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Attitude Determination Using the SAGE III ISS Disturbance Monitoring Package

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The SAGE III ISS payload extends the NASA Langley Research Center's long legacy of satellite atmospheric occultation measurements. Unlike its predecessors, SAGE III ISS encounters off-nadir attitudes and jitter conditions caused by the mechanical instability of the International Space Station (ISS) environment. This is a considerable problem for limb scatter science in particular because this technique does not track an emissive source with a known astronomical location as with solar and lunar events. The solar, lunar, and limb retrieval algorithms for the SAGE III science data product require precise and accurate knowledge of the instrument boresight pointing with respect to Earth and the Sun. Without knowledge of the attitude anomalies at the instrument scan head from the ISS reported attitude (e.g., caused by internal bending modes of the space station) and without characterizing the payload mechanical jitter, the data retrievals are compromised. A subsystem on the SAGE III ISS payload designated as the Disturbance Monitoring Package (DMP) which is comprised of a Miniature Inertial Measurement Unit (MIMU) built by Honeywell Aerospace of Clearwater, Florida, was added to quantify this disturbance. This MIMU measures rotation in inertial space in three orthogonal axes to a resolution of 1 μrad at 200 Hz using Ring Laser Gyros (RLGs). Currently, the DMP data are used to flag spectra with associated attitude anomalies above a threshold believed to significantly degrade the retrievals. However, in future versions of the science data product the DMP is expected to aid solar and lunar science data retrievals by improving pointing knowledge through better relative attitude determination, and to aid limb scattering retrievals by providing a Kalman-filtered research product for absolute attitude determination. The ISS Program performed attitude maneuvers in 2017 to calibrate observations made between the main science instrument's Sun-tracking measurements and the DMP's RLGs. Using attitude determination algorithms on DMP rate data (dead reckoning) and SAGE III sensor assembly solar tracking (absolute reference measurement) the pointing information needed for post-processing science measurements can be derived, ensuring that the data retrievals maintain the high standard expected of this class of instrument. Specific examples of deficiencies from pointing uncertainties caused by various ISS operations in the current publicly released data will be discussed along with expected improvements to the products by using these attitude determination algorithms.