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The Pierre Auger Observatory as a Cosmo-Geophysics Laboratory

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The Pierre Auger Observatory, located near Malargüe, Argentina, is the world's largest facility dedicated to ultra-high-energy cosmic rays. The Observatory combines about 1600 water-Cherenkov detectors over 3000 km² with 27 fluorescence telescopes. After more than two decades of operation, this hybrid design has made it a unique laboratory for phenomena beyond cosmic-ray astrophysics. The CosmoGeophysics Task Force coordinates this interdisciplinary program. In space weather, the surface detector has recorded low-threshold counting rates (scalers) since 2005. These rates reveal Forbush decreases linked to interplanetary coronal mass ejections. Sixteen years of these publicly available, very low-noise data have established them as a new proxy of solar activity. In atmospheric electricity, a dedicated fluorescence-detector trigger has recorded ELVES since 2013. These are transient luminous events in the lower ionosphere produced by strong lightning. Their microsecond resolution allows lightning geolocation to within a few kilometres. The world's largest sample of multiple ELVES ruled out the ground-reflection explanation for triple ELVES and revealed halos. Cameras installed in 2023–2024 enabled simultaneous sprite observations. The surface detector has also observed downward terrestrial gamma-ray flashes, which last tens of microseconds and cover up to 200 km². They include the first flashes with an asymmetric azimuthal structure, suggesting sources more complex than a simple downward beam. Lightning detection systems, a new electric-field mill network being deployed for the AugerPrime radio upgrade, and a planned lightning-mapping array will link lightning development to gamma-ray emission. We review the origins of the CosmoGeophysics task force, its main results, and its prospects, highlighting opportunities for the Latin American high-energy and geophysics communities.

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