CubeSounder: Development of Microwave Radiometer 3D Weather Imaging Sensors

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Abstract

We present the development of a novel microwave sounding weather sensor designed to compete with state-of-the-art (SOA) weather satellites with >10x improvement to SWaP-C (size, weight, power and cost). We designed millimeter-wave filter banks and combined them with now commercially available low noise amplifiers (LNAs), to develop a direct detector spectrometer capable of imaging the 60GHz Oxygen and 180GHz water vapor lines, from the atmosphere. Our first prototype sensor flew into the stratosphere on a high-altitude balloon platform in April of 2022 and we have scheduled a second demonstration flight in mid-2023. We will present our spectrometer design process as well laboratory demonstrations of sensitivity. The CubeSounder project represents a disruptive approach to atmospheric monitoring that would be deployable on an unprecedented scale.

Spectrometer Design

Data from microwave radiometers on large U.S. weather satellites is the single highest impact driver of global weather forecasting. These satellites carry heterodyne mixer-based sensors which are effective but high volume, mass, and power systems. To deliver a low SWaP-C instrument capable of comparable observations, we designed a direct detection microwave spectrometer. As illustrated in the figure, light enters through a pyramidal feed horn, then is amplified at broadband by two LNAs. Frequencies are then selected off as the light travels through the filter-bank. Each channel of the filter-bank terminates on a diode detector.

Millimter-Wave Filter Bank

The primary novel technology of our spectrometer is the filter-bank. We have developed a new type of millimeter-wave filter bank that is light weight, passive, and cheap to fabricate. We utilize constructively interfering resonant cavities milled into aluminum split blocks to define filter frequencies and bandwidth. Prototype filters has been demonstrated to operate well from 50-200GHz. We will present our filter design workflow which will allow for quick simulation and construction of future filters.

Conclusions

The high cost of traditional weather satellites limits the number that is practical to deploy. This leaves holes in atmospheric monitoring coverage that could be filled by a smaller more scalable sensor. CubeSounder develops a low SWaP-C sensor able to fill that niche on a space or near space platform. CubeSounder is made possible by funding from NASA flight opportunities and ASU NewSpace.

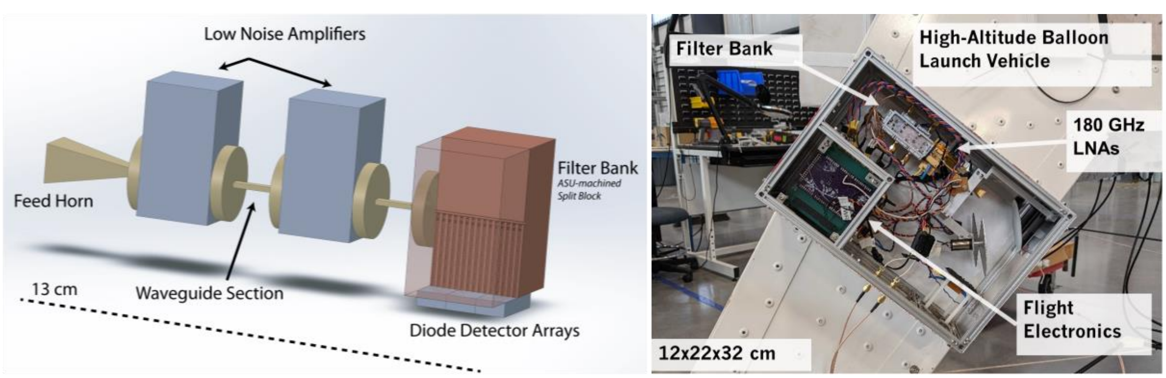

Figure Insert: *LEFT:* Our microwave spectrometer instrument design. *RIGHT:* CubeSounder 180GHz prototype instrument on high-altitude balloon vehicle.