

**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.](#)

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## 1 New Instrumentation

### 1.1 183 GHz Microwave Radiometer

Radiometrics Corporation has proposed to deploy at North Slope of Alaska (NSA)-Barrow a new 183 GHz microwave radiometer that they have developed under a U.S. Department of Energy (DOE) Small Business Innovation Research (SBIR) grant (ECO-00609).

**STATUS** – The radiometer has been shipped to Barrow to participate in the Radiative Heating in Under-explored Bands Campaign (RHUBC). The instrument appears to be working well.

### 1.2 High-Frequency (90/150 GHz) Microwave Radiometer

*Mentor: Maria Cadeddu, Argonne National Laboratory*

In response to 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, a new High-Frequency Microwave Radiometer (MWRHF) has been acquired, and is currently deployed at Southern Great Plains (SGP) (ECO-00491).

**STATUS** – A hardware failure has occurred in the 150 GHz channel. The instrument will be returned to the manufacturer for repair. A second instrument will be deployed with the ARM Mobile Facility (AMF) at Heselbach, Germany in late April 2007.

### 1.3 Infrared Sky Imager

*Mentor: Vic Morris, Pacific Northwest National Laboratory*

An infrared (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 2006 and returned to service in August 2006.

**STATUS** – In late January SGP technicians resolved hardware problems and restored the IRSI to operation. Software modifications by the manufacturer have corrected the image mask problem, which has permitted cloud fraction to be derived from the images. In February Vic Morris conducted a comparison of cloud fractions from the IRSI and the total sky imager (TSI). The comparisons indicate the IRSI is still not producing correct values. In March Vic plans to present the results of the comparison at the ARM Science Team Meeting.

**STATUS** – Vic is working with Heitronics to arrange an extended demonstration of their Nubiscan instrument as a potential alternative to the device from BSI.

## 1.4 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 – Installation of the MFR on the Cessna will occur in the next month or so. A contract is in place to do the MFR installation, which will include:

- purchase and installation of new larger wingtips,
- modification of the starboard wingtip to accommodate the MFR,
- installation of the MFR instrument.

## 1.5 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-Central Facility (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).

STATUS – A new digiCORA-III will be installed on Nauru in April. A new digiCORA-III will be installed on Manus in June, after the necessary antenna upgrade kit is acquired. The old digiCORA-II systems will not be used as spares; they will be returned to the SGP. TWP Operations believes the procedural differences between the two systems are too great and the need to switch the antenna is too complicated for routine use.

## 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*

AMF (Heselbach) – Awaiting a new DSP card. Denny Hackel will return to Germany to install the card and complete the blackbody testing.

NSA – This Windows XP-based AERI is operating nominally. RFI continues to be a problem at this site. Efforts to try to reduce the RFI noise in the NSA-C1 data via post-processing of the raw data are on going. A second ER-AERI (not upgraded) was installed at Barrow in January following replacement of the laser in the interferometer by Bomem. Unfortunately the interferometer was misaligned by Bomem during the laser replacement. SSEC personnel attempted to correct the misalignment. The extent to which the data are affected by the misalignment is being determined. The old OS/2-based computer did not survive the trip to Barrow and was returned to SSEC for repair, then resent to Barrow and installed. The instrument is now operating in support of RHUBC.

SGP – Both the OS/2-based AERI and the Windows XP-based AERI are operating nominally.

TWP (Darwin) – This AERI is out of service for repair, reintegration, realignment, and recalibration. It is expected to return to service in April, upgraded for Windows XP and rapid sampling.

TWP (Nauru) – This Windows XP-based AERI is operating nominally.

Spare –The OS/2-based spare AERI at Space Science and Engineering Center would need 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). Upgraded AERI systems are currently operational at SGP, NSA-Burrow, and Tropical Western Pacific (TWP)-Nauru.

STATUS – An upgraded electronics rack and Windows XP computer were shipped to Germany to replace the old OS/2 electronics rack used with the AMF AERI system. A new DSP card is needed to complete the upgrade. Denny Hackel will return to Germany to install the card and complete the blackbody testing. The electronics rack from Nauru was repaired, upgraded, and integrated with the Darwin interferometer subsystem. The system has been shipped to Darwin for installation in April.

## 2.2 Aerosol Observing System

*Mentor: John Ogren and Anne Jefferson, NOAA/ESRL/GMD*

The repaired CPC (Condensation Particle Counter) was returned to SGP on 23 February. The NOAA loaner will be returned to the mentor.

### 2.2.1 Reconfigure Southern Great Plains Aerosol Observing System

The aerosol observing system (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 13 May – 1 June 2007.

## 2.3 Balloon-Borne Sound System

*Mentor: Barry Lesht, Argonne National Laboratory*

Vaisala has introduced an improved temperature sensor for the RS92 radiosondes. According to Vaisala, the new sensor offers the following benefits:

- Five times better mechanical strength for RS92 radiosondes without losing fast response, accuracy and very small solar radiation absorption
- The temperature sensor is strengthened with a strong quartz fiber, which is firmly integrated into the current sensor structure
- The new structure makes the sensor less prone to a damage during flight preparation or sounding
- The protective boom frame has been removed to improve the air flow to the sensor
- The removal of the protective boom frame changes slightly the visual appearance of the sensor boom.

During the short transition period the RS92 radiosondes with the fiber-reinforced temperature sensor can be traced by the radiosonde serial number. If the four last digits are between 3000 and 5999, the radiosonde is manufactured with the fiber-reinforced temperature sensor.

Overall radiosonde data recovery was excellent during February, with NSA reporting 56 soundings of 56 scheduled (100% recovery), SGP 107/112 (96%), TWP/C1 (Manus) 55/56 (98%), and TWP/C2 (Nauru) 51/56 (91%). Although some soundings were missed at NSA because of bad weather, a few additional soundings were done as part of RHUBC. The RHUBC soundings use non-windfinding RS92 radiosondes.

Donna Holdridge and Mike Ritsche have begun work on software that will merge the radiosonde raw pre-launch data with the data collected by the SurfREF system at SGP. When completed the merged streams will be submitted as a new data product to help us assess the accuracy of the radiosonde data.



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

January 2007 – Soundings from SGP and NSA (Barrow) are now available to the global telecommunications system (GTS). Soundings from TWP (Manus and Nauru) will also be available to the GTS once the new DigiCORA-III systems are installed and operational there.

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

*Mentor: Tom Stoffel, National Renewable Energy Laboratory*

SIRS (24@SGP) and BRS (1@SGP) – Data for February 2007 were generally excellent with 100% data collection except at E10 (83%) and E19 (87%) due to communication problems between the data system computers and the SIRS data logger. Of the 1-minute irradiance data collected, more than 97% of the shortwave and 100% of the longwave data passed automated data quality tests. “Failed” shortwave (solar) data are generally limited to low irradiances (less than 300 W/sq m) at high solar zenith angles or can be attributed to the varying thermal offsets and time responses of the thermopile-based radiometers to rapidly changing sky conditions, e.g. cloud cover and water vapor concentrations.

SKYRAD/GNDRAD (3@TWP, 2@NSA, 1@AMF) – Downwelling broadband solar and atmospheric irradiances (SKYRAD) data for February 2007 were excellent with 100% data collection at all stations (NSA, and TWP). Installation of the ARM Mobile Facility (AMF) at Heselbach, Germany in the Black Forrest continues. At Nauru (TWP / C2) direct normal irradiance (DNI) data invalid 2/01/07 – 2/10/07. Of the 1-minute irradiance data collected, at least 98% of the shortwave and 100% of the longwave data passed automated data quality tests.

#### **2.4.1 Pyrgeometer Calibration Improvements**

Tom Stoffel and Ibrahim Reda have initiated an investigation into the source of the bias in the ARM Climate Research Facility (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 pyrgeometers 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 National Renewable Energy Laboratory (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.

STATUS – The new Dow Corning cooling fluid has been delivered to NREL. This new fluid offers better low temperature performance for providing more uniform blackbody temperature control. At the ARM Science Team meeting in Monterey, 26-30 March 2007, Tom and Reda described a method to ensure the pyrgeometer calibrations are traceable to the WISG.

## **2.4.2 Radiometer Calibration Facility Data Acquisition System Replacement (deferred to FY2008)**

The data acquisition system in the Radiometer Calibration Facility 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 (CO<sub>2</sub>FLX)**

*Mentor: Marc Fischer, Lawrence Berkeley National Laboratory*

The CO<sub>2</sub>FLX instruments at 4, 25, and 60 m on the SGP-CF tower are operating nominally with the exception of the net radiometers. [The NR-lite net radiometer was re-installed in mid-February.](#)

## **2.6 Carbon Monoxide System (CO)**

*Mentor: Sébastien Biraud, Lawrence Berkeley National Laboratory*

The CO system was operating nominally.

## **2.7 CO<sub>2</sub> (Precision Gas) System (PGS)**

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

The PGS is operating nominally.

## **2.8 Cimel Sun Photometer**

*Mentor: None (external data provided by NASA AERONET)*

[AERONET believes the Cimel programming problem has been resolved.](#)

[AMF \(Heselbach\) – Awaiting an upgraded replacement capable of Internet data transfer.](#)

[NSA \(Barrow\) – AERONET has upgraded this instrument to add a channel at 1640 nm at no cost to ARM. It has been shipped to Barrow for reinstallation.](#)

[SGP \(CF\) – Removed in February and returned to AERONET to address internal programming problems. A loaner Cimel was furnished by AERONET until the problem can be corrected. AERONET will also upgrade the SGP instrument to add a channel at 1640 nm at no cost to ARM.](#)

[TWP \(Nauru\) – A new Cimel was installed in late November. The Cimel that had been at Nauru has been sent to AERONET for recalibration and upgrade to add a channel at 1640 nm. It will then be sent to Germany where it will be swapped with the Cimel currently with the AMF.](#)

### **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). Internet transfer of CSPOT data to AEORNET has been initiated at TWP-Nauru and SGP sites.

### **2.9 Disdrometer**

*Mentor: Mary Jane Bartholomew, Brookhaven National Laboratory*

SGP – Returned to the manufacturer to investigate sensitivity problems. Deployment of an optical rain gauge at SGP would benefit measurement of light rain conditions that the tipping bucket gauges have difficulty with. This would also benefit ARSCL processing, which currently uses the moisture detector on the MWR at SGP-CF as a sensitive light rain detector. The sampling rate of the tipping bucket rain gauges associated with the disdrometers will be increased from 1-min to 1-s to improve rain rate resolution for comparison.

TWP (Darwin) – Operating nominally.

### **2.10 Energy Balance Bowen Ratio Station**

*Mentor: David Cook, Argonne National Laboratory*

Two recalibrated EBBR units were installed at E4 (Plevna) and E8 (Coldwater).

Vaisala no longer supports the combined temperature and relative humidity probes in the EBBR (2 per system) but does still offer recalibration services. 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*

AMF (Heselbach) – A newly calibrated IRGA has been sent to Germany to replace the unit used in Niger.

SGP – Most ECOR stations are operating nominally. Data gaps and other problems at E1, E10, E14, E21, and E24 suggest problems with the IRGA serial ports. Problems with the new optical isolators implemented to protect the ECOR computer serial ports during lightning have been traced to the serial driver chips in the infrared gas analyzers (IRGA). In preparation for CLASIC, several IRGAs were returned to the manufacturer for repair. Time keeping problems that occur following an unplanned shutdown of the ECOR computer have been addressed with a revised maintenance procedure and a script to update the BIOS clock every 24 hours.

### **2.11.1 Add Wetness Sensors**

Periods of dew, frost, and precipitation often cause data from the CO<sub>2</sub>/H<sub>2</sub>O 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).

January 2007 – Wetness sensor testing on an ECOR system similar to the ARM ECORs began at Argonne in mid-January.

### **2.12 G-Band (183.3 GHz) Water Vapor Radiometer**

*Mentor: Maria Cadeddu, Argonne National Laboratory*

The GVR is operating nominally. GVR data are now available from the ARM Archive (nsagvrC1.b1). Varying levels of RFI are observed in all four channels. Software modifications have been implemented to permit hourly data ingest (rather than daily) in support of RHUBC.

### **2.13 Global Positioning System (SuomiNet)**

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

[Replacement receivers are in route to Manus and Darwin to preempt a failure due to the same problem experienced at Nauru.](#)

SGP – Telecommunications problems at El Reno (E19) continue to affect data availability from the SuomiNet station. Wireless data communication equipment has been ordered for installation at El Reno (E19). All other SGP SuomiNet global positioning system (GPS) stations and their associated meteorological sensors are operating nominally.

TWP (Manus) – Operating nominally.

[TWP \(Nauru\) – In November the GPS receiver at Nauru failed. The repaired receiver is in route and will be installed in April.](#)

TWP (Darwin) – Operating nominally.

NSA (Barrow) – (System belongs to the University of Alaska at Fairbanks (UAF) and is installed at NOAA/CMDL site.) Operating nominally using a spare ARM met system.

NSA (Atqasuk) – In June 2006 University Navstar Consortium 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, NOAA/ESRL/GMD*

[There have been 687 IAP flights to date \(March 2000 through 5 March 2007\).](#)

The high (85%) relative humidity nephelometer continues to have problems. The instrument that was returned to the manufacturer in September for diagnosis and repair of this problem has not yet been returned. Presumably part of the issue with the long delayed repair is figuring out how to deal with the water-soluble calibrator substance.

## **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). An ECR has been submitted to install the IRTs at NSA and TWP in ventilated enclosures similar to those in use at the SGP.

NSA – Data were generally good.

SGP – Data were generally good at most sites. The data were missing at E16 and E19. Higher sky temperatures were measured at E13 than both the AERI and the IRT at C1 because at low temperatures (below-60°C) the error due to the reflectance and temperature of the mirror becomes significant.

TWP – Data were generally good at Manus and Darwin. In February the SKYRAD and GNDRAD IRTs at Nauru both failed. Both have been replaced.

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

*Mentor: Gary Hodges, NOAA/ESRL/GMDivision; John Schmelzer, Pacific Northwest National Laboratory*

John Schmelzer has indicated he plans to retire in May.

AMF – Operational at Heselbach.

SGP – 9 of 22 Extended Facilities do not have operational multi-filter rotating shadowband radiometers (MFRSRs).

NSA – MFRSRs, MFRs, and normal incidence multi-filter radiometers (NIMFRs) have been recalibrated and returned for re-installation at Barrow and Atqasuk.

TWP – Operating nominally.

Twice-per-day cleaning of the NIMFR at SGP has been initiated to eliminate the step-change in the measurements observed following the current once-per-day cleaning events.

### **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 has manufactured custom-designed and custom-built filter-detector assemblies to meet ACRF specifications (ECO-00580).

STATUS – John Schmelzer is refurbishing and calibrating MFRSR sensor heads using the new filter-detectors at the rate of 3-4 per week. [Newly upgraded heads are being sent to SGP for installation with the new data loggers.](#)

### **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). New calibration processing will be implemented. Old data will be reprocessed to apply corrections and the new processing algorithms.

STATUS – [Data from the first MFRSR with the new data logger is now being ingested using the improved calibration and processing.](#)

### **2.16.3 Establish MFRSR Calibration Facility at SGP**

[With the impending retirement of John Schmelzer, a facility for calibrating the MFRSRs is to be established at SGP. MFRSR calibration includes \(1\) cosine response characterization, \(2\) spectral bandpass characterization of the filter detectors, and \(3\) absolute \(lamp\) calibration. To establish the facility, the cosine bench and related items acquired by John Schmelzer at PNNL on behalf of ACRF will be relocated to the SGP Radiometer Calibration Facility \(RCF\). Some modifications to the RCF may be necessary. Additional equipment will need to be acquired, including a monochromator and computer for performing the spectral characterizations. Joe Michalsky at NOAA GMD will be overseeing the task of establishing the facility as well as the routine calibrations to be performed using the facility. Joe will also direct other NOAA GMD staff to prepare documentation and train the SGP calibration technicians, and to review the resulting calibrations to ensure their validity prior to deployment in the field. \(ECO-00617\)](#)

### **2.16.4 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).

STATUS – [Data from the first MFRSR with the new data logger is now being ingested. Once the first installation has been verified subsequent installations will follow.](#)

## 2.17 Millimeter Cloud Radar

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

NSA/C1 – 100% up time in February.

SGP/C1 – In December the MMCR started to experience intermittent traveling wave tube (TWT) helix voltage faults. In January the problems worsened (67% uptime) so the TWTA was removed and sent to ASE for diagnosis and repair. ASE found no problems with the TWTA, which was returned and reinstalled in February. Periodic faults continue to occur. [At the request of ASE a dummy load was placed on the TWTA at the end of February to help diagnose the problem.](#)

TWP/C1 (Manus) – 100% up time in February. [The power output of this system continues to decline. When our next order of new TWTs arrives in March or April one will be sent to ASE to repair the old TWTA from Nauru, which will then be sent to Manus for replacement.](#)

TWP/C2 (Nauru) – 100% up time in February.

TWP/C3 (Darwin) – 100% up time in February.

### 2.17.1 MMCR Processor Upgrades

(ECO-00283) The spare PIRAQ-III processor will be installed in the MMCR at Darwin to replace the PIRAQ-III that failed. The NSA (Barrow) upgrade will be delayed until the failed processor is repaired or another spare is purchased.

[STATUS – The failed boards from Darwin were sent to Vaisala for repair. Vaisala reported that they are unable to find the problem. Kevin urged them to look closer since exchanging those boards with the spares repaired the radar.](#)

### 2.17.2 Add Polarization at Barrow

(ECO-0052) 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 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).

#### **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).

January 2007 – The compression algorithms have been implemented at SGP.

#### **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). The spare antenna is complete and the contract for the new feed and sub-reflector has been placed. Once these are complete, they will be installed on the antenna reflector and calibrated. The Barrow MMCR antenna will most likely be refurbished first to avoid impacting planned IOPs and SGP.

#### **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 task is currently on hold (EC-00275).

### **2.18 Micro-Pulse Lidar**

*Mentor: Rich Coulter, Argonne National Laboratory*

[AMF – The new MPL at Heselbach is now operational.](#)

SGP – Good data to greater than 15 km is normal during nighttime and 10-15 km during daytime with no additional averaging beyond the 3 second averaging time presently in use by the instrument itself.

NSA – The system is again producing good data following replacement of the detector by NSA technicians in January.

TWP – The new MPL at Nauru has been working well. [Replacing the detector at Darwin failed to resolve problems manifesting as thin, false cloud layers near 10 km and 20 km. The laser diode may need to be replaced.](#)

A value-added processing (VAP) has been developed to produce a file with separated polarization states, averaged to 30 seconds. This will appear similar to the present MPL data in terms of averaging time. It will have two data streams, one for circular polarization and a second for cross polarization.

Rich Coulter and Tim Martin have developed and tested a means to automatically restart the new MPLs. This has not yet been implemented because some of the laser power supplies need to have their firmware updated to support external control.



## 2.19 MicroWave Radiometer

*Mentor: Maria Cadeddu, Argonne National Laboratory*

Six MWRs were compared during October-November 2006: serial numbers 04, 10 (both from SGP/CF), 11 (SGP/B1), 12 (SGP/B5), 18 (SGP/B6), and 21 (NSA/C2). Differences of as much as 0.7 K in brightness temperatures at 23.8 GHz (corresponding to ~0.5 mm PWV) were observed between radiometers. Shipment of several of these radiometers to Radiometrics for diagnosis and repair has been delayed due to funding limitations under the Continuing Resolution and the need to repair MWRs from TWP.

AMF (Heselbach) – Operational.

NSA/C1 (Barrow) – Comparisons of the MWR wet window flag with the MWRP wet window flag and tower precipitation sensor revealed that the threshold for indicating the presence of liquid water required adjustment (for both MWR and MWRP).

NSA/C2 (Atqasuk) – Not in service. In October this radiometer was sent to the SGP central facility for inclusion in the MWR Inter-comparison IOP.

SGP-CF – Operating nominally.

SGP-E14 – Operating nominally.

SGP/B1 (Hillsboro) – Not in service. In October this radiometer was sent to the SGP central facility for inclusion in the MWR Inter-comparison IOP.

SGP/B4 (Vici) – No radiometer installed. In December 2005 the radiometer at Vici was sent to Darwin as a replacement for one damaged by lightning.

SGP/B5 (Morris) – Not in service. In October this radiometer was sent to the SGP central facility for inclusion in the MWR Inter-comparison IOP.

SGP/B6 (Purcell) – In October this radiometer was sent to the SGP central facility for inclusion in the MWR Inter-comparison IOP. In December this radiometer was sent to Manus to replace the failed MWR there.

TWP/C1 (Manus) – This radiometer (#15) experienced a failure in October. A replacement circuit card failed to restore operation. A replacement radiometer from SGP (#18 formerly at SGP/B6) was shipped in December. Radiometer #15 required extensive (and expensive) repairs after ten years on Manus Island. It will be compared with MWRs at SGP prior to returning to service.

TWP/C2 (Nauru) – A replacement (#17) was installed in late November. [The MWR \(#16\) has been repaired and returned to SGP for comparison with other MWRs there.](#)

TWP/C3 (Darwin) – Operating nominally.

### 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.

STATUS – The connectors on MWR #16, formerly on Nauru, were replaced when the instrument was repaired. All three TWP MWRs have been converted to standard connectors.

### 2.20 MicroWave Radiometer Profiler

Mentor: Maria Cadeddu, Argonne National Laboratory

AMF (Heselbach) – Operational. Awaiting LN<sub>2</sub> calibration.

NSA (Barrow) – The LN<sub>2</sub> calibration did not happen in early February due to difficulties obtaining LN<sub>2</sub>. An attempted calibration in late February was unsuccessful, but a successful calibration was obtained in mid-March. Prior to this, drifts in the calibration of the V-band channels were noticeable, particularly at 51.25 GHz, which affected the 6-channel retrieval of LWP; however, the 2-channel LWP retrieval was in agreement with the MWR. The 2-channel PWV retrieval showed a slight (0.8 mm) bias relative to the MWR due to a slight bias at 23.8 GHz. The data will be reprocessed to apply the updated calibration.

### 2.21 Narrow Field of View Radiometer (NFOV)

Mentor: None

The 2-channel NFOV radiometer has been installed at Heselbach.

CORRECTION: Recalibration of the 2-channel NFOV at NASA GSFC resulted in good agreement with a Cimel sunphotometer [at 870 nm](#) and 673 nm. (A 5% bias was observed at low radiances [at 673 nm](#), but the bias disappeared at higher radiance values.)

With the advent of the 2-channel NFOV, there no longer appears to be any interest in the 1-channel NFOV. Consequently it has been suggested that the 1-channel NFOV be retired.

### 2.22 Raman Lidar

Mentor: Rob Newsom, Pacific Northwest National Laboratory

The instrument's uptime (percent of time scientific data were collected) for February 2007 was 70.6%. The majority of the lost time occurred between 6-14 February, initially due to a laser problem, followed by several days during which cloudy skies prevented a system restart (a clear sky is required for system realignment following work on the optics train).

The sensitivity of the lidar has declined significantly since 2004. The problem is believed to be due either to a loss of reflectivity of the receiving telescope mirrors or a loss of transmissivity of the interference filters. [Interference filters have been sent to the supplier for testing.](#)

No water vapor mixing ratio data are available from the Raman lidar since early 2004 because of difficulties encountered in combining the analog detection (AD) and photon counting (PC) signals from the Licel electronics during the daytime. To help resolve this problem, a photomultiplier tube, base, and housing have been sent to Licel Electronics in Germany for testing with their equipment. A teleconference to discuss the problems encountered in merging the PC and AD signals, and potential solutions, was held on 16 February. Participants included Bernd Mielke (Licel), David Turner, Diana Petty, Rob Newsom, John Goldsmith, Rich Ferrare, Connor Flynn, and Zhien Wang. One outcome of the teleconference was the decision to proceed to process the nighttime data, which do not seem to be affected by the problem. [Rob Newsom is coming up to speed on the automated processing code. He is also currently investigating various techniques for using the analog signal to estimate the dead time correction and “glue coefficients” \(used to combine the AD and PC signals\) simultaneously.](#)

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.

[STATUS – Rob Newsom, John Goldsmith, and Dave Turner will be at SGP 10-12 April 2007 to install the new sensor.](#)

### **2.23 Rotating Shadowband Spectrometer**

*Mentor: Peter Kiedron, NOAA/ESRL/GMD*

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

[Processed Langley data are available though January 24, 2007 at <http://iop.archive.arm.gov/armiop/0special-data/asrc-rss/rss105/langley/>. A comprehensive document on lamp calibration is available at: \[http://www.arm.gov/publications/tech\\\_reports/handbooks/rss/manuals/\]\(http://www.arm.gov/publications/tech\_reports/handbooks/rss/manuals/\)](#)

### **2.24 Radar Wind Profiler – 915 MHz**

*Mentor: Rich Coulter, Argonne National Laboratory*

[AMF – The new 1290 MHz system is now operational at Heselbach.](#)

SGP – Currently, all systems at SGP are operating nominally. The SGP/C1 (central facility) and SGP/I3 (Meeker) have had the digital receiver upgrades successfully installed. The problem with RASS data being “reflected” at large range gates has mysteriously improved recently. Although the 60 Hz noise problem continues at I2 (Medicine Lodge), based on the experience at Meeker, this problem will be resolved when the system is upgraded later in 2007.

NSA – System crashes frequently. The planned upgrade to new hardware, LAPXM software, and a new computer should 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 Cloud Land Surface Interaction Campaign (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 have been upgraded. The systems at SGP/I2, SGP/I3, and NSA/C1 will be upgraded in 2007 (ECO00567).

[STATUS – The upgrade for the NSA system has been ordered.](#)

### **2.25 Radar Wind Profiler – 50 MHz**

*Mentor: Rich Coulter, Argonne National Laboratory*

This system has been out of service for over a year.

In January 2006 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.

### **2.26 Soil Water and Temperature System**

*Mentor: John Harris, University of Oklahoma*

[Data are OK for most sites. Sites E9 and E27 were problematic in February. Sites with one or more sensors needing replacement: E1, E5, E6, E8, E10, E13, E15, E16, E19, E20. New sensor arrays installed at E13, E19, and E20 last year will be activated in April or May.](#)

#### **2.26.1 Replace In-Ground Sensor Arrays**

New redundant sensor arrays will be installed at all SGP EF sites. These will be installed in a phased manner: 5 sites per year over the 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).

STATUS – In 2006, new sensor arrays were installed at E13, E19, and E20. Though initially planned, no new sensor array was installed at Cyril (EF-24) due to a gypsum outcropping. The original sensor array had been installed in a “hole” in the gypsum filled with soil. There was no other such area of soil and it is unlikely that soil moisture measurements at the site would be representative of the actual conditions of the surrounding area. The new sensor arrays will replace the original arrays (i.e., be connected to the data loggers) as soon as sufficient precipitation has “healed” the soil. The mentor believes this will happen within the next two rain events. The next round of sensor array installation is planned for April, but could be delayed until May depending on weather conditions.

## **2.27 Shortwave Spectrometer (SWS)**

*Mentor: Scott Kittelman, University of Colorado*

On January 11, 2006, the Shortwave Spectrometer was reinstalled and calibrated at the Southern Great Plains Central Facility by Warren Gore and Tony Trias from NASA Ames. [Data ingest has been restarted. Data are available from the ARM Archive from 12 January 2007 to present. Since the reinstallation, no errors have been observed in the data checks of the raw data.](#)

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

*Mentor: Mike Ritsche, Argonne National Laboratory*

[AMF \(MET, ORG\) – Operational at Heselbach.](#)

[NSA \(METTWR\) – LoggerNet software upgrades have been completed. Accumulation of hoar frost and ice on the wind direction sensors continues to be a problem, particularly at the 40-m level of the Barrow tower. The measurements of the chilled mirror hygrometer \(CMH\) at Barrow are suspect due to a dubious calibration in December 2006.](#)

[SGP \(SMOS\) – Installation of new Vaisala temperature/relative humidity probes \(BCR 1298\) to replace old probes no longer supported by Vaisala has been completed. Data ingests were disabled during the installation, but have been reactivated. The SGP temperature/humidity calibration chamber was recalibrated in February. Due to the stability of the chamber calibration, recalibration frequency will be reduced from annually to biennially, which will save \\$10K. A tool is being developed to aid the field technicians align the wind direction sensors more accurately.](#)

[TWP \(SMET, ORG\) – All systems are operating nominally.](#)

### **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 – Calibrations are underway. A schedule for calibrating all SMOS rain gauges over the next six months has been developed.

### **2.28.2 Upgrade T/RH Probes and Wind Sensors for NSA Met Systems**

Ice develops on the wind vanes, cup anemometers, 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 – Deferred until higher priority instrument procurements are completed.

### **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 Hot Plate Total Precipitation Sensor (TPS)**

*Mentor: Mark Ivey, Sandia National Laboratory*

In late February and early March, the Hot Plate Total Precipitation Sensor indicated precipitation during periods when precipitation was not observed at the site or by other precipitation sensors nearby. Mark Ivey discussed this problem with the manufacturer. Yankee indicated that anomalous precipitation had been observed under cold conditions at other installations and an upgrade to the instrument’s firmware was required. We are in the process of obtaining and installing that upgrade.

### **2.31 Total Sky Imager**

*Mentor: Vic Morris, Pacific Northwest National Laboratory*

AMF – Operational at Heselbach.

NSA – The instrument has been reinstalled and is operational.

SGP – Operating nominally.

TWP – TSIs at Nauru and Darwin are operating nominally. Images at Manus and Nauru are occasionally hazy. Efforts to reduce moisture inside the camera housing continue.

New, improved mirror controllers are being developed by Ray Edwards at Brookhaven National Laboratory.

## 2.32 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. Turkey vultures have been observed roosting on the wind speed/direction sensor.

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 proposed (ECO-00595).

SOWs have been prepared, quotes obtained, and Purchase Requisitions submitted for maintenance on these two towers. SGP tower maintenance is tentatively scheduled for 23-27 July; NSA tower maintenance is scheduled for mid-August.

## 2.33 Vaisala Ceilometer

*Mentor: Vic Morris, Pacific Northwest National Laboratory*

Data are generally good at NSA and SGP. Electronic ringing in the backscatter plot is visible at NSA-C2 (Atqasuk) and SGP-B5 (Morris, OK), but this does not affect the instrument's ability to detect clouds.

Data were generally good at Manus, but the systems at Darwin and Nauru experienced reduced sensitivity to high clouds due to optical cross-talk problems.

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

*Mentor: Kevin Widener, Pacific Northwest National Laboratory*

AMF – Operational at Heselbach.

SGP – Operating nominally; 94.8% up time in January.

### 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 VAP similar to the existing ARSCL but on a regular 3D grid.
- Development of an "AVA Simulator." Patterned after the well-known International Satellite Cloud Climatology Program Simulator, the AVA Simulator will perform forward simulations of radar observables, using as input large-eddy simulation 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 – Consideration of the AVA, as such, has been deferred until 2008 when simulations have been carried out to demonstrate its capabilities and further refine its requirements.

#### 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.



October 2006 – 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.

STATUS – Clarification of the scientific requirements for a portable Raman lidar is necessary before proceeding.

### **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 a 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 – In December 2006 a description of the desired instrument capabilities was published in Fed Biz Ops (solicitation number 111506). Based on the published description, Rough Order of Magnitude cost estimates have been received from several interested organizations.

### **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 Science Team Executive Committee. The Science Team Executive Committee 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 YES 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 Add 1.6 $\mu\text{m}$ 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  $\mu\text{m}$  to permit the retrieval of droplet size distribution. Andy Lacis and colleagues have suggested a 1.6  $\mu\text{m}$  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  $\mu\text{m}$  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  $\mu\text{m}$  channel.

### **3.7 Aerosol Particle Sizing Spectrometer to Replace Optical Particle Counter at Southern Great Plains**

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

### **3.8 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 SBIR Phase II award and deployed at Barrow since April 2005.

### **3.9 Thin Cloud Rotating Shadowband Radiometer (TC-RSR) for LWP, $r_{eff}$ , and $\tau_{cloud}$**

Andy Vogelmann and Mike Reynolds have proposed to modify an existing Brookhaven National Laboratory Fast Rotating Shadowband Radiometer (FRSR) to enable Qilong Min to apply his algorithms to retrieve liquid water path, visible optical depth, and effective radius for thin clouds. If approved, BNL had hoped to complete the work by summer for deployment during the AMF deployment to Germany or during CLASIC at SGP in June 2007. This would be a BNL-owned instrument, with additional costs to ACRF for each IOP deployment for field operation and data reduction.

### **3.10 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 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](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](http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/044.htm)

### 4.2 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](http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/040.htm)

### 4.3 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](http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/045.htm)

### 4.4 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>

STATUS – Global Aerospace’s Phase II proposal was not selected for funding. The reasons given by NSF were that the proposal was not sufficiently innovative and the potential market was too small. Matt Heun is still interested in pursuing this if it were to become a DOE SBIR subtopic.

#### 4.5 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 3<sup>rd</sup> to the 2<sup>nd</sup> 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 and demonstration.” *Journal of Atmospheric and Oceanic Technology* 20:1505-1522.