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Three RESET Intern Projects: Atmospheric Data and Technology Assessments

by Gail Vaucher, Martha Hebert, Joyce Williams, Paul Cuaresma, Randall Dunkin, Jaime Wilson, Brian Leftridge

NOTICES

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Three RESET Intern Projects: Atmospheric Data and Technology Assessments

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14. ABSTRACT

Three complex environmental topics were investigated as part of the Research Experiences for Science, Technology, Engineering and Mathematics (STEM) Educators and Teachers (RESET) Internship Program. Due to the coronavirus disease restrictions, the Army Educational Outreach Program's onsite laboratory experience was redesigned into a virtual US Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL) RESET internship. The high school teacher participants had 40 h to discover, explore, and exercise fundamental scientific principles. This report documents the following content: 1) Project 1a: Developing Atmospheric Data Quality Control Tools – A comparison of meteorological variables from Site A (Local Rapid Evaluation of Atmospheric Conditions [L-REAC] Sensor Module Site) and a new Site B (Meteorological Measurement Tripod [MMT] Site). Results showed that the new site produced data worthy of its expanded mission. 2) Project 1b: Investigating Solar Radiation Averages for Hybrid Power Grid Applications – An investigation into representing solar radiation using running mean calculations. Results showed shorter running mean intervals preserved details; clear sky conditions had the best mean error. 3) Project 1c: Assessing the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology. User feedback on the Diamond B Technology Solution's LR-x, founded on L-REAC, reported that LR-x preserved the user-friendly and intuitive attributes. Participants reported mutually constructive/ productive experiences.

15. SUBJECT TERMS

MMT, atmospheric data, hybrid power grid, solar radiation, running mean averaging, mean error, L-REAC, LR-x

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Executive Summary

Preparing the next generation of exceptional scientists and engineers requires informed and inspirational teachers. In 2020, the Army Educational Outreach Program (AEOP) supported this mission through a Research Experiences for Science, Technology, Engineering and Mathematics (STEM) Educators and Teachers (RESET) Internship Program. Due to the coronavirus disease 2019 (COVID-19) restrictions, what was to be an onsite laboratory experience was redesigned into a virtual, interactive RESET internship with the US Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL).

Consistent with DEVCOM ARL's commitment to enable future operational overmatches through the exploitation of situational understanding, three distinct research topics were pursued, which focused on the dynamic, complex physical work environments of US Soldiers and disaster relief personnel. The professional high school teachers chosen for this program were given a total of 40 h to discover, explore, and exercise fundamental scientific principles from the information and data provided by ARL's computational domains and associates. Products from their work resulted in tools useful to several ARL projects.

This report documents the three projects executed, namely:

- Project 1a: Developing Atmospheric Data Quality Control Tools
- Project 1b: Investigating Solar Radiation Averages for Hybrid Power Grid Applications
- Project 1c: Assessing the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology

Project 1a: An active ARL meteorological data resource was recently relocated, based on internal ARL requirements, and its mission expanded to service additional projects. Due to the expanded mission, there was a need to assess the quality of data being issued from the new location (Site B) with respect to the old location (Site A); and to initiate a characterization of the new site. Limited by COVID-19 and economics, Site A data sampled by the L-REAC* Sensor Module on 2019 June 20 was compared to the Site B Meteorological Measurement Tripod data acquired on 2020 June 20. Both data resources spanned a full 24 h cycle, and were sampled on building roofs that were within 2 miles of each other. The two days selected for comparison were under clear sky and low humidity. Having the identical meteorological sampling design, all variables were graphically displayed and

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* L-REAC is a registered trademark of the US Department of the Army.

compared. Results showed that all variables reported reasonable values, indicating similar site characteristics. In short, the new location was deemed worthy of the expanded mission requirements.

Project 1b: Solar energy is a resource being integrated into hybridized tactical and disaster relief power generation. Solar radiation is a key parameter in the process of optimizing this future hybridized power. How best to represent in-situ irradiance is one of the many decisions being made as the process for optimizing tactical power is addressed. In this project, the impact of applying a running mean to represent the solar radiation attribute was addressed. To challenge the running mean processes, four atmospheric conditions were considered: clear sky, partly cloudy, overcast, and monsoon sky conditions. The monsoon sky condition included all three former conditions (clear, partly cloudy, overcast) within a single 24-h period. The running means experimented with spanned 10–60 min of time. Calculated running means were compared against the original 1-min sampled datasets. Results showed that the longer the running mean, the fewer details were preserved between the original and calculated solar radiation values. The impact of these lost details was quantified using a mean error. Based on the error calculations, clear sky conditions showed the least impact from data loss. Sunrise/sunset times consistently showed error increases as the twilight changed between darkness and full sunlight. Concave curve fitting underestimated solar radiation values; and convex solar radiation curve matching resulted in overestimated irradiance magnitudes.

Project 1c: ARL's Local Rapid Evaluation of Atmospheric Conditions (L-REAC) System evolved from an airborne hazard decision aid concept to a patented operational ARL technology. Following its successful technology transfer to Diamond B Technology Solutions (DBTS), a marketable technology (LR-x*) advanced into a tool able to service users, worldwide. Gleaning user feedback regarding this next phase of technology required a skilled neutral assessment. In this project, the intern learned the history and operation of both the L-REAC and LR-x Systems. Once understanding and proficiency were demonstrated (within one business day), data were gathered from LR-x users who had agreed to be independently interviewed by phone. Questions asked included their professional backgrounds, work experience, and specific questions related to their use and operation of the LR-x. Interview responses were collated, transcribed, and quantifiable tallies were converted into percentages to preserve their anonymity. The interviewed subjects gave an overall excellent rating of the LR-x technology. They consistently reported the technology as easy to use and intuitive; a significant

* LR-x is a registered trademark of Diamond B Technology Solutions.

attribute of the original ARL L-REAC invention. They all remarked on the seamless system start; that the technology saved them crucial steps when compared to other plume technology. The users commented that the technology would greatly increase communication and coordination. A tally of the materials gleaned from the interviews is summarized in Table 3.

As an internship aimed at providing real-world experience to seasoned high school teachers preparing and inspiring the next generation, candid feedback regarding their 40-h investment of time is summarized in Section 5 (Lessons Learned). Mentor comments conclude the documentation of these mutually very constructive and productive RESET internship experiences.

1. Introduction

Preparing for the future requires foresight in science, engineering, technology, and education. Educating the next generation of researchers begins with their teachers—in this case, high school teachers. Amidst the coronavirus disease 2019 (COVID-19) restrictions, the Army Educational Outreach Program (AEOP) Research Experiences for Science, Technology, Engineering and Mathematics (STEM) Educators and Teachers (RESET) Program adjusted their annual strategy, facilitating the execution of three virtual RESET internship projects with the US Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL). Consistent with DEVCOM ARL's commitment to enable future operational overmatches through the exploitation of situational understanding, three distinct research topics were pursued, which focused on the dynamic, complex physical work environments of US Soldiers. Topic applications also extended to disaster relief missions. The professional high school teachers were given a total of 40 h to discover and explore fundamental scientific principles in the information and data provided by ARL's computational domains and associates. Products from their work resulted in tools useful to several ARL projects. In this report, ARL's Computational and Information Sciences Directorate 2020 RESET projects are documented. However, first we examine the RESET Program, which provided the high school teachers this opportunity, and this year's novel method for completing the real-world experiences.

1.1 Research Experiences for Science, Technology, Engineering and Mathematics (STEM) Educators and Teachers Program

The AEOP RESET Program is designed to provide teachers and educators, from high-need areas working with underserved populations, a summer research experience at participating Army Research Centers and Laboratories. The goal is to reinforce teachers' content knowledge through research experience and interactions with Army and Department of Defense (DOD) scientists and engineers, and to translate this knowledge and experience into enhanced STEM research curricula.

Launched in 2016, RESET provides STEM educators with an online professional development module, titled "Introduction to Research (Level I)". Teachers participate online as cohorts, with a subset of the cohort traveling to Army Research Centers and Laboratories to participate in a four-week long experiential learning opportunity (Level II). Level II participants conduct research onsite under the mentorship of Army scientists or engineers. While at the labs, Level II participants continuously share their experiences with their Level I cohorts through ongoing online discussions. At the end of the summer, the full group of participants reconvenes to develop enhanced STEM curricula and enriched learning experiences for their students.

Due to the global COVID-19 pandemic, RESET converted its agenda into a fully virtual format for 2020. All 27 interns participated in an enhanced Level I experience that included virtual question-and-answer sessions with 16 Army scientists and engineers representing ARL, the US Army Corps of Engineers, and the US Army Public Health Center. In addition, four RESET educators participated in a virtual Level II experience in meteorological research under the mentorship of an ARL Principal Investigator, at White Sands Missile Range, New Mexico. Pending the removal of COVID-19 restrictions, RESET plans to return to the original, in-person Level II research experience at Army Research Centers and Laboratories in 2021.

1.2 The Virtual RESET Internship Structure

The best way to learn the fundamental scientific principles is through hands-on experiences and interactive discussions. While in-person interactions were not an option, the three projects selected for the RESET internships were designed around mastering key scientific skills over a very short time period (40 h), using standard software tools and scheduled discussions. The final deliverables were purposefully relevant and well-timed products supporting current ARL research programs.

The four internships were executed over two 5-day periods, due to the range of time zone differences spanning 16 h (meaning, in one case, the intern communicated in the context of a day in advance, of the mentor's location; while the mentor would be speaking "back to her future"). Each participant was given a syllabus, which included the project's title, dates, participants, objectives, and a 5-day outline of expected goals. These goals consisted of the following:

- Day 1: Introduction/Background of the Project, Data, and Methods
- Day 2: Data Processing
- Day 3: Data Analyses
- Day 4: Documentation
- Day 5: Presentation

Daily in and out briefings enabled participants to hear and learn from their colleagues working on other projects. The final presentations were peer-reviewed and presented to the ARL workforce and their associates. The final presentation schedule was designed to allow maximum participation from all four participants, across the 16-h time zone spread.

The three project topics selected for this experience included:

- Project 1a: Developing Atmospheric Data Quality Control Tools
- Project 1b: Investigating Solar Radiation Averages for Hybrid Power Grid Applications
- Project 1c: Assessing the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology

As mentioned before, each project was linked to an ARL application. The context/ application of the project's research is explained in the first portion of each major section, followed by a review of the project's objective, data, data processing, results, and conclusions. Written documentation provided by the intern has been included in this report, especially in the Conclusions sections. To encourage future participation in this program, Section 5 (Lessons Learned) includes candid intern feedback. The contributions of all four interns and the support provided by Tennessee Technological University have advanced ARL's research. A portion of their success is presented in the subsequent sections. Each represents a seed of opportunity.

2. Project 1a: Developing Atmospheric Data Quality Control Tools

In 2020, scheduled building renovations relocated the Local-Rapid Evaluation for Atmospheric Conditions (L-REAC)* Sensor Module (a 6-m tripod supporting multiple L-REAC-relevant meteorological sensors) from its "Site A" southwestern United States desert location, to within 2 miles of its original site ("Site B"). The original sensor tripod placement was physically near the center of a two-story occupied building's flat roof. The new placement was on the northern half of a single story, occupied building's flat roof. The loose small rock roof materials for both buildings were the same, as was the north-south orientation of the rectangular building structures. Both sampling sites were chosen based on their 360° of unobstructed, horizontal air flow, as well as 180° of unobstructed vertical view.

After careful planning, the site transfer occurred within an 8-h period on 2020 March 20, minimizing data down time. The equipment change of location was

* L-REAC is a registered trademark of the US Department of the Army.

(literally) the final onsite L-REAC Project task completed before a mandatory COVID-19 telework directive was implemented. Using remote access to Site B, the L-REAC Sensor Module data were subsequently monitored for functionality.

The Site B, L-REAC Sensor Module continued to sample data using the same meteorological instruments, sensor mount design, and sensor output formats; however, the system's name and mission were updated. The L-REAC Sensor Module's new name became the ARL Meteorological Measurement Tripod (MMT)*. The updated mission expanded from providing real-time and archived data to the airborne hazard decision aid, L-REAC System, and its associated customers, to providing real-time and historical meteorological data to various ARL research and development projects (including the L-REAC System).

As an example of the expanded mission, starting 2020 March 20, government and university personnel associated with US Army Test and Evaluation Command (ATEC) and ARL began integrating these data into their missions.

Once the MMT data acquisition and automated processes had become routine, the next objective was to compare old and new data acquisition sites. Since these sites were within 2 miles, it was anticipated that there should be little difference between the two sites. With the RESET internship, the site comparison was quantitatively addressed, and will be explained in the subsequent subsections.

2.1 Project 1a: Objective

Project 1a, Developing Atmospheric Data Quality Control [QC] Tools, was built on the goal of constructing and implementing tools for quantitatively assessing the L-REAC and MMT atmospheric data quality. The importance for having high data quality can be discerned in the context of its L-REAC System application. As reported in Ms Hebert's final presentation (see Appendix A), the L-REAC is a system, invented by ARL, to improve Soldier/civilian situational awareness of environmental airborne hazards during potentially life-threatening events (Vaucher et al. 2011a). More specifically, discerning current areas of hazardous and safe environments is accomplished through measured atmospheric parameters provided by the L-REAC System. These parameters are sampled by the L-REAC Sensor Module; processed by the L-REAC Model Module; visually displayed to the user by the L-REAC End User Display Module; preserved in the L-REAC Archive Module; and graphically evaluated in the L-REAC QC Module. The time needed

* For this report, "L-REAC data" refers to the data acquired by a suite of sensors mounted on a 6-m tripod at Site A (before 2020 March 20, 0900 MT); "MMT Data" refers to measurements taken by this same sensor suite and tripod located at Site B (after 2020 March 20, 1500 MT).

to process L-REAC data from sample to actionable intelligence ranges between 1 and 10 min (depending on the user-selected model resolution). The final products give users mapped near real-time situation assessments. In the next section, a description of the L-REAC/MMT data will set the foundation for the data comparison objective.

2.2 Project 1a: Data

Five standard meteorological parameters were acquired by both the L-REAC and MMT datasets. Table 1 lists these variables, along with their respective instruments: pressure (barometer), temperature (thermometer), relative humidity (hygrometer), wind speed/direction (anemometer), and solar radiation (pyranometer). There were actually three temperatures sampled, each at a unique height: 5.7 m above roof level (ArL), 0.7 m ArL, and 2 m ArL. The 2 m ArL sensor also sampled relative humidity. A 2 m ArL pyranometer quantified solar radiation in W/m^2, from the tripod's boom mount, extending due-south. All sampled values were reported as 1-min averaged values, and quantified in the metric system. A micrologger acquired the measurements. The weather-resistant enclosure ensured the safe functioning of the electronics.

Table 1 L-REAC Sensor Module/MMT hardware. For additional sensor information, see Volume 1 (Vaucher et al. 2009).

Variable	Sensor	Manufacturer	Model	Units
Pressure	Barometer	Vaisala	PTB-101B	Millibars
Temperature	Thermometer		107-L	Celsius
Temperature/ Relative Humidity (RH)	Thermometer/ Hygrometer	Vaisala	HMP45AC	Celsius/Percent
Wind Speed and Wind Direction	Anemometer (Wind Monitor)	RM Young	05103	Meter/Second, and Degrees
Solar Radiation	Pyranometer	Kipp/Zonen	CM3	Watts/Meter^2
Micrologger	ALL	Campbell Scientific	CR23X	
Weather-Resistant Enclosure	ALL	Campbell Scientific	ENC 16/18	

As mentioned earlier, both locations used the same tripod layout, and a near center-roof placement along the east-west axis. Along the north-south axis, the new Site B location was on the northern side of center, whereas the original site was closer to the building's longitudinal center position.

The data selected for a comparison were sampled near the summer solstices:

- Site A, L-REAC: 2019 June 20 (Julian Day #171)

- Site B, MMT: 2020 June 20 (Julian Day #172*)

Additional features linking the chosen datasets will be described in the next section.

2.3 Project 1a: Data Processing

Restricted to remote-only interactions, and having an extremely limited time to execute the comparison, the data chosen for this task were previewed by the mentor for potential gross error data entries. The analysis tool selected for the data comparison was the commonly accessible software, Excel. For efficiency, the study was confined to a clear sky, desert case in June (near the June solstice/seasonal maximum sun duration). Fortunately, New Mexico June weather is fairly consistent with its clear sky characteristics. Using the same date (June 20) for both 2019 and 2020, the L-REAC data from 2019 and the MMT data from 2020 were used in this comparison study. To frame the common attributes of these two sampled days, a summary of the atmospheric conditions follows:

During the 2019 June 20 sampling period at Site A, very warm and dry conditions were present over the desert southwest. A weak upper disturbance passed to the north over Colorado and Northern New Mexico in the morning and early afternoon, but had little effect over Site A (Fig. 1). Zonal (westerly) flow aloft set up a thermal surface lee trough over eastern Colorado and New Mexico in the afternoon, resulting in a compression of pressure gradients and an efficient mix-down of winds in the low-levels of the atmosphere to the surface. Because of the very warm temperatures, winds mixed down from higher in the atmosphere (forecast soundings indicated winds coming down from as high as 4100–4600 m above ground level [AGL]). No atypical weather issues occurred (Thomas 2020).

* Important Note: Calendar Year 2020 is a leap year, whereas 2019 is a non-leap year. Consequently, the two data resources were not exactly one year separated. However, the seasonal inclination and climatological tendencies were accepted as close.

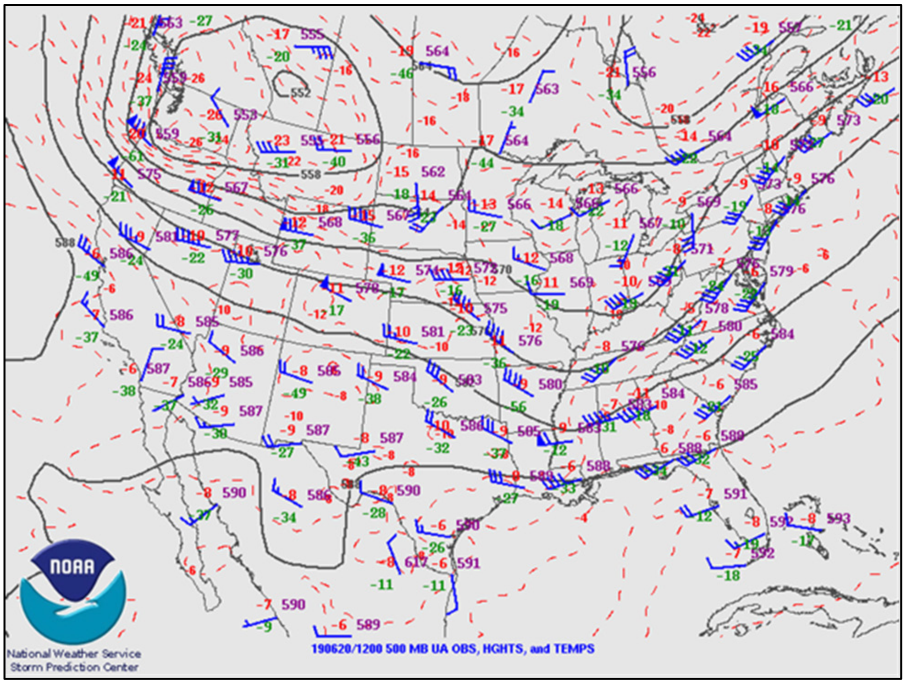

Fig. 1 2019 June 20, 1200 UTC, 500 mb

On 2020 June 20, about a year later, a weak surface cold front extended from the departing upper low in the Plains, and dropped into northeast New Mexico. This weak frontal boundary reached the northern White Sands Monument area between midnight and sunrise (Fig. 2). Thus, a light westerly breeze continued overnight, becoming light and variable after daybreak before shifting to the north and northeasterly by mid-morning. Breezes picked back up again in the mid-morning and afternoon. With the southern branch of the jet stream to the south keeping high cloud cover over northern Mexico, skies were clear over Site B during most of the period. The air mass over the range was very dry, with relative humidity peaking well before sunrise at less than 20%.

Each full day time series was independently plotted and visually previewed for potential anomalies acquired during the data transfer task. Per normal data processing, the night-time, negative solar radiation values were changed to zeros (nighttime negative values is a known artifact of the sensor). The time stamp was left in its default "minutes after midnight" units. Consequently, 0000 MT = 00 min or local midnight; 0600 MT would equal 360 min after midnight (min); 1200 MT = 720 min; 1800 MT = 1080 min; and 2359 MT = 1440 min.

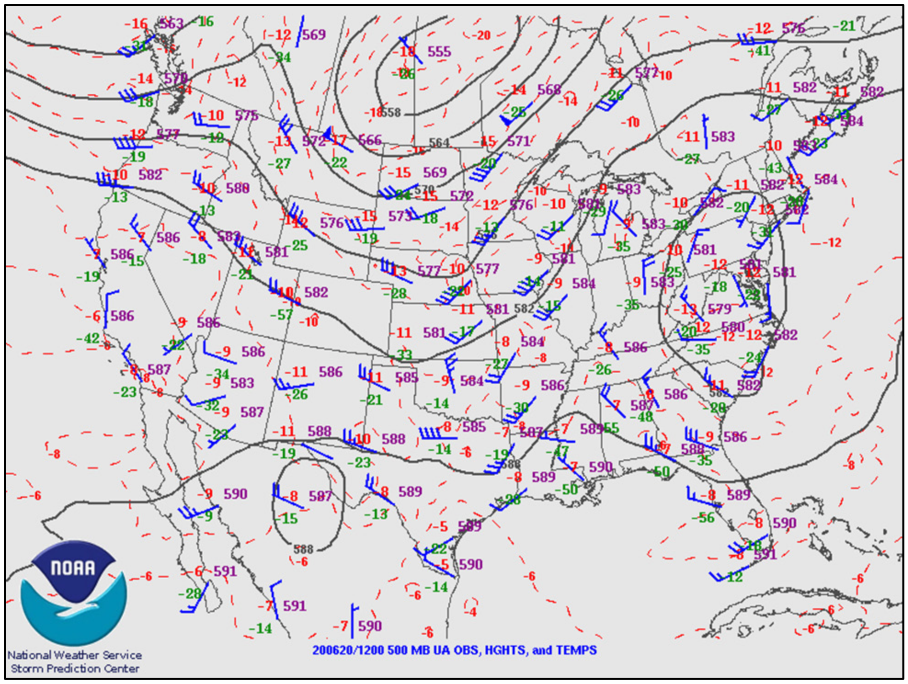

Fig. 2 2020 June 20, 1200 UTC, 500 mb

To better characterize the atmosphere, a qualitative stability was calculated. Using a vertical temperature gradient equation:

1) Delta Temperature = Temperature (top) – Temperature (surface),

where positive results were described as a stable environment with cooler air near the surface. A negative temperature gradient indicated instability, caused by warmer air near the surface trying to rise and reach its equilibrium.

Once the 2019 and 2020 time-series were reviewed, they were then combined onto a single plot, by variable, for a qualitative comparison. The results are described in the next section.

2.4 Project 1a: Results

With only 40 h to complete the task, a qualitative assessment was chosen. The order of evaluating the meteorological variables was critical in forming these non-numeric conclusions in a timely manner.

Starting with the solar radiation (Fig. 3), both locations showed the expected smooth Gaussian (omega) shaped, diurnal curve. Night hours were flat-lined at zero —indicating no significant radiation measured. A symmetrical rise and fall of solar radiation centered around solar noon (or 1300 MT daylight savings time), completed the generic characterization. Of interest were the three seemingly random data points occurring just after 1500 MT. Both locations reported these novel solar radiation drops. With no changes made in the tripod design, it was presumed that a systematic shadowing by the tripod structure (guy wires) noted at Site A, were also found at Site B. The slightly larger solar radiation values at the original site during the midday period show some unique traits. The elevated values could be a result of the MMT using an aged sensor (older by 1 year of sampling), the L-REAC sensor being positioned higher in elevation (second- vs. first-story elevation), or possibly there was a local filtering effect at Site B. Clearly, additional review of surrounding days would be needed to fully solve this mystery. However, for the qualitative study, the two data sites were considered compatible with respect to solar radiation measurements.

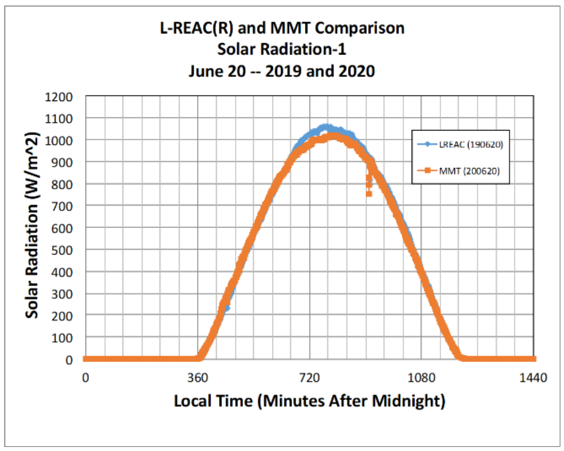

Fig. 3 L-REAC and MMT solar radiation at 2 m ArL data comparison

Relative humidity was examined next, as a uniquely moist atmosphere could skew a comparison. However, as Fig. 4 shows, both sites describe a typical June dry desert atmosphere. The morning periods of slight moistening from each year's data seemed to be out of phase (Fig. 4); however, being less than 20%, this observation does not present a significant concern.

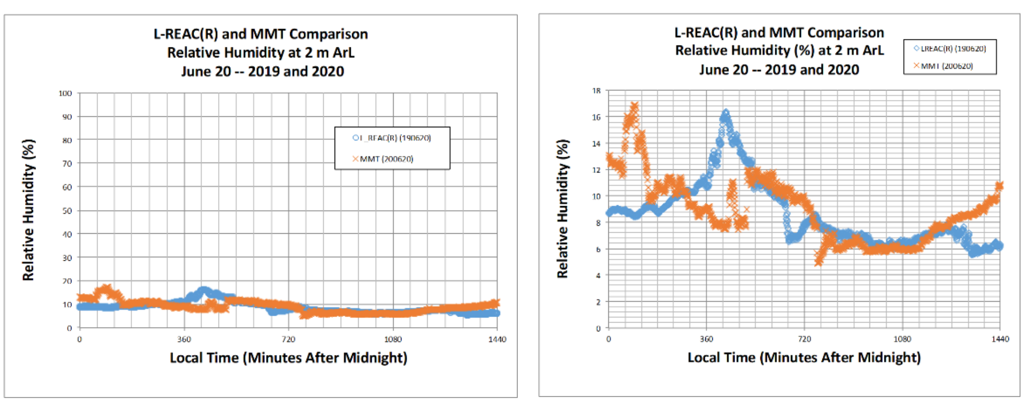

Fig. 4 L-REAC and MMT relative humidity at 2 m ArL data comparison

The temperature comparisons first looked at each level sampled, starting with the 5.7 m ArL (Fig. 5). Pre-dawn showed some relative phase shifting; however, after sunrise, the typical temperature increase through 1800 MT, followed by a downward trend to finish out the day, aligned well for both years.

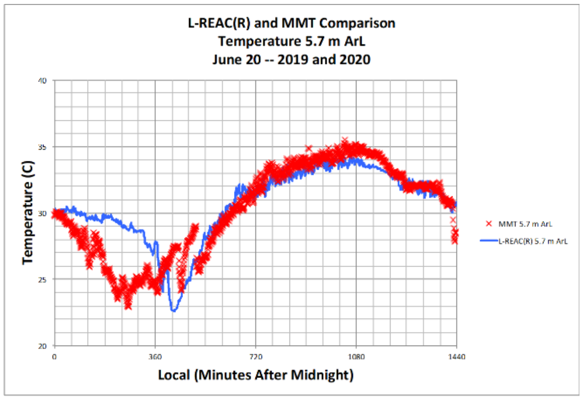

Fig. 5 L-REAC and MMT temperature at 5.7 m ArL data comparison

The slightly warmer 0.7 m ArL daytime temperatures (Fig. 6) also presented the typical clear sky pattern of radiative cooling from midnight to sunrise, followed by a warming daylight trend through sundown (~1800 MT), after which both temperatures cooled through the subsequent midnight.

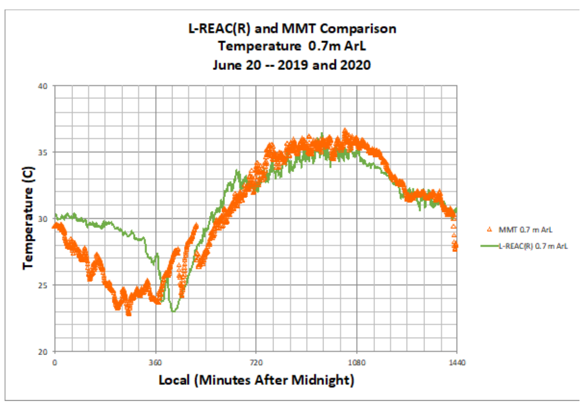

Fig. 6 L-REAC and MMT temperature at 0.7 m ArL data comparison

The 2 m ArL temperature (Fig. 7) was consistent with the former two temperature patterns. The phase-shifted, pre-dawn minimum could easily be a function of locally created effects for that day (i.e., building fans turning on/off). Post-sunrise surface temperatures showed an aligned warming, followed by evening cooling, indicating that qualitatively the two sites were reasonably comparable, especially in the context of the other temperatures sampled (Fig. 8).

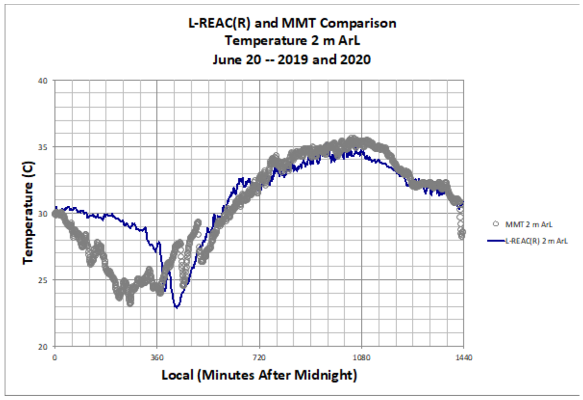

Fig. 7 L-REAC and MMT temperature at 2 m ArL data comparison

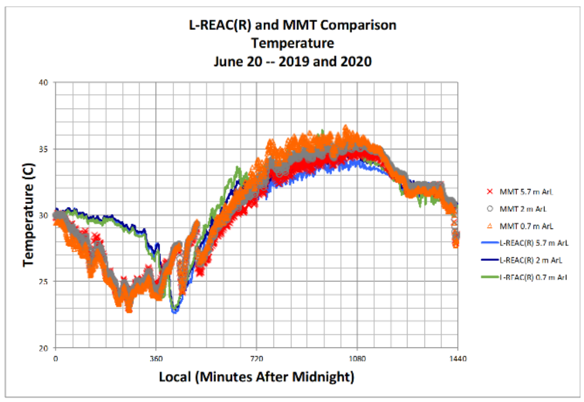

Fig. 8 L-REAC and MMT temperature at 2 m ArL data comparison

To better capture the thermal comparison, a temperature gradient was calculated ($\Delta T = Temp_{5.7m} - Temp_{0.7m}$). With this formula, when the near surface value was warmer (greater) than the aloft measurement, the net result was negative (unstable atmosphere). Conversely, when the surface values were cooler than above, the net results were positive (stable atmosphere). Figure 9 shows the temperature gradient for both locations. As expected, the positive temperature gradient (stable) was found at night, while the atmosphere was undergoing clear sky, radiative cooling. During the day, the sun was heating the soil, creating an unstable, negative temperature gradient. The daytime and evening align relatively well. The pre-dawn curve novelties could again be a function of a local effect, or residue thin cirrus clouds keeping the longwave radiation from cooling the surface. In the context of the L-REAC application, if a chemical spill were to occur during the negative-valued temperature gradient time periods, the unstable nature of the air would assist in reducing the local chemical concentration through the natural upward mixing of this unstable air. Conversely, the overnight stable atmosphere could potentially limit the natural dispersion of an airborne chemical, allowing informed potential victims to escape through safe zones.

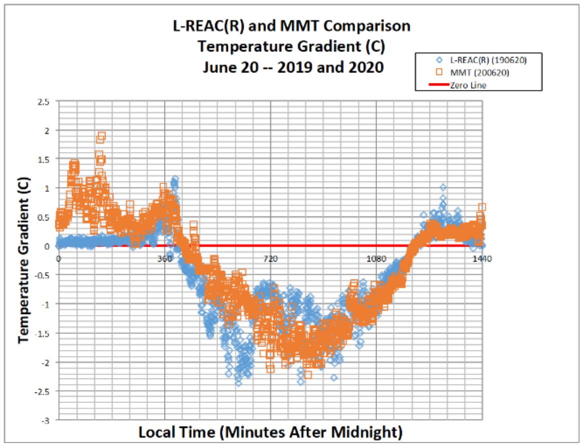

Fig. 9 **L-REAC and MMT 5 m temperature gradient (5.7–0.7 m ArL) data comparison**

Pressure values showed the same timing of rise and fall trends (Fig. 10), though the absolute magnitudes were distinct. A review of this sensor was flagged.

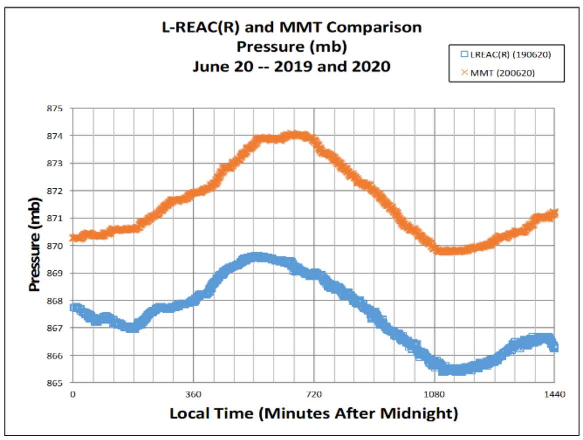

Fig. 10 **L-REAC and MMT pressure at 1 m ArL data comparison**

Wind speed and direction were not expected to track. However, a review of the wind direction (Fig. 11) showed a typical clear sky, June pattern: westerlies overnight and in the afternoon; along with easterly winds in the morning hours. MMT started its easterly winds later in the day. But, the probability of getting the same local, low wind, air flow one year later is very low considering all factors. In fact, the L-REAC data seem to indicate that the pre-dawn hours were involved in a stronger airflow from the west than the subsequent year's MMT data. Not until the sun rose did the two curves show compatibility (Fig. 12).

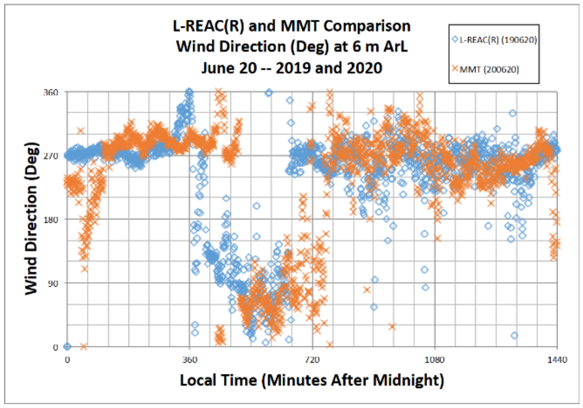

Fig. 11 L-REAC and MMT wind direction at 6 m ArL data comparison

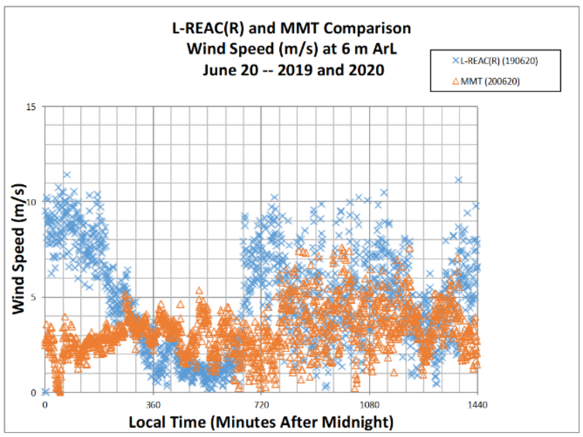

Fig. 12 L-REAC and MMT wind speed at 6 m ArL data comparison

2.5 Project 1a: Conclusions

The RESET experience was to provide hands-on experience with the scientific methods. Consequently, the conclusions documented here are primarily those of the RESET intern. For additional materials, see Appendix A (Project 1a Briefing).

After making a qualitative comparison between data taken from separate locations on 2019 June 20 and 2020 June 20 with the same tripod, sensor, and data logger, no significantly unusual activity was observed; therefore, the MMT data were determined to be reasonable.

In conclusion, the MMT continues to be worthy of use with the L-REAC System and any other scientific application. The L-REAC is appropriate for the protection and service of the Soldier, as well as civilians. This system would be a powerful tool for the entire nation, especially near factories that could feasibly have a hazardous chemical leak where evacuation was necessary.

3. Project 1b: Investigating Solar Radiation Averages for Hybrid Power Grid Applications

Reliable and resilient electrical power resources are a critical element of the Soldier's work environment. Hybridizing isolated microgrid technology is a constructive strategy for minimizing single-use fuels, minimizing energy storage (weight), maximizing the flexibility and adaptability in load handling, and better enabling the provision of uninterrupted power. Blending solar energy into traditional microgrids requires strategic energy management. Through earlier studies (Jane et al. 2020), ARL determined that integrating atmospheric intelligence would significantly strengthen optimizing opportunities of power distribution. One key meteorological variable for solar energy is solar radiation. Restricting the atmospheric intelligence to onsite resources only, ARL found a need to model the solar radiation parameter. Validating these data with measured pyranometer data posed another question: how to best represent the atmospheric conditions, specifically solar radiation. The RESET internship addressed this issue, as described in the following sections.

3.1 Project 1b: Objective

RESET Project 1b, "Investigating Solar Radiation Averages for Hybrid Power Grid Applications", was constructed on the objective "to determine the most representative averaging interval for solar radiation (and if time, temperature)." The immediate application of this solar radiation data was for determining the power generated by a photovoltaic [PV] panel. The atmospheric data required in the standard PV power conversion equation includes both solar radiation and PV panel temperatures. The strongest atmospheric influence comes from the in-situ solar radiation. Due to the limited 40-h internship experience, Mr Dunkin, and later in a separate internship experience Mr Cuaresma, focused their respective investigations on solar radiation.

3.2 Project 1b: Data

Solar radiation data sampled by a pyranometer represents the irradiance value for that moment in time, at the location of the sample. Plotting each of these moments in sequence creates a solar radiation time series that can be used to characterize the atmosphere over a given time interval. For practical purposes, the time series can also be represented by an averaged solar radiation measurement. The variation of samples within this average can be captured using an error calculation.

To challenge the most representative averaging routines, four persistent atmospheric conditions over a 24-h period were considered: clear sky, partly cloudy sky, overcast sky, and monsoon sky. As explained in Section 2.4, the 24-h clear sky solar radiation time series is characterized by a smooth Omega/Gaussian shape. No radiation is reported at night (zero flat line), and a symmetrical, upside-down "U" shaped curve is observed over the daylight hours. The partly cloudy sky retains this Omega shape, but has numerous drops in the solar radiation values representing times when the incoming sun is filtered and/or blocked by clouds. The overcast sky solar radiation time series also has an Omega shape; however, the amplitude of the Gaussian shape is significantly lower, and there are persistent smaller oscillations within the longer, 24-h curve. The monsoon sky shows all three previously described sky conditions within a single 24-h period. The monsoon day begins with a smooth clear sky curve in the morning hours; short bursts of cloud interruptions (partly cloudy) drop the solar radiation magnitudes through the midday, followed by a sharp systematic drop in solar radiation magnitudes during the afternoon (overcast) as the clouds fill in and often release heavy monsoon downpour rains. The overcast impacts persist through sunset, but its measured effect is lost through the lack of sunlight after sunset. Putting the prose into an equation:

Monsoon Sky = Clear Sky (morning) + Partly Cloudy Sky (midday) + Overcast Sky (afternoon and evening),

with all sky conditions as a function of time of day.

3.3 Project 1b: Data Processing

Due to the COVID-19 telework requirements, the logistics for processing the sensor-recorded data was a function of the intern's available tools. As an example, the Project 1b data were provided in a tab-delimited text-file. For one intern, the data were then imported into Microsoft Excel Version 16.38 on a MacBook Pro running OSX Catalina version 10.15.5. For another intern, a windows version of Excel was used. In both cases, the given data were organized for visual acuity and consistency.

The data processed for the four sky cases were limited to thermodynamic variables: atmospheric pressure, temperature, relative humidity, and solar radiation. Three unit conversions translated the original data into the metric system, and prepared the numbers for averaging: 1) Local time was converted from h/min/s into decimal days due to the data spanning two days; 2) The atmospheric pressure was changed from "Inches of Mercury (Hg)" into millibars (mb); and 3) Temperature was converted from Fahrenheit to Celsius.

Solar radiation data were averaged at 5-, 10-, 15-, 30-, and 60-min intervals. A running mean average was used to ensure an equal weighting of all values. For this publication, the results will focus on the 10-, 30-, and 60-min running mean averages.

The averaged data were graphically compared against the original “truth” data.

Finally, a mean error difference (Calculated Average – truth) was calculated for each averaged interval. The results are displayed in the next section.

3.4 Project 1b: Results

Project 1b results are divided into two sections. Section 1 summarizes the impact of lengthening the running mean average as a function of the sky condition. Section 2 reviews the error calculations for these same sky scenarios. In both sections, the time units were decimal days (dec day). This choice was to accommodate cases where the data spanned two days. In decimal days, a 0.25 dec day magnitude represents 0600 MT; 0.5 dec day equates to 1200 MT; and 0.75 dec day represents 1800 hr MT.

3.4.1 Running Mean Average Results

The results of the four sky condition cases follow. These results are organized, starting with the simplest, the clear sky case, through the most complex, the monsoon sky case. A briefing summary of these results is also available in Appendix B.

Clear Sky Case: The clear sky case generated the visually “best fit” running average. As seen in Fig. 13, the raw data show a uniform and symmetric Omega-shaped solar radiation curve. When inspecting the Clear Sky 10-, 30-, and 60-min running averages, the results reveal a nearly identical distribution. Only when the scales were significantly expanded were the curve novelties exposed. For example, focusing on the running mean apex (max) of the 10- and 60-min running averages (Fig. 14), there is a consistent underestimation of the measured data in the convex apex region for both clear sky cases. Note that the shorter average stays closer to the measured values than a longer running average. This principle was true for all cases.

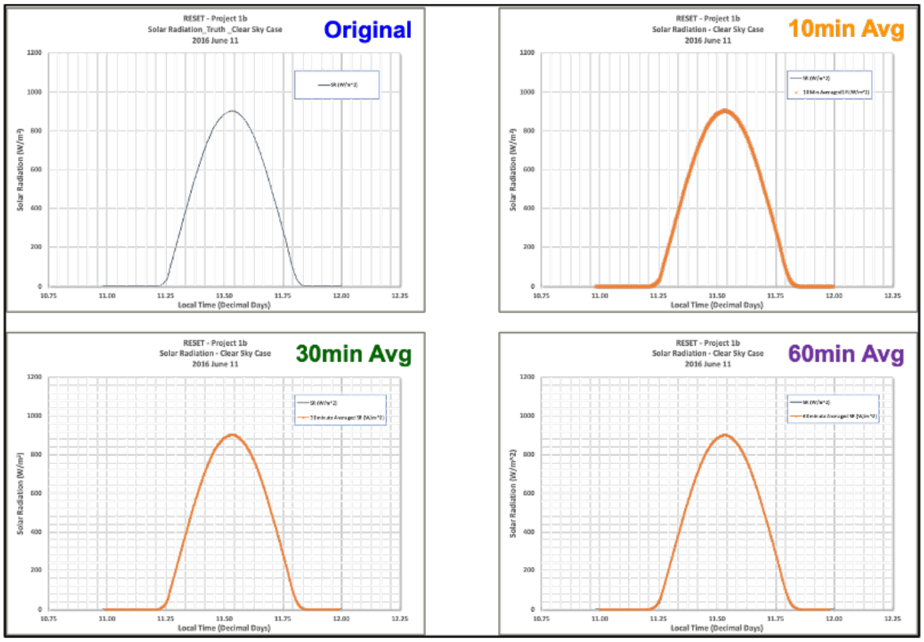

Fig. 13 Clear sky, solar radiation: raw data vs. running mean averaged data

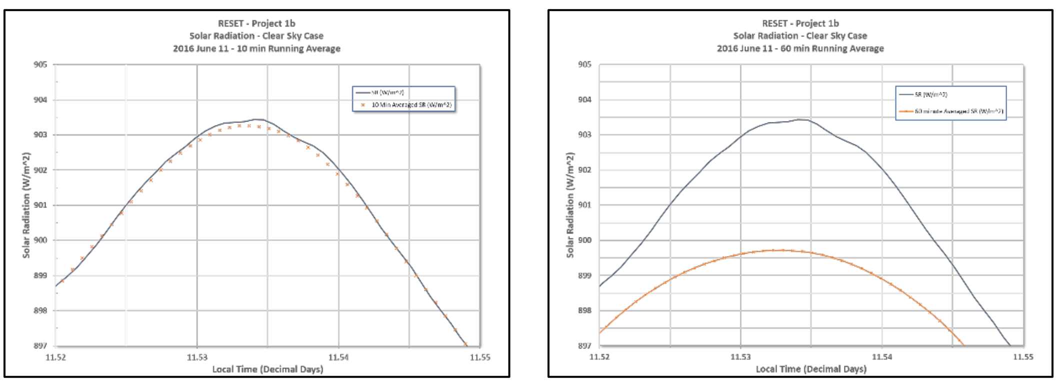

Fig. 14 Measured vs. calculated solar radiation values sampled over the midday: a) 10-min running mean average; b) 60-min running mean average

During sunrise/sunset time periods, the concave mean curves of the clear sky case consistently overestimated the sampled data (Fig. 15), whether using the 10-min or 60-min averages. Between these milestones, the two averaged data types came close to agreement with the measured values.

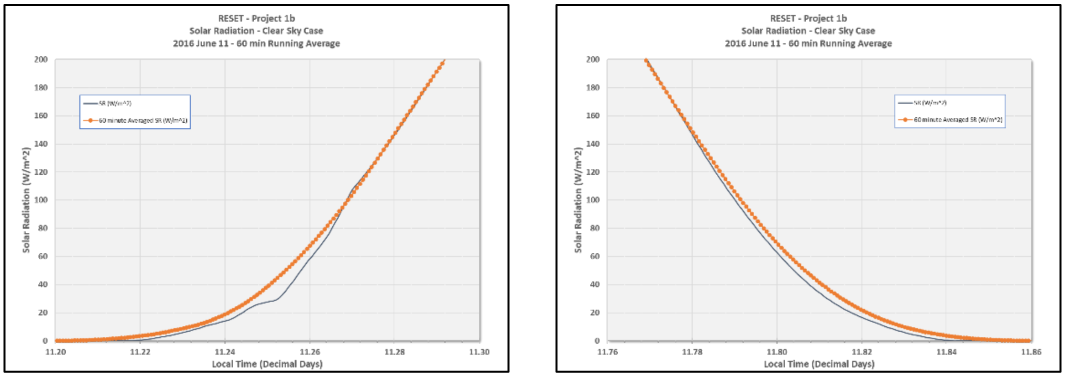

Fig. 15 Measured vs. 10-min running average solar radiation values sampled at a) sunrise, and b) sunset

Partly Cloudy Case: The partly cloudy sky case results in Fig. 16 show an increase in unreported measured data, as the running average interval increases. The 10-min running average, however, showed some potential usefulness, as it captured some of the longer and deeper radiation drops.

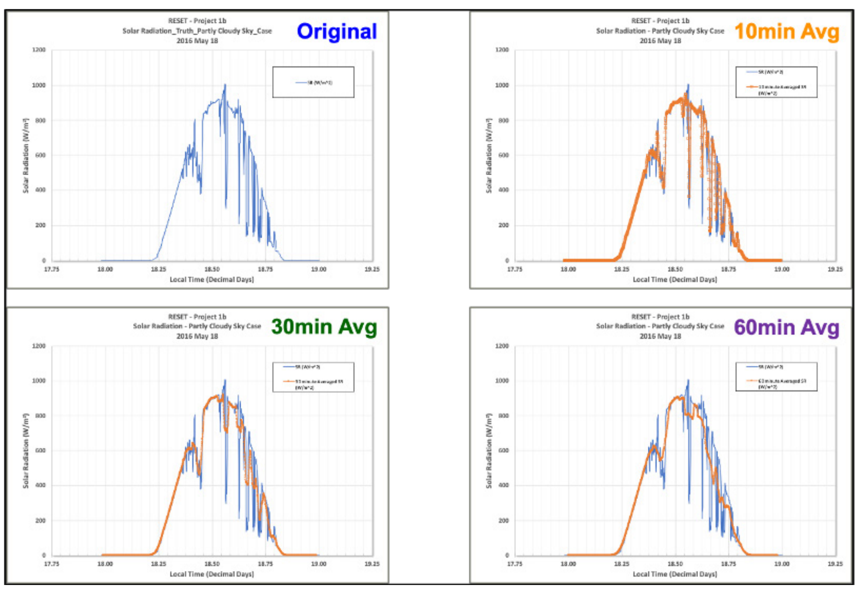

Fig. 16 Partly cloudy, solar radiation: raw vs. running mean averaged data

Overcast Case: In the overcast case (Fig. 17), the lower amplitude of the Gaussian curve was successfully captured by all tested time intervals. The shorter solar radiation oscillations embedded within the time series were best captured with the shorter running average (10 min), implying a potential "best fit" character. A study into reoccurring high-frequency patterns observed during overcast skies could help to quantitatively identify the truly best fit option for this sky condition.

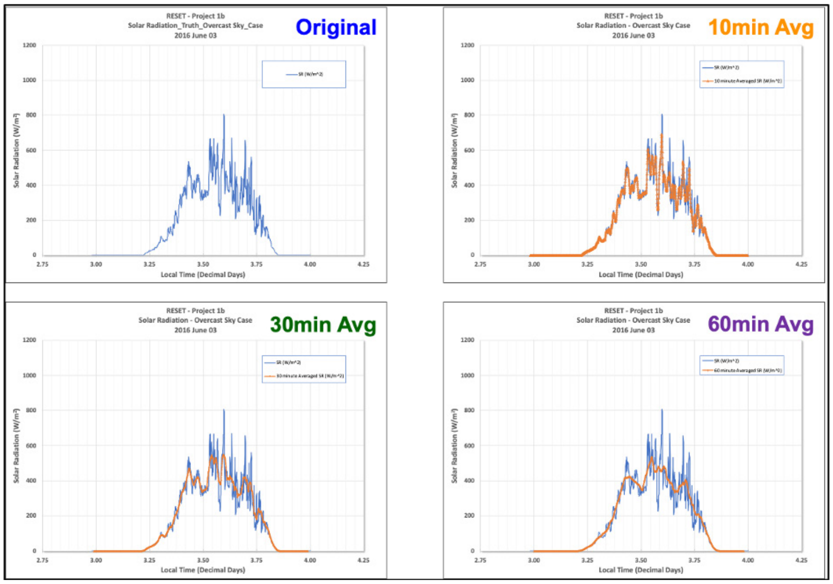

Fig. 17 Overcast sky, solar radiation: raw vs. running mean averaged data

Monsoon Sky Case: The monsoon sky case presented no new patterns (Fig. 18). The morning clear sky period tracked well with all averaging intervals; the midday partly cloudy portion did best with the shorter running averages, grossly missing the sharp magnitude drops as the length of the average increased; the underlying magnitude drop of the overcast section in the afternoon–evening was present in all running averages and showed good agreement, as long as the radiation changes were not severe or over a short duration.

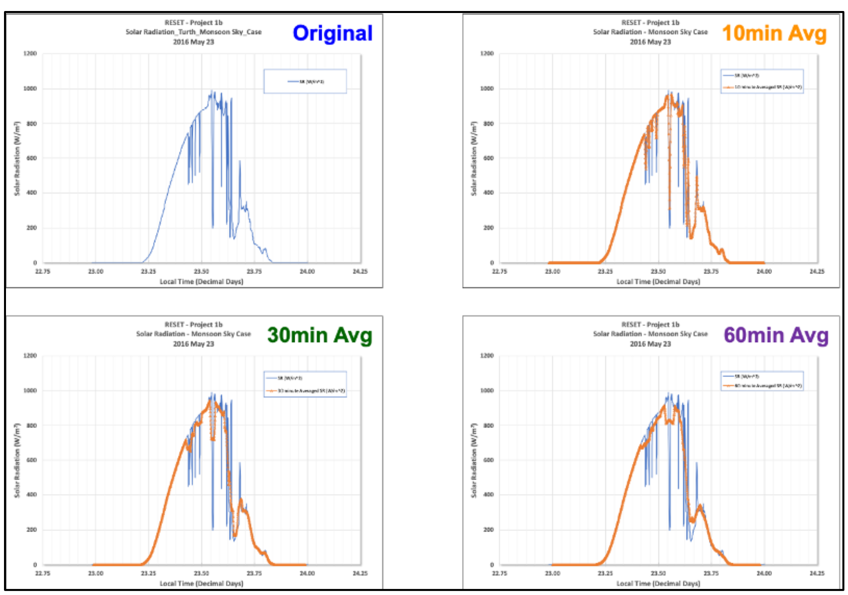

Fig. 18 Monsoon sky, solar radiation: raw vs. running mean averaged data

The underlying question raised in these results was, “Is the loss of solar radiation details significant for the energy management system’s optimization routine?”

A balance must be met between the data input and application. Too much information can be computationally expensive in terms of time. Too little intelligence may not be efficient or sufficient for the system to harmoniously work in a combat-ready environment. To help find that balance, a mean error was calculated.

3.4.2 Mean Error Results

The observed comparison trends have qualitatively framed the potential for using a running mean average to represent the solar radiation. In this section, a differential between the statistically determined and observed solar radiation provides a modest assessment of these patterns.

Clear Sky: When kept on the same graphical scales (Fig. 19), the clear sky cases confirm the smallest overall differences between averaged and measured values. The max overestimation of solar radiation for a 10-min running mean was less than 3 W/m^2. For a 60-min running mean, it was less than 17 W/m^2. For times of underestimating the solar radiation (such as during sunrise and sunset), these values were less than 5 W/m^2 for both 10- and 60-min running mean averaging extremes. When one grossly expands the error results (see Appendix B), a subtle cosine wave shape in the error curve comes into focus during daylight hours. The higher frequencies within this wave are a study unto themselves, and will not be discussed here.

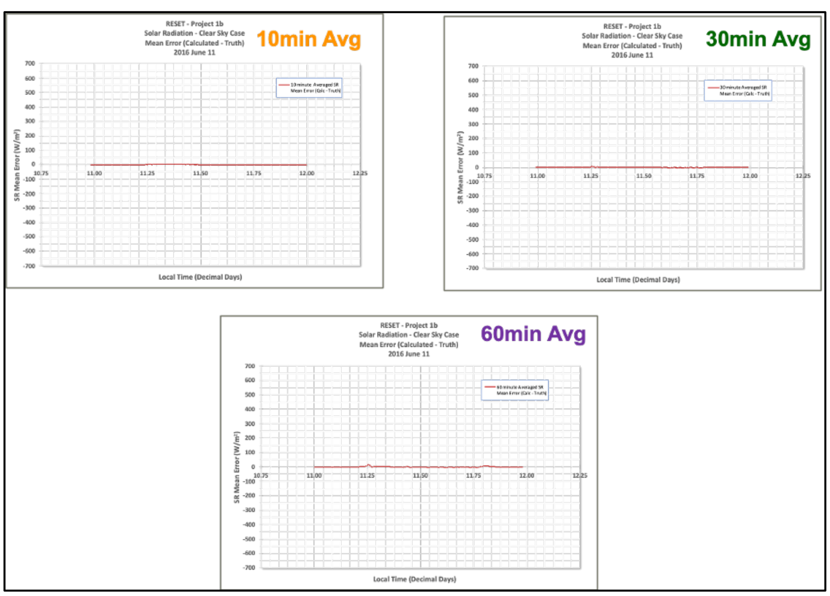

Fig. 19 Mean error, clear sky case: 10-, 30-, and 60-min averaging

Partly Cloudy: The partly cloudy cases show oscillations shortly before solar noon, when the clouds began to occult the solar energy (Fig. 20). The afternoon was highly populated with positive/negative spikes of greater magnitudes, as the algorithm responded to the periodic sharp solar radiation changes caused by traversing clouds. Quantitatively, using a 10-min running mean, the reported variations between calculated and measured values were less than +/–312 W/m^2. A repeated pattern of diminished +/– magnitudes completed the daylight hours. A subtler error reduction at the close of the day was observed in the overcast case, which is presented next.

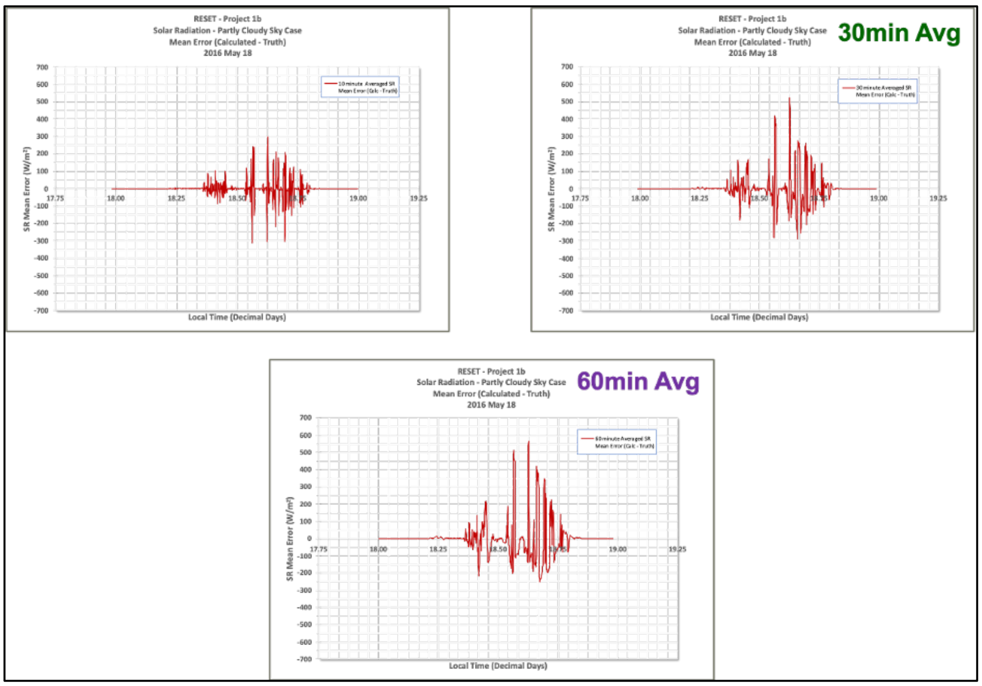

Fig. 20 Mean error, partly cloudy sky case: 10-, 30-, and 60-min averaging

Overcast: The overcast sky cases began an oscillatory pattern right away, but in a more muted net effect than the partly cloudy (Fig. 21). No doubt the systematically lower mean error magnitudes are, in part, due to the persistent, dense cloud deck creating smaller net radiation changes. The 10-min running mean reports differences of less than 230 W/m^2, with the numbers showing larger underestimated magnitudes.

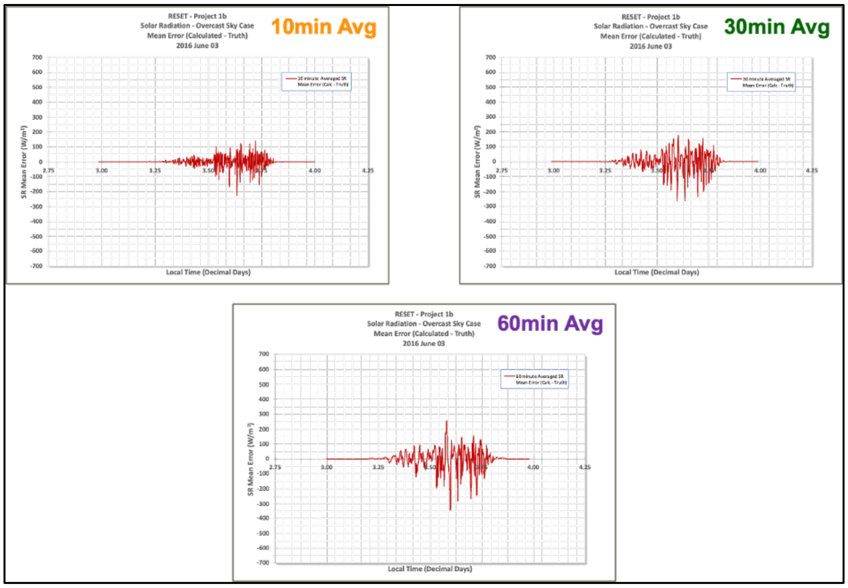

Fig. 21 Mean error, overcast sky case: 10-, 30-, and 60-min averaging

Monsoon: The monsoon sky case confirmed a "quiet" almost linear error curve at the start of the day (clear sky); followed by midday large spikes generated under partly cloudy conditions (Fig. 22). These relatively large changes persisted until the full overcast sky generated a more muted oscillatory pattern in the late afternoon/ evening. Maximum differences in the 10-min average report values less than 425 W/m^2. The max overestimations (423 W/m^2) exceed the underestimations (–353 W/m^2). Perhaps this is due to the timing of these values originating during the midday, when solar radiation magnitudes are already nearing their peak values and the sunlight is starting to wane?

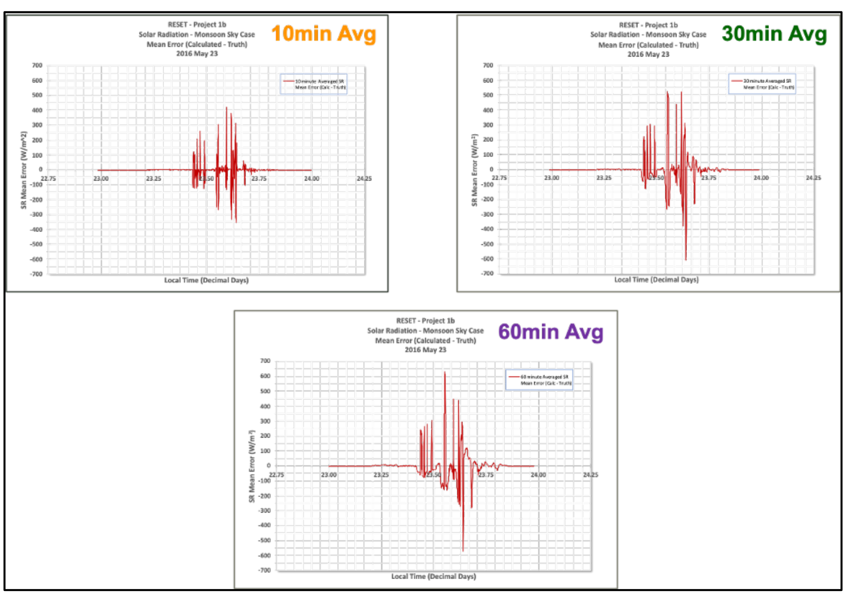

Fig. 22 Mean error, monsoon sky case: 10-, 30-, and 60-min averaging

In summary of the mean error calculations between all cases, the data indicate that as the running average time interval increased, the mean error peak magnitudes and density variations increased. This dual increase implied an overall greater magnitude of mean error; indicating that shorter running mean averages will more closely align with the original data details.

Two observations stem from the mean error sign interpretation. A positive mean solar radiation error showed an overestimated calculation of solar radiation; a negative error indicated an underestimated solar radiation. Using the enlarged graph of clear sky errors (Appendix B – Slide 15), prior to solar noon, the error tendency was toward an overestimation of the solar radiation. Whereas, in the afternoon, underestimating solar radiation trends were noted. Between these two leanings, the solar radiation difference decreased near solar noon. Finally, at the start and end of daylight, where solar radiation is lowest but not zero, the error data revealed large magnitudes of mean error variance. This pattern reinforced a need for shorter running averages over periods of systematic changes in the incoming solar energy.

3.5 Project 1b: Conclusions

In keeping with the quest for hands-on experience with the scientific methods, the following conclusions are primarily those of the RESET intern. For additional materials, see Appendix B (Project 1b Briefing).

Based on the results, the lower running average interval seemed to generate the best fit between measured and averaged solar radiation data. When solar radiation was lowest in strength but not zero, the mean error indicated the highest magnitude of over and underestimation of solar radiation. Partly cloudy and monsoon cases were the most difficult to reproduce via running means, due to the perpetual variations in radiation magnitudes. High variability due to random cloud occultation or systematic diurnal cycles resulted in the greatest mean error magnitudes.

Lessons learned included a renewal toward the attention to details and documentation. Having models to represent and communicate data is important. Processing data in Excel is like playing music—noting the repeated patterns helps to bring out the magnificent details integrated in the atmospheric processes and design.

4. Project 1c: Assessing the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology

In the early 2000s, ARL conducted three progressively more complex urban field studies aimed at characterizing the airflow and stability around a small cluster of urban buildings. As part of the final study, three disaster response drills were executed. Observing the emergency response within the densely instrumented urban field site, the need for a tool to link health and safety professionals with relevant atmospheric-environment data became apparent. In answer to the witnessed technology gap, ARL investigated the options and subsequently invented a user-friendly airborne hazard decision aid, called the Local Rapid Evaluation of Atmospheric Conditions (L-REAC) System. The L-REAC System evolved from a concept into a patented product with a registered trademark (Vaucher 2012). The prototype became an operational resource in 2011, when a range fire threatened the workforce of ARL and neighboring businesses. The success of the technology led to a technology transfer, with Diamond B Technology Solutions, LLC (DBTS), who secured an exclusive license agreement in 2017. Working in collaboration with ARL, DBTS advanced the concepts of the L-REAC System into a marketable product, capable of servicing users, worldwide. The DBTS technology is called the "LR-x".* With client use expanding, the need for an independent review of current user feedback regarding the marketable technology was considered mutually constructive. Consequently, the Project 1c RESET internship set out to evaluate technology performance through the eyes of its users. Using the 2011 L-REAC System evaluation methods as a template (Vaucher et al. 2011b), this chapter documents the investigation and its results.

4.1 Project 1c: Objective

The Project 1c Assessing the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology objective was to learn and assess the impact of a state-of-the-art airborne hazard decision aid technology. The investigator was purposefully chosen as a neutral professional with respect to the technology, yet familiar with research in the areas of hazardous materials and their impact on humanity (Williams 2006).

* LR-x is a registered trademark of Diamond B Technology Solutions.

4.2 Project 1c: Training, Data, and Data Processing

Before the data for this study could be acquired, the intern had to learn both the L-REAC and LR-x Systems, along with their respective histories. Concurrently, the intern learned how to operate the primary subject of the investigation, the LR-x. Once the understanding and proficiency were demonstrated (within one business day), the acquisition of data was addressed.

Unlike the earlier projects, the data for this investigation was largely non-numeric, and had to be acquired through one-on-one interviews. Specifically, these data were gathered from five LR-x users, who agreed to be independently interviewed by phone, prior to the internship. Table 2 describes the qualifications of each person interviewed.

Table 2 Project 1c interviewed subjects

Interview No.	Years of experience	Years using LR-x	Occupation
1	33	3	HaxMat/Emergency Services Instructor
2	20	1	Technology Developer
3	30 plus	2	Hazardous Materials Trainer
4	20	1.5	Safety Consultant
5	10	0.5	HazMat Team Member

A series of questions were defined by the interviewer prior to contact. Questions included the professional background of the one interviewed, their work experience, and specific questions related to the use and operation of the LR-x (Table 3). Interview responses were documented in notes by the intern. These responses were collated, and evaluator comments were transcribed. Quantifiable tallies were converted into percentages based on the total number of participants. LR-x experiences focused on user applications of the decision aid's plume model and how these compared/contrasted with other plume databases and applications.

Table 3 Project 1c results

Tally -- "Assess the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology"	Easy (10)	Sort of Easy (8)	Neutral (6)	Difficult (4)	Very Difficult (2)	Not Relevant (0)	Total Percentages
1.Ease of Use	100%	0%	0%	0%	0%	0%	100%
1.1 Setup	100%	0%	0%	0%	0%	0%	100%
1.2 Learning	100%	0%	0%	0%	0%	0%	100%
1.3 Operating the system	60%	0%	0%	0%	0%	40%	100%
1.4 Communication of results	100%	0%	0%	0%	0%	0%	100%
2.Data Input requirements	100%	0%	0%	0%	0%	0%	100%
3.Use of Multiple Variables (T, WS,Terrain, etc.)	100%	0%	0%	0%	0%	0%	100%
4.System Software	80%	0%	20%	0%	0%	0%	100%
5.Equipment requirement (Internet access)	100%	0%	0%	0%	0%	0%	100%
6.Ability to secure funding for aquiring the product	20%	0%	40%	40%	0%	0%	100%
7.Intergration with existing systems (KML)	0%	0%	0%	80%	0%	20%	100%

4.3 Project 1c: Results

The interviewed subjects gave an overall excellent rating of the LR-x technology. They consistently reported that the technology was "easy to use" and "intuitive". They all remarked on how seamless the system startup was, as compared to other technologies. Those interviewed reported that for other plume models there was a need to enter detailed input prior to generating their first action-able, plume-relevant output. With the LR-x, the user reported being able to enter just a physical address, after which a plume-steering wind flow graphic would manifest, representing the most recent atmospheric conditions over the area of concern. Once the toxic chemical was defined, this information was easily entered, LR-x plume model run, and a plume output, representing up to three concentrations of the chemical, was overlaid onto the earlier actionable wind field.

LR-x users were equally impressed by the real-time output generated and the atmospheric forecast models, provided. They thought it was easy to learn and were all appreciative of the multiple variables that the LR-x provided. Some of those variables include wind speed, wind direction, local temperature, terrain mapping, and Tier II chemical locations. Two of the system users mentioned that the system was dependent on the internet and not all locations had internet. Consequently, they noted that the internet dependency may hinder a fire department from acquiring the technology. Regarding small fire departments, three of the users commented that cost might keep smaller fire departments from acquiring the product. One user mentioned the inability of the system to transfer or rename keyhole markup (KLM) overlay files. This concern was raised to the LR-x developers and is being addressed.

The interviewed subjects reported that the technology saved them crucial steps when compared to other plume technology. The LR-x users commented that the technology would greatly increase communication and coordination. A tally of the materials gleaned from the interviews is summarized in Table 3.

4.4 Project 1c: Conclusions

To maintain neutrality, the conclusions documented here represent the RESET intern's experience. For additional materials, see Appendix C (Project 1c Briefing).

Evaluators unanimously stated that they would recommend the LR-x System. All evaluators reported that the LR-x would be an asset to their profession/ application. All users commented on their incredible experience with using the system and how amazing the technology really is.

Based on the interviewer's training experience, which resulted in generating three scenarios, the interviewer was also very impressed by the fact that one could easily type in any address in the United States and have it respond appropriately; and that the information produced was timely, relevant, and in enough detail to constructively inform emergency responders.

5. Lessons Learned

In this section, some final thoughts from each project are presented. To preserve the candid nature of the text, any editing was limited to grammatical adjustments, for consistency of the report's writing style.

5.1 Project 1a: Final Thoughts

Comments from coauthor Ms Hebert:

"This internship has definitely stretched me in that it has made me move outside of my little box into the vast world of meteorology and technology. My students only see what is right in front of their face, which unfortunately with my students is [often] failure. I look forward to sharing with them that the sky is actually not the limit; there is no limit to what they can contribute to society and more importantly to and for themselves."

5.2 Project 1b: Final Thoughts

Comments from coauthor Mr Cuaresma:

"As a high school physics teacher, this research internship reminded me how to keep scientific research a central focus in my science teaching. Not all students will agree that scientific research is exciting; however, in this high-tech, modern society, it is imperative that they understand and experience the process. This will allow them to be critical of the data that they are analyzing and to generate good questions for scientific discourse.

Although this internship lasted only for five working days, I am grateful for the rigor of this research experience. I am confident that I will convey the skills and knowledge learned to my students. Finally, I have learned the importance of modeling data and communicating the results through verbal and written scientific discourse. Overall, this research experience has made me a better science coach for my students."

5.3 Project 1c: Final Thoughts

Comments from coauthor Dr Williams:

"This experience has been so awesome and inspiring; and I have learned so much. It will impact my life as an informed citizen. I will be able to incorporate the experience and the approved information in my teaching. It will facilitate me in encouraging students to pursue STEM careers, by letting them know of the interesting and useful things a life in the STEM field can provide."

6. Summary

The 2020 RESET internship was originally intended to be an onsite RESET/ARL event. Due to the COVID-19 restrictions, the proposed projects were redesigned into virtual experiences conducted over brief 40-h periods. During these five 8-h days, each participant successfully learned the scientific and technical aspects of their individual project, received and processed real-world data, analyzed their processed data in the context of a scientific application, and documented their results in both a stand-alone presentation and a written summary. Their final presentations (Appendixes A–C) were reviewed by the project's Principal Investigator, and evaluated through a standard ARL approval process. Each participant provided a written summary documenting their work. Their final reports were used as input for this report. Their scientific findings and technical results will be integrated into various ARL projects, as described in the project introductions.

7. Conclusion

The successful completion of these short 40-h RESET internships is a credit to the professionals participating and those sponsoring these high-quality high school teachers. We look forward to working with the future scientists and engineers they inspire!

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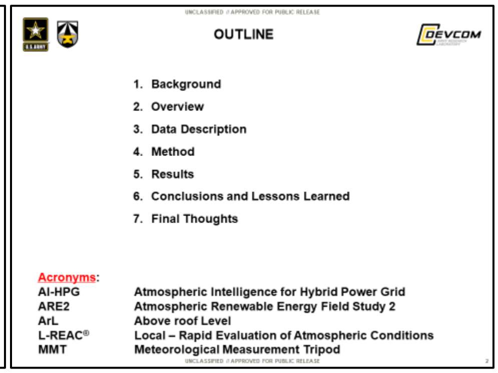
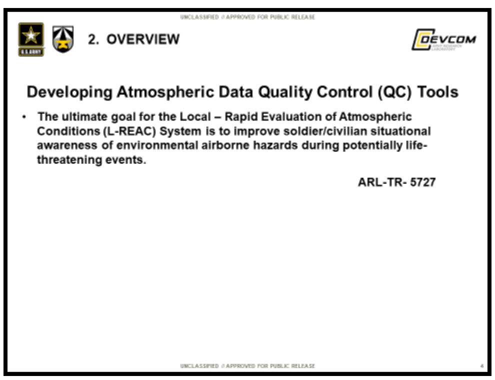
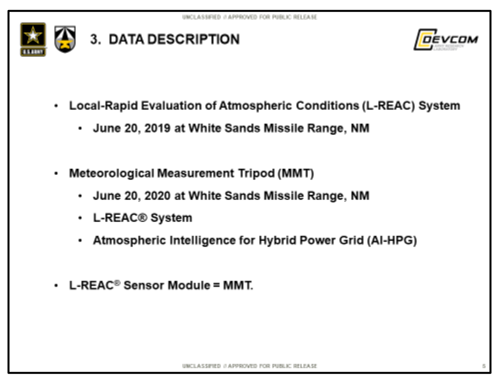
Appendix A. Project 1a: Developing Atmospheric Data Quality Control Tools – 2020 July 1 MT, Briefing Slides

SUMMARY: The Project 1a Briefing that follows was given by Ms Hebert on Wednesday, 2020 July 1, to the US Army Combat Capabilities Development Command Army Research Laboratory workforce and their associates. Personal identifiable information has been removed from the document. Project 1a figures originated in this briefing. The final topic of all RESET internship presentations was a summary of the speaker's recent experience in educating students during the COVID-19 pandemic.







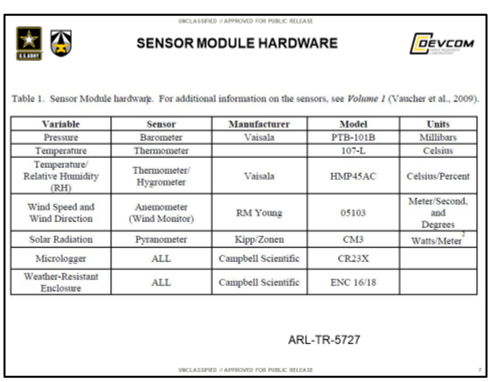
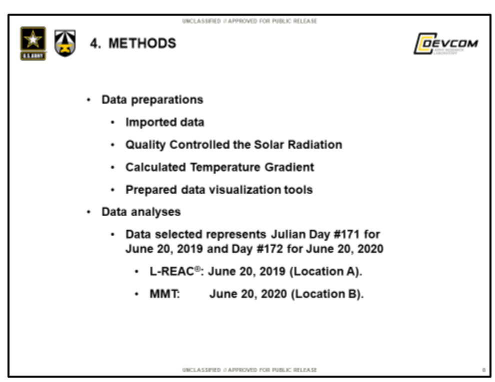
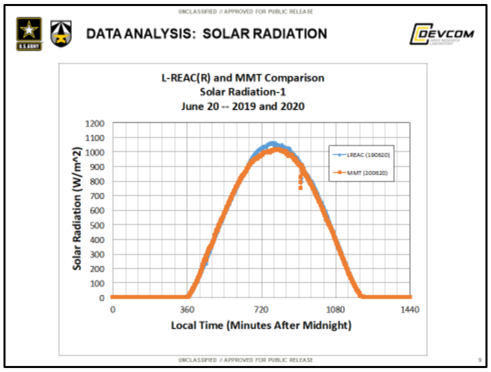
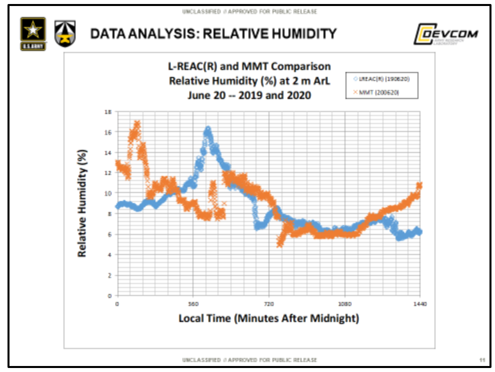


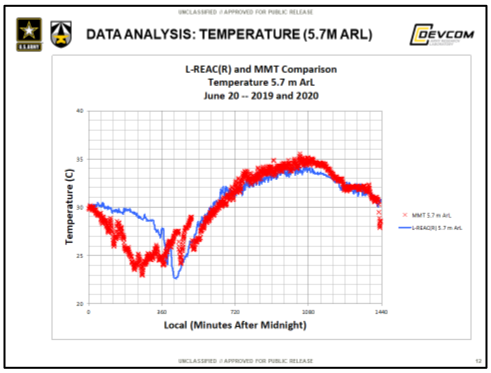
Table 1. Sensor Module hardware. For additional information on the sensors, see *Volume 1* (Vaucher et al., 2009).

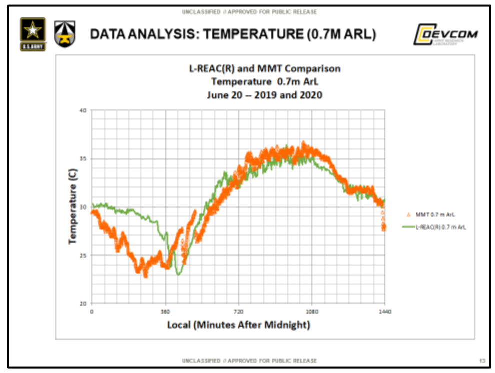
Variable	Sensor	Manufacturer	Model	Units
Pressure	Barometer	Vaisala	PTB-101B	Millibars
Temperature	Thermometer		107-L	Celsius
Temperature/ Relative Humidity (RH)	Thermometer/ Hygrometer	Vaisala	HMP45AC	Celsius/Percent
Wind Speed and Wind Direction	Anemometer (Wind Monitor)	RM Young	05103	Meter/Second, and Degrees
Solar Radiation	Pyranometer	Kipp/Zonen	CM3	$Watts/Meter^2$
Micrologger	ALL	Campbell Scientific	CR23X	
Weather-Resistant Enclosure	ALL	Campbell Scientific	ENC 16/18	

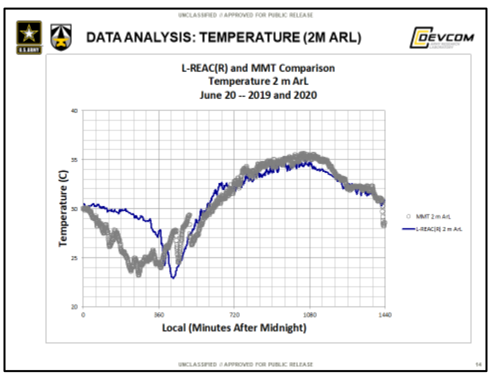


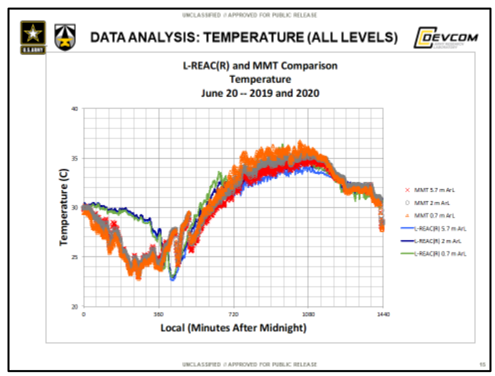

DATA ANALYSIS: SOLAR RADIATION
DEVCOM
L-REAC(R) and MMT Comparison
Solar Radiation-1
June 20 -- 2019 and 2020
Solar Radiation (W/m^2)
Local Time (Minutes After Midnight)
L-REAC (190620)
MMT (200620)

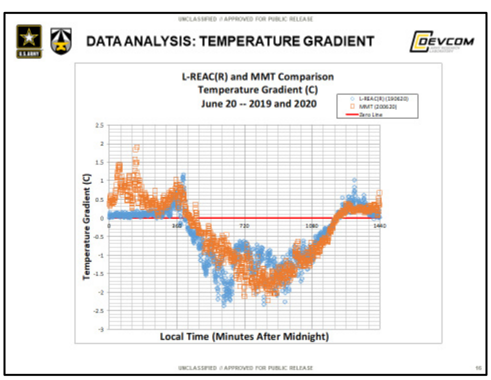

DATA ANALYSIS: RELATIVE HUMIDITY
DEVCOM
L-REAC(R) and MMT Comparison
Relative Humidity (%) at 2 m ArL
June 20 -- 2019 and 2020
Relative Humidity (%)
Local Time (Minutes After Midnight)

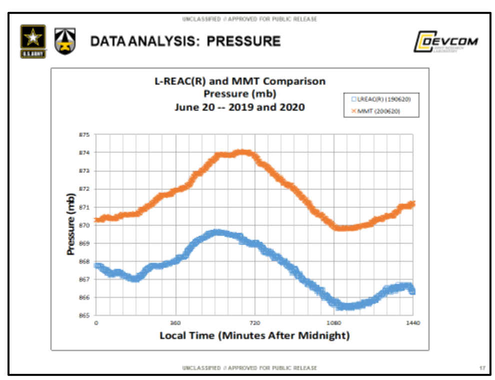

DATA ANALYSIS: TEMPERATURE (5.7M ARL)
DEVCOM
L-REAC(R) and MMT Comparison
Temperature 5.7 m ArL
June 20 -- 2019 and 2020
Temperature (C)
Local (Minutes After Midnight)


DATA ANALYSIS: TEMPERATURE (0.7M ARL)
DEVCOM
L-REAC(R) and MMT Comparison
Temperature 0.7m ArL
June 20 -- 2019 and 2020
Temperature (C)
Local (Minutes After Midnight)


DATA ANALYSIS: TEMPERATURE (2M ARL)
DEVCOM
L-REAC(R) and MMT Comparison
Temperature 2 m ArL
June 20 -- 2019 and 2020
Temperature (C)
Local (Minutes After Midnight)


DATA ANALYSIS: TEMPERATURE (ALL LEVELS)
DEVCOM
L-REAC(R) and MMT Comparison
Temperature
June 20 -- 2019 and 2020
Temperature (C)
Local (Minutes After Midnight)


DATA ANALYSIS: TEMPERATURE GRADIENT
DEVCOM
L-REAC(R) and MMT Comparison
Temperature Gradient (C)
June 20 -- 2019 and 2020
Temperature Gradient (C)
Local Time (Minutes After Midnight)


DATA ANALYSIS: PRESSURE
DEVCOM
L-REAC(R) and MMT Comparison
Pressure (mb)
June 20 -- 2019 and 2020
Pressure (mb)
Local Time (Minutes After Midnight)

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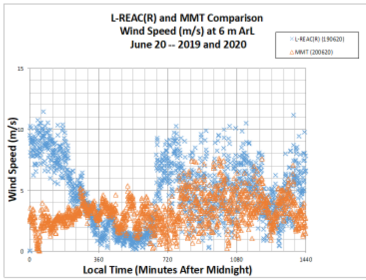
DATA ANALYSIS: WIND SPEED



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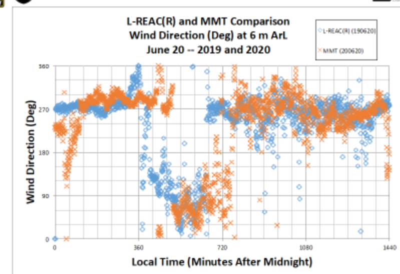
DATA ANALYSIS: WIND DIRECTION



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5. RESULTS

- After making a qualitative comparison between data taken from separate locations on 2019 June 20 and 2020 June 20 with the same tripod, sensor, and data logger, I see that there is no unusual activity; therefore, I determine that the data are reasonable.

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6. CONCLUSIONS AND LESSONS LEARNED

- In conclusion, the MMT continues to be worthy of use with the Local – Rapid Evaluation of Atmospheric Conditions (L-REAC®) System and any other scientific applications such as the AI-HPG Project.
- The L-REAC® is appropriate for the protection and service of the soldier as well as civilians.
- This system would be a powerful tool for the entire nation especially near factories that could feasibly have a hazardous chemical leak and evacuation is necessary.

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7. FINAL THOUGHTS

- This internship has definitely stretched me in that it has made me move outside of my little box into the vast world of meteorology and technology.
- My students only see what is right in front of their face which unfortunately with my students is failure.
- I look forward to sharing with them that the sky is actually not the limit; there is no limit to what they can contribute to society and more importantly to and for themselves.

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U.S. EDUCATION DURING THE COVID-19 ADVENTURE

- Describe how the 2020 school year adapted to COVID-19 requirements.
- Describe the 2021 education program for your school(s).
- List 1-3 Cons of the COVID-19 Experience.
- List 1-3 Pros of the COVID-19 Experience.

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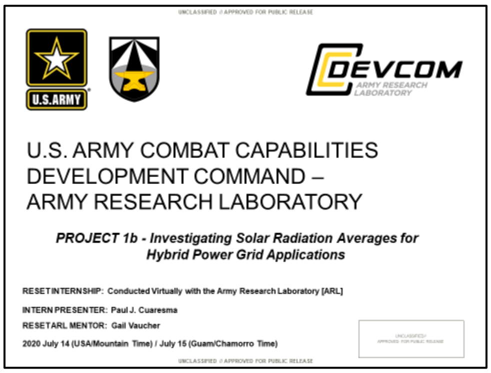
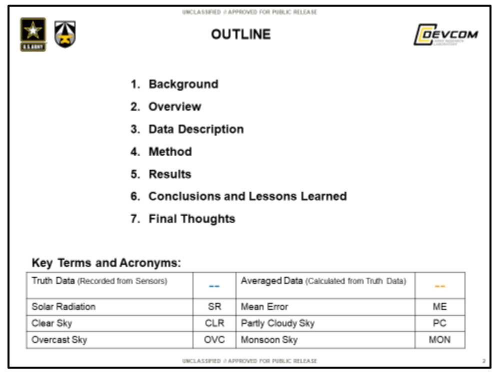
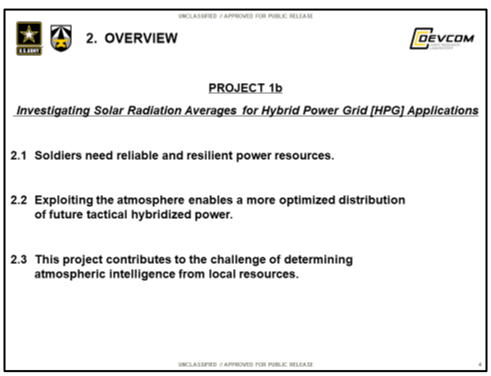
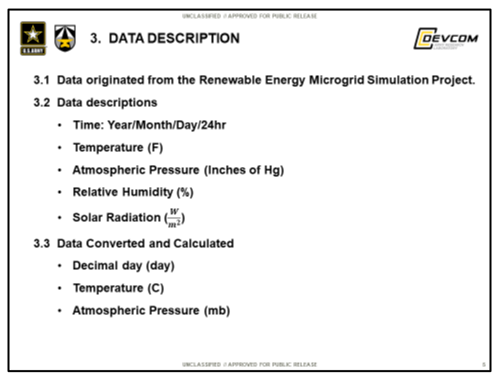
Appendix B. Project 1b: Investigating Solar Radiation Averages for HPG Applications – 2020 July 14 MT, Briefing Slides

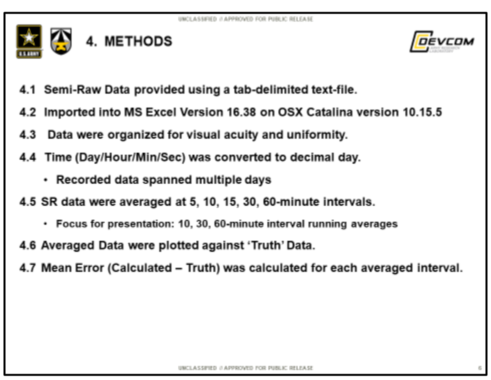
SUMMARY: The Project 1b Briefing that follows was given by Mr Cuaresma on Wednesday, 2020 July 14 Mountain Time (2020 July 15 Chamorro Time), to the US Army Combat Capabilities Development Command Army Research Laboratory workforce and their associates. Personal identifiable information has been removed from the document. Project 1b figures originated in this briefing. The final topic of all RESET internship presentations was a summary of the speaker's recent experience in educating students during the COVID-19 pandemic.

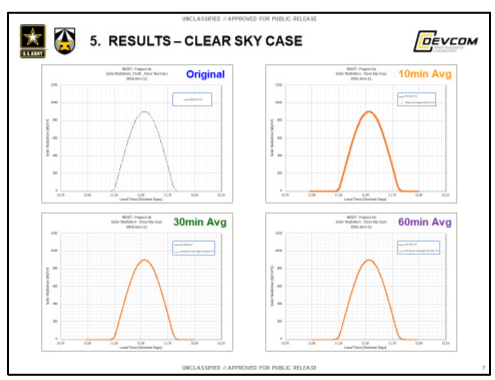


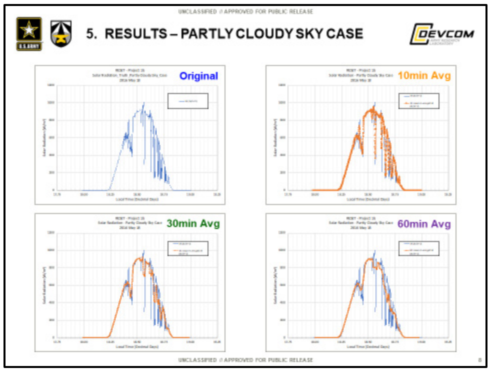








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5. RESULTS – PARTLY CLOUDY SKY CASE
DEVCOM
Original
10min Avg
30min Avg
60min Avg
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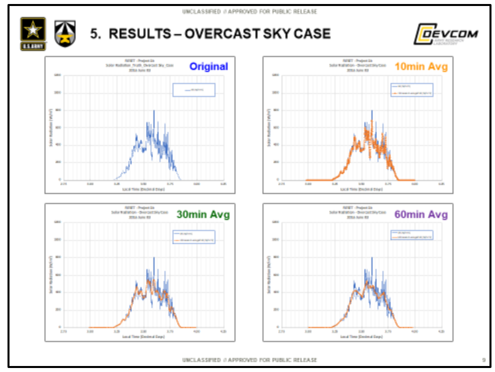
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5. RESULTS – OVERCAST SKY CASE
DEVCOM
Original
10min Avg
30min Avg
60min Avg
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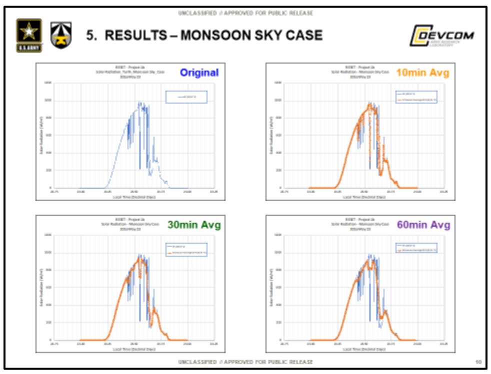
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5. RESULTS – MONSOON SKY CASE
DEVCOM
Original
10min Avg
30min Avg
60min Avg
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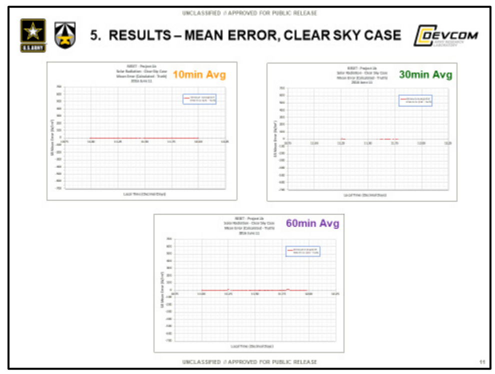
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5. RESULTS – MEAN ERROR, CLEAR SKY CASE
DEVCOM
10min Avg
30min Avg
60min Avg
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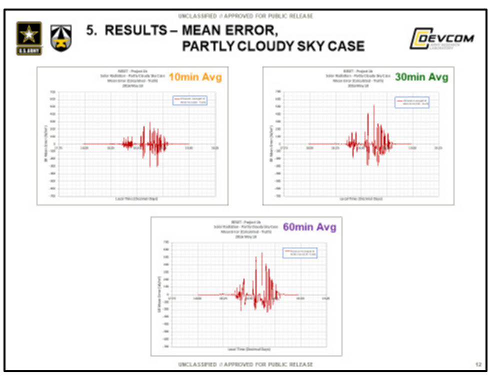
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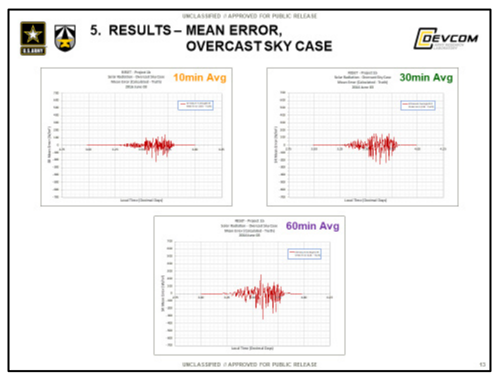
5. RESULTS – MEAN ERROR, PARTLY CLOUDY SKY CASE
DEVCOM
10min Avg
30min Avg
60min Avg
UNCLASSIFIED // APPROVED FOR PUBLIC RELEASE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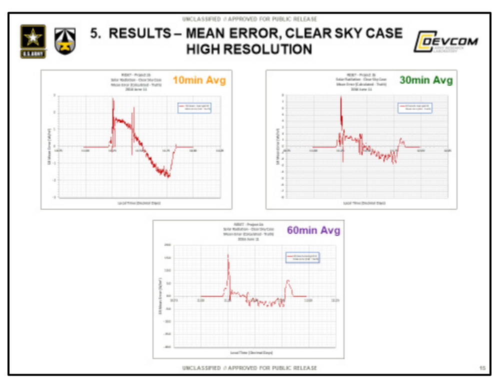
5. RESULTS – MEAN ERROR, OVERCAST SKY CASE
DEVCOM
10min Avg
30min Avg
60min Avg
UNCLASSIFIED // APPROVED FOR PUBLIC RELEASE


UNCLASSIFIED // APPROVED FOR PUBLIC RELEASE
5. RESULTS – MEAN ERROR, MONSOON SKY CASE
DEVCOM
10min Avg
30min Avg
60min Avg
UNCLASSIFIED // APPROVED FOR PUBLIC RELEASE


UNCLASSIFIED // APPROVED FOR PUBLIC RELEASE
5. RESULTS – MEAN ERROR, CLEAR SKY CASE HIGH RESOLUTION
DEVCOM
10min Avg
30min Avg
60min Avg
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6. CONCLUSIONS AND LESSONS LEARNED

DEVCOM

6.1 Conclusions

- A lower running average interval seems to indicate best balance of data processing and minimal mean error.
- Mean Error: When solar radiation is lowest in strength but not zero, data indicates the highest magnitude of over and under-estimation of truth SR.
- Partly Cloudy and Monsoon Cases are most difficult to process
    - High variability resulting in greatest magnitudes of Mean Error

6.2 Lessons Learned

- Details and Documentation
- Models to represent and communicate data
- Processing data in Excel is like playing music

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7. FINAL THOUGHTS

DEVCOM

7.1 Details, Details, Details!!

7.2 From big picture to tiny details in research publications.

7.3 Research experience makes me a better coach when teaching my students to perform their own research.

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U.S. EDUCATION DURING THE COVID-19 ADVENTURE

DEVCOM

- Describe how the 2020 school year adapted to COVID-19 requirements.
- Describe the 2021 education program for your school(s).
- List 1-3 Cons of the COVID-19 Experience.
    - Formative Feedback is practically impossible
    - Group collaboration requires a different level of discipline
    - Very tedious file and communication management
- List 1-3 Pros of the COVID-19 Experience.
    - Coffee!
    - Applied technology skills
    - Stayed safe and focused on family time

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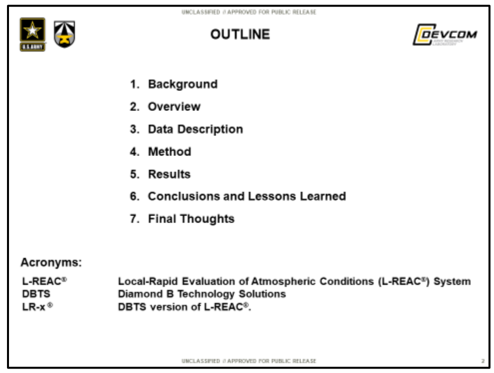
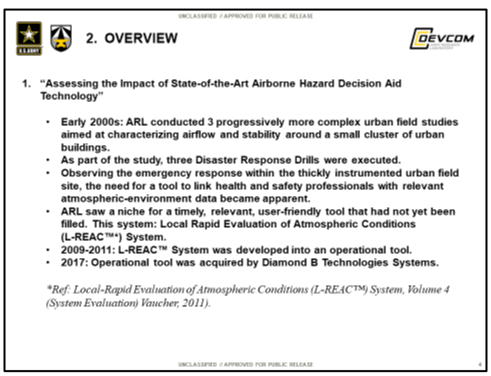
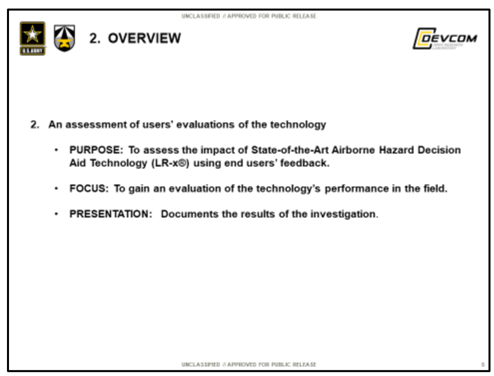
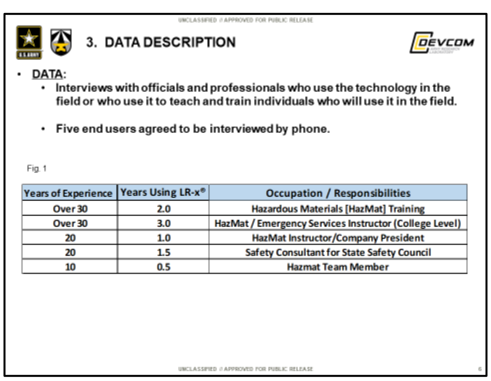
Appendix C. Project 1c: Assessing the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology – 2020 July 1 MT, Briefing Slides

SUMMARY: The Project 1c Briefing that follows was given by Dr Williams on Wednesday, 2020 July 1, to the US Army Combat Capabilities Development Command Army Research Laboratory workforce and their associates. Personal identifiable information has been removed from the document. Project 1c figures originated in this briefing. The final topic of all RESET internship presentations was a summary of the speaker's recent experience in educating students during the COVID-19 pandemic.

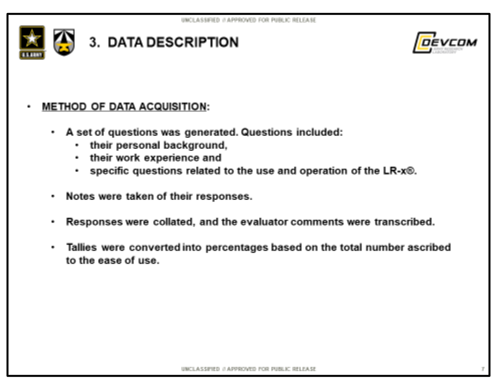








Years of Experience	Years Using LR-x®	Occupation / Responsibilities
Over 30	2.0	Hazardous Materials [HazMat] Training
Over 30	3.0	HazMat / Emergency Services Instructor (College Level)
20	1.0	HazMat Instructor/Company President
20	1.5	Safety Consultant for State Safety Council
10	0.5	Hazmat Team Member



3. DATA DESCRIPTION

- **END USER'S INTERVIEWS:** The End Users were…
  - Asked about their experience with the LR-x®.
  - Asked about their work experience and experience with use of plume models.
  - Asked to compare the LR-x® to other plume databases and applications they have used.

4. METHODS

- **DATA ANALYSES:**
  - Data were collected through interviews with five end users,
  - The end users' responses were transcribed then assigned numerical values, tallied and tabulated into percentages.

5. RESULTS

5. Interview Results Quantified

Fig 2

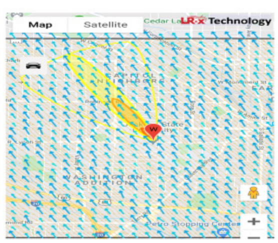
Tally-- "Assess the Impact of State-of-the-Art Airborne Hazard Decision Aid Technology"	Easy (10)	Sort of Easy (8)	Neutral (6)	Difficult (4)	Very Difficult (2)	Not Relevant (0)	Total Percentages
1.Ease of Use	100%	0%	0%	0%	0%	0%	100%
1.1 Setup	100%	0%	0%	0%	0%	0%	100%
1.2 Learning	100%	0%	0%	0%	0%	0%	100%
1.3 Operating the system	60%	0%	0%	0%	0%	40%	100%
1.4 Communication of results	100%	0%	0%	0%	0%	0%	100%
2.Data Input requirements	100%	0%	0%	0%	0%	0%	100%
3.Use of Multiple Variables (T, WS,Terrain, etc.)	100%	0%	0%	0%	0%	0%	100%
4.System Software	80%	0%	20%	0%	0%	0%	100%
5.Equipment requirement (Internet access)	100%	0%	0%	0%	0%	0%	100%
6.Ability to secure funding for aquiring the product	20%	0%	80%	0%	0%	0%	100%
7.Intergration with existing systems (KML)	0%	0%	40%	40%	0%	20%	100%

6. CONCLUSIONS AND LESSONS LEARNED

- The End Users:
  - Gave an overall excellent review of the technology.
  - Said it was easy to use and intuitive; that the technology saved them crucial steps when compared to other plume technology.
  - Commented that the technology would greatly increase communication and coordination.
  - Voiced a concern that the technology is internet based and that cost may prevent smaller fire departments from accessing the technology.
- Conclusions:
  - Evaluators unanimously stated that they would recommend the system.
  - All evaluators reported that the LR-x® System would be an asset to their profession / application.
  - All the users commented on the incredible experience with using the system and how amazing the technology is really.
  - One end user shared a document created by him and a partner that they use to accumulate information about a chemical.
  - My experience: I had the opportunity to use the LR-x® System; it was amazing, seamless and fantastic to use.

6. CONCLUSIONS AND LESSONS LEARNED

Image 1: *An image of a chlorine spill at the local University*



7. FINAL THOUGHTS

- This experience has been so awesome and inspiring, and I have learned so much.
  - It will impact my life as an informed citizen.
  - I will be able to incorporate the experience and the approved information in my teaching.
  - It will facilitate me in encouraging students to pursue STEM careers, by letting them know of the interesting and useful things a life in the STEM field can provide.

U.S. EDUCATION DURING THE COVID-19 ADVENTURE

1. Describe how the 2020 school year adapted to COVID-19 requirements.
   - My school district decided to go 100% virtual thinking it would only be two weeks
   - The School district cancelled school for the rest of the year
   - The district chose to give everyone a 100 for the final term unrelated to amount or quality of work
2. Describe the 2021 education program for your school(s).
   - My school district has not made a decision as of yet
   - School is scheduled to start August 7th
3. List 1-3 Cons of the COVID-19 Experience.
   - Students had connection issues(devices, internet access)
   - Teachers were unprepared
   - We were caught unprepared as a district
4. List 1-3 Pros of the COVID-19 Experience.
   - I got a chance to use my virtual teaching experience
   - My students really bought into the online learning experience
   - I got a chance to get back to teaching.

List of Symbols, Abbreviations, and Acronyms

AEOP	Army Educational Outreach Program
AGL	above ground level
ArL	above roof level
ARL	Army Research Laboratory
ATEC	US Army Test and Evaluation Command
COVID-19	coronavirus disease 2019
DBTS	Diamond B Technology Solutions
dec days	decimal days
DEVCOM	US Army Combat Capabilities Development Command
DOD	Department of Defense
Hg	mercury
L-REAC	Local Rapid Evaluation of Atmospheric Conditions System
LR-x	Diamond B Technology Solutions version of ARL's L-REAC
MMT	Meteorological Measurement Tripod
MT	Mountain Time
PV	photovoltaic
QC	Quality Control
RESET	Research Experiences for STEM Educators and Teachers
SR	solar radiation
STEM	Science, Technology, Engineering and Mathematics

1 (PDF)	DEFENSE TECHNICAL INFORMATION CTR DTIC OCA
1 (PDF)	DEVCOM ARL FCDD RLD DCI TECH LIB
1 (PDF)	ATEC B THOMAS
20 (10 PDF, 5 HC, 5 CD)	DEVCOM ARL FCDD RLC E B MCCALL T JAMESON FCDD RLC ED G VAUCHER (1 PDF, 5 HC, 5 CD) C HOCUT R BRICE R RANDALL M LEE J RABY FCDD RLD FS J CRALEY FCDD RLS ER J WILSON B LEFTRIDGE
4 (PDF)	RESET INTERNS P CUARESMA R DUNKIN M HEBERT J WILLIAMS