Exploring the potential for transformative weather radar observations from the stratosphere

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Abstract

Suborbital platforms such as stratospheric balloons carrying remote-sensing instruments offer the potential to transform understanding of thunderstorm microphysics, dynamics, and kinematics. This study proposes a Stratospheric Observations of Earth Systems (SOES) facility to begin by flying weather radars in the stratosphere.

The proposed SOES program will be transformative to the operational monitoring of weather by complementing and expanding NOAA's remote-sensing networks. SOES provides a cost-effective solution for filling in the gaps in ground-based radar coverage, which will yield direct improvements in severe storm monitoring and warning especially in the interior West and during major severe weather outbreaks. Moreover, we anticipate the numerical weather prediction and hydrologic modeling systems that regularly incorporate radar data will provide more accurate forecasts of severe weather and precipitation. *But the greatest benefit of the proposed SOES facility will be new insights that will be gained by observing storm evolutions, 3D properties, and vertical updraft/downdraft structures from the vertical vantage point.* The proposed facility offers observations at unprecedented resolutions in time and space and from a unique vantage point; these could indeed be considered revolutionary. The advent of ground-based Doppler radar revealed observations of thunderstorm dynamics that are used today to identify rotating updrafts in the parent supercell that often occur prior to and during tornado formation. This critical information from Doppler radar has undoubtedly saved hundreds of lives in recent decades. These observations also inspired new theories regarding supercell thunderstorm and tornado formation. Today, convection-allowing models incorporate these newly designed physical processes to better forecast thunderstorm movements, evolution, and expected severity.

By offering observations from a new vertical vantage point, the proposed SOES facility has the potential to revolutionize our understanding of severe storms, perhaps much like horizontal scans from Doppler radar did decades ago. Today's routine observational platforms do not provide details regarding the evolution of the breadth, depth, strength, or tilt of thunderstorm updrafts/downdrafts. It is not possible to obtain these details using horizontal scanning radars situated on the ground. SOES will provide the first observations of updraft/downdraft structures and evolutions at unprecedented spatial-temporal resolution. The pulse of a thunderstorm can be felt by observing the characteristics of the updraft. These observations were inferred using ground-based radars during the seminal severe weather research studies of the 1960s. Sir Keith Browning used radar scans to develop a 3D model of the airflows in a hail-producing thunderstorm (Browning and Ludlam, 1962). Using observations of reflectivity at horizontal polarization and incidence, they discovered features that are largely controlled by the storm updraft/downdraft structure including the "forward overhang" and "echo-free vault". The persistence of the overhang and its width was attributed to the presence of an updraft and its location was coincident with a swath of hailstones observed at the surface. Curiously, in the conclusions of their seminal study on the inference of airflows in thunderstorms, Browning and Ludlam stated the following: "Observations inside severe storms are hazardous to make and difficult to interpret, but the concentrated use of conventional ground-based techniques can be rewarding, and the addition of new methods of observation, such as those using a vertically-directed Doppler radar stationed beneath or flown over the storm, will accelerate progress."

Presentation of this proposed concept is intended to initiate dialogue with commercial suborbital vehicle companies to find a successful pathway moving forward.