ESTIMATING STELLAR SPOTS FROM CA II H&K ACTIVITY PROXY IN SOLAR-LIKE STARS

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Abstract

The magnetic phenomena on the solar surface have been the subject of several investigations over the last 400 years. The early indicator of the solar magnetic activity was the sunspot counting. The main indicators now are the International Sunspot Number, the Group Number, the Total Sunspot Area, and Photometric Sunspot Index. Several improvements in observational techniques have allowed measuring the magnetic activity using the solar/stellar spectra. The standard spectroscopic activity indicator is the S-index, based on the Ca II H&K emission lines, jointly the chromospheric component R'_{HK}. Observations to stellar spots in other stars remain unclear, it is worth proposing a theoretical estimate to spot amount on other solar-type stars using the Sun as a star. We report a calibration between the spectroscopic chromospheric activity proxies (S-index and R'_{HK}) and the sunspot indicators over the last decades. Our results indicate a quadratic power-law relationship.

Introduction

Previous papers have already pursued the relation between Sunspots and chromospheric/photometric indicators (Shapiro et al. 2014; Mandal et a. 2020) . In this work, we propose a theoretical estimate between Ca II activity proxies to indirectly quantify sunspots in solar-type stars.

We highlight some sunspot observational indicators used in this study: International Sunspot Number (ISN), Sunspot Group Number (GSN), Total Sunspot Area (TSA), and Photometric Sunspot Index. Additionally, we used the magnetic activity proxies from the Ca II resonance H&K lines, i.e. S-index and R'_{HK}.

The goal is to propose a theoretical estimate to spot amount in other solar-like stars based on the correlation between sunspots indicators and spectroscopic activity indexes. We used a Least-Square polynomial fit between these two categories of indicators. Similarly to proposed by Bertello et al. 2016.

Observational Data

- International Sunspot Number from Royal Observatory of Belgium, Brussels. The dataset cover from late 1960 to 2016.
- Group Sunspot Number from Royal Observatory of Belgium, Brussels. The dataset cover from late 1960 to 2016.
- S-index measurements from the Mt. Wilson Observatory (Egeland 2017)
- Total Sunspot Area recently updated by Mandall et al. 2020.
- Photometric Sunspot Index, from Mandall et al. 2020.

Results and conclusions

- Our results, regarding the sunspots indicators and spectroscopic chromospheric proxies from Ca II H&K emission lines, indicates a quadratic power law.
- Figures 1 and 2 present the least-square polynomial best fit between Ca II H&K activity proxies and Sunspots indicators.
- The polynomial fit:

$$\log(ISN) = a_1 \cdot [\log(S_{MW})]^2 + b_1 \cdot \log(S_{MW}) + c_1$$
$$\log(ISN) = a_2 \cdot [\log(R'_{HK})]^2 + b_2 \cdot \log(R'_{HK}) + c_2$$
$$\log(TSA) = a_3 \cdot [\log(S_{MW})]^2 + b_3 \cdot \log(S_{MW}) + c_3$$
$$\log(TSA) = a_4 \cdot [\log(R'_{HK})]^2 + b_4 \cdot \log(R'_{HK}) + c_4$$

$$a_1 = -2.79 \cdot 10^2;\ b_1 = -4.06 \cdot 10^2;\ c_1 = -1.45 \cdot 10^2$$
$$a_2 = -6.74 \cdot 10^1;\ b_2 = -6.48 \cdot 10^2;\ c_2 = -1.56 \cdot 10^3$$
$$a_3 = -6.95 \cdot 10^2;\ b_3 = -1.04 \cdot 10^3;\ c_3 = -3.83 \cdot 10^3$$
$$a_4 = -1.78 \cdot 10^2;\ b_4 = -1.72 \cdot 10^3;\ c_4 = -4.17 \cdot 10^3$$

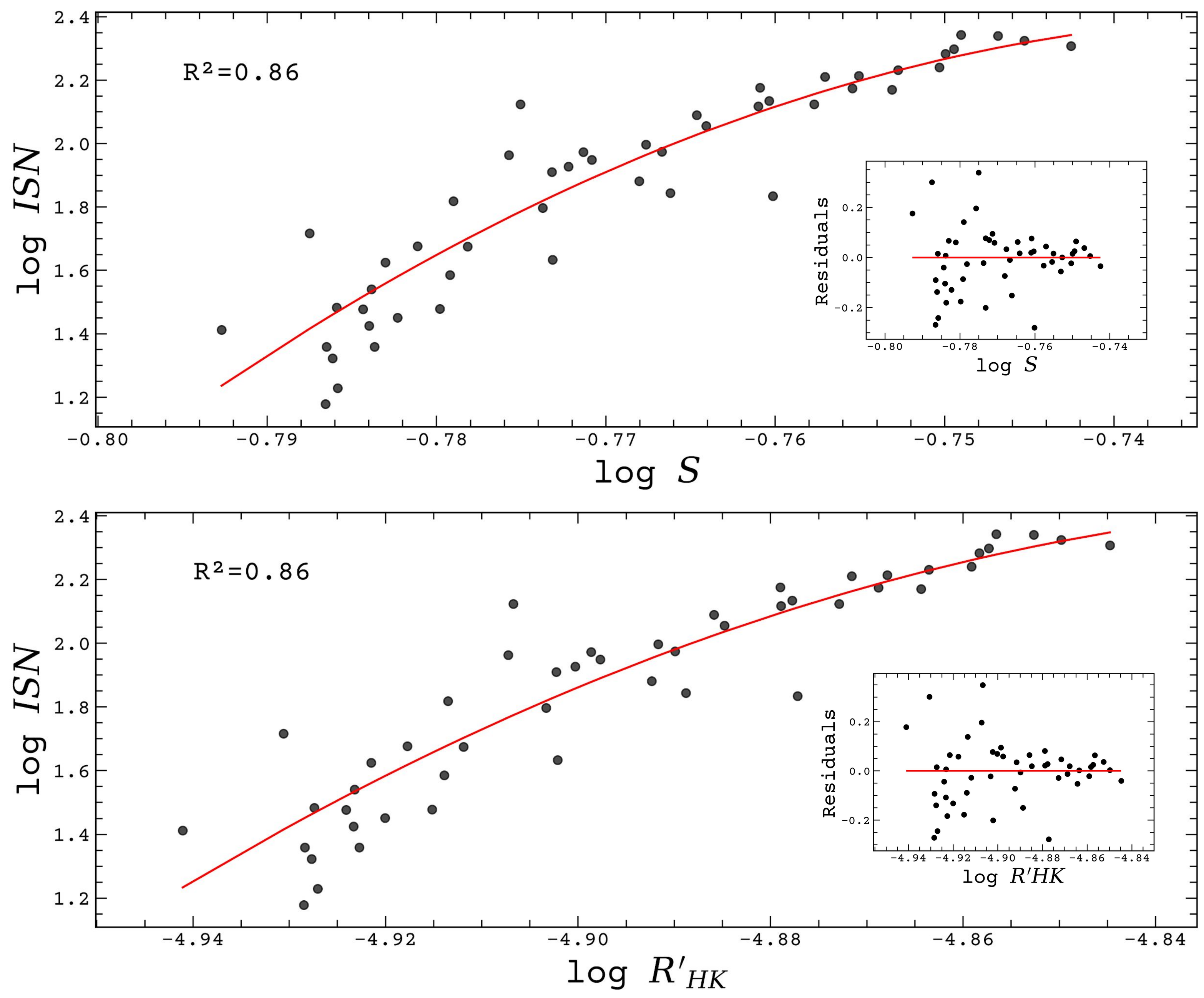

Fig 1. The ISN daily average computed yearly as a function of Ca II proxies. The observations cover from late 1960 until 2016. The red line is the best least-square polynomial fit.

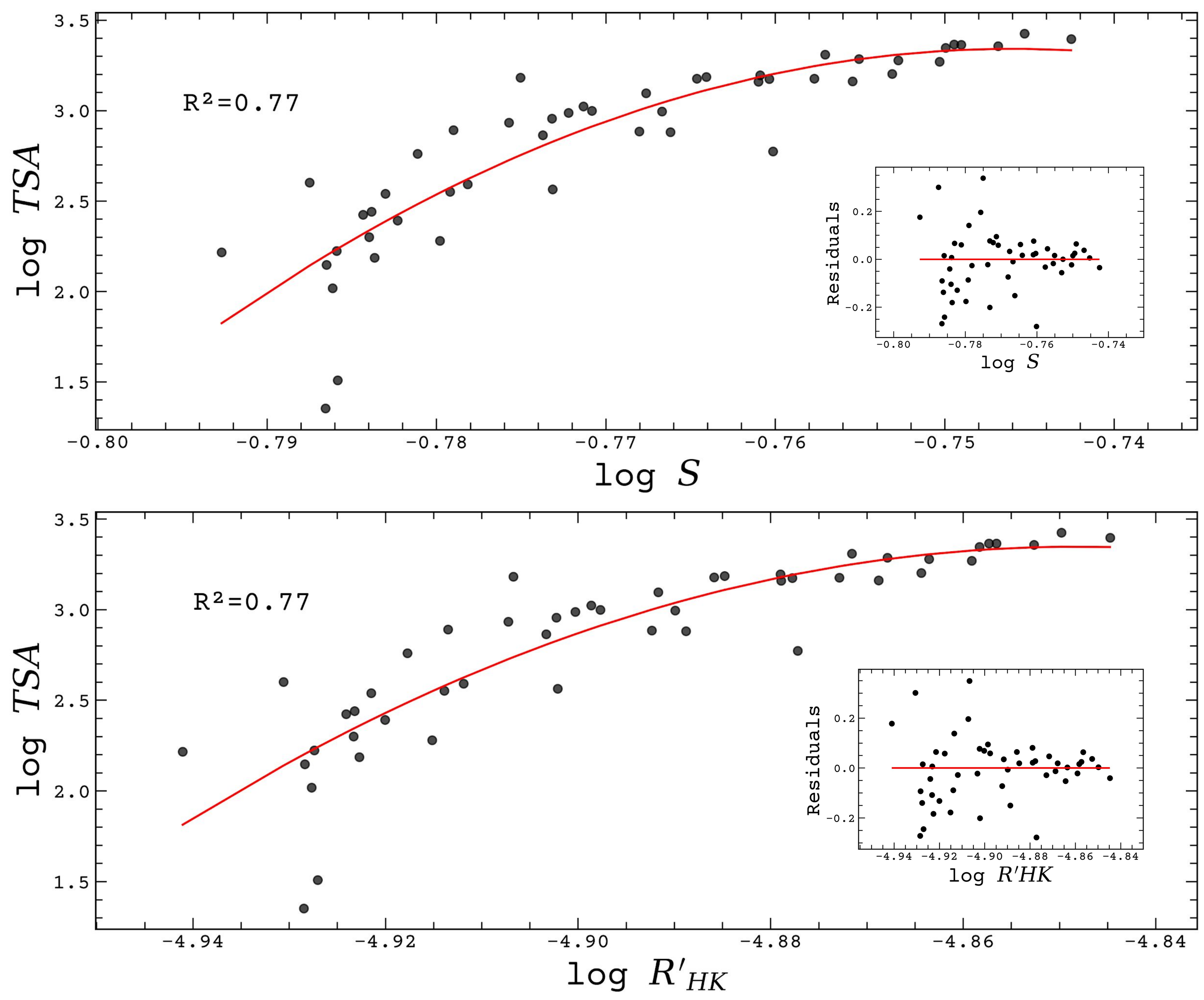

Fig 2. The ISN daily average computed yearly as a function of Ca II proxies. The observations cover from late 1960 until 2015. The red line is the best least-square polynomial fit.

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