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Weather Radar Characteristics of Thick Cloud Layers over the Eastern Range Associated with a Triggered Lightning Risk

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RCEU 2023 Project Proposal

Project Title

Weather Radar Characteristics of Thick Cloud Layers over the Eastern Range Associated with a Triggered Lightning Risk

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I. Project Description

At the NASA Kennedy Space Center (KSC) and Cape Canaveral Space Force Station (CCSFS), safety rules used by the 45th Weather Squadron (45WS) during space launch activities include the Lightning Launch Commit Criteria (LLCC). The 45WS Launch Weather Officer (LWO) evaluates all of the LLCC before giving the "go" for launch at the Eastern Range (ER) in Florida. To identify clouds associated with the natural or triggered lightning threat, the LLCC utilize a variety of measurements such as radar and cloud type categories relative to temperature levels and cloud history thought to be associated with cloud electrification. Historically, non-thunderstorm electrified (NTE) clouds have received less research attention than thunderstorms because they do not produce high impact weather and are not associated with the natural lightning threat. Knowledge of their electrification mechanisms and methods to detect them remotely are limited. Nonetheless, NTE clouds can pose a significant range safety risk when the flight path of a space launch vehicle goes through or near them because they can trigger a lightning flash even in the absence of other weather such as rain, winds or natural lightning.

The LLCC identifies the thick cloud layer as a potential NTE cloud and a triggered lighting risk. A thick cloud layer is one or more physically connected cloud layers whose combined vertical extent exceeds 4500 feet. The 45WS LWO uses ground radar and visual measurements from aircraft to identify the presence of any thick cloud layers in the launch vehicle flight path when making the "go/no go" evaluation for weather. The 45WS has scrubbed a number of planned space launches from the ER in the past including a recent SpaceX mission due to thick cloud layers. The purpose of this study is to learn more about the radar properties of thick cloud layers that are electrified versus those that are not in the hopes of improving the LLCC. From past research, the 45WS has identified a database of over 70 thick cloud layer events and their synoptic weather environments. Recent 45WS research has identified whether each event was likely electrified or not according to a network of surface electric fields mills at KSC/CCSFS.

II. Student Duties, Contributions, and Outcomes

The student will analyze Melbourne next generation radar (NEXRAD) data of each thick cloud layer to characterize its horizontal and vertical extents, reflectivity statistics and hydrometeor types. The student will subdivide the radar outcomes into thick cloud layers that are hazardous NTE clouds and those that are not. The student will develop conceptual models of NTE thick cloud layers. Using these models, the project can improve the LLCC, increase launch availability and maintain range safety during a period of increasing space launch activity at the ER.

a. Specific Student Duties

Phase 1 [2 weeks]: The student will conduct a literature review of cloud electrification, microphysical processes, and the use of weather radar. The student will use radar visualization and analysis tools, including GR2Analyst and Python code in Jupyter notebooks. *Phase 2 [4 weeks]:* The student will download radar and temperature data for the cases of electrified and non-electrified thick cloud layers. The student will conduct hypothesis-driven analysis of their radar structure and polarimetric properties as a function of temperature. *Phase 3 [3 weeks]:* The student will develop conceptual models of the cloud structure and processes associated with electrified and non-electrified thick cloud layers, including means tested differences in radar profiles. *Phase 4 [1 week]:* The student will synthesize project outcomes into a preliminary research poster.

b. Tangible Contributions by the Student to the Project *(10% of Review)*

By providing radar analysis and conceptual models of electrified and non-electrified thick cloud layers, the RCEU student will contribute significantly to an ongoing multi-university, NASA KSC and 45WS collaborative research effort to refine the LLCC for thick cloud layers, improve forecasting and safely increase space launch availability over the ER.

c. Specific Outcomes Provided by the Project to the Student *(30% of Review)*

Student outcomes include the opportunity to develop knowledge and skills regarding polarimetric radar, cloud microphysics, cloud electrification, triggered lightning, radar analysis tools, Python programming, statistical means testing, operational space launch forecasting at the Eastern Range, research methods and oral presentations. The student will also benefit from close collaboration and interaction with fellow UAH undergraduate and graduate researchers, meteorologists in NASA KSC Weather and operational space LWO's in the 45WS. These project interactions will allow the RCEU student to learn about NASA, the US Space Force, careers in weather operations and research meteorology, and life as a graduate student researcher.

III. Student Selection Criteria

The student should be of sophomore standing or higher in the Atmospheric and Earth Science (AES) BS, Atmospheric Science/Meteorology Concentration, having completed AES 209 Data Analysis Tools, AES 212 (Severe Weather Analysis and Laboratory) and AES 301 (Introduction to Earth & Atmospheric Physics) by the start of the RCEU project.

IV. Project Mentorship *(30% of Review)*

Dr. Carey will supervise and mentor the student during scheduled weekly meetings and informal "open door" daily discussions. The student will attend Dr. Carey's regular research roundtables during the summer, fostering a collaborative environment and interactions with AES graduate students in SWIRLL and Cramer Research Hall. Interactions with AES graduate students will provide additional opportunities to learn computer programing, explore various research methods, sharpen oral presentation skills and learn about life as a graduate student. Members of Dr. Carey's project team, including NASA KSC meteorologists and 45WS LWO's, will assist the RCEU student with project feedback and knowledge building during bi-weekly telecons. The student will have a dedicated computer and working space nearby Dr. Carey's office in the UAH SWIRLL Operations Center along with other AES undergraduate student researchers, thus providing organic opportunities for peer-to-peer mentorship, networking and learning.

Contingency Plan (optional)

In the event that in-person research at UAH SWIRLL is interrupted for an extended period due to health or safety concerns (e.g., pandemic, severe weather etc.), the student could continue with the research project remotely with the use of available UAH and NSSTC software and technology. Mentor and research team meetings would be conducted using Zoom voice-video conferencing about two times per week to maintain continuous progress. UAH NSSTC IT services the specialized computer and software needs of AES and ESSC faculty, staff and students. With a Windows or Mac computer at home, the RCEU student would use an NSSTC VPN account and remote software (e.g., Windows Remote Desktop, Putty/Xming, XQuartz) to access UAH NSSTC networked computer resources remotely, including GR2Analyst radar software, Python tools and peer-reviewed journal articles available on a NSSTC multi-user Windows server. At the beginning of the project, NSSTC IT would provide computer login credentials, VPN software and VPN login credentials. The student would test VPN, remote login and remote computer functionality early in the project. Although the project is envisioned to be an in-person experience at UAH SWIRLL, this plan would allow us to be ready for most contingencies, thus mitigating impacts to the project and student research experience.