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Spatial and Temporal Distribution of Nanoflare Heating during Active Region Evolution

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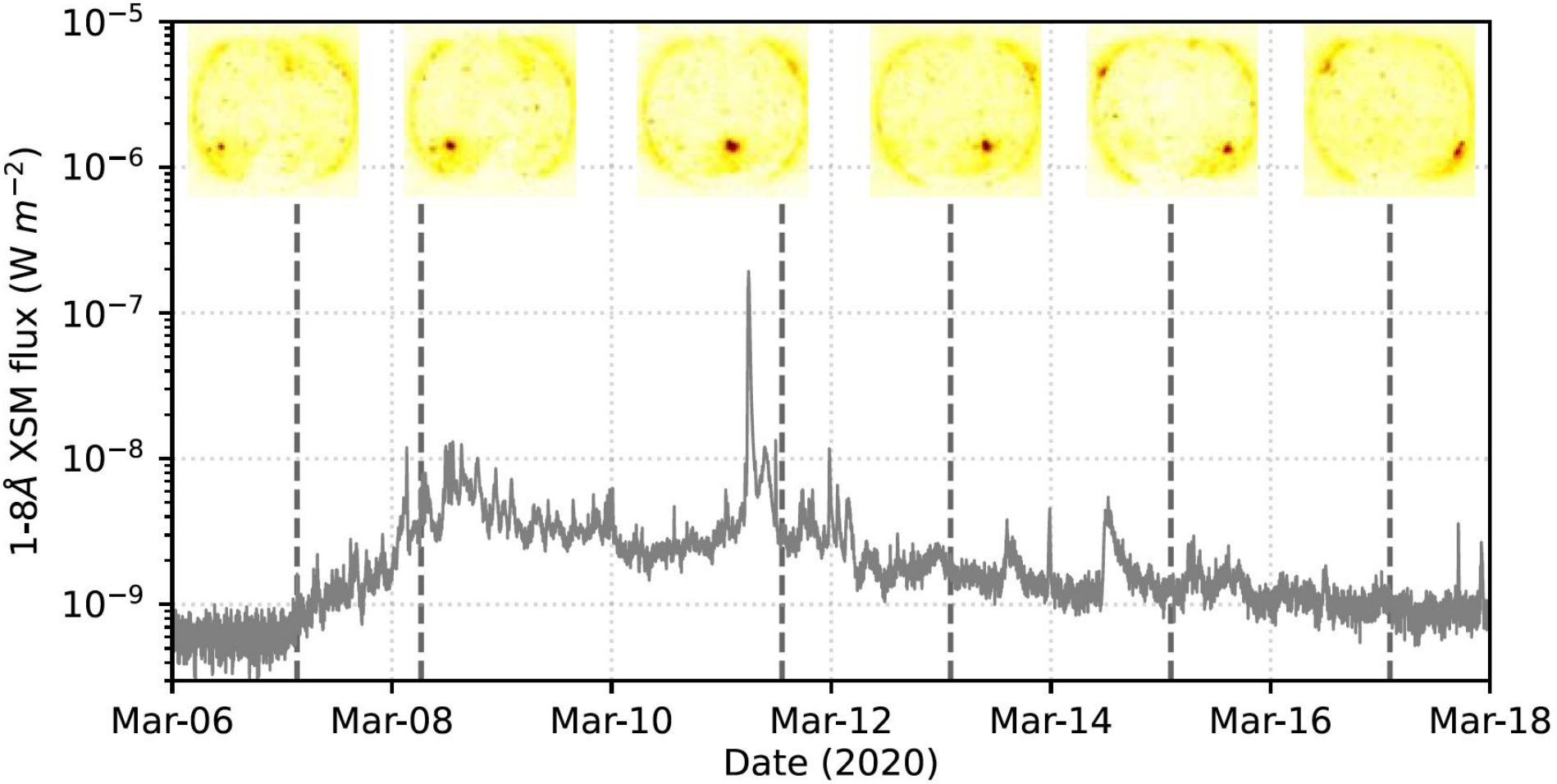
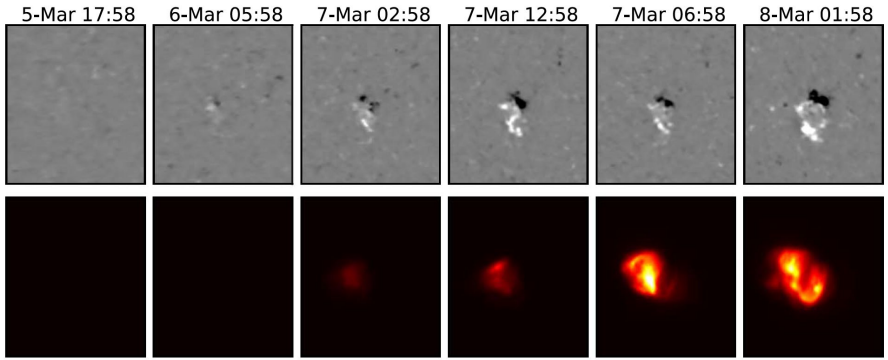
We choose AR 12758

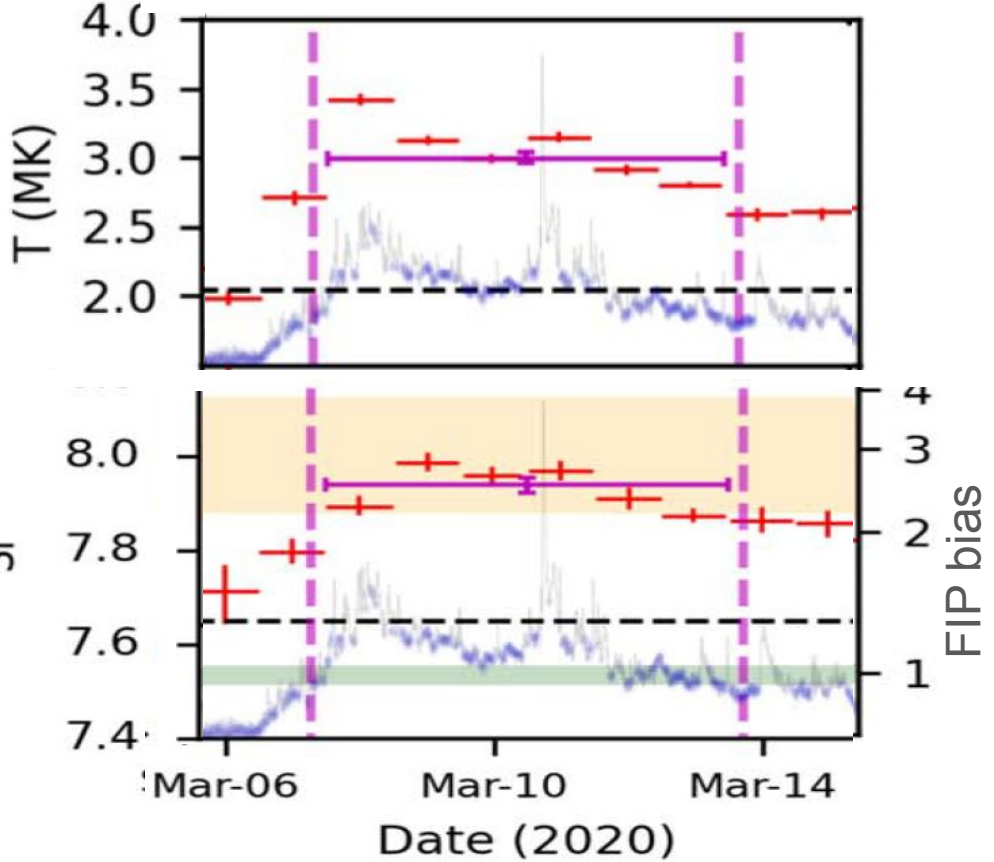


Formation of AR12758



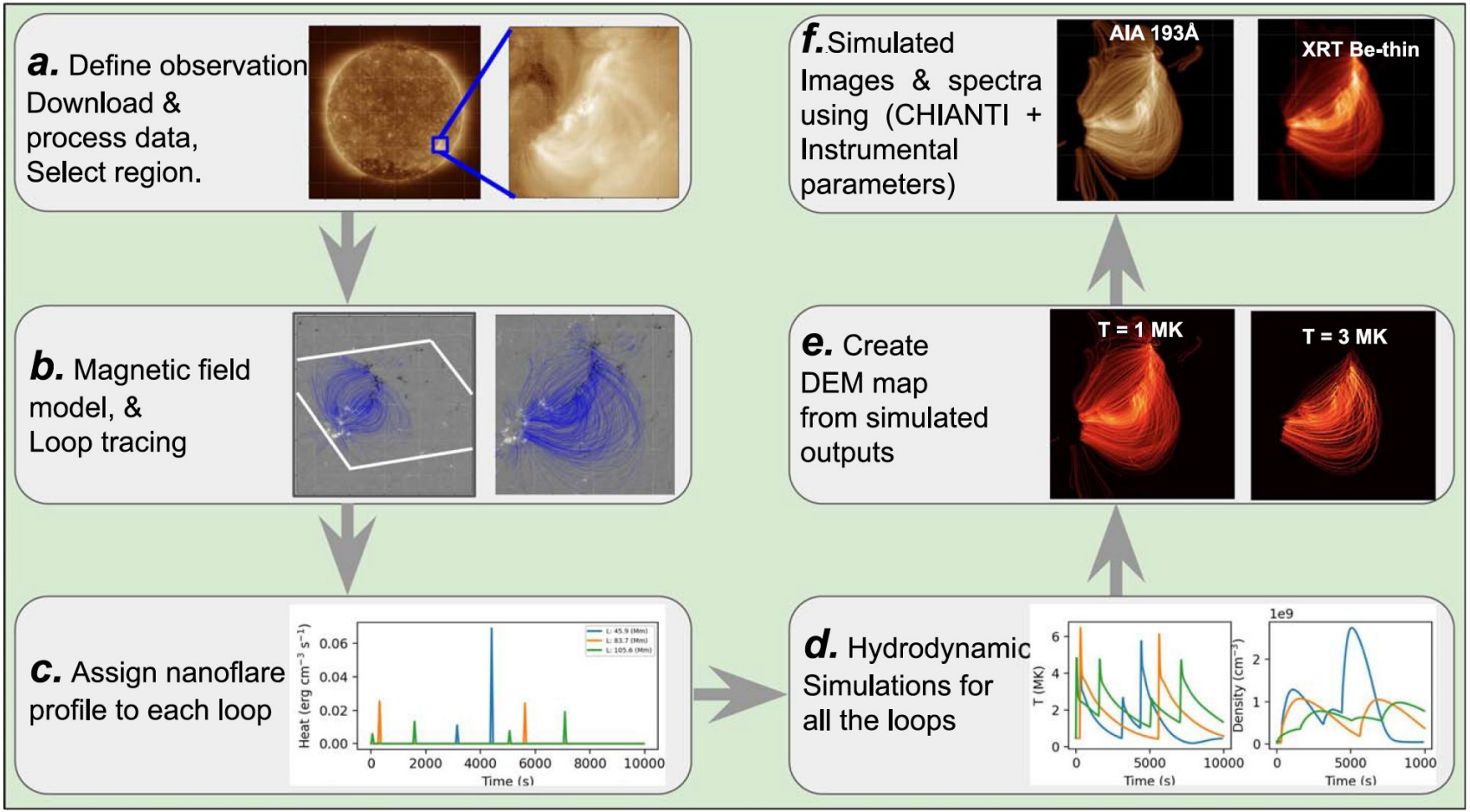
Evolution of this AR was studied from soft X-ray disk-integrated spectroscopy.

Evolution of plasma parameters!



Mondal et al (ApJ 955:146, 2023b)

Combined observations with model



https://github.com/biswajitmb/SunX.git

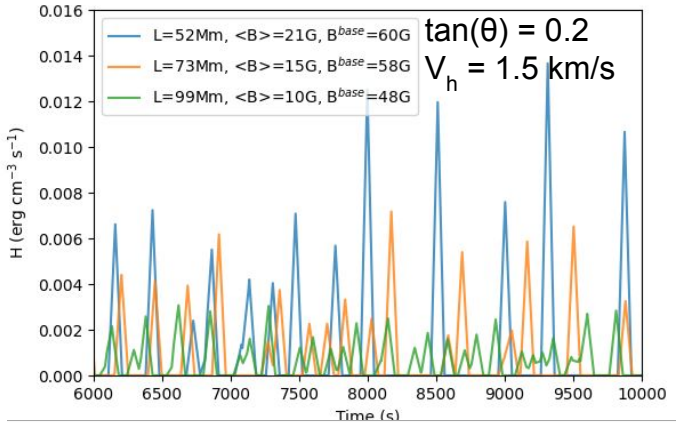
Nanoflare heating sequence

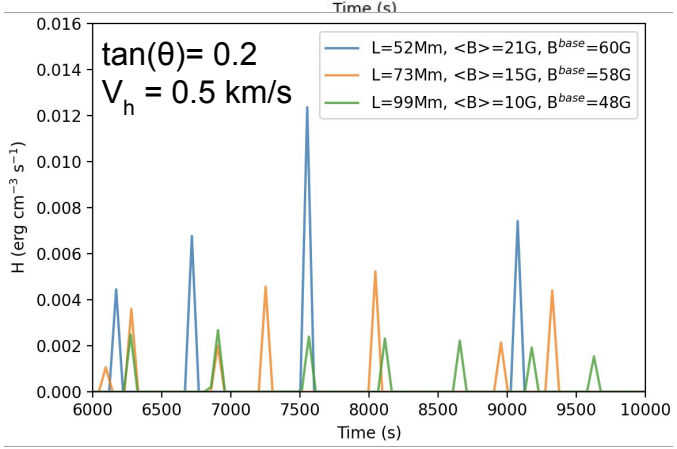
- Consider triangular heating profiles having a duration, τ = 100 s.
- The peak heating rate during an event is randomly chosen between minimum (H_0^{min}) and maximum (H_0^{max}) values that are loop dependent.

$$H_{0_i}^{max} = \frac{1}{\tau}\frac{(tan(\theta) < B >_i)^2}{8\pi}(erg\ cm^{-3}\ s^{-1})$$

$$d_i^l = \frac{\tau L}{F_i} \times H_i^{l-1}$$

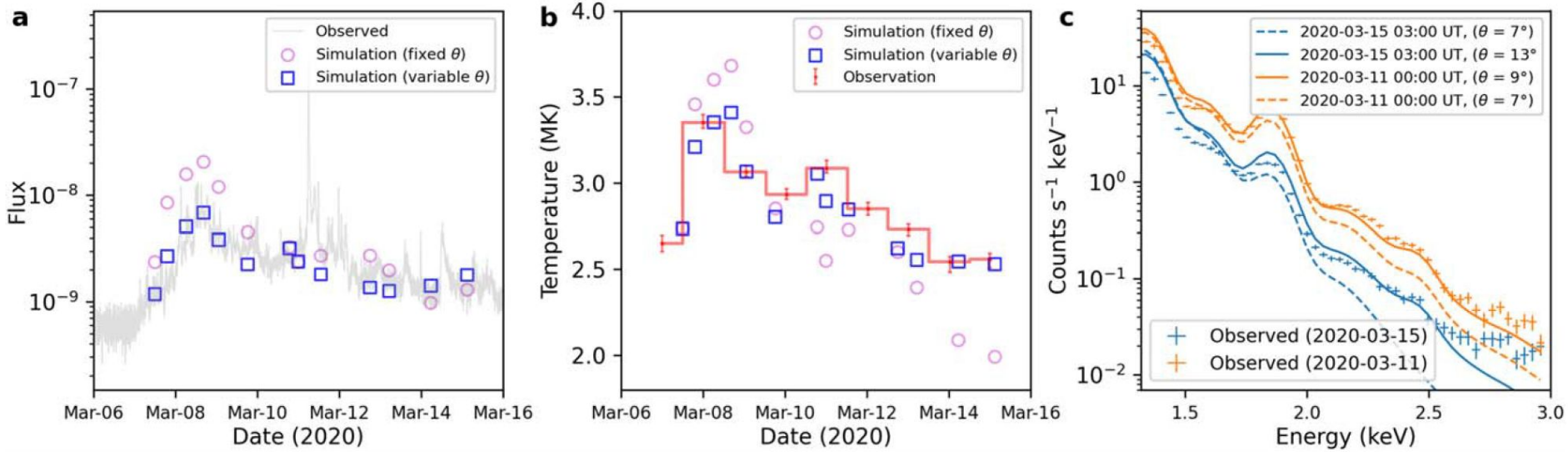
$$F = -\frac{1}{4\pi} V_h tan(\theta) B^{base} < B >$$



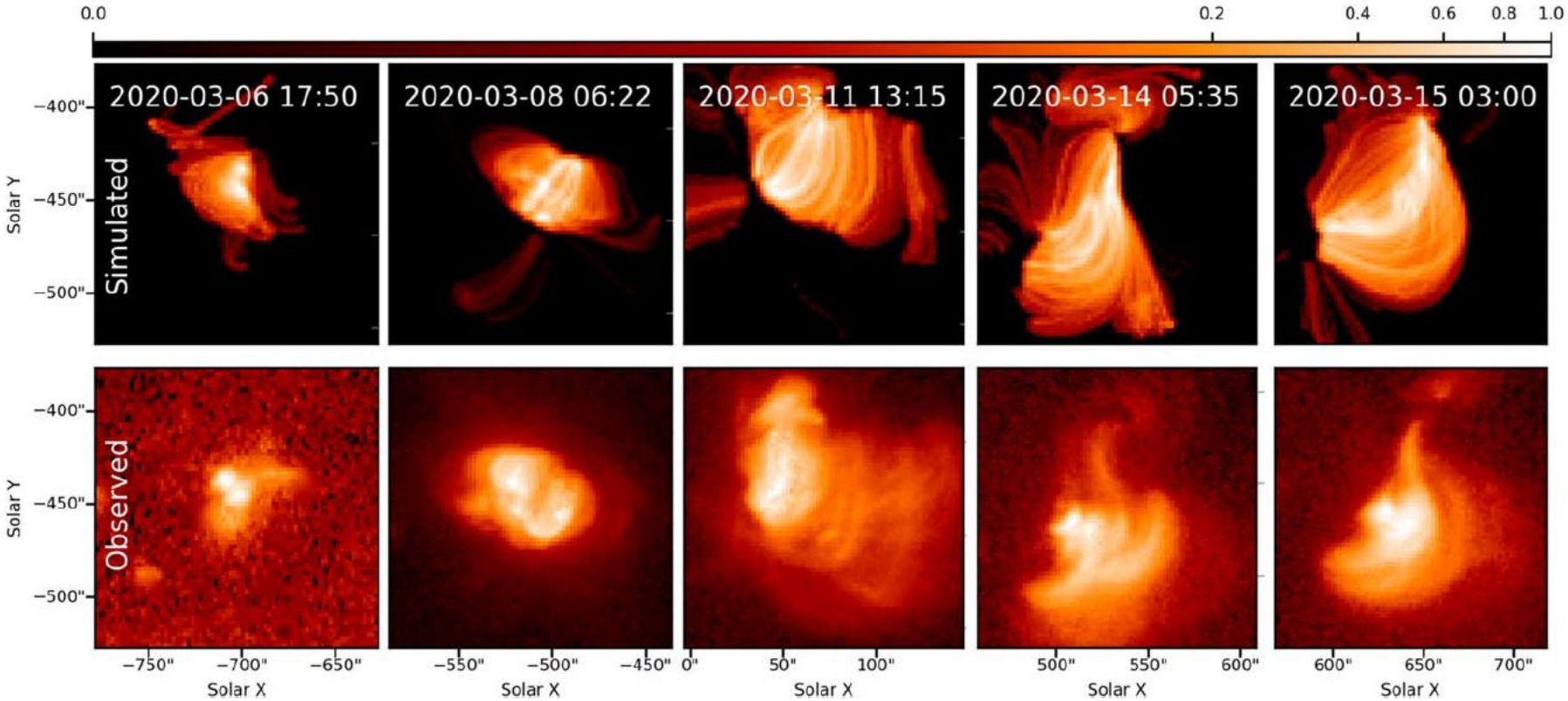


Mondal et al (ApJ 945:37 2023a)

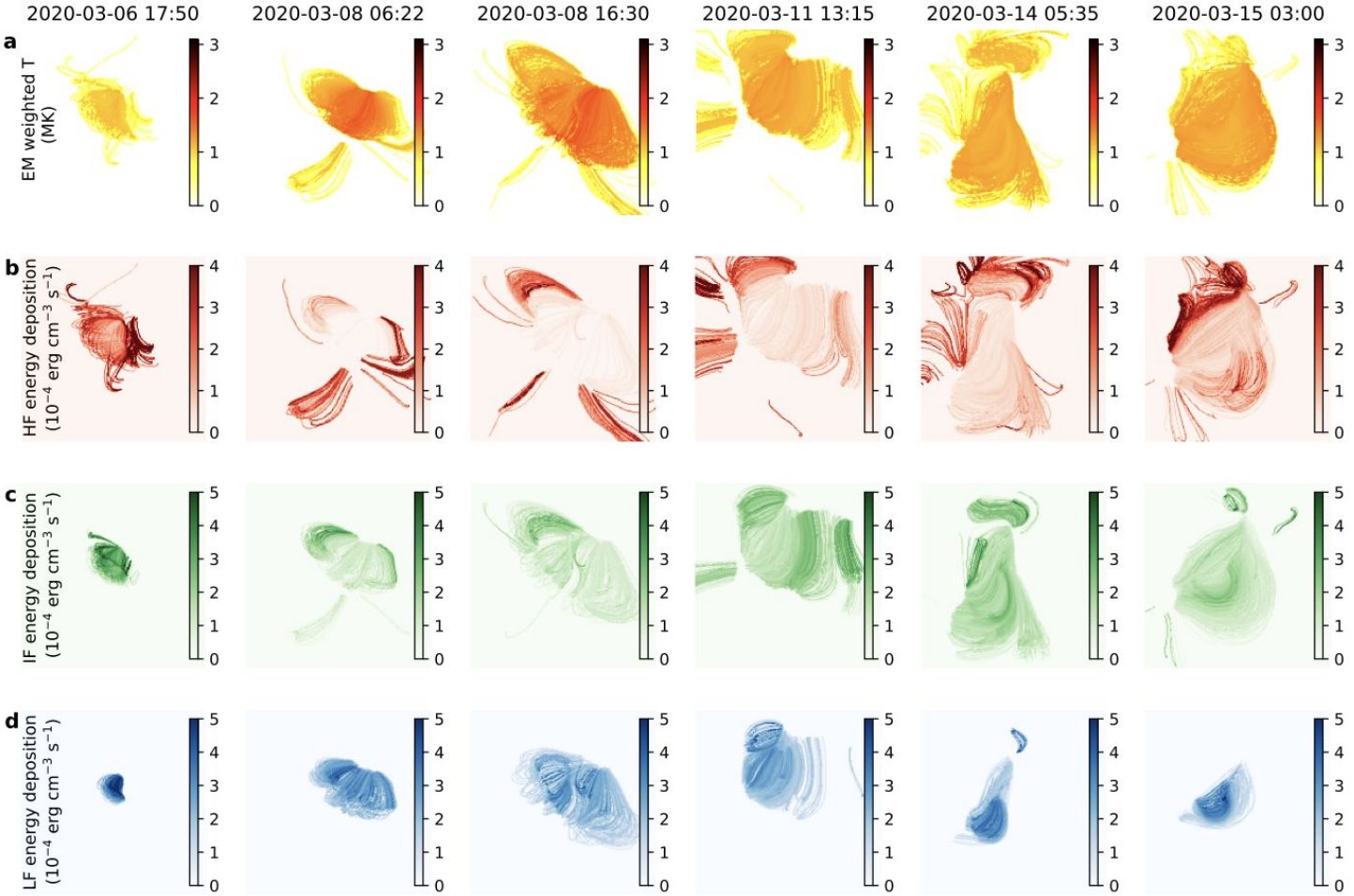
Observed and predicted X-ray flux and temperature



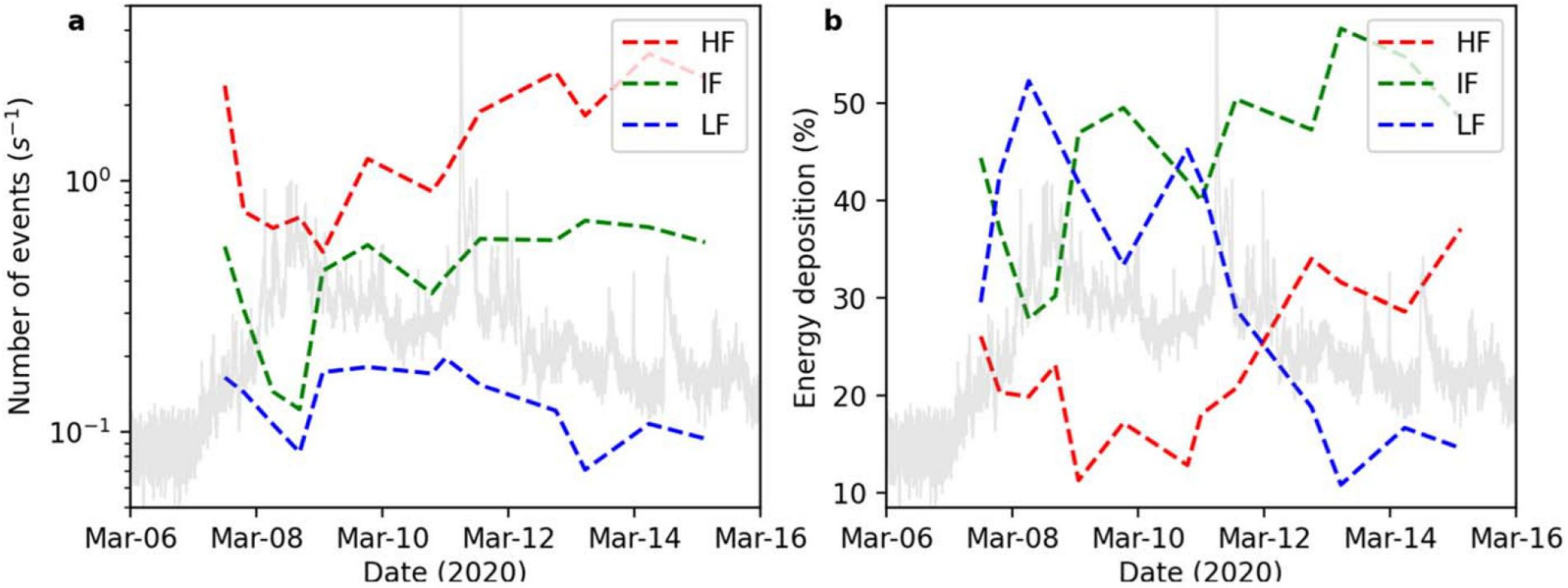
Observed and predicted X-ray emission geometry



Heating is different over time and space



Time evolution of nanoflare heating



Summary

- Investigated the evolution of nanoflare heating during the evolution of AR 12758.
- Heating frequency is highly changes with the evolution of AR.
- Model could reproduce the observed spatially integrated variation of X-ray flux and temperatures.
- During the emerging phase, energy deposition is dominated by LF events. Post-emergence, energy is deposited by both LF and IF nanoflares.
- As the AR ages, the contribution from IF and HF nanoflares increases.
- Spatial distribution of heating frequencies across the AR reveals a clear pattern:
  - core of the active region spends most of its time in a LF heating state.
  - periphery is dominated by HF heating
  - the region between the core and periphery experiences IF heating.

Thank You for your attention!