CHAPS: A Compact Hyperspectral Imager for Air Pollution Remote Sensing

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Air pollution is responsible for ~7 million premature deaths every year. Current and planned low Earth orbit and geostationary satellite instruments have long provided global surveys, revealing pollution characteristics and trends. We need a robust, sustainable observing strategy, however, for measuring the distribution of air pollution at high spatial and high temporal resolution. The Compact Hyperspectral Air Pollution Sensor (CHAPS) incorporates technologies enabling a sustainable approach to air pollution observation from space. CHAPS is a hyperspectral imager using freeform optics in a form factor suitable for accommodation on a small satellite or hosted payload. It will make measurements of air pollution at unprecedented spatial resolution from low Earth orbit (1 x 1 km\(^2\)) and will characterize, quantify, and monitor emissions from urban areas, power plants, and other anthropogenic activities. The compact size and relatively lower cost of CHAPS makes a constellation feasible for the first time, with unprecedented spatiotemporal sampling of global point pollution sources. NASA recently funded the development of a CHAPS-Demonstrator (CHAPS-D), which will result in an airborne demonstration of a CHAPS prototype instrument. CHAPS derives heritage from the TROPOspheric Monitoring Instrument (TROPOMI) on the Sentinel-5 Precursor, which uses a freeform mirror telescope. Freeform optics has potentially huge advantages over traditional optical designs, including fewer optical surfaces, less mass and volume, and improved image quality. CHAPS-D combines a radiometrically calibrated freeform hyperspectral imager (300-500 nm @ 0.5-nm resolution) with associated detector and payload electronics within the design constraints of a 6U CubeSat. We present the measurement requirements and preliminary design of CHAPS-D.