BACKGROUND PAPER
ON
NEXT GENERATION STORM PENETRATING AIRCRAFT WORKSHOP

PURPOSE: Highlight pertinent operational research requirements of interest to America’s space program to the Next Generation Storm Penetrating Aircraft (NGSPA) Workshop (23-25 Oct 06, South Dakota School of Mines and Technology, Rapid City, SD).

DISCUSSION: Representatives from America’s space program are unable to attend this workshop. This background paper is intended to provide an overview of select operational research requirements that may prove useful to members of the NGSPA Workshop when determining the operational benefits that such a research tool might provide. Many of these interest areas provide the mutually beneficial opportunity to work on both important scientific research while at the same time addressing significant operational challenges.

- **Operational Research Areas of Interest:** (in space program priority order)
  - **Lightning Cessation:** Investigate decaying convective cores. What conditions lead to the End of Storm Oscillation in the electric fields? What conditions preclude the last lightning flash? Can these conditions be inferred by routine ground based weather sensors (i.e., dual-polarized radars and surface electric field mills)?
    
    Lightning advisories are the most frequently issued weather watch/warning/advisory at Cape Canaveral Air Force Station and NASA Kennedy Space Center (CCAFS/KSC), ensuring resource protection and personnel safety. The greatest technical challenge to meteorologists is the timely cancellation of these advisories while ensuring personnel safety. Improvements in this area have the potential to save the Government and tax payers several millions of dollars per year in unnecessary work stoppage and space launch schedule delays.

  - **Initial Electrification:** Investigate the evolution of non-electrified convective cells from genesis through first lightning discharge. What conditions lead to initial electrification? Can these conditions be inferred by routine ground based weather sensors (i.e., dual-polarized radars and surface electric field mills)? Do these conditions suggest the possibility of new ground based remote sensors to profile electric fields in clear air to thunderstorm cores?
    
    While there’s been considerable progress forecasting the onset of lightning at CCAFS/KSC, further improvements are required. The NGSP could help improve lightning forecasting through in-cloud measurements of initial electrification in developing cumulonimbus correlated to operational sensors, particularly dual-polarized radar. This would be a primary benefit to CCAFS/KSC of these efforts.

    A secondary benefit to this type of research would be improved Lightning Launch Commit Criteria (LLCC) and Space Shuttle Flight Rules (FRs). All space launches from NASA, Air Force, and entrepreneurial ranges under FAA jurisdiction must obey the same set of LLCC. These LLCC are a complex set of 12 weather rules to avoid natural and rocket triggered lightning. The FRs apply only to space shuttle landings. Since the exact weather conditions for natural and triggered lightning can not be specified, these rules are necessarily conservative to assure launch safety. A better understanding of these lightning conditions would allow less restrictive LLCC and avoid unnecessary launch delays and scrubs. The possible cost savings are significant; typical costs associated with a (space shuttle) mission scrub typically exceeds $1M. Most of the LLCC try to infer the possibilities of hazardous electric fields aloft from the presence of various weather phenomena. An effective remote profiler of electric fields would allow eliminating about half the LLCC and consequent increased safe launch opportunity and cost savings.

    A special interest in LLCC improvement is the present ‘Thick Cloud Rule’. This LLCC essentially says to avoid stratiform clouds 4,500 ft thick or more if any part of the cloud have a vertical extent such that a portion of the cloud has temperatures of 0°C to -20°C within 5 NM of the launch path. While electric fields capable of causing rocket triggered lightning can exist in these clouds, the current rule has a False Alarm Rate of approximately 80%; a frequent source of LLCC violations at the launch ranges.
Other Research: CCAFS/KSC also has a need for improved warnings of convective winds and hail. Measurement of cloud conditions correlated to operational sensors such as dual-polarized radar may help to improve these warnings. This research would also benefit National Weather Service warnings, military weather warnings, and the aviation industry, among others. In addition, improved rules for forecasting lightning in anvil clouds, both intra-cloud and cloud-to-ground lightning, would be useful. Likewise, improved rules for forecasting cloud-to-ground lightning from thunderstorm debris cloud would also be useful.

- **Required Sensors:** The sensors utilized by the previous storm penetrating aircraft should prove sufficient to researchers interested in addressing these operational research interests.

- **CCAFS/KSC - A Thunderstorm Research Location:** The local climate, coupled with a unique sensor suite make CCAFS/KSC a prime location from which to conduct storm penetrating research:
  - Thunderstorms occur frequently over central FL (known as the ‘lightning alley’ of the U.S.)
  - Exceptionally dense network of ‘operational’ meteorological sensors:
    - 4-D lightning detection system
    - High performance local cloud-to-ground lightning detection system
    - Network of 31 surface electric field mills with high temporal resolution tipping bucket rainfall gauges
    - Network of mesoscale weather towers
    - Many other weather sensors
  - Local meteorologists, are available to collaborate with researchers
  - Previous field experiments include: CaPE, and the ABFM Project
  - Several local airfields (i.e., KCOF, KTTS, KMLB) offer excellent forward operating locations for the research aircraft

**RECOMMENDATIONS:** The operational research requirements outlined in this paper be used as additional justification for the acquisition of this operationally relevant research tool.

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**BIBLIOGRAPHY:** (copies available on request)


