ON THE POSSIBILITY OF PROBING THE FLARE PRODUCTIVITY OF AN ACTIVE REGION IN THE EARLY STAGE OF EMERGENCE

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STATEMENT 1:

The slope of the magnetic power spectrum is in a good correlation with the flare productivity of solar active regions. A number of works revealed that the slope of the power spectrum – the spectral index – is steeper for more flare-productive active regions (see Abramenko 2005, Mandage 2016)

STATEMENT 2:

The slope of the magnetic power spectrum increases abruptly as soon as the active regions starts to emerge. At the very beginning of the emergence the spectral index increases significantly and reaches values typical for mature active region (see Hewett 2008, Kutsenko 2019)

QUESTION:

Can we predict the future flare productivity of an active region by measuring the slope of its magnetic power spectrum during the initial phases of emergence?

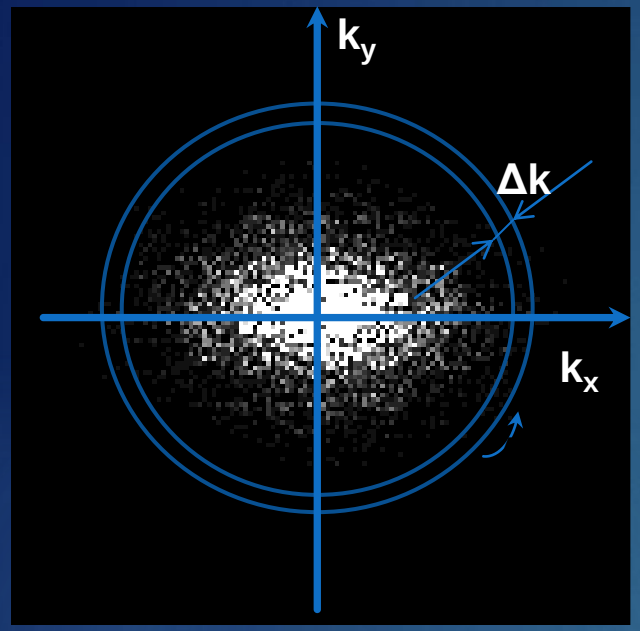
Abramenko V.I., 2005, ApJ, 629, 1141

Mandage R. S., McAteer R. T. J., 2016, ApJ, 833, 237

Hewett R. J., Gallagher P. T., McAteer R. T. J., Young C. A., Ireland J., Conlon P. A., Maguire K., 2008, Sol. Phys., 248, 311

Kutsenko O. K., Kutsenko A. S., Abramenko V. I., 2019, Sol. Phys., 294, 102

Power spectrum calculation

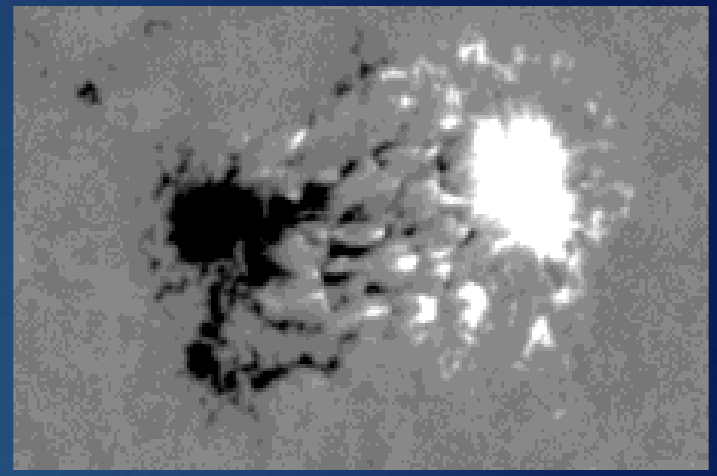


1. 2D spectrum calculation:

$$F(k) = \frac{1}{2}\left|U(k)\right|^2$$

$$k = \frac{2\pi}{l}$$

U(k) – Fourier transform

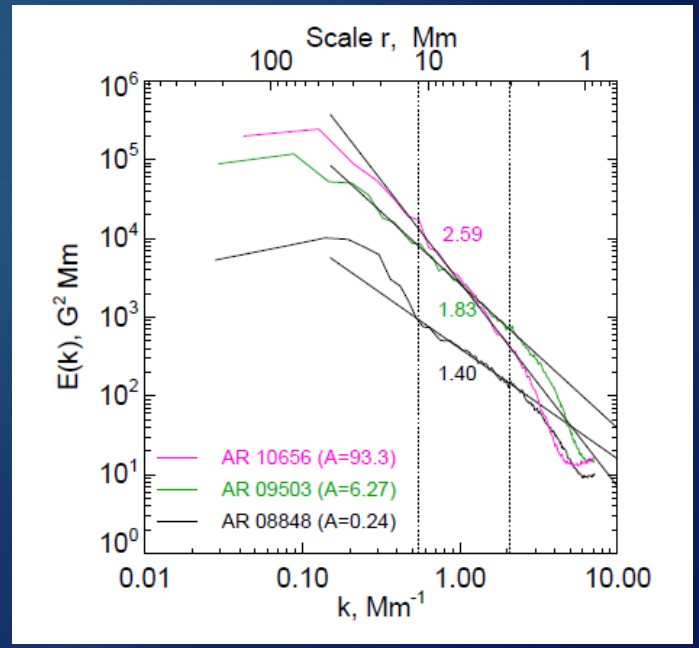


2. 1D spectrum calculation :

$$E(k) = \int_0^{2\pi} F(k)\,dS(k) \qquad k = \sqrt{k_x^2 + k_y^2}$$

$$E(k) \sim k^{\alpha}$$

Inertial range α: 2,4-10 Mm
α ≈-1 – quiet Sun
α≈-5/3 and more – active regions

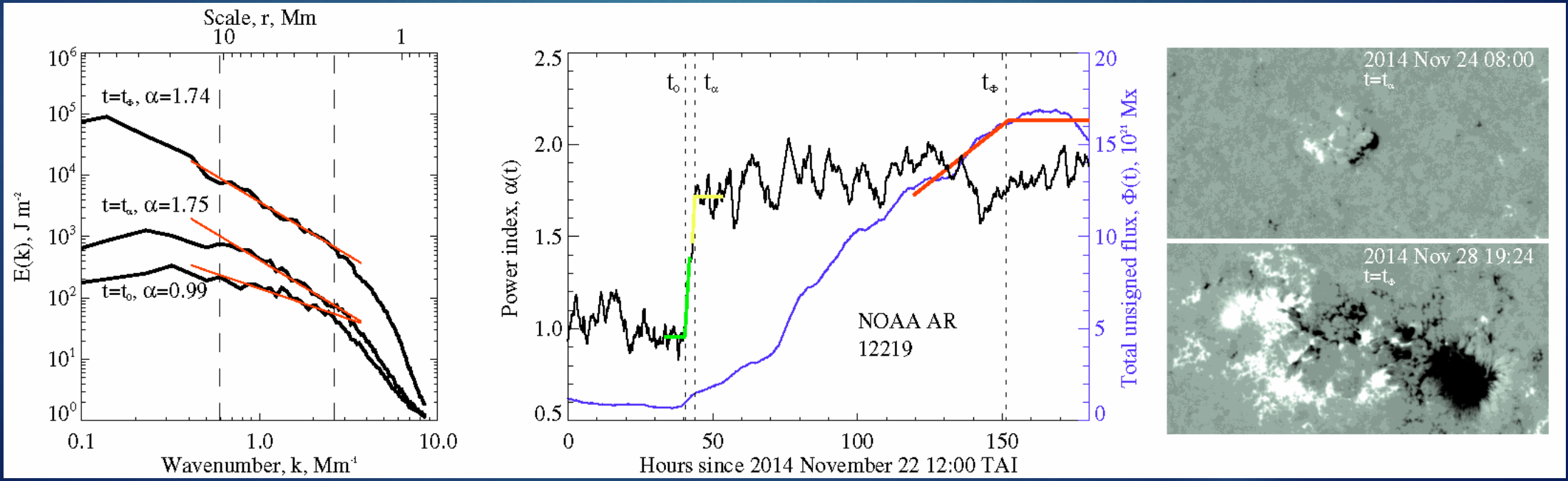


Abramenko V.I., 2005, ApJ, 629, 1141

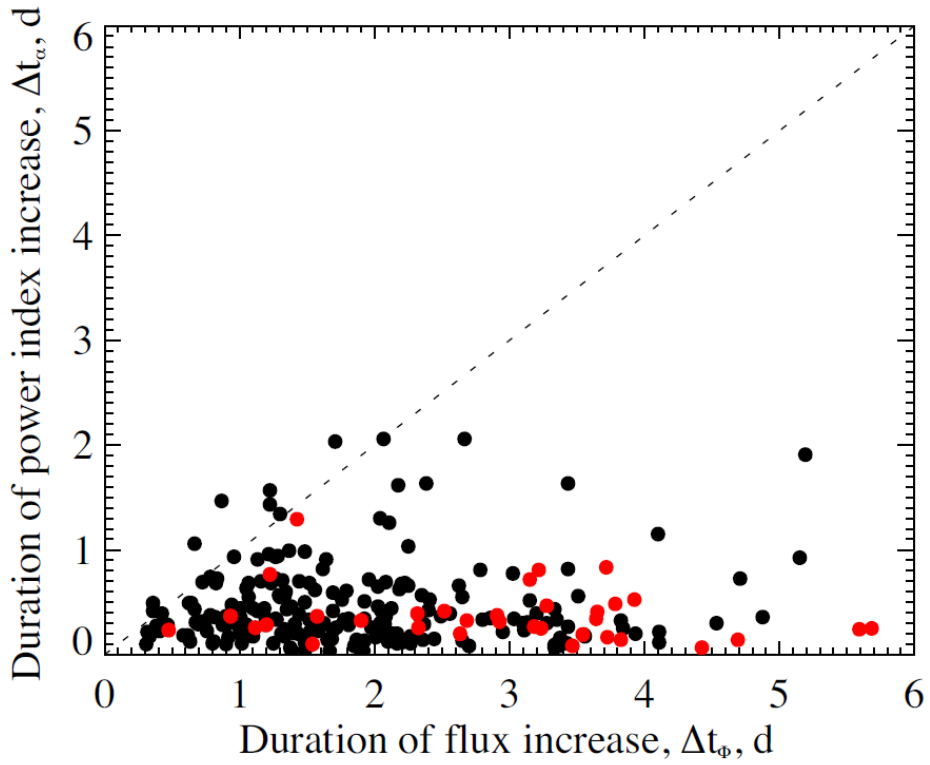
DATA AND METHODS

423 active regions:

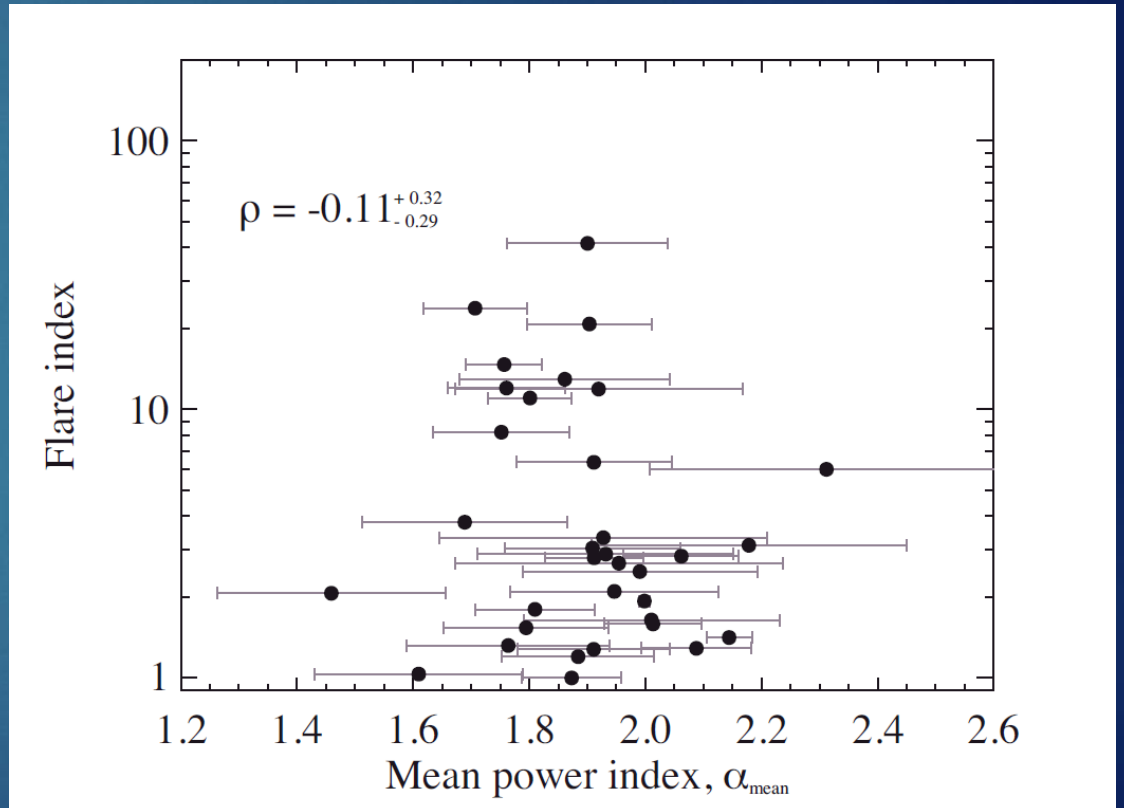
- The power index, α;
- The duration of the power index increase, $\Delta t_\alpha = t_\alpha - t_0$;
- The duration of the magnetic flux emergence, $\Delta t_\Phi = t_\Phi - t_0$;
- The flux emergence rate, $R_{av} = (\Phi_{max} - \Phi(t_0))/\Delta t_\Phi$



The duration of power index increase vs the duration of magnetic flux emergence

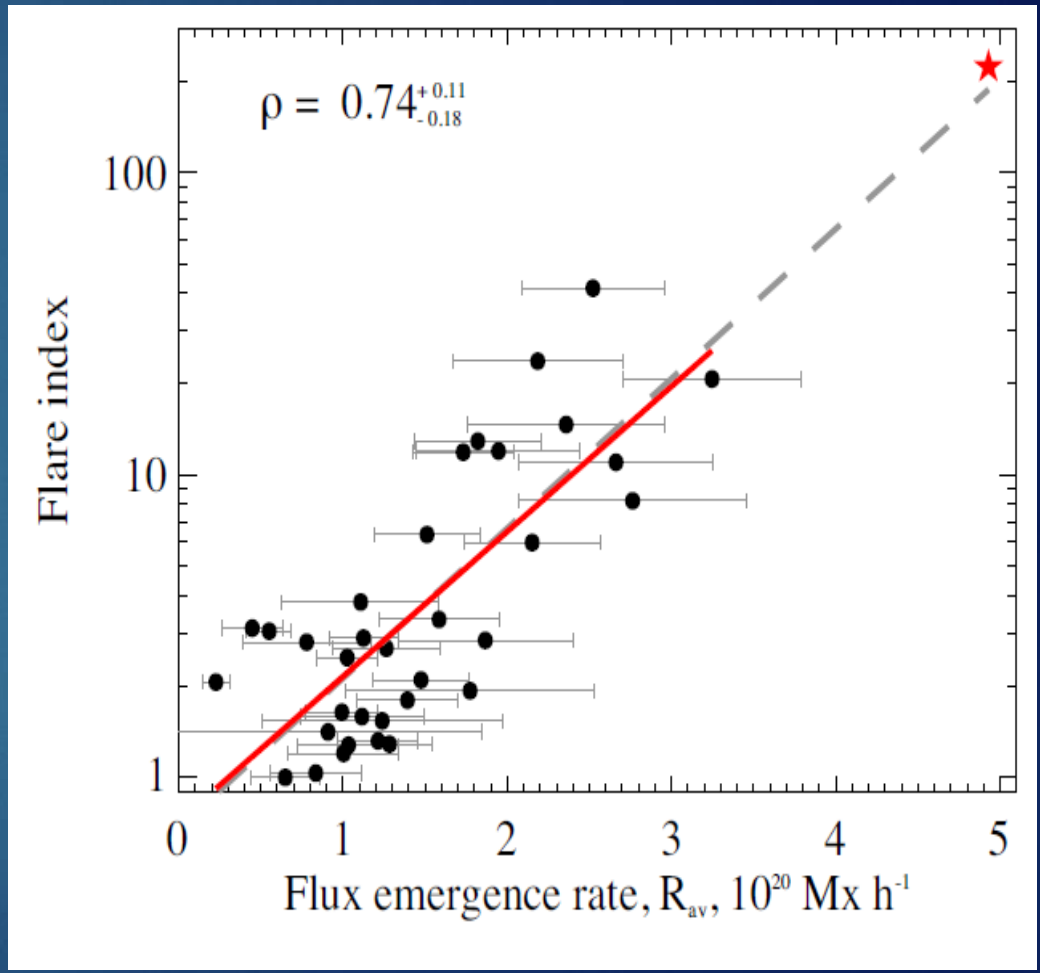


Flare index vs power index – no correlation (?)



CONCLUSIONS

- Power index increases abruptly as soon as the first imprints of magnetic flux appear on the photosphere
- Unfortunately, we found no correlation between the power index and flare productivity for ARs in our dataset
- Flare index shows a good correlation with the flux emergence rate
- Flux emergence rate measurements might be employed to make early forecasts of active region flaring activity (?).



Kutsenko A.S., AbramenkoV.I. and Kutsenko O.K. MNRAS **501,** 6076–6082 (2021)