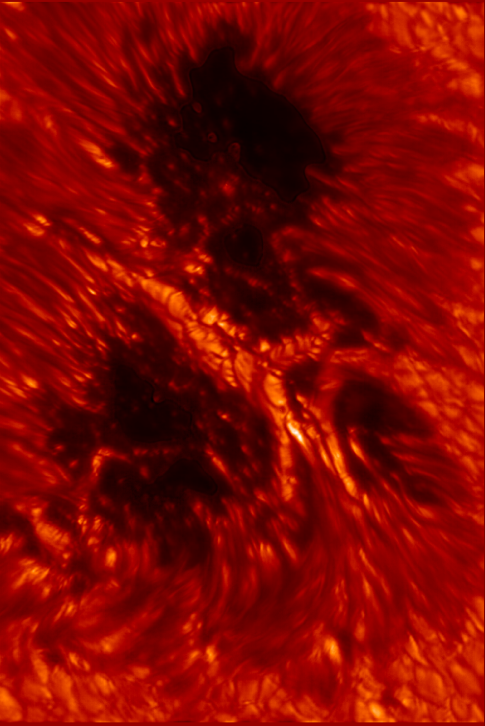




Identification of chromospheric dynamical signatures in solar flares with DKIST

Sarah Riley^{1,2}

¹Montana State University,
Department of Physics

²DKIST Ambassador,
National Solar Observatory

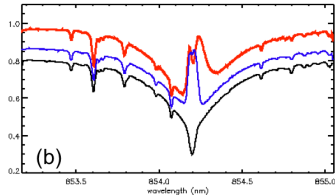
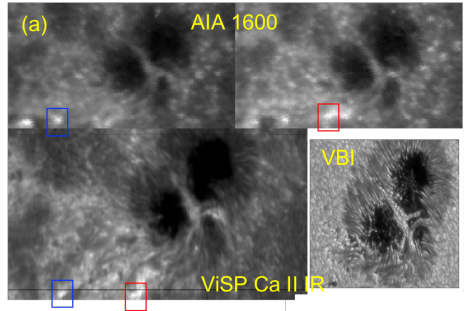
Hinode-17/IRIS-15/Sphere-3 Conference
2024 Jul 26

- ▶ Investigate the **temporal-spatial scales** of flare energy release, and dynamics at these scales, and use these signatures to diagnose associated physical mechanisms involved in flare loop heating.

Motivating Question

- ▶ What dynamical signatures are associated with different evolutionary stages of solar flares?

- ▶ Atmospheric energy transfer mechanisms
 - ▶ Thermal conduction
 - ▶ Non-thermal electrons
- ▶ Waves
- ▶ etc...



N-D k-means

$$\text{data}_m = X_m = (x_{m,1}, \dots, x_{m,n})$$

Goal: Minimize the “Within cluster distance”($\mathcal{D}$).

$$\mathcal{D} = \sum_{i=1}^M \sum_{j=1}^k \delta_{c_i,j} \|X_i - \mu_j\|^2$$

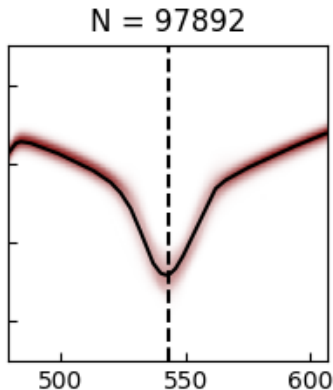
Iterative approach

- Update the label association

$$c_j = \underset{1 \leq j \leq k}{\operatorname{argmin}} \|X_i - \mu_j\|^2$$

- Update the decision centroid

$$\mu_j = \frac{1}{M_j} \sum_{i=1}^M \delta_{c_i,j} X_i$$



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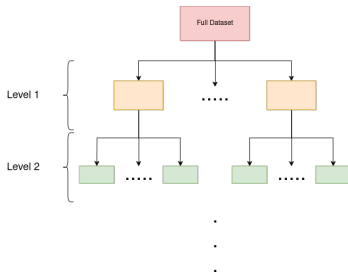
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Hierarchical k-means

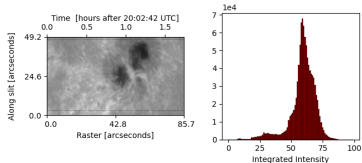
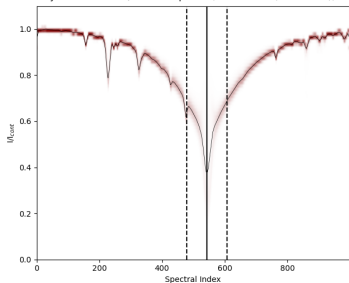
- Useful when the data has structure.
- Improved computational performance



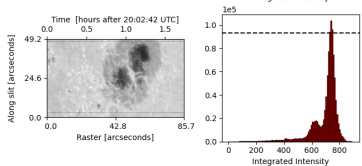
Current results

2022 Dec 27 (AR 13176)

Intensity statistics and Quiescent Spectra (AKEMR Ca II (854.21 nm))



Intensity calculations with the spectral interval

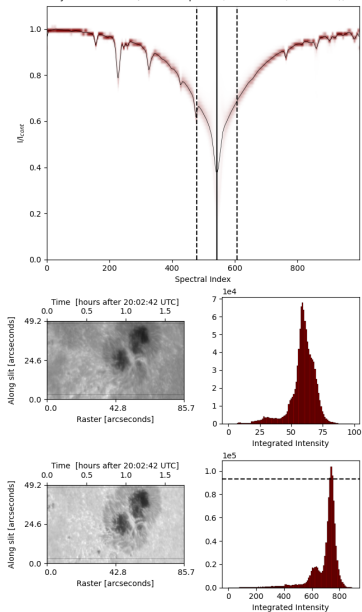


Intensity calculations with the full spectrum

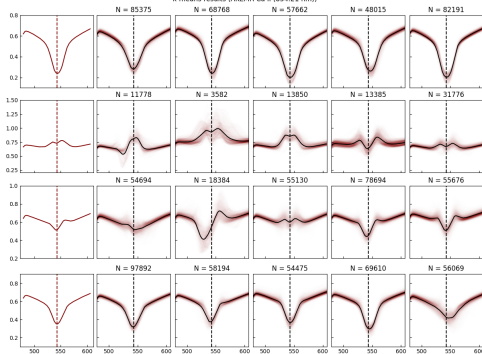
Current results

2022 Dec 27 (AR 13176)

Intensity statistics and Quiescent Spectra (AKEMR Ca II (854.21 nm))



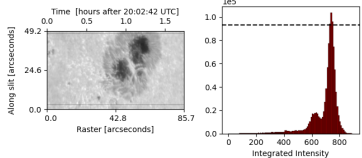
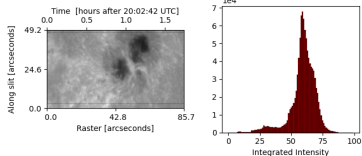
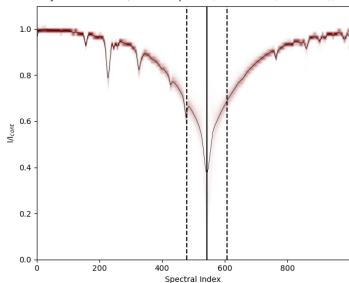
k-means results (AKEMR Ca II (854.21 nm))



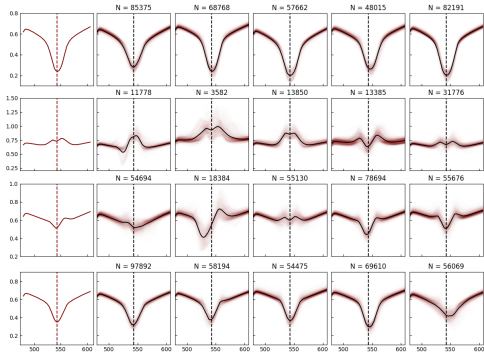
Current results

2022 Dec 27 (AR 13176)

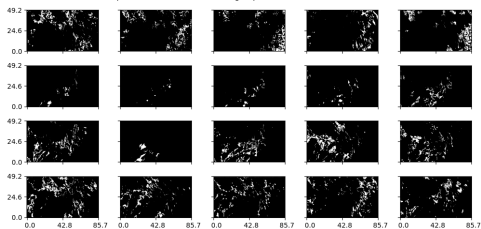
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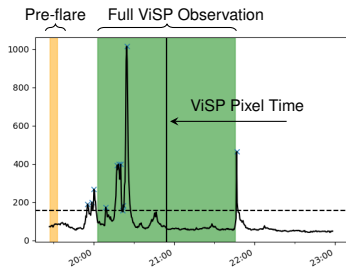
k-means results (AKEMR Ca II (854.21 nm))



spatial distribution of k-means groups (AKEMR Ca II (854.21 nm))



Spectral profiles in time

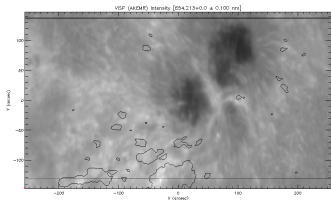


$$\Delta t = \text{ViSP Obs Time} - \text{AIA Peak Time}$$

- ▶ $\Delta t > 0$ (Decay Phase)
- ▶ $\Delta t < 0$ (Rise Phase)

Filters

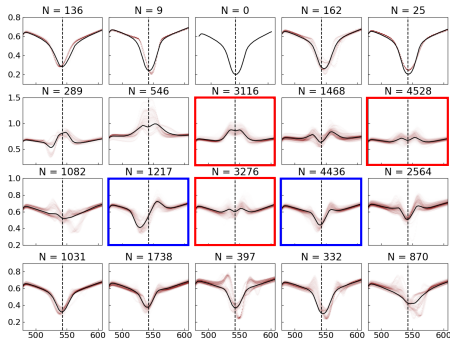
- ▶ AIA 1600 Peak $\geq 2 \times$ Pre-flare
- ▶ Only Flaring Pixels



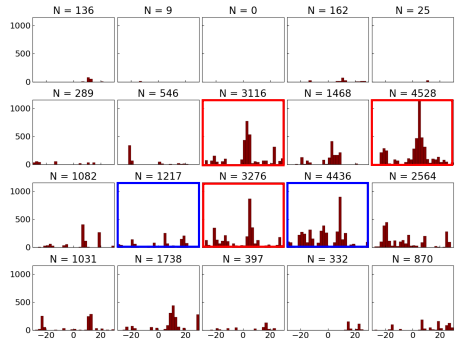
Current results

Time analysis

Filtered subset



± 30 minutes interval

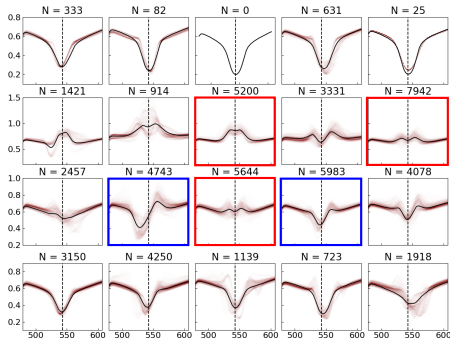


- **Centroid reversal groups** most dense: $|\Delta t| \leq 10$ minutes
- **Asymmetric absorption groups** most dense: $|\Delta t| \geq 10$ minutes

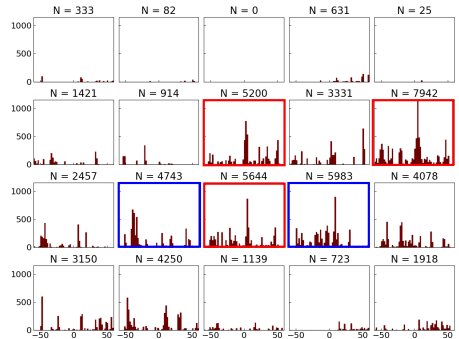
Current results

Time analysis

Filtered subset



± 60 minute interval



- Centroid reversal groups most dense: $|\Delta t| \leq 10$ minutes
- Asymmetric absorption groups most dense: $|\Delta t| \geq 10$ minutes

Concluding remarks

Review

From the **k-means analysis** :

- ▶ We efficiently identified dynamic signatures on the DKIST scale

From the **time analysis** :

- ▶ We showed how the dynamic signatures are distributed in the AIA 1600 evolution of a flaring pixel

Next steps

- ▶ Utilize ViSP/VBI observations to conduct time analysis
- ▶ Compare the decision centroids to radiative transfer model derived spectra

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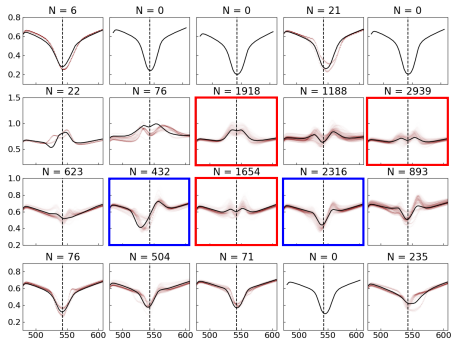
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-

Thank You

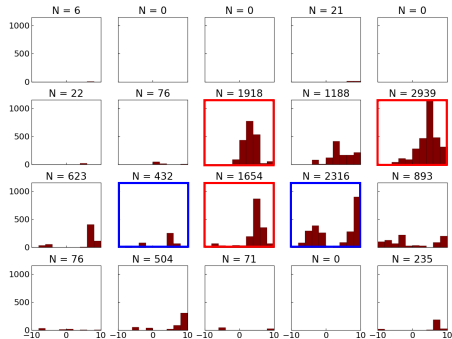
sarah.riley1@montana.edu

Backups

Filtered subset



± 10 minute interval



- Centroid reversal groups most dense: $|\Delta t| \leq 10$ minutes
- Asymmetric absorption groups most dense: $|\Delta t| \geq 10$ minutes