

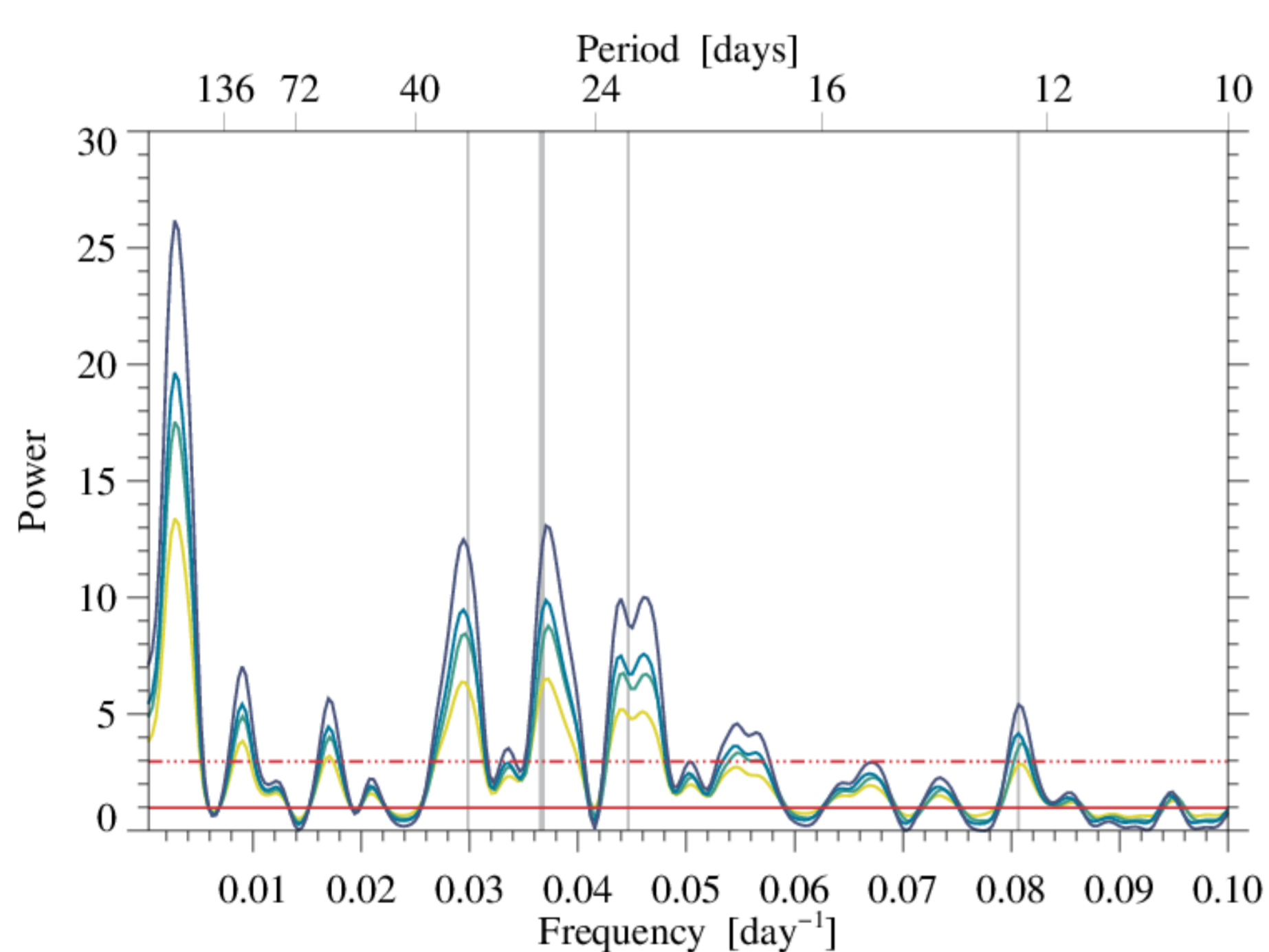
Characterization of Chromospheric Activity Based on Sun-as-a-star Spectral and Disk-resolved Observations

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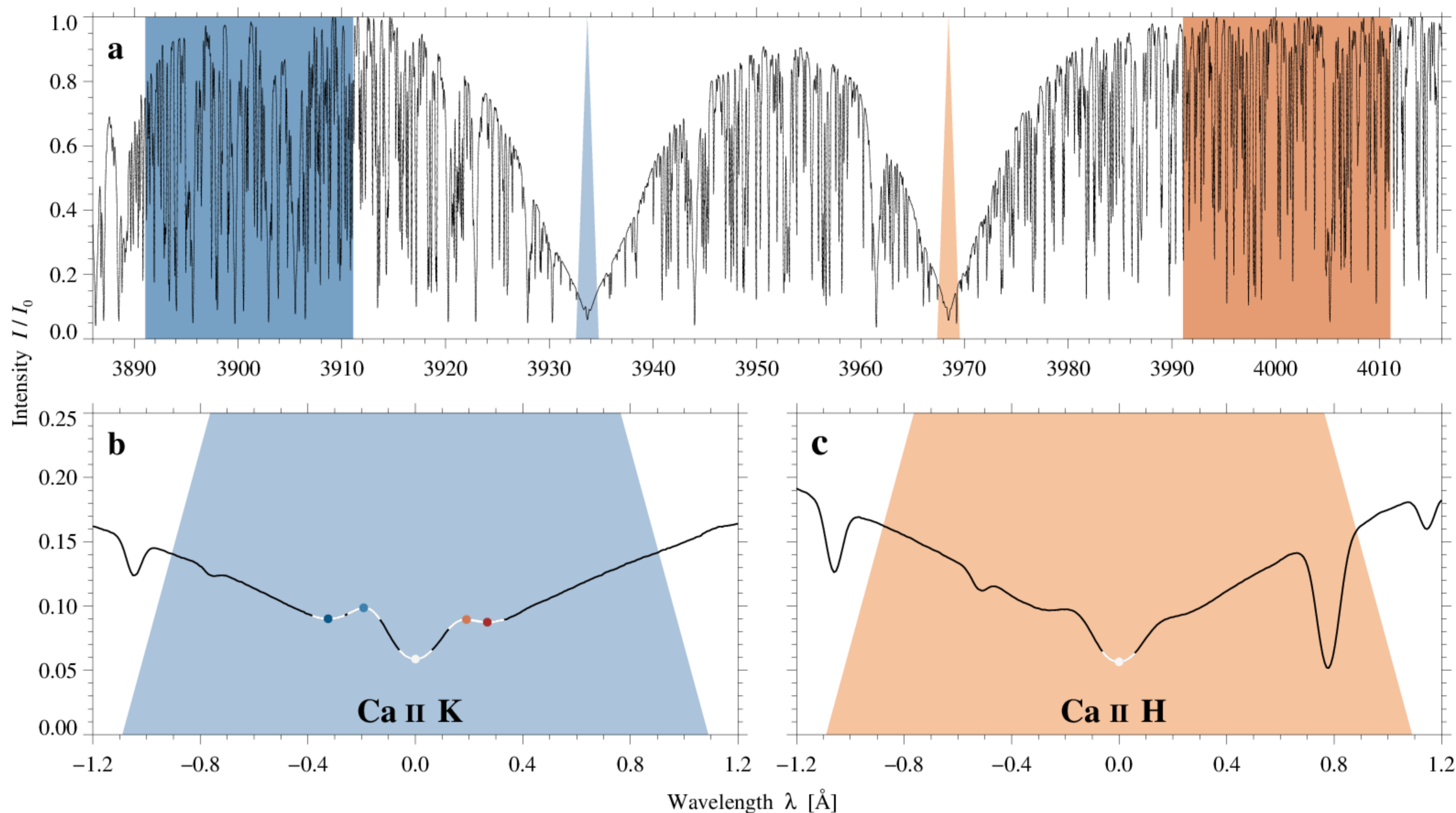
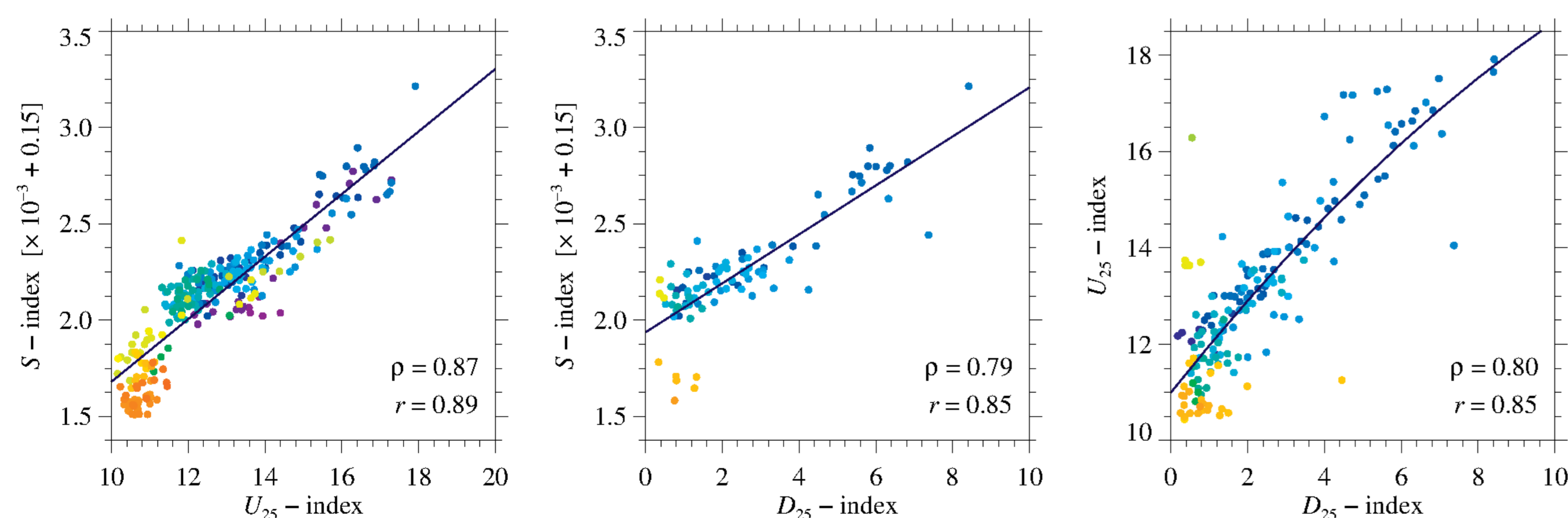
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Activity Across the Spectrum

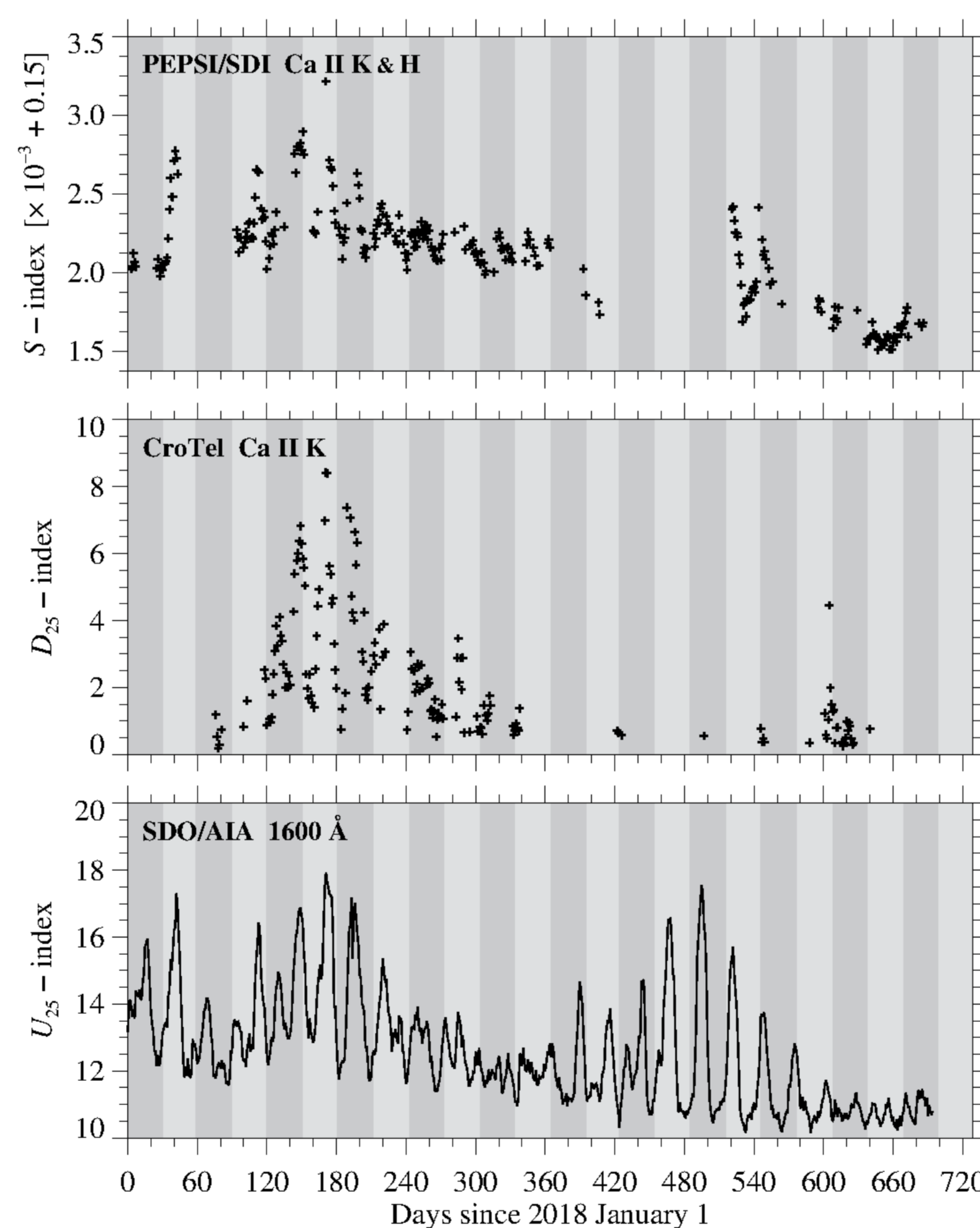
The strong chromospheric absorption lines Ca II H & K are tightly connected to stellar surface magnetic fields. Only for the Sun, spectral activity indices can be related to evolving magnetic features on the solar disk. The Solar Disk-Integrated (SDI) telescope feeds the Potsdam Echelle Polarimetric Spectroscopic Instrument (PEPSI) of the Large Binocular Telescope (LBT) at Mt. Graham International Observatory (MGIO), Arizona, U.S.A. We present high-resolution, high-fidelity spectra that were recorded on 266 days in 2018/19 and derive the Ca II H & K emission ratio, i.e., the S-index. Additionally, we compile excess brightness and area indices based on full-disk Ca II K line-core filtergrams of the Chromospheric Telescope (ChroTel) at Observatorio del Teide, Tenerife, Spain and full-disk UV 1600 Å images of the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO). Thus, Sun-as-a-star spectral indices are related to their counterparts derived from resolved images of the solar chromosphere. All indices display signatures of rotational modulation. Bringing together different types of activity indices has the potential to join disparate chromospheric datasets yielding a comprehensive description of chromospheric activity across many solar cycles.



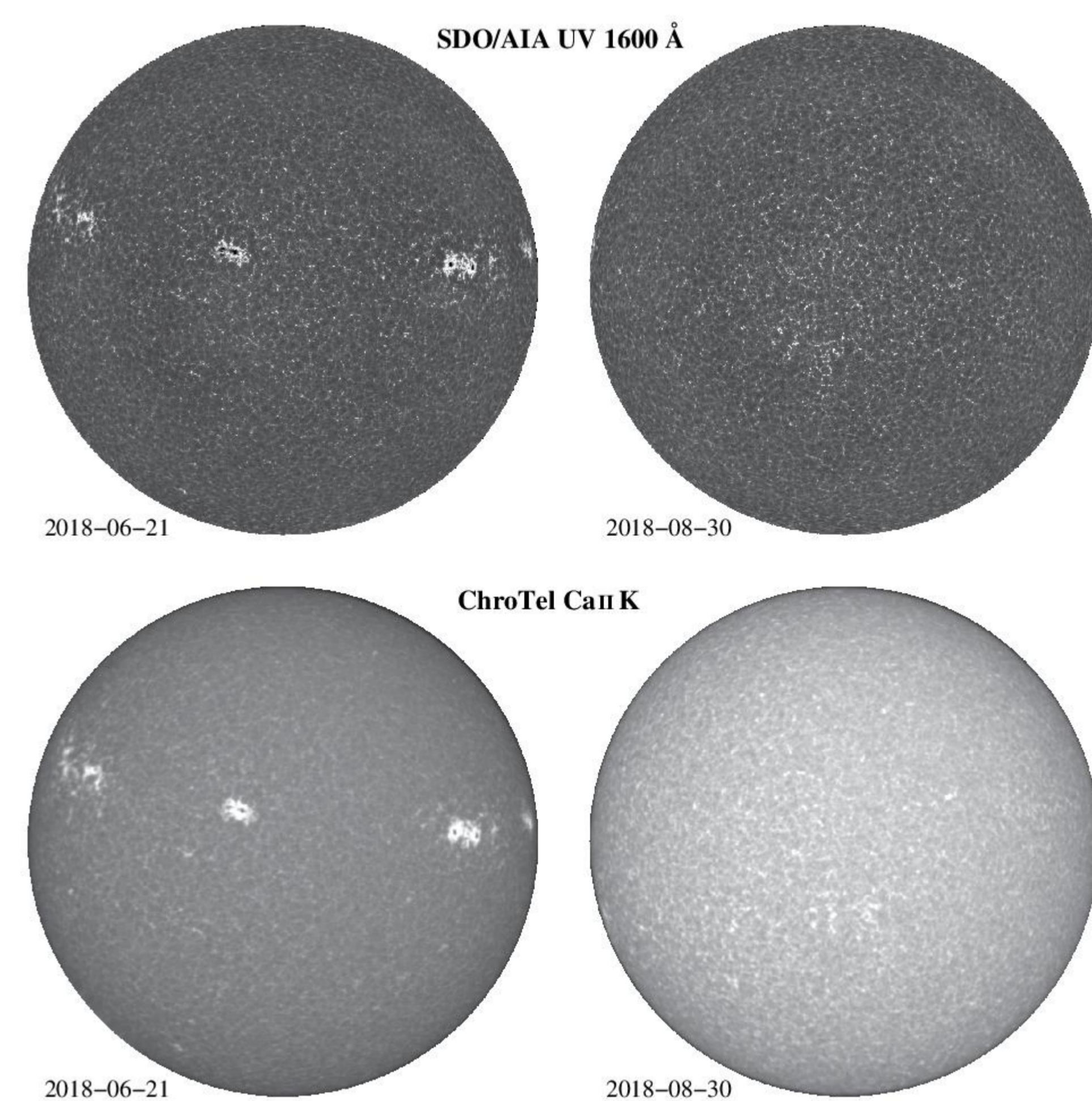
Lomb-Scargle periodogram (dark blue) of the PEPSI/SDI-index time-series for 2018. Three periodograms (light blue, cyan, and yellow) refer to error estimates, when only three-quarters, two-thirds, and half of the data points were used. The thick gray vertical line indicates the Carrington rotation period of 27.3 days, which is accompanied by two side maxima at 33.5 and 22.4 days (thin gray lines), respectively.



(a) Average Ca II H & K spectrum computed from 60 consecutive exposures obtained by PEPSI/SDI on 2018 June 21. Details of the line fitting procedure are shown in the ± 1.2 Å range around the cores of (b) the Ca II K and (c) the Ca II H chromospheric absorption lines. White segments indicate the range of parabola fits and colored bullets refer to local minima and maxima, i.e., K_{1v} (dark blue), K_{2v} (light blue), K_3 (white), K_{2r} (light red), K_{1r} (dark red), and H_3 (white). The 20 Å-wide wavelength bands of the blue and red pseudo continua are marked by light blue and light red rectangles, respectively. The blue and red triangular bands (FWHM = 1.09 Å) are used in the computation of the S-index



Time-series of the PEPSI/SDI Ca II H & K S-index (top), ChroTel Ca II K index D_{25} (middle), and SDO/AIA UV 1600 Å index U_{25} (bottom). The alternating dark and light gray rectangles denote one-month periods. The plus signs reflect the irregular data coverage of the S- and D_{25} -indices, while the U_{25} -index has a continuous coverage.



Full-disk images from the AIA UV 1600 Å channel (top) and the ChroTel Ca II K 3933.6 Å Lyot filter (bottom). Full-disk images representing high and low solar activity were selected according to the PEPSI/SDI S-index. A two-dimensional limb darkening function was subtracted from the UV 1600 Å images to enhance the contrast of chromospheric fine structure.

Scatter plots of the S-, U_{25} -, and D_{25} -indices. The diagonal straight line represents a linear fit to the data, and Pearson's linear and Spearman's rank-order correlation coefficients r and ρ are given in the lower-left corners of each panel, respectively. The number of common data values differs in each plot, and their chronological order is color-coded. The relation between the S-index and the two excess brightness indices is clearly linear, where the quadratic fit between the two excess brightness indices, is indicative to the morphological differences between bright regions seen in the K-line and 1600 Å C IV and continuum.