An Eclipse-Ballooning Study of Shadow Bands During the April 2024 Total Eclipse

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We planned a comprehensive study of shadow bands for the 8 April 2024 total solar eclipse. These mysterious low-light-level bands of light and dark have been observed dating back to at least the 9th century. They appear to travel rapidly on the ground, parallel to the direction of the Sun's crescent, minutes before and after totality.

Our plan for April 2024 included light-sensor data obtained in high altitude balloon (HAB) payloads, light-sensor data obtained in a plane, radiosonde data obtained using weather balloons to study atmospheric turbulence, and ground-based observations. The program was motivated by the apparent detection of shadow bands using light sensors in a high-altitude balloon (HAB) launched by a University of Pittsburgh team during the 21 August 2017 total solar eclipse (see Madhani et al. 2020, JASTP, 211, 105420).

The analyses of Madhani et al. utilized spectrograms to uncover a shadow band signal of about 5 Hz both at an altitude of 25 km in all four of their HAB light sensors and in all 20 of their ground light sensors. However, this finding was at odds with the conclusions of Codona (1986, A&A, 164, 415), who theorized that crescent sunlight passing through regions of the Earth's turbulent atmosphere a few minutes before and after totality cause intensity fluctuations (called scintillation), that gives rise to the observed shadow band phenomena. These turbulent regions are generally at an altitude < 3 km. Hence, the detection of shadow bands in HAB data in 2017 was inconsistent with shadow bands being solely due to atmospheric turbulence.

The main goal of our 2024 eclipse campaign was to either confirm or refute the 2017 findings of Madhani et al. The most notable differences between the 2017 and 2024 eclipse campaigns were: (1) the use of improved light sensors, (2) the launch of radiosondes to measure the altitude of turbulent atmospheric regions, and (3) in the event of poor ground weather near our balloon launches (making it impossible for us to confirm the detection of shadow bands on the ground), being prepared to fly light sensors in a plane to a clear-weather location along the eclipse path in the hope that ground observations of shadow bands would be reported near the same vicinity.

We were stationed in Concan, Texas, for all of our eclipse campaign balloon launches and ground observations. While our two HAB light sensor payload launches and 31 radiosonde launches all successfully collected data, poor ground weather foiled our ground observations. We were unable to observe, photograph, make a video, or use our ground light sensors to study shadow bands on the ground. Fortunately, our light sensors flown in a plane in northeast Vermont found clear weather. An excellent video of shadow bands in East Brunswick, Canada, demonstrates that they were observed on the ground before and after totality. Moreover, radiosonde data exists for the north east part of the eclipse path. Given the geographic proximity of these locations, these data are useful for our shadow band study. In this talk, our preliminary findings will be summarized.

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