominally.

Sebastien Biraud will be on site in October to add a NAFION drier to the system to improve water trapping.

2.7 CO_2 (Precision Gas) System (PGS)

Mentor: Margaret Torn and Sebastien Biraud, Lawrence Berkeley National Laboratory

The PGS is operating nominally. KNF pumps were sent to LBNL for scheduled maintenance. New set of pumps installed on September 7, 2006.

2.8 Cimel Sun Photometer

Mentor: None (external data provided by National Aeronautic and Space Administration Aerosol Robotic Network)

NSA (Barrow) – Removed in mid-October for annual recalibration. It will be re-installed in March after the sun rises again in Barrow.

SGP (CF) – Removed at the end of September for annual recalibration. It will be re-installed as soon as it returns. It will be collocated with the shortwave spectrometer optics on the Optical Trailer roof.

TWP (Nauru) – Experiencing power problems due to corroded solar panels. New solar panels have been shipped to Nauru.

AMF (Niamey) – Operating nominally.

The new CSPHOT has been calibrated by AEORNET and shipped to Nauru where it and will be swapped with the CSPHOT there. That instrument will then be returned, calibrated, and swapped with the CSPHOT at the AMF in Germany.

2.8.1 Internet Data Transfer

The transfer of CSPHOT data from the Cimel instrument to AERONET using geostationary operational environmental satellite or Meteosat will be replaced with an Internet data transfer to improve reliability of the transfer, to permit ACRF personnel to monitor the transfer, and to allow the raw data to be acquired, ingested, and archived for use by ARM Science Team members (ECO-00555).

September 2006 – Internet data transfer was successfully tested with the new CSPHOT before it was sent to AERONET for calibration. The other four ARM-owned CSPHOTs will require an upgrade to support Internet data transfer. AERONET personnel will install the upgrades when the instruments are returned for annual calibration.

2.9 Disdrometer

Mentor: Mary Jane Bartholomew, Brookhaven National Laboratory

The need for accurate measurements of rain drop size distribution at TWP-Darwin and SGP-CF was assigned a high priority by the Cloud Properties working group. NOAA Environmental Technology

Laboratory has had good experience with the Joss-Waldvogel impact disdrometers offered by Distromet (http://www.distromet.com/) (ECO-00488). The first disdrometer and its associated tipping bucket rain gauge were deployed at Darwin in December 2005, prior to the start of TWP-ICE. The second disdrometer and rain gauge were deployed at SGP in April. Collection and ingest are installed and operational; data are available from the ARM Archive. Dead time corrections are being prepared to account for multiple raindrops that occur too close in time to be distinguished from a single large drop.

TWP (Darwin) – The manufacturer has completed annual re-calibration of the disdrometer. The instrument is being returned to Darwin. The accompanying rain gauge will also be returned to service when the disdrometer is returned.

SGP – The instrument and its accompanying rain gauge are operating nominally.

2.10 Energy Balance Bowen Ratio Station

Mentor: David Cook, Argonne National Laboratory

All EBBR stations are operating nominally. Occasional problems with the automatic exchange mechanism and in-ground sensors are noted. Observed biases between the EBBR net radiometer and Solar Infrared Station radiometer suite are attributed largely to poor longwave sensitivity for low sky temperatures in the EBBR net radiometer.

Vaisala no longer supports the combined temperature and relative humidity probes in the EBBR (2 per system). Replacement probes are available from the EBBR manufacturer. The mentor has proposed that replacement of all 32 probes be phased in over 3 years. As the old probes are replaced they can be used as spares for the systems not yet upgraded to the new probes.

2.11 Eddy Correlation Station

Mentor: David Cook, Argonne National Laboratory

SGP – All 10 ECOR stations are operating nominally.

AMF – The CO_2 concentration and flux data from the AMF ECOR are periodically affected by aircraft operations at the adjacent Niamey airport.

2.11.1 Add Wetness Sensors

Periods of dew, frost, and precipitation often cause data from the CO_2/H_2O sensor and sonic anemometer to be incorrect. Adding a wetness indication would provide the data user with a more reliable source of information concerning this condition (ECO-00536).

September 2006 – Wetness sensors have been received. One has been sent to the mentor for incorporation into a test ECOR system.

2.12 G-Band (183.3 GHz) Water Vapor Radiometer

Mentor: Maria Cadeddu, Argonne National Laboratory

In May the G-Band Water Vapor Radiometer (GVR) was returned to ProSensing for upgrades based on the evaluation of its first year of deployment. The GVR has been returned to Barrow and will be installed in August. Raw data are being collected. Development of an ingest module is underway to permit GVR data to be available from the ARM Archive (ECO-00591).

Publication:

Cadeddu, MP, JC Liljegren, and A Pazmany. "Measurements and retrievals from a new 183 GHz water vapor radiometer in the Arctic." Accepted for publication in *IEEE Transactions of the Geoscience Remote Sensing*.

2.13 Global Positioning System (SuomiNet)

Mentor: None (external data provided by SuomiNet/COSMIC)

SGP – Telecommunications problems at LeRoy (E3), El Reno (E19), and Cordell (E22) continue to affect data availability from these SuomiNet stations. All other SuomiNet GPS stations and their associated meteorological sensors are operating nominally.

TWP – The temperature/relative humidity sensor associated with the Manus Island SuomiNet system was replaced on 16 October. The system is now operating nominally.

NSA (Barrow) – (System belongs to the University of Alaska at Fairbanks (UAF) and is installed at NOAA/CMDL site.) The temperature/relative humidity probe associated with the Barrow system failed in August 2005. In June, following discussions with UAF personnel, NSA personnel replaced the failed GPS met system with a spare from the SGP and returned the failed system to UAF for repair.

NSA (Atqasuk) – In June University Navstar Consortium (UNAVCO) personnel installed a GPS receiver at Atqasuk for geodetic purposes. The spare ARM GPS meteorological system currently in use at Barrow will be connected to this receiver once the UAF met system is repaired and returned to Barrow, then the Atqasuk station will be incorporated into SuomiNet to provide precipitable water vapor data.

2.14 In-situ Aerosol Profiling

Mentor: John Ogren and Betsy Andrews, National Oceanic and Atmospheric Administration/Earth System Research Laboratory/Global Monitoring Division

The new Cessna 206 that replaced the old Cessna 172 began flights over the SGP in September 2005 using the aerosol equipment package from the 172. In February FAA approval was obtained for the new equipment racks and IAP flights resumed over SGP with the new equipment on March 2, 2006. The three main improvements to the equipment are (1) the inlet does not have a 1-um impactor upstream of the instruments for better comparison with remote sensing instruments at the surface and in orbit; (2) a

3-wavelength PSAP which, together with the total sky imager (TSI) nephelometer (~450, 550 and 700 nm), will allow for calculation of spectral single scattering albedo; (3) three Radiance Research nephelometers measuring scattering at three relative humidities (<40%, 64%, 85%) downstream of a 1 um impactor for better characterization of the hygroscopic growth of the particles.

The high (85%) relative humidity nephelometer continued to have problems after being replaced in September. Diagnostic efforts are continuing. The ozone instrument pump was replaced and the instrument now appears to be operating correctly.

2.15 InfraRed Thermometer

Mentor: Vic Morris, Pacific Northwest National Laboratory

InfraRed Thermometers (IRTs) have been deployed at 12 SGP extended facilities (ECO-345), operating at 5 Hz sampling rate. IRTs are also part of the SKYRAD and GNDRAD systems at TWP, NSA, and AMF. These are currently sampled at 0.5 Hz. Plans to increase the sampling rate of the SKYRAD IRTs to 5 Hz are in progress (ECO-00368).

The IRTs are operating nominally at all sites. For sky temperatures less than -60°C the IRTs at SGP report higher sky temperatures than the AERI over the 10-µm passband of the IRT. This problem is believed to be associated with the instrument enclosures because the problem does not occur when the IRT is removed from an enclosure.

2.16 Multi-Filter Rotating Shadowband Radiometer and Related Systems (MFR, GNDMFR, NIMFR)

Mentor: Gary Hodges, National Oceanic and Atmospheric Administration/Earth System Research Laboratory/Global Monitoring Division; John Schmelzer, Pacific Northwest National Laboratory

SGP – 8 of 22 Extended Facilities do not have operational MFRSRs due to a shortage of spare sensor heads. In May the normal incidence multi-filter radiometer (NIMFR) was returned to service after repair. Recurring shading problems are being investigated. Possible contributors include settling of the instrument stands, problems with the shadow bandsor band positioning motors, and incorrect alignment.

NSA – MFRSR operating nominally. At Atqasuk the 940 nm channel of the NIMFR has failed.

TWP – Operating nominally.

AMF – Operating nominally.

Twice-per-day cleaning of the Normal Incidence Multi-Filter Radiometer (NIMFR) at SGP has been initiated to eliminate the step-change in the measurements observed following the current once-per-day cleaning events.

Gary Hodges traveled to several SGP extended facilities in October to investigate recurring shading problems with the MFRSRs.

2.16.1 Filter-Detectors

ACRF has ~50 multi-filter radiometers deployed in a variety of configurations including the MFRSR, the downward-facing MFR, and the NIMFR. The 6 narrow band (10 nm) filter-detectors in almost all of these sensors have degraded over time and are in urgent need of replacement. Perkin-Elmer is producing custom-designed and custom-built filter-detector assemblies to meet ACRF specifications.

STATUS – Most, but not all, of the filter-detectors have been delivered. John Schmelzer has begun using these to repair failed sensor heads.

2.16.2 Multi-Filter Rotating Shadowband Radiometer Calibration and Data Processing Improvements

Problems with the calibration and data processing of the MFRSRs were revealed during the ALIVE campaign (ECO-00571). Joe Michalsky convened a meeting at Pacific Northwest National Laboratory during the last week of January to discuss the calibration issues and develop a plan to address them. Participants included Gary Hodges, Patrick Disterhoft, Mikhail Alexandrov, John Schmelzer, Jim Barnard, Annette Koontz, Peter Armstrong, and Jim Liljegren. The details of the meeting and plan are given in ECO-00571. Nighttime measurements will be collected from the existing MFRSRs to derive an offset correction. New calibration processing will be implemented based on the consensus procedures developed during the meeting. Old data will be reprocessed to apply the offset corrections and the new calibration and processing procedures. Collection and ingest development are proceeding but have been delayed by the need to accommodate both the current proprietary data loggers and the new Campbell Scientific data loggers.

STATUS – In October nighttime measurements were implemented on all MFRSRs at the SGP.

2.16.3 Data Logger Replacement

The proprietary data loggers supplied with the MFRSRs and related instruments are to be replaced with Campbell Scientific CR1000 data loggers. This will permit them to be more easily maintained. It will also permit modifications to the operation of the instruments and data acquisition to be easily implemented (ECO-00350).

August 2006 – The data logger program and output file format are being finalized. Nighttime measurements must be acquired with the current data loggers prior to replacing them with the new Campbell loggers to allow corrections to be developed for and applied to earlier data.

STATUS – SGP technicians Dan Nelson and Mark Klassen traveled to PNNL to meet with John Schmelzer to prepare for the deployment of the replacement data loggers, and to discuss on-site calibration of the MFRSRs.

2.17 Millimeter Cloud Radar

Mentor: Kevin Widener, Pacific Northwest National Laboratory; Karen Johnson, Brookhaven National Laboratory

SGP/C1 – nominal operation.

NSA/C1 – In July Jay Mace reported that the MMCR is not in good agreement with Cloudsat: there appears to be ~20 dBz discrepancy. Review of data back to July 2005 suggests there may have been a gradual degradation rather than an obvious change. In addition, the transmit power is not being reported. In September Kevin Widener traveled to Barrow to investigate this problem. Kevin determined that the coherent up/down converter (CUDC) was defective. Kevin will return to Barrow in October to install a spare CUDC. Kevin also determined that the TWT needed to be replaced due to low output power. Two additional TWTs will be ordered.

TWP/C1 (Manus) – While at Manus to install the new processor, Kevin Widener observed the sensitivity shift phenomenon that has been affecting this system. BoM technicians will replace RF switching circulators during their next site visit in October. The TWT for this system is currently down to about 50% power output and will need to be replaced in the next 6-9 months.

TWP/C2 (Nauru) – In August the Traveling Wave Tube (TWT) failed. A new TWT was purchased in June and was sent from SGP to Applied Systems Engineering (ASE) in Texas to install it in a complete assembly or TWTA that includes the TWT, modulator and power supply. This TWTA has been shipped to Nauru for installation during the November visit by BoM technicians. A second TWTA was sent from Darwin to SGP for ASE to repair. This will become the SGP spare after it is repaired. The failed Nauru TWTA will become the TWP spare after it is repaired.

TWP/C3 (Darwin) – In July the RF attenuator was recalibrated; the calibration was off by several dB. A low noise amplifier failed in August 2005 due a lightning strike, but was not discovered until Kevin and Ken Moran compared the calibration with the upgraded Manus MMCR. The amplifier was replaced on July 18. The available data are good but there was a loss of ~15 dB of sensitivity.

Kevin initiated a discussion of ways to detect these types of problems in a timelier manner. Karen Johnson indicated that efforts to catch up processing the Active Remotely-Sensed Cloud Locations (ARSCL) value-added products are being made, which would help compare the performance of the MMCRs against other sensors.

2.17.1 Processor Upgrades

(ECO-00283) In June, Kevin Widener and Rex Pearson installed the new processor at Manus. In August, Kevin and Rex installed the new processor at Nauru. This completes the PIRAQ processor upgrades for the TWP.

STATUS – Spectral imaging problems with the PIRAQ-III processor have been resolved at Darwin by installing newly developed filter coefficients. The spare PIRAQ-III processor will be installed in the MMCR at NSA (Barrow) and another spare purchased. The C40 processor from the Barrow MMCR will become a spare for the MMCR at SGP.

2.17.2 Add Polarization at Barrow

Acquisition and installation of an orthomode transducer is necessary to add polarization to the MMCR at Barrow. Modifications to the PIRAQ-III processor will be necessary to support the polarization capability. Polarization will be added during the summer of 2006 using the C40 processor. The modifications to the PIRAQ processor will be completed prior to the upgrade of the SGP system, and then installed at Barrow later in 2006 (ECO-00552).

September 2006 – The orthomode transducer has been received. Because the PIRAQ processor does not support polarization, the installation of the orthomode transducer at Barrow is on hold until the next processor upgrade.

2.17.3 Spare Traveling Wave Tubes

New traveling wave tubes (TWT) will be ordered to replace the TWTs originally delivered with the MMCRs, which are well beyond their rated lifetime and are beginning to fail (ECO-00425).

STATUS – The first TWT has been delivered to SGP, incorporated into a TWTA, and sent to Nauru to repair the MMCR there. Two more TWTs have been received, which will go to Manus and Barrow. Two additional TWTs will be ordered as spares.

2.17.4 Millimeter Wave Cloud Radar Spectra Processing

Spectra files produced by the upgraded MMCRs (C40 or PIRAQ-III processors) range from 8 to 15 Gigabytes per day. Algorithms for eliminating clear-sky periods and compressing the files need to be developed and implemented locally (ECO-00391).

September 2006 – The algorithms have been developed and tested. Implementation is underway. Karen Johnson is developing a test plan to validate each installation before data are irretrievably discarded. Hardware has been received at SGP for the first installation.

2.17.5 Refurbish Millimeter Wave Cloud Radar Antennas

Beginning in 2007, over a three-year period the MMCR antennas will be refurbished and characterized on an antenna range (ECO-00551).

August 2006 – A new 2-m antenna has been ordered. This antenna will be swapped for each antenna that is removed from service to be refurbished so that the radar is not out of service for an extended period.

2.17.6 Radome or Radome Dryer

The detrimental effect on the data of standing water on the current fabric radome has prompted the pursuit of a more satisfactory solution. Unfortunately discussions with potential suppliers have not been fruitful. This taskis currently on hold (EC-00275).

2.18 Micro-Pulse Lidar

Mentor: Rich Coulter, Argonne National Laboratory

All MPL systems are working well with the exception of the system at Nauru and Niamey. The Nauru MPL is exhibiting a low signal-to-noise ratio. The system is currently double pulsing: a condition where the laser produces two pulses per trigger instead of one, which can be identified by an artifact in the backscatter data at 0.25 km. The AMF MPL has a dying laser diode, which results in poor data quality. This system will be replaced as soon as the remaining new MPLs successfully complete acceptance testing.

2.18.1 Retrofit Spectra-Physics Lasers

The type-1 and type-2 units use Spectra-Physics lasers that are no longer supported (except for the AMF unit, which uses a LiteCycles laser that is no longer supported). ARM has one spare Spectra-Physics laser head. Four old Spectra-Physics laser supplies have been retrofitted by Sigma Space to use Coherent F-System laser diode modules and two remain to be retrofitted (ECO-00362).

July 2006 – The remaining two laser diode supplies are currently in the field (at NSA and SGP). Once the new type-4b-YAG MPLs are deployed to NSA and SGP, these systems will be removed and upgraded. The Coherent F-System laser diode module is an interim measure until the new MPLs are deployed. Double pulsing of the lasers retrofitted with Coherent supplies has been occasionally observed in several MPL systems in the field. This produces an artifact at 0.25 km.

STATUS – The type-1 MPLs at SGP and NSA have been removed from service and their laser diode supplies sent to Sigma Space Corp. for upgrade.

2.19 MicroWave Radiometer

Mentor: Maria Cadeddu, Argonne National Laboratory

AMF (Niamey) – Fewer RFI spikes were observed in the MWR data this month. The sun was observed in the field of view around solar moon.

NSA/C2 (Atqasuk) – The instrument was returned to the manufacturer to diagnose/repair a thermal instalbility problem. The manufacturer discovered mechanical damage due to being dropped. The instrument will be sent to SGP for comparison with other MWRs to determine whether significant damage was sustained. The thermal stabilization has been repaired and the instrument has been included in the MWR Comparison IOP at the SGP central facility.

SGP/B5 (Morris) – Instrument was returned to the manufacturer to diagnose/repair thermal instability problem. This instrument has been repaired and has been included in the MWR Comparison IOP at the SGP central facility.

SGP/B6 (Purcell) – This instrument failed to restart after relocation to the SGP central facility for the MWR Inter-comparison IOP. Replacing both analog and digital electronics circuit boards restored operation.

TWP/C1 (Manus) – The instrument has developed an apparent communication problem. A spare digital circuit board has been sent to Manus to correct the problem if possible.

TWP/C2 (Nauru) – The MWR has been powered down due to corrosion in the dew blower that causes the fuse to blow. BoM technicians will install a replacement blower during their next visit in late November.

2.19.1 Unify MicroWave Radiometer Connectors

The Impulse connectors on the 3 MWRs at the TWP sites make it difficult to substitute a spare MWR in case of a failure, as occurred in Darwin prior to TWP-ICE due to a lightning strike. Accordingly, the Impulse connectors are being replaced with the standard connectors used on all other MWRs. The damaged MWR has been repaired, its connectors replaced, and shipped to Naru. It wil be swapped with the NWR there in November, which will then be sent to the manufacturer for connector replacement. After the connectors are replaced the MWR will then be swapped with the unit at Manus. SGP technicians have built new cables with the standard connectors to replace the cables with the Impulse connectors at TWP sites. These have been shipped to the TWP.

2.20 MicroWave Radiometer Profiller

Mentor: Maria Cadeddu, Argonne National Laboratory

NSA (Barrow) – In September NSA Site Operations technicians successfully completed a liquid nitrogen calibration of the MWRP.

AMF (Niamey) – RFI at Niamey causes frequent spikes in the MWRP data. A shift in the calibration of some channels occurred following an unplanned power outage in June. Still awaiting recalibration with liquid nitrogen.

2.21 Narrow Field of View Radiometer (NFOV)

Mentor: None

The Narrow Field of View (NFOV) radiometer has been removed from service at SGP and sent to NASA GSFC for calibration using the AERONET facilities. It will be deployed with the AMF in Germany.

2.22 Raman Lidar

Mentor: Diana Petty, Pacific Northwest National Laboratory

The Raman lidar is operating nominally with an uptime of over 98% in September. Work on the MERGE algorithm that combines the analog detection and photon counting data continues, as a10% bias in the water vapor mixing ratio persists. To assist with this work, a photomultiplier, base, and housing have been sent to Licel Electronics in Germany for testing with their equipment.

Temperature profile retrievals are adversely affected by high solar background noise during the daytime. This is believed to be due to out-of-band leakage into the rotational Raman channel. Adding a wider band filter to block the leakage is being considered.

2.22.1 Add Automatic Alignment System

Due to small thermal gradients in the laser and the lidar enclosure, the alignment of laser beam in the detectors' field-of-view (FOV) changes with time, which can affect the data quality, sometimes substantially. To address this operationally, the laser beam is swept through the detectors' FOV using a pico-motor controlled steering mirror to find the optimal location. This "alignment tweak" is scheduled to occur every 3 hours. Accounting for the potentially 3-hourly changes in alignments is the single largest uncertainty in the data processing codes. It affects all measurements, but the aerosol extinction measurements and the temperature profiles seem to be the most sensitive. Licel has recently developed a new product that permits the alignment of the lidar to be actively maintained (ECO-00586). The Licel alignment sensor was delivered in September. Installation is planned for October or November 2006.

2.23 Rotating Shadowband Spectrometer

Mentor: Peter Kiedron, State University of New York at Albany

The Rotating Shadowband Spectrometer (RSS) is operating nominally. Field calibrations are nominal. Automatic processing of calibration data is under development by Peter Kiedron and Jim Schlemmer.

At the Radiative Processes Working Group meeting last month, Tom Stoffel mentioned that the new RSS NREL has received exhibits the same calibration instability as the ARM RSS.

2.24 Radar Wind Profiler – 915 MHz

Mentor: Rich Coulter, Argonne National Laboratory

SGP – Currently, all systems at SGP are operating nominally, though the RASS data at Medicine Lodge are "reflected" at large range gates. The SGP/C1 (central facility) and SGP/I3 (Meeker) have had the digital receiver upgrades successfully installed.

NSA – System crashes frequently. Maybe the upgraded hardware, LAPXM software, and new computer will (eventually) help resolve this problem.

2.24.1 Upgrade to Digital Receivers

The four 915 MHz RWPs at the SGP are now 9-13 years old and are exhibiting increasingly frequent, strange, and expensive-to-repair failures. This may pose problems for CLASIC, scheduled in 2007. Due to the age of these systems, parts are increasingly difficult to obtain (Vaisala no longer has exact replacements for some items; the available parts must be modified for use in our systems). Vaisala offers an upgrade for these systems that will replace the present interface, receiver and computer (including DSP board) with new components and will include the latest version of LAPXM, the operating system. The systems at SGP/CF and SGP/I3 will be upgraded first, prior to CLASIC. The systems at SGP/I2 and SGP/I3 will be upgraded in 2007. The RWP at NSA will also be upgraded to be consistent with the SGP systems (ECO-00567).

September 2006 – Rich Coulter and Tim Martin traveled to SGP in late September to install the digital receiver upgrades in the RWP systems at SGP/C1 and SGP/I3. A significant improvement in this version of LAPXM (also included with the new 1290 MHz RWP) is that we will be able to create hourly spectral data files. When implemented, this will alleviate the data collection problem associated with the large, growing daily data file that the collection procedure must presently handle and which creates occasional gaps in the spectral data files.

2.25 Radar Wind Profiler – 50 MHz

Mentor: Rich Coulter, Argonne National Laboratory

In January the 50 MHz RWP at the SGP ceased transmitting. The transmitter was returned to ATRAD in Australia for diagnosis and repair. After reinstalling the transmitter the output power was still zero. The power tube was replaced but the output power is still zero. Vaisala has loaned SGP test equipment to help diagnose the problem. The system is currently out of service.

2.26 Soil Water and Temperature System

Mentor: John Harris, University of Oklahoma

2.26.1 Replace In-Ground Sensor Arrays

The in-ground sensors for the SWATS deployed at all 22 SGP Extended Facilities (EFs) are arranged in two redundant vertical arrays so that if/when a sensor fails, there is a redundant sensor at the same level. This is necessary because disturbing the soil to replace a failed sensor adversely affects the measurements for 6-12 months afterward depending on soil type. At this time 8 of the 22 SWATS installations have at least one failed sensor, and 5 sites have 2 or more failed sensors. These sensors cannot be replaced without disturbing the soil and invalidating the measurements at all levels. To address this problem, new redundant sensor arrays will be installed at the SGP EF sites. These will be installed in a phased manner: 5 sites per year over the next 4 years beginning in 2005 with the sites having multiple failed sensors given highest priority. After the soil recovers from the installation process in 6-12 months, the new sensor array will be connected to the existing SWATS data acquisition system in place of the old sensor array (ECO-00493).

September 2006 – Don Bond installed replacement sensor arrays at the first two sites in late March. In May, John Harris and Don Bond installed new sensor arrays at three Extended Facilities to replace old sensors that have ceased to function. These sensors were installed at Lamont (EF-13/CF-1) down to a depth of 60 cm, at El Reno (EF-19) down to a depth of 175 cm, and at Meeker (EF-20) down to a depth of 85 cm. New sensors for the next five sites to be replaced in the fall have been ordered.

2.27 Shortwave Spectrometer (SWS)

Mentor: John Pommier, NASA Ames Laboratory

The SWS will be returned to NASA-Ames Research Center to recalibrate the instrument with the Airborne Science Facility's 30-inch integrating sphere, to test different integration times to eliminate a low signal to noise ratio and to do a stray light test.

2.28 Surface Meteorological Instrumentation (SMET, SMOS, SURTHREF, THWAPS, MET, ORG, PWS)

Mentor: Mike Ritsche, Argonne National Laboratory

SGP (Surface Meteorological Observing Station [SMOS]) – All systems operating nominally. New Vaisala temperature/relative humidity probes received (15) to replace old probes no longer supported by Vaisala (EWO-11056). TWP (SMET, ORG) – Lower wind sensor at Manus replaced. ORG at Darwin was repaired and is now operating correctly. BoM tipping bucket rain gauges at Manus and Darwin have been connected to the SMET systems. The Nauru gauge will be connected during the next technician visit in November. NSA (METTWR) – Annual calibrations have been performed at the Barrow site. All T/RH probes were replaced. Wind direction sensors were replaced on the 20-m and 40-m levels due to excessive icing noticed during previous winter. The wind speed sensor was replaced on the 10 m level due to icing on the cups. All other wind sensors were checked for proper operation. A barometer calibration check was performed at the Atqasuk site.

AMF (MET, ORG) – In May the ORG was not reporting rainfall and was replaced. The ORG appears to be underreporting relative to the PWS and non-ACRF tipping bucket rain gauge.

2.28.1 Develop Dynamic Rain Gauge Calibration Facility

The tipping bucket rain gauges at the 15 SGP/EF sites with SMOS are currently calibrated using only a "static" calibration: a measured volume of water is poured into the gauge and the number of bucket tips is checked to ensure they correspond. In reality, as the rain rate increases and the bucket tips more frequently some rain is not collected. The purpose of the dynamic calibration is to determine the correction factor as a function of rain rate to account for this behavior (ECO-00495).

STATUS – Problems have developed with the software developed by the University of Iowa that have prevented successful calibrations from being obtained. An alternative approach is being developed.

2.28.2 Create Atmospheric Radiation Measurement Program Climate Research Facility Wind Sensor Repair Facility

Rather than return ACRF wind sensors to the manufacturer for repair, it is cost effective and far quicker to perform the repairs and calibrations on-site. Repair facilities will be established at the SGP central facility and the TWP Darwin site (ECO-00561).

STATUS – All necessary components have been received at SGP; spare parts are in route to TWP. Testing and repair procedures have been prepared and distributed to the SGP and TWP Site Operations Teams. SMOS and THWAPS wind sensor checks will begin soon.

2.28.3 Upgrade T/RH Probes and Wind Sensors for NSA Met Systems

Ice develops on the wind vanes, cup anemoneters, and aspirator inlets for the temperature and relative humidity sensors, which clog and affect the data quality. To alleviate these problems the mentor has proposed to replace the wind speed and direction sensors at NSA (both Barrow and Atqasuk) with sonic anemometers, and to replace the temperature and relative humidity probes with new, heated probes designed to operate in cold environments (ECO-00595).

STATUS – Awaiting prioritization and 2007 funding.

2.29 Tandem Differential Mobility Analyzer

Mentor: Don Collins, Texas A&M University

Data from the Tandem Differential Mobility Analyzer (TDMA) are currently acquired and processed by Don Collins. Processed data are then delivered to ACRF on a monthly basis and stored in the IOP area of the Archive as "beta-data." An ingest is being developed to produce netcdf files for inclusion in the main Archive (ECO-587).

2.30 Total Sky Imager

Mentor: Vic Morris, Pacific Northwest National Laboratory

SGP – Operating nominally. Birds occasionally perch on system, affecting the imagery. Deterrents have been installed.

TWP – In early July rust spots suddenly developed on one-half of the mirror at Manus. Communication with the mirror control board failed in late August. The mirror was replaced in mid-October; several unsuccessful attempts were made to re-establish control of the shadowband. The instrument will be sent to Darwin for repair.

NSA – Operating nominally. On October 30 the TSI will automatically stop collecting data because the sun will not rise more than 5° above the horizon. The instrument will be stored until mid-February.

AMF – Operating nominally.

2.31 Meteorological Tower Systems

Mentor: David Cook, Argonne National Laboratory

60-m tower at SGP C1 (central facility) – nominal operation.
21-m tower at SGP E21 (Okmulgee) – nominal operation.
40-m tower at NSA C1 (Barrow) – problems due to ice formation on temperature/humidity sensors and on the wind direction vanes continue. Replacement of these sensors with sonic anemometers and heated temperature/humidity probes has been proposedis being considered (ECO-00595).

2.32 Vaisala Ceilmeter

Mentor: Vic Morris, Pacific Northwest National Laboratory

Operating nominally at all sites. Electronic ringing in the backscatter plot is visible at SGP-B5 (Morris, OK), but this does not affect the instrument's ability to detect clouds.

2.33 W-band (95 GHz) Atmospheric Radiation Measurement Program Cloud Radar

Mentor: Kevin Widener, Pacific Northwest National Laboratory

In March the AMF W-band ARM Cloud Radar (WACR) was successfully deployed at Niamey. In April the SGP WACR was returned to service. In May the pulse repetition frequency at Niamey was changed from 10 kHz to 8333 Hz to increase the maximum unambiguous range from 15 km to 18 km. This also decreases the maximum unambiguous Doppler velocity from 8 m/s to 6.6 m/s.

2.33.1 Spare Extended Interaction Klyston Amplifier

A spare Extended Interaction Klyston Amplifier (power tube) and modulator will be purchased to support the two WACRs deployed at SGP and AMF.

July 2006 – Ordered.

2.33.2 Controller Modification

To permit using a corner reflector for calibration, the WACR at SGP will be returned to ProSensing in September for controller firmware modification and RF switch characterization (ECO-00585). A new, larger corner reflector will also be needed.

STATUS – The SGP WACR has been re-installed. Awaiting delivery of the new 6-inch corner reflector for calibration.

3 Future Instrumentation Planning

In this section instrumentation that have been proposed for future acquisition and discussed by the Science Team Working Groups – but not yet approved for purchase – are presented along with any status information.

3.1 Atmospheric Radiation Measurement Program Volume-Imaging Array

The ARM Volume-Imaging Array (AVA) is a proposed radar system to be deployed at the ARM SGP site to address the ARM program's need of mapping 3D cloud and precipitation structures at short to medium ranges (i.e., 20-75 km). The AVA system will provide time-resolved 3D precipitation fields, domain-averaged rainfall rate, cloud coverage throughout a volume, cloud-top heights, hydrometeor phase information (using polarization), horizontal and vertical variability of clouds and precipitation, and low-level convergence and divergence using dual-Doppler techniques. Principal elements of the AVA proposal prepared by Pavlos Kolias include:

- Three networked scanning radars arranged in a triangle with 20-30 km legs: one operating at 35 GHz (same 8.6-mm wavelength as the MMCR) and capable of scanning the vertical region probed by the current MMCR, and two radars operating at 9.4 GHz (3.2-cm wavelength, so-called "X-band"). All three radars will be transportable, scanning, polarimetric and Doppler.

- Development of a useful 3D cloud Value Added Product (VAP) similar to the existing ARSCL but on a regular 3D grid.

- Development of an "AVA Simulator." Patterned after the well-known ISCCP Simulator, the AVA Simulator will perform forward simulations of radar observables, using as input LES model and cloud-resolving model outputs of cloud properties together with the characteristics of the AVA radars. The results will be used to develop and optimize volumetric radar scanning strategies, develop and evaluate inverse retrieval techniques, and develop prototype 3D ARSCL-like VAPs for the ARM community.

- A collaborative effort with the Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS) to deploy the CIRPAS 9.4-GHz phased-array radar at the ARM SGP site every year for 1-2 months of continuous observations.

STATUS – Cost estimates have been prepared for site preparation, installation, and operation support. This proposal will be extensively discussed during the upcoming Science Work Group meetings.

3.2 Portable Raman Lidar

Leosphere http://www.lidar.fr/ offers a portable MPL-type lidar that can be augmented with Raman capability. Raymetrics http://www.raymetrics.gr/(sold by Kipp & Zonen) also offers a Raman Lidar. Both concerns have been invited to deploy their systems at SGP for comparison with the SGP Raman Lidar and MPL. Leosphere is planning to deploy a lidar at the SGP in late October.

STATUS – Iwona Stachlewska of Leosphere deployed their non-Raman EZ Lidar at the SGP on 19 October for comparison with the ARM MPL system. Leosphere expects to have a commercial Raman system available in mid-to-late 2007. Raymetrics will not be able to furnish a demonstration Raman lidar system.

3.3 Absolute Scanning Radiometer

To provide an absolute IR flux reference, which could be used to calibrate the Eppley PIRs, Ells Dutton has suggested that ARM develop an Absolute Scanning Radiometer (ASR). This instrument would be functionally equivalent to an ASR developed by Rolf Philipona for the WMO. This instrument would not be used for routine data acquisition, but instead would provide a calibration reference. As such it would participate in WMO inter-comparisons at Davos, Switzerland every five years. Although an Small Business Innovation Research (SBIR) solicitation for an ASR was issued circa 2000, no successful proposals were received. Ells Dutton, Tom Stoffel, and Joe Michalsky are planning to develop a specification so that ACRF may send out a request for proposals to identify interest and cost for such an instrument.

STATUS – A description of the desired capabilities has been prepared for publication in Fed Biz Ops.

3.4 High-Resolution Oxygen A-Band and Water-Band Spectrometer

Qilong Min has submitted a proposal to build an A-band spectrometer for ARM following his presentation to the Cloud Properties working group in October 2004 on this topic. The 3-year proposal and budget were sent out for technical reviews. The technical reviews, along with the proposal and budget, were then provided to the STEC. The STEC directed Qilong to present his plan and budget to the Cloud Properties working group at their November 2005 meeting for prioritization. Qilong presented a revised work plan (water-band/cloud phase components removed) and has submitted a revised budget.

3.5 Rotating Shadowband Spectrometer Overhaul

Peter Kiedron has demonstrated that the RSS built by Yankee Environmental System is capable of providing valuable measurements of direct, diffuse, and global spectral irradiance. Peter has also identified problems with the RSS that affect the stability of its calibration and the linearity of its response. Peter has recommended that the RSS be removed from service and sent to him at SUNY-Albany for a complete overhaul.

3.6 Narrow Field of View Radiometer for Atmospheric Radiation Measurement Program Mobile Facility

The 2-channel Narrow Field of View (NFOV) that was deployed with the AMF at Pt. Reyes has been redeployed at SGP. A second 2-ch NFOV has been suggested for the AMF, although not for the Niger deployment.

Science Team members (Alexander Marshak and others) have decided that this is no longer necessary. Due to the deployment of the new SWS at SGP, the 2-channel NFOV at SGP can be deployed with the AMF in 2007.

3.7 Add 1.6 μm Channel to Multi-Filter Rotating Shadowband Radiometer and Narrow Field of View

Alexander Marshak has recommended that ARM support the development of a NFOV radiometer at 1.6 µm to permit the retrieval of droplet size distribution. Andy Lacis and colleagues have suggested a 1.6 µm channel be substituted for the unfiltered (broadband) channel in the MFRSR. A cursory examination of Perkin-Elmer's web pages reveals Indium-Galium-Arsinide (InGaAs) detectors are available that operate in this spectral region. This would require a development effort.

July 2006 – Two InGaAs detectors and two 1.6 µm filters have been purchased to determine the feasibility of implementing them in the MFRSR and/or NFOV. In the MFRSR this filter-detector would replace the unfiltered (broadband) channel. Because the unfiltered channel is now being used in a broadband radiometer best estimate VAP for quality checking purposes, only a limited number of MFRSRs would be modified to accept a 1.6 µm channel.

3.8 Aerosol Particle Sizing Spectrometer to Replace Optical Particle Counter at Southern Great Plains

John Ogren has suggested replacing the aging Optical Particle Counter (OPC) included in the SGP AOS with a new Aerosol Particle Sizing Spectrometer (APS) to be integrated into the existing TDMA.

3.9 Future Microwave Radiometers

The 2-channel MWRs range between 6-13 years old. They are no longer being manufactured; Radiometrics has replaced them with an instrument that sequentially tunes to 5 frequencies in the 22-30 GHz range. Although Radiometrics continues to support the MWRs, it is useful to begin considering replacements for these instruments. Although 5 K-band channels may provide more robust retrievals than 2 channels, RPG offers a comparably priced 3-channel radiometer (23.8, 31.4, 90.0 GHz) that could also be considered because it increases the sensitivity to thin liquid water clouds. It is also desirable to acquire a final, "production" version of the 183 GHz microwave radiometer developed by ProSensing under a U.S. Department of Energy (DOE) SBIR Phase II award and deployed at Barrow since April 2005.

3.10 Modified Muti-Filter Rotating Shadowband Radiometer for Liquid Water Path

Qilong Min has proposed to modify the existing MFRSRs to permit him to retrieve liquid water path. Software modifications would be required to position the shadow band at several additional angles near the solar disk; modifications to the shadow band would be needed to either narrow it or increase its distance from the diffuser. A narrower diffuser (and modification to the sensor head) and an improved stepper motor and motor controller have also been proposed. A first phase might utilize a Rotating Shadowband Radiometer loaned to Min from Brookhaven National Laboratory.

3.11 Infrared Thermometers for the Southern Great Plains Extended Facility Sites

Six IRTs were purchased in FY 2004, 9 additional IRTs were purchased in FY 2005. Some of these have been deployed with the AMF. Twelve SGP EF sites are currently equipped with IRTs; 10 additional IRTs would be needed to permit an IRT to be deployed at all 22 SGP extended facilities.

4 Small Business Innovation Research

The DOE SBIR web page is at http://www.er.doe.gov/sbir/

4.1 Oxygen A-Band Spectrometer (FY 2005)

Based on recommendations from the 2004 ARM Science Team meeting breakout session on photon path length measurements, a subtopic requesting the development of an A-band spectrometer was included under the Atmospheric Technology.

In May 2005 Dr. Fedor Dimov of Physical Optics Corporation was awarded a Phase I grant for A-band spectrometer development. The Phase II proposal by Kevin Yu and Fedor Dimov was not selected for funding.

4.2 Eye-Safe Ultraviolet Backscatter Lidar for Detection of Sub-visual Cirrus (FY 2006)

Based on recommendations from the 2004 Cloud Properties working group meeting, this subtopic was substituted for the A-band spectrometer subtopic. Connor Flynn is the technical contact. Phase I funding was awarded to Aculight Corporation: "Eye-Safe ultraviolet Backscatter Lidar for Detection of SubVisual Cirrus"
http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/039.htm

and to Physical Sciences, Inc.: "Field-Worthy ultraviolet Backscatter Lidar for Cirrus Studies."
http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/044.htm

4.3 Instrumentation for Remotely Sensing Aerosol Optical Properties – Aerosol Phase Function (FY 2006)

Based on recommendations from the Aerosol working group, this subtopic was added to the aerosol measurements subtopic. Phase I funding was awarded to Aerodyne Research, Inc.: "CAPS-Based Particle Single Scattering Albedo Monitor."
http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/040.htm

4.4 Unmanned Aerospace Vehicle-Suitable Cloud Radar (FY 2006)

Phase I funding was awarded to ProSensing, Inc: "High-Power, Pod-Mounted W-band Cloud Radar for Unmanned Aerospace Vehicles (UAV)."
http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/045.htm

4.5 Radiometer Radiosonde (FY 2006 National Science Foundation Solicitation)

The objective is to obtain a radiosonde with an onboard radiometer suitable for accounting for the radiative heating of the temperature sensor in the upper atmosphere. This is potentially interesting to

ARM as a means for directly measuring the heating rate profile. Global Aerospace was awarded Phase I funding:
http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0539943

July 2006 – Matt Heun of Global Aerospace inquired about ARM's requirements for heating rate profile measurements. The BBHRP focus group provided their requirements to Matt. Matt and his colleagues have determined that, within the context of their current NSF SBIR project, they cannot control the tilt of the radiometers sufficiently to achieve the accuracy requirements provided by ARM; however, this could become the subject of a future DOE SBIR subtopic. Global Aerospace representatives have been invited at attend the ARM Radiative Heating Profile Workshop being organized by Warren Wiscombe.

4.6 In-situ Measurement of Cloud Properties with Large Sample Volumes (FY 2007)

Warren Wiscombe contributed the following sub-topic and will be the technical contact.

The DOE ARM Program was formed to study the climatic effects of clouds. These effects, particularly how clouds respond to climate change (the so-called "cloud feedback" problem), are large yet poorly understood from both a measurement and modeling point of view (cf. Stephens 2005). Currently, there is a huge gap in spatial scale between in-situ measurements of cloud properties, typically from aircraft and balloons whose instruments have sample volumes on the order of cubic centimeters, and remote sensing retrievals of cloud properties, which have sample volumes ranging from tens of cubic meters (radar and lidar) to thousands of cubic meters (satellites). Most acute is the fact that in-situ measurements at a particular point give no information on the vertical distribution above and below that point, while active remote sensing retrievals typically give instantaneous vertically-resolved information. Since clouds are inhomogeneous down to centimeter scales, there is a complete lack of comparability between in-situ measurements and remote retrievals; simple assumptions of homogeneity to scale up the in-situ measurements are certainly false. Clouds also evolve considerably in the course of a minute, and thus methods, which are slow in time (such as a balloon ascending, or an aircraft ascending or descending) fail to capture the instantaneous state which remote sensing sees. Thus, there is a great need for in-situ measurements which have fast vertical reach and much larger sample volumes, ranging from cubic meters to hundreds of cubic meters, in order to allow meaningful comparisons with surface and satellite retrievals of cloud properties. Without confidence in those surface and satellite retrievals, which are our only way to extend our reach to the whole planet, it is impossible to make progression key global change issues concerning cloud feedbacks on global warming.

Therefore, grant applications are sought to develop instruments to measure cloud properties in-situ, for scales ranging from cubic meters to hundreds of cubic meters, with particular emphasis on fast vertical profiling above and below the in-situ platform. (The platform need not be a traditional aircraft or balloon; instruments for small UAVs, kites, gliders, and tethered balloons will also be considered.) An example of such an instrument can be seen in Evans et al. (2003). Measurements of the following cloud properties are particularly wanted, in order of decreasing priority for cloud-climate applications: (a) extinction coefficient at one or more wavelengths in the solar spectrum away from strong water vapor absorption bands; (b) total water content (liquid plus ice); (c) liquid and ice water content separately; (d) effective radius, defined as the ratio of the 3rd to the 2nd moment of the drop size distribution; (e) absorption coefficient or single-scattering albedo at one or more wavelengths in the solar spectrum away from strong water vapor absorption bands; (f) the scattering phase function for ice clouds; (g) the drizzle and precipitation fraction of the total condensed water content; (h) the supersaturation; (i) the dispersion, a measure of the width of the drop size distribution.

Stephens, G. 2005. “Cloud feedbacks in the climate system: A critical review.” *Journal of Climate* 18:237-273.

Evans, KF. 2003. “In situ cloud sensing with multiple scattering lidar: Simulations anddemonstration.” *Journal of Atmospheric and Oceanic Technology* 20:1505-1522.