

# USING COSMIC RAYS DETECTED BY HST AS GEOPHYSICAL MARKERS

Gonzalo Tancredi<sup>1</sup>, Nathan D. Miles<sup>2,3</sup>, Susana E. Deustua<sup>2</sup>, Germán Schnyder<sup>1</sup>,

Sergio Nesmachnow<sup>1</sup>, Geoffrey Cromwell<sup>4</sup>

<sup>1</sup> Universidad de la República, Montevideo, Uruguay; <sup>2</sup> Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA; <sup>3</sup> Department of Earth, Planetary, and Space Sciences, University of California Los Angeles, Los Angeles, CA, USA; <sup>4</sup> U.S. Geological Survey, California Water Science Center, Santa Maria, CA, USA

## Abstract:

The Hubble Space Telescope (HST) has been operational for over 30 years, and throughout that time it has been bombarded by high-energy charged particles colloquially referred to as cosmic rays. In this paper, we present a comprehensive study of more than 1.2 billion cosmic rays observed with HST using a custom-written Python package, HSTcosmicrays, that is available to the astronomical community. We analyzed 75,908 dark calibration files taken as part of routine calibration programs for five different CCD imagers with operational coverage of Solar Cycle 23 and 24. We observe the expected modulation of galactic cosmic rays by solar activity.

We model the observed energy-loss distributions to derive an estimate of  $534 \pm 117$  MeV for the kinetic energy of the typical cosmic ray impacting HST. For the three imagers with the largest nonuniformity in thickness, we independently confirm the overall structure produced by fringing analyses by analyzing cosmic ray strikes across the detector field of view. We analyze STIS/CCD observations taken as HST crosses over the South Atlantic Anomaly and find a peak cosmic ray particle flux of  $\sim 1100$  particle  $s^{-1} cm^{-2}$ . We find strong evidence for two spatially confined regions over North America and Australia that exhibit increased cosmic ray particle fluxes at the  $5\sigma$  level.

**Acknowledgment:** The data used in this paper were obtained from the Mikulski Archive for Space Telescopes (MAST) and its cloud-hosted counterpart, the HST Public Data Set (<https://registry.opendata.aws/hst/>), on AWS. Support for N.D.M. and S.E.D. was provided by NASA through grant number HST AR 14587.

**References:** Miles et al. (2021); The Astrophysical Journal, 918:86, <https://doi.org/10.3847/1538-4357/abfa9b>

**Session:** 4. The interaction of the sun with the planets, and Space weather

**Oral or Poster:** Oral