1-6-2024

Study of Soalr Atmospheric Heating Due to Active Regions

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ABSTRACT

The Sun is our nearest star, which anchors the entire solar system around it. Any major activities on the Sun have a direct impact on the entire heliosphere, including the Earth. Hence, it is important and interesting to understand the underlying physics of all activities on the Sun. One of the long-unsolved mysteries of the Sun has been the heating of upper atmospheric layers, leading to the emission of higher energy radiations like Ultraviolet and X-rays. Solar flares are known to be one source of heating upper layers, but even non-flaring, comparatively quiet regions of the Sun also seem to be hot and emit ultraviolet rays from the chromosphere of the Sun.

In this project, we studied the evolution of the non-flaring active region NOAA 13304 over nine days as it crossed the disk centre of the Sun, focusing on chromospheric brightening as a proxy for hot plasma in the chromosphere. We identified three distinct regions with varying levels of brightening: the quiet sun, plage region, and very bright and short-living regions, known as UV bombs. To study their properties and coupling with the photospheric magnetic field, we studied different magnetic field parameters, such as the vertical component of the current, current helicity, and free energy. Our findings revealed a strong correlation between the mean magnetic field and UV emission brightness in the plage and quiet sun regions but not in the bomb region, suggesting that UV bombs have a different physical mechanism that makes them bright; most possibly, it is the magnetic reconnection in the chromosphere. Similar behavior was observed for vertical current (J_Z). The mean current and helicity were highest in the bomb region, followed by the plage region, and lowest in the quiet sun region, indicating distinct physical processes in bomb regions. Mean photospheric magnetic free energy correlated positively with UV emission only in the quiet sun region. Analysis of coronal temperature using the Hannah & Kontar DEM algorithm showed a low percentage of hot pixels in all regions during the active region's decaying phase, with no correlation between hot pixels and UV emission. UV bombs contributed about 10% to chromospheric heating, while plages contributed up to 35%, with the quiet sun contributing the remainder. We propose a model where chromospheric bright patches in UV images result from multiple small-scale reconnections involving sunspot magnetic fields and background magnetic fields in network regions and plages. This model differs from the U-shaped bipolar region model by Peter et al. (2014).