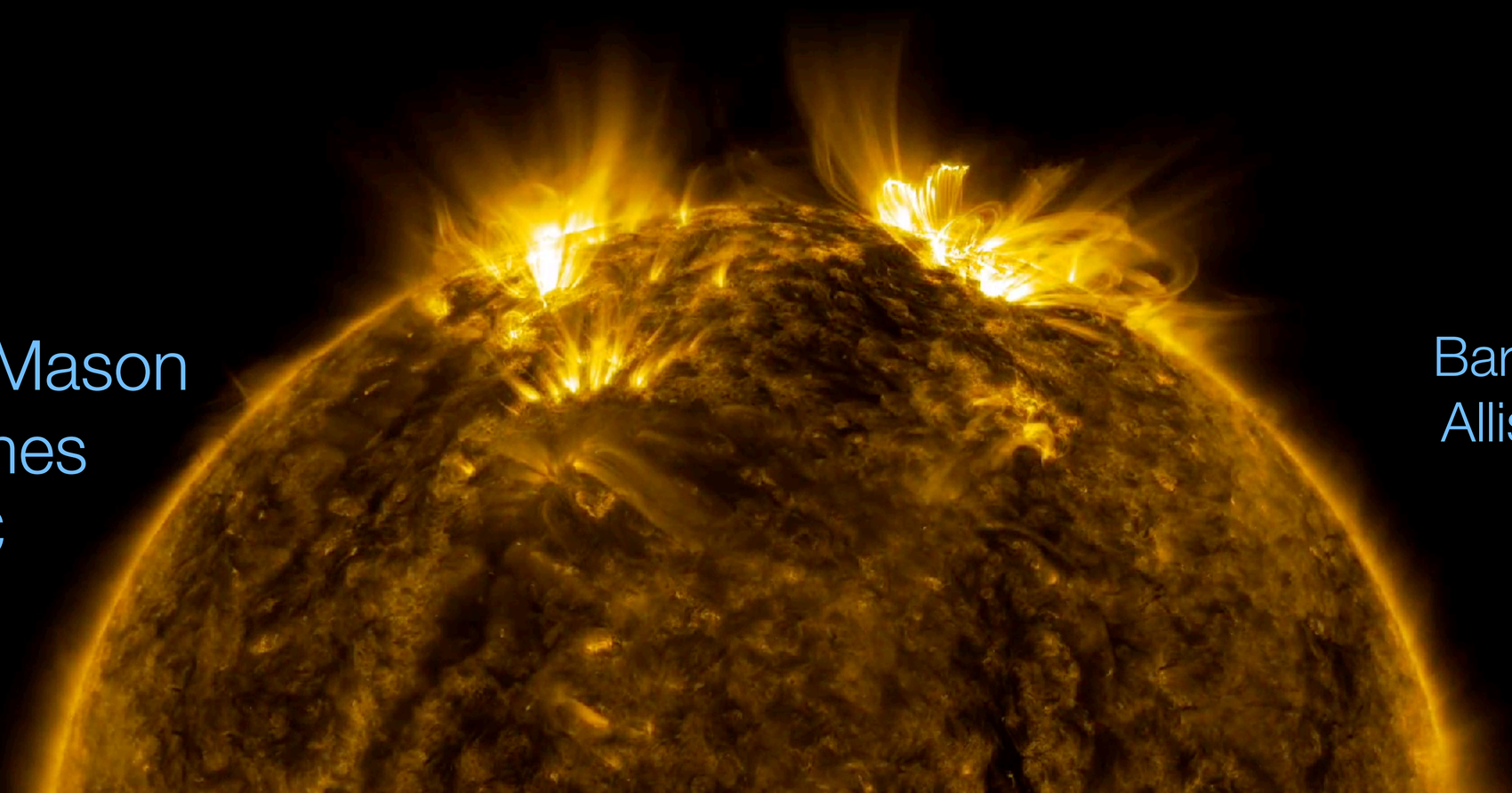
Irradiance Coronal Dimming
and its
Connection to CME Kinematics



James Paul Mason
@starfleetjames
NASA/GSFC
NPP Fellow

Barbara Thompson
Allison Youngblood
Nick Arge

2018-08-02

Background

Why coronal dimming and what is it?

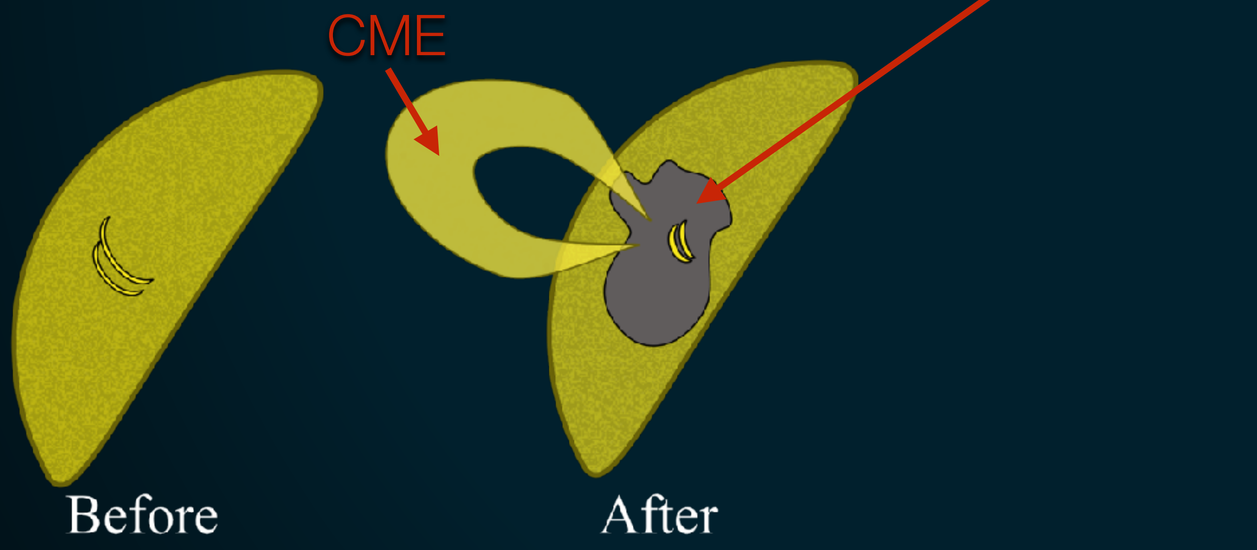
Problem statement

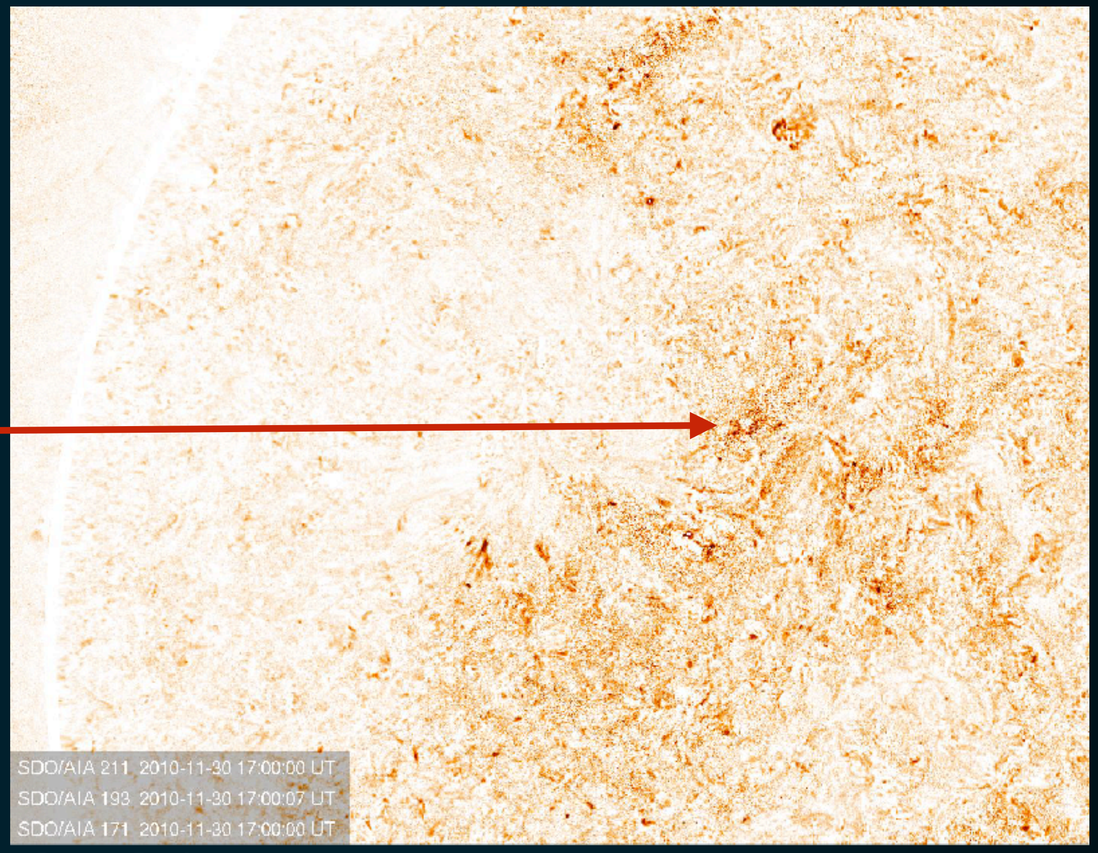
- Establish connections between **irradiance** coronal dimming and CME kinematics
- Then we can create new space weather instruments, and **estimate stellar CME speed & mass**[1]

[1] *Harra et al., Sol. Phys., 291:1761 (2016)*

What dimming looks like: images

- μ lifetime = 8 hours
- Rarely > 24 hours
- “Transient coronal holes”





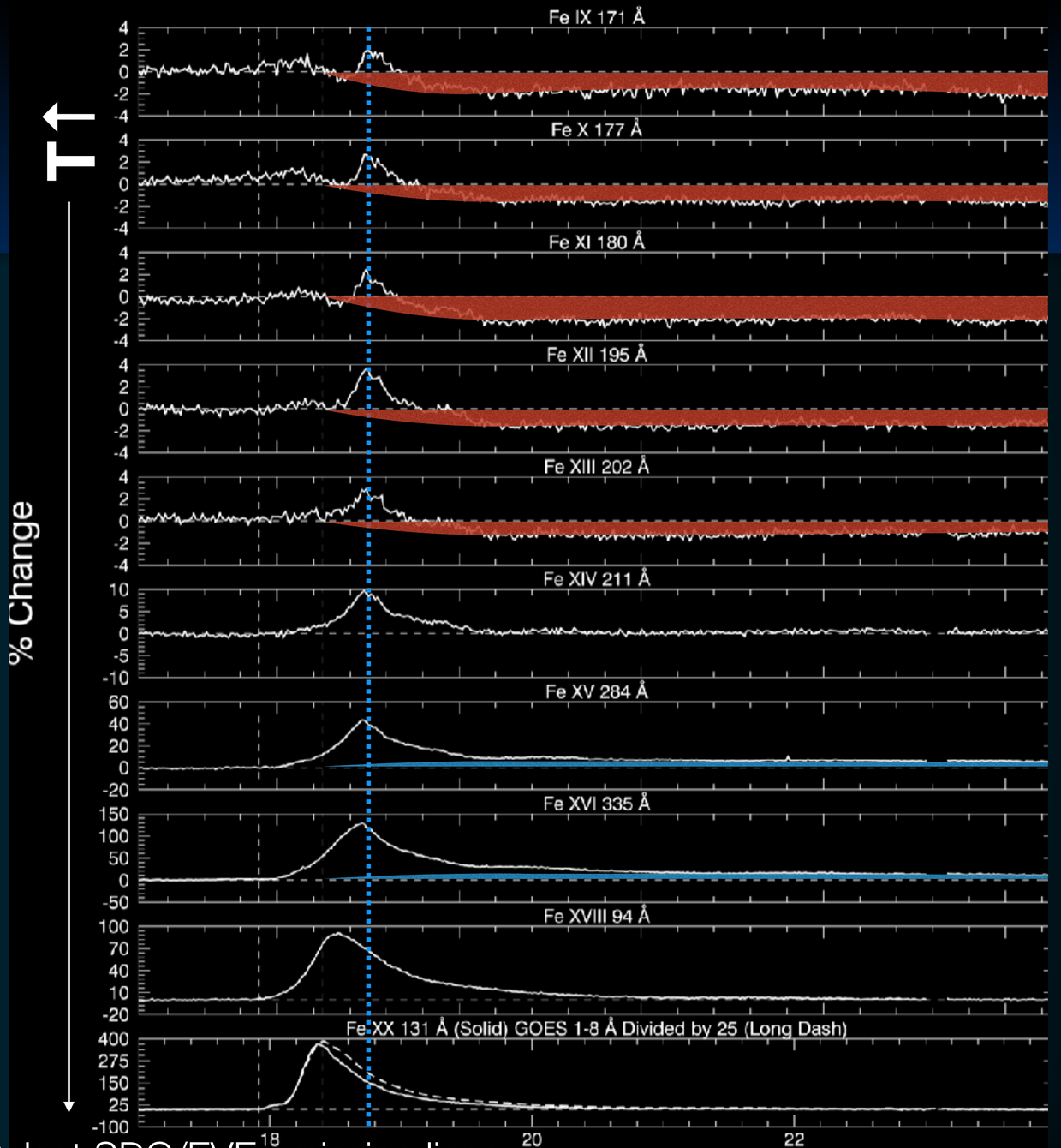
SDO/AIA multi-channel persistence

⏱10 hours

Stats from Reinard & Biesecker, ApJ, 674:576 (2008); figure from Mason et al., ApJ, 789:61 (2014); movie courtesy of Barbara Thompson

What dimming looks like: spectra

- Dimming in lines that trace ambient corona (~1 MK in Sun)
- Flare peak interferes, but can be removed



Select SDO/EVE emission lines

Mason et al., ApJ, 789:61 (2014)

Dimming profile ↔ CME kinematics

- 30 events study to derive empirical relationship

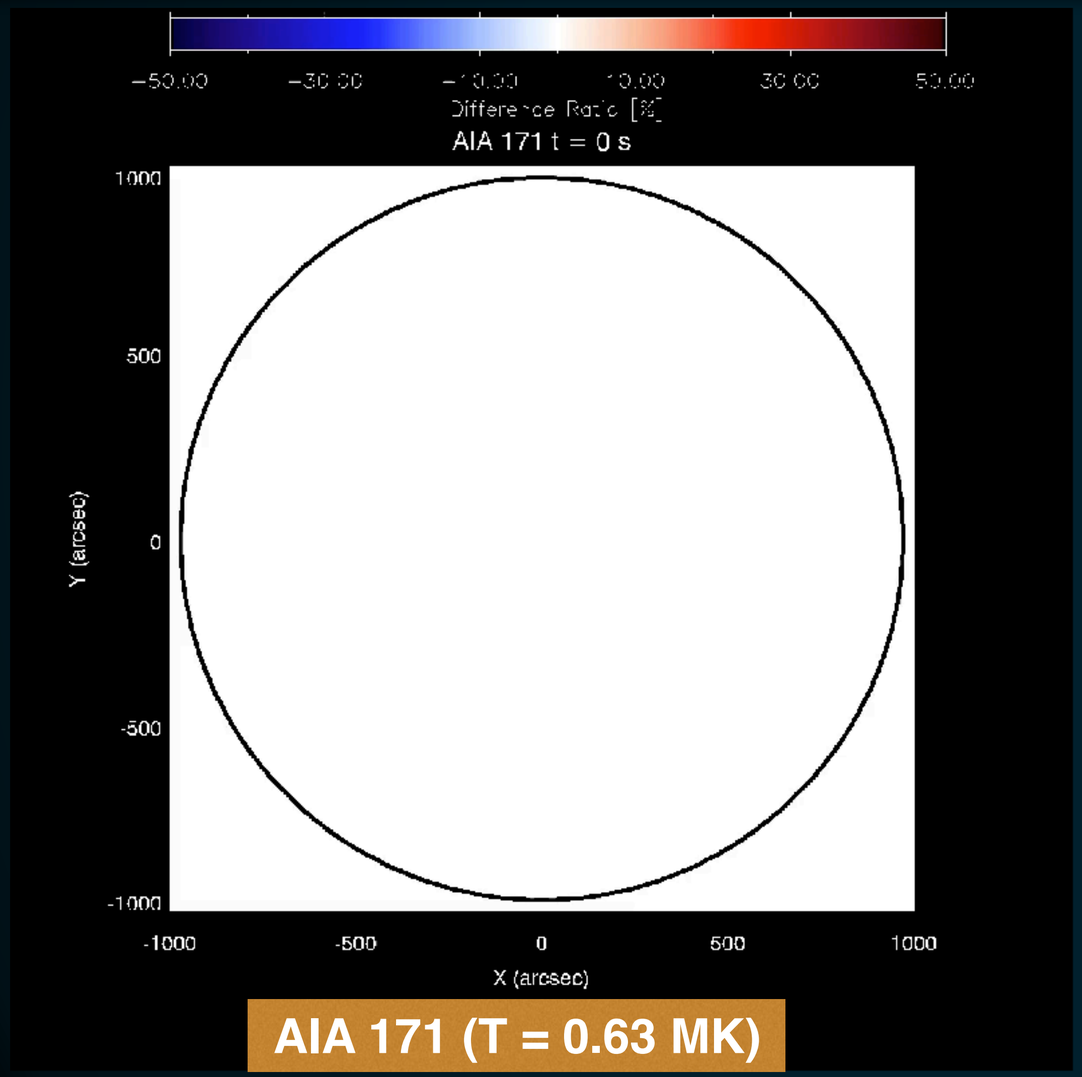
$$v_{CME}\left[\frac{km}{s}\right] \approx 2.36 \times 10^{6}\left[\frac{km}{\%}\right] \times s_{dim}\left[\frac{\%}{s}\right]$$

$$m_{CME}[g] \approx 2.59 \times 10^{15}\left[\frac{g}{\%}\right] \times \sqrt{d_{dim}}[\%]$$

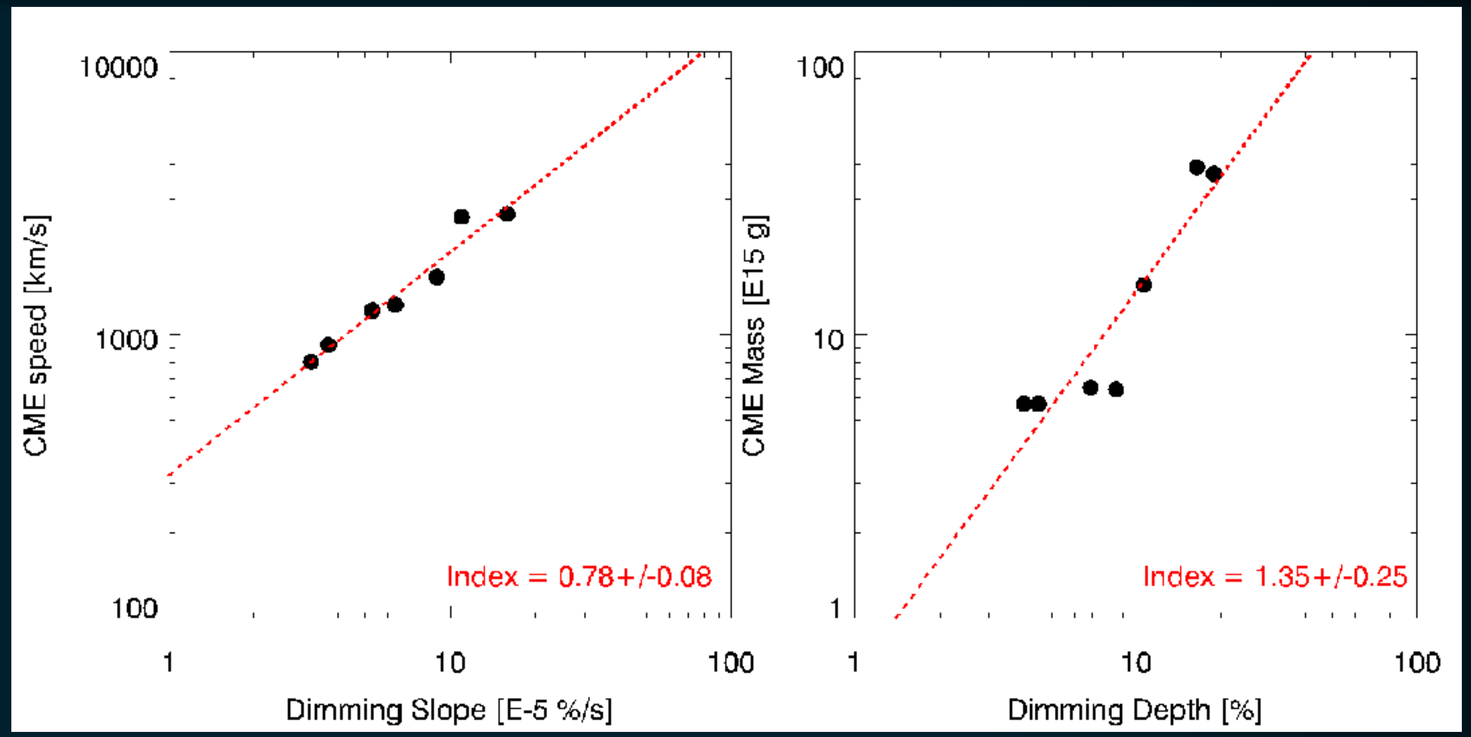
- Fast CMEs dim fast
- Massive CMEs dim a lot

Mason et al., ApJ, 789:61 (2014)

MHD simulations of dimming for confirmation of empirically derived relationships to CMEs



AIA 171 (T = 0.63 MK)



Red line: Mason et al. empirical relationship

Black dots: MHD results

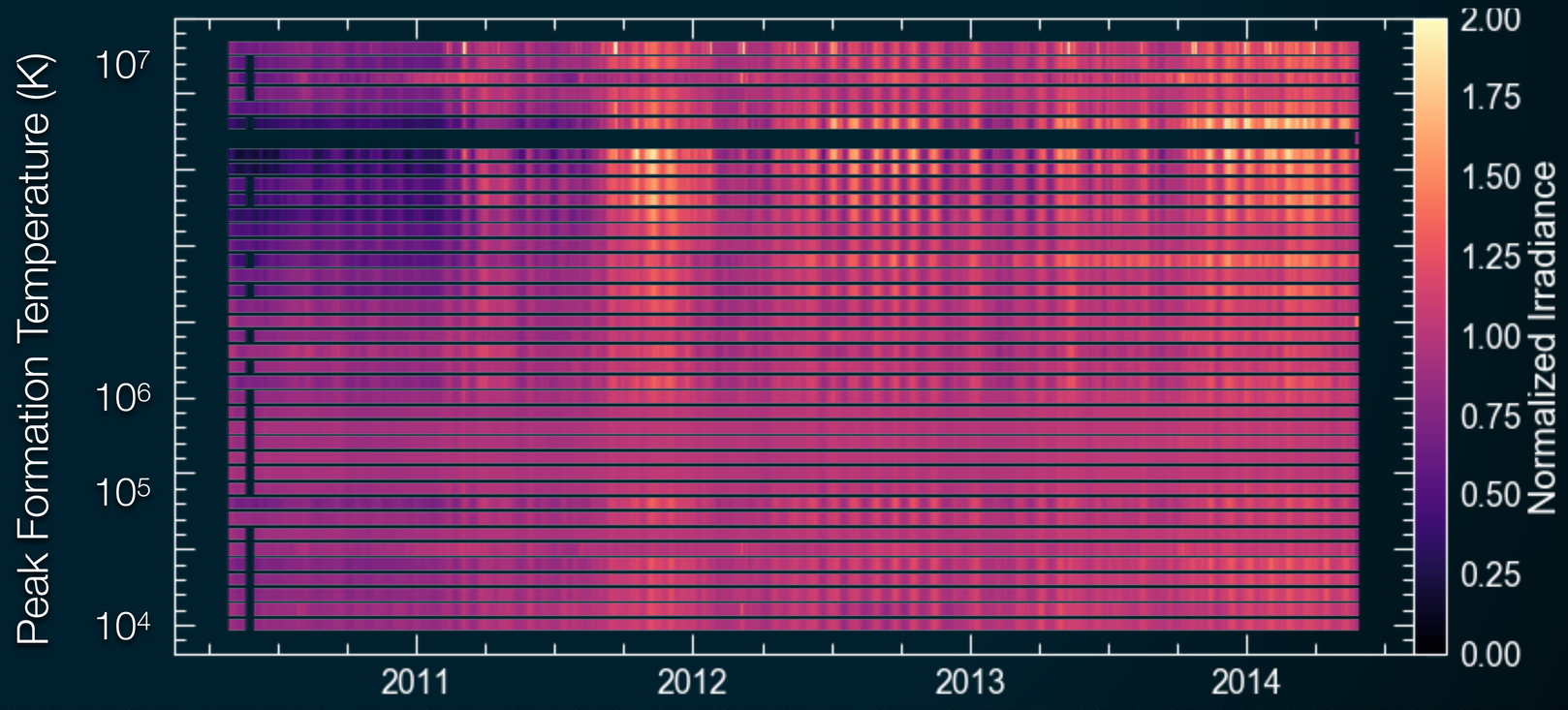
Courtesy of Meng Jin

Making a big irradiance dimming catalog

For more statistics

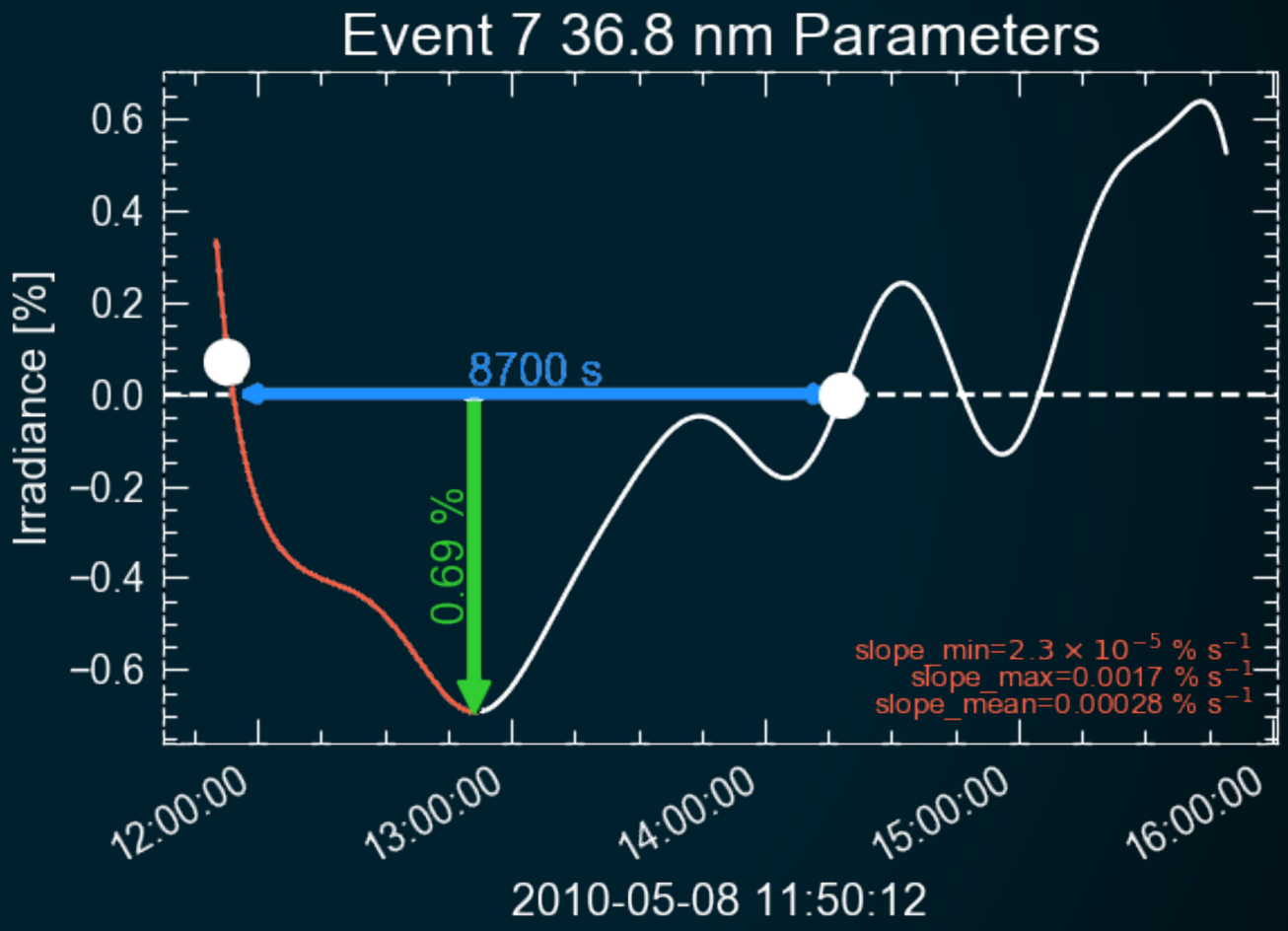
The input: SDO/EVE lines

- Solar Dynamics Observatory (SDO) EUV Variability Experiment (EVE)
- 60 - 1060 Å, 1 Å resolution, ~0.25% precision, ~30% accuracy, no spatial resolution
- Search the 39 extracted emission lines for dimming



The output: James's EVE Dimming Index (JEDI) catalog

- csv file (125 MB):
  - 5052 rows (potential events)
  - 24303 columns (parameters, e.g., depth, slope, duration per λ permutation)
- Millions of plots (12 GB)



JEDI current status

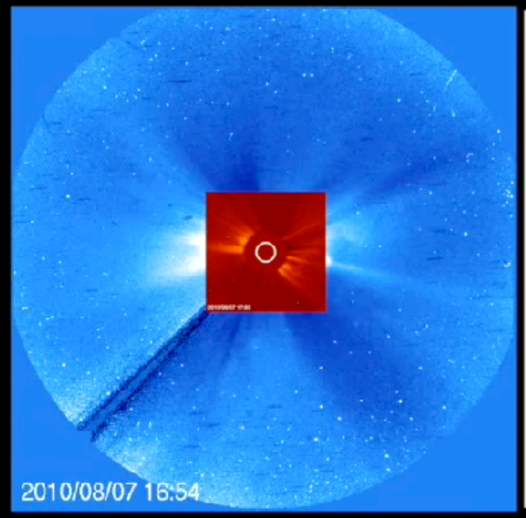
Released v1.0.1: A New Hope

github.com/jmason86/James-s-EVE-Dimming-Index-JEDI

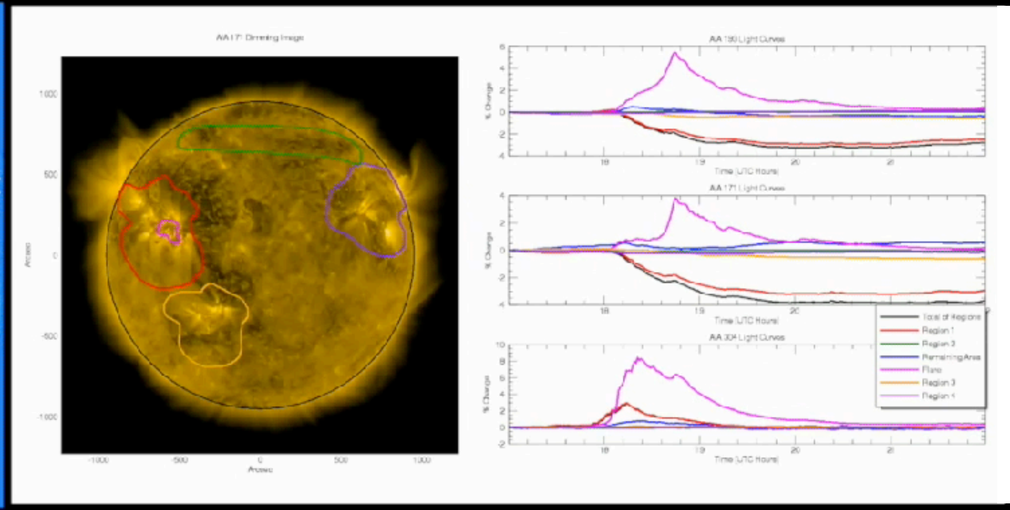
Working on v2: Error Strikes Back

Ongoing work

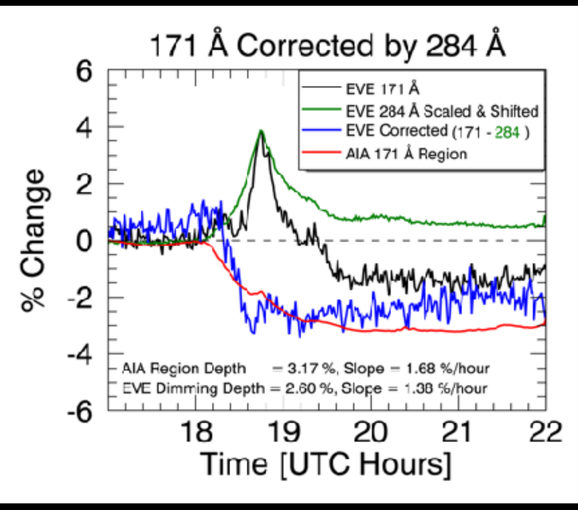
- Comparing JEDI to CME catalogs (CDAW, CACTus)
- And image-based dimming catalogs (DEMON, CoDiT)
- Apply machine learning, develop robust dimming/CME relationship, validation of catalog (e.g., spot checking like these images)
- Working on Star Dimming Observability Calculator (StarDOC[1])



CME



Dimming in images



Dimming in irradiance

[1]*Part of Jake Wilson's (high school student) summer internship at NASA, images from Mason et al., ApJ 789:61 (2014)*

Stellar dimming?

- Parke Loyd searching Hubble data
- Allison Youngblood searched EUVE data (nothing found, effective area too small)
- Meng Jin running MHD simulations for other stars to predict what we might expect to see

-friendly summary

@starfleetjames

1. Solar dimming is measurable in images but also in **ultraviolet irradiance** (sun-as-a-star measurements)
2. Dimming contains **kinematic information** about coronal mass ejections (CMEs)
3. Measure dimming on other stars → detect/characterize **stellar CMEs**