

Polarimetric calibration strategy for the Multi-Angle Imager for Aerosols (MAIA) satellite instrument

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The MAIA instrument was developed at the Jet Propulsion Laboratory as a space-based version of the Airborne Multiangle SpectroPolarimetric Imagers (AirMSPI/AirMSPI-2). It is primarily aimed at aerosol retrievals over a globally distributed set of target areas to investigate linkages between different types of airborne particles and human health. To meet this objective, the MAIA instrument has a requirement of <0.005 uncertainty in degree of linear polarization (DoLP) for all angles of linear polarization (AoLP) over the wide dynamic range of expected radiances. Meeting this level of sensitivity in the space environment and with an associated limitation on data rate has required the implementation of several calibration and onboard data processing approaches. MAIA's robust polarimetric calibration plan and processing pipeline is based on the as-built preflight characterization of the instrument.

MAIA is a division of time polarimeter, whose optics encode polarimetric information as temporal variations in intensity sampled at the focal plane. To do this, MAIA uses a combination of photo-elastic modulators, waveplates, focal plane polarizers, and rapid detector readouts. Spectral filters on the focal plane sample 14-wavelength UV-SWIR wavelength channels operating in pushbroom fashion. A two-axis gimbal enables camera pointing in both the along-track and cross-track directions. Three of the spectral bands (440, 646, and 1044 nm) are designated as polarimetric channels. MAIA's instrument electronics applies an onboard look-up table to convert a sequence of subframe data collected in each pixel (25 subframes for 440 and 646 nm, 50 for 1044 nm channels) to reconstruct the linear Stokes parameters I, Q, and U. This reduction in data volume enables the production of high accuracy DoLP and AoLP data for all 1216 spatial pixels in each wavelength channel while meeting data downlink constraints.

Preflight polarimetric calibration was successfully performed on the MAIA camera in a thermal vacuum chamber, demonstrating its performance in a simulated space environment. In addition to the camera, the MAIA instrument contains an On-Board Calibrator (OBC) with 12 distinct fully polarized targets with different AoLPs, which will be illuminated by sunlight and observed by the camera at regular intervals on orbit. Measurements of the OBC are planned to track the instrument's polarimetric behavior over its deployment lifetime and update, as needed, the calibration coefficients used in ground data processing. The combined preflight and OBC calibration algorithms and procedures are designed to achieve and maintain polarimetric accuracy over the entire MAIA mission.

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