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Preliminary Thermal Validation Tests for Education-Class CubeSats and Weather-Balloon Payloads

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Abstract

Low development and launch costs of CubeSats, a type of small spacecraft typically one to three liters in volume, have made space science accessible to educational institutions, offering engaging opportunities for students in the science, technology, engineering, and mathematics (STEM) disciplines. Some university teams working on these education-class CubeSats conduct high-altitude flight experiments using balloons to test their instruments in the harsh environment at the edges of the troposphere and the stratosphere. Whether for the balloon experiment or for the actual spaceflight, temperatures of the operating environments are of concern. Instruments flown in space must be qualified for wide thermal ranges (e.g., −40°C to 70°C) in vacuum conditions. Likewise, instruments flown on the balloons must be able to operate in a similarly large range of temperatures (e.g., −50°C to 50°C) in the reduced pressure environment. Unfortunately, a thermal-vacuum chamber—standard testing equipment for spacecraft—is not accessible to many university teams. This paper presents incubator testing and cooling-bath testing methods as preliminary thermal validation tests that may be carried out easily, safely, and inexpensively, without any need for the expensive thermal-vacuum chamber. We also discuss an add-on demonstration in which a CubeSat prototype was flown on a weather balloon to an altitude of ~16 km. The two lab tests and the flight described in this paper may be adopted by university teams to conduct preliminary thermal validation tests for their education-class CubeSats and weather-balloon payloads.

1. Introduction

With the establishment of CubeSat development standards over two decades ago (Puig-Suari, Turner, and Ahlgren, 2001), these small satellites have been making space science accessible to a large number of educational institutions. One of the reasons CubeSats achieve low costs is their small size, being measured

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