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First ARM/ASR Radar Workshop: Workshop Summary and Recommendations

KB Widener and P Kollias

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ARM

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Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

AMF	ARM Mobile Facility
ARM	Atmospheric Radiation Measurement (Climate Research Facility)
ARSCL	Active Remote Sensing of Clouds
ASR	Atmospheric System Research
C-SAPR	C-band scanning ARM precipitation radar
DQR	Data Quality Report
IOP	intensive operational period
Ka-SACR	Ka-band ARM scanning radar
KAZR	Ka-band ARM zenith radar
MC3E	Midlatitude Continental Convective Clouds Experiment
NSA	North Slope of Alaska
QC	Quality Control
RHI	range height indicator
SACR	scanning ARM cloud radar
SGP	Southern Great Plains
VAP	value-added products
W-SACR	W-band scanning ARM cloud radar
X-SAPR	X-band scanning ARM precipitation radar

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1.0 Day 1: February 21, 2013

1.1 Welcome from the University of Miami

Dean Roni Avissar and Professor Bruce Albrecht

The Dean of the Rosenstiel School of Marine and Atmospheric Sciences, Professor Roni Avissar, mentioned in his welcome message the large investments currently underway at the Rosenstiel School and especially the new Marine Technology & Life Sciences Seawater building that is a state-of-the-art facility expected to support biomedical science and air-sea interactions, including the effects of hurricanes. Professor Albrecht highlighted the contributions of Dr. Roger Lhermitte (Emeritus Professor at the Division of Meteorology and Physical Oceanography) to the development of millimeter wavelength (mm-wavelength) radars.

1.2 Management Perspective and Workshop Charter

Jim Mather, ARM Technical Director

Jim Mather discussed the Atmospheric Radiation Measurement (ARM) Climate Research Facility radar landscape before and after the American Recovery and Reinvestment Act period. He underlined the need to learn how to operate these radars, have high quality data, and perform transforming science.

1.3 State of ARM Radar Operations and Engineering

Kevin Widener, Leader, ARM Radar Operations and Engineering Group

Kevin Widener discussed the operational status of the ARM radars.

- All Ka-band ARM zenith radars (KAZRs) are operating except the one located at the Tropical Western Pacific Manus site.
- The second ARM Mobile Facility (AMF2) will deploy to Finland after the Marine ARM GPCI Investigation of Clouds field deployment.
- The scanning ARM cloud radars (SACRs) at the Southern Great Plains (SGP), first ARM Mobile Facility (AMF1) and North Slope of Alaska (NSA) are operational.
- The C-band scanning ARM precipitation radar (C-SAPR) at the SGP is operational, but the one at Tropical Western Pacific-Manus is still down.
- The X-band scanning ARM precipitation radar (X-SAPR) at Barrow is operational, and one of the X-SAPRs at the SGP is operational.
- The contract for the development of the 0.5 degree beamwidth X-SAPR2 at the Azores has been placed and a new Request for Quotation for the C-SAPR2 has been send out with a time deadline of four months and a maximum ceiling price of $2 million.

1.4 State of Atmospheric System Research Radar Science

Pavlos Kollias, Leader, ASR Radar Science Group

Pavlos Kollias discussed the role of the Atmospheric System Research (ASR) Radar Science group. The top priority of the radar science group is to strengthen the one-dimensional (1D) column observations with the calibration of the KAZRs using the SACR corner reflector strategy, the addition of multi-wavelength observations (additional SACR frequency and collocation of radar wind profilers next to each KAZR), and the use of the recorded radar Doppler spectra. The calibrated radar measurements in the column can also be used as a calibration reference for the scanning precipitation radars at the ARM sites. Thus, the Radar Science Group considers the calibration of the ARM radars as the theme of the workshop. Another important priority of the Radar Science Group is the building of a broad ARM/ASR radar team that works together towards achieving the scientific objectives of the ASR program.

1.5 Value-Added Product Development

Michael Jensen, ARM Cloud Products Translator

Michael Jensen outlined the development, evaluation, and production stages for value-added products (VAPs) and the main differences between operational and research products. There are 7.5 full-time employees in VAP development and 4.5 full-time employees in radar products. One of the concerns of the VAP process is that not many scientists check the evaluation products. Jensen also offered his opinion on how the Radar Science Group can help the infrastructure: develop PI products that could be converted to VAPs, share code, sponsor VAPs, evaluate evaluation products and provide feedback, and express needs and priorities.

At the end of session, the Radar Science Group recommended the development of mechanisms and processes to enforce communication between the Radar Operations and Engineering Group, the Radar Science Group, and the developers at the laboratories. Such mechanisms could include a monthly detail teleconference between the radar groups and another one with the participation of the radar VAP developers.

1.6 Radar Calibration

Nitin Bharadwaj, ARM Radar Engineer

Nitin Bharadwaj discussed the internal calibration of the SACRs and KAZRs, which is superior to the one available at the ARM SAPR systems. Furthermore, the SACR systems (at least the one at the SGP) are calibrated using a novel approach, with a corner reflector. The corner reflector is 500 meters away from the Ka-/W-band scanning ARM cloud radar (W-SACR) location and 200 meters away from the Ka-/X-SACR location. It was suggested by workshop attendees that we should correct for two-way gaseous attenuation from the radar to the corner reflector location. Using the SACR comprehensive calibration data, the KAZR systems are also calibrated using observations when the SACR is pointing vertically. Overall, the workshop attendees characterized the SGP KAZR and SACR calibration work outstanding. The calibration model developed there by the ARM Radar Operations and Engineering Group appears to be quite viable; it represents a quantum leap forward. A complete raster scan of the corner reflector takes

20 minutes, and it is repeated twice a day. It is recommended that a subset of the complete raster scan (completed in 2–3 minutes) is repeated more frequently to keep track of the radome effect on the antenna pattern. Pointing calibration at this point is accomplished using the sun. However, despite its strong emission signal, the sun is not an optimum pointing calibration reference at mm-wavelengths (smeared image). The sun is a much better pointing calibration technique for centimeter-wavelengths (cm-wavelengths). Another important datastream from the SACRs is the sky noise (radiometer) data that are included in the ingest files. No specific numbers were provided about the signal levels in dBZ (radar reflectivity) at a reference height that saturate the KAZR and SACR receivers. It was pointed out at the meeting that knowledge of saturation information is crucial for the use of radar observations in multi-frequency retrievals.

At the end of session, the Radar Science Group recommended that we should accelerate the scheduling for the installation of corner reflectors at all ARM fixed and mobile sites and the implementation of a calibration scan strategy that will be repeated more than twice a day (once every two hours). Attendees acknowledge the work that Nitin and the rest of the Radar Operations and Engineering Group is doing and suggested that ARM should internally find how to best use its resources (developers) to assist in the short term to accomplish core activities (e.g., strengthening of the column measurements) rather than using resources for generic VAP development. The workshop attendees also agreed that if there are hardware/signal processing solutions to data quality, they should also be implemented as a high priority. One such example is the mitigation of second trip echo at the SACRs.

1.7 Ingest VAPs and Data Quality Reports

Eugene Clothiaux, The Pennsylvania State University

Eugene Clothiaux led a session with co-speakers Scott Collis, Karen Johnson, and Adam Theisen. Collis mentioned that all SAPR data would move to the CF/radial data format in the near future. This is highly desired by the Radar Science Group, because it is expected to enable access to the data to more users. Collis also mentioned the need for calibration/aux files that will contain well-documented calibration coefficients. During the Midlatitude Continental Convective Clouds Experiment (MC3E) the SAPRs were calibrated using disdrometer measurements. Overall, the calibration of the SAPR systems is quite different from the one envisioned for the KAZR/SACR system. There is poor internal calibration in the X-SAPRs, and there are no plans for corner reflectors at X-/C-SAPRs. Ground-based measurements of the particle size distribution using optical or impact disdrometers is one possibility. Karen Johnson suggested the renaming of the KAZR operating modes from boundary layer/cirrus (BL/CI) and GE to long pulse (LP) and short pulse (SP) respectively.

The workshop attendees agreed with the proposed renaming. Karen also stated that currently there is no saturation information (saturation curves) in the KAZR and SACR ingest files. Karen also stated that currently we have no algorithm for second-trip mitigation in the SACR data and that it is highly desirable that if hardware/signal processing can mitigate the second trip all together, this should be done sooner rather than later to minimize the volume of data affected by second-trip echoes. Data reprocessing is backed-up in ARM, and prioritization is needed. Two other options are reprocessing on demand (if there is new calibration information and a user wants the data, then the archive performs the processing) or having the users performing the calibration corrections using the new calibration files. The issue was not resolved during the session. Low priority: move KAZR data format to the CF/radial format.

Eugene Clothiaux and Adam Theisen led the discussion for metadata and Data Quality Reports (DQR). There is a need for machine-readable data and DQRs. Jimmy Voyles indicated that such provisions already exist in variable stages. The infrastructure has the process in place to capture the information of the radar in the new archive format. The workshop attendees suggested to change the default color from green to white (no documentation on the quality of the data) in the new ARM Data Archive data depot. It will be task of the instrument mentors, developers, Data Quality Office, and radar scientists to change their color to red, yellow, and eventually to green. Adam also suggested moving radars to a baseline state of operation so we can start submitting Data Quality Problem Reports once a radar goes down or issues are observed. All radar scientists are encouraged to submit Data Quality Problem Reports to the system. The case of the NSA radars was used in the discussion as an example to figure out how to proceed with posting/reporting data issues and how to request the assistance of the Radar Science Group for testing and evaluating sampling modes and the performance and quality of the radar observables. This discussion led to recommendations and the articulation of an action plan by the Radar Science Group during the second day of the meeting.

1.8 Quality Control Data Products Definition and Algorithm Review (Part I: SAPR)

Scott Collis, Argonne National Laboratory

Scott Collis led the discussion on ARM SAPR products. Brenda Dolan (Colorado State University), Courtney Schumacher (Radar Science steering committee, Texas A&M), Silke Tromel (Radar Science steering committee, U. of Bonn), Alexander Ryhzkov (University of Oklahoma), and Scott Giangrande (Brookhaven National Laboratory) also presented their algorithms for developing Quality Control (QC) data products from the SAPRs. Collis provided a brief presentation of the SAPR VAPs under development, in evaluation, and in production. No details were provided about the algorithms used in the data production. Only C-SAPR algorithms are available at this point. Currently, we have no such algorithms developed/evaluated for X-SAPRs. From the X-SAPR network at the SGP there is an evaluation product (Convective Vertical Velocity). Collis underlined that the presented algorithms products are not suitable for the NSA X-SAPR (no effort has been put towards the development/evaluation of such products) or for the X-SAPR2 at the Azores.

The Radar Science Group indicated that the NSA and Azores sites are unique sites in the vicinity of very climatically climatically cloud systems and that we need to: (1) assess the added information from X-band measurements at these two sites and (2) develop a suite of algorithms capable of observing low-level stratiform clouds with precipitation at both sites. Furthermore, it is important to work on the development of sea-clutter mitigation algorithms at these two coastal sites. The Radar Science Group recommended the development of a small group of radar scientists that are willing to develop cloud-sensing algorithms at X-band.

Courtney states that it looked reasonable to assume that we will have reasonable performance from C- and X-band algorithms for precipitation, and there are available algorithms in the university community. Brenda presented a comparison of specific differential phase (Kdp) fields from the X-band radars at the SGP during MC3E using the Dixon and DROPS methods. Silke presented the Bonn dual X-band radar network algorithms. Alexander reported that beam blockage at the C-SAPR is significant. Correlation coefficient (RHO-HV) does not attain high values in rain (max value 0.98 and should be at least 0.995).

This points to major issues in the hardware. Alexander provided a very good assessment of the C-SAPR performance. Differential reflectivity (ZDR) is well-calibrated. Differential propagation phase (PHI-DP) is very well-processed. Scott Giangrande presented his novel algorithm for Kdp processing that he developed using MC3E data and is currently used in the C-SAPR processing.

1.9 Challenges Facing a Reliable ARM Radar Network

Kevin Widener

Kevin Widener led a discussion on the challenges associated with the ARM radar network. Despite the two recent hirings, it is clear that the ARM Radar Operations and Engineering Group is under-staffed for taking on the task to maintain 33 radars at seven different locations. Two additional issues have contributed in the limited operational capability of the acquired radar systems. First, while the SACRs are state-of-the art radar systems with versatile digital transceiver capabilities and comprehensive internal calibration, at the same time, due to the rules associated with the American Recovery and Reinvestment Act funding, there was not time for the development of a research and development prototype systems. As a result, ARM proceeded to field six prototypes. Thus, the ARM Radar Operations and Engineering Group is troubleshooting these systems while they are deployed at the ARM sites. The main technical challenges so far involved the high power supply for the transmitter and the scanner slip rings. On the other hand, the SAPR technology is mature; however, there are several upgrades that need to be done.

2.0 Day 2: February 22, 2013

2.1 Discussion Continued from Previous Day

The second day started by continuing the discussion from the first day. Nitin mentioned that is desirable to upgrade the C-SAPR digital receiver and to integrate the radar controller. For the X-SAPRs, Nitin suggested the installation of built-in test equipment for calibration and to consider down the road to replace the single offset dual-polarization antennas with parabolic ones for better polarimetric performance. The workshop attendees suggested that we should collect observations before we move on to a recommendation for such replacement. For the SACRs the ARM Radar Operations and Engineering Group recommends to slave the radar control boards to a master for better timing of the two frequencies and to the W-SACR front end to reduce losses and improve sensitivity. The day ended with the ARM Radar Operations and Engineering Group looking for feedback on the science expectations with respect to operations (e.g., 24x7 operation versus shorter, high data quality periods) and for prioritization of issues related to the ARM radars in order to optimize scheduling and resource allocation.

Pavlos presented a set of recommendations from the Radar Science Group. The first set of recommendations is related to the desire to have an intensive operational period (IOP) at the NSA possibly in 2014. The goal of the IOP will be to: (1) assess the quality of the X-SAPR observations for a variety of sampling modes, (2) assess the real-time signal processing of the X-SAPR by collecting I/Q time series, and (3) assess the potential of the SACR to provide the mesoscale coverage expected by the X-SAPR. This will require the implementation of different scan strategies for the SACR. One of the expected outcomes of the IOP will be an assessment of the polarimetric capability of the X-SAPR offset antenna. If the IOP findings suggest that the antenna is a primary source for low-quality polarimetric

measurements, the Radar Science Group will recommend its replacement in a timely manner and another IOP at the NSA when the new antenna is in place. Another critical outcome of the IOP is an objective assessment of the value of the X-SAPR observations at the NSA and the effort required to produce high-quality VAPs from the NSA X-SAPR.

The Radar Science Group also finds the SGP KAZR and SACR calibration work outstanding. The calibration model developed there appears to be quite viable; it represents a quantum leap forward. As a result, there is much to gain by extending this model to the NSA and the AMFs. Thus, the Radar Science Group recommends that corner reflectors and the calibration model be extended to the NSA and AMFs as rapidly as is possible. The Radar Science Group supports the Radar Operations and Engineering Group not revisiting Manus in the upcoming year to focus activities on KAZR/SACR calibration. In return, we would support a "Year at Manus" in the near future in which focus is placed on the site to obtain high-quality data from it.

Other recommendations and priorities from the radar science group include:

- The processes for reconciling SACR/KAZR calibration and finalizing treatment of calibration within SACR/KAZR ingest are high priority; reprocessing of SGP and other site data requires it.
- Follow-up NSA IOP with a similar IOP for the X-SAPR2 at the Azores as soon as possible.
- X-band radars are at the interface of the precipitation and cloud/radiation communities. The Radar Science Group will facilitate interactions between these two communities within the ASR community and will form a group of radar scientists to work on such research algorithms for the X-SAPR2.
- The Radar Science Group will work with Karen Johnson to redesign and rebuild the Active Remote Sensing of Clouds (ARSCL) VAP in an attempt to make it fully automated.

At the end of the session, Roger Marchand (University of Washington) suggested a short IOP at the SGP to test the impact of the azimuthal spacing between range height indicator (RHI) scans (currently 2 degrees) of the BL-RHI scan strategy on the quality of the 3D cloud observations. Roger is in favor of the BL-RHI scan strategy; however, he suggests that we should reduce its azimuthal sector limit (currently 90 degrees) so we can have more density in azimuth RHI scans.

2.2 QC Data Products Definition and Algorithm Review (Part II: SACR/KAZR)

Michael Jensen, Brookhaven National Laboratory

Michael Jensen led the discussion on SACR, KAZR, and micro-ARSCL products. Pavlos stated that we should start thinking about a joint grid (time-range) dual-wavelength radar VAP from the Ka-/W-SACR systems. The workshop attendees stated that it is a bit premature to think about such products; however, they agreed that we should start developing some examples to see if the two radar systems are sampling the same volumes.

Karen Johnson described the SACR VAP algorithms. The presentation was detailed and included all major modules: feature mask, gaseous attenuation, and Doppler velocity unfolding. It was suggested that maybe there is better code than Liebe for water vapor attenuation correction. Furthermore, it was

suggested that we use the MERGESONDE VAP instead of the sounding for WV attenuation correction. Karen also presented the KAZR processing that also includes gaseous attenuation correction and Doppler velocity unfolding. Furthermore, the KAZR processing includes rain gauge, liquid water path (LWP), merge sounding, micropulse lidar (MPL), and ceilometer.

Ed Luke described the Micro-ARSCL VAP that estimates several morphological parameters of the recorded radar Doppler spectra. Ed is using graphical processing units to process the radar Doppler spectra and has achieved speeds of 230 kspectra/sec. This implies that he can process all the recorded radar Doppler spectra in the ARM Data Archive in 2–3 days. Ed's post-processing of the radar Doppler spectra leads to improved quality radar moments. Once such example is the radar Doppler spectrum width. It was recommended at the meeting that Prosensing provide Ed with their real-time code that estimates the spectrum width. This will enable a more detailed understanding of the observed differences in the spectrum width field estimated by the standard (real-time) and micro-ARSCL (post-processing) algorithms. The micro-ARSCL also provides a very good first estimate of the presence of insects in the KAZR observations. The insect mask and spectrum width estimates from the micro-ARSCL should be used as input to the KAZR-ARSCL VAP. Workshop attendees were impressed by the computational capabilities of graphical processing units-based programming, and it was suggested that in the future all real-time processing should be done the same way.

2.3 Radar Science

Pavlos Kollias, McGill University

A series of presentation from ASR radar PIs:

- Chandra Chandrasekar (Colorado State University) presented a general framework for network, multi-frequency retrievals. Chandra is more interested in signal processing at the radar level.
- Alexander Ryzhkov (University of Oklahoma) stated that polarimetry-based estimates of rainfall rate are more accurate than traditional, non-polarimetric Z-R relationships at S-band. Rainfall and liquid water content estimates based on specific attenuation are more robust and not dependent on the shape of the drop-size distribution. Use total differential propagation phase (PHI-DP) in the path as path-integrated attenuation (PIA). Alexander presented examples of R(Z), R(A), and R(Kdp) from Vance NEXRAD.
- Silke Tromel (University of Bonn) presented the results of a consultation with the ASR modeling group about what they want from radar observations. The key message is that modelers like to do their own statistics. Modelers are interested in conducting fundamental science and not just model verification. They need quality-controlled radar fields, not raw data. At the top of their list are also user-friendly data, gridded but not smoothed.
- Jay Mace (University of Utah) wants to understand errors in retrieval algorithms originating from the assumption made in the forward model that connects the state vector with the observations vector. There are several examples of published algorithms that differ in orders of magnitude when applied to the same data set. Forward model assumptions can kill you. Jay fit a forward model on snow Doppler spectra from the AMF deployment at Colorado and illustrated that there are large uncertainties. Jay's framework can be used to guide a comprehensive approach in in situ measurements.

- Mark Miller (Rutgers University) presented nested Weather Research and Forecasting (Model) simulations from the Two-Column Aerosol Project. Mark is trying to forward-model the model out to radar observations to evaluate the potential of the SACR scan strategies to map the 3D cloud fields.
- Hans Verlinde (The Pennsylvania State University) presented mixed-phased Doppler spectra work. Hans indicated that the quality of the recorded radar Doppler spectra from the KAZR is superior. There is a wealth of information in the radar Doppler spectra about dynamical and microphysical processes in mixed-phased clouds. Hans indicated that the NSA X-SAPR observations are very noisy and that he will work with the Radar Science Group to set up the proposed IOP at the NSA.

Appendix A: Action Items

A.1 Action Items

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Coordination/Communication	2013.01.01	Establish monthly conference call between ASR and ARM radar groups	1	Kollias/Widener	Continuous	
Coordination/Communication	2013.01.02	Establish monthly conference call between VAP developers and ASR radar PIs	2	Kollias/Johnson/Collis	Continuous	Feedback, not waiting for a year to adjust if necessary, validation
Coordination/Communication	2013.01.03	Recommend having annual ARM/ASR Radar Workshop approximately one month before ASR Science Team Meeting	4	Kollias/Widener	Annual	Resist growth, less than 30 attendees, keep formated and focused, aids communication to end users at STM
Coordination/Communication	2013.01.04	How do we communicate data quality and data availability for present or future deployments (ARM-wide issue)	3	Mather		User ASR Radar Science group to provide feedback - works as prototype for rest of ARM, ECR to be submitted by Jim
Prioritization Guidance	2013.02.01	Strengthening 1-D measurements should be the top goal for the ARM radars	1			Guiding principle
Prioritization Guidance	2013.02.01	Whether vertical or scanning radars, we need the best vertical profiles	1			Guiding principle

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
IOPS/Field Campaigns	2013.03.01	Hans Verlinde to propose XSAPR IOP at Barrow to evaluate quality of polarization parameters (and scanning options?) in late April, early May	1	Verlinde	3/15/2013	Hans is working on it.
IOPS/Field Campaigns	2013.03.02	Roger Marchand to propose an IOP that will evaluate optimum beam spacing for the Boundary Layer mode in the SACRs at SGP, MWR/Parsivel for radar ground validation	1	Marchand	3/15/2013	Pavlos to contact Roj.
~~IOPS/Field Campaigns~~	~~2013.03.03~~	combined with 2013.03.02	~~3~~	~~Marchand~~	~~summer 2013~~	-
IOPS/Field Campaigns	2013.03.04	Revisit Collis ground validation field campaign when Manus CSAPR is operational for a period of time	3	Collis	mid-2014	
Radar Operations	2013.04.01	Get developmental IRIS software license to utilize spare RVP9s	3	Widener		$40K, await budget uncertainty to clear
Radar Operations	2013.04.02	In short-term, scale back on-site mentor support of Manus CSAPR and SACR radars but plan for intensive period there once other sites are fully operational and calibrated	2	Widener		KAZR is still high priority! Additional spare parts on-site

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Radar Operations	2013.04.03	Increase frequency of BOM visits to Manus to every two months once CSAPR and SACR are operational and fully calibrated	1	Voyles	mid-2014	
Radar Operations	2013.04.04	Fix SACR pointing issues: Antenna mounting and shimming with solar calibration Assure pedestal pointing accuracy	2	Bharadwaj	Apr-13	Verify where the radar is pointing and how this aligns with data. Kollias and Miller to provide feedback.
Radar Operations	2013.04.05	Define spec for pointing accuracy requirement - 0.1 degree?	2	Bharadwaj		Get input from Kollias.
Radar Operations	2013.04.06	Analyze and document SGP wind farm effects	3	Theisen		
Radar Operations	2013.04.07	Investigate KAZR and SACR spectral width algorithms	3	Venkatesh		Get details of ProSensing spectra width estimates comparing to Ed Lukes spectra processing
Radar Operations	2013.04.08	Use short pulse compression on the KAZR while deployed with MAGIC	1	Widener		Boundary layer chirp mode
Radar Operations	2013.04.09	Evaluate performance of XSAPR wrt dual polarization	4	Bharadwaj		
Radar Operations	2013.04.10	Develop radar operations plan for each AMF deployment	3	Widener		
Radar Calibration	2013.05.01	SACR/KAZR/WACR Calibration priority: 1. AMF1 (needs to be done before packup) 2. Barrow 3. Darwin 4. Manus	1	Widener		Mimic disk from SGP. Adjust gate spacing to match KAZR and SACR (submit BCR).

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Radar Calibration	2013.05.02	Determine to what extent ice/snow on corner reflector (or antenna) is a problem at Barrow and mitigate as necessary	3	Lindenmaier		
Radar Calibration	2013.05.03	Ask NSA Operations to take pictures of radome and corner reflector each day for a period of time?	1	Widener		
Radar Calibration	2013.05.04	Investigate the feasibility of using calibration scans to determine if there is significant attenuation at a given time and use this information to flag the data	4	Bharadwaj		
Radar Calibration	2013.05.05	Develop a calibration scan that takes less time and implement at 1-2 hourly intervals in between more detailed 12-hourly full raster scans (i.e. look for symmetry in antenna pattern)	3	Bharadwaj		
Radar Calibration	2013.05.06	Make it a high priority to get corner reflectors at all sites.	1	Widener		
Radar Calibration	2013.05.07	Calibration corner reflector siting MUST be considered when selecting a site for one of the AMFs.	1	Voyles		No corner reflector, no SACR?

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Radar Calibration	2013.05.08	Investigate the use of microARSCL to perform quality of Doppler spectra	5	Luke		
Radar Calibration	2013.05.09	DQ Office to analyze zenith measurments for radar leveling	3	Theisen		
Radar Upgrades	2013.05.09	Record KAZR radiometer-mode data continuously	1	Widener		
Radar Upgrades	2013.06.01	Mitigate SAPR 2nd trip echoes and dual polarization clutter filtering- in hardware to the extent possible	3	Bharadwaj		
Radar Upgrades	2013.06.02	Mitigate SACR 2nd trip echoes	2	Bharadwaj		More work than SAPR
Radar Upgrades	2013.06.03	Consider increasing the height of the SGP CSAPR to reduce beam blockage	5	Widener		
Radar Upgrades	2013.06.04	Upgrade the CSAPR receiver (including increasing A/D from 14 to 16-bit)	4	Bharadwaj		Possible use of spare XSAPR RVP9s
Radar Upgrades	2013.06.05	Add signal generator to XSAPR for signal injection	3	Bharadwaj		Possible contract to vendor
Radar Upgrades	2013.06.06	Break out the BITE information from XSAPR for storage	3	Bharadwaj		
Radar Upgrades	2013.06.07	Modify W-SACR front end to reduce losses and improve sensitivity	3	Widener		Will be done on W-SACR-2, need to retrofit
Radar Upgrades	2013.06.08	Upgrade strategy for WACR	5	Widener		

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Radar Upgrades	2013.06.09	Provide list of upgrade options with approximate costs for prioritization	1	Widener		Prior to 2013 budget meetings
Radar Upgrades	2013.06.10	Fix SACR timing issues which may include slaving both radars to a common trigger	3	Widener		
Radar Upgrades	2013.10.11	Develop sea/ice clutter removal algorithms for coastal radars (Barrow and Azores)	3	Bharadwaj		
Radar Upgrades	2013.06.12	Investigate saving SACR spectra data when scanning but saving when near zenith	4	Bharadwaj		
Data Quality	2013.07.01	Provide a height versus time field of maximum reflectivity (in dBZe) without saturation. Also provide a height versus time field of the minimum detectable reflectivity (in dBZe) which would allow for consistent long-term time series analysis of the data that accounts for power trends within the radar	1	Johnson		To happen with 2013.08.03
Data Quality	2013.07.02	Change the default data quality display in the archive user interface to something other than green/good	2	Theisen		To work with Archive
Data Quality	2013.07.03	Begin subjecting the radars to the full DQPR process	1	Theisen		

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Data Quality	2013.07.04	Mark Miller should submit a DQR on historic AMF1 rain gauge data	4	Miller		
Data Quality	2013.07.05	Develop a better DQR/DQPR entry mechanism for scientists to submit quality issues and to receive feedback on status (ARM-wide)	3	Mather		Probably needs an ECR
Data Flow/Reprocessing	2013.08.01	Rename KAZR files to short and long pulse	1	Johnson		With ns in file name
Data Flow/Reprocessing	2013.08.02	ARM needs to communicate better operational processes including key contacts (e.g. DQPR/DQR, mentors/translators/DQ Office)	5	Mather		Present at Radar breakout meeting, need feedback from scientist
Data Flow/Reprocessing	2013.08.03	Create calibrated but otherwise uncorrected b1-level files	1	Johnson		
Data Flow/Reprocessing	2013.08.04	Need assistance from ASR radar science group to assist in analysis and validation in establishing the requirements of radar calibration to complete the DQPR processes	2	Clothiaux		

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Data Flow/Reprocessing	2013.08.05	Review three options for reprocessing b1-level data: 1) Brute force reprocessing of the b1-level files 2) Reprocessing of only companion calibration files 3) Application of calibration (and other) corrections on demand	1	Mather		Done by STM?
VAPS	2013.09.01	Clarify process for prioritizing product development effort - we may benefit from diverting some developer effort from high order VAPs to the calibration effort in the short term	2	Mather		
VAPS	2013.09.02	Fully automate ARSCL (much work has already been done toward this)	1	Johnson		
Radar Science	2013.10.01	Review which microwave model to use for water vapor attenuation corrections - currently using Liebe (1985) in ARSCL. Roger Marchand to provide alternatives	3	Marchand		
Radar Science	2013.10.02	Review whether water vapor product for attenuation correction can be improved esp. in the boundary layer (e.g. by incorporating MWRP data)	2	Johnson		Use merged sounding if available

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Radar Science	2013.10.03	The quality of the KAZR spectra are amazing and there have been great advances in processing spectra through MicroARSCL - should now consider potential applications	2	Luke/Verlinde		
Radar Science	2013.10.04	Strengthen radar science/climate science communication and review methods for making radar data more useful to modelers	2	Shumaker/Tromel		
Radar Science	2013.10.05	Consider specific attenuation as a basis for precipitation retrievals	3	Ryzchov		
Radar Science	2013.10.06	Quantify uncertainties for cloud retrievals using objective framework	2	Mace		
Radar Science	2013.10.07	Develop strategies to integrate high-resolution models and radar data - in part through the use of radar simulators	2	Kollias		
Radar Science	2013.10.08	Develop strategy for building up a library of microphysical observations such as mass-constrained particle size distributions and habits	3	Verlinde/Mace		
Radar Upgrades	2013.10.09	Develop sea/ice clutter removal algorithms for coastal radars (Barrow and Azores)	3	Bharadwaj		

Category	Task #	Action Item	Priority (1-5)	Assignment	Due Date	Comments
Radar Science	2013.10.10	Science requirements drive radar scanning and sampling strategies and revisited annually for effectiveness (need feedback)	3	Kollias/Bharadwaj		Annual radar workshop
Radar Science	2013.10.11	Develop cloud algorithms for XSAPRs	2	Kollias		

Appendix B: Agenda

B.1 Agenda

ARM/ASR Radar Workshop
Agenda Rev. 6.0
February 21–22, 2013
University of Miami

Thursday, February 21, 2013	Session
08:30 Opening Session (Chair: Mather) • Welcome from University of Miami (Albrecht & Dean Avissar) • Management Perspective and Workshop Charter (Mather) • State of ARM Radar Operations and Engineering (Widener) • State of ASR Radar Science (Kollias) • VAP Development (Jensen)	A1
09:45 Radar Calibration (Chair: Bharadwaj) • 09:15–10:00 ARM Radar Calibration Plan (Bharadwaj, Widener) • 10:00–10:15 Break • 10:15–11:00 Recommendations/Discussion	B1
11:30 Ingest VAPs and DQR (Chair: Clothiaux) • Definition/Review of Ingest VAPs (Collis, Johnson, et al.) • Metadata Discussion (Clothiaux, Theisen, et al.)	C1
12:30 Lunch	
13:30 Ingest VAPs and DQR (Chair: Clothiaux) - continued	
14:00 QC Data Products Definition and Algorithm Review Part I SAPR (Chair: Collis) • C-SAPR (Collis, Schumacher, et al.) • X-SAPR (Collis, Troemel, et al.)	D1
16:30 Challenges Facing a Reliable ARM Radar Network (Chair: Widener) • What are the science expectations? • What are the economic realities? • Towards common digital receiver for precipitation radars • Issues related to remote radar operation - can we succeed 24/7? • Continuous improvement activities for ARM radars	E1
17:30 Social Activity	
18:30 Adjourn	

Friday, February 22, 2013	Session
08:30 Recap Day 1 (Chair: Clothiaux) Radar Calibration - DQR Summary	A2
09:30 Radar Sampling Strategies (Chair: Bharadwaj)	B2
10:30 QC Data Products Definition and Algorithm Review Part II: SACR/KAZR (Chair: Jensen) • Ka/W-SACR (Johnson et al.) • KAZR (Johnson et al.) • Micro-ARSCL (Luke et al.)	C2
12:00 Lunch	
13:00 Radar Science (Chair: Kollias)	D2

Presentations: Advance radar products and science (15 minutes + 5 minutes discussion)
- Precipitation I (Chandra)
- Precipitation II (Ryzhkov)
- Statistical Summaries for Modelers (Silke/Schumacher)
- Clouds I (Mace)
- Clouds II (Miller)
- Clouds III (Verlinde)
- State of Vertical Velocity Retrievals (Ghate/Comstock)

Discussion: Interaction with the broader research community
- Analysis and Visualization Tools
- Links to modeling efforts/organizations
- Adaptive Sampling versus Routine “Climatological” Observations
- Wrap up – next steps

17:00 Adjourn

Appendix C: Attendees

C.1 Attendees

Last Name	First Name	Institution
Collis	Scott	Argonne National Laboratory
Helmus	Jonathan	Argonne National Laboratory
Theisen	Adam	ARM Data Quality Office (University of Oklahoma)
Giangrande	Scott	Brookhaven National Laboratory
Jensen	Mike	Brookhaven National Laboratory
Johnson	Karen	Brookhaven National Laboratory
Luke	Ed	Brookhaven National Laboratory
Troyan	David	Brookhaven National Laboratory
Chandrasekar	Venkatchalam	Colorado State University
Dolan	Brenda	Colorado State University
Jo	Ieng	McGill University
Kollias	Pavlos	McGill University
Shupe	Matthew	National Oceanic and Atmospheric Administration
Ryzhkov	Alexander	University of Oklahoma
Bharadwaj	Nitin	Pacific Northwest National Laboratory
Lindenmaier	Andrei	Pacific Northwest National Laboratory
Mather	Jim	Pacific Northwest National Laboratory
Venkatesh	Vijay	Pacific Northwest National Laboratory
Voyles	Jimmy	Pacific Northwest National Laboratory
Widener	Kevin	Pacific Northwest National Laboratory
Clothiaux	Eugene	The Pennsylvania State University
Miller	Mark	Rutgers University
Schumacher	Courtney	Texas A&M University
Troemel	Silke	University of Bonn
Mace	Jay	University of Utah
Marchand	Roger	University of Washington
Albrecht	Bruce	University of Miami

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