Natural influences on night sky brightness and implications for site quality characterization

Theme: Measurement and Modeling

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Introduction

The loss of nighttime darkness around the world is well-documented, and it poses challenges for the scientific productivity of astronomical observatories and the management of ecologically protected places. The natural components of night-sky brightness (NSB) vary considerably over the course of the 11-year solar magnetic activity cycle (Benn and Ellison 1998; Krisciunas et al. 2007; Grauer et al. 2019) and even around solar minimum (Grauer and Grauer 2021). This complicates efforts to assign objective night-sky quality metrics to sites such as International Dark Sky Parks. A better understanding of natural sources of NSB and their behavior over periods from minutes to years is key to observatory site characterization and protection, as well as for conservation of protected areas. One particularly valuable outcome of such an increased understanding may be the ability to predict NSB values. By scheduling astronomical observations around anticipated changes in NSB, scientific facilities could be made more productive and cost-effective. In this work we aim to improve the interpretation of time-series NSB data from both light-polluted and unpolluted sites.

Method

We use data from three Unihedron Sky Quality Meter-Lens (SQM-L) devices at sites in the southwestern U.S. spanning a distance of 300 km: Kitt Peak National Observatory (31.9624, -111.6004), Mt. Lemmon, Arizona (32.4426, -110.7887) and Cosmic Campground, New Mexico (33.4795, -108.9225). Data were filtered to remove contamination from twilight, moonlight and clouds, then matched up with time series of two solar geomagnetic indicators: Bz GSM (the *z*-component of the interplanetary magnetic field near the Earth in Geocentric Solar Magnetospheric coordinates) and the kinetic energies of solar wind protons obtained from the NASA OMNIWeb Science Data Portal.

Results

The NSB measurements in Fig. 1 show the known seasonal variation often attributed to the Russell-McPherron (1973) effect. The temporal window of the data set brackets the time between the minimum of Solar Cycle 24 to the ongoing maximum of Cycle 25; over this time we see an average NSB increase of about 0.5 magnitudes per square arcsecond (mpsa). Near solar maximum there are many specific instances of high NSB values likely due to the impacts of solar coronal mass ejections on the Earth's magnetosphere. However, there are also isolated peaks in the NSB measurements that correlate strongly with the apparent arrival of fast and energetic solar wind streams that reverse the polarity of Bz. We searched for, but did not find, strong evidence of a time delay between the onset of solar geomagnetic events and elevated NSB reported by, e.g., Krisciunas *et al*. 2007. We also note

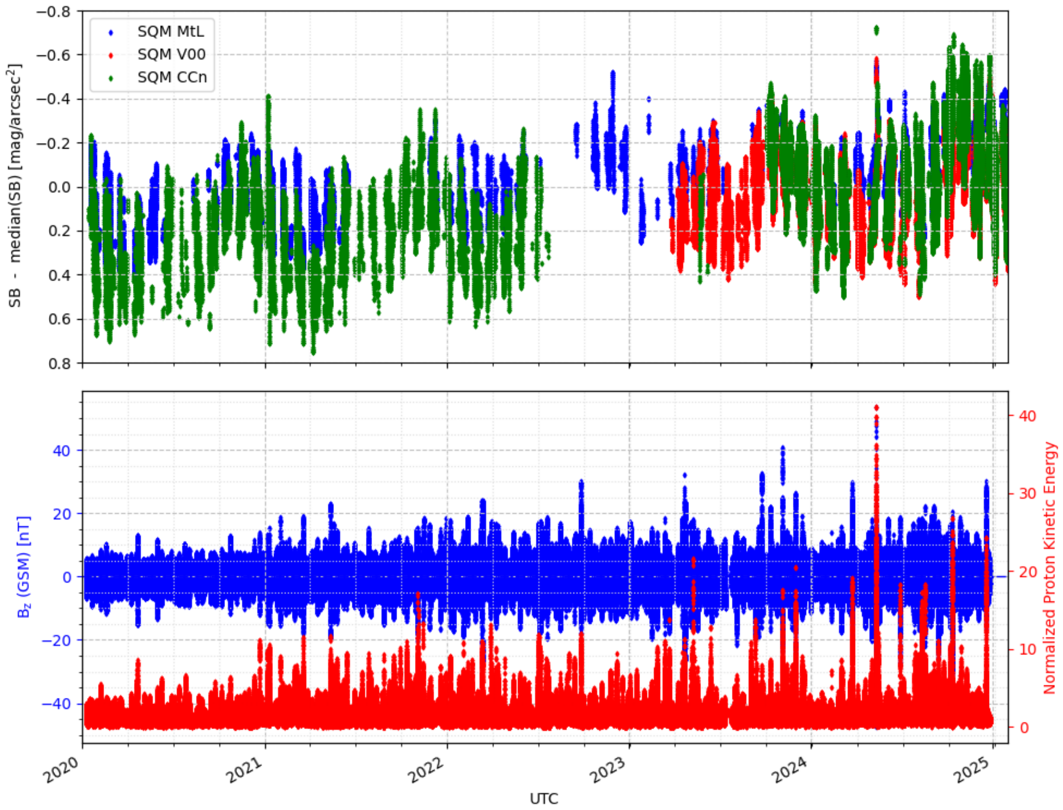

Fig. 1. NSB measurements and solar geomagnetic activity indicators during the rise of Solar Cycle 25 during 2020-2025. The upper panel shows individual measurements from SQM-Ls at three sites separated by up to 300 km: Kitt Peak National Observatory, Arizona ("V00", red points), Mount Lemmon, Arizona ("MtL", blue points) and Cosmic Campground, New Mexico ("CCn", green points). Each trace is the difference at each time between each individual measurement from that location and the median value for the full time series. The lower panel shows the z-component of the interplanetary magnetic field (blue trace) and the normalized energy of solar wind protons (red trace) at one-minute intervals from the NASA OMNIWeb Science Data Portal.

the dispersion of NSB measurements for all three monitors is roughly the same at solar minimum as at solar maximum, ranging up to ±0.3 mpsa.

References

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