7.4 DEPLOYMENT OF A RESEARCH AIRCRAFT FOR INTERDISCIPLINARY EDUCATION

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1. INTRODUCTION

Atmospheric science instruction that provides hands-on training with field instrumentation enhances student understanding of atmospheric processes and measurement methods (Horel *et al.* 2013; Clements and Oliphant, 2014; Laird, 2015). Interpretation of aircraft observational data within the framework of a broader atmospheric analysis builds student capabilities for research studies (Ivanova, 2012). An NSF-supported educational deployment project using the University of Wyoming King Air research aircraft was conducted at Embry-Riddle Aeronautical University (ERAU) in Prescott, Arizona during 25 March – 8 April 2014. The primary goal of the project, Student Training in Airborne Research and Technology (START) was to engage undergraduate students from multiple degree programs in the collection and application of aircraft-based atmospheric measurements.

The UW King Air B200T (UWKA) has a long history of research with advanced instrument systems. UWKA field campaigns and sensor development have contributed significantly to meteorological discovery and applied research, particularly through studies of cloud microphysics and mesoscale dynamics (Vali *et al.* 1998; French *et al.* 2000; Wetzel *et al.* 2001; Rodi, 2011; Parish and Oolman, 2012; Wang *et al.* 2012). Educational components have been included in the UWKA initiatives for more than 20 years (Fabry *et al*. 1995; Rauber *et al*. 2007).

The two-week instructional field project at ERAU provided aircraft sensor briefings, aircraft safety training, campus seminar presentations, logistical planning and data collection for 10 flights in northern Arizona (Figure 1), radiosonde launch training, in-class usage of aircraft data in real time during flights, and post-analysis using archived measurements and model simulations for case studies. Seventeen students, eight faculty members and a NWS scientist took part in data collection aboard the King Air. The field project overall engaged more than 200 campus participants.

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Degree programs represented (students and faculty) were aeronautical engineering, aeronautical sciences, computer engineering, global security, meteorology and mechanical engineering. Flight missions were designed to collect measurements of many types of atmospheric conditions that can be related to instrument design, sampling protocol, local forecast problems, numerical modeling, air quality, cloud evolution and aviation hazards. Continuing benefit has been gained through cross-disciplinary use of atmospheric measurements and faculty collaboration.

Outreach was accomplished and is continuing through campus seminars, an open house for the UWKA at the ERAU Flight Center, and making the data sets available for research fellowships. Seminars and conference presentations were attended by AMS Chapter members from across Arizona, local middle school and high school students, ERAU students and parents, and students/faculty from other universities.

Fig. 1. View of UWKA right wing-tip instrumentation with one of the flight target areas (San Francisco Peaks) in background.

2. PROGRAM OBJECTIVES

The project has provided unique multi-sensor atmospheric measurements with application across several disciplines. For aeronautical sciences and meteorology, the flights collected high-resolution air motion data, turbulence parameters, cloud and aerosol size distributions and icing rates from sensors and optical scattering probes. Participants from multiple engineering degree programs gained new knowledge relevant to design of atmospheric sensor systems, and for planning a new campus initiative to construct an experimental instrumented aircraft.

Standard UWKA instrumentation was requested for this field program [http://flights.uwyo.edu/n2uw/], with data processed at 1 and 25 samples per second, including geolocation, forward and downward images recorded once per second, thermodynamic variables, three-dimensional air motions, turbulence, aircraft attitude parameters, longwave and shortwave radiation fluxes, water/ice concentrations, particle imaging and aerosol/cloud particle size distributions. The Wyoming Cloud Radar and Wyoming Cloud Lidar instrument systems were not requested, to provide more space for student participants on the flights and to maximize the number of flight hours possible within a limited budget allocation.

The UWKA deployment activities were based at Love Field (KPRC), a small community airport near the campus, which is also the location of fixed-wind and helicopter flight training for the ERAU aviation degree programs (Figure 2). Many events of strong wind shear including convective outflow conditions have been noted, and visibility in the flight training area can be restricted due to blowing dust and local fog. Study of local meteorological scenarios with airborne sampling and integration of these studies with forecast modeling have the potential to enhance the aeronautical sciences curriculum and contribute to the operational aspects of the flight training program.

Fig. 2. Example of approach and landing at KPRC airfield. The primary runway is oriented 030 - 210 deg.

The timeline selected for the deployment was late March to early April in order to target high wind conditions and the possible occurrence of springtime convective and orographic cloud systems. Since the ERAU spring semester courses end in late April, the UWKA deployment took place in the latter part of the semester. Students involved with the START project participated in daily forecast briefings, onboard data collection, launching radiosondes in support of the project missions, and conducting preliminary analysis of data sets.

In advance of the deployment, students worked with faculty to identify goals for the flight missions (depending on meteorological events during the deployment time frame):

1. Observe the effects of atmospheric wave dynamics on aircraft-measured turbulence and orographic cloud development
2. Produce case study data sets for mesoscale model validation studies during strong cross-wind conditions which limit pilot training operations
3. Investigate the potential for leeside eddies and flow reversal in the flight approach/departure zone of the KPRC airport due to nearby mountains
4. Characterize particulate size distributions associated with aerosol sources such as wind-driven dust lofting which restricts the visual range of pilots
5. Identify cloud and precipitation particle size distributions associated with parameters obtained from the NWS dual-polarization radar (located on the Mogollon Rim northeast of Prescott)
6. Obtain aircraft data sets that can be used to create instructional resources for pilot training on aviation safety factors (icing, turbulence, wind shear)
7. Demonstrate sensor systems and data communication methods for future atmospheric research projects (designed for a smaller experimental aircraft)

The flights did capture a wide variety of event conditions during the two-week project, including dust lofting, wind shear, boundary layer turbulence, mountain wave dynamics (Figure 3), cloud microphysical processes and convective cell structure. Concentrating the flight operations close to KPRC allowed sampling multiple conditions within single flights.

Fig. 3. UWKA flight for 30 March 2014 over San Francisco Peaks near Flagstaff, AZ.

The field deployment began with an aircraft orientation and safety briefing that was provided for project participants at the UWKA hangar base. Tom Drew (UWKA Research Pilot) presented information on aircraft layout, in-flight communications, logistics and operational procedures. Participants were introduced to the aircraft instrumentation (Figure 4) and onboard data visualization systems (Figure 5). Larry Oolman (UW Senior Research Scientist) led a software training session on April 26 (and additional training prior to flights) to describe the in-flight data display functions and use of software for real-time and post-flight data access.

Fig. 4. Briefing session for students and faculty on the external configuration and sensor systems of the UW King Air at KPRC operations base.

Fig. 5. Interior view of UW King Air from entryway, showing instrument racks and data visualization computers used by the UW lead scientist and Embry-Riddle participants.

Aeros software available from the National Center for Atmospheric Research (NCAR) Earth Observation Laboratory (EOL) was used both in real-time and for post-flight study of the aircraft measurements [http://www.eol.ucar.edu/software-center]. Students and faculty conducted data analysis using time series, 2-D and 3-D scatterplots and flight tracks, size distributions and vertical profiles with multiple simultaneous parameters, visualization options and time segment selection. Aeros allows quick visualization of multiple inter-related aircraft parameters with flexible graphical views. It is excellent for application in assignments and projects with undergraduate students from multiple Departments, from freshman level and perhaps no prior training with meteorological display packages. The Aeros real-time flight track monitoring (Figure 6) and parameter time series displays were also used in classes during individual flight missions.

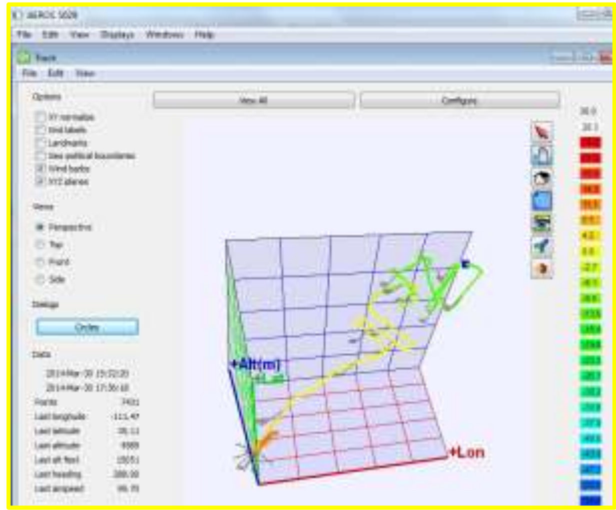

Fig. 6. Three-dimensional flight track visualization using NCAR/EOL Aeros software, as displayed in real-time for a class session during the 30 March flight.

Educational components of this project included training in research flight operations and radiosonde launch procedures. Radiosonde launches (Figure 7) were scheduled at noon on flight days, and were conducted by meteorology students using the ERAU radiosonde system atop a 3-story academic building on campus. Students also gained experience with participation in meteorological forecast briefings that were typically held at 8 am and 4 pm in the ERAU Weather Center or the UWKA hangar base location.

The flight mission discussions provided an opportunity to learn practical aspects of research flight logistics, including the constraints of having multiple agency centers coordinating airspace control, and flight altitude limitations in the vicinity of designated wilderness areas and other federal lands. An XChat application allowed text conversation via Internet and satellite communications between students aboard the aircraft and those on campus, with real-time discussion of radiosonde launch operations and class monitoring of enroute decision-making.

Fig. 7. Radiosonde release at 1916 UTC 30 March 2014 from rooftop launch facility at ERAU campus.

A course on meteorological instrumentation and measurement included instruction on sensors aboard the UWKA. A component of this class also guides students in building their own basic sensors, including comparison of ground-based and aircraft measurement parameters. An example of a student project was the construction of a basic hot-wire anemometer, with testing and calibration of the sensor using one of the ERAU wind tunnels.

3. IMPLEMENTATION

3.1 Logistics

The UWKA was based at Prescott's Love Field (KPRC) in a leased hangar that included an office area which served as the base of flight operations. The UWKA group was comprised of Dr. Jeff French, Larry Oolman, Tom Drew and Ben Heesen. Jeff French and Larry Oolman provided essential scientific advisement and flight mission leadership, and flight operational guidance by the expert research pilot (Tom Drew) enhanced the success of mission objectives.

Flight operations for this project commenced with a Test Flight day on March 25, followed by nine Research Flight days during March 26 to April 8. The allocation of 32 flight hours was utilized for quite diverse meteorological events. Flight summaries and data were archived by the UWKA Flight Center.

3.2 Data use in classes and student projects

Descriptions of student-led analysis for flight measurement periods are provided below, from student research projects and courses. The NCAR Aeros software for aircraft data processing and visualization has been used by most of the students, due to ease of application for rapid analysis of many parameters. IDL programming is used by Meteorology students with prior training on the Unix-based campus computers. Students produced graphics from individual flight missions for class assignments and case study research.

The flight on 26 March 2014 accomplished multiple measurement goals with sampling in four locations in northern Arizona (Figure 8). The aircraft track shows blue shading where the optical scattering probes indicate particle concentrations above specified thresholds (for cloud cell and dust layer sampling). Within the western portion of the flight track (Figure 9), constant-altitude flight legs were conducted near Prescott to document mechanical turbulence generated by topographic features near the ERAU flight training area, followed by sampling convective cloud microphysical structure with passes through cells at multiple heights in the area west of Flagstaff. Measurements in a region of dust lofting were obtained east of Flagstaff.

Fig. 8. UWKA flight track (gold/blue) for 26 March 2014 from Prescott airport (KPRC). Google Earth background indicates terrain features and county lines.

Fig. 9. Western portion of UWKA flight track for 26 March 2014, with focus on cross-valley transects and in-cloud microphysics sampling periods. Graphic captured from NCAR real-time aircraft tracking application.

Data plotted by students from the flight segments through convective cells (Figure 10) provide first-hand observations on the characteristics of cloud microphysical structure. The time series of cloud liquid water content and air temperature (Figure 11) for flight segments at increasing altitude and with increasing ice accumulation (Figure 12) demonstrate rapid production of cloud condensate in parcels ascending to the upper portions of cloud cells, and the influence on icing hazard.

Fig. 10. UWKA forward-looking camera image during sampling convective cloud cells on 26 March 2014.

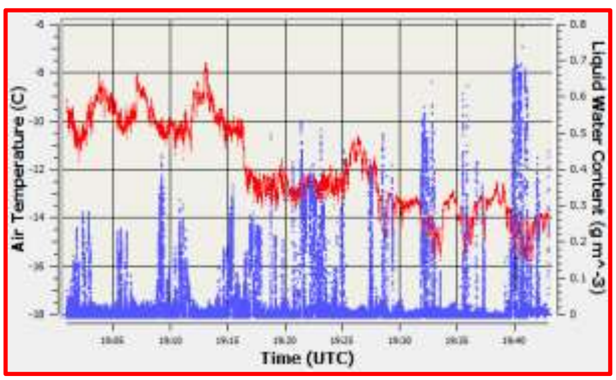

Fig. 11. Time series of temperature (red) and cloud liquid water concentration (blue) at increasing altitude (Fig. 12), during 1913-1945 UTC on 26 Mar 2014.

Fig. 12. Time series of icing detector counts (light blue) during cloud passes at increasing altitude (gold) for 1913-1945 UTC on 26 March 2014.

The measurements allow students to investigate how various aircraft instruments may be limited in accuracy for monitoring ice accumulation. Figure 13 indicates aircraft ice accumulation rate estimated from the icing rate counter (Rosemount Icing Detector) has a significantly lower magnitude than that calculated from a more complete method using size distributions detected with an optical scattering instrument (the Cloud Droplet Probe). This graph is an example of a simple IDL application that undergraduate students can quickly modify to explore relationships between variables from the aircraft data sets.

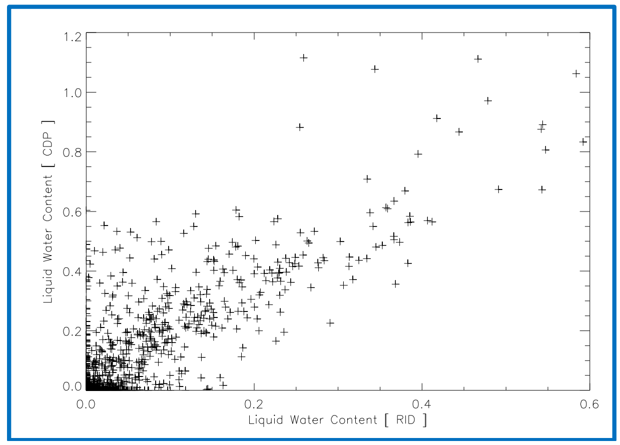

Fig. 13. Comparison of liquid water content calculated from Cloud Droplet Probe (CDP) data and estimated from Rosemount Icing Detector counts (RID) during transect through the upper portion of a convective cloud (see Fig.12) sampled by the UWKA on 26 March 2014.

Dust plumes were sampled in the eastern portion of the flight track during this mission (Figure 14). Figure 15 presents time series plots for particle concentrations obtained from the UWKA aerosol probe (PCASP; particle diameters 0.1 – 3 µm) and cloud droplet probe (CDP; diameters 2 – 50 µm), during which the aircraft was in and above the dust layer. Aerosol particle size distributions measured at different altitudes along the aircraft track illustrate the need for instruments which can detect a wide range of airborne particles, and how surface-generated dispersion processes are critical in determining the accuracy of aerosol trajectory forecasts (Figure 16). A student combined the aircraft data with surface observations of winds and visibility at downwind airports (Figure 17) to verify the effect of dust transport on flight restrictions. This data set will also be used for instructional exercises on the radiation flux impacts of dust lofting.

Students are accessing particle size distribution data from multiple instruments to become familiar with the characteristics of cloud and aerosol sources and interactions. Examples such as this provide students with their own personal discovery with measurements they collected, to evaluate and understand variation in size-dependent particle type concentrations, transport and dispersion, gravitational settling trajectories, potential activation or collection into cloud droplet populations, and aerosol impacts on atmospheric radiation flux, cloud optical properties and visual range.

Fig. 14. UWKA forward-looking camera image at the top of a dust layer sampled on 26 March 2014.

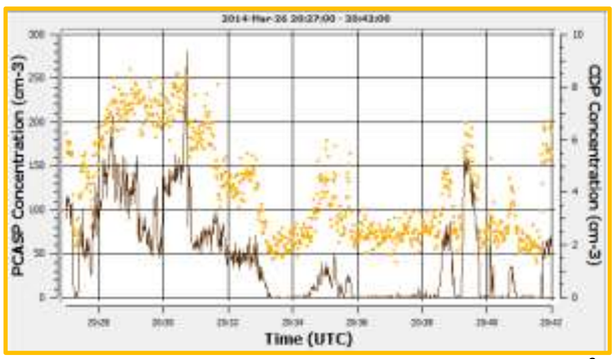

Fig. 15. Time series of particle concentrations (cm^{-3}) obtained from the UWKA PCASP aerosol probe (gold dots) and Cloud Droplet Probe (brown) for the period 20:27-20:42 UTC).

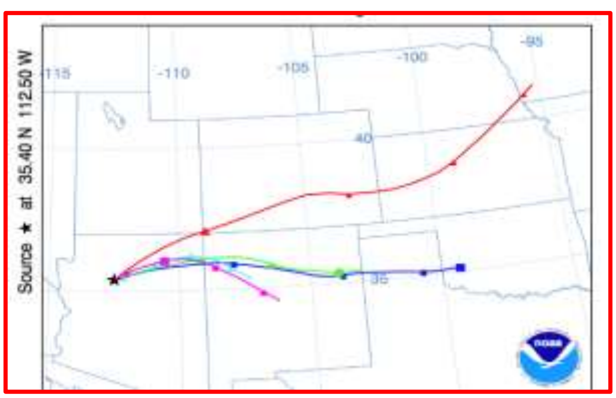

Fig. 16. Particle trajectory estimated using the NOAA Hysplit model for the flight period on 26 March 2014.

Time(CDT)	Temperature °F	Dew Point °F	Wet Bulb Temperature °F	Relative Humidity %	Wind Speed mph	Wind Gust mph	Wind Direction	Peak Wind Speed mph	Quality check	Pressure in	Sea level pressure in	Altimeter in	1000 m Pressure in	Weather conditions	Visibility miles
20:05	64.9	15.1	43.4	14	48	62	SSW		OK	24.76		29.69	24.77	haze	4.00
19:56	64.9	16.0	43.5	15	47	69	SW		OK	24.76	29.57	29.69	24.77	haze	3.00
19:53	64.4	13.8	43.3	15	49	69	SW		OK	24.76		29.69	24.77	haze	3.00
19:43	66.0	16.0	44.0	14					OK	24.76		29.69	24.77	haze	2.00
19:21	66.0	15.1	43.8	14					OK	24.76		29.69	24.77	haze	1.50
19:09	66.0	12.9	43.4	13					OK	24.76		29.69	24.77	haze	0.75
19:04	66.0	16.0	44.0	14					OK	24.76		29.69	24.77	haze	1.25
19:01	66.0	19.0	44.7	16					OK	24.76		29.69	24.77	haze	2.00
18:56	66.0	19.9	44.9	17					OK	24.77	29.58	29.70	24.78	haze	1.25
18:50	66.2	19.4	44.8	16					OK	24.78		29.71	24.79	haze	1.25
18:40	64.0	19.9	44.0	18	43	56	SW	56	OK	24.78		29.72	24.80	haze	2.50
18:38	64.0	19.9	44.0	18	46	56	SW		OK	24.79		29.73	24.81	haze	3.00
18:24	64.9	19.9	44.4	18	39	54	SW	54	OK	24.81		29.75	24.82	haze	2.50
17:56	66.0	23.0	45.6	19	26	43	SSW		OK	24.82	29.62	29.76	24.83	clear	10.00

Time(CDT)	Temperature °F	Dew Point °F	Wet Bulb Temperature °F	Relative Humidity %	Wind Speed mph	Wind Gust mph	Wind Direction	Peak Wind Speed mph	Quality check	Pressure in	Sea level pressure in	Altimeter in	1000 m Pressure in	Weather conditions	Visibility miles
1:53	46.0	30.9	38.8	55	46	58	W	62	OK	24.19	29.58	29.63	24.72	haze	4.00
1:42	50.0	26.6	39.1	40	47	62	W	62	OK	24.17		29.60	24.70	haze	2.00
0:53	57.0	10.9	38.6	16	31	43	WSW		OK	24.13	29.46	29.55	24.66	overcast	7.00
0:32	57.9	10.9	39.0	15	28	45	WSW		OK	24.12		29.54	24.65	haze	6.00
0:25	57.9	10.0	38.9	15	33	49	WSW		OK	24.12		29.54	24.65	haze	5.00
23:53	59.0	10.0	39.4	14	28	39	SW		OK	24.12	29.45	29.54	24.65	overcast	8.00
23:28	61.0	10.0	40.3	13	29	46	WSW		OK	24.12		29.54	24.65	overcast	8.00
22:53	63.0	8.1	40.9	11	37	48	WSW	53	OK	24.12	29.44	29.54	24.65	haze	4.00
22:46	63.0	10.0	41.3	12	33	48	WSW	53	OK	24.12		29.54	24.65	haze	5.00
21:53	63.0	16.0	42.4	16	33	40	SW		OK	24.13	29.45	29.55	24.66	mostly cloudy	7.00
21:11	64.0	21.0	44.0	19	30	41	WSW	41	OK	24.16		29.59	24.69	haze	5.00
20:53	61.0	18.0	41.9	19	26	33	SW	37	OK	24.17	29.51	29.60	24.70	mostly cloudy	10.00
19:53	59.0	19.0	41.3	21	17	25	SW		OK	24.21	29.55	29.65	24.74	overcast	10.00

Fig. 17. Meteorological reports from the airports at Winslow, AZ (upper) and Farmington, NM (lower).

The mission focus on April 2 was the collection of mesoscale wind and cloud structure data for validation of forecast model simulations during a rapidly evolving mesoscale convective event. Flight legs aligned at 130 / 310 deg (magnetic) were conducted at 1,000 ft intervals from 12,000 to 18,000 ft MSL along two transects approximately 20 nm apart (Figure 18). A radiosonde launched from the ERAU campus at 1921 UTC (Figure 19) indicated an elevated inversion layer. The King Air flight encountered convective cloud cell tops to 17-18 kft with cloud top temperatures ~-18° C within two hours of the radiosonde observations.

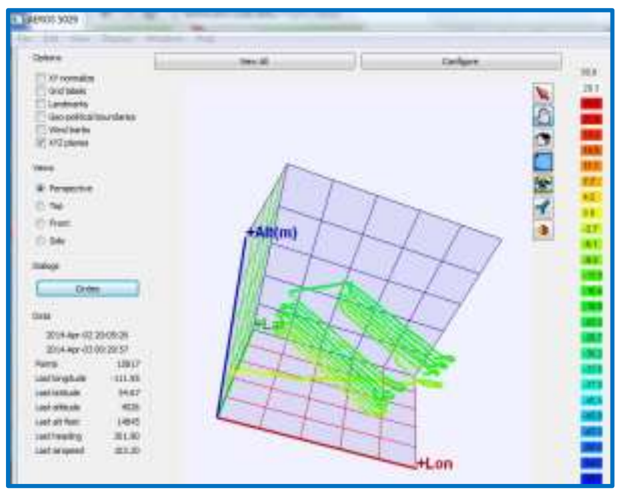

Fig. 18. 3-D track for the UWKA flight on 2 April 2014, depicting a series of constant-altitude legs along two transects, in an area of convective clouds with large liquid water content and ice crystals.

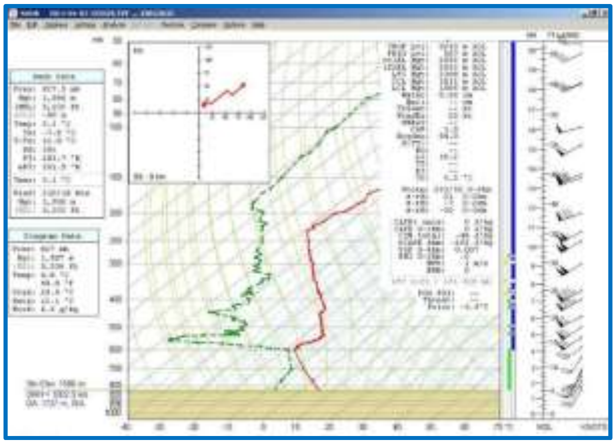

Fig. 19. Radiosonde data obtained from the launch from the ERAU campus on 2 April 2014.

Fig. 21. Plan view of flight track pattern and winds during the UWKA mission on 2 April 2014.

Aircraft measurements of wind velocities plotted for the stacked flight segments are shown in Figure 20 for the flight period 2106-2251 UTC, sampled along SE-NW oriented tracks (Figure 21). Winds measured along the upper-level transects were southwest and exceeded 40 m s^{-1}. Forecast simulations using the Advanced Research WRF model produced strong SW winds at 500 mb (Figure 22) across most of Arizona during the aircraft sampling period. A student research project is currently in progress to evaluate the UWKA aircraft measurements of thermodynamic and cloud structure during these flight segments, for comparison with higher-resolution WRF model simulations and NWS dual-polarization radar parameter fields.

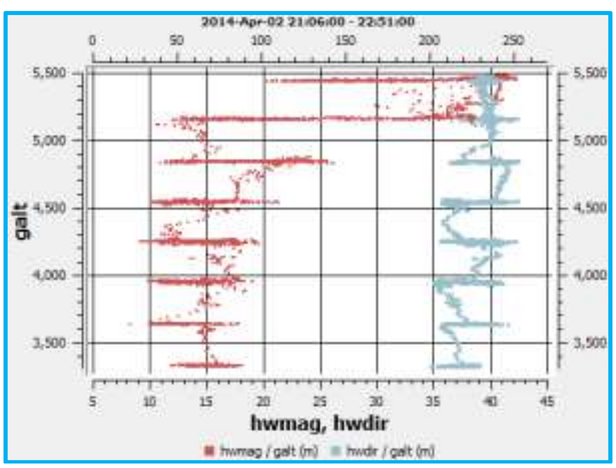

Fig. 20. Vertical variability in along-track wind speed (lower axis hwmag in m s^{-1}; red) and wind direction (upper axis hwdir; grey) sampled by the UWKA on 2 April 2014.

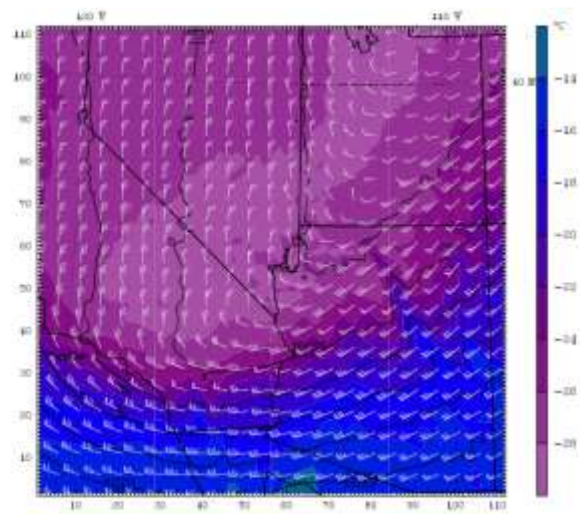

Fig. 22. WRF model graphic display of 500-mb wind velocities (white barbs, m s^{-1}), temperatures (ºC, color shading) and geopotential height (m, contours) for a valid time of 00 UTC on 3 April 2014.

4. OUTREACH

Undergraduate students and faculty were involved in outreach communications for the project through seminars, aircraft tours, publication of stories in the *Horizons* campus newspaper and documentation with photographs and video. A campus seminar was presented on March 28 by Tom Drew (UW Research Pilot), Dr. Jeff French (UW Flight Center Director) and ERAU Meteorology faculty members (Dr. Dorothea Ivanova and Dr. Melanie Wetzel). The open seminar introduced the START field program objectives, the multiple scientific applications possible with UWKA research capabilities, a review of case study observations of cloud icing risk from a research pilot's perspective, and a summary of ice crystal and cloud droplet size distributions related to cloud icing conditions.

It is estimated that more than 105 people attended this seminar (based on student sign-in sheets and other known participants). Attendees included several AMS Chapter members (from Flagstaff, Phoenix and Tucson), ERAU faculty and staff, and students from multiple Departments.

The UWKA was made available for public education at the ERAU maintenance hangar during a campus Discovery Day event. Shuttles from the main campus to the KPRC airport brought a wide variety of visitors, including students from middle schools and high schools, ERAU students and their parents, and local community members. It is estimated that 75 people attended this event (based on information from shuttle drivers).

5. EDUCATIONAL IMPACT

The START project entrained a broad range of participants during events and instructional sessions. Table 1 presents the participant numbers in these activities. Many participants were involved in multiple events. The number of individual participants who were involved (or directly learned from START project activities) is at least 210.

Table 1. Participation in project activities

Event or Role	**Date(s)**	**Participant Numbers**
Onboard flight scientist role	25 March – 8 April	26
Aircraft orientation / safety briefings	25 March	29
Aircraft data console briefings	26 March	26
Campus seminar	28 March	105
UWKA Open House at ERAU hangar	4 April	75
In-class utilization of real-time data	3 – 8 April	72

The faculty and students were able to utilize preliminary data files from the flights immediately after the conclusion of each flight, due to the efficient data management process of the UWKA flight group and the availability of Aeros software from NCAR/EOL. Data were also plotted in real-time and viewed in classroom sessions during flights. This demonstration of instrument systems and communication modes conveyed the scientific value of this technology to students.

With the rapidly expanding availability of airborne platforms for observation, research and training, the considerations of flight safety, aircraft instrument configuration and logistical planning are essential to the effective use of airspace. The UWKA deployment has provided case studies for local forecast modeling that would benefit pilot training. The project has also expanded awareness of instrument system applications for engineering students, and has encouraged aeronautical science students to consider career options for research pilots.

Feedback from all participants, both during the project and several months later, shows a durable impact and academic growth derived from this investment. Survey comments of students from the meteorology and other degree programs are shown below:

"Before this project I knew very little about airborne research. I feel that the experience gave me first-hand knowledge on how it works and the instrumentation that is used. It is one of the best experiences I've had being a Meteorology major."

"It helped further my research dramatically and deepened the knowledge that I knew about these scientific methods."

"I would absolutely recommend the experience to anyone in our degree field as I felt it was extremely hands on and very informative yet exciting and fun as well."

"This project increased my knowledge of airborne research and technology. I specifically was curious about how aircraft could be used to gather data for research on how aerosol particles are dispersed throughout China, negatively impacting agriculture, the environment and polluting the air."

"I would simply say that this should happen every year if possible as it truly is my favorite hands on experience we have had here at ERAU."

"The onboard flight study was extremely eventful and informative. We were given knowledge of the detailed technology used for the live feed coming from the instruments on the aircraft. We were able to go through many different types of environments, from storm clouds, dust plumes, low level flights and high level flights."

"It really was a fantastic learning opportunity. Projects like this should continue in the future, as all majors (especially meteorologists and pilots) could benefit from seeing how atmospheric research is done."

Faculty members have initiated new inter-departmental research collaborations as a result of this project. Data parameters have been collected from the Garmin-1000 (G1000) avionics data systems aboard ERAU aircraft for the time periods of the START project missions. Comparison of the UWKA with correlative G1000 data (such as air temperature profiles, winds and turbulence variables) are being used to evaluate the representativeness and utility of G1000 observations for local-scale analysis of lapse rate, stability, wind shear and turbulence, and applicability of these observations for WRF model forecasts and case study simulations of severe weather and aviation hazard events.

Comments from faculty…

"This was a great program and not only interesting but an excellent look at a realistic research process in atmospheric science. One of the best opportunities for both students and faculty I have seen at ERAU."

"Using the datasets for my own research was a plus. A research publication is in process."

"It has been a superb hands-on experience for our students, with exposure to several diverse airborne sensors and associated onboard processing systems, along with immersion into the life of an airborne researcher. In addition, students will now understand experientially how several datasets used in class and/or for undergraduate research projects were acquired. Participation in this project is a huge resume builder for our students wishing to move into research internships and/or graduate studies."

"A unique experience for many of our students that will increase their motivation toward a career in STEM disciplines."

"I was very pleased with the program. It provided an application for theory learned in the classroom, and students experienced scientific operations firsthand as an exploration based on curiosity."

"I think that it would be great addition to our program if we could regularly incorporate projects such as this… any type of field experience/data collection serves as a practical connection to what is presented in the classroom."

"This has been an excellent opportunity for students and faculty to collaborate on various research objectives focused on topics of local interest. It enabled students to apply their theoretical knowledge of atmospheric science to field research. Students learned to anticipate what atmospheric phenomena to expect during flight based on the model forecast fields, and then observed these conditions with data parameter plotting in real time while aboard the aircraft."

The START project initiated new opportunities for cross-disciplinary student research. A Van's RV-12 aircraft will be assembled during the coming year by a team of students from aeronautical engineering and other degree programs, to be used for student-led research projects in aerodynamics, aeronautical engineering and atmospheric sciences. The RV design is a two-seat fixed-wing aircraft which will also be suitable for research pilot training and testing of remotely-piloted control functions and systems.

The overall program allowed students to directly contribute to data collection and analysis, building first-hand knowledge of airborne measurement technology and atmospheric sciences research. The UWKA team members contributed significantly to the learning process with respect to scientific planning, flight logistics and data access.

6. RECOMMENDATIONS

Involving students in field experiences using atmospheric sensor systems and platforms generates new instructional resources and student research opportunities. A suggestion from the current project experience is that as many faculty as possible be drawn into the proposal process so that the benefit reaches multiple disciplines. An aircraft platform can be deployed near a campus location to allow many participants.

Scheduling the deployment during a summer term may be most efficient for projects oriented toward undergraduate students, due to the typically large class load that the students and faculty carry for undergrad degree programs during fall and spring terms. If a university devotes a summer-semester course to this type of project, the student cohort could be involved in focused training with "canned" data sets prior to the deployment period, then begin more extensive data interpretation during and immediately following the flights. Since a short deployment period may "miss" certain of the expected meteorological events or conditions, project goals should be flexible regarding how the resultant data sets will be applied to a range of instructional purposes.

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