Advancements on the Hyper-Angular Rainbow Polarimeter (HARP) polarization characterization during NASA Plankton Aerosol and Ocean Ecosystem (PACE) pre-launch calibration

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So far three iterations of the Hyper-Angular Rainbow Polarimeter (HARP) have been constructed at the University of Maryland Baltimore County (UMBC): AirHARP, HARP CubeSat, and HARP2. HARP represents a technical achievement on making advanced remote sensing measurements in a compact package for low cost. The wide field-of-view (FOV) polarized images taken by HARP fill a niche only previously filled by the POLDER instruments (whose measurements ended in 2013). Multiangular polarimetric measurements are important for the advancement of cloud and aerosol studies by providing increased sensitivity to aerosol shape and type information, and the retrieval of cloud microphysical properties with a high spatial resolution. On PACE, HARP2 will assist in atmospheric correction for studies of ocean color by providing a full global polarimetric coverage in four spectral wavelengths: 440 (± 10), 550 (± 10), 670 (± 10), and 870 (± 20) nm. But being an entirely custom instrument, the characterization of HARP in the lab is an ongoing process. Both AirHARP and HARP CubeSat underwent a "static" calibration technique using the normalization of their wide-FOV views to characteristic pixels at the CCD center. HARP2 advanced on this by using a dynamic calibration rig, allowing for tip/tilt scanning of the full CCD view space. In doing so, a unique polarization phenomenon, not previously recorded, was identified. An apparent change in the polarization plane toward the far corners of the instrument FOV was unexpectedly observed and identified as a strong culprit in polarization measurement error at far view angles seen in HARP CubeSat vicarious calibration efforts in 2022. To fully model and correct for this new phenomenon, an optical ray- tracing model was tuned to the HARP lens distortion effect and multiple polarization plane rotations performed across the FOV. Further, we examine the ranges of error contribution due to binning the plane changes across the FOV with varying levels of granularity. Finally, we present the resulting error expectations of the HARP2 polarimetric calibration using comparison to a known reference "Pol-Box" which has an analytical polarization state.

Keywords: polarimeter, calibration, satellite data