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Understanding the Effects of Anthropogenic Space Weather

The August 2017 launch of Taiwan's Formosat-5 satellite atop a SpaceX Falcon 9 rocket and the resulting plasma hole over the western United States. Credit: SpaceX

The ionosphere, the layer of Earth's atmosphere where gases have been stripped of their electrons by solar and cosmic radiation, hosts a large number of charged particles that can affect the propagation of radio waves. Although scientists have long known that natural disturbances like solar flares can interfere with radio wave transmissions, more recent studies have shown that rocket launches also create ionospheric disturbances that can introduce additional errors into navigation, positioning, and other satellite-based systems.

To better understand the effects of anthropogenic space weather, *Chou et al.* evaluated the ionosphere's response to the August 2017 launch of Taiwan's Formosat-5 satellite atop a SpaceX Falcon 9 rocket. The team measured perturbations in Global Navigation Satellite System signals, which are routinely used to determine changes in the ionosphere's electron content, and determined that the launch generated a circular shock wave that spanned an area 4 times larger than the state of California. The researchers attribute this megawave—the largest rocket-induced shock wave on record—to the launch's unique, nearly vertical trajectory.

The results indicate that this circular wave was followed by an even larger disturbance that developed as chemical reactions between the ionospheric plasma and the second-stage rocket exhaust temporarily depleted the layer's electrons. This created a 900-kilometer-wide plasma hole that persisted for several hours. Although the perturbations generated by the circular shock wave amounted to just 3% of background conditions, the plasma hole created electron depletions of up to 70%, a disturbance consistent with navigating and positioning errors of about 1 meter.

Because payload launches are expected to increase in the near future, these findings underscore the importance of understanding how space vehicle launches and other anthropogenic disturbances affect space weather and, in turn, GPS and other positioning, navigation, and timing services. (*Space Weather,* https://doi.org/10.1002/2017SW001738, 2018) **—Terri Cook, Freelance Writer**