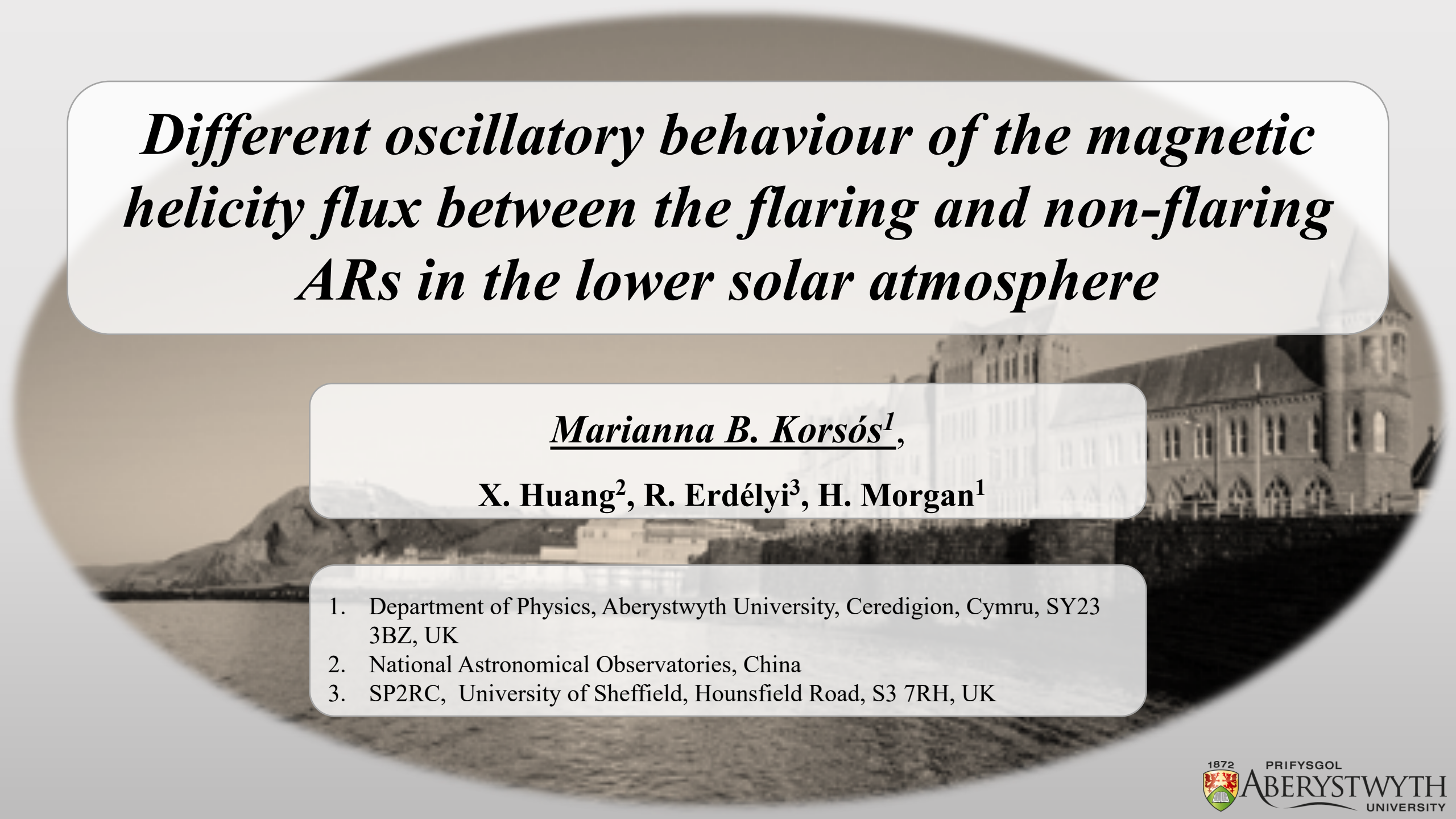
Different oscillatory behaviour of the magnetic helicity flux between the flaring and non-flaring ARs in the lower solar atmosphere

Marianna B. Korsós[1],

X. Huang[2], R. Erdélyi[3], H. Morgan[1]

1. Department of Physics, Aberystwyth University, Ceredigion, Cymru, SY23 3BZ, UK
2. National Astronomical Observatories, China
3. SP2RC, University of Sheffield, Hounsfield Road, S3 7RH, UK



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Oscillation of the magnetic helicity flux components

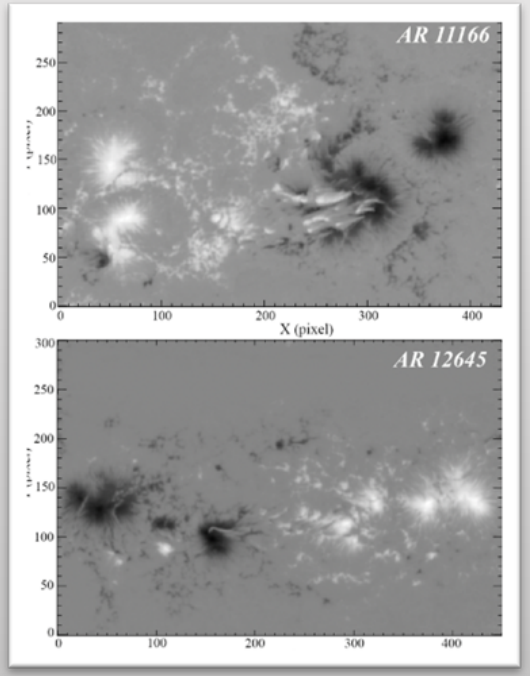
- Magnetic helicity is a typical scalar quantities that contribute to the description of an AR at any instant in 3D.
- The temporal integration of the photospheric helicity flux gives an estimate of its coronal helicity.
- *Korsós et al. (ApJL, 897, 2020)* studied the temporal evolution of shearing, emergence, and total terms of the magnetic helicity flux of 3-3 flaring/non-flaring *delta-type ARs*, during each AR's solar disc passage.

by Berger (1989)

$$\left.\frac{dH}{dt}\right|_S = 2\int_S (\mathbf{A}_p \cdot \mathbf{B}_h)\mathbf{v}_{\perp z} dS - 2\int_S (\mathbf{A}_p \cdot \mathbf{v}_{\perp h})\mathbf{B}_z dS$$

Horizontal= Shearing Perpendicular =Emergence

Flaring ARs			Non-flaring ARs		
AR	Common periods	Flares	AR	Common periods	Flares
AR 11166	**YES**	**X1.5**	**AR 12645**	**No**	**C-class No CME**
AR 12192	**YES**	**M8.6/X1.6 X3.1/X1.0/X2.0**	**AR 12470**	**No**	**C-class No CME**
AR 11890	**YES**	**X3.1/X1.1 X1.1**	**AR 11785**	**No**	**C-class No CME**



Oscillation of the magnetic helicity flux components

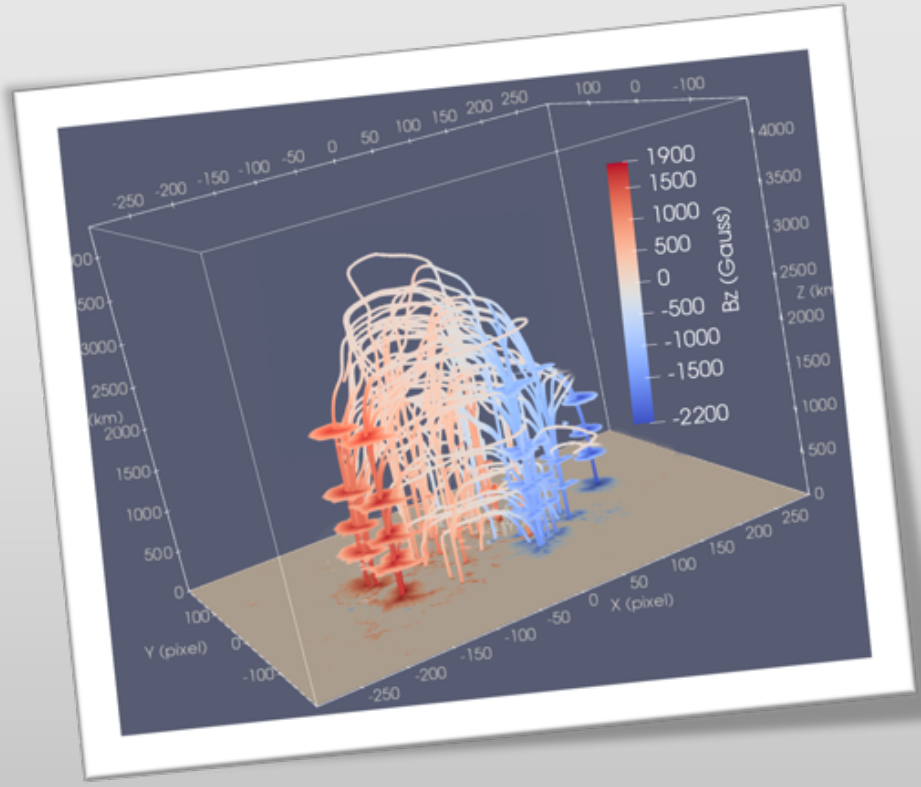
For the study:

1) The *3D solar coronal magnetic fields* of 14 Flaring (X-class) and 10 Non-flaring *delta –type ARs* were obtained by *PF extrapolation* **from photosphere to 3.6 Mm** with **z**=SDO/HMI pixel (0.5 arcsec) **step size.**

2) The **temporal resolution** is **an hour**.

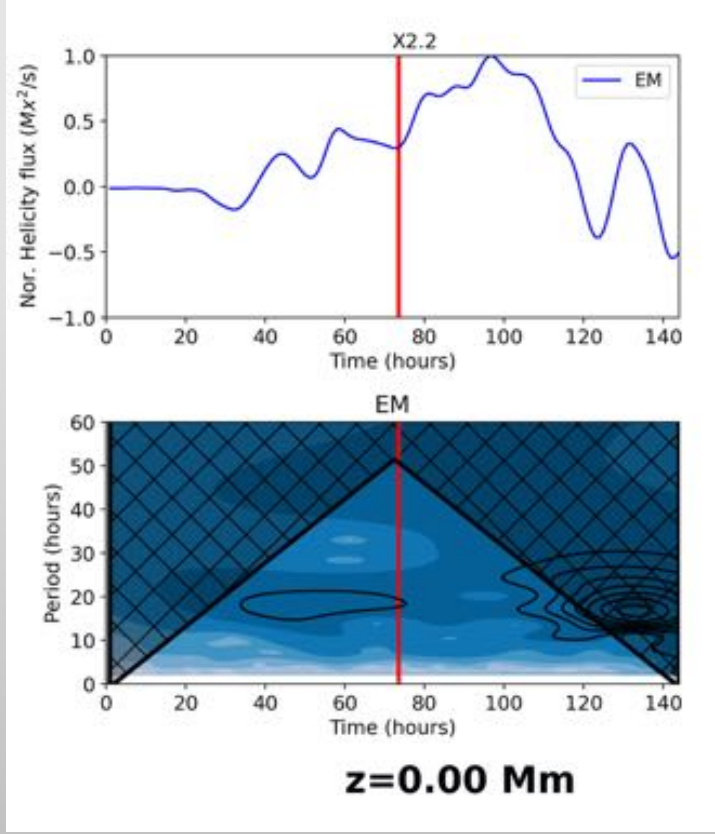
3) The *Emergence (EM), Shearing (SH), and Total helicity flux terms* were *calculated with DAVE4VM* (Schuck, ApJ, 2008) from the photosphere up to 3.6 Mm at each 0.36 Mm step.

4) To ***investigate distinctive oscillatory patterns*** of the ***three helicity flux terms as a function of height***, we focus on ***the evolution of three magnetic helicity injection rates by wavelet analyses.***

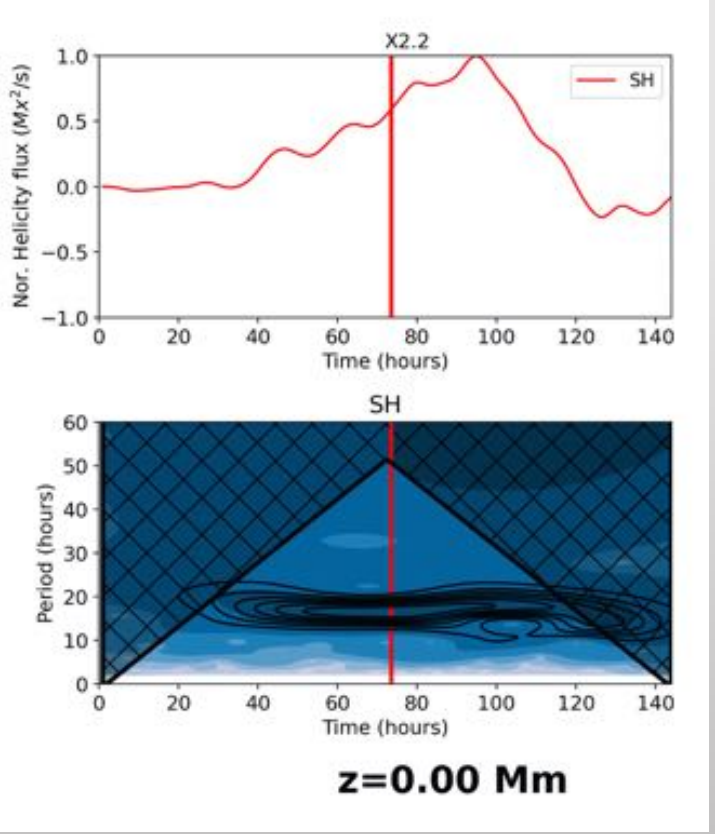


Flaring AR 11158

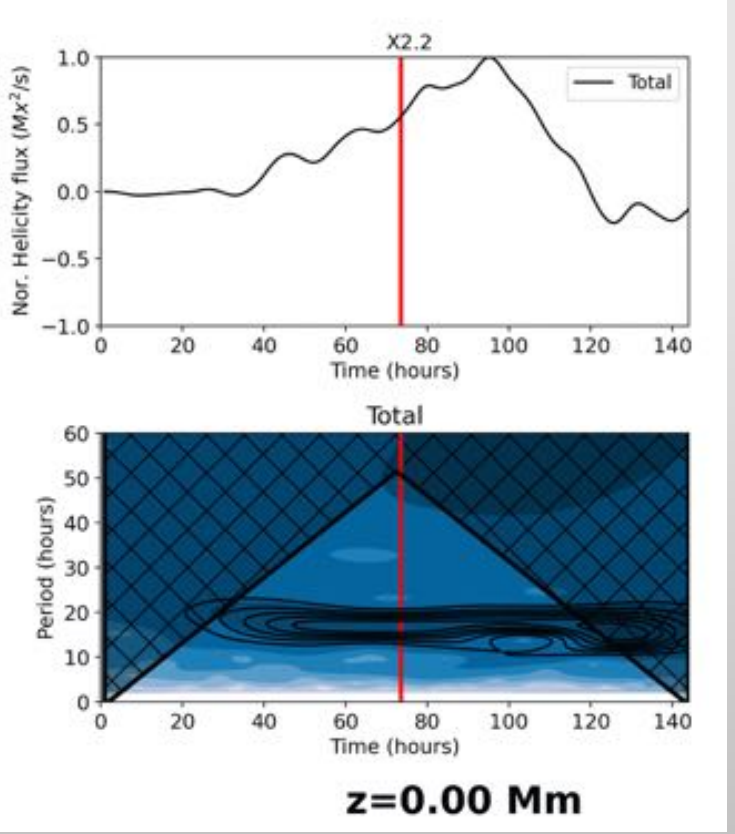
Emergence term



Shearing term

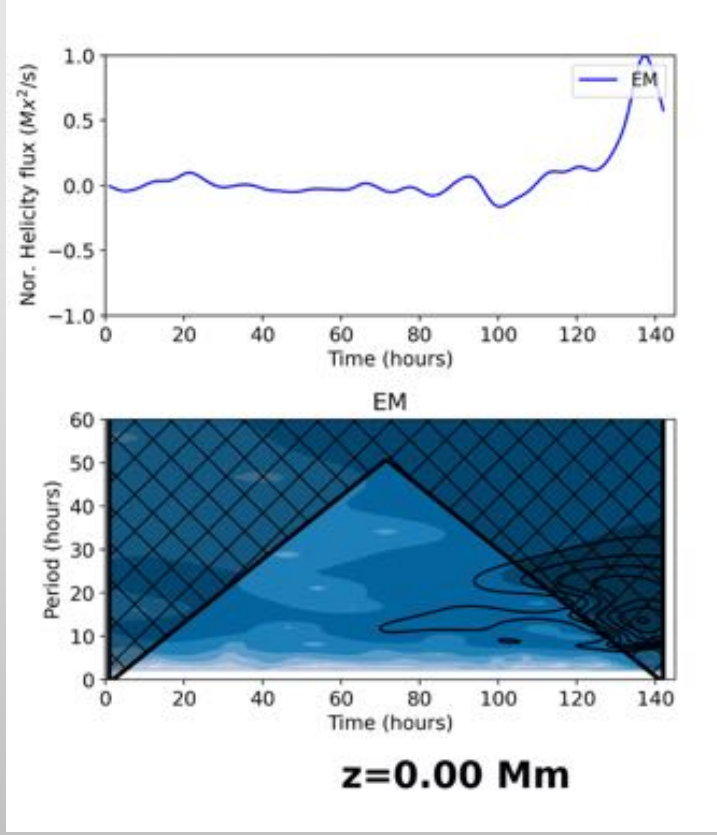


Total

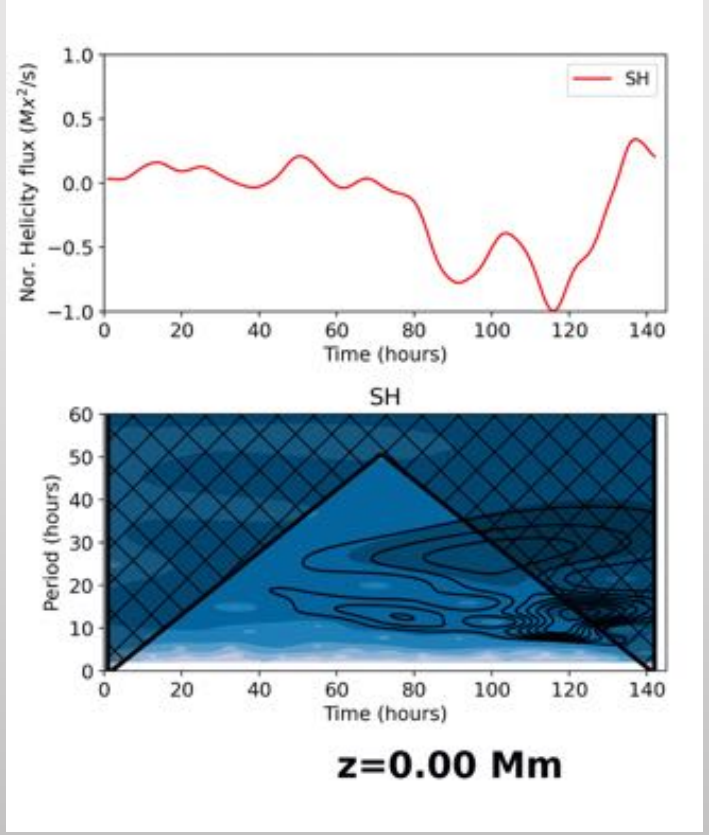


Non-Flaring AR 12047

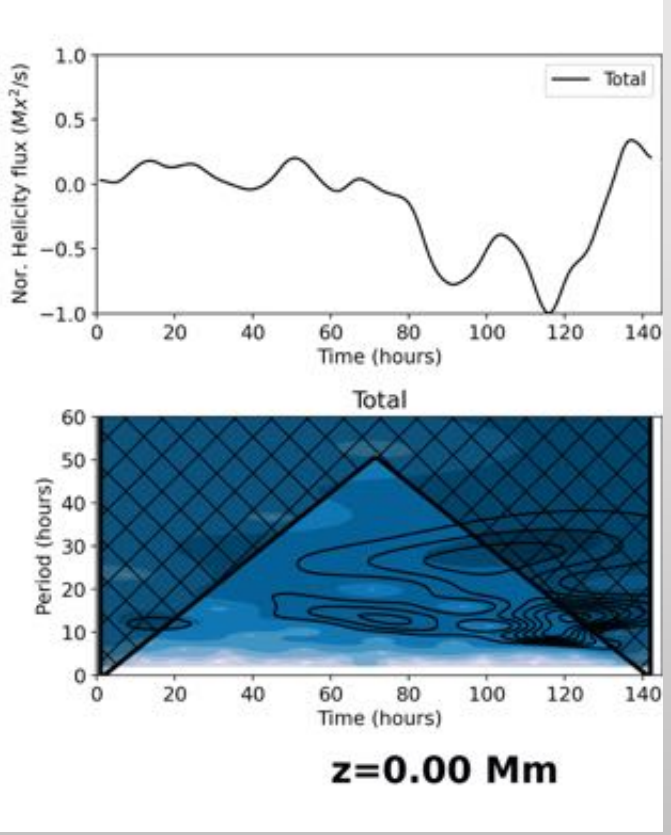
Emergence term



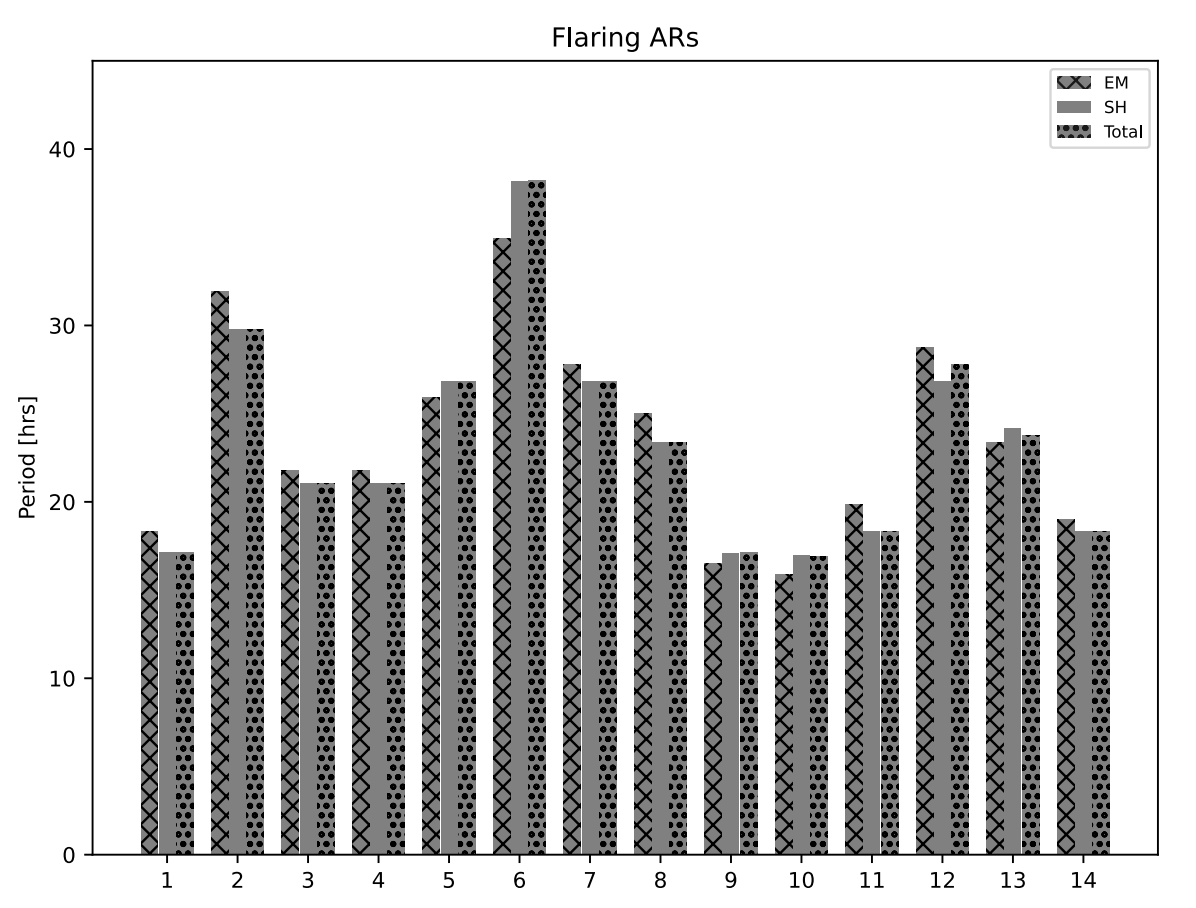
Shearing term

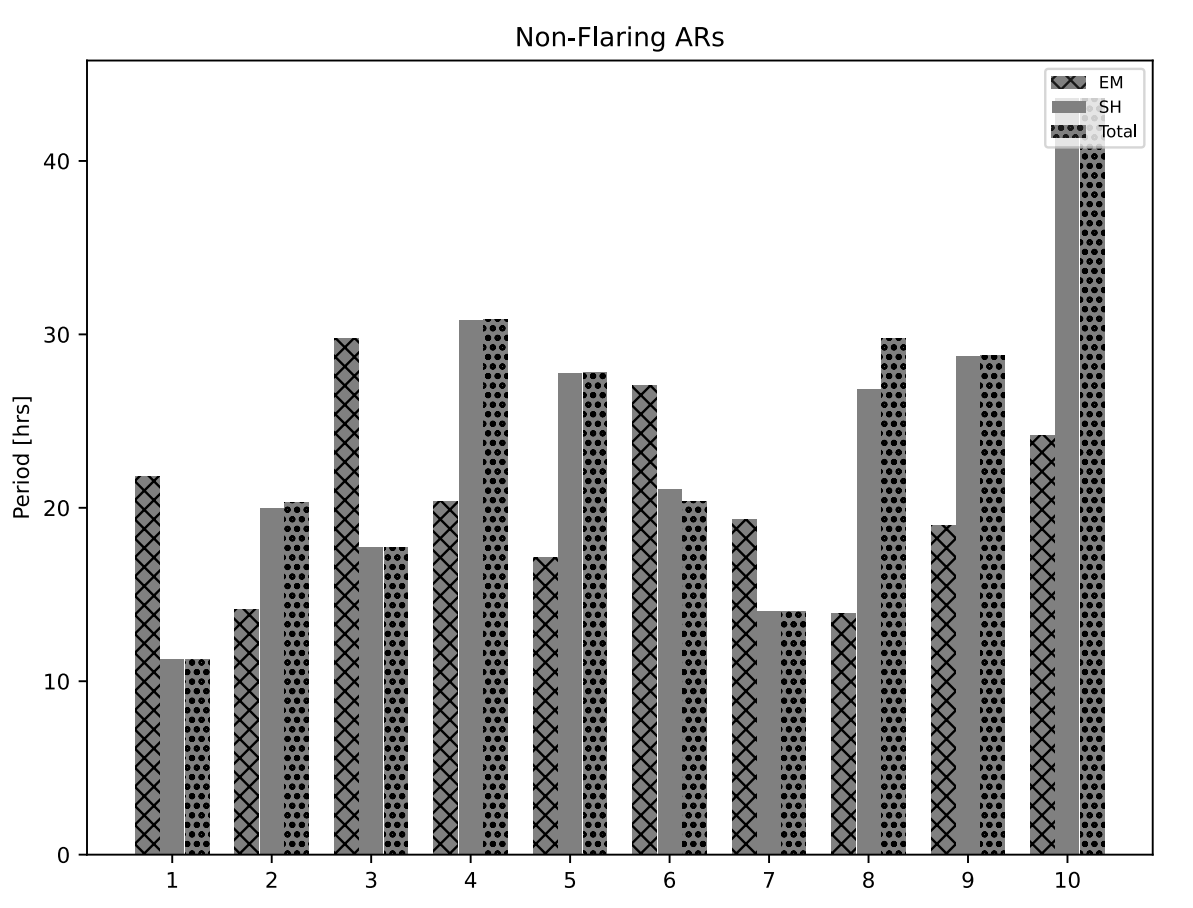


Total



Different Oscillation behaviour of the magnetic helicity flux components in Flaring and Non-Flaring ARs



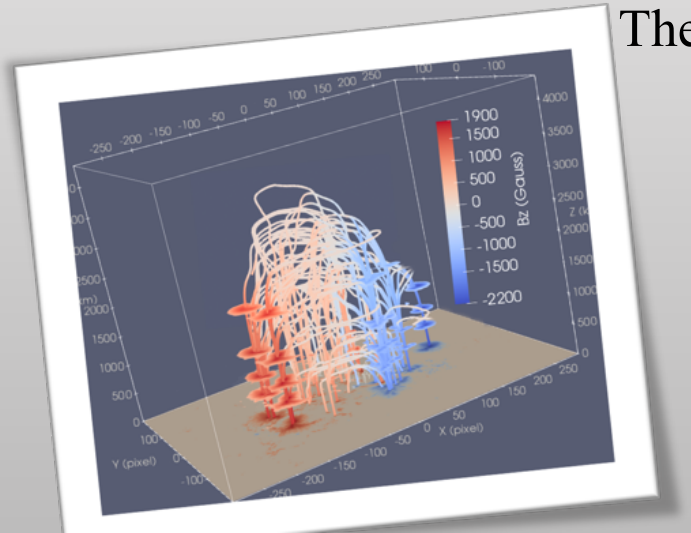


Summary

- The *3D solar coronal magnetic fields* of 14 Flaring (X-class) and 10 Non-flaring **delta-type ARs** were obtained by *PF extrapolation* **from photosphere to 3.6 Mm.**

- In the lower solar atmosphere, normalized Emergence, Shearing, and Total helicity flux terms
  - Flaring ARs:
    - *The largest oscillation of the three helicity fluxes are quasi-similar.*
    - *The common periods appearing before the flare from the photosphere up to the lower corona.*
  - Non-Flaring ARs:

    There is NO common long period oscillation of the three helicity flux term.



When the *horizontal and the vertical components* of the helicity flux became a *coupled oscillator system then* the AR would be cradle of *larger energetic explosion(s)*.