Simultaneous, Multi-Wavelength Flare Observations of the M dwarf Wolf 359. E. V. Quintana\textsuperscript{1}, T. Barclay\textsuperscript{2}, J. Schlieder\textsuperscript{2}, P. Boyd\textsuperscript{2}, and B. Thackeray-Lacko\textsuperscript{2}. \textsuperscript{1}Goddard Space Flight Center, Exoplanets and Stellar Astrophysics Laboratory, 8800 Greenbelt Road, Greenbelt, MD, 20771, \textsuperscript{2}University of Maryland, College Park, Department of Astronomy, College Park, MD, 20742.

Introduction: Wolf 359, aka CN Leo, is a nearby late-M dwarf that is known to produce frequent flares with a duration of minutes to hours. M dwarfs are smaller, cooler and less luminous than the Sun, and therefore difficult to observe in detail. At just 2.4 parsecs away, Wolf 359 is bright, making it an ideal target for the study of stellar activity in low mass stars. We have begun a pilot study to obtain simultaneous, multi-wavelength observations of Wolf 359 to form a comprehensive picture of its stellar activity. We will present results from our observations in the optical, UV, X-ray, and radio wavelengths using K2, Swift, and ground based observatories. We will discuss the potential impact on exoplanet habitability and describe the prospects of future multi-wavelength flare observations in the era of TESS.

Stellar Activity: Most of what is known about stellar activity comes from studies of our Sun. The Sun’s magnetic activity is sustained through a complex combination of convection and radiation, while smaller stars rely proportionally less on radiation, with the smallest being completely convective. The intrinsic magnetic activity of convective low-mass stars like Wolf 359 is manifested in part by stochastic, short-term brightenings; flares. The magnetic activity driving flares is critical to planetary atmospheres and habitability. High-energy radiation and energetic particle emission associated with activity drive photochemistry, can erode atmospheres, and impact habitability.

Observations: K2, the repurposed Kepler mission, observed Wolf 359 for over 80 days in May-August 2017. These high-precision, 1-minute cadence photometric observations will allow us to measure the epochs, frequencies and energies of flares. Simultaneous X-Ray and Ultra-Violet observations were taken using the space-based SWIFT observatory. These higher energy wavelengths reveal the amount of energy being released during flare events. We obtained simultaneous radio observations with a wide range of frequencies which will allow us to look for correlations between radio bursts, coronal mass ejections, and optical flaring events. Our full analysis will begin when the K2 data is downlinked in September 2017.

Planets?: Low-mass stars are the most common stars in the Galaxy and have been targeted in the tens-of-thousands by K2. The Kepler and K2 missions have taught us that M dwarfs typically host multiple small planets, many of which reside within the habitable zone. Observations from the Hubble Space Telescope and ground-based telescopes have ruled out the presence of giant planets like Neptune orbiting Wolf 359. The existence of smaller Earth-sized planets, however, remains uncertain. If Wolf 359 does harbor small planets, and they transit the star as viewed from Earth, K2 could reveal their presence. Regardless, the information gained by studying Wolf 359 will help us understand the stellar-planetary environment of similar stars that harbor planets.

Figure 1: Intense stellar activity, such as flares and coronal mass ejections, can project energetic particles towards a planet which interact with the atmosphere.

Implications: M Dwarfs will be prime targets in the search for habitable worlds by the upcoming James Webb Space Telescope. There are predictions that a combination of flares and energetic particles from an M Dwarf could strip a planet’s atmosphere. However, these predictions rely on extrapolating observations of the Sun’s radiation environment by orders of magnitude to model events on M dwarfs. This multi-wavelength campaign to observe the M dwarf Wolf 359 will pave the way towards a larger study with TESS, the Transiting Exoplanet Survey Satellite - set to launch in mid-2018. TESS is expected to find a large number of planets orbiting nearby M dwarfs that are amenable to follow-up observations. Our long-term goal is to study flares in a population of both young and old M dwarfs, and in a wide range of M dwarf masses (from TRAPPIST1-like stars that are about 8% the mass of our Sun, to Kepler-186-like stars that are about 50% the mass of our Sun) and metallicities. These observations will help us understand if we can apply our knowledge of the Sun’s activity to low mass stars, or if new models will need to be established. M dwarfs constitute more than 70% of all stars in the Solar neighborhood, thus understanding their stellar activity and effects on planets will have big implications on the abundance of potentially habitable planets in our galaxy.