The Polar Cloud Satellite (PCS): The First CubeSat Mission to Study Noctilucent Clouds

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1.) Abstract

Members of the Spaceflight Sciences, Policy, and Operations Club (SSPOC) are designing a 1U CubeSat, the Polar Cloud Satellite, that will host an ultraviolet instrument that will image noctilucent clouds. Noctilucent clouds, formally called polar mesospheric clouds (PMCs), are clouds made of ice particles and water vapor that form in the polar regions of the Earth at altitudes ranging from 76 to 85 kilometers. The formation of PMCs at much lower latitudes than usual since their discovery in the 1980s can possibly be linked to increased carbon dioxide output by humans. NASA's Aeronomy of Ice in the Mesosphere (AIM) satellite was launched in 2007 to study these clouds and how they form. Our team plans to purchase and integrate an ultraviolet instrument that will be used to image PMCs, but with a much smaller satellite than AIM. We hope to collaborate with an AIM institution at some level, such as data comparison with AIM's images. Our team will assemble and test the satellite bus and its systems, integrate the ultraviolet payload, and operate the mission from a spaceflight operations center on campus, perhaps in the College of Aviation's Department of Applied Aviation Sciences.

2.) Noctilucent Clouds and NASA's AIM Satellite

- PMCs appear in the polar regions of the northern hemisphere between mid-May and mid-August, and in the polar regions of the southern hemisphere between mid-November and mid-February
- PMCs have been subject to intensive investigations using balloons, sounding rockets, and aircraft, but much less so using satellites
- It is possible, though not certain, that PMCs are a phenomenon created by emissions due to global industrialization
- To study how and why PMCs form, NASA launched the AIM satellite in 2007 with a camera and sensor payload, and it is still operational today [1]
- The mission has been very successful, and we are planning to replicate the observations of AIM with a CubeSat
- We will then compare our observations with that of AIM and determine if CubeSats can be used to reliably study and observe PMCs

3.) Project Goals

1) Design, build, launch, and operate the first CubeSat dedicated to observing noctilucent clouds

2) Establish a satellite ground station/mission operations center on campus, preferably associated with the College of Aviation's Department of Applied Aviation Sciences

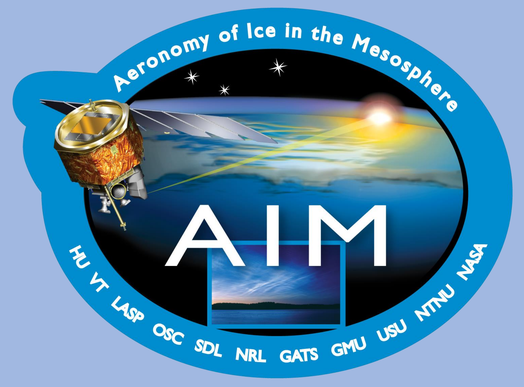

Fig. 1. *AIM Logo* [3]

Fig. 2. *Noctilucent Cloud* [4]

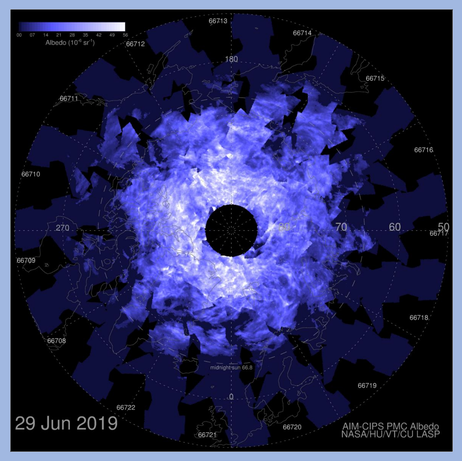

Fig. 3. *View of Noctilucent Clouds with AIM* [5]

4.) Payload Description

- The CIPS camera instrument on AIM detected PMCs between 255-275 nm (Ultraviolet wavelengths) [2]
- Our payload will also be an ultraviolet imager
- Photonis, based in France, offers UV photocathodes that we may be able to utilize to image PMCs
- UV imaging is not typically done on 1U CubeSats, but we believe the idea is worthy of further investigation

5.) Satellite Bus Subsystems

- Electrical Power System: solar cells and lithium-ion batteries
- Communications: UHF hardware, including transceiver and antennas
- Thermal: reflective paints, heat sensors, multilayer insulation
- Structure: 7075 aluminum, custom machined or commercially procured
- Onboard Computing: NanoMind A3200 (GomSpace)
- Attitude Control: hysteresis rods, magnet, magnetorquer

6.) Funding Sources

- Project funds (~$5,000)
- National Science Foundation grant for geophysical/atmospheric science
- Corporate sponsorships
- Donations from COAS, COA departments

7.) References

[1]: Russell III, J. M. et al. (11 September 2008). The Aeronomy of Ice in the Mesosphere (AIM) mission: Overview and early science results. *Journal of Atmospheric and Solar-Terrestrial Physics, 71*, 289-299.

[2]: McClintock, W.E. et al. (17 November 2008). The cloud imaging and particle size experiment on the Aeronomy of Ice in the mesosphere mission: Instrument concept, design, calibration, and on-orbit performance. *Journal of Atmospheric and Solar-Terrestrial Physics, 71*, 340-355.

[3]: "AIM Logo," NASA, 13 September 2006. https://www.nasa.gov/mission_pages/aim/multimedia/aim-logo.html.

[4]: "NLC Photograph courtesy of Tom Elkund," NASA AIM, http://aim.hamptonu.edu/graphics/press/lg/Nlc_Tom_Eklund.jpg.

[5]: "North 2019 – 29 June 2019," Laboratory for Atmospheric and Space Physics, http://lasp.colorado.edu/aim/browse-images.php?dataset=pmc.