Wyoming King Air as a National Facility
UW/NSF Cooperative Agreement 8 (CA8)
AGS-1917369: Year 2 Annual Report

Contents:

1. CA Status

The University of Wyoming King Air (UWKA), the Wyoming Cloud Radar (WCR), Wyoming Cloud Lidars (WCL), and associated instrumentation have been available to the broader NSF-funded science community through the NSF/GEO/AGS Lower Atmospheric Observing Facilities (LAOF) Program since 1988 (WCR was added in 2004, WCL was added in 2010). The UWKA facility is funded through a Cooperative Agreement (CA) between the University of Wyoming (UW) and NSF. The current CA, the 8th, began on 9/1/2019 and runs through 8/31/2024.

This report describes activities during Year 2 (September 2020-August 2021) of CA8. It is noted here that Year 2 is not completed as of this writing. Where appropriate, planned activities for the coming 1.5 months are included.

Table 1 lists all projects supported during Year 2 of CA8. Four of the projects (SWEX, SPICULE/ESCAPE, APART {TRANS^{2}AM}, and CHACHA) are supported through NSF deployment pool (DP) funds. Of these, only APART (TRANS^{2}AM) has/will have flight hours on the UWKA during Year 2. SWEX, SPICULE/ESCAPE, and CHACHA are included here because effort was expended in support of preparation for these projects during Year 2. Two other projects: DILBERT, funded directly through CA8 funds, and FLUX-20, funded outside of NSF, are also included in this table. We estimate a total of ~77 hours will be flown by the UWKA by the end of Year 2. Details of efforts, progress, and outcomes (where appropriate) for each of these projects during Year 2 are provided in the following two sections.

Table 1: Hours flown for project support during Year 2 of CA8

	HOURS FLOWN			
Project name	**Non-NSF Funded**	**CA8 Funded**	**NSF DP Funded**	**Total**
FLUX 20	5.4			5.4
SWEX			-	0
SPICULE/ESCAPE			-	0
DILBERT		17.3		17.3
APART (TRANS^{2}AM)			~50* (planned for Yr 2)	50
CHACHA			-*	0
Grand Total				**77.7**

* Some portion of flight hours for APART/TRANS2AM and all flight hours for CHACHA will be flown in Year 3

2. Projects Supported under NSF CA and Deployment Pool in Year 2

Project: SWEX

The **Sundowner Winds Experiment** (SWEX) is designed to investigate mechanisms driving downslope windstorms in the lee of the narrow Santa Ynez Mountains that are influenced by complex interactions with a cool, stable, and shallow marine boundary layer. Originally, the project was slated to deploy in spring 2020. SWEX was postponed due to COVID-19 and re-scheduled for spring 2021. In late winter 2021, SWEX was once again postponed due to COVID-19. Due to a conflict with another scheduled deployment of the UWKA in spring 2022, The UWKA will not participate in SWEX and another aircraft will be selected to support the project. It is possible that the WCL will be a part of the 2022 deployment of SWEX, however, that depends on the ability of that aircraft to accommodate the instrument.

Outcomes:

Preparations were once again well underway in early 2021 when the decision was made to postpone the project until 2022. Effort towards SWEX in Year 2 focused mostly on the early preparations for the deployment (prior to postponement) followed by the assessment and working with NPS-CIRPAS engineers to determine if the WCL would be part of the payload for the 2022 deployment on the Twin Otter. The determination of the WCL deployment has not yet been made.

Project: SPICULE/ESCAPE – WCR on C130

The **Secondary Production of Ice in Cumulus Experiment** (SPICULE) and the **Experiment of Sea Breeze Convection, Aerosols, Precipitation, and Environment** (ESCAPE) were scheduled to utilize the WCR on the NCAR/NSF C130 aircraft in summer 2021 (following the postponement of SPICULE in summer 2020 due to COVID-19). Between September of 2020 and April 2021, UWKA facility personnel worked on the preparation, installation, ground testing and flight testing of WCR on the C130. The WCR has not been flown on the C130 since the last major WCR upgrade in 2015 and installation on the C130 required significant efforts. UWKA personnel worked closely with EOL/RAF staff to re-establish the electrical requirements for the radar, define the aircraft cabling for the radar, and setup a plan for installation and to conduct dedicated test flights in Fall 2020.

Outcomes:

The WCR was installed on the C130 in November 2020 and successfully tested on the ground. Two test flights were carried out late in November when the operation and the acquisition modes for SPICULE/ESCAPE research flights were tested. The radar performed well and delivered the expected sensitivity and quality data. WCR processing software was upgraded to work with WCR3 on C130 and reflect the changes in the C130 aircraft data required for processing the radar data.

Another major development for WCR on the C130 also took place. A radar-dedicated GPS aided IMU was installed on the WCR rack at the C130 ramp. This is where the C130 nadir port accommodating the two down-pointing antennas is located. The aircraft inertial navigation system (INS) was insufficient to represent the attitude (antenna beam pointing) at the ramp due to movement of the ramp itself resulting from aircraft pressurization. This reduces the accuracy of the down antennas' beam-pointing and the correction of the radar Doppler measurements for the aircraft motion contribution. As part of our preparations and flight testing, a high-accuracy Applanix AV410 IMU was installed at the location of the WCR. The Applanix used is the previous (now spare) IMU from N2UW, which became available due to CA7 instrument upgrades. The Applanix data showed that, as expected, the C130 tail/ramp movement deviates from the measurements provided by the C130 INS, resulting in a poor beam-pointing calibration of the two down antennas. The preliminary calibration accomplished using the Applanix showed major improvement in the radar Doppler correction with anticipated accuracy on the order of 0.1 to 0.2 m/s. It is clear that for future deployments of the WCR on the C130, a WCR-dedicated IMU installed near the down antennas must be used as part of the installation in order to secure high-quality WCR Doppler products and more accurate geolocation of the radar data. The WCR still relies on the C130 INS data for the WCR zenith-pointing antenna, located some 20 feet forward of the WCR/C130 ramp. The use of two different IMUs for different antennas is a unique and somewhat more complicated setting for WCR on the C130. New processing software for WCR on the C130 was developed and tested this year using data from the test flights. However, due to the cancellation of SPICULE and ESCAPE deployments on the C130 this new software has not yet been fully tested during an experiment. We expect that the next utilization

of this software will come with the 4th generation of the WCR currently under development as part of the NSF MSRI grant.

Project: DILBERT

The **Deployable Instruments, Laramie Based, Engineering Research Test** flights (DILBERT) is funded directly through hours programmed into CA8. The Research Engineering and Technical Support Group (RETSG) continues to lead an effort to upgrade equipment on the University of Wyoming King Air (UWKA), DILBERT is the flight program that supports that effort. The overarching objective of the program is to install newly acquired and upgraded facility equipment and test it in a way that would validate the functionality of the equipment for use during an NSF funded deployment. Specifically, objectives for the flights are to 1) test the in-flight functionality of the proposed equipment, 2) characterize the data received from the new instrumentation, and 3) compare results of old systems vs. new systems to identify potential problems prior to supporting research.

Outcomes:

Flight operations were based at the UW Flight Facility in Laramie, WY with a total of 17.3 hours flown between September 2020 and May 2021. The following equipment, purchased under CA7 and mostly installed and ground tested during Year 1 of CA8, was successfully tested during DILBERT. All items are now deployable on the UWKA.

1. King Air 3-Screen Display Stations
2. New Inverters (Main, Aux, De-Ice Heat)
3. Replacement Time Server
4. DMT LWC-301
5. DMT SP2-XR
6. SPEC HVPS Probe
7. Mensor Static Pressure Sensor (still being characterized)

Details of each of the above items and other instrument development efforts during Year 2 are provided in Section 4 of this report.

Project: APART (TRANS^{2}AM)

The **Ammonia Phase Partitioning and Transport** (APART) Experiment (which has been renamed by the investigators to **Transport and Transformation of Ammonia** (TRANS^{2}AM)) is scheduled to begin research flights on the UWKA in August 2021, late in Year 2, and extend through mid-October of the same year. The experiment will be flown out of the UW Flight Facility in Laramie with a focus region in NE Colorado, primarily near cattle feedlots. UWKA facility staff began holding regular project meetings with the TRANS^{2}Am science team in January 2021, in order to ensure project preparations stayed on track in terms of planning for flight operations, outreach activities, and payload management. The instrument payload is quite challenging and required the fabrication of two custom cabinets and support structures and a modified sampling inlet to support user-supplied equipment. Also, modifications to the UWKA data system were needed to meet the aircraft Maximum Zero Fuel Weight requirement and cabin egress requirements.

Instrumentation upload began in June 2021, with two months allotted prior to research operations due to the amount of design work, fabrication, and reconfiguration of the UWKA's interior to accommodate multiple user-supplied instruments. The project is now in active test flight operations, with multiple flights completed or planned to test out basic system operations and instrument functions in a variety of conditions. Full research flight operations will begin in

August 2021. Approximately half of the allocated research flight hours are expected to be used by the end of this fiscal year, encompassing the first month of the project's research operations.

The project also includes several components related to public outreach. Project planning included developing a detailed plan for reaching out to the agricultural community in order to raise awareness about the project's goals, including the UWKA's role in day-to-day flight operations. The lead investigator presented an overview of the project that included an open question-and-answer session to personnel in the local ranch and dairy industries to address any potential concerns about the sampling operations. Regular publicly-available status updates regarding the project will also be available online. Some student-oriented public outreach will also take place during the project.

The UWKA will also participate in an open house/community outreach day in September 2021, in association with the Wyoming Air National Guard. This display will be on a "STEM Day" that is specifically targeting outreach to Wyoming high school students. While this activity is being led by the facility, APART/TRANS^{2}AM PIs have agreed to make the aircraft available for that day and to participate in the event.

Project: CHACHA

The **Chemistry in the Arctic: Clouds, Halogens, and Aerosols** (CHACHA) experiment is scheduled for deployment in winter/spring 2022. This is an incredibly ambitious program for the UWKA both in terms of instrument payload and operations (deployment to Utqiagvik, AK). Because of the challenges associated with CHACHA, preparations started very early, beginning with regular meetings between UWKA personnel and the PI team earlier this year. Much of the focus for these meetings is on instrument design and requirements for user-supplied equipment and payload accommodations. Facility personnel are closely monitoring the weight and balance along with the power requirements of the payload as the science team finalizes their instrument construction. Changes to the final payload may still be necessary depending on actual weight/size/power requirements of the completed instruments. The total electrical draw of the payload is still being determined and the facility has been engaged in discussions with the PI Team to identify changes necessary to meet the electrical load requirements of N2UW. Design of a major alteration to the aircraft is underway to support installation of the CVI inlet. An FAA-approved 8110-3 engineering analysis will be required and we anticipate field approval from the Flight Standards District Office. However, there remains risk associated with FAA denial of this certification path. A 3D model has been created to provide more detail about the fit and form of equipment in the cabin. A new rack is being fabricated to support the CIMS instrument and will be sent to the University of Michigan. Some of the PI team is expected to visit Laramie at the end of Year 2 as part of instrument preparations.

3. Projects Supported with non-NSF Funding in Year 2

Project: FLUX 20

FLUX was a small (two research flights) project that took place in September 2020. The goal of the project was to test the ability to collect CO2/CH4 measurements suitable for eddy covariance estimates using a user-supplied Picarro CO2/CH4 gas analyzer. The instrument is not part of the facility-supported instrument suite and had not flown on the UWKA prior. Facility staff (funded outside of the CA) spent several weeks working with the PI prior to the start of project operations to design flight profiles that would allow the aircraft to make measurements at low altitudes in order to satisfy the science needs while remaining within

acceptable safety margins. Additionally, staff from the engineering group worked with the PI to integrate the new instrument into the payload and complete ground testing and calibration. Ultimately, the project was a success, collecting covariance measurements during the two planned research flights. This project also had a minor outreach component. Although there was no student participation during the research flights, the flight crew worked with the PI to obtain video documentation of instrument displays during various phases of flight, to be used as a part of student projects in graduate courses taught by the PI.

4. Other Activities in Year 2

King Air Advisory Panel

The King Air Advisory Panel (KAAP) is composed of five members external to UW that represent both users and operators of aircraft for atmospheric research. Members serve voluntarily for a five-year term. Current KAAP members include: Paquita Zuidema, Chair (U. Miami), Paul Shepson (SUNY-Stony Brook), Jeff Stith (NCAR/EOL/RAF-retired), Beat Schmid (DOE/ARM Aerial Facility), and Teresa Campos (NCAR/EOL). The committee meets nominally every six months, during which time facility personnel provide updates to the KAAP and solicit feedback regarding the direction of the facility.

During Year 2, two meetings were held, one on October 29, 2020 and the second split across two days on April 14 and 21, 2021. Both of these virtual meetings included ~2-3 hours of presentation material, most of which focused on the development of the Next Generation UWKA (MSRI Projects 1-5). A ~45-minute update on the state of the Cooperative Agreement was presented to the KAAP at the beginning of each meeting. Materials presented to the KAAP are available on the web at:
https://drive.google.com/drive/folders/1KAFjIxCJOkQ3MEFkLWww5qpl7NZWZGWx?usp=sharing
KAAP provided a report that was emailed to the UWKA PI-team and NSF LAOF program manager following the spring 2021 meeting. This report is also available through the above link.

Safety Program – Audit

The safety program for UWKA Flight Facility has been certified as Stage 3 (the highest level of certification) through the International Standard for Business Aircraft Operations (ISBAO) since 2012. At that time, UW was the first university to receive this level of certification. At Stage 3, external audits are required every three years as part of re-certification. In January 2021, the UW flight facility underwent an audit performed by Chris Chop, a certified ISBAO auditor. The outcome of the audit was very positive, with the summary stating: *"The University of Wyoming Flight Center has an extremely well-functioning SMS that is sustained by continuous improvement. Safety Risks are effectively managed and safety management activities are fully integrated into the operation; positive safety culture is clearly sustained. Safety cultural attributes of the highest order were observed in practice during the audit."* The outcome of the audit was a re-certification of UW's Stage 3 compliance. The next external audit is due in early 2024. Between now and that time the facility continuously conducts an internal audit, with some elements of the program reviewed against the audit protocols on a monthly basis.

Project Requests Reviewed

During Year 2, only one request for use of the UWKA facility was reviewed. The low number of requests is due primarily to the published unavailability of the UWKA and WCR for 12-18

months following the completion of CHACHA as we transition from the current aircraft to the Next Generation UWKA. Any request for the UWKA-2 in mid-2023 remains high risk with a large degree of uncertainty regarding the completion and availability of the new aircraft. Several Letters of Intent (LoI's) for UWKA-2 deployments in 2024 have been received. We anticipate a higher-than-average number of annual requests for the aircraft in the coming years.

Development of New Capabilities/Instruments

In-house development, testing, and integration of recently acquired instruments and capabilities for the UWKA facility continued in Year 2. Postponement of other deployments has allowed completion of several of these projects that begun during Year 1. These capabilities, described below, have been developed to allow them to be directly transferrable to the new aircraft (see section 5 of this report).

King Air Science Displays

The new three-screen science displays were functionally completed during Year 1. In Year 2, efforts have focused on testing the new display systems under real-world conditions and refining the ergonomic elements such as the touchscreen input and keyboard/mouse. Both display systems have been tested in the aircraft simultaneously under in-flight project conditions and result in an improved ability of the system scientist and instrument operators to interact with project instruments.

Power Inverters

Three new DC-AC 2000 VA inverters were procured, installed, and ground tested during CA8, Year 1. The result is more AC capacity on the aircraft, as well as the ability to support AC probe "de-ice", such as required by the SPEC cloud microphysics probes. This installation was successful and supported DILBERT test flights in Year 2. To meet the increased AC electrical load demand of the TRANS^{2}AM and CHACHA projects payloads, the third "de-ice" inverter was recently reconfigured to serve as a general-purpose AC inverter capable of providing electrical AC power for instrument loads when AC de-ice power is not needed.

Network Time Server

A smaller form-factor GPS-based time server was installed earlier in CA8 to replace the aging unit. The facility recently became aware of a intermittent issue with the unit's ability to drive an aircraft (TSO'd) GPS antenna as opposed to a small commercial-type antenna. In collaboration with the manufacturer, the unit's performance was evaluated, firmware upgraded and a decision made to reconfigure the research GPS timing system to power the active GPS antenna from a different source. The risk of having a single time server was identified and work is ongoing to provide redundancy for the timing subsystem through the installation of an additional backup time server. Acquisition and testing of this backup system is considered critical for CHACHA.

LWC-301

A Droplet Measurement Technologies (DMT) LWC-301 ('hotwire') liquid water instrument was purchased in the middle of Year 1 as a replacement to the LWC-100 which was no longer supported by the manufacturer and not repairable by UW King Air facility personnel. The new LWC-301 probe is more robust and mostly alleviates the problem of overheating sensing elements in low airflow conditions. It was tested as part of the DILBERT flights during Year 2 and is now fully operational as a UWKA facility-supplied instrument.

Single Particle Soot Photometer (SP2)

A DMT Single Particle Soot Photometer-Extended Range (SP2-XR) was purchased in Year1 and installed on the UWKA in Year 2 as part of the DILBERT flights. The SP2-XR detects single particles using light scattering and provides an estimate of particle size. This can be used to determine an aerosol size distribution that can further be validated against other instruments. The SP2-XR also uses laser-induced incandescence to measure refractory black carbon in individual particles, providing an estimate of black carbon mass. Two flights were conducted in February and March of 2021. Data from the SP2-XR were compared with the facility-supported Ultra-High Sensitivity Aerosol Spectrometer. Measurements from the two instruments show good agreement, providing confidence in the SP2-XR. Analysis is ongoing and is being led by Dr. Shane Murphy and an MS-level graduate student (see graduate student developments, below)

High Volume Particle Sampler (HVPS)

A SPEC, Inc., HVPS was acquired in Year 1 and was installed and tested on the UWKA as part of a non-NSF project deployment at the end of Year 1. Throughout this second year, work has focused on validating the measurements provided by the HVPS during the non-NSF project and later, DILBERT flights. The instrument is now fully operational and replaces the PMS 2DP for measuring and imaging precipitation particles. The HVPS completes the suite of next-generation Optical Array Probes (OAPs) on the UWKA that already include a CIP-25 grayscale and SPEC 2DS, which both came online during CA7.

Mensor Static Pressure System

New static pressure transducers manufactured by Mensor were acquired during Year 1. The new sensors will eventually replace the existing HADS pressure sensors (one of two existing HADS sensors is non-functional). Ground testing of the new Mensor transducers revealed a systematic offset between the new units and the original HADS transducers. After COVID-related delays in returning these to the manufacturer for inspection and re-calibration, they have been returned and acceptance testing is ongoing. Additionally, the digital sensor output is also being tested when interconnected with the new distributed data system developments. We anticipate testing the Mensor transducers on a non-interference basis during TRANS^{2}AM and CHACHA flights.

CNC Milling Machine

The facility acquired a new HAAS VM-2 vertical milling machine. Until now, any machine work requiring CNC milling needed to be outsourced. This has created significant cost and/or time problems with prior projects. With this capability in-house, the facility will now have an increased level of fabrication capability for future work. The purchase, while principally serving the UWKA facility, was split funded with the Department of Atmospheric Sciences.

OAP Processing Software Development

The UWKA facility continues development of its new OAP processing software (WOPRS: Wyoming OAP Processing Software). This effort began in Year 1 of the CA and is necessary to take advantage of the modern OAPs recently acquired and now supported through the facility. The effort is being led by PI French and an MS-level graduate student (see graduate student developments, below). Output from initial runs of the software is being presented at the International Conference on Cloud Physics (ICCP) in August. The software will be officially adopted by the facility to support OAP measurements during CHACHA.

WCL-specific Developments

Data collected by the WCL during the 2018 BB-FLUX project were used to develop an aerosol identification and aerosol extinction coefficient retrieval algorithm. The retrieved aerosol extinction coefficient, compared to the attenuated lidar backscattering coefficient, provides a clear separation of the dense smoke plume and the background aerosol in the BB-FLUX data set. The retrieved aerosol extinction coefficients at the flight level are strongly correlated (rr > 0.8) with PCASP aerosol data products and NCAR carbon monoxide (CO) concentration, providing a first-order estimate for converting WCL extinction coefficients into vertically resolved CO and aerosol concentration within wildfire smoke plumes. A manuscript highlighting this new algorithm has been submitted to *J. Atmos. Ocean. Technol.*

A novel method has also been developed to reconstruct the composite biomass plume vertical structure with WCL consecutive transects (also using BB-FLUX measurements). The vertical structures evident in several fire plume cross sections reconstructed from the WCL show distinct macrophysical and microphysical properties. These structures, supported through in-situ measurements, are closely related to the plume-particle transport, fire intensity, and the thermodynamic structure in the boundary layer. A manuscript describing this this analysis results has also been submitted to *J. Atmos. Ocean. Technol*.

Webpage Development

Revisions to the UWKA facility web pages begun in Year 1 were continued in Year 2. In addition to minor updates, several larger-scale efforts are underway. A major focus has been the modification process to the next-generation King Air. In addition to updating its main overview page (https://www.uwyo.edu/atsc/uwka/next-gen-king-air.html), there is now an additional page to track Next Generation Wyoming King Air status updates (https://www.uwyo.edu/atsc/uwka/next-gen-king-air-updates.html). This provides a simple summary and images describing the main milestones in the modification process, and is updated at the end of each month.

Recently, the main website was updated to include a more detailed overview summarizing the process for requesting the UWKA, both for NSF-funded and non-NSF-funded projects. Documentation is under development for describing facility instrumentation and will be updated on the website late in Year 2 or early Year 3. This document will group all facility instruments by general category (*ie.* atmospheric state, cloud physics, trace gas, etc.) and provide a short summary description of each instrument's purpose, further breaking down each output data set into several categories – e.g., measured values, derived parameters, and diagnostics.

This documentation will become part of the longer-term project planned for the website: the development of a full facility user's guide. The user's guide will provide a complete description of the facility for all potential users. Included in the guide will be aircraft specifications and capabilities, a process overview for project planning, including user-supplied instrumentation, and detailed descriptions of the UWKA's research systems and flight operations and limitations. These individual pieces are being developed in a modular format to better support incremental updates to the website and will be focused on the next generation UWKA.

Graduate Student Developments

Two graduate students were supported through the CA during Year 2, a second year MS-student (Shaffer) and a first year MS-student (Rademacher). Shaffer began midway through Year 1 and is working on the development of WOPRS (see above section on OAP processing

software). He successfully presented a research plan to the thesis committee and will be presenting a poster at the upcoming ICCP meeting in August 2021. Shaffer is scheduled to complete MS requirements midway through Year 3. Rademacher began at UW early in Year 2 and has completed one year of studies. An under-represented minority, he has worked under the guidance of Dr. Shane Murphy for the lab and flight testing of the new SP2-XR (see Section 4 above). He has one more year for completion of MS requirements. A new student (Shimkus) will be joining the department at the start of Year 3. She will be working on further developments of the departmentally-owned cloud droplet generator that is used for the calibration of the DMT Cloud Droplet Probe (CDP); and will be responsible for the calibration of the CDP in preparation for CHACHA.

5. Personnel Support of MSRI-specific Developments and Next Generation UWKA

Development of the replacement King Air is a significant effort outlined in the CA8 proposal. The NSF Mid-Scale Research Infrastructure grant awarded to the University of Wyoming for the development of the Next Generation Wyoming King Air (UWKA-2) relies upon personnel time from CA8 dedicated to the new aircraft development. Below we provide a summary of the personnel, supported through CA8, who have dedicated a portion of their funded CA8 effort towards the MSRI effort. Reporting on the outcomes of the MSRI is beyond the scope of this report.

At the start of Year 2, the baseline replacement aircraft had been acquired and was located at Avcon LLC in Newton, KS (where it remains today). Avcon won the contract to conduct modifications and complete required certifications to the aircraft to transform it into a platform suitable for atmospheric research. Modification and Certification are scheduled to be complete in 2023, at which time the aircraft will return to the University and UWKA facility efforts will transition to installing research infrastructure and populating the aircraft with instruments followed by ground and flight testing of those instrument systems.

Some members of the UWKA facility team have expended significant efforts towards the development of the new aircraft during Year 2. These include:

- Jeff French, PI, CA8 (co-PI, MSRI Award) – roughly 40% of Dr. French's effort towards the CA8 award in Year 2 has focused on the development of the new aircraft. His role is the primary manager for the development of the aircraft, working closely with facility engineers, operations staff, the University's outside consultant/expert, and the Avcon management team. All contracts, changes in work orders, etc., are routed through him. Weekly (internal) meetings are held to ensure progress is being made on the aircraft program and bi-weekly meetings with Avcon are held for status reporting. Other (ad-hoc) meetings include design reviews and discussions of schedule changes and modifications.
- Bart Geerts, co-PI, CA8 (PI, MSRI Award) – roughly 80% of Dr. Geerts' effort towards the CA8 award in Year 2 has focused on the development of the new aircraft. This principally focuses on the overall management of the MSRI award, reporting requirements for that award, and reporting to the UW administration regarding progress.
- Matt Burkhart, Senior personnel CA8 (senior personnel and Project 5 Lead, MSRI Award) – approximately 30% of Mr. Burkhart's effort towards the CA8 award in Year 2 has supported the electrical and software engineering aspects of the new Wyoming King Air (FL-862). He spent a significant amount of time on design and project management (scheduling/reporting) activities associated with modifications for FL-

862. He participated in conceptual design development, preliminary design reviews and critical design reviews for various aircraft modifications. He has specifically collaborated with the prime contractor (Avcon) on the design of the research electrical system, upper and lower antenna layouts, under-wing wire tunnels, antenna provisions/ICDs and specific modifications to support existing facility instruments. He leads the Wyoming effort to review Avcon's 400A generator upgrade to ensure the modification meets UW requirements. Matt ended the year with initial development of a plan and schedule to transition instrumentation and infrastructure from the current aircraft to the FL-862.

- Nick Mahon, Senior Personnel CA8 (senior personnel, MSRI Award) – Mr. Mahon has spent approximately 31% of his CA8 time allocation supporting the MSRI award. His work has mainly focused on tasks related to MSRI: Project 1 including planning, document and design review, and engineering specifications for modifications to FL-862. The specific modifications include the major zenith ports in support of WCR4 (MSRI: Project 2), minor multipurpose zenith ports, starboard window alteration, atmospheric research pylons, wing wiring provisions, nose extension, removable nose boom and the upper/lower hard points. Planning consists of weekly internal and bi-weekly external meetings to discuss current action items with respect to Project 1. Document and design review involves evaluation of 3D models and layout drawings, FAA certifications plans, aircraft flight manual supplements and structural load documents. Engineering specifications relate to interface control drawings that define the UW requirements as presented to our aircraft modifier.
- Brett Wadsworth, Chief Pilot/Flight Center Director UW; and Brett Spiker, Director of Maintenance for UW – Both Mr. Wadsworth and Mr. Spiker play an active role in the development of the new aircraft. Both participate in the weekly internal meetings and the bi-weekly meetings with Avcon to represent operational considerations of the development work. Particular considerations for the new aircraft include: aircraft weight & balance; aircraft asymmetric loading; electrical system limitations and functionality, and the aircraft interior. A trip was made to Kansas City, MO by Mr. Spiker and Mr. Wadsworth to accept the installation of the new Garmin G-1000 NXi avionics suite early in Year 2. During November 2020, Mr. Spiker attended the KA-350 Initial Training course for in-depth training on the aircraft systems & maintenance procedures. In late January 2021, Mr. Wadsworth attended the KA-350 Initial Training program and received his “type-rating” to fly the aircraft, the first of UW’s three pilots to do so. In May, the second pilot Mr. Tom Drew attended the same course and successfully received a “type-rating”. Both the maintenance and flight training was split funded through the CA and the MSRI and the training included systems for both the new aircraft (Beechcraft 350i) and the current aircraft (Beechcraft 200T). Mr. Spiker spent roughly 25% of his CA8 time allocation and Mr. Wadsworth spent roughly 20% of his CA8 time allocation supporting the MSRI award.
- All above listed members of the CA8-funded facility team travelled to Newton, KS to meet with Avcon and inspect the status and progress of the modifications to FL-862 in January 2021. A second trip is planned for late August of this year, near the end of Year 2.
- Samuel Haimov, Senior Personnel CA8 (Senior personnel MSRI Award) – One of the sub-projects within the MSRI is the upgrade of WCR (Project 2). This includes hardware and software upgrades and repackaging of the radar in order to be installed on FL-862. The MSRI also includes a major upgrade to UW’s airborne Ka-band precipitation radar (KPR). Part of these upgrades include new operational KPR features that are relevant to the future development of the WCR. Some of the research on this, in

particular the Quadratic Phase Code (QPC) mode of operation, has been conducted as part of the Year 2 work of CA8. Overall, Dr. Haimov has spent about 50% of his CA8 time allocation supporting MSRI: Project 2.

6. Personnel Changes during Year 2

Several personnel changes occurred during Year 2, as well as an anticipated change that will occur in Year 3 that required action during Year 2 to ensure maintaining expertise within the facility.

Machinist/Master Technician

The Machinist/Master Technician that supports all the mechanical fabrication in the facility recently retired (William Kuestner, June 2021). Bill was a 20-year member of the facility team. A search is underway for his replacement. Final interviews have been conducted and we anticipate hiring his replacement near the end of Year 2 or early in Year 3. The selected candidate will be hired at approximately the same level as Mr. Kuestner to ensure we maintain capability at this critical position.

Aircraft Maintenance Technician

At present, the UW Flight Center operates with a single aircraft mechanic. Pre-2017, the facility had two mechanics, one supported through the CA and the other supported through a University personnel line item. With the loss of the University line late in CA7, we were reduced to a single mechanic and that left the facility vulnerable to single point failures as well as a reduction in our safety margin. Cory West, a recent hire into the facility engineering group, is also a certified A&P mechanic with Inspection Authorization (IA). We have initiated moving Cory into an Aircraft Maintenance Technician (AMT) position that will allow him to maintain his duties as an engineering technician and perform duties as an AMT. This move should be complete by the start of Year 3.

Information Manager/Project Scientist

As part of CA8, a new line was added to the budget for a roughly 1/3-FTE Information Manager. During Year 1, funds associated with this position were allocated to an outside contractor to help build the base structure for a new website for the facility. As we transition to the new website and content is being created, the work is being accomplished directly by facility personnel. Project Scientist Dr. Dave Plummer is leading the effort of assembling and publishing the new webpages and the development of the facility user's guide (end of Section 4, above). Moving forward, Dave will also be responsible for assembling the data necessary to build the archive of past and future data within the EOL data archive, assuming that initiative is approved.

Project/Aerosol Scientist

The use of Information Manager funds to partially support one of the existing facility project scientists, released funds to address another critical, short- and medium-term need in the facility. Dr. Anna Robertson was brought onboard in early 2021 as a temporary (1-year) hire to

assist the facility with air chemistry and aerosol instrument installations and characterizations directly related to TRANS^{2}AM and CHACHA payloads. Anna is also assisting the facility with aerosol and gas-phase inlet characterization and instrument calibration. The creation of this temporary position has released facility personnel in the engineering group to concentrate on other aspects of facility support and to provide more time for development activities for the new aircraft. The facility has always been without a dedicated aerosol/air chemistry-focused research scientist; this role has historically fallen on a technician, engineer, and/or faculty member as needed. With the increase in air chemistry and aerosol projects, a dedicated facility person was deemed necessary in order to effectively communicate with PIs to enable successful project deployments and facility instrument support.

Radar Scientist

The facility radar scientist, Dr. Sam Haimov, announced his intention to retire in mid- to late-2022. This is a critical position in the facility, as Dr. Haimov has been the facility expert that supports the WCR (and the KPR); serving in the department for more than 25 years. A search is underway for Sam's replacement. We seek to have a replacement starting as early as Fall 2021, providing one-year of overlap between Sam and the new radar scientist.

7. Spending Summary for Year 2

Table 2 lists spending in Year 2 by category. Actual amounts expended and encumbered are through June 30, 2020 (first 10 months of year 2). Major categories that are under-spent include Salaries, Fringe, Indirect Costs, Instrument Maintenance, Supplies, and Travel. With two months remaining in Year 2, much of the unspent funds in the Salary category will be spent out. We anticipate no more than 10% of the salary allocation funds remaining at the end of Year 2. Fringe rates are adjusted annually by the University. The fringe rate budgeted in the original award was higher than the actual amount paid during Year 2 resulting in underspending. University fringe rates set for the coming year (beginning July 2021) have increased significantly, we anticipate utilizing some of the remaining funds to cover Year 3 Fringe. Underspending in Instrument Maintenance, Supplies, and Travel reflect a lack of NSF project deployments and on-site planning meetings due to COVID-19. Lastly, Indirect Costs are charged to the award at the time direct charges are made in the other categories. Expending Salary funds during the last two months of the award will reduce the amount of unspent Indirect Costs by the end of Year 2. Unspent funds from Year 2 will be carried through to the following CA8 years.

Table 2: Spending by Category during CA8 year 2, through June 30, 2021

Category	Year 2 Allocation	Encumbered	Expended	Unspent
Equipment	$45,000.00	$0.00	$35,816.18	$9,183.82
Fringe	$448,826.00	$5,655.97	$289,917.53	$153,252.50
Indirect Cost	$748,516.00	$0.00	$541,369.28	$207,146.72
Insurance	$30,000.00	$0.00	$37,649.00	($7,649.00)
Maint. Data System	$25,000.00	$0.00	$17,313.45	$7,686.55
Maint. Instruments	$30,000.00	$14.53	$3,087.69	$26,897.78
Mechanic Training	$4,000.00	$0.00	$0.00	$4,000.00
Pilot Training/Physicals	$24,000.00	$75.00	$17,151.00	$6,774.00

Publications	$5,000.00	$0.00	$266.93	$4,733.07
Safety Program	$10,000.00	$0.00	$602.50	$9,397.50
Safety Training	$5,000.00	$0.00	$6,440.00	($1,440.00)
Salary	$988,037.00	$12,443.04	$734,330.59	$241,263.37
Salary - GA	$47,196.00	$7,544.00	$37,520.00	$2,132.00
Software License	$2,000.00	$0.00	$207.78	$1,792.22
Supplies	$20,000.00	$0.00	$2,795.60	$17,204.40
Test Flights	$13,500.00	$0.00	$18,448.54	($4,948.54)
Travel	$29,500.00	$0.00	$5,502.99	$23,997.01
Tuition and Fees	$19,568.00	$0.00	$17,704.60	$1,863.40
Subtotal:	**$2,495,143.00**	**$25,732.54**	**$1,766,123.66**	**$703,286.80**

Table 3 lists the distribution of salaries for all persons funded through CA8. Column 2 – "CA Salary (% of Total Salary)" lists that percent of the total salary budgeted for Year 2. Column 3, indicates the salary that was budget as per the submitted CA8 Year 2 budget. Column 4 shows the salary that has been used through June 30, 2021 (ten out of the twelve months) with the last column indicating the % available that has been actually used (Column 4 divided by Column 3). Personnel that show "82%" of salary used in the last column are on target to utilize the full Year 2 allocation by the end of the Award Year. The exception to this is for the PI, co-PIs, and Business Manager whose CA Salaries are charged only during summer months. Personnel with percent salary used under 82% reflect persons who are funded partially through other programs for more than 25% of their time. Releasing personnel to work (and be funded) through other projects is allowed on a non-interference basis to the CA. The highlighted Project Aerosol Scientist was originally unbudgeted in Year 2 and the hire was made midway through Year 2 (see Section 6).

This table does not include the distribution of fringe.

Table 3: Distribution of Salaries during CA8 year 2, through June 30, 2021

Title/Position	CA Salary (% of Total Salary)	CA Salary ($ Available)	CA Salary ($ Used)	Percent CA Salary Used
Facility Management Team				
PI, French	33%	$30,835.00	$6,457.90	21%
Co-PI, Geerts	11%	$16,043.00	$0.00	0%
Co-PI, Rodi	33%	$48,300.00	$22,890.00	47%
Exec Business Manager	8%	$5,678.00	$0.00	0%
Project Science Group				
Project Scientist	75%	$76,652.00	$62,752.50	82%
Project Scientist / Information Manager	75%	$49,397.00	$40,608.10	82%
Radar Scientist	75%	$76,710.00	$62,760.00	82%
Lidar Scientist	75%	$69,999.00	$51,789.78	74%
Project Aerosol Scientist	75%	$43,125.00	$23,579.12	55%
Senior Personnel	8%	$11,133.00	$14,529.33	131%
Engineering Group				

Research Scientist Sr., ETT	75%	$77,016.00	$47,377.04	62%
Engineer, Sr.	75%	$69,797.00	$57,247.50	82%
Master Technician	75%	$52,546.00	$42,908.23	82%
Machinist	75%	$46,538.00	$30,605.52	66%
Technician	75%	$36,226.00	$26,891.74	74%
Engineer/Systems Analyst	75%	$41,545.00	$34,841.84	84%
Technician	75%	$36,226.00	$28,624.30	79%
Operations Support Group				
Chief A/C Mechanic	75%	$66,397.00	$36,340.00	55%
Chief Research Pilot	75%	$81,311.00	$66,742.50	82%
Research Pilot	75%	$73,952.00	$60,992.50	82%
Student Support				
Graduate Student	100%	$23,598.00	$18,660.00	79%
Graduate Student	100%	$23,598.00	$18,860.00	80%
Undergraduate		$0.00	$240.00	

8. Budget and Plans for Year 3

Table 4 lists the planned spending for Year 3. The top half of the table lists projected spending for salaries. The salaries used in the table are *actual (or expected) salaries* for each position at the start of Year 3, this may be different (lower *or* higher) than what was actually in the budgeted in the CA8 proposal for Year 3. This budget indicates we anticipate spending $973K on salary and $428K on Fringe in Year 3. The difference in the anticipated spending, and that contained within the budget submitted with the CA8 proposal, is due to changes in salary, personnel, and that facility personnel have not received merit raises over the last 2 years (University Policy for raises). Some of that has been offset by targeted promotions with raises.

The lower half of Table 4 lists the anticipated spending in all categories other than salary. This amount matches that budgeted in the original CA proposal. The amount listed as 'Grand Total' represents the total anticipated

The final line in the table lists the amount of unspent funds from Year 1 and 2. This amount will be reduced somewhat by the end of Year 2 (August 31, 2021).

Table 4: Year 3 Budget Estimate: Sept 1, 2021 to August 31, 2022

Title/Position	$/Month	NSF Mo/Yr	Salary
Facility Management Team			
PI	$8,347	3.0	$25,041
Co-PI	$10,765	1.0	$10,765
Co-PI	$3,000	3.0	$9,000
Exec Business Manager	$4,791	1.0	$4,791
Project Science Group			
Project Scientist	$8,367	9.0	$75,303
Project Scientist / Information Manager	$5,414	9.0	$48,726
Radar Scientist	$8,368	9.0	$75,312

Lidar Scientist	$6,330	9.0	$56,970
Project Aerosol Scientist	$4,792	9.0	$43,125
Senior Personnel	$8,367	0.8	$6,275
Engineering Group			
Research Scientist Sr., ETT	$8,408	9.0	$75,672
Engineer, Sr.	$7,663	9.0	$68,967
Master Technician	$5,760	9.0	$51,840
Machinist	$5,101	9.0	$45,909
Master Technician	$5,167	9.0	$46,503
Engineer/Systems Analyst	$4,646	9.0	$41,814
Aircraft Maintenance Technician	$5,167	9.0	$46,503
Operations Support Group			
Chief A/C Mechanic	$7,268	6.0	$43,608
Chief Research Pilot	$8,869	9.0	$79,821
Research Pilot	$8,079	9.0	$72,711
Students			
Graduate Student	$1,886	12.0	$22,632
Graduate Student	$1,886	12.0	$22,632
TOTAL Months/Year		164.8	**$973,920**
FRINGE			**$427,887**
TOTAL PERSONNEL			**$1,401,807**
OTHER CATEGORIES			
Facility Upgrades			$45,000
Maint: Data System			$25,000
Mechanic Training			$4,000
Instrument Maintenance			$30,000
Supplies			$20,000
Safety Program			$10,000
Safety Training			$5,000
Calibrate/Test Flight			$13,500
Pilot Training/Physicals			$24,000
Insurance			$30,000
Software License			$2,000
Travel			$29,500
Publications			$5,000
GA Tuition and Fees			$19,568
TOTAL OTHER			**$262,568**
Indirect Cost	44.5%		**$720,622**
GRAND TOTAL			**$2,384,997**

Unspent funds from Years 1 and 2..unbudgeted for Year 3, available for unanticipated expenses. (This amount includes funds that will be expended during the last 2 months of Year 2)			$1,524,288

9. Status of Supplemental Deployment Pool Funding

Table 5 lists the status of deployment pool funding (supplement to CA8) as of June 30, 2021. None of the funds in the deployment account for CA8 have yet been expended, as we continue to expend the remaining funds left in CA7 deployment (not shown). The funds available in CA7 and CA8 deployment accounts are sufficient to cover all costs associated with APART (TRANS²AM) and some of CHACHA. A supplemental request for $390,344 was submitted on May 14, 2021. Those additional funds together with the existing funds in the deployment account following APART (TRANS²AM) will be sufficient to cover the expected costs of CHACHA.

Table 5: Status of Deployment Pool Funding Account, supplement to CA8

Row Labels	Sum of Beg. Budget	Sum of Encumbered	Sum of Expended	Sum of Available
16101-1004405A-1 NSF Deploy CA8	$478,136.47	$0.00	$0.00	$478,136.47
Aircraft Operations	$219,125.00	$0.00	$0.00	$219,125.00
Data Processing	$19,025.00	$0.00	$0.00	$19,025.00
Ferry	$11,402.56	$0.00	$0.00	$11,402.56
Fringe	$2,600.70	$0.00	$0.00	$2,600.70
Indirect Cost	$148,678.71	$0.00	$0.00	$148,678.71
Purchased Services	$25,520.00	$0.00	$0.00	$25,520.00
Salary	$6,119.30	$0.00	$0.00	$6,119.30
Trailer Deployment	$4,070.08	$0.00	$0.00	$4,070.08
Travel	$31,582.68	$0.00	$0.00	$31,582.68
WCR Install	$5,512.44	$0.00	$0.00	$5,512.44
Instrument Installation	$4,500.00	$0.00	$0.00	$4,500.00

10. Project Queue

Table 6 lists the project queue for NSF-funded projects utilizing the UWKA/WCR/WCL facility in Years 3 through 5. At present, there are only two projects approved for the UWKA (APART and CHACHA). Following CHACHA, the UWKA facility is currently projected to be unavailable for 12-18 months as we transition to the new aircraft. A number of LoI's exist for the new aircraft beginning early in Year 5 (beginning in September 2023). CAESAR, if approved, will utilize the WCR on the NSF/NCAR C130 in February-April 2023.

Table 6: Queue for funded and pending NSF projects for the UWKA/WCR/WCL facility.

Cat	Project	Facilities Support Services	Deployment Dates	Location	PI	Status	NSF Science Program

FY 2021							
S	**APART**	UWKA DA, FC	1 Aug–15 Oct 2021	WY & CO	Fischer	Funded	AGS/ATC
FY 2022							
S	**CHACHA**	UWKA, AVAPS DM, FC	15 Feb – 16 Apr 2022	AK	Shepson	Funded	OPP & AGS/ATC
FY 2023							
L	**CAESAR**	NSF/NCAR C-130, AVAPS, HAIS, WCR, WCL DA, DM, EO, FC, OC, PM	23 Feb – 7 Apr 2023	Sweden or Norway	Zuidema	Pending	AGS/PDM
S	**ARISE**	UWKA, ISFS, MPD, ISS/Lidar	1 Sep – 15 Oct 2023	OK & KS	Julie Lundquist	LoI	AGS/PDM
FY 2024 & Beyond							
L	**ICECHIP**	C-130 or UWKA with WCR; S-Pol DA, DM, FC	EOP1: 1 – 30 Jun 2024 EOP2: May/Jun 2025	Great Plains	Adams-Selin	In Review	AGS/PDM
L	**TEAMx-US**	UWKA, CRL, WCR, AVAPS, ISFS, ISS, MPD	1 Jun – 31 Jul 2024	Innsbruck, Austria	De Wekker	LoI	AGS/PDM
S	**CAVEAT-Q**	UWKA, WCL	1 Nov – 23 Dec TBD	Southeast US	Knupp	LoI	AGS/PDM
S	**PROMO**	UWKA, WCL, WCR	8 wks ~Dec – Mar TBD	Utah	Steenburgh	LoI	AGS/PDM

11. Other Funding Support for Key Personnel

Table 7 lists all external, non-CA8 support received by senior personnel on the CA8 award during Year 2. Senior personnel receiving no additional external support are not listed.

Table 7: External Support for Key Personnel.

Name	CA8 Year 2 NSF Salary Available (% of total salary)	CA8 Year 2 NSF Salary Used (% of total salary)	Other Support	Year 2 Non-CA8 External Support (% of total salary)
French, PI	33%	6.98%	NSF SNOWIE- .237%, SALSSA 9.187%	9.42%

Geerts, Co-PI	11%	0%	Honorarium- .346%, DOE 3.35%, WRR 1.622%	5.32%
Burkhart, Research Scientist, ETT	75%	44%	BLM- 2.01% NSF Hotplate- 3.43% MSRI- 11.38% EDF- 2.12% CSU 1.80% CBM .982%	18.56%
Haimov, Radar Scientist	75%	61%	MSRI- 2%	

12. Publications in 2020-21 Resulting from UWKA/WCR/WCL

The following is a list of refereed publications in 2020 and 2021 resulting from NSF LAOF support of the UWKA facility. Included in the 2021 list are known publications that are currently under review.

2021 Publications to date

Butterworth, B. J., and co-authors, 2021: Connecting Land-Atmosphere Interactions to Surface Heterogeneity in CHEESEHEAD19. *Bull. Amer. Meteor. Soc.*, **102**, E421-E445.

Cann, M., K. Friedrich, D Behringer, J. R. French, 2021: A Case Study of Cloud-top Kelvin-Helmholtz Instability Waves near the Dendritic Growth Zone. *J. Atmos. Sci.,* submitted.

Deng, M., and co-authors, 2021: Wildfire Smoke Observations in the Western U.S. from the Airborne Wyoming Cloud Lidar during the BB-FLUX Project. Part I: Data Description and Methodology. *J. Atmos. Meas. Tech.*, submitted.

Deng, M., R. M. Volkamer, Z. Wang, J. R Snider, N. Kille, and L. J. Romero-Alvarez , 2021: Wildfire Smoke Observation in Western US from Airborne Wyoming Cloud Lidar During the BB-FLUX Project. Part II: Vertical Structure and Plume Injection Height. *J. Atmos. Meas. Tech.*, submitted.

Deng, M., J. French, L. Oolman, B. Geerts, S. Haimov, D. Plummer and Z. Wang, 2021: Retrieval and Evaluation of Ice Water Content from an Airborne Cloud Radar in Orographic Wintertime Clouds. *J. Atmos. Meas. Tech.*, submitted.

Friedrich, K., and co-authors, 2021: Microphysical Characteristics and Evolution of Seeded Orographic Clouds. *J. Appl. Meteor. Climatol.*, **60**, 909-934.

Grasmick, C., B. Geerts, X. Chu, J. R. French, and R. M. Rauber, 2021: Detailed dual-Doppler Struture of Kelvin-Helmholtz Waves from an Airborne Profiling Radar over Complex Terrain. Part II: Evidence for Precipitation Enhancement from Observations and Modeling. *J. Atmos. Sci.,* submitted.

LeMone, M. A., W. M. Angevine, and J. Dudhia, 2021: The Role of Radiation in Heating the Clear-Air Convective Boundary Layer: Revisiting CASES-97. *Boundary-Layer Meteorology*, **178**, 341-361.

Lin, G., C. Grasmick, B. Geerts, Z. Wang, and M. Deng, 2021: Convection Initiation and Bore Formation Following the Collision of Mesoscale Boundaries over a Developing Stable Boundary Layer: A Case Study from PECAN. *Mon. Wea. Rev.*, **149**, 2351-2367.

2020 Publications

Bergmaier, P., and B. Geerts, 2020: LLAP Band Structure and Intense Lake-Effect Snowfall Downwind of Lake Ontario: Insights from the OWLeS 7–9 January 2014 Event. *J. Appl. Meteor. Clim.*, **59**, 1691-1715.

Friedrich, K., K.Ikeda, S. A. Tessendorf, J. French, R. M. Rauber, B. Geerts, L. Xue, R. M. Rasmussen, D. R. Blestrud, M. L. Kunkel, N. Dawson, and S. Parkinson, 2020: Making Snow: Quantifying Snowfall from Orographic Cloud Seeding. *Proc. Nat'l Acad. Sci. USA*, **117 (10)**, 5190-5195.

Grasmick, C., and B. Geerts, 2020: Detailed dual-Doppler structure of Kelvin–Helmholtz waves from an airborne profiling radar over complex terrain. Part I: Dynamic structure. *J. Atmos. Sci.*, **77**, 1761:1782. https://doi.org/10.1175/JAS-D-19-0108.1

Jensen, A. A., P. T. Bergmaier, B. Geerts, H. Morrison, and L. S. Campbell, 2020: Sensitivity of convective cell dynamics and microphysics to model resolution for the OWLeS IOP2b lake-effect snowband. *Mon. Wea. Rev.*, in press. https://doi.org/10.1175/MWR-D-19-0320.1

Majewski, A. and J. R. French, 2020: Supercooled drizzle development in response to semi-coherent vertical velocity fluctuations within an orographic-layer cloud. *Atmos. Chem. Phys.*, **20**, 5035–5054. https://doi.org/10.5194/acp-20-5035-2020

Rodriguez, B., N. P. Lareau, D. E. Kingsmill, and C. B. Clements, 2020: Extreme Pyroconvective Updrafts During a Megafire. *Geophys. Res. Lett.*, 9 pp.

Theys, N., and co-authors, 2020: Global nitrous acid emissions and levels of regional oxidants enhanced by wildfires. *Nat. Geosci.*, **13**, 681-686.

Yang, J., Z. Wang, A. J. Heymsfield, K. J. Suski, and D. W. Toohey, 2020: High ice concentration observed in tropical maritime stratiform mixed-phase clouds with top temperatures warmer than -8°C. *Atmos. Res.*, **233**, 12 pp.