Cloud Imaging and Particle Size (CIPS) Instrument Overview

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Introduction

The NASA Aeronomy of Ice in the Mesosphere (AIM) mission was launched in 2007 to study polar mesospheric clouds (PMCs), the highest clouds in the earth's atmosphere (*Russell et al*., 2009). Also known as noctilucent clouds, PMCs form near the summer polar mesopause in both hemispheres, about 82 km (50 miles) above the surface of the earth. They are composed of water ice crystals, with particle sizes less than about 100 nanometers. PMCs form in the summer because the mesopause region is colder in summer than at any other time. Changes observed in PMCs in recent decades are caused in part by anthropogenic effects on the atmosphere.

The AIM mission measures PMCs and their environment to better understand the underlying chemistry and physics, and the forces that cause the clouds to vary. AIM measurements have led to numerous discoveries concerning PMCs, including their composition, formation mechanisms, response to external forcing, and new models that describe their brightness and variability. In addition, AIM science objectives have evolved to capitalize on recent scientific discoveries and newly realized instrument capabilities. Thus, in addition to PMC science, AIM measurements are being used to explore atmospheric waves and their roles in global and vertical coupling, the influx and makeup of meteoric particles, and the effects of solar and geomagnetic forcing on composition and structure of the mesosphere and lower thermosphere.

The AIM satellite has three instruments: CIPS, CDE (Cosmic Dust Experiment), and SOFIE (Solar Occultation For Ice Experiment). CDE, which is no longer operational, is an *in-situ* dust detector that measured cosmic dust input, a potential key factor in PMC formation (*Poppe et al*., 2011). SOFIE measures vertical profiles of particle extinction as well as temperature, water vapor, ozone, nitric oxide and methane (*Gordley et al*., 2009). More information on CDE and SOFIE is available at https://spdf.gsfc.nasa.gov/pub/data/aim/cde/ and http://sofie.gats-inc.com/.

CIPS Instrument

The CIPS instrument (*McClintock et al*., 2009) is a panoramic imager that measures ultraviolet radiation scattered by PMCs and atmospheric gases. The instrument consists of a 2×2 array of cameras operating in a 10-nm passband centered at 265 nm, each with an overlapping field of view (FOV). The total FOV is 80° × 120°, centered at the sub-satellite point. CIPS images are acquired simultaneously in each camera. From 2007 through February of 2016 images were acquired every 43 seconds in the summer hemisphere between the terminator and a dayside latitude of about 40 degrees. Since 12 February in 2016 images have been acquired at all sunlit latitudes. From 20160212 through 20181102 images were acquired throughout the orbit on a 3-minute cadence; however, geophysical quantities are derived only from sunlit images. Since 20181103 images have been acquired only on the sunlit side of the orbit, on a 2-minute cadence. There are ~15 orbits per day, and ~20-25 four-camera images per orbit.

CIPS PMC data products include cloud albedo, particle radius, and ice water content along each orbit strip, with 56.25 km^2 spatial resolution. The version 4 CIPS PMC retrieval algorithm is described in *Lumpe et al*. (2013). Version 5 PMC data were first released for all CIPS seasons in 2020; a description of the version 5 PMC retrieval algorithm is currently in preparation for publication.

In addition to PMCs, CIPS measures atmospheric gravity waves (GWs) near the stratopause, at an altitude of 50-55 km (*Randall et al*., 2017). GWs play a significant role in coupling the atmosphere, because they transfer momentum and energy from the troposphere to higher altitudes. CIPS is unique in providing the only available imaging data set that can reveal horizontal GW structures near the stratopause. The primary level 2 CIPS GW data products are the Rayleigh Albedo Anomaly (RAA) and RAA variance, with a horizontal resolution of 56.25 km^2 (*Randall et al*., 2017). Statistical analyses (e.g., *Forbes et al*., 2021; 2022) are facilitated by the level 3A RAA variance data product, which consists of global maps with a resolution of 0.5° × 0.5° (lat × lon). At the time of this writing the RAA data version is being updated from v1.10 revision 06 (v01.10r06) to v1.10r07, a detailed description of which is in preparation for publication.

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