Unveiling Coronal Origins of Type III Solar Radio Bursts on a Spotless Day

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Overview

Our project aims to understand how high-energy particles are produced and propagate from the Sun, crucial for improving space weather predictions. We focus on electron acceleration within the solar atmosphere and their journey into the solar system, using data from advanced radio telescopes like the Low-Frequency Array (LOFAR) and Nancay Radioheliograph (NRH), and X-ray and Extreme Ultraviolet (EUV) instruments. We also utilize remote sensing and in-situ measurements from spacecraft such as the Parker Solar Probe and Solar Orbiter.

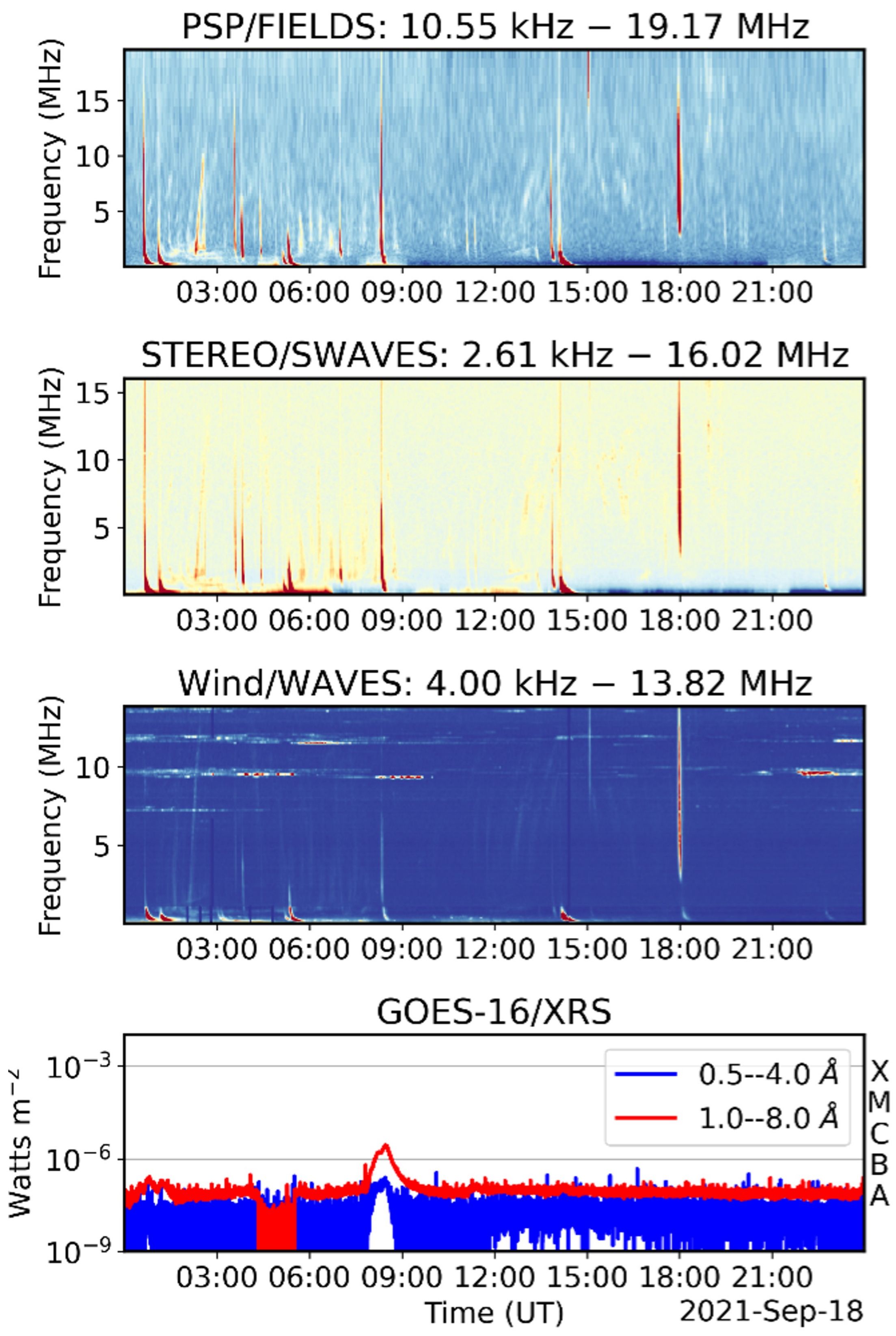
By identifying the regions of electron acceleration and simulating their paths along magnetic field lines, we aim to uncover the fundamental mechanisms driving these processes.

Methodology

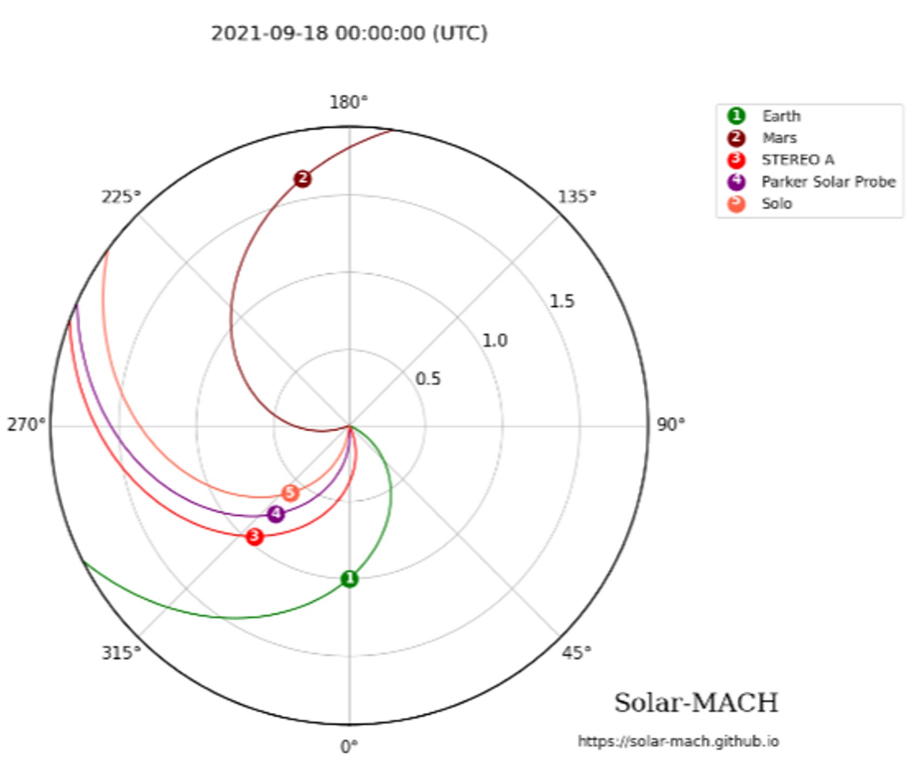
We analyze data from LOFAR, NRH, and satellite observations, alongside simulations of electron trajectories in the solar magnetic field. Direct measurements from the Parker Solar Probe and Solar Orbiter provide in-situ data.

The study is divided into two phases: low solar activity focusing on small-scale magnetic reconnection, and high solar activity examining flares and CMEs.

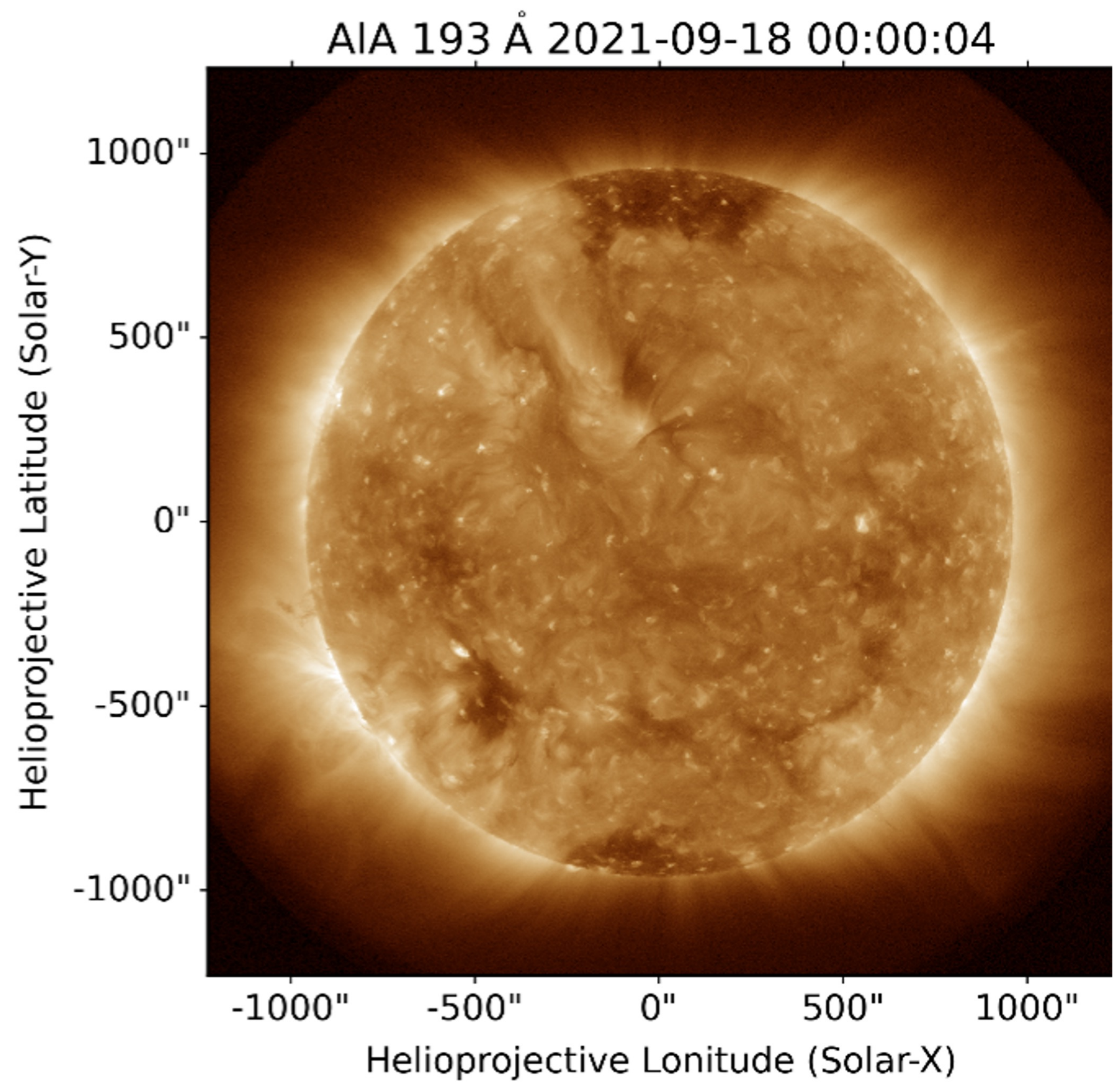
Radio Bursts



Interplanetary Magnetic Field



Solar Corona



Case Study and Findings

On September 18, 2021, type III radio bursts were observed during a period with no visible sunspots, indicating electron beams accelerated along open magnetic field lines from the Sun. We found a good correlation between the intensity in EUV observations of the southeast region on the solar disk, enhanced radio flux density, and an increase in particle flux from the MAVEN spacecraft connected magnetically to this region. This suggests the southeast region as the likely source of these radio bursts.

Radio bursts can originate from active regions behind the solar limb and still be detectable on the Earth side, highlighting the connectivity of solar magnetic structures and the propagation of energetic particles. The findings challenge traditional associations with sunspot-related events, indicating that non-sunspot regions can also be significant sources of magnetic reconnection and particle acceleration events.

Implications

Understanding how charged particles get accelerated and travel through space is essential for our ability to forecast space weather patterns more accurately. This knowledge is essential to protect the technological systems that our modern world heavily relies upon. By closely examining major solar eruptions like flares and CMEs, as well as subtle magnetic reconnection events, we aim to gain new insights into the energization and transport of particles originating from the Sun's atmosphere.

These discoveries will pave the way for developing more reliable predictive models that can help us prepare for and mitigate the impacts of solar storms on vital infrastructure like satellites, power grids, aviation systems, and telecommunication networks. Moreover, this cutting-edge research will guide the design of future space exploration missions, ensuring the safety of astronauts venturing into the harsh environment of space.

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