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Reflections on Current Questions in the Van Allen Radiation Belts, Electron Precipitation, and Space Weather

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The Van Allen Radiation belts were first discovered by James Van Allen using observations by the Explorer 1 and Explorer 3 spacecraft in 1958 during the International Geophysical Year. Despite being discovered at the dawn of the space age, there are multiple fundamental and basic scientific questions in radiation belt physics which are still open. It has long been recognized that the trapped electron fluxes in the outer radiation belt are highly dynamic. This high dynamism is thought to be due to competing drivers causing acceleration, loss, and transport, with growing evidence regarding the importance of non-linear processes in the belts. It is these factors, plus the complex energy interlinkages in the inner radiation belt, which lead to the open questions. Radiation belt particle fluxes are important for most satellites-orbiting the Earth, due to the potential radiation damage and internal electronics "upsets". Even the operators of Low Earth Orbiting satellites in very low altitude orbits find themselves "rediscovering the South Atlantic Magnetic Anomaly".

Another example of the wider interactions between the radiation belts and the Earth-system is energetic electron precipitation (EEP), where electrons are lost into the upper atmosphere; the most energetic will penetrate well below classic ionospheric heights to impact the upper stratosphere directly. As well as being part of the competing processes driving the dynamic radiation belts, EEP has been linked to significant changes in the chemical composition of the stratosphere and mesosphere potentially playing a role in regional climate variability. Because of these findings recent efforts have been made to incorporate EEP into climate modeling codes.

Aspects of radiation belt studies sit inside the wider topic area of Space Weather. That is a generic term for how the changing space environment impacts our technological systems. It is most commonly used to describe the links where processes which start on the Sun drive activity in and around the Earth which can pose a hazard to such systems. There are multiple ways that different systems can be affected, through different physical processes; due to our evolving technological systems, space weather hazards are themselves evolving with time.

In this Meet the HGE Experts session at URSI AT-AP-RASC 2022 I will attempt to discuss how the research fields above have evolved, and identify some questions for the future. I will also discuss some of my personal experience and accomplishments.