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Global Solar Magnetic Variations Characterized by Excess Brightness Indices and Spectroscopic Proxies

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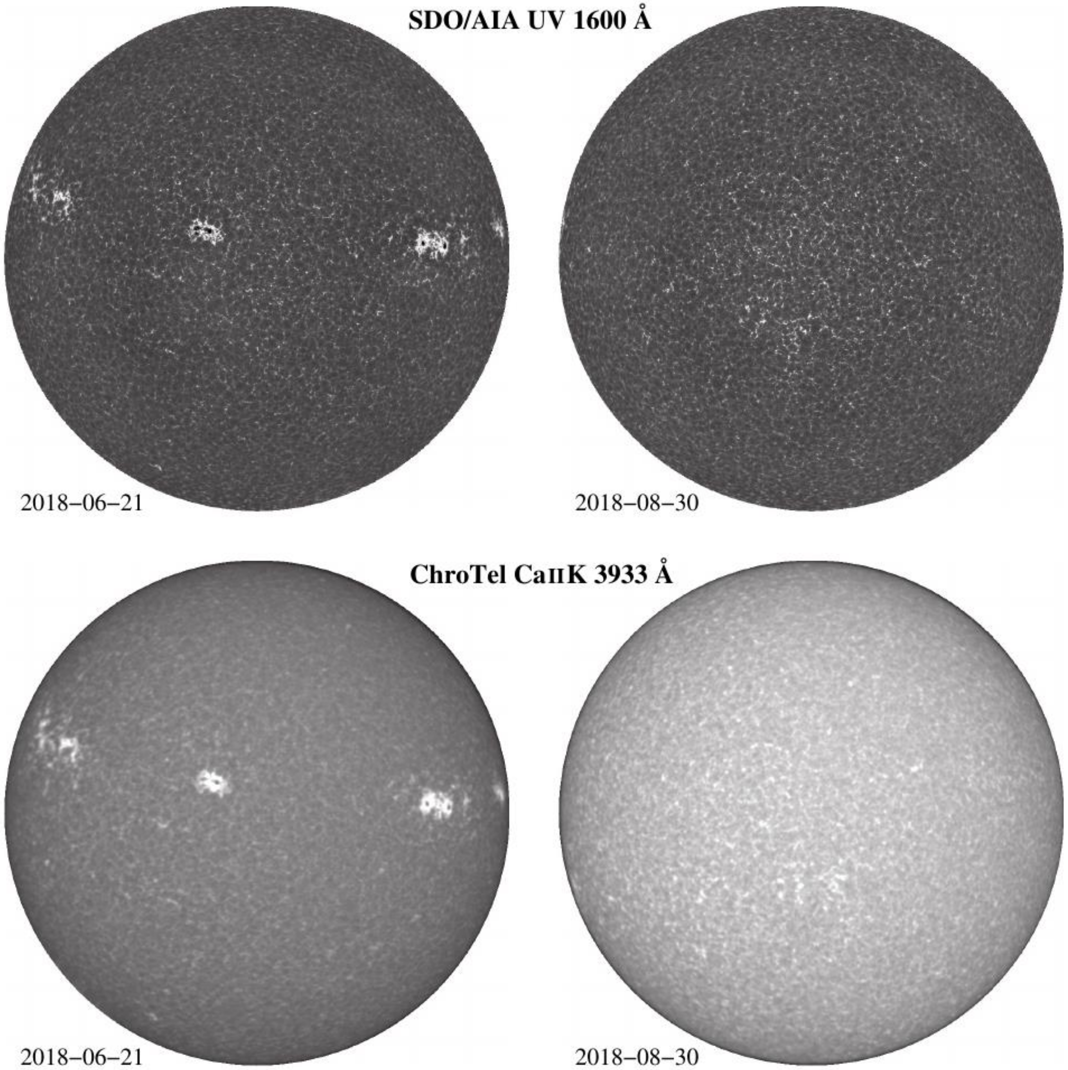
Motivation

- Ground-based and space-mission instruments feed **large archives of synoptic observations of the Sun**. The synergy between spectral and image information, available in the case of the Sun, facilitates a global and comprehensive picture of solar activity variations.
- The **Ca II H&K** is one of the most well studies spectral lines. It is a well known **empirical relation to the magnetic flux density** is utilized to restore long-term magnetic variance. Due to morphological similarities, the Ca II K plage indices are used as **proxies for the UV irradiance variations**.
- 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**.
- Compute the **PEPSI S-index** – part of the ongoing effort to characterize solar activity via its PEPSI spectra.

Full-disk Synoptic Observation



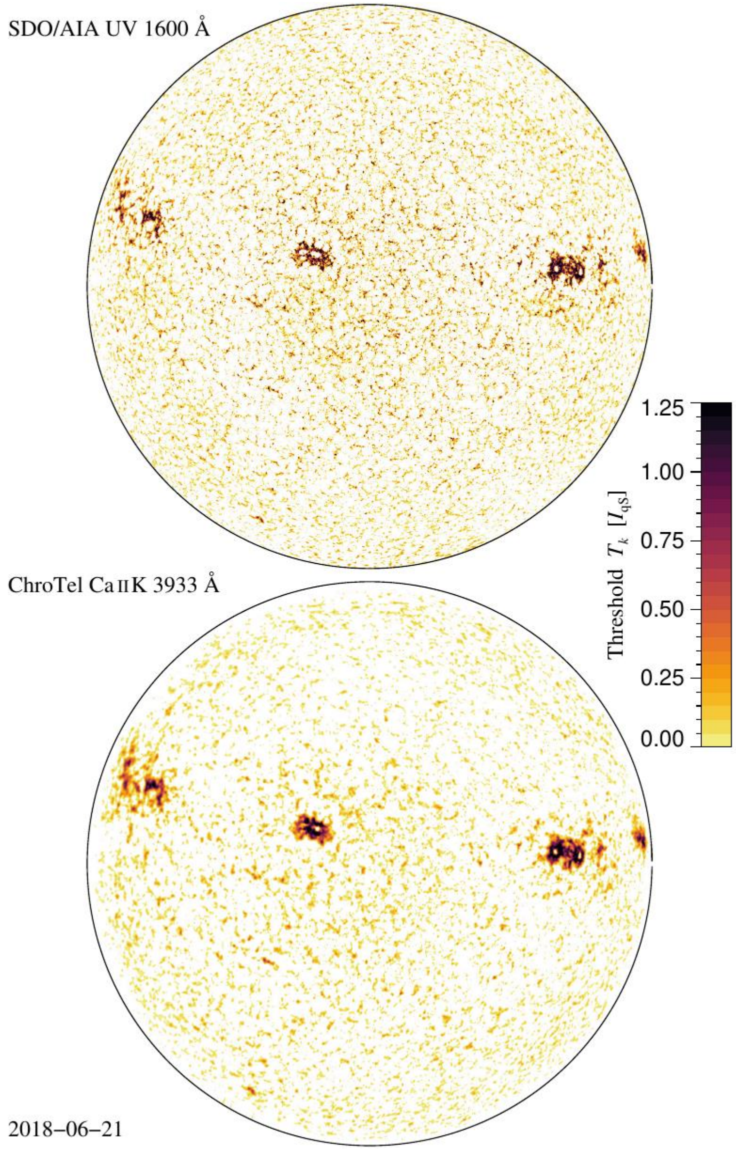
- **Ca II K filtergrams** (0.3 Å FWHM) best image for each day corrected for differential rotation.
- **SDO/AIA UV 1600 Å full-disk long-term integration image**, an average of 300 individual UV images
- Iterative **CLV correction**
- **Zernike polynomials** uneven background correction
- Final result: **enhanced contrast images**

Area and Excess Brightness Indices

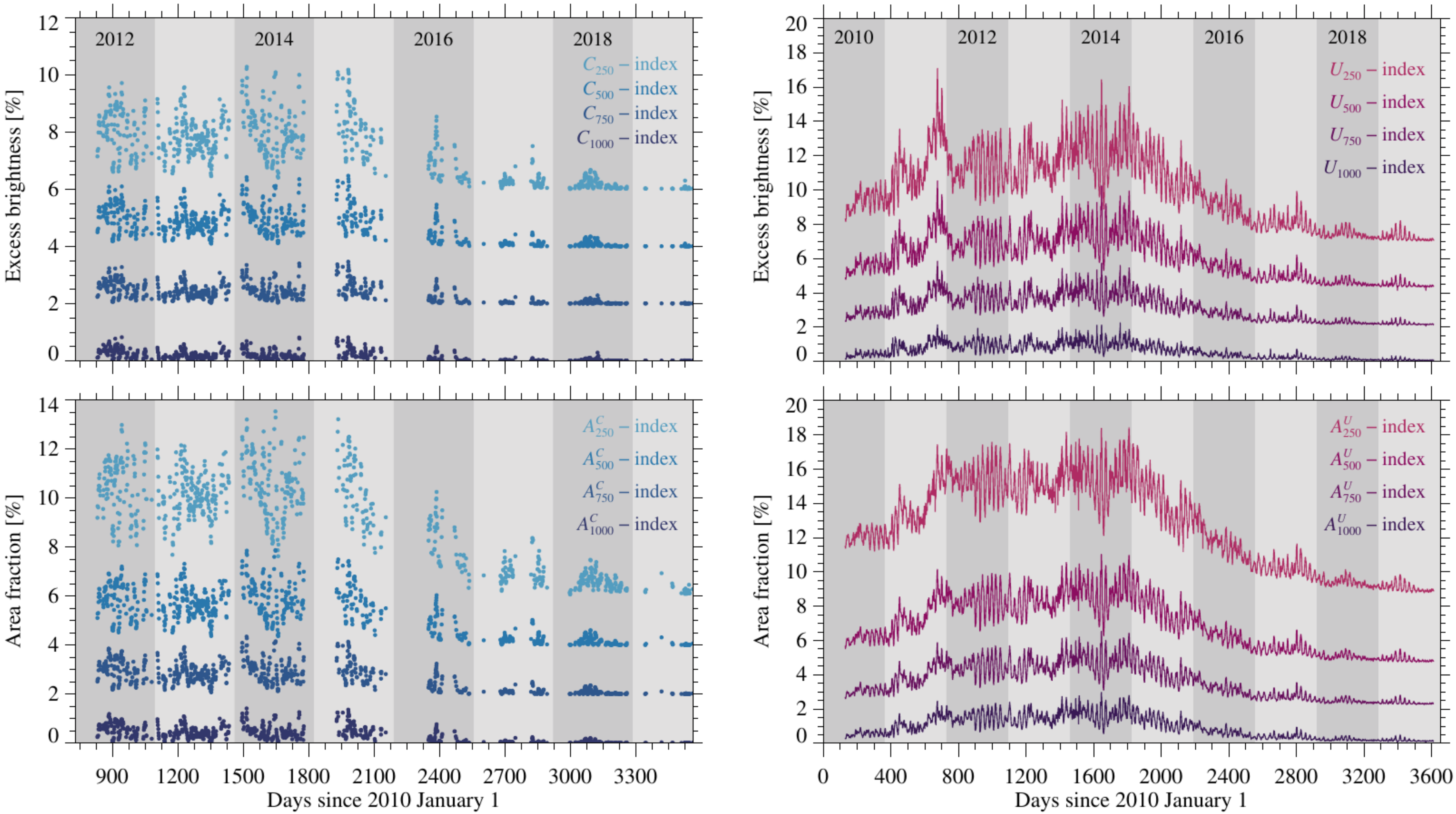
$$D_k = \frac{1}{1000}\sum_{ij} f_{ij} \quad \begin{cases} f_{ij} = Rij - Tij & R_{ij} \geq T_k \\ f_{ij} = 0 & R_{ij} < T_k \end{cases}$$

$$C_k = \frac{1}{L}\sum_{ij} f_{ij} \qquad U_k = \frac{1}{L}\sum_{ij} f_{ij}$$

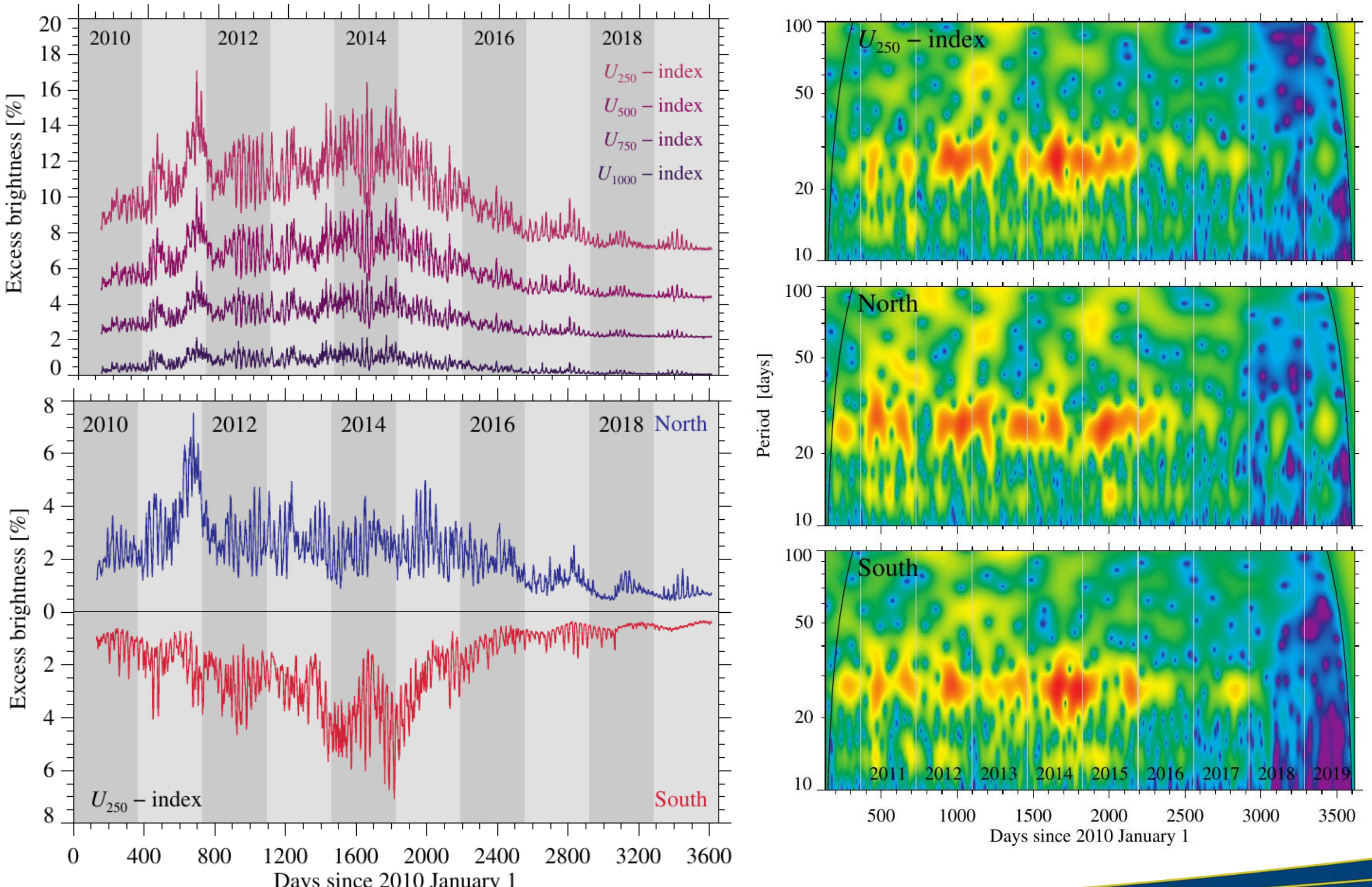
- ❑ R_{ij} is **the intensity excess of a pixel**
- ❑ T_k is the **intensity threshold** given as a fraction of the normalized quiet-Sun intensity I_{qS}=1 at μ=1
- ❑ $L = \sum L_{ij}$ total brightness of the ***"featureless"* Sun**
- ❑ **Area indices** A^C_K (or A^U_K) is the fraction of the solar disk covered by the features exceeding the brightness threshold



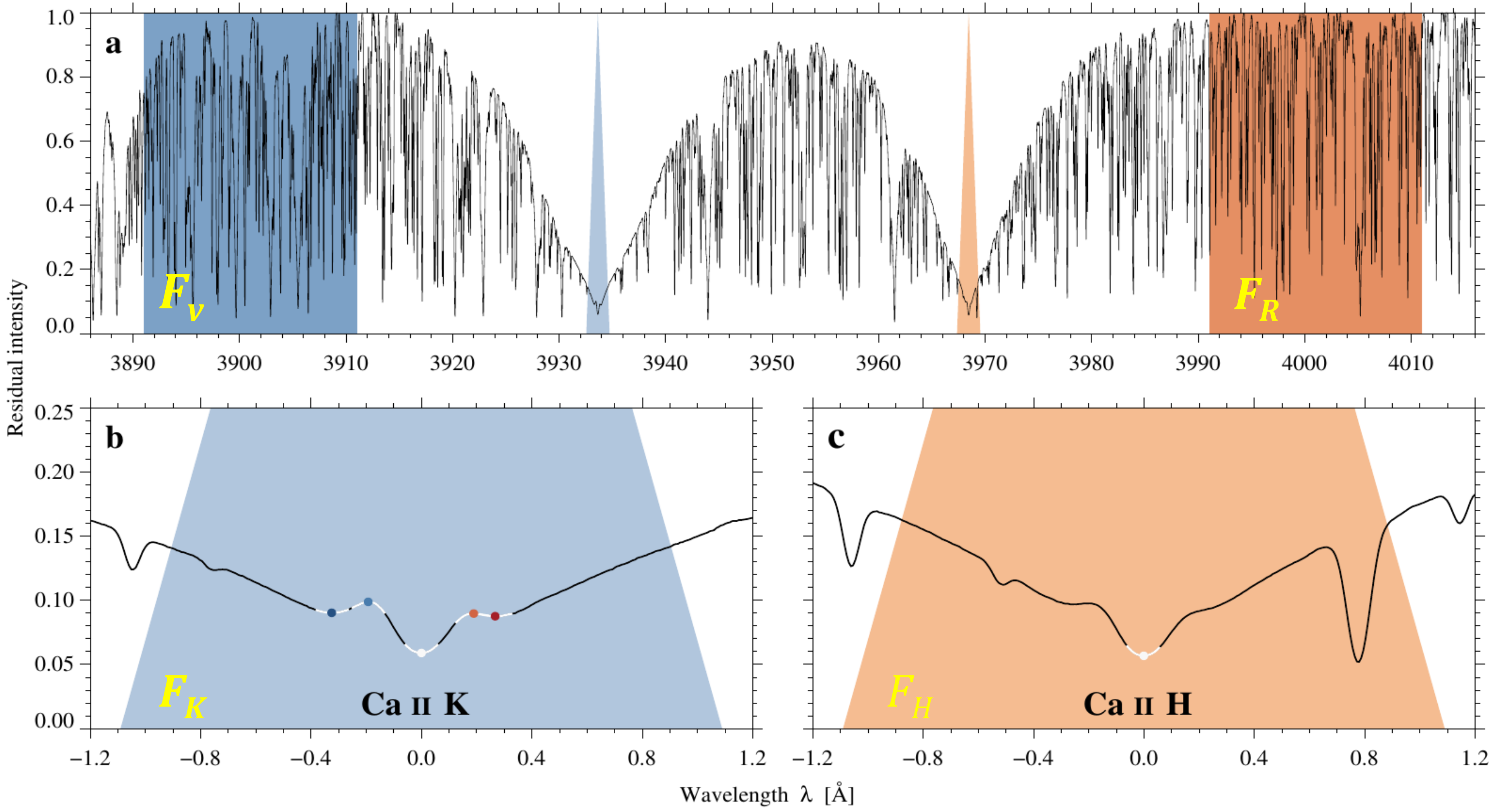
Area and Excess Brightness Indices



Area and Excess Brightness Indices: AIA 1600 UV

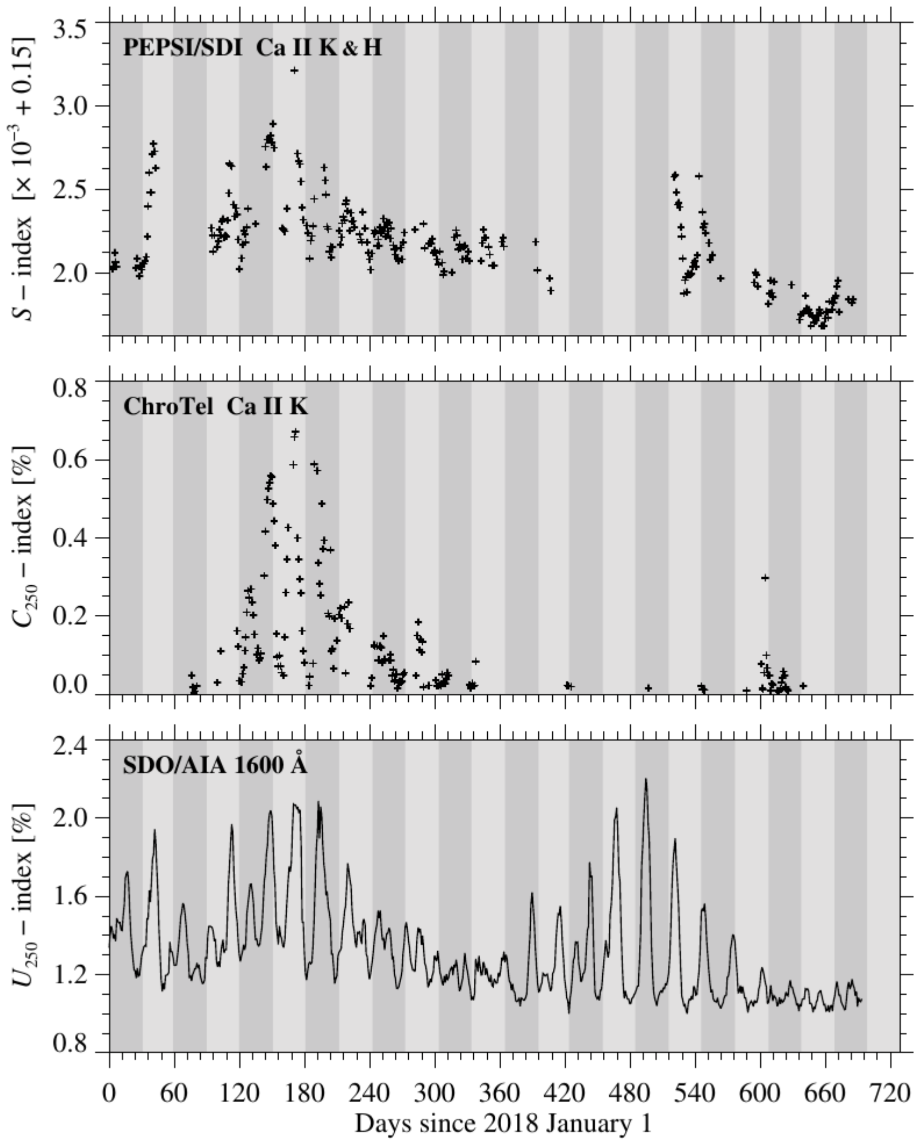


The PEPSI/SDI *S*-index



$$S_{PEPSI} = \alpha \times 8\ \frac{F_H + F_K}{F_R + F_V}$$

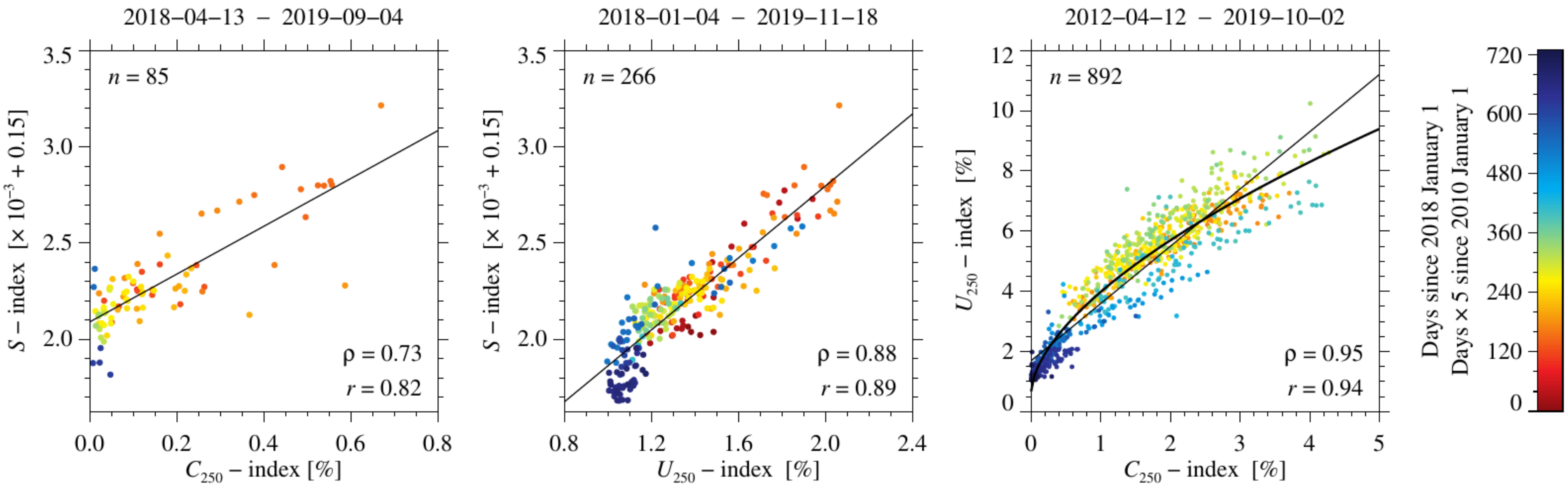
Spectroscopic vs Disk-resolved Indices



- **Time–series** of the PEPSI/SDI Ca II H&K S–index (top), ChroTel Ca II K index D_{250} –index (middle), and SDO/AIA UV 1600 Å index U_{250} –index (bottom).
- All display **rotational modulation**
- The S- and the U_{250}-index have a **significant basal component** even during activity minimum
- While plages dominate the Ca II H&K and UV 1600 Å continuum emissions during high solar activity, the **magnetic network sustains the basal emission during low activity periods**

Thank you for your attention!

Spectroscopic vs. Disk-resolved Indices



- Scatter plots of the S-, C_{250}-, and U_{250}-indices. The diagonal straight lines represent linear fits. In addition, a geometric regression model was applied to the U_{250}-index (thick curve).
- 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.
- 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.