DOE/SC-ASR-15-002

Atmospheric System Research Working Group Session Reports

February 2015

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Monday, November 17

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2:00 - 2:30 p.m.	Plenary talk #2 – Pierre Gentine
2:30 - 4:00 p.m.	Discussion of Science Questions » Question #1: led by Yunyan Zhang, with science nugget presented by Steve Klein » Question #2: led by Margaret Torn, with science nugget presented by Ian Williams » Question #3: led by Larry Berg, with science nugget presented by Alex Guenther
4:00 - 4:10 p.m.	Review of Data Products: Shaocheng Xie
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3:00 - 7:30 p.m.	**White Oak A: Radar Science & Operations Meeting (chaired by P. Kollias and N. Bharadwaj)**
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4:20 - 5:00 p.m.	SACR-2, KAZR-2, XSAPR-2, CSAPR-2 - Bharadwaj/Mead
5:00 - 5:15 p.m.	Break
5:15 - 5:30 p.m.	Radar activities timeline – Bharadwaj
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6:20 - 6:30 p.m.	Break
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6:50 - 7:10 p.m.	A new concept of quasi-vertical profiles of polarimetric radar variables – Ryshkov
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6:30 - 8:30 p.m	**Middlebrook: ALWG AOS Harmonization (by invitation)**

Tuesday, November 18

8:00 - 10:00 a.m.	**Salon FGH: Joint CAPI/ALWG/CLWG Plenary Session on CCN Framing presentations (20 minutes each, 10 minutes questions/ discussion and transition)**
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8:30 - 9:00 a.m.	Marine aerosol sources: sea salt and organics - Lewis and Burrows
9:00 - 9:30 a.m.	Coalescence scavenging (Azores/VOCALS) - Wood
9:30 - 10:00 a.m.	Dicsussion
10:00 - 10:30 a.m.	Break
10:30 - 12:00 p.m.	**Salon FGH: Joint CLWG/CAPI/ALWG Session on modeling warm clouds (Miller, Wood)**
10:30 - 10:40 a.m.	Overview of the Cases: Why they were selected, their role in guiding ASR science (ENA and SGP), and objectives for the session - M. Miller
10:40 - 10:55 a.m.	Short surveys of the characteristics of the ENA cases - X. Dong
10:55 - 11:10 a.m.	Modeling perspective for warm low clouds - M. Zhang
11:10 - 11:20 a.m.	Discussion
11:20 - 11:35 a.m.	Results from RACORO observations - A. Vogelmann
11:35 - 11:50 a.m.	Results from RACORO modeling - W. Lin
11:50 - 12:00 p.m.	Discussion
12:00 - 1:30 p.m.	Lunch Break
12:00 - 1:30 p.m.	**White Oak A: ARM Data Discovery Tool Hands on Tutorial - How to Find and Order ARM Data: Recent Changes and "Help" Session - R. McCord**
1:30 - 2:30 p.m.	**Salon FGH: DOE Plenary Session**
2:30 - 3:30 p.m.	**Salon FGH: ALWG Plenary** » Summary of GEIA Conference (June 2014) - GuentherM » AOS Committee Update - McComisey, Wang, Flynn
2:30 - 3:30 p.m.	**White Oak A: CLWG - Warm Clouds (Miller, Zhang)**
2:30 - 2:45 p.m.	ENA synoptic/cloud variability - D. Mecham
2:45 - 3:00 p.m.	Cloud regime variability over the Azores and the influence of atmospheric dynamics - G. Tselioudis & J. Remillard
3:00 - 3:15 p.m.	Near-surface density currents observed under a stratocumulus-topped marine boundary layer - S. Yuter
3:15 - 3:30 p.m.	Discussion
2:30 - 3:30 p.m.	**White Oak B: CAPI - Warm Clouds**
2:30 - 2:45 p.m.	Are subtropical stratocumulus to cumulus transitions driven by dynamics or microphysics? - C. Bretherton
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4:00 - 5:30 p.m.	**White Oak A: CLWG - Warm Clouds (Miller, Zhang)**
4:00 - 4:15 p.m.	What can we learn from high resolution photography of clouds from the surface? - S. Schwartz
4:15 - 4:30 p.m.	Observations of Shallow Cumulus Mass Fluz at Barbados and its relationship to cloudiness and boundary layer structure - K. Lamer
4:30 - 4:45 p.m.	Mass and water vapor transports in Cumulus topped boundary layers: A case study from the ARM Darwin facility - V. Ghate
4:45 - 5:30 p.m.	Discussion
4:00 - 5:30 p.m.	**Oakley: CAPI-Warm Clouds**
4:00 - 4:15 p.m.	Simulations of Aerosol, Cloud, and Precipitation Effects in Comparison with ARM Data - C. Zhou
4:15 - 4:30 p.m.	Factorization of aerosol indirect effects - S. Ghan
4:30 - 4:45 p.m.	MBL cloud properties and surface CCN properties from Azores-AMF observations - X. Dong
4:45 - 5:00 p.m.	Causes and consequences of bimodal CCN spectra - J. Hudson
5:00 - 5:30 p.m.	Discussion on Data products for CAPI - lead by L. Riihimaki
4:00 - 5:30 p.m.	**Salon FGH: Radar session: "Breaking new ground with Doppler spectra: Microphysics and dynamics, models and observations" (Ed Luke, Ann Fridlind)** Talks (8 minutes each): 1. How to derive quantitative properties of microphysical modes from Radar Doppler Spectra-A case study on riming - S. Kneifel 2. Dual-Pol spectra-new opportunities - V. Chandrasekar 3. Using Differential Doppler Velocity in UAZR and KAZR spectra to estimate vertical air motion and DSD parameters - C. Williams 4. Constraining ice sticking efficiency within a single column bin microphysics model using S-band profiler Doppler spectra - M. van Lier-Walqui 5. Data products, tools, and the March 11-12, 2013 NSA mixed-phase case study period - E. Luke 6. Discussion to identify currently unfulfilled needs, challenges, and possible model/observation comparison activity
5:30 - 7:00 p.m.	Dinner Break
7:00 - 8:30 p.m.	**Salon FGH: ARM Reorganization Session**

3:00 - 3:15 p.m.	Aerosol-cloud interactions and synoptic-scale processes from MAGIC - D. Painemal
3:15 - 3:30 p.m.	Large increase in cloud drop concentrations and albedo over sea surfaces colder than 7° C - D. Rosenfeld
3:30 - 4:00 p.m.	Break
4:00 - 5:30 p.m.	**White Oak B: ALWG Absorbing Aerosol Breakout (chaired by McComiskey)** (5 Minute presentations) Introduction and Objectives - McComiskey Measurement Science 1. Status of the Photothermal Interferometer - Castillo 2. Sub-cloud surface albedo algorithm with results for SGP and Table Mountain - Flynn 3. MFRSR-CID, released for SGP, NSA, and other sites; Extension to SAS-He and longer wavelengths - Flynn Experimental and Observational Studies 4. Absorbing aerosol morphology and optical properties - Mazzoleni 5. Wavelength-dependent measurements of soot optical properties - Foresieri/Onasch 6. Findings from the SAAS Experiment - Aiken 7. Morphological Characteristics of Soot-Containing Aerosols during CARES - Moffet 8. ASR process studies of light absorption by black and brown carbon: Progress, Challenges, and Directions - Dubey 9. Heterogeneity in aerosol leading to large difference in direct radiative forcing efficiency over the NW Atlantic Ocean - Chand 10. TBD - Jefferson 11. Absorbing aerosol: A major cause for systematic biases in retrieving cloud properties from satellite - Z. Li 12. Chemistry of Atmospheric Brown Carbon - Laskin Modeling Studies 13. Global Modeling of Absorption due to Primary Organic Aerosol - Feng 14. Can we separate the effects (Semi-Direct effects) of radiative forcing due to rapid adjustment from the total aerosol-radiative forcing? - Kotamarthi

4:00 - 5:30 p.m.	**White Oak A: CLWG - Warm Clouds (Miller, Zhang)**
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5:30 - 7:00 p.m.	Dinner Break
7:00 - 8:30 p.m.	**Salon FGH: ARM Reorganization Session**

Wednesday, November 19

8:30 - 10:00 a.m.	**White Oak A: ALWG - Secondary Organic Aerosol (Shilling, Wang)** 1. Viscosity/Phase - Martin, Zelenyuk 2. Growth Mechanisms - Madronish, Shilling 3. Sulfate as a Trigger or Regulator for SOA Production and Properties - Thornton, Srivastava 4. Cross-cutting for Model Intercomparisons and Lab Chamber/Standards - Zaveri 5. Discussion
8:30 - 10:00 a.m.	**Salon FG: Ice Processes - CLWG/CAPI Joint Ice Session** Framing Presentations (20 minutes each, including questions) 1. Overview of relevant processes in GCMs - Xiaohong Liu 2. Results from analytical/toy model of ice growth - M. Ovchinnikov 3. How ice crystal habits affect cloud properties - A. Solomon
8:30 - 10:00 a.m.	**Salon H: MAGIC breakout session (chaired by Lewis)**
10:00 - 10:30 a.m.	Break
10:30 - 12:00 p.m.	**White Oak A: ALWG - Mixing State (Riemer, McGraw)**
10:30 - 12:00 p.m.	**Salon FG: Ice Processes - CLWG/CAPI Joint Ice Session (continued)** » Brief summaries from group leaders on individual group directions/priorities » Discussion: Focus on potential joint activities, leveraging activities, communication, joint priorities, etc.
12:00 - 1:30 p.m.	Lunch Break
1:30 - 3:30 p.m.	**White Oak A: ALWG Session 1**
1:30 - 2:30 p.m.	Absorbing Aerosol: Discussion of Group Activities - McComiskey
2:30 - 3:00 p.m.	Mixing State: Morphological Mixing State - Fast, Zaveri, Zelenyuk, Moffet, Gilles, Mazzolini, Sedlacek, Laskin, Knopf
1:30 - 3:30 p.m.	**White Oak B: ALWG Session 2**
1:30 - 2:30 p.m.	SOA: Cross-Cutting Activities for Model Intercomparisons and Lab/Chamber Studies - Zaveri
1:30 - 3:30 p.m.	**Oakley: CAPI - ICE NUCLEATION**
1:30 - 1:45 p.m.	Ice nucleating particles at SGP and in the U.S. High Plains - P. DeMott

1:45 - 2:00 p.m.	Laboratory investigations of mechanisms for contact freezing - R. Shaw
2:00 - 2:15 p.m.	Ice number concentration retrieval in stratiform clouds and related results - Z. Wang
2:15 - 2:30 p.m.	Satellite remote sensing of Ni/IWC; a proxy for ice nucleation rates in cirrus clouds - D. Mitchell
3:00 - 3:15 p.m.	Ice generation in convective clouds as learned from two recent field projects - J Yang
3:15 - 3:30 p.m.	Impacts of uncertainty in ice nucleation parameterizations and dust on modeling deep convective clouds and precipitation - J. Fan
1:30 - 3:30 p.m.	**Salon H: CLWG-ICEPRO/QUICR: Ice properties and related uncertainties (McFarquhar, Mitchell, Fridlind)** QUICR overview (Shaocheng Xie) Status of ICEPRO deliverables (Max 5 slides each) » D1: Development of single-particle databases from in-situ data (McFarquhar) » D2: Characterization of ice particle properties on environmental conditions (McFarquhar/Mitchell) » D3: Radiative closure studies from ISDAC (Lubin) » D4: Radiative closure studies from SGP (Mlawer) » D5/D6: Improved retrievals of ice properties and habits (Dong) » D7: Upgrade CAM5 microphysics to make self-consistent (Mitchel/Morrison) » D8: High-resolution simulations from MC3E (Fridlind) » D9: Modeling impoact of new ice property parameterizations (Harrington) » D10: Framework for converting ice particle uncertaintiesto model output (Fridlind/Mitchell/McFarquhar) » D11: Linking optical properties and microphysics (Fridlind) » D12: Gaps in microphysics databases (Fridlind/Mitchell/McFarquhar)
1:30 - 3:30 p.m.	**Salon FG: CLWG-PHASE: Discussion of ongoing case study activity, documentation of this activity from both model and observational perspectives, identify papers, consider future directions that build from this activity and take cross-over activities (from morning discussion) into account (de Boer, Harrington)**
3:30 - 4:00 p.m.	Break

4:00 - 5:30 p.m.	**White Oak A: ALWG Session 1**
4:00 - 4:30 p.m.	Mixing State: Modeling - Regional and Global Scale - Fast et al.
4:30 - 5:00 p.m.	Mixing State: Mixing State and Remote Sensing - Moffet, Knopf, Gilles, Laskin, Flynn, Ferrare
5:00 - 5:30 p.m.	Mixing State: CARES and TCAP Modeling/Data Comparisons - Fast, Zaveri, Zellenyuk, Moffet, Gilles
4:00 - 5:00 p.m.	**White Oak B ALWG Session 2**
	SOA: Sulfate as a Trigger or Regulator for SOA Production and Properties - Thornton, Srivastava
4:00 - 5:30 p.m.	**Oakley: CAPI - Ice Nucleation**
4:00 - 4:15 p.m.	LES simulations using stochastic immersion freezing parameters constrained with CFDC data from M-PACE and ISDAC - A. Fridlind
4:15 - 4:30 p.m.	Impact of transition from singular approach to stochastic approach of heterogeneous ice nucleation on mixed-phase clouds in CAM5 - X. Liu
4:30 - 5:00 p.m.	Science discussion (e.g., IN instrument intercomparison, SPIN, filter sampling, IN closure, IOP on ice formations, etc.)
5:00 - 5:30 p.m.	"Ice Nucleation" white paper discussion
4:00 - 5:30 p.m.	**Salon H: CLWG-ICEPRO: General discussion on upgrading models and parameterizations, ICEPRO FG whitepaper discussion**
4:00 - 5:30 p.m.	**Salon FG: CLWG-MJO (Long, Hagos)**
4:00 - 4:05 p.m.	Brief introductory remarks on MJO related activities
4:05 - 4:20 p.m.	Sub-grid and large-scale effects of convection on moisture during DYNAMO in radiosonde observations and a cloud-permitting model - M. Janiga
4:20 - 4:35 p.m.	High and very high resolution simulations of the MJO in a Global Circulation Model - R. Pilon
4:35 - 4:50 p.m.	Precipitation structures during DYNAMO MJO event: Comparisons among cloud resolving model and radar observations - X. Li
4:50 - 5:05 p.m.	MJO moist processes in observations, cloud permitting model and cumulus parameterizations - S Hagos
5:05 - 5:20 p.m.	The user of CRMs in exchanging size for rain in a tropical latent heating retrieval - C. Schumacher
5:20 - 6:00 p.m.	Discussion
5:30 - 7:00 p.m.	Dinner Break

7:00 - 8:30 p.m.	**White Oak A: Radar Session: "Introduction to scanning radar forward simulations using CRM output from the aerosol-deep convection interactions study (MC3E)"**
7:00 - 7:05 p.m.	Meeting objectives/logistics - P. Kollias
7:05 - 7:20 p.m.	Scanning radar simulator: Instrument Model - P. Kollias
7:20 - 7:50 p.m.	Scanning radar simulator: Forward Model - A.r Ryzhkov
7:50 - 8:00 p.m.	Discussion on next steps - Kollias and Ryzhkov
8:00 - 8:20 p.m.	A profiling ARM radar simulator for GCMs - Xie and Zhang
8:20 - 8:30 p.m.	Discussion and next steps - Kollias and Xie
7:00 - 8:30 p.m.	**Middlebrook: AMIE/DYNAMO observation-modeling integration (C. Zhang) - by invitation**

Thursday, November 20

8:30 - 10:00 a.m.	**Salon FG: Deep Convection: CLWG/CAPI Joint session (Schumacher, Varble, Li, Morrison)** Framing Presentaions (20 min each) 1. Microphsyics/MC3E, observations - J. Fan 2. High level overview of aerosol-deep convective-microphysics interactions from a modeling perspective - Z. Lebo 3. Anvil Clouds of Mesoscale Convective Systems - R. Houze 4. Impact of aerosol on anvil and cloud radiative forcing for DCC systems - Z. Li 5. Vertical velocity retrievals - S. Collis 6.
10:00 - 10:30 a.m.	Break
10:30 - 12:00 p.m.	**Salon FG: Deep Convective - CLWG/CAPI Joint Session (continued)** » Brief summaries from group leaders on individual group directions/priorities » Discussions: Focus on potential joint activities, leveraging activities, communication, joint priorities, etc.
12:00 - 1:30 p.m.	Lunch Break

1:30 - 3:30 p.m.	**Salon H: CAPI - Deep Convection**
1:30 - 1:40 p.m.	In-situ and satellite closure observations of CCN and cloud microstructure of the Manus plume and background in GO AMAZON - D. Rosenfeld
1:40 - 1:55 p.m.	Aerosol and updraft properties in aircraft and ground-based observations during four days of MC3E: CN, CCN, H-TDMA, UHSAS, C-SAPR, NEXRAD, LMA, and tri-Doppler wind retrievals - A. Fridlind/M. van Lier Walqui
1:55 - 2:05 p.m.	Aerosol impacts on MC3E anvils, cold pools, and precipitation characteristics - S. van den Heever
2:05 - 2:15 p.m.	Aerosol effects on cloud field properties and precipitation of tropical convective clouds - Seoun-Soo Lee
2:15 - 2:25 p.m.	Untangling microphysical impacts on deep convection applying a novel modeling methodology - W. Grabowski
2:25 - 2:35 p.m.	Inferred differences in ice crystal nucleation rates between continental and maritime deep convective clouds - D. Mitchell
2:35 - 2:45 p.m.	The spring 2014 SGP Ice Nuclei Characterization Experiment - S. van den Heever (for P. DeMott)
2:45 - 3:00 p.m.	Contributed 1-slide overviews plus slides to frame discussion
3:00 - 3:30 p.m.	Discussion (MC3E Intercomparison, focus group, and general)
1:30 - 3:30 p.m.	**Salon FG: CLWG-MCO / Deep Convection / Cold Pools (Varble, Schumacher, Rowe, Feng)**
1:30 - 2:00 p.m.	Observational retrievals in deep convection
2:00 - 2:30 p.m.	MCO Trello page, Discussion on group objectives for MCO
2:30 - 3:30 p.m.	Cold Pools

2.0 Monday, November 17, 2014

2.1 Land-Atmosphere-Cloud Interactions Plenary Session Summary

Larry Berg, Margaret Torn, David Turner, and Yunyan Zhang

There has been growing momentum within Atmospheric System Research (ASR) to address science issues related to the interactions of the land surface, planetary boundary layer (PBL), and life cycle of clouds. While a number of different U.S. Department of Energy programs have established efforts related to the understanding of important processes in the subsurface and surface, plant canopy, and atmosphere, they are generally only focused on parts of the problem, and they have not investigated the myriad of feedback among the surface, PBL, and clouds. The Land-Atmosphere-Cloud Interaction (LACI) Plenary session held at the 2014 ASR Working Group Meeting was designed to present perspectives from both the land surface and atmospheric communities and highlight areas in which research conducted by ASR scientists could make significant progress in improving our understanding of LACI.

Overview presentations were given during the meeting by Joe Santanello (NASA) and Pierre Gentine (Columbia University). These two individuals were selected because of their different viewpoints on current science questions related to LACI. Both speakers highlighted that LACI includes many different complex interactions that are important on a range of temporal scales ranging from minutes to years. During his talk Joe highlighted that many scientists within the land surface research community view the atmosphere as a boundary condition for their models, and likewise, the atmospheric science community views the land surface as the bottom boundary condition for their regional and global simulations. Both perspectives tend to minimize the important feedback that can occur within the coupled system. The talks presented a number of science questions related to spatial and temporal scales, the development of proper models and diagnostics, the applicability of satellite data, development of the atmospheric boundary layer, and the initiation of convection.

After these two plenary sessions, there was a discussion period during which three overarching science questions were presented and discussed:

- How important is the influence of the land surface on the boundary layer turbulence and structure, cloud life cycle, and precipitation?
- What boundary layer and land processes contribute to the diversity of soil moisture-precipitation feedback observed in nature and simulated in models using spatial scales ranging from meters to tens and hundreds of kilometers?
- How does feedback between biogenic emissions, biomass burning, secondary organic aerosol (SOA), PBL, and clouds influence the cloud lifecycle?

The discussion focused on the development of a subset of questions related to each topic (the subset of questions, including those developed by the committee before the meeting is attached for reference).

The session concluded with a review of data products and discussion of measurement needs, in particular those related to soil moisture. It was determined that an ad hoc group would be established to develop a recommendation related to the soil moisture measurements that would then be passed to ARM Climate Research Facility management.

How important is the influence of the land surface on the boundary layer turbulence and structure, cloud life cycle, and precipitation?

- Diurnal Cycle of LACI
  - How do land surface processes impact the diurnal cycle of the boundary layer structure, and the occurrence and spatial extent of clouds and precipitation?
  - What is the effect of soil moisture anomaly (dry or wet) on the surface flux partitioning, carbon flux, boundary layer turbulence structure, and cloud occurrence? What is the role of irrigation, groundwater, and phenology? Which soil moisture is most important at ARM sites: near-surface, root zone layer, or groundwater?
  - What is the role of the surface radiation balance and the participation of direct and diffuse radiation on photosynthesis and the sensible and latent heat fluxes?

- Surface Heterogeneity
  - How large is the flux footprint of clouds seen at the ARM sites? What does that tell us about the relevant spatial scales?
  - What is the impact of land surface heterogeneity on the probability density functions of thermodynamic variables and vertical velocity, and their relationship with clouds and precipitation? Are the representations applied in models consistent with observations?
  - How is land surface heterogeneity represented in models and how does it impact the probability density functions of variables in the PBL?
  - What new data products and/or surface stations are needed?
- Boundary Layer/Turbulence
  - What are the long-term boundary layer turbulence statistics at ARM sites? How do they compare to the representations in models? What is the impact of entrainment at the PBL top on the thermodynamic properties, trace gases, and aerosol in the PBL?
  - What are the relevant spatial scales? How does the surface heterogeneity impact the relevant scales?
  - What is the role of longwave flux divergence on the surface energy balance and its impact/coupling with the boundary layer turbulence?
- Regime
  - What is the impact of the surface on cold pool dynamics and the life cycle of convection?
  - How can we define local versus nonlocal (including wave dynamics) effects on LACI?
  - What are the relevant diagnostics? Can water isotopes be applied to better understand the water cycle?

What boundary layer and land processes contribute to the diversity of soil moisture-precipitation feedbacks observed in nature and simulated in models (Large Eddy Simulation [LES], Cloud-Resolving Model [CRM], Mesoscale Models [MM], global circulation models [GCM])?

- Scale dependence of feedback pathways
  - What are the proper linkages between soil moisture, boundary layer, clouds, and precipitation in nature and how are they simulated in models? How do they change as a function of scale?
  - How do those linkages change in different flow and hydrological regimes? How does the change in PBL state (shallow/deep, dry/humid, etc.) define the feedback sign between surface fluxes and clouds?
  - What is the relative role of changes in the leave area index and the direct and diffuse radiation?
- Regional and local scale transport
  - How do we quantify relative roles of local moisture sources and regional-scale transport over a range of spatial and temporal scales
  - Can we use high-resolution models coupled with land models to improve the representation of LACI in large-scale models (e.g., MM and GCM)?
  - What treatments of surface and subsurface water transport are needed?

- Impact of Clouds
  - How does radiative cloud forcing (shading and enhanced diffuse radiation) impact the surface sensible and latent heat flux, carbon flux, and biogenic emissions, as well as their spatial structure?

How do feedbacks between biogenic emissions, biomass burning, SOA, boundary layer, and clouds influence the cloud lifecycle?

- Surface processes
  - What are the important links between land use, soil moisture, biogenic emissions, carbon fluxes, and clouds over a range of landscapes (from the Amazon to the Artic)?
  - How well do our models represent these links?
  - How do changes in the land use influence changes in biogenic emissions?
  - What are the uncertainties in biogenic emissions and SOA formation? How do we quantify them?
  - Can the treatment of the wet and dry removal of aerosol be improved?
  - What is the seasonal dependence of the aerosol transport on the Southern Great Plains (SGP), and what is its impact on clouds?
- Boundary layer processes
  - How does vertical mixing (with alternating cycles of high and low relative humidity [RH]) change SOA?

2.2 Radar Science and Operations Meeting Report

Pavlos Kollias

The radar operations group provided a detailed update on the operational status of ARM radar systems at the various sites. New and detailed information also was provided about the second generation radar systems that are currently being tested (e.g., KAZR-2 and SACR-2 systems in Oliktok [OLI] and Eastern North Atlantic [ENA]) and about the nearly completed system to be delivered to ARM for installation (XSAPR-2 in ENA). The operations group also provided detailed information about their upcoming schedule and task list and received feedback from the science group.

The participants spent considerable time discussing the two upcoming Calibration, Grooming, and Alignment (CGA) periods, which are joint science-operations activities at the ENA and OLI sites. The main objective of CGAs is to perform an extensive evaluation of the new radar systems at these sites; among other things it includes the testing of several sampling strategies and radar data quality. The participants agreed that the best period to conduct the OLI CGA is April 2015, and two scientists are expected to physically be there for a period of up to 2 weeks to represent the radar science group and provide quick feedback on the status of the CGA. The ENA CGA will take place in June 2015 and will include the evaluation of the XSAPR-2 radar. Two scientists also are expected to visit the ENA site during the CGA. Eugene Clothiaux (Pennsylvania State University) will be the science point of contact for the OLI CGA (KAZR-2, SACR-2), and Pavlos Kollias (McGill University) will be the science point of contact for the ENA CGA (KAZR-2, SACR-2, XSAPR-2).

Three short scientific presentations on radar applications for ice/snow research were discussed at the end of the meeting. The radar science and operations will have its next meeting in late February 2015.

3.0 Tuesday, November 18, 2014

3.1 Aerosol Life Cycle Working Group Absorbing Aerosol Sessions

Allison McComiskey

The Aerosol Life Cycle Working Group (ALWG) convened a session on absorbing aerosol to provide an overview of related activities ongoing within the group and to discuss potential collaborations, new ideas, and ways in which these activities might be integrated into a directed group effort. The subject of absorbing aerosol has continually been of strong interest to the working group, and there have been suggestions in the past to make this a focus group, but a clear direction has not yet revealed itself. The sessions at this year's working group meeting were intended, at most, to help find a direction and, at least, to suggest potential collaborations or directions for individual principal investigators to place their work better into the larger context of program-wide activities.

The first session was a survey of current research. Principal investigators gave 14 5-minute presentations that fell naturally into three categories: (1) Measurement Science; (2) Experimental Studies: Lab, Field, and Satellite; and (3) Modeling Studies. (See the list of presentations and abstracts below.) Measurement science is especially important in this area because, currently, no ideal instrument to measure aerosol absorption exists. Different methods contain either sensitivity or bias issues that are larger than the signal required determining aerosol radiative forcing to a desired quantity (e.g., 1 W m^{-2} globally averaged). Presentations in this area showed development of an in situ method with very strong potential, and development of retrievals from passive radiometry that will help reduce uncertainties. Experimental studies were heavily weighted toward particle morphology and brown carbon (BrC) effects on light absorption and represented a good mix of lab and field studies. Modeling studies focused on parameterizations of BrC absorbing properties and mechanisms that dominate in the semi-direct effect.

The survey session was followed by a 1-hour discussion. The group agreed that the survey presentations were good and very useful. The first point of discussion was that there is a large overlap with the interests of this group and the ASR Aerosol Mixing State Focus Group. While the mixing state group has focused more on single particle analyses and how to parameterize that information for inclusion into models, a suggestion was made that this group serve to better understand how mixing state affects bulk optical properties. This is often referred to as the "scaling up" problem—from single particle analyses to bulk optical properties in the real ambient column—which can be very difficult. However, the Two-Column Aerosol Project (TCAP) campaign was designed in part to address this problem. Closure studies using TCAP observations are ongoing and lidar aerosol typing may help with tying mixing state to optical properties. These activities would bring together a set of principal investigators with a wide range of expertise. Other related activities include characterizing the evolution of soot from various sources in both laboratory experiments (e.g., Soot Aerosol Aging Study) and field campaigns (e.g., Biomass Burning

Observation Project) and modeling of optical properties for different prototypical particle morphologies which may be useful in developing model parameterizations.

The question was raised as to the importance of the vertical profile of absorbing aerosol in its radiative impacts. Modeling at a range of scales is needed to test the sensitivity of radiative fluxes to vertical profile, but measurements from various locations and regimes are also required to constrain these sensitivity studies. It was agreed that the ARM Facility might have a useful (if not complete) set of data from various past campaigns to start building such a data set. The upcoming Layered Atlantic Smoke Interactions with Clouds campaign is of strong interest and questions were raised as to the source of any potential information during the campaign on vertical profiles (i.e., flights or ground-based lidar measurements). A related discussion was of the role of removal in controlling the persistence of elevated layers and therefore vertical structures. It was suggested that this would be a topic to work on with the Cloud-Aerosol-Precipitation Interactions (CAPI) group. While the Cloud Condensation Nuclei (CCN) session on the previous day suggested potential pathways to better understanding of scavenging and removal processes of marine aerosol in stratocumulus regimes, the removal of absorbing aerosol will be a more difficult case.

Finally, because of time limitations, there was a brief discussion on whether current instrumentation is good enough to solve these problems, especially with regard to measuring bulk optical properties. Because there is not yet a “gold standard” or ideal instrument for measuring aerosol absorption, it was suggested that the best approach may be redundancy in related measurements that provide confidence in a “best estimate” of absorption. This might include at least one of the following methods: direct (photo-thermal interferometry, photo-acoustic spectrometer), filter (particle soot absorption photometer, continuous light absorption photometer, Aethalometer), and subtraction (cavity attenuated phase shift + nephelometer). Such redundancy on a continuous basis in variable conditions would also provide an excellent opportunity to better characterize measurement uncertainties in the field.

While the discussion time was short and there was no attempt to define topics or objectives for a focus group, the session participants felt that these session were a very useful exercise to better understand where the strengths and interests of the group lies, how those relate to other formal efforts in the ALWG and ASR program and ARM Facility, and for providing guidance in thinking about potential future collaborative efforts. One suggestion was made to provide a framework for determining where the weak spots in our understanding of absorbing aerosol impacts lie. Analysis of error in four separable aspects of the problem could reveal where best to place future efforts: (1) emissions and transport to speciated mass concentrations, (2) composition to optical properties, (3) optical properties to radiative properties/fluxes/heating rates, and (4) feedback due to radiative flux and heating effects.

3.2 Aerosol Life Cycle Working Group Plenary Session

Allison McComiskey

A short plenary session for the Aerosol Life Cycle Working Group was held before breaking into focus groups and other science focus area sessions. The topics for the plenary session were those that cross-cut all ALWG science areas and that were useful for principal investigators to have in mind as they attend the more science oriented sessions.

The first presentation, given by Alex Guenther (PNNL), was a summary of the GEIA (Global Emissions Initiative) Conference that took place in Boulder, Colorado, in June 2014. The ALWG has consistently discussed the importance of good emissions databases for aerosol modeling and also the reality that emissions research is mostly outside of the scope of ASR and ARM, and hence the need to partner with others to get the needed information. Alex Guenther has served as recent past chair of GEIA and is also an active member of the working group. In the presentation, Alex described the structure of GEIA and presented some highlights of the meeting within the different GEIA working groups. In discussions following the presentation, it was determined that the best path to a two-way interaction between GEIA and the ASR ALWG is for individuals working on specific topics or with specific needs to communicate directly with the chairs of appropriate working groups within GEIA. It is hoped that, though these types of communication, ASR principal investigators can express their most pressing needs to GEIA so they can help us find the best databases and also that relevant GEIA efforts might be prioritized. This would inform GEIA of important work being done in the field that might help them better evaluate particular databases, thus strengthening ASR's involvement in the emissions community. Specific issues that were raised included:

- Interest in having better characterization (e.g., chemical speciation, properties) of primary particle emissions as well as aerosol precursors.
- The need for emissions data that include speciation of volatile organic compounds. Semi-volatile, high molecular weight compounds are likely important for SOA production but data are not available for model input.
- Volatile organic carbon (VOC) flux measurements around the SGP central facility are needed specifically to contribute to the broader effort to investigate land–atmosphere interactions. Data for the oak woodlands and some croplands are most needed and could be implemented relatively easily where energy and water fluxes are already being measured.

The second presentation was a tag-team given by Allison McComiskey (NOAA) and Connor Flynn (PNNL) on the activities of the Aerosol Observing System Committee. The intent of these presentations was to provide background on ARM activities that relate to current and future instrument procurement and organization as well as new and significantly enhanced data processing activities. We felt that this would be useful to the ALWG to provide context for the recent request by ARM on measurement needs. A review of existing instrument systems, recommendations for a new baseline set of instruments, and discussions about specialized instrumentations that have been deemed important by principal investigators was given. ARM has asked the group to prioritize and provide strong justifications for implementing the recommended baseline instrumentation and any other recent requests that have been made. The group was instructed to discuss these needs in the science sessions and to continue to provide feedback between now and the spring meeting. It is expected that the working group chairs will compile this information during that time and present the program management and administration with priorities and any strong recommendations.

3.3 Cloud-Aerosol-Precipitation Interactions Session on Warm Low Clouds – Working Group Findings, Needs and Recommendations

Rob Wood, Steve Ghan, and Graham Feingold

Marine low cloud transitions: Large Eddy Simulation models should be used to explore whether there is sensitivity of the subtropical stratocumulus-to-cumulus (Sc–Cu) transition to observed aerosol variability determined from the Marine ARM GPCI Investigation of Clouds (MAGIC). Chris Bretherton (University of Washington) explained that current theory to understand the decoupling that leads to cloud breakup considers increased cloud top entrainment driven by increased latent heat fluxes over a warmer sea surface temperature (SST) as being the primary driver of decoupling. That said, the theory (e.g., Bretherton and Wyant 1997, "deepening-warming" mechanism) does allow for precipitation to play a role in the breakup, and it is understood (e.g., through precipitation susceptibility estimates) that precipitation may be sensitive to aerosol. Pockets of open cell convection (POCs) are thought to be an example of rapid precipitation-driven breakup, but the relevance of POCs and precipitation-driven decoupling to the overall Sc–Cu climatology is not clear.

MAGIC data are being used to explore reasons for observed seasonal and synoptic variability in offshore aerosol and cloud droplet concentration gradients over the NE Pacific (David Painemal, NASA). There are remarkable summer–winter contrasts with much weaker offshore decreases in CCN and cloud droplet concentrations during winter. There is also strong synoptic variability within a season that could drive exploratory modeling sensitivity tests (see discussion in the previous paragraph).

The vertical distribution of aerosols in typical marine boundary layer (MBL) regimes is not well understood. Decoupling of the marine PBL is common (especially at ENA). As Xiquan Dong (University of North Dakota) showed, observations can be used to begin to explore sensitivity of aerosol–cloud interaction (ACI) metrics (e.g., sensitivity, ACI of cloud droplet concentrations measured using surface remote sensing to aerosols measured at surface) on whether PBL is well mixed or decoupled. Initial results from both the ENA site and from the MAGIC campaign indicate values of ACI close to unity for coupled PBLs, with values decreasing in deeper, more decoupled PBLs. This may have significant impacts upon how surface aerosol observations from low cloud regimes (e.g., ENA, MAGIC) are interpreted. Updated CCN vertical profile estimates from the micropulse lidar/high spectral resolution lidar/Raman lidar should be constructed to examine this problem.

Aerosol observations from the Marine Stratus/Stratocumulus Experiment (presented by Jim Hudson, Desert Research Institute) indicate considerable variability in the bimodality of aerosol spectra under marine low clouds. A bimodal spectrum can be produced by aqueous phase cloud processing (sulfur dioxide to sulfate) or by physical processes (coalescence scavenging and consequent redistribution of aerosol sizes). The bimodality can be used to understand which processes (coalescence versus aqueous chemistry) shape the aerosol size distributions in the MBL. The appearance and disappearance of bimodality appears to occur on short spatial scales, suggesting that it may be used in conjunction with cloud measurements (e.g., at the ENA site) to establish if there is a connection between the mesoscale circulations typical of the MBL and the aerosol size distribution. If so, it may be possible to tease out the causes of the processing.

Continental shallow cumulus clouds: Yangang Liu (BNL) showed that RACORO (Routine AAF Clouds with Low Optical Water Depths Optical Radiative Observations) data are being used to explore and unravel complex interactions between aerosols, updraft speed, lateral entrainment, droplet concentration, and precipitation. Initial results suggest that condensate loading and droplet concentrations in continental shallow cumulus clouds are strongly tied to the updraft speed, but there are correlations between aerosols and these variables that need to be better understood. Cloud-resolving/LES modeling work by the Brookhaven National Laboratory group and collaborators (discussed in the morning joint session on modeling) can help to understand cause and effect.

New aerosol sources over cold SSTs: Danny Rosenfeld (Hebrew University of Jerusalem) presented an analysis of satellite data over the Southern Ocean, which show increases in cloud droplet concentration with decreasing SST once the SST falls below about 7°C. There is a need to understand whether the satellite-observed increases of cloud droplet concentrations over SSTs colder than approximately 7°C are related to increased aerosol primary production from sea spray as seen in two laboratory studies. Data from the Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study could help explore this. There are some concerns about the possibility of retrieval artifacts due to covariability of SST and solar zenith angle at high latitudes and possible problems with broken clouds.

Low clouds at SGP: Cheng Zhou (University of Michigan) has been using shallow low cloud cases from SGP to set up both CRM and Single-Column Model cases (using MC3E forcing data), and to compare these with observations to understand the sensitivity of continental low clouds to changes aerosols. Interestingly, the signs of the changes in some cloud macrophysical variables (e.g., liquid water path, precipitation, etc.) differ between cases and between the two models. Sensitivities also are found to be dependent upon the time of day. Further work should explore if the differences can be related to different process treatments in the two models.

Large-scale modeling: Steve Ghan (PNNL) discussed using the suite of Aerocom models to ascertain factors causing differences in each model's aerosol indirect effect. This can be done by breaking aerosol indirect effect into different components (factors) representing sensitivity of one variable to the next in the chain from emissions to radiative forcing. However, the factors that affect the anthropogenic aerosol influence on the energy balance might differ from sensitivities estimated from present day variability in cloud and aerosol variables. Some of the factors could be related to observable metrics that can be used to constrain some of these factors using ARM data. The probability of precipitation is already one factor that has been explored, but others might involve ACI metrics.

Value-added product (VAP) prioritization for CAPI warm clouds: The most pressing need is for drizzle VAPs. Existing methods are available (e.g., the O'Connor lidar-radar approach used in CloudNet), and should be applied to data from marine low cloud deployments. A VAP for cloud droplet concentration that uses a narrow field of view in addition to the current wide field of view radiometer to constrain cloud optical thickness should be explored. It was felt that there is currently no need to try to use micropulse lidar for a CCN profile VAP that can be applied to CAP-MBL because there are too many assumptions. Instead, we should look forward to using the Raman lidar for ENA because it can measure the RH profile and therefore better account for the hygroscopic growth of aerosols.

There remain problems with CCN measurements at low supersaturations that need to be addressed (e.g., with longer-column measurements that allow longer times for particles to grow to detectable size).

3.4 Summary of Joint Cloud Condensation Nuclei Session

Jian Wang, Steve Ghan, Rob Wood, and Allison McComiskey

The goal of the joint ALWG/CAPI/Cloud Life Cycle Working Group (CLC Working Group) CCN session is to bring all three working groups together in a plenary discussion on potential overlapping areas of interest. The presentations and discussions focused on the theory of CCN activation and its representations in global climate models (led by Steve Ghan, PNNL), sea spray aerosol as a major source of MBL CCN (led by Ernie Lewis, BNL, and Susannah Burrows, PNNL), and removal of CCN by coalescence scavenging (led by Rob Wood, University of Washington).

While the Köhler theory to predict particle CCN activity (i.e., the ability of particle to serve as a CCN at a given supersaturation) is well established, especially for inorganic salts, some complications remain. For example, organics could exhibit a range of hygroscopicities, which could also vary as organics age in the atmosphere. For water insoluble particles such as mineral dust, adsorption of water molecules on a particle surface allows droplet activation at a lower supersaturation than that predicted by Köhler theory. The effect due to adsorption can be described by a Frenkel-Halsey-Hill isotherm, and is being incorporated into GCMs. As aerosol particles take up water, water soluble gas-phase species may condense into the growing droplets, leading to an increase of solute mass. The increasing solute mass lowers the equilibrium water vapor pressure over droplet surface; therefore, the critical supersaturation required for activation. This effect depends on not only the distribution of water soluble gas-phase species, but also the concentration and size distribution of aerosol particles. At present, more studies are needed to further understand this impact due to condensation of water soluble gas-phase species and represent it efficiently in GCMs.

Besides the representation of the CCN and its activation, uncertainty in a simulated CCN spectrum also comes from our incomplete understanding and representation of some of the major sources and sinks of aerosol particles. In the MBL, sea spray aerosol may represent one of the major sources of CCN. Sea spray aerosol particles are often enriched with organics, which are mostly derived from marine dissolved and colloidal matter. These organics contribute significantly to the mass of particles with diameters less than ~200 nm, an important size range for CCN. Recent studies suggest that sulfate and marine organics could explain significant variability in monthly mean cloud droplet number concentration (as observed by satellites) over the Southern Ocean. The flux of sea spray aerosol depends on a number of factors including wind speed, and currently there are large uncertainties (i.e., range over an order of magnitude) in the flux estimates. Simulations using a new mechanistic parameterization suggest the seasonal cycle of the organic fraction in submicron sea spray correlates with chlorophyll in some ocean regions, where chlorophyll correlates with presence of surfactants (e.g., lipid-like organic macromolecules), but this correlation may not exist in all regions of the oceans because of differences between ocean ecosystems. The simulations also suggest strong seasonal and spatial variations in marine biota and, therefore, in the organic fraction of sea spray aerosol. More detailed chemical composition measurements are needed to understand the organic enrichment and mixing state of sea spray aerosol, including their seasonal and spatial variations, and to evaluate model simulations.

Droplet loss resulting from coalescence scavenging in light precipitation from marine low clouds is significant and a major sink of MBL CCN. A simple CCN budget model incorporating coalescence scavenging is capable of predicting the major spatial variation of cloud droplet concentrations (N_d) in regions of persistent low-level clouds, demonstrating the importance of light precipitation for setting "background" N_d in the remote MBL. A significant fraction of the variability in N_d across regions of extensive low clouds is therefore likely related to drizzle sinks rather than source variability. Future research includes the evaluation of scavenging parameterizations using ARM data. For example, an Azores open cell case with copious drizzle (discussed in the joint warm cloud session) is being developed and could be used to examine the impact of coalescence scavenging on CCN population and test parameterizations. Future work also is needed to address the dependence of the scavenging on scales resolved and parameterized, and extend to shallow cumulus clouds.

3.5 Outcomes from the Radar Science Organized Breakout Session on "Breaking New Ground with Radar Doppler Spectra: Microphysics and Dynamics, Models and Observations"

Ed Luke and Ann Fridland

This session was well attended with participants overflowing outside the meeting room. The half-hour discussion following the scheduled presentations placed significant emphasis on ice/mixed-phase.

Ed Luke (BNL updated the group that roughly seven years of new MicroARSCL evaluation data became available since the 2014 ASR Principal Investigator Meeting, including coverage of the MC3E, RACORO, and CAP-MBL campaigns, and showed MicroARSCL data from the March 11−12, 2013 NSA case study period identified by the Mixed-Phase Interest Group.

It was strongly articulated that there is a need for more ground-based and airborne in situ measurements focused on characterizing particle size distribution (PSD) and particle habit to provide truth for the development of better ice radar/lidar forward models for simulators, and mass/density/fall-speed relationships for retrievals.

There was a general consensus that polarimetric and Doppler spectral approaches applied together hold promise for breakthroughs in characterization of ice/mixed-phase processes. Initiation of a new complementary breakout session on radar polarimetry was proposed to run in parallel with future radar Doppler spectra breakouts.

Gijs de Boer (University of Colorado, Boulder) attended this session and encouraged participation in the ice breakout sessions that he would co-chair on the following day. Several radar spectra breakout attendees did subsequently participate in the mixed-phase breakout where they expressed interest in collaborating on a paper on the March 11−12, 2013, NSA case study.

4.0 Wednesday, November 19, 2014

4.1 Summary of Cloud Phase Focus Group Session

Matthew Shupe, Anthony Del Genio, and Jerry Harrington

During this session, members of the Cloud Phase focus groups met to discuss ongoing activities. As there was a desire to keep the focus on discussion rather than presentations, there were no scheduled presentations during this session. The first 1.5 hours were dedicated to discussion on topics related to phase in stratiform clouds and an ongoing case study on that topic. During this time, participants worked to develop hypotheses based on the March 2013 NSA case study, discuss what tools could be used to address those hypotheses, and establish small teams that could work together to further pursue such efforts. The last half-hour of the session was dedicated to discussion on potential topics of interest in understanding cloud phase in convective cloud regimes—a topic that recently was brought forth as one that had substantial interest from a variety of angles.

To initiate discussion on the stratiform cloud case currently being analyzed within the group, a few slides were presented as a refresher on what the case looks like, which specific periods were of interest, and what previous work had been done. Our focus was reaffirmed to be on several transitions in the ice crystal precipitation falling from the cloud and an improved understanding of the mechanisms and processes related to these transitions. As a part of the review and the discussion, several questions were formulated, including:

1. What is the role of the upper level cloud and how does it relate to the observed shift in precipitation intensity and velocity and spectra skewness observed to occur below it?
2. Are shifts in precipitation occurring at time when large-scale dynamics are static? What is the role of aerosols in these shifts?
3. What is driving the descent of the cloud layer during the second half of the two-day period? If large-scale processes drive the descent, are the relevant dynamic scales synoptic or mesoscale, or both?
4. What causes the decrease in ice to be associated with an increase in turbulence? What role are changes in humidity at cloud top playing?
5. What causes the large variability in spectral width? Is this also a signature of many small droplets?
6. What is the strength of the turbulence and how it is related to the large-scale flow and the liquid water productions and the wind direction and the large-scale tendencies?

From discussion of these questions two hypotheses were developed. Specifically, the first hypothesis is that the upper cloud plays a minimal role in governing precipitation and local dynamical changes because it is a relatively thin ice cloud. To evaluate this hypothesis, several analyses will be undertaken. First, using input from remotely sensed microphysical retrievals, radiative transfer simulations will be performed to evaluate the impact of the upper level cloud on cloud top cooling rates. This analysis could potentially benefit from information on ice crystal habit from the Ice Properties and Processes focus group, as such information could inform and improve microphysical retrievals. Second, a detailed temporal analysis of cloud-scale dynamics will be carried out to better evaluate the impact of having this upper level cloud present. It is hoped that the work carried out in evaluating this hypothesis will result in a publication focusing on cloud-scale dynamics, to be led by Stefan Kneifel (McGill University), Ed Luke (BNL), Matt Shupe (University of Colorado, Boulder), Maike Ahlgrimm (European Center for Medium-Range Weather Forecasts),and Heike Kalesse (Leibniz Institute for Tropospheric Research). In addition to this hypothesis, a second hypothesis was developed on the first observed transition. Specifically, this hypothesis states that the first transition in precipitation was the result of a shift in larger scale dynamics. This hypothesis will be evaluated using a combination of surface and remote sensor observations from Barrow, along with results from the nested weather research and forecasting simulations. A paper on this topic will be pursued by a team consisting of Amy Solomon (NOAA), Gijs de Boer (University of Colorado, Boulder), Mariko Oue (Pennsylvania State University), Maike Ahlgrimm (European Center for Medium-Range Weather Forecasts), and Kara Sulia (University at Albany).

The discussion on cloud phase in convective clouds was wide-reaching and exploratory. Encouragingly, in addition to numerous comments from people actively engaged in convective cloud research, there were also substantial contributions from participants who are generally associated with research in high latitude environments. One topic that drew particular attention included phase in shallow convective clouds over the Southern Ocean and the potential for temperature-dependent phase partitioning in convective schemes to be partially responsible for large biases observed there. In addition, there was an interest in thinking about the impact of hydrometeor phase on the amount of ice present in the anvils associated with deep convection. It was not entirely clear how ARM measurements could help to address these issues, although a few suggestions were made, including that there may be "southern ocean like" clouds available for analysis at NSA during the summer, and at ENA during the winter. It was clear that additional discussion should be encouraged in order to better establish what the central questions are related to cloud phase in convective clouds and how those may be addressed within the context of ASR and ARM.

4.2 Summary of Ice Properties and Processes Working Group Session and Future Plans

Updates on the progress made on the 12 deliverables and 3 metrics originally defined in the Ice Properties and Processes white paper were first given. The remainder of the session was devoted to discussion centered on four questions. Tangible developments from this and subsequent discussions are as follows:

1. ***Model/measurement intercomparison studies***: To address needs for modeling studies of Ann Fridlind (NASA) and others, measurements on the size dependence and distance from cloud top dependence of ice particle aggregation is needed. Chandra (University of Colorado, Boulder) volunteered radar measurements showing the dependence of aggregation on distance from cloud top and other factors. This complements ongoing efforts by Greg McFarquhar (University of Illinois, Urbana) and Xiquan Dong (University of North Dakota) who are deriving fractional contributions of aggregates from MC3E and other databases. Combined, this would integrate retrievals from radar, in situ data, and modeling studies, and would contribute to better understanding aggregation.

2. ***Closure studies****:* We discussed whether anything new or different should be done, including whether future campaigns should be done differently to make them more relevant. There was discussion on the ongoing collaborations at SGP (led by Eli Mlawer, Atmospheric and Environmental Research, Inc.) and NSA (led by Dan Lubin, Scripps Institution of Oceanography). In addition, it was emphasized that cases were needed from a variety of climates, not necessarily including all ice clouds.

3. ***Ice processes****:* We discussed what processes our focus for improving the representation (e.g., fall speeds, single-scattering properties, etc.). It was emphasized that the shape parameter for a gamma distribution, denoted as μ, was sorely needed to relate measurements to the size distribution moments. However, those estimating μ from in situ data noted that μ is poorly constrained, and that measurements from different probes using different size ranges can give very different values, especially given that μ is very sensitive to the concentrations of small ice crystals. Further, examination of in situ data by Greg McFarquhar (University of Illinois, Urbana) has shown that adequate treatment of uncertainties means that volumes of equally realizable solutions in (N_0, λ, μ) phase space rather than point values is required to adequately represent gamma distributions.

4. ***m-D/A-D relations***: David Mitchell (Desert Research Institute) presented a means of treating the process of ice particle riming in terms of *A-D* and *m-D* power laws for dendrites, and a means of generalizing this approach to other ice crystal habits was offered by Jerry Harrington (Pennsylvania State University). This may be useful in modeling the life cycle of Arctic stratus clouds. Since the meeting, another approach of improving *m-D/A-D* relations, especially for problematic small ice crystals, has been proposed using high-resolution ice crystal images (Lance, Stratton Park Engineering Company, and David Mitchell, Desert Research Institute); this will be implemented in CAM5 and is critical for determining optical properties of thin cirrus near the tropopause. Alternate approaches of using single particle databases to constrain models predicting the ice particle properties also were discussed.

5. ***New field studies:*** We discussed whether any high priority observations were missing, and whether there were any other groups we should team up with for future measurement campaigns. Different ideas were raised here, including a campaign over the NSA to look at aerosols and ice nucleation at various temperatures (including T <−40°C where in situ measurements are absent), field campaigns trying to better constrain *m-D* relations, and a field campaign over the Southern Oceans.

4.3 Cloud Life Cycle Working Group–Quantification of Uncertainties in Cloud Retrievals/Ice Properties and Processes—Ice Characterization and Related Uncertainties

Greg McFarquhar, David Mitchell, and Ann Fridlind

The beginning of the session was devoted to a single Quantification of Uncertainties in Cloud Retrievals (QUICR) presentation on a new method of implementing uncertainty analysis in retrievals. The method will provide an uncertainty value associated with each retrieval value, and was well-received by the group.

The remainder of the session was devoted to the Ice Properties and Processes focus group, which is now in a mature stage (focus group approved in March 2014). The group's white paper[1] identifies 12 specific milestones or project deliverables over a 5-year horizon. Some involve principal investigators extending their funded project to cover deliverables requested by other principal investigators; others are collaborations between two or more principal investigators. At this session no new deliverables were identified nor major changes made in existing deliverables. Each deliverable discussion was led by a group Principal Investigator who included work from one or more group PIs to cover current status. A single presentation (CLWG_CAPI_JointIceSession.pptx) summarizing the discussion is available. A brief summary of current progress on identified deliverables (see white paper) follows:

1. **Single particle databases of ice properties**: first databases delivered and currently in use by multiple group principal investigators; manuscripts completed or in preparation

2. **Dependence of ice properties on environmental conditions**: new results from multiple principal investigators; manuscripts in preparation

[1] http://asr.science.energy.gov/science/working-groups/clc/docs/icepro_whitepaper_20140130-1.pdf

3. **Spectral radiative closure during the Indirect and Semi-Direct Aerosol Campaign**: in new calculations using LES results and ice properties, ice had to be scaled up to reach agreement on test pixel; difficult parts done
4. **Spectral radiative closure at SGP**: clear-sky radiative closure (first step) identified design flaw in the shortwave spectro-radiometer; instrument characterizations need improvement; ongoing
5. **Improved ice properties in retrievals**: MC3E in situ data have been applied to MC3E-specific next-generation radar retrievals of ice PSDs; manuscript in preparation
6. **Ground-based remote sensing of ice habit**: microphysical regimes identified in Millimeter Wave Cloud Radar data reported in 2013 publication; confirmed upgrade to NSA radar is happening
7. **Upgrade CAM5 microphysics**: cloud ice and snow classes now combined and new m-D and A-D relationships incorporated with look-up table approach, now testing (Single-Column Model, GCM)
8. **High-resolution MC3E simulations**: two-moment outflow versus in situ PSDs agree poorly; bin microphysics stratiform melting layer agrees with roundness; manuscripts in preparation
9. **Improved ice in models**: new results from models with habit evolution of unrimed and rimed ice; manuscripts in preparation and in press
10. **Ice uncertainties in models**: SPARTICUS 3D simulation results use traditional sensitivity test approach (in preparation); recent manuscript describes PSD uncertainty
11. **Ice optical properties**: recent manuscript reports fast optical properties model dependent on element aspect ratios, now being implemented in SPARTICUS simulations
12. **Measurement gaps**: process-oriented analyses added to deliverables (aggregation, multimode PSD fits); identified poorly sampled regions (Southern Ocean, Arctic cirrus).

4.4 Introduction to Scanning Radar Forward Simulation Using Cloud-Resolving Model Output from the Aerosol-Deep Convection Interactions Study (MC3E)

Pavlos Kollias

This session, organized by the radar science group, marked the first step toward the development of a radar simulator suitable for CRMs with bulk schemes. This is radar simulator, mainly scanning, will be designed to accommodate all radar systems operational at ARM sites. The aerosol-deep convection interaction study (MC3E) CRM simulations were selected as first test cases. The goal of the meeting was to discuss the requirements for the simulator and its complexity.

The different modules of a state-of-the-art radar simulator were discussed and presented in detail. Pavlos Kollias (McGill University) discussed the instrument model of a radar simulator that accounts for the radar characteristics, the sampling strategy and volume, and the radar receiver (noise addition, signal processing). Alexander Ryzhkov (National Severe Storms Laboratory) discussed the forward model that treats the interaction of electromagnetic waves with the model-generated particles. Great emphasis was put on the assumptions required to interface the numerical model output with the radar forward model.

The aforementioned breakdown of the radar simulator (instrument and forward models) helped to stimulate discussion with the 40-plus participants. The majority of the participants found the proposed sophistication of the instrument model unnecessary and suggested that we should steer future efforts toward the development of a simplified, flexible simulator that produces mainly radar reflectivity and polarimetric variables. Thus, the next step for the radar science group is to apply such a simplified approach to the CRM simulations from the MC3E case study and present the results in the upcoming 2015 science team meeting.

The last 20 minutes of the breakout session were dedicated to a presentation of the ARM-funded effort to develop of profiling cloud radar simulator for GCM. Shaocheng Xie (LLNL) explained the basic structure and applications of the cloud radar simulator for GCMs. Future breakout sessions organized by the radar science group will provide information on further developments of both simulators (scanning for CRM and profiling for GCM).

4.5 Summary of Marine ARM GPCI Investigation of Clouds Session

Ernie Lewis

The MAGIC session that was held Wednesday, November 19 during the 2014 Atmospheric System Research Fall Working Group Meeting consisted of nine presentations and was well attended, with nearly 50 attendees. Ernie Lewis (BNL) gave a brief introduction on the status of MAGIC activities, and there were four other short (~5 minute) “status” presentations. Mike Jensen (BNL) reported that the best estimate ship motion and attitude corrections would be finished soon and that selected legs would be released for evaluation within a week or so. Mary Jane Bartholomew (BNL) discussed the status of the data in the archive and showed where to find these data. Karen Johnson (BNL) summarized the radar data obtained during MAGIC and the status of ship motion correction applied to these data. Pat Minnis (NASA) gave a brief overview of the satellite cloud products available for MAGIC.

The next four presentations, each approximately 30 minutes, discussed MAGIC science. Chris Bretherton (University of Washington) discussed LES simulations that he and his student Jeremy McGibbon had started and some of the issues they faced involving use of the European Center for Medium Range Weather Forecasting data for large-scale forcing. Xiaoli Zhou (McGill University) discussed the physical basis for the boundary layer decoupling, and reported that there appeared to be a threshold delta-q (difference in water vapor mixing ratio between the top 25% of the boundary layer and that in the lowest 25%) of 1.5 g/kg above which decoupling systematically occurs. Christine Chiu (University of Reading, United Kingdom) discussed extending the ENCORE (Ensemble Cloud Retrieval) Method to drizzling clouds during MAGIC, which involves using lidar-attenuated backscatter at one wavelength, radar reflectivity, and validation with CIMEL sunphotometer-measured zenith radiance. Finally, Peng Wu (University North Dakota) discussed cloud and drizzle property retrievals during MAGIC that employed empirical correlations between effective radius and radar reflectivity for cloud retrievals and an empirical determination of a parameter relating radar reflectivity and lidar backscatter for drizzle retrievals. Each of the science presentations promoted considerable interest and discussion, which unfortunately had to be interrupted so the session could continue (as it was, the session ran over its allotted time by 30 minutes). Fortunately, much of this discussion continued after the session.

4.6 Summary of Secondary Organic Aerosol Session

Jian Wang, John Shilling, Sasha Madronich, Scot Martin, Alla Zelenyuk, Manish Shrivastava, Joel Thornton, and Rahul Zaveri

The SOA session focused on progress during the last year and future plans for three topics on SOAs. These three topics, identified through discussions during last year Fall Working Group meeting, are (1) SOA growth mechanisms (led by John Shilling, PNNL, and Sasha Madronich, NCAR), (2) effects of SOA viscosity/phase on SOA formation, properties, and evolution (led by Scot Martin, Harvard University, and Alla Zelenyuk, PNNL), and (3) sulfate as a driver for SOA formation (led by Manish Shrivastava, PNNL, and Joel Thornton, University of Washington).

The growth mechanisms of SOA strongly influence the number–diameter distribution of the atmospheric aerosol population and, therefore, the CCN spectrum and aerosol optical properties. A number of joint activities were successfully completed last year. For example, a collaborative chamber SOA growth study was carried out at PNNL to examine the grow rates of particles with different sizes and chemical compositions. The data were analyzed with the MOSAIC aerosol box model, which suggested that SOA particles are semisolid and SOA species are semi-volatile. Follow-on experiments were planned to examine particle growth under different conditions (e.g., high RH). Concerted efforts also have focused on modeling SOA formation from biogenic VOC using process level, regional, and global models. Future studies are planned to examine SOA formation and particle growth under both pristine and polluted conditions using data sets from recent field campaign, such as GoAmazon2014/5.

Formation, properties, transformations, and temporal evolution of SOA particles depend strongly on SOA phase/viscosity. Because of a lack of data, models have assumed that SOA particles are low-viscosity solutions that maintain equilibrium with the gas-phase by rapid evaporation/condensation and mixing. Recent experimental evidence indicates that SOA particles are semisolid with viscosities that are many orders of magnitude higher than assumed. Last year, a number of studies focused on SOA viscosity, phase state, and their dependence on RH, temperature, precursor, and aging. For example, X-ray microscopy results show that ambient SOA particles often have substantially higher viscosity than those generated in laboratory. Chamber studies and field observations show that the traditional picture of liquid-like SOA is inconsistent at times with observed SOA size distribution growth or vertical distribution of SOA concentration in the boundary layer. The RH dependence of SOA phase state and viscosity were characterized in a series of laboratory and field studies. Future work will include the impact of phase and viscosity of organic particles on reactive uptake (e.g., carbonyls) during SOA formation. Several proposals submitted by staff from the Environmental Molecular Sciences Laboratory were funded to support future studies of SOA growth mechanism and the effect of SOA phase and viscosity on SOA properties and transformations.

A white paper on "Sulfate as a Driver of SOA Formation," prepared by Manish Shrivastava (PNNL) and Joel Thornton (University of Washington), was presented and discussed during the session. Sulfate affects particle acidity and liquid water content, both of which can influence SOA formation. These influences of sulfate and acidity on SOA formation are not limited to only biogenic SOA precursors, but likely also influence SOA formation from anthropogenic VOC and biomass burning oxidation products. Moreover, these interactions depend not only on sulfate but also on other anthropogenic emissions such as nitrogen oxides and ammonia. A need to re-evaluate both present day and pre-industrial climate simulations with respect to impacts of sulfate/nitrogen oxides/ammonia regimes and particle acidity on

SOA formation was recognized and would serve as a motivation for research in this area. Future research will include systematic examination of the impact of sulfate and particle acidity on SOA formation from representative precursors in chamber studies and the contribution of isoprene epoxydiols to SOA formation using data collected during GoAmazon2014/5. A plan to incorporate existing knowledge of the impact from sulfate/nitrogen oxides/ammonia into GCM parameterizations also was discussed.

It is recognized that various aerosol processes and properties (including the ones described above) can interact with each other in complex and perhaps heretofore unknown ways. Existing aerosol models differ in approaches, assumptions, and levels of detail, and it is not clear if any of them represent all the necessary processes and properties to reliably predict the three climate-relevant endpoints: optical, CCN, and IN properties. To help streamline the model development and evaluation process, a vision for a "perfect" holistic aerosol model was presented by Rahul Zaveri (PNNL) as part of the cross-cutting activities. The initial objective of this exercise was to describe all the known or desired physico-chemical aerosol processes and properties (with a particular focus on organics) and schematically visualize how they would interact with each other. This schematic can be used to evaluate qualitative uncertainties and importance of the various processes and properties as well as connections with other ASR focus groups. The group discussed ideas for developing a uniquely comprehensive holistic model that can be used as a benchmark for evaluating computationally efficient SOA and other process parameterizations (to be) used in climate models. A comparison of different existing models with respect to a set of well-defined conditions (i.e., a chamber experiment) also was planned.

5.0 Thursday, November 20, 2014

5.1 Cloud Life Cycle Working Group Cold Pool Interest Group Summary

Angela Rowe and Zhe Feng

The cold pool interest group had its first breakout session during the Spring 2014 Meeting, where brief presentations were given to show the range of ongoing cold pool research within the ASR community. Observations of cold pool properties focused on the SGP region and the tropical ocean during the ARM Madden-Julian Oscillation Experiment. The main issue that arose from the breakout was how to deal with the disconnect between what is available from observations and what high-resolution models are able to produce, particularly noting a need for low-level observations (e.g., rain rates, raindrop size distributions, T, q). This served as the framework to move the group forward for the Fall Working Group meeting.

Topics for the Fall Meeting breakout session focused on integrating observational data sets and models to understand cold pool properties and the role of cold pools in convective initiation and organization, highlighting what data sets are currently used to address this issue, and what is needed to move the science forward. A list of current available data products was presented to the group to facilitate further discussion on the aforementioned topics. It was then emphasized that the biggest errors in GCMs, related to this subject, are the inability of the models to produce clouds when they are present, and the relationship among the large-scale environment, downdrafts, and cold pool formation. It is therefore important for large-scale modelers to know when and where cold pools exist in a bulk sense and what large-scale conditions that GCM can produce lead to these cold pools. Related to this need for knowing ensemble cold pool characteristics, the use of long-term, high-resolution surface meteorology data is important to look at boundary passages and relate their properties to that of the broader environmental conditions. Also, new instrumentations such as AERI and Doppler lidars can provide high temporally resolved boundary layer details to fill in gaps in low-level observations. A need for robust, automated, cold pool detection algorithms using observations has been identified. These algorithms would be used to obtain statistics from large observational data sets and applied to high-resolution model outputs, which will require collaborations within the group.

To address the need to understand the relationship between the precipitation and downdraft with the cold pool areas, polarimetric radar data is valuable to infer precipitation drop-size distributions and to investigate the sensitivity to microphysics. In addition, scanning radar will be helpful for looking at 3D moisture fields when soundings are not representative of high-frequency variability, as was shown for the ARM Madden-Julian Oscillation Experiment. An intensive operation period was suggested to investigate this utility to address the crucial need for high-resolution, spatially representative moisture measurements for understanding cold pools and subsequent convective initiation.

The final topic to discuss in the meeting was how to move forward to encourage effective communication among the group. We had set up a Trello page for the group, which had received limited traffic and contributions prior to this meeting. Based on feedback, it was decided to move forward with the page, but to make use of tagging capabilities within the program to focus direct interaction for research specifically related to individuals. It is our goal to use this tool to continue the research discussion from the meeting and to inform the group on current research activities and available data sets to move forward with cold pool-related research.

5.2 Summary of the Cloud-Aerosol-Precipitation Interactions Deep Convection Breakout Session

Zhanqing Li, Hugh Morrison, and Jiwen Fan

This session covered seven contributed science presentations, followed by three one-slide project overviews and discussion (see the agenda for details). Science presentations covered a range of topics relevant to aerosol effects on deep convection, including both modeling and observational studies. Discussion initially centered on contrasting studies supporting or opposing “convective invigoration” (enhanced updraft strength from microphysics effects of aerosol loading). The last 30 minutes of the session were devoted primarily to discussion of the Deep Convection Cloud-Resolving Model Intercomparison Project, currently focused on MC3E (led by Jiwen Fan, PNNL). This joint project involving the CLC and CAPI Working Groups, is motivated by previous studies showing a large spread of cloud-resolving model simulations of deep convection, including aerosol effects, and large biases relative to observations. It has been highly challenging to identify the causes of these differences and biases. The Deep Convection Model Intercomparison Project involves the use of new methodologies to untangle these behaviors. A brief update of the current status of the project was given, and observational analyses needed in support of the project were discussed. Participants also engaged in a discussion on how to entrain the wider community of ASR scientists into the project, primarily through analysis of observations and from the developers and users of the microphysics schemes being tested.

This session also was relevant to the proposed Aerosol-Deep Cloud Interactions Focus Group (led by Zhanqing Li, University of Maryland). However, there was limited time for covering specific issues pertaining to this area, and discussion has instead taken place primarily through e-mail. To avoid this problem in the future, it was agreed by the organizers that it would be beneficial to ensure adequate time for discussion by re-structuring the format of this session in future meetings. This could be done by limiting individual science presentations to one or two slide highlights and focusing on discussion of collaborative projects, as well as more general topics of interest to the group. This would follow the format taken by several other breakout sessions at this meeting. Finally, many participants noted the challenge of having parallel CAPI and CLC sessions on deep convection, and suggested that future meetings should have parallel sessions partitioned by regime (for example, shallow clouds versus deep convection) instead of by working groups.

Key Recommendations

- continue support of the Deep Convection Model Intercomparison Project, especially through the involvement of the wider community of ASR scientists
- if possible, avoid overlapping CAPI and CLC sessions on deep convection in future meetings
- re-organize this breakout session in future meetings to focus more on discussion of collaborative projects
- coordinate with the CLC Working Group on a possible joint CLC/CAPI deep convection interest group
- explore opportunities for collaboration with the Aerosol Lifecycle Working Group, focusing particular on cloud effects on aerosols for deep convection
- coordinate jointly with the CLC Working Group to come up with a list of observational and infrastructure needs for deep convection studies
- support the design of future field experiments to study aerosol-deep cloud interactions, including identification of locations best suited for these studies using the ARM Mobile Facility

5.3 Summary of the Joint Cloud Life Cycle/Cloud-Aerosol-Precipitation Interactions Deep Convection Session

Adam Varble, Hugh Morrison, Courtney Schumacher, and Zhanqing Li

This session was split into two segments. The first, from 8:30 am to 10:15 pm, covered five framing presentations on a range of topics relevant to deep convection from CLC and CAPI perspectives (see agenda for details). The second segment, from 10:45 am to noon, started with two short summary presentations on activities related to deep convection within the CLC and CAPI Working Groups given by Adam Varble (University of Utah) and Zhanqing Li (University of Maryland), respectively. These talks, as well as the earlier framing presentations, set the stage for group discussion in the remainder of the session.

The discussion initially centered on the idea of forming a collaborative CLC and CAPI interest group on deep convection. There is considerable overlap between the two groups, and aerosol effects on deep convection operate through the same physical and dynamical processes as other effects of interest to the

CLC Working Group. Arguably, aerosol effects on deep convection represent part of a broader topic of microphysical-dynamical interactions in deep convection. However, one unique aspect in CAPI, with a strong tie in the Aerosol Lifecycle Working Group, concerns cloud effects on aerosols, which have not been studied extensively in ASR for deep convection. If there is sufficient interest in this topic, attention will need to be broadened. There was some concern expressed that, because so many people would be involved, such a joint CAPI/CLC deep convection group may not facilitate collaborative work. However, it was noted that the most effective projects and groups tend to grow organically on their own, and that there is a natural breakdown into smaller project-oriented groups after larger groups meet. It was suggested that collaborative efforts within the larger group could center around specific projects such as the Deep Convection Model Intercomparison Project, currently focused on MC3E. There was strong support for avoiding overlapping sessions of interest to both CLC and CAPI, so that future meetings could be based on parallel sessions for different regimes (shallow clouds, deep convection, etc.), rather than parallel sessions between CLC and CAPI.

Discussion later in the session focused on observational needs to support CLC/CAPI goals for deep convection studies. It was pointed out, for example, that we have not had a large, coordinated field campaign to address convective transport, which is a key uncertainty. It was also argued that there is a need for more detailed long-term measurements in addition to case study-centered field campaigns, which is especially important for deep convection given its large natural variability. Finally, the importance of CLC and CAPI scientists providing feedback on ARM infrastructure was stressed (e.g., the under-utilization of scanning radars was mentioned).

Key Recommendations

- avoid overlapping sessions for CLL Working Group/CAPI whenever possible at future meetings
- continue support of the CLC Cold Pool Focus Group
- continue support of the joint CLC/CAPI Deep Convection Model Intercomparison Project
- consider a joint CLC/CAPI deep convection interest group, with a focus for collaborative work on specific projects such as the Deep Convection Model Intercomparison Project
- coordinate jointly between CLC and CAPI to come up with a list of observational and infrastructure needs for deep convection studies.

5.4 Cloud Life Cycle Working Group Mesoscale Convective Organization Summary

Adam Varble and Courtney Schumacher

The first half-hour of this session focused on convective dynamics and microphysics retrievals. Discussions at past meetings have emphasized the importance of convective vertical velocity and microphysics retrievals to understanding the life cycle of deep convective systems and helping to untangle causes for biases in simulations of deep convection. Convective vertical velocity can be retrieved more accurately than bulk microphysics properties such as condensate mass and number concentrations; however, vertical velocity retrieval uncertainties are still poorly quantified and sample sizes are small. In addition to multi-Doppler retrievals, innovative new retrievals using multifrequency vertical profilers and stereo photogrammetry using digital cameras may lead to more accurate estimation of convective vertical velocity. Each method has its own strengths and weaknesses and while some of this research is only in beginning stages, it should be of interest to anyone working on deep convection in CLC and CAPI Working Groups.

The second half-hour consisted of an overview of the Mesoscale Convective Organization (MCO) Trello website[1], showcasing its usage for active communication between researchers working on the same mesoscale convective case studies or research topics. Researchers can link figures, animations, publications, presentations, data sets, and other information to topics on the MCO Trello website or specific field campaign websites linked on the website. This may lead to more collaborative research on larger topics than one researcher can address themselves, an objective that is stressed in the ASR program.

The second hour focused on cold pools (see CLC Working Group Cold Pool Interest Group Summary). Outside of cold pools, there was no time for discussion during this session of research related to the life cycles and modes of the MCO, including their dependence in environmental conditions; however, these topics were touched on in the ARM Madden-Julian Oscillation Experiment session. Emphasis at past meetings has also been put on development of GCM parameterizations for mesoscale organization, but no one requested time to present such work. It is unclear how widespread such research is in ASR despite agreement of its importance at meetings.

Key Recommendations

- There is a lot of interest in the Cold Pool Interest Group, and this group should continue to be supported. There may be enough ongoing work to fill a full 2-hour session at future meetings.
- Some work presented on deep convection does not have a focus on mesoscale systems, but the CLC Working Group does not have a deep convection group outside of the MCO. A joint CLC Working Group/CAPI Deep Convection Working Group may solve this issue.
- Retrieved convective draft properties suffer from small sample sizes. Retrievals using Vertical profiler (e.g., 920 MHz) and multi-Doppler need to be extended in time to more operational products, but the manpower to do this may be lacking.
- The MCO group should continue to address topics outside of cold pools and convective updrafts at the next meeting to see what the community is working on and to decide whether the research being performed is aligned with the stated MCO-related goals of ASR.

[1] https://trello.com/mesoscaleconvectiveorganization2, password required.