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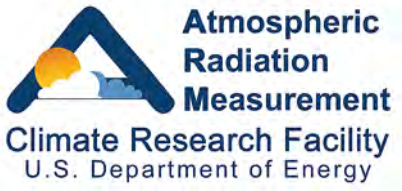
ACRF Instrumentation Status: New, Current, and Future

July 2008



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Abstract

The purpose of this report is to provide a concise but comprehensive overview of Atmospheric Radiation Measurement Climate Research Facility instrumentation status. The report is divided into the following five sections: (1) new instrumentation in the process of being acquired and deployed, (2) field campaigns, (3) existing instrumentation and progress on improvements or upgrades, (4) proposed future instrumentation, and (5) Small Business Innovation Research instrument development. New information is highlighted in blue text.

Acknowledgments

This report is developed largely from the information submitted to and managed within our Instrument Mentor Monthly Summary (IMMS) reporting system (http://www.db.arm.gov/IMMS/). Special thanks to our Instrument Team for providing timely and complete updates to the IMMS, to Kathy Doty, our developer and administrator of IMMS, and Rolanda Jundt, who ensures this information is posted accurately on the ARM website.

Contents

1. New Instrumentation

This section describes approved new instrument deployment and upgrade activities for the current fiscal year.

1.1 Thin-Cloud Rotating Shadowband Radiometer (TC-RSR) for Liquid Water Path, Visible Optical Depth, and Effective Radius for Thin Clouds

Andy Vogelmann and Mike Reynolds modified an existing Brookhaven National Laboratory (BNL) fast-rotating shadowband radiometer (FRSR) to enable Qilong Min to apply his algorithms to retrieve liquid water path (LWP), visible optical depth (τ_{cloud}), and effective radius (r_{eff}) for thin clouds. The thin-cloud rotating shadowband radiometer (TC-RSR) will remain a BNL-owned instrument; however, the ARM Climate Research Facility (ACRF) will incur costs that cover field operation and data reduction for each field campaign deployment.

This development work is documented in Engineering Change Order ECO-00635, *Develop and Test Thin-Cloud Rotating Shadowband Radiometer (TC-RSR)*. The system is calibrated and currently undergoing final testing at RMR Company before field-testing at the Southern Great Plains (SGP) site. Andy will submit a field campaign request when the system is ready for deployment, most likely in January 2008.

The development team is hopeful that measurement accuracies of optical depths within 2%, r_{eff} within 10%, and LWP within 2 gm^{-2} are attainable. Other field campaigns and experiments that might use this system include the ARM Mobile Facility (AMF) deployment to the Azores and with the VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS) experiment off the coast of Chile. This instrument is well suited to study thin, oceanic clouds and marine stratus for shipboard and marine deployments.

STATUS – Development is in progress. See http://www.rmrco.com/dev/tcrsr/. An Intensive Operational Period Request (IOPR), IOPR-2007-05707, was submitted by Mary Jane Bartholomew and approved. The TC-RSR is deployed at our SGP site for performance evaluation and inter-comparisons with ACRF instruments. The resulting data set will be documented and archived for scientific record at our ACRF Data Archive. Engineering Work Order EWO-12403, *Thin Cloud Rotating Shadowband Radiometer,* is open to track the installation and testing of the TC-RSR.

The TC-RSR experienced technical/performance issues and had to be returned to BNL for evaluation. The system has been returned to the SGP for reinstallation.

1.2 Infrared Sky Imager (IRSI)

Mentor: Vic Morris, Pacific Northwest National Laboratory

An infrared sky imager (IRSI) from Blue Sky Imaging (http://www.aas.org/career/bluesky.html) was deployed at the SGP site in September 2005 to provide nighttime cloud-cover measurements, which was documented in Engineering Change Order ECO-00429, *Purchase and Deploy an IR Sky Imaging System*.

Problems with moisture infiltration of the imager necessitated its return to the manufacturer for repair/revision in October 2005. The unit was returned to the SGP site in late June 2006 and returned to service in August 2006. In late January 2007, 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 2007, 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 cloud fractions.

Vic Morris has completed an inter-comparison of IRSI systems. This field campaign was approved under IOP number 2007-05673, *IRSI Inter-Comparison Study*, associated EWO-12214, *ACRF Field Campaign #07-5673 (Morris) IRSI Inter-Comparison Study*, and conducted from August 27 to September 23, 2007. Four instruments were installed during the inter-comparison. Data were analyzed and results presented at the American Geophysical Union (AGU) meeting in December 2007 and the ARM Science Team meeting in March. The daytime images from both the All-sky Thermal Infrared Camera (ASTIC) and All-sky Infrared Visible Analyzer (ASIVA) compared well with the TSI, but the cloud fraction data under-estimated the TSI values. The Nubiscope provided the best comparison but has poor (10-min) time-resolution. The cloud height data from all the tested IRSIs provide poor estimates compared to the active remote sensing cloud layer (ARSCL). Additional instrument evaluations may be required for the selection process. Data from the IRSI Inter-Comparison Study were submitted to the ACRF Data Archive for the BSI ASTIC, Heitronics Nubiscan, Solmirus ASIVA, Atmos CIR4, and the Longwave Flux Analysis. Joe Shaw has agreed to a demonstration at SGP of Montana State University's wide-angle Infrared Cloud Imager.

1.3 Rotating Shadowband Spectrometer (RSS) Overhaul

Please refer to Engineering Change Request ECR-00661, *RSS Refurbishment*, in the RSS section of this report.

1.4 Aerodynamic Particle-Sizing Spectrometer (APS) to Replace Optical Particle Counter (OPC) at Southern Great Plains

Please refer to Engineering Change Order ECO-00640, *Replace AOS Optical Particle Counter with Aerodynamic Particle Sizing Spectrometer,* in the Tandem Differential Mobility Analyzer (TDMA) section of this report.

1.5 Infrared Thermometers (IRTs) for the Southern Great Plains Extended Facility Sites

Please refer to Engineering Change Order ECO-00345, *Install Zenith-Pointing IRT Network at SGP,* in the infrared thermometer (IRT) section of this report.

1.6 Add Scanning Capability to the W-Band ARM Cloud Radar (WACR)

Please refer to Engineering Change Order ECO-00658, *WACR–Add Scanning Capability*, in the WACR section of this report.

1.7 Next-Generation Microwave Radiometers (MWRs)

Please refer to Engineering Change Order ECR-00664, *Next Generation MWR Procurement/Deployment*, in the MWR section of this report.

1.8 Photoacoustic (PA) Spectrometer

The December meeting of the Science Team Executive Committee (STEC) approved the Working Group's recommendations to deploy an instrument that provides photoacoustic (PA) extinction of aerosols. The PA instrument and associated measurements will be added to the existing ACRF AOS and the SGP. A science objective is to produce a high-quality data set to investigate the reported bias in the absorption measurements made by the particle/soot absorption photometer instruments.

Engineering Change Order ECO-00663, *Photoacoustic Instrument to Enhance Aerosol Optical Data Quality at ARM,* is approved and in process to document this specification, procurement, and deployment. Dubey Manvendra is the leader. The procurement requisition is complete and discussions are ongoing related to field installation details. The PA instrument has been received and is undergoing characterization.

2. Field Campaigns

Contact: Sylvia Edgerton, ACRF Science Liaison

This section provides information for ACRF field campaigns that have a significant impact on instrumentation and Instrument Team resources. Please refer to the ACRF Field Campaign web page for approved activities at http://www.arm.gov/acrf/fc.stm.

AMF to CHINA 2009 – Engineering Change Order ECO-00646, *AMF/AAF Deployment to China FY 2009*, and Engineering Work Order EWO-12358, *Design Data System Infrastructure for China Taihu Site*, are open to communicate information related to this deployment. Aerosols in China have exceptionally high-loading and diverse properties whose influence has been detected across the Pacific Rim. The rapid pace of changes in the atmospheric environment over China provides a natural testbed for identifying and quantifying the climatic effects of aerosols. Preliminary analyses of multiple satellite data sets (MODIS, TMI, TRMM) indicate more complex and unique aerosol indirect effects than what is found in relatively cleaner environments. Unfortunately, China is one of the least observed regions, especially in terms of aerosol and cloud properties. To verify the satellite findings and gain a deeper understanding requires either in situ measurements or independent, ground-based remote sensing data, or ideally both.

RHUBC-II 2010 – Engineering Work Order EWO-12438, *Radiative Heating in Underexplored Bands Campaign 2 (RHUBC-II)*, documents instrumentation requirements for this experiment. The Radiative Heating in Underexplored Bands Campaign (RHUBC-II) was selected for support by ACRF as an offsite campaign. Led by principal investigators David Turner and Eli Mlawer, RHUBC-II will take place from August to October 2009 at a location near Cerro Chajnantor in Chile, at an altitude of more than 5000 m. This effort is a follow-on to RHUBC-I, conducted from February 22 to March 14, 2007, at the ACRF North Slope of Alaska (NSA) site in Barrow. During RHUBC-II, the same spectral band will be

explored; however, this absorption band is much more transparent in the dry, low-pressure conditions at Chajnantor. These conditions represent the upper troposphere that is poorly observed but important for climate studies. Therefore, significant fundamental advances that are pertinent to reducing uncertainties in the radiation calculation of global climate models will be gained.

AMF-Azores – Engineering Work Order EWO-12453, *Extension to Cloud, Aerosol, and Precipitation in the Marine Boundary Layer (CAP-MBL) Field Campaigns*. The AMF will be deployed in the Azores to support the Clouds, Aerosol, and Precipitation in the Marine Boundary Layer (CLAP-MBL) field campaign. From April through December, the AMF will be located on Graciosa Island in the Azores, a Portuguese archipelago located about 3900 km from the east coast of North America. The Azores are ideally located to sample the transition from the overcast stratocumulus regime in the spring to the broken trade cumulus regime in the summer. Led by principal investigator Robert Wood, scientists involved in the campaign will use data from the AMF to study processes controlling the radiative properties and microphysics of marine boundary layer clouds, a high-priority science question.

3. Existing Instrumentation

This section describes activities that are ongoing to improve the performance or maintain existing instrumentation, including any planned or in-progress upgrades. The information is abstracted primarily from the Instrument Mentor Monthly Summary (IMMS) reports database (http://www.db.arm.gov/IMMS/), which can be used for a collective and historical view of instrument status. Individual IMMS reports may be reviewed by following links to specific instruments from our Instrument web page (http://www.arm.gov/instruments). ACRF Mentors provide updates to our IMMS under these categories:

1. Data Review
2. Instrument Performance Issues and Trends
3. Current Task Status
4. Near-term Plans
5. Accomplishments.

Information related to the progress and status of instrument engineering is available from our Engineering Change Order (ECO) database (http://eco.arm.gov).

Helpful links to instrument-related ACRF web pages are listed below:

- Instrument Systems and Mentors, http://www.arm.gov/instruments/mentors.php
- Instrument Locations, http://www.arm.gov/instruments/location.php
- Instrument Mentor Monthly Summaries, http://www.db.arm.gov/IMMS/
- Data Quality Reports, http://www.db.arm.gov/cgi-bin/PIFCARDQR2/SignIn.pl?form=dqr
- Data Quality Program, http://dq.arm.gov/.

3.1 Aerosol Observing System (AOS)

Mentor: John Ogren and Anne Jefferson, NOAA/ESRL/Global Monitoring Division (GMD)

There are no open engineering tasks related to the AOS instrument suite.

3.2 Atmospherically Emitted Radiance Interferometer (AERI)

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

There are no open engineering tasks related to the AERI instrument suite.

3.3 Balloon-Borne Sound System (BBSS)

Mentor: Rich Coulter (with Mike Ritsche and Donna Holdridge), Argonne National Laboratory

There are no open engineering tasks related to the BBSS instrument suite.

3.4 Broadband Radiometer Station (BRS, SIRS, SKYRAD, GNDRAD, BSRN)

Mentor: Tom Stoffel, National Renewable Energy Laboratory

Engineering Change Order ECO-00642, *Replace SGP/RCF BORCAL Data Acquisition and Control System,* is approved for FY2008 implementation and is in process. The data acquisition system in the Radiometric Calibration Facility (RCF) used for annual BORCAL activities is more than 10 years old and needs to be updated. National Renewable Energy Laboratory (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. System components are on order.

Engineering Change Order ECO-00559, *Pyrgeometer Calibration Improvement*, is in process. Tom Stoffel and Ibrahim Reda have initiated an investigation into the source of the bias in the ACRF pyrgeometer blackbody calibration system in accordance with 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 3°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. In addition, a replacement fluid with better low-temperature (viscosity) characteristics has been identified. 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 the NOAA Earth System Research Laboratory's (ESRL's) Global Monitoring Division.

Reda has replaced the fluid in the pyrgeometer blackbody calibration system at the NREL with a new Dow Corning fluid that offers better low-temperature performance and provides more uniform blackbody temperature control. Preliminary data suggest the 3°C temperature difference between the top of the blackbody hemisphere and the 45° elevation at -30°C is now less than 1°C. Reda continues to explore methods for confirming/correcting this lower ΔT.

3.5 Carbon Dioxide Flux System (CO_2FLX)

Mentor: Marc Fischer, Lawrence Berkeley National Laboratory

There are no open engineering tasks related to the CO2FLX instrument suite.

3.6 Carbon Monoxide (CO) System

Mentor: Sébastien Biraud, Lawrence Berkeley National Laboratory

There are no open engineering tasks related to the CO instrument suite.

3.7 Cimel Sun Photometer (CSPOT)

Mentor: None (external data provided by NASA AERONET). Infrastructure Contact is Laurie Gregory at Brookhaven National Laboratory.

There are no open engineering tasks related to the CSPOT instrument suite.

3.8 Disdrometer (DISDROMETER)

Mentor: Mary Jane Bartholomew, Brookhaven National Laboratory

There are no open engineering tasks related to the DISDROMETER instrument suite.

3.9 Eddy Correlation Station (ECOR)

Mentor: David Cook, Argonne National Laboratory

Engineering Change Order ECO-00657, *Replace Single Board Computer in ECOR*, is in process to upgrade the computers in the ECOR instruments. Dave Cook is the leader. The computers are being upgraded due to maintenance and performance issues. Systems have been purchased and are in evaluation and testing.

Engineering Change Order ECO-00633, *Improve Eddy Correlation Station Software,* is in process. Tim Martin, in association with David Cook, has proposed to systematically evaluate, document, and reorganize the instrument software to allow for code maintenance and more flexible incorporation of additional logic and sensors, such as the proposed wetness sensor. In addition, the user interface needs to be improved to give access to more debugging and diagnostic messages from the ECOR program. Tim Martin reports that the ECOR Version 2.0 software is being tested at Argonne National Laboratory. The software will be deployed and tested on our ACRF systems soon.

Engineering Change Request ECO-00536, *Add Wetness Sensors to ECOR System,* is in process. 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. Wetness sensor testing began at Argonne in mid-January on an ECOR system similar to the ACRF ECORs. Testing so far indicates that different phases of water and

types of dew/frost/precipitation produce different voltage levels from the wetness sensor. Changes to the ECOR programming are underway.

3.10 Energy Balance Bowen Ratio (EBBR) Station

Mentor: David Cook, Argonne National Laboratory

Engineering Change Order ECO- 00645, *Replace T/RH and PRTD Probes in EBBR with Combined T/RH/PRTD Probes*, is in process to upgrade the temperature and relative humidity sensors of our EBBR systems. These upgrades to our 14 operational systems will take place over the next 4 years; spares are included. Dave Cook is the leader. The new combined T/RH probes have been installed in two EBBR systems and are being calibrated at the vendor presently.

3.11 G-Band (183.3 GHz) Water Vapor Radiometer (GVR) (ProSensing)

There is also a GVRP radiometer developed by Radiometrics under the U.S. Department of Energy (DOE) Small Business Innovative Research (SBIR) program. This system is also known as the MP183. The GVRP has 15 channels between 170 GHz and 183.31 GHz. This system has not completed the ACRF baseline processes.

Mentor: Maria Cadeddu, Argonne National Laboratory

Engineering Change Order ECO- 00637, *Upgrade Computer for GVR*, is in process to provide an updated control and user interface computer for the GVR. Maria Cadeddu is the leader. The computer is installed and the performance of the system is in review. This ECO is now completed.

3.12 Infrared Thermometer (IRT)

Mentor: Vic Morris, Pacific Northwest National Laboratory

Engineering Change Order ECO-00616, *Install IRTs in Ventilated Enclosures,* is in process to update our IRT enclosures. In implementing ECO-00345, *Install Zenith-Pointing IRT Network at SGP*, a HEPA-filtered, ventilated enclosure for the IRTs was designed that keeps debris and, incidentally, most rain, off the gold mirror and IRT lens. This enhancement is being implemented on the Tropical Western Pacific (TWP) and NSA IRT instruments. Vic Morris is leading this ECO. Danny Nelson, Jeff Zirzow, and Krzystof Krzton are tasked under Vic's direction to provide designs for SGP, NSA, and TWP respectively.

Engineering Change Order ECO-00368, *Increase Sample Rate of Infrared Thermometers*, is in process to increase the IRT sampling rate to 5 Hz. All systems are functioning, except Nauru (see EWO-1228).

Engineering Change Order ECO-00345, *Install Zenith-Pointing IRT Network at SGP*, is in process. In FY2004, six IRTs were purchased and nine additional IRTs were purchased in FY2005. Some of these have been deployed with the AMF. There are 12 SGP extended facility sites currently equipped with IRTs; 10 additional IRTs would be needed to permit an IRT to be deployed at all 22 SGP extended facilities.

The Working Groups and STEC recommended the addition of the remaining SGP IRTs during FY2008.. Vic Morris is the leader. The goal is to complete installation of nine IRTs this year. One additional system will be budgeted for FY2009.

This year's allocation of IRTs (6) is on order with the delivery expected this month. SGP site operations have provided a plan and are working with the mentor to incorporate these systems.

3.13 Micropulse Lidar (MPL)

Mentor: Rich Coulter, Argonne National Laboratory

There are no open engineering tasks related to the MPL instrument suite.

3.14 Microwave Radiometer (MWR and MWR3C)

Mentor: Maria Cadeddu, Argonne National Laboratory

Engineering Change Order ECO-00664, *Next-Generation MWR Procurement/Deployment*, is approved for action. The Working Groups and STEC have approved the competitive procurement of next-generation 3-channel microwave radiometers (MWR3Cs). The systems are specified to provide three channels operating at 23, 31, and 90 GHz. The strategy is to replace our current aging MWRs with systems that broaden our measurement performance parameters and provide an economic product life cycle for the future. A procurement specification is in development based on the November 2007 "ACRF MWR Futures" workshop outcomes.

The procurement specification is completed and has been provided to the PNNL contracting team for an open solicitation. Maria Cadeddu is the leader. The technical review of proposals and selection process is complete. The final contract award is in negotiation.

3.15 High-Frequency Microwave Radiometer (MWRHF)

Mentor: Maria Cadeddu, Argonne National Laboratory

There are no open engineering tasks related to the MWRHF instrument suite.

NOTE: The two high-frequency microwave radiometers (MWRHFs) are new instruments that are still under testing.

3.16 Microwave Radiometer Profiler (MWRP)

Mentor: Maria Cadeddu, Argonne National Laboratory

There are no open engineering tasks related to the MWRP Instrument suite.

3.17 Millimeter Wave Cloud Radar (35 GHz) (MMCR)

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

Engineering Change Order ECO-00655, *MMCR - End-to-End Calibration Analysis*, is in process to provide a calibration study of the ACRF MMCR systems, as recommended and approved by the STEC for FY2008. A contract was awarded to ProSensing to perform an end-to-end characterization of the MMCR transmitter/receiver calibration.

Engineering Change Request ECO-00638, *Data Ingest Frequency Change for IOPs*, is in process with the goal to support the Indirect and Semi-Direct Aerosol Campaign (ISDAC)/Routine In Situ Cloud and Aerosol Measurement (RISCAM) experiment. This is being tracked in ECO-00638. The MMCR quicklook is running now in cirrus mode and has been migrated to the new PIRAQ computer system.

See http://engineering.arm.gov/~widener/nsa_mmcr/nsa_mmcr_recent.jpg.

Engineering Change Order ECO-00552, *Barrow MMCR-Polarization Upgrade,* is on hold (waiting). Because the PIRAQ-III processor does not support polarization, the installation of the orthomode transducer at Barrow is on hold while calibration issues are being reconciled.

Engineering Change Order ECO-00551, *Refurbish Millimeter Wave Cloud Radar Antennas,* was begun in 2007, and over a three-year period, the MMCR antennas will be refurbished and characterized on an antenna range. 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 be refurbished first to avoid impacting planned field campaigns at SGP. Contract negations are in process for new antennas with a new contractor. For FY2008, two antennas with engineering and fabrication costs are approved for procurement and installation at our SGP and TWP sites. The SGP antenna is 10 ft. in diameter, while antennas used at our tropical sites are 6 ft. in diameter. Two additional antennas are planned for FY2009 to support upgrades to our TWP sites.

Engineering Change Order ECO-00420, *Software I/Q Balancing on MMCR's,* was approved to remedy a problem with balance of the MMCR I and Q channels. This slight imbalance makes spectral analysis very difficult under certain conditions. Radar data provided by the site scientist office at NSA are being analyzed to evaluate software fixes.

Engineering Change Order ECO-00391, *Millimeter Wave Cloud Radar Spectra Processing*, is in process to filter the spectra files produced by the upgraded MMCRs (C40 or PIRAQ-III processors), which range from 8 to 15 GB per day. Engineering Change Order ECO-00575, *Study Network Transfer of MMCR and WACR Spectra to Archive,* is active in Data System Engineering to support this task. Algorithms for eliminating clear-sky periods and compressing the files need to be developed and implemented locally. The data are collected, processed, and shipped hourly. The MMCR spectra compression software has been running at the SGP site since October 1, 2007. Baseline Change Request BCR-01301, *Install MMCR_Spec_Filter (Compress Spectra for MMCR)*, tracks this effort. The compression results are monitored via plots posted at http://c1.dmf.arm.gov/data/process/sgp/sgpmmcrspecmaskC1.a0/2007/.

Overall, the results look very good. There is concern that spectra for some very thin potential clouds are being removed. Approaches to identify these features and retain the spectra at such time-height points without saving very large hydrometeor-free regions of data are under evaluation. All raw (uncompressed) spectra data are being retained for 90 days to allow time to review the compression results. Discussion is ongoing to determine when the shipping of spectra on hard drives will be halted.

3.18 Multi-Filter Rotating Shadowband Radiometer and Related Systems (MFRSR, MFR)

Mentor: Gary Hodges, NOAA/ESRL/GM Division

Engineering Change Request ECO-00350, *MFRSR Integrating of Campbell Data Logger,* is in process to modernize the data acquisition systems for our MFRSR instrument. Fifteen sites are updated at the SGP, with six SGP sites remaining, and the deployment of additional systems has resumed after issues related to the collection software, logger memory, and communications infrastructure were resolved. The TWP, NSA, and AMF research site upgrades will follow. Gary Hodges is leading this effort.

3.19 Narrow Field-of-View (NFOV) Radiometer

Mentor: Gary Hodges, NOAA/ESRL/GMD

There are no open engineering tasks related to the NFOV instrument suite.

3.20 Optical Rain Gauge SGP (ORG)

Mentor: Mary Jane Bartholomew, Brookhaven National Laboratory

There are no open engineering tasks related to the ORG instrument suite.

Note: There are also ORGs installed with the TWP and AMF Metrological Towers. Mike Ritsche is the mentor for these systems.

3.21 Precision Carbon Dioxide Mixing Ration System (PGS)

Mentor: Sebastien Biraud, Berkley National Laboratory

There are no open engineering tasks related to the PGS instrument suite.

3.22 Radar Wind Profiler – 915, 1290 MHz (RWP)

Mentor: Rich Coulter, Argonne National Laboratory

There are no open engineering tasks related to the 915- and 1290-MHz RWP instrument suite.

3.23 Radar Wind Profiler – 50 MHz (RWP)

Mentor: Rich Coulter, Argonne National Laboratory

Engineering Change Order ECR-00662, *50-MHz Wind Profiler Decommissioning*, was submitted to begin the process of removing this radar wind profiler. This recommendation was generated by the ARM Sunset Committee, which is chaired by the ARM Chief Scientist. This aging system has experienced maintenance and performance conditions that are too expensive given the science utility of the corresponding data set.

3.24 Raman Lidar (RL)

Mentor: Rob Newsom, Pacific Northwest National Laboratory

There are no open engineering tasks related to the RL instrument suite.

3.25 Rotating Shadowband Spectrometer (RSS)

Mentor: Peter Kiedron, NOAA/ESRL/GMD

Peter Kiedron demonstrated that the rotating shadowband spectrometer (RSS), built by Yankee Environmental Systems, Inc., 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 for a complete overhaul.

An Engineering Change Request ECR-00661, *RSS Overhaul: Perform Maintenance and Overhaul of RSS*, was submitted and approved to perform the upgrade and overhaul of the RSS. Peter Kiedron is the lead. The Working Groups and STEC recommended the re-engineering of the RSS for implementation in FY2008. A BCR is in process (BCR-01457, *Defield RSS and Ship to NOAA and Boulder*) that has removed and shipped the RSS to NOAA for refurbishment. A Data Quality Report is filed to document the outage and a message is posted on the RSS Instrument webpage. The disassembly, analysis, and characterization of the RSS are ongoing, and while good progress is being made, technical issues with the stability and performance of the RSS are under evaluation.

3.26 Shortwave Spectrometer (SWS)

Mentor: Connor Flynn, Pacific Northwest National Laboratory

There are no open engineering tasks related to the SWS instrument suite.

3.27 Soil Water and Temperature System (SWATS)

Mentor: Daniel Hartsock, University of Oklahoma

The soil water and temperature system (SWATS), deployed at the SGP site, is designed to provide information about the temperature of the soil and the status of water in the soil profile. Because the SWATS array is aging, the sensor arrays are undergoing a replacement program.

Engineering Change Order ECO-00493, *Replace Failing SWATS Sensors*, is in process to add new redundant sensor arrays that will be installed at all SGP extended facility sites. These will be installed in a phased manner: five sites per year over four 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. Sensor arrays for FY2009, from Campbell Scientific, have arrived at the SGP. ACRF Operations and the mentor are working toward connecting the three previously refurbished sites (2006). Once that is complete, the next phase of reinstallations can begin. The specific sites have not yet been determined, but will most likely be those that have the greatest number of bad sensors within the redundant profile arrays. There are four other sites (E1, E5, E6, and E8) that still need confirmation whether or not a reinstallation was performed (2007). In addition to the 90 new sensors just received, there are 90+ unused sensors in storage at the SGP (and most likely uncalibrated).

3.28 Surface Meteorological Instrumentation

Mentor: Mike Ritsche, Argonne National Laboratory (SMET, SMOS, SURTHREF, THWAPS, MET, METTWR [NSA Site])

Engineering Change Order ECO-00595, *Upgrade T/RH Probes and Wind Sensors for NSA Met System.* Ice develops on the wind vanes, cup anemometers, and aspirator inlets for the temperature and RH 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 RH probes with new, heated probes designed to operate in cold environments. System components have been received; configuration and testing is ongoing in support of this ECO, which is approximately 90% complete.

Engineering Change Request ECR-00672, *Upgrade Dynamic Rain Gauge Calibration System*, is approved. This task is in process to improve the characterization and performance of our precipitation measurements.

3.29 SuomiNet Global Positioning System (SuomiNet)

Mentor: None (external data provided by SuomiNet/COSMIC). Rick Wagener, Brookhaven National Laboratory, is our infrastructure contact.

Please see http://www.unidata.ucar.edu/data/suominet/ and http://www.arm.gov/xds/static/suomigps.stm for the details on the SUOMIGPS data.

3.30 Tandem Differential Mobility Analyzer (TDMA)

Mentor: Don Collins, Texas A&M University

Engineering Change Request ECO-00640, *Replace AOS Optical Particle Counter with Aerodynamic Particle Sizing Spectrometer*. The Working Groups and STEC approved the addition of an APS in FY2008 to replace the Optical Particle Counter (OPC) component of the TDMA. Don Collins, TDMA Instrument Mentor, has responsibility for integrating the APS with the SGP AOS. The procurement

group has received the procurement specification and final negotiations are advancing with the vendor, TSI Inc. This instrument system has been received at Texas A&M University.

Engineering Change Request ECO-00587, *Develop Collection and Ingest for TDMA*. Data from the tandem differential mobility analyzer (TDMA) currently are 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 ACRF Data Archive as "beta data." An ingest is being developed to produce netCDF files for inclusion in the main data archive. The communications group is contacting Don Collins to develop a web area, enter instrument metadata, and edit the instrument handbook. The TDMA needs to have an entry added to the IMMS reporting system.

Data from 2005-2007 have been processed for delivery to the ACRF Data Archive. The raw data delivered to the Archive is a second task under ECO-00587.

3.31 Total Precipitation Sensor (TPS)

Mentor: Mark Ivey, Sandia National Laboratory

The total precipitation sensor (TPS), TPS-3100, was returned by Yankee Environmental Systems, Inc., in October. We shipped the instrument to Jessica Cherry at the University of Alaska Fairbanks (UAF), who will set up the instrument at UAF for evaluation.

Engineering Change Order ECO-00344, *Snow Measurement Instrumentation Needs for the NSA*, is in process to add and evaluate this capability. Bernie Zak is the leader.

3.32 Total Sky Imager (TSI)

Mentor: Vic Morris, Pacific Northwest National Laboratory

Engineering Change Request ECR-00674, *Tasks Associated with TSI Camera and Software Upgrade*, is in review to provide an upgraded camera for the TSI. Vic Morris is the lead.

Engineering Change Order ECO-00644, *Subcontract to Upgrade TSI Software*, was approved to upgrade the TSI software to allow use of new versions of the Axis camera. Concepts to incorporate the packaging and mechanical design of the new version of the Axis camera will be covered in a new ECR. There are six tasks related to the associated software specification; three are completed.

Engineering Change Order ECO-00625, *Upgrade TSI Control Boards*, was approved and is in process to update the control boards of our TSI-880 systems. This update will reconcile issues with the real-time clock and power supplies.

3.33 Tower - Meteorological Tower Systems (TWR)

Mentor: David Cook, Argonne National Laboratory

Engineering Change Order ECO-00645, *Replace T/RH and PRTD Probes in EBBR with Combined T/RH/PRTD Probes,* was approved to provide a replacement meteorology system for the tower. The new system is using sonic anemometers in place of the cups and vanes, and a new Vaisala T/RH system in place of the present ones. Testing of the new system will begin in November at Argonne National Laboratory. The new combined T/RH probes have been installed in two EBBR systems and are being calibrated at the vendor presently.

3.34 Vaisala Ceilometer (VCEIL)

Mentor: Vic Morris, Pacific Northwest National Laboratory

There are no open engineering tasks related to the VCEIL instrument suite.

3.35 W-Band (95-GHz) ARM Cloud Radar (WACR)

Mentor: Kevin Widener, Pacific Northwest National Laboratory

Engineering Change Order ECO-00658, *WACR–Add Scanning Capability*, is in process to plan the initial science, operational, and technical objectives of the development and lead to a procurement specification. Kevin Widener is the leader. During the December 2007 ARM STEC meeting, a scientific and programmatic consensus was reached to add a scanning capability to our SGP W-band ARM cloud radar (WACR). This enhancement to the WACR will provide an ACRF product for evaluating the 3D cloud properties first at the SGP site and then, depending on portability (or transportability) and robustness, other ACRF research sites. The contract with ProSensing is placed and the scanner is being procured.

Engineering Change Order ECO-00654, *WACR–Spectra Notch Filter*. The WACR has a software deficiency in the way that the direct current (DC) signal is processed in the Fast Fourier Transform (FFT). ProSensing has identified a method for handling this by incorporating a notch filter to take many averages of the I/Q signal and use this in the FFT. The data stream will remain unchanged. The contract has been placed with ProSensing and work is underway.

Engineering Change Order ECO-00391, *Millimeter Wave Cloud Radar Spectra Processing,* proposes that we evaluate the feasibility of implementing data reduction algorithms at each MMCR and WACR installation and shipping the resulting files to the ACRF Data Archive via the Internet. A version of this software is in the release process to test ECO-00391 and ECO-00575. Implementation is underway and documented in BCR-1349, *Install WACR_Spec_Filter in Production*.

4. Future Instrumentation Planning

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

4.1 ARM Program Volume-Imaging Array (AVA)

The ARM Volume-Imaging Array (AVA) is a proposed radar system to be deployed at the SGP site to address the ARM Program's need to map 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 Kollias include the following:

- 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), 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 active remote sensing cloud layer (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 large-eddy simulation (LES) model and cloud-resolving model (CRM) 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 ACRF SGP site every year for 1-2 months of continuous observations.

STATUS – Consideration of the AVA, as such, is on hold, until simulations have been carried out to demonstrate its capabilities and further refine the requirements.

4.2 Collaborative Adaptive Sensing of the Atmosphere

ACRF is a member the Collaborative Adaptive Sensing of the Atmosphere (CASA) consortium; this concept is being assessed to determine its utility to ARM and ACRF science objectives. There is a good analysis data set available to the community that spans the CLASIC experiment. The precipitation fields and related data products from the CASA array are being incorporated into ARM cloud modeling and properties research. In parallel, a life-cycle cost and logistical feasibility assessment is underway within the ACRF infrastructure, including site preparation and leasing, infrastructure, operations, towers, installation costs, radar modifications, data infrastructure, and processing impacts. See http://www.casa.umass.edu.

STATUS – Ongoing review of needs and impact

4.3 Absolute Scanning Infrared (ASIR) Radiometer

To provide an absolute infrared (IR) flux reference, which could be used to calibrate the Eppley PIRs, Ellsworth Dutton suggested that ARM develop an absolute scanning infrared (ASIR) radiometer. This instrument would be functionally equivalent to an ASIR developed by Rolf Philipona for the World

Meteorological Organization (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.

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. At this time, an estimated beginning of the instrument deployment would be FY2010—depending on the review of overall instrument priorities by the STEC and ACRF Infrastructure Management Board.

4.4 Raman Lidar (RL) for Optical Extinction and Water Vapor Profiles

There is the need to deploy a Raman or high-spectral resolution lidar to measure extinction at the NSA Barrow site to provide measurements of optical extinction and water vapor profiles.

STATUS – Scientists within the ARM Working Groups are refining science needs and discussing instrument and measurement approaches. A target milestone for deployment, pending favorable scientific and infrastructure review, will take place in FY2010.

4.5 Upwelling Spectral Measurements Using Multi-Filter Radiometers (MFRs) at ARM Mobile Facility Sites

Downlooking multi-filter radiometers (MFRs) for the AMF are needed to estimate the surface spectral albedo. The Working Groups and STEC recommend acquiring two, one for the main AMF and one for its "supplemental" facility. The radiometers will be placed on 10-m towers for better representative measurement. This task has been approved for FY2009 implementation.

Engineering Change Order ECR-00659, *Add Two MFRs to the AMF Instrument Suite*, was entered to guide and document the addition of upwelling MFRs to the ACRF AMF. Gary Hodges is the leader. Some ramp up to provide this measurement is expected this year. The first radiometer will be installed and verified during our AMF Azores experiment in FY2009, even though surface albedo at the AMF central site will not be representative of the local scale due to the dominant effects of the surrounding sea surface. A second upwelling MFR is proposed for addition to the AMF Supplemental Site during FY2010; a spare MFR head will be purchased then.

4.6 1.6-Micron Multi-Filter Rotating Shadowband Radiometer (MFRSR) Channel

This device was built by replacing an unfiltered channel on a multi-filter rotating shadowband radiometer (MFRSR) with an InGaAs detector and a 1.6-µm filter for scientific evaluation. The Radiative Processes Working Group would like to have these data available for analysis and ran at the SGP in field campaign mode. Before a field campaign can begin, we need to run this system through the SGP Cosine Bench Calibration. Pending review of the data, the Radiative Processes Working Group would like to consider the costs to add a 1.6-µm channel to select ACRF MFR/MFRSR heads. This task is approved by the STEC to continue for evaluation. Sally McFarlane, Science Translator for the Radiative Processes working group, reports: "The Radiative Processes Working Group suggested that ARM should evaluate the addition of a near-IR channel to the MFRSR for the potential to improve retrievals of aerosols, cloud

size distributions, and surface albedo. As a test of this capability, an unfiltered channel on a multi-filter rotating shadowband radiometer (MFRSR) was replaced with an InGaAs detector and a 1.6-µm filter for scientific evaluation. This MFRSR was run at the SGP Central Facility from 12/20/2007 through 02/08/2008. These data are now available on the ARM website for evaluation purposes: http://www.db.arm.gov/cgi-bin/PIP/viewPIP.pl?pipNo=33. Please contact Joe Michalsky (joseph.michalsky@noaa.gov) if you have any questions about the data set."

4.7 Automatic Radiosonde Launcher for the North Slope of Alaska Barrow Research Site

The sonde launcher is proposed to optimize downstream operational costs and thereby enable additional daily sonde launches. However, additional information is requested to determine its ability to work reliably in such an extreme climate. This information may be obtained either from demonstration or, perhaps, verification from operations at a similar site.

Doug Sisterson talked with Vaisala about this system. Their specification does state performance in climates from tropical to polar; there is a need to verify NSA suitability. There is an Autosonde operating in Whitehorse, Yukon, but that is only at about 60.66 N (Barrow is at 71 N). There is also a system at Bodo, Norway, at 69 N. Barry Lesht was checking with Vaisala to see if they have any installed at higher latitudes and to ascertain performance.

STATUS – Based on the December STEC meeting discussions, this system is on hold until possibly FY2010.

5. Small Business Innovation Research

The U.S. Department of Energy (DOE) Small Business Innovative Research (SBIR) web page is available at http://www.er.doe.gov/sbir/.

5.1 Eye-Safe Ultraviolet Backscatter Lidar for Detection of Sub-Visual Cirrus (FY2006/FY2007)

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 for "Eye-Safe UV Backscatter Lidar for Detection of SubVisual Cirrus." See http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/039.htm.

Phase I funding was also awarded to Physical Sciences, Inc., for "Field-Worthy UV Backscatter Lidar for Cirrus Studies." See http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/044.htm.

STATUS – Awarded funding to proceed to Phase II development. See http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase2/p2_award.htm.

5.2 Instrumentation for Remotely Sensing Aerosol Optical Properties – Aerosol Phase Function (FY2006/FY2007)

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., for "CAPS-Based Particle Single Scattering Albedo Monitor." See http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/040.htm.

STATUS – Awarded funding to proceed to Phase II development. See http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase2/p2_award.htm.

5.3 Unmanned Aerospace Vehicle-Suitable Cloud Radar (FY2006)

Phase I funding was awarded to ProSensing, Inc., for "High-Power, Pod-Mounted W-Band Cloud Radar for UAVs." See http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/045.htm.

STATUS – This instrument system proposal did not receive SBIR Phase II funding.

5.4 In Situ Measurement of Cloud Properties with Large Sample Volumes (FY2007)

The following two proposals were selected for 2007 Phase I funding:

- "Dual Wavelength In Situ Cloud Lidar" by Physical Optics Corporation

  NOTE: This same company received 2005 Phase I funding for the Oxygen A-Band instrument.
- "A Dual-Wavelength In Situ Cloud Lidar with Very Large Sample Volume" by SPEC Incorporated.

STATUS – This instrument system proposal did not receive SBIR Phase II funding.