On the oscillatory behaviour of magnetic helicity in flaring and non-flaring solar active regions

Sz. Soós[1], M. B. Korsós[1,2], H. Morgan[2], R. Erdélyi[1,3]

BACKGROUND

Space Weather is one of the most important research areas today. Solar flares and Coronal Mass Ejections could have a major impact on our technology-based civilization. For this reason, it is **vital to develop further the existing prediction capabilities.**

METHODS

1. To test the conjecture by Korsós et al. (2020), we re-visit their work, and apply it to an **order of magnitude larger** number of active region (AR) **sample** size.
2. We track the evolution of total, shearing, and emergence magnetic helicity flux (**T**, **SH**, **EM**) components through the photosphere of ARs.
3. Construct the wavelet power spectrum of original and smoothed data series (Fig. 1).
4. We **identify local** significant **peaks** in the wavelets with persistent homology (Huber 2021).
5. We **study the distribution of** the identified local wavelet **peaks** (Fig. 2a-c, Fig. 4a-c).
6. Finally we **model the distributions with** Gaussian Mixture Model (**GMM** - Fig. 2d-f).

RESULTS

- We found that for both in the flaring and non-flaring ARs the PDF peaks, and **the associated periods are arranged in bands.** These bands are between
  (i) 2-9 hrs, (ii) 11-14 hrs, and (iii) 19-21 hrs.
- Fig. 2f clearly show the 1/*x* dependence of the GMM-fitted EM peaks.
- **In the flaring ARs,** the distributions of **peaks changes after the flares** (Fig. 4a-c).
  In Fig. 4b,c, the lower periods are separated into two groups (~2.5 and ~4 hours).
- For **non-flaring ARs**, we found that **there is not much change** in the peak distribution before and after of a chosen arbitrary time.

Emergence magnetic helicity flux component does play a crucial role in the formation of flares

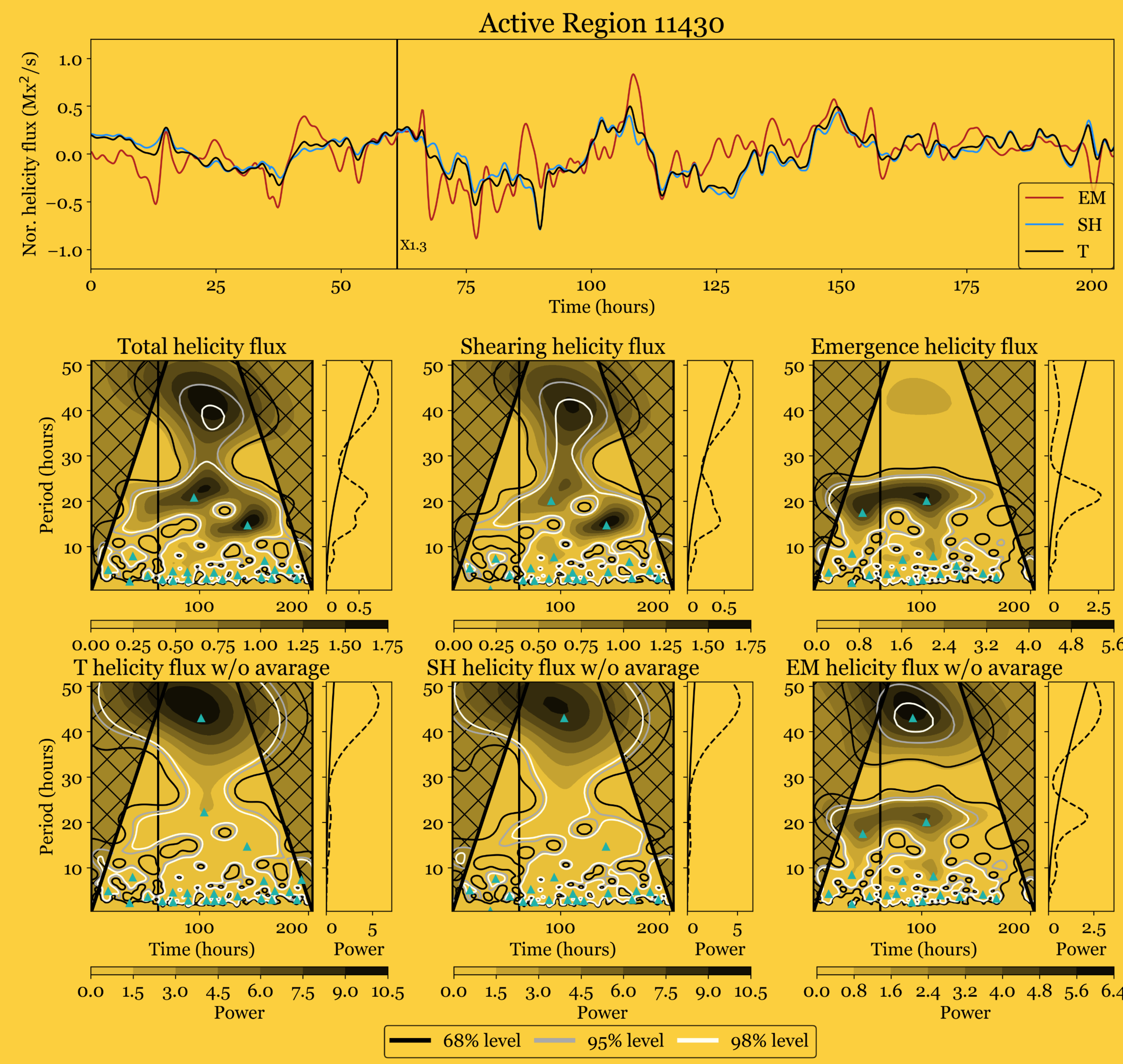

Fig. 1 - Wavelet analysis of a typical flaring AR.

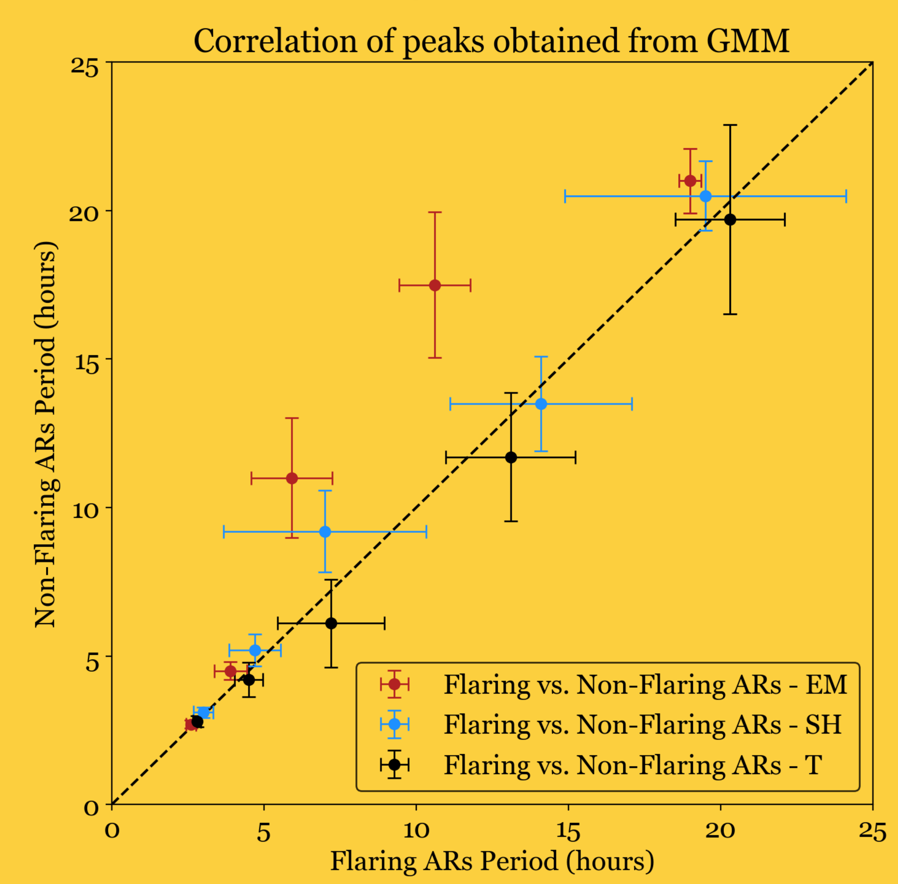

Fig. 3. We examined the **correlation of the means of Gaussians obtained from GMM** of flaring and non-flaring ARs. From this, we can see that the **EM clearly becomes distinct from T and SH.** Based on that, we propose that the evolution of **the EM should have a pronounced role in the flare-CME triggering processes.**

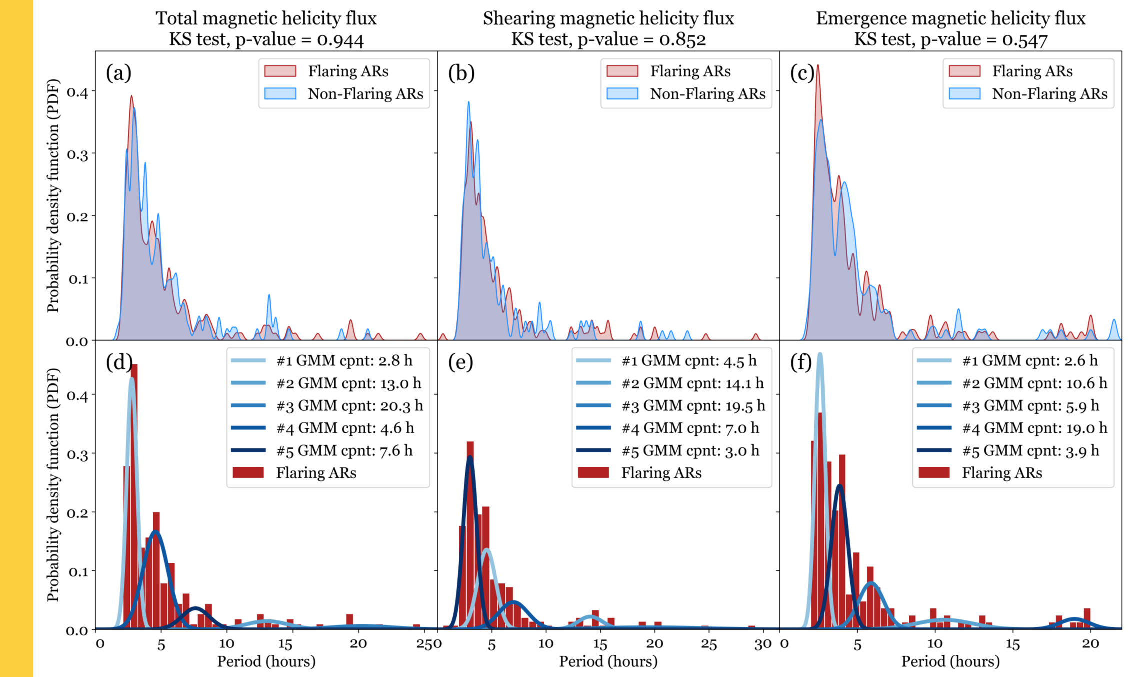

Fig. 2 - (a, b, c) PDFs of found peaks in ARs, (d, e, f) PDFs modelled with GMM.

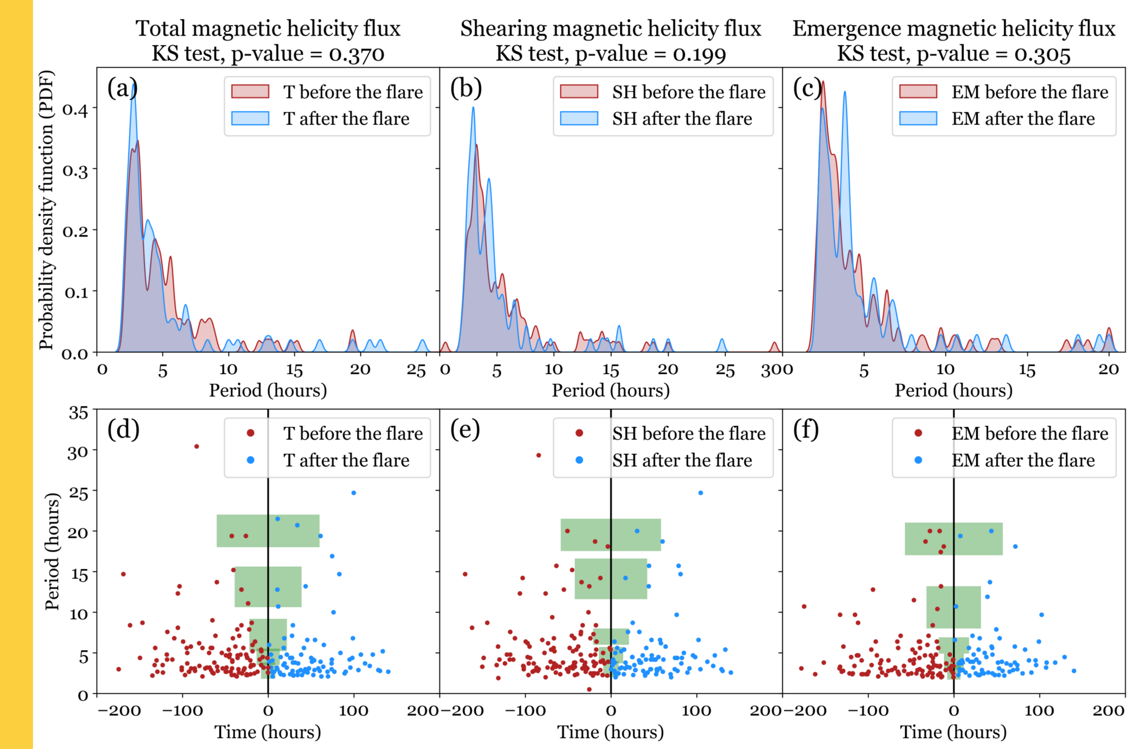

Fig. 4 - (a, b, c) PDFs of peaks before/after the flares, (d, e, f) T/SH/EM periods of all flaring ARs.

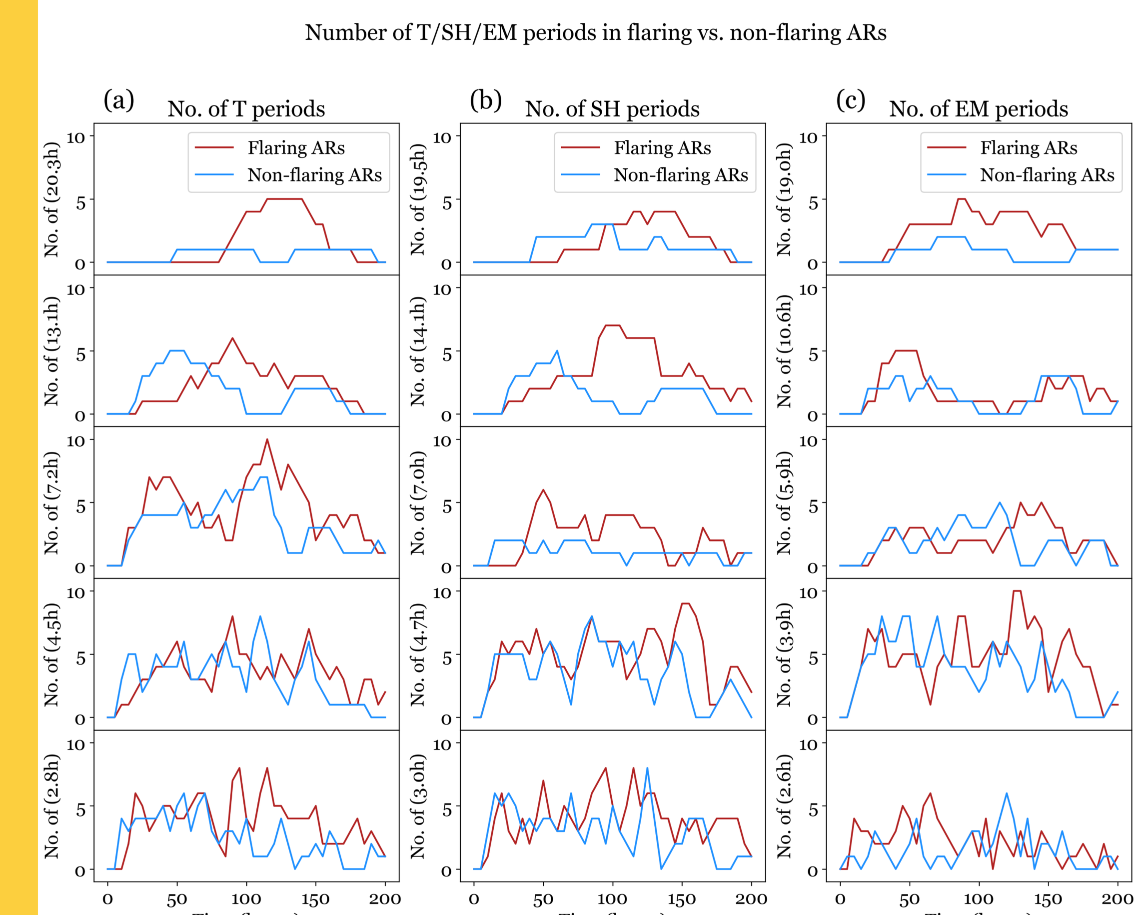

Fig. 5 - Number of (a) T, (b) SH and (c) EM periods in green rectangles of flaring and non-flaring ARs. Long periods (~20 hour) appear in the T and EM of flaring ARs.

The presence of long periods seen in EM (~19 hour) **and T** (~20 hour) **suggests that the EM component does play a crucial role in the formation of flares.**

[1] Eötvös Loránd University, HU
[2] Aberystwyth University, UK
[3] University of Sheffield, UK