

Coronal Propagating Disturbances (PDs) and spicular connections

Dipankar Banerjee

Indian Institute of Astrophysics
Bengaluru



V. Pant (IIA)

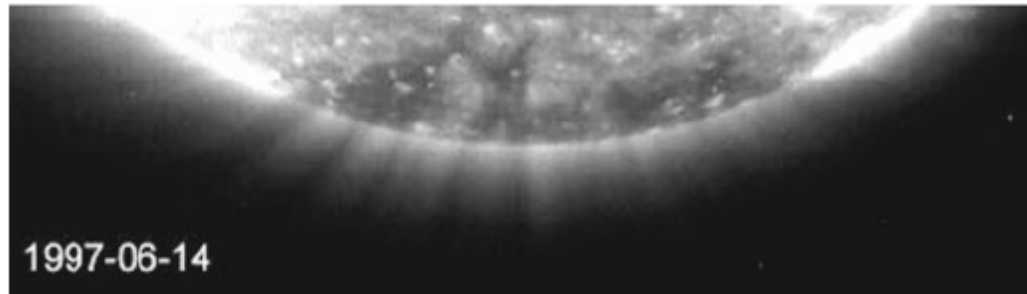
T. Samanta (IIA)



What are Plumes?

- Plume are extend as bright narrow structures from chromosphere to corona
- Mostly rooted in Coronal Holes

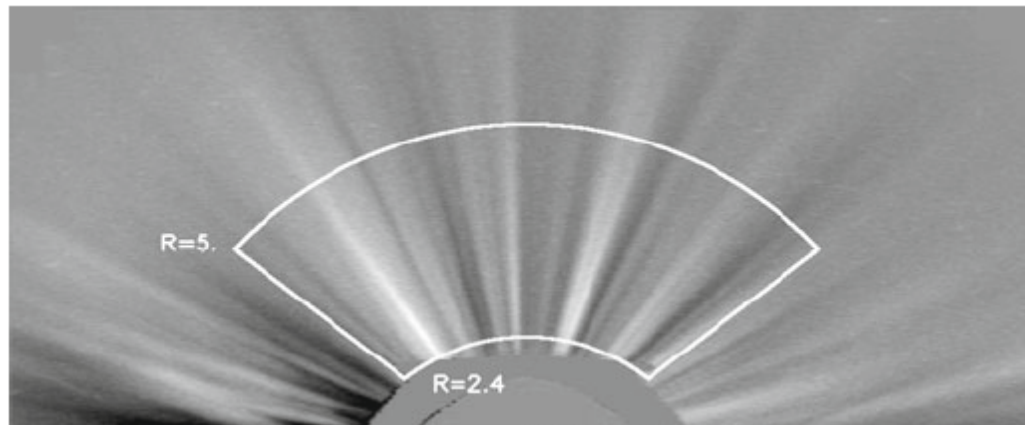
Southern
Coronal
Hole



Gabriel et
al 2009

EIT 171 A

Northern
Coronal
hole



Wilhem
et al 2011

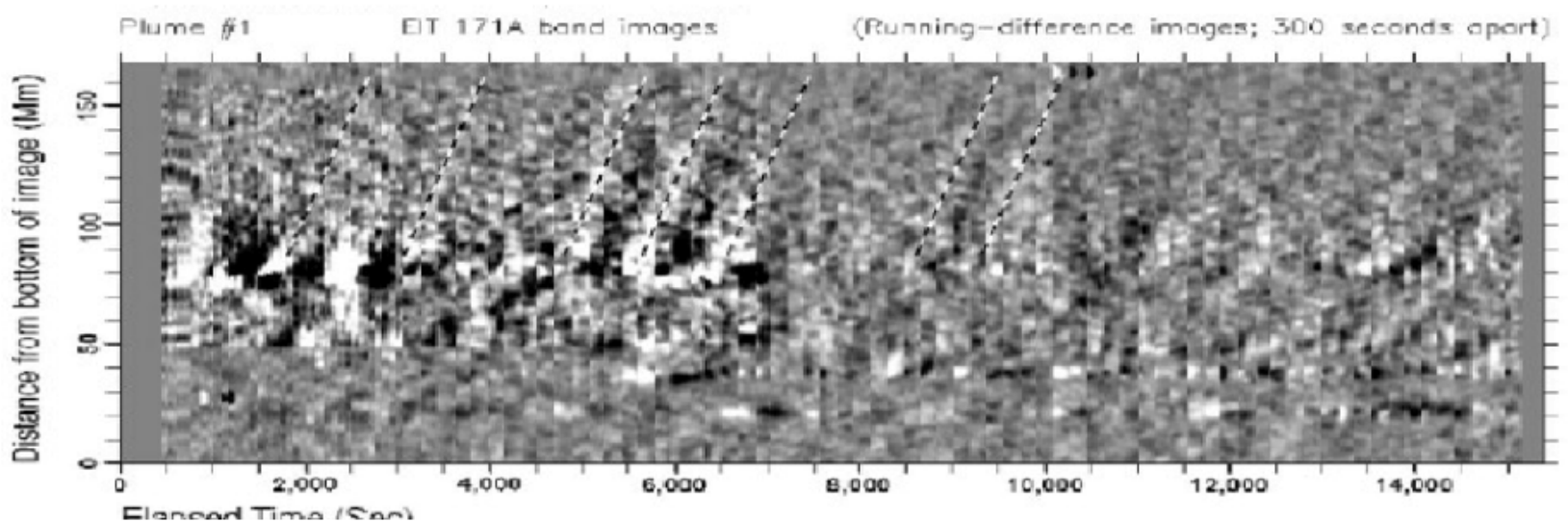
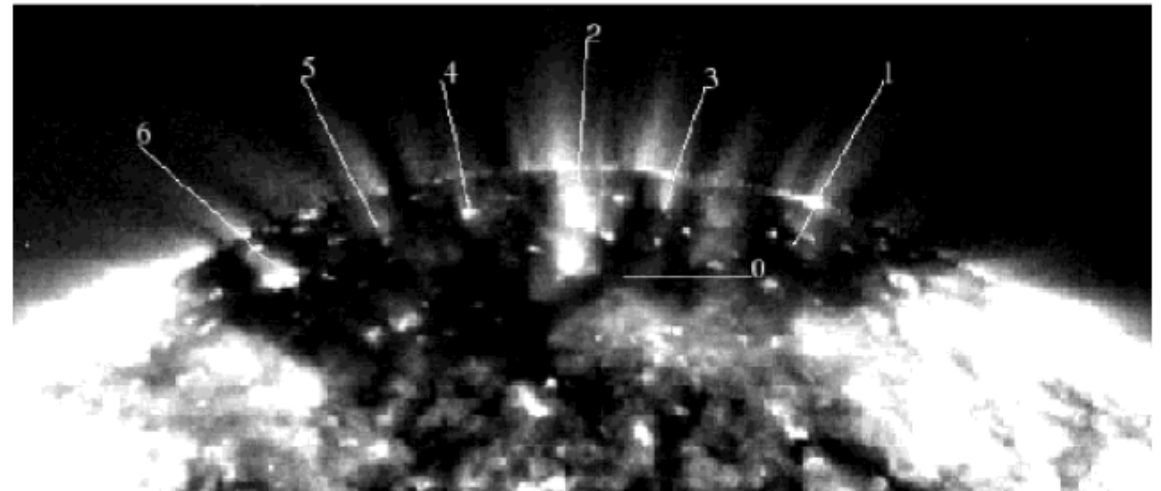
LASCO-C2

Intensity oscillations

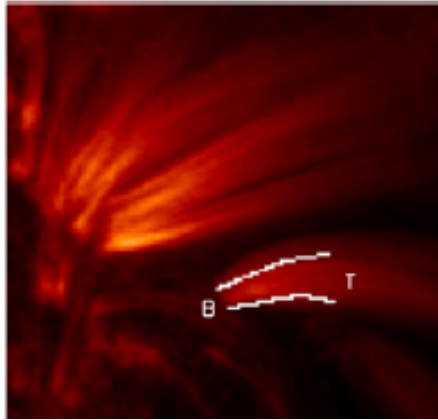
Ofman et al, (1997) first reported the quasi-periodic variations in polar plumes. Deforest & Gurman (1998), found their ubiquitous presence. Ofman et al (1999, 2000) interpreted these disturbances as slow magneto-acoustic waves.

Polar plumes – South pole
From SoHO/EIT 1996 Mar 7
Using 171 Fe ix/ Fe x channel

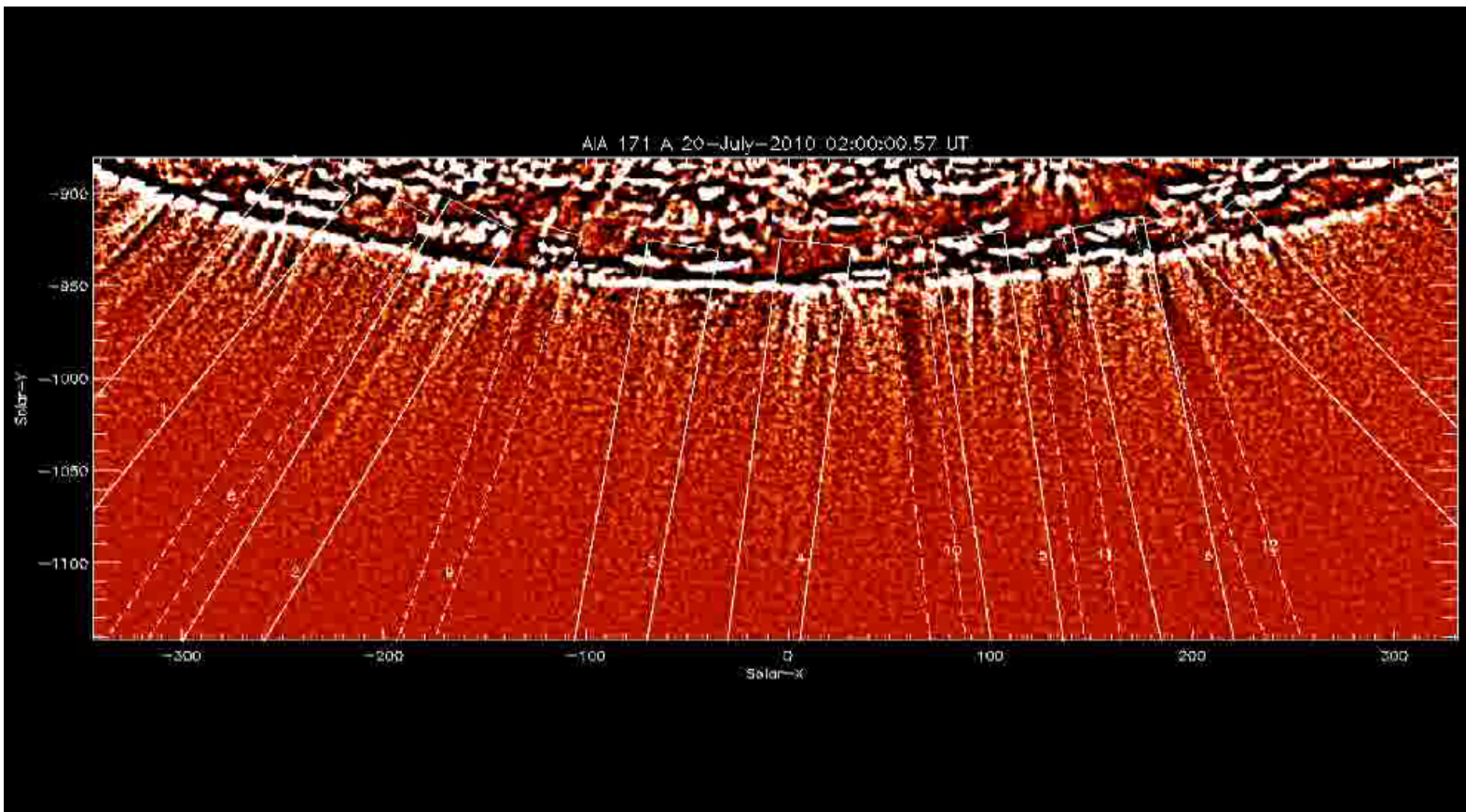
Periodicities: 10-15 min.
Speeds: 75 to 150 km/s.



Propagating slow waves in open structures



Parameter	Average	Range
Oscillation Period, P	284.0 ± 10.4 s	145–550 s
Propagation Speed, v	99.7 ± 3.9 km s ⁻¹	$O(45)$ – $O(205)$ km s ⁻¹
Relative Amplitude, A	$3.7\% \pm 0.2\%$	0.7–14.6%
Detection Length, L_d	8.3 ± 0.6 Mm	2.9–23.2 Mm
Energy Flux, F	313 ± 26 erg cm ⁻² s ⁻¹	68–1560 erg cm ⁻² s ⁻¹



Propagating
Disturbances
In the off-limb
Polar region
As seen by
AIA 171 A

PD's in polar plumes revisited..

Motivation:

Waves or flows?

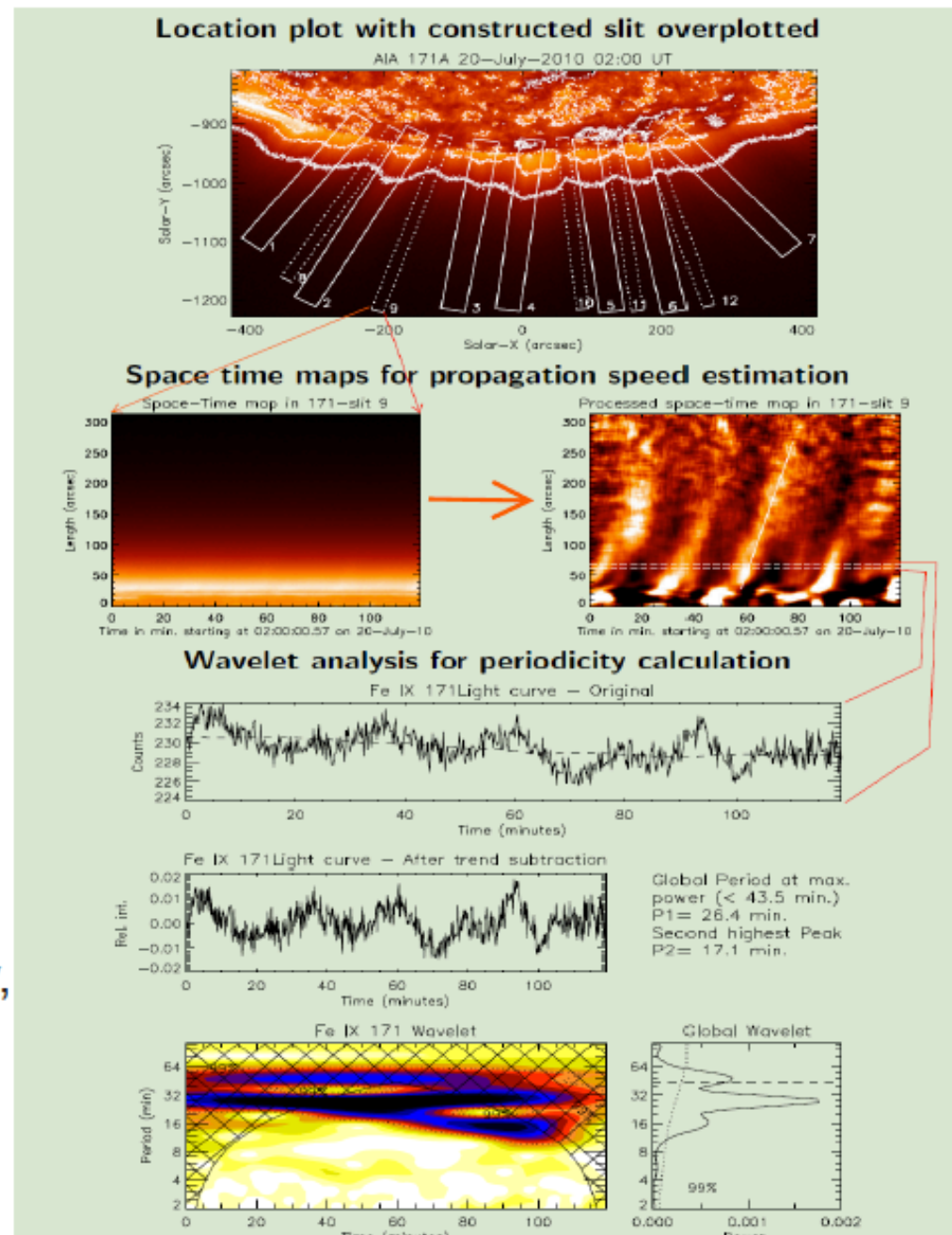
Preferred channels – Inter plumes or plumes?

Data:

- Location ---> South polar region
- Duration ---> 2 hours
- Spatial resolution---> 0.6 arcsec
- Cadence----> 12s

Analysis:

Images from three coronal channels of AIA/SDO, centered at 171 Å, 193 Å and 211 Å, with their peak temperatures at 0.8 Mk, 1.25 Mk and 1.6Mk respectively, are used in this analysis. The adjacent figure illustrates the techniques used for the detection of intensity oscillations and estimation of propagation speeds and periodicities.



Slow waves: Detections

- Small amplitude propagating intensity disturbances were extensively studied with imaging telescopes in open/extended loop structures close to active regions (Berghmans & Clette 1999; De Moortel et al. 2000; King et al. 2003) and also in polar plumes (Deforest & Gurman 1998; McIntosh et al. 2010; Krishna Prasad et al. 2011).
- There were some spectroscopic observations as well by several authors using CDS onboard SOHO (Ireland et al. 1999; O'shea et al., 2001) and more recently using SUMER and EIS (Banerjee et al. 2009; Gupta et al. 2010)
- Based on some of the observed properties all these authors interpreted the observed oscillations in terms of slow magneto-acoustic waves.
- Wang et al. (2009) observed low frequency (12 & 25 min) oscillations for the first time, both in intensity and Doppler shift using EIS supporting this nature.
- De Pontieu & McIntosh (2010) report oscillations in line width in addition to the intensity and Doppler shift and they cautioned on the ambiguous detection of high speed up-flows as slow waves.
- Recent observations indicate that the effect of up-flows is more prominent close to the foot points of the supporting structure and the slow waves dominate away from the base (Nishizuka & Hara, 2011, Tian et al. 2012).
- Slow waves were also found to be omnipresent at longer periods (Krishna Prasad et al. 2012, 2014).

Observational properties and current ambiguities

Periodicities: Similar. No Knowledge on the driver. P-mode leakage? Spicular flows? Source of low frequency oscillations is not known. Impulsive heating?

Propagation speeds: Acoustic? Temperature dependence? No shocks? Suffers from the projection effects and error in measurement.

Oscillation Amplitudes: Temperature dependence? Possible for flows? Simultaneous measurements in multiple channels is required.

Disappearance after some height: Damping? Dispersed flows? Or material fallen back? Frequency dependence of the detection length might be the key.

Asymmetry in line profiles: Not observed always. LOS effects? Suffers from low signal-to-noise affects. Gupta et al. (2012) observed minimal R-B asymmetry in the PD's which can be reproduced by adding random noise to simulated profiles. The effect is predominantly observed at loop foot points.

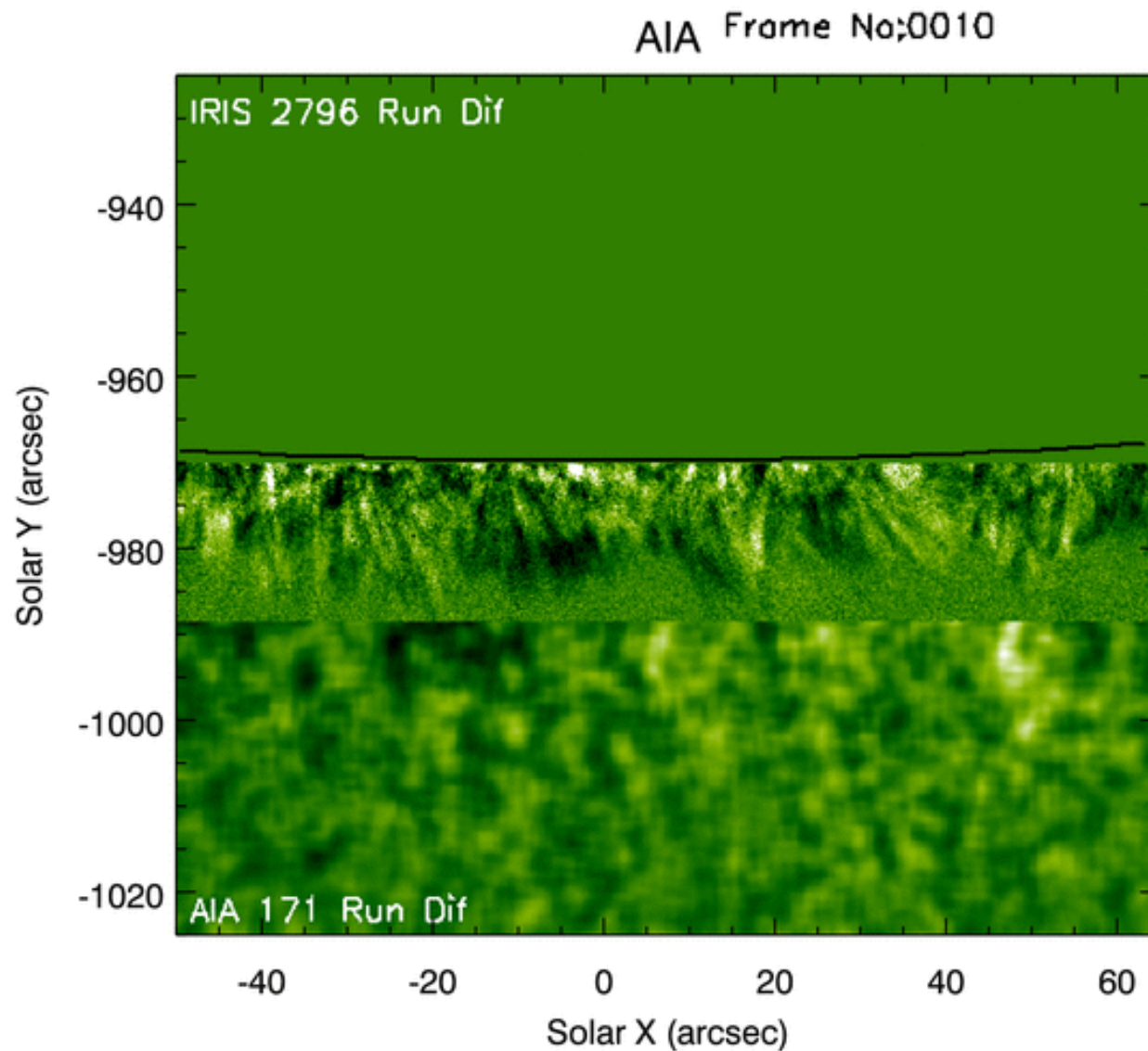
What about the driver?

How are the slow waves generated?

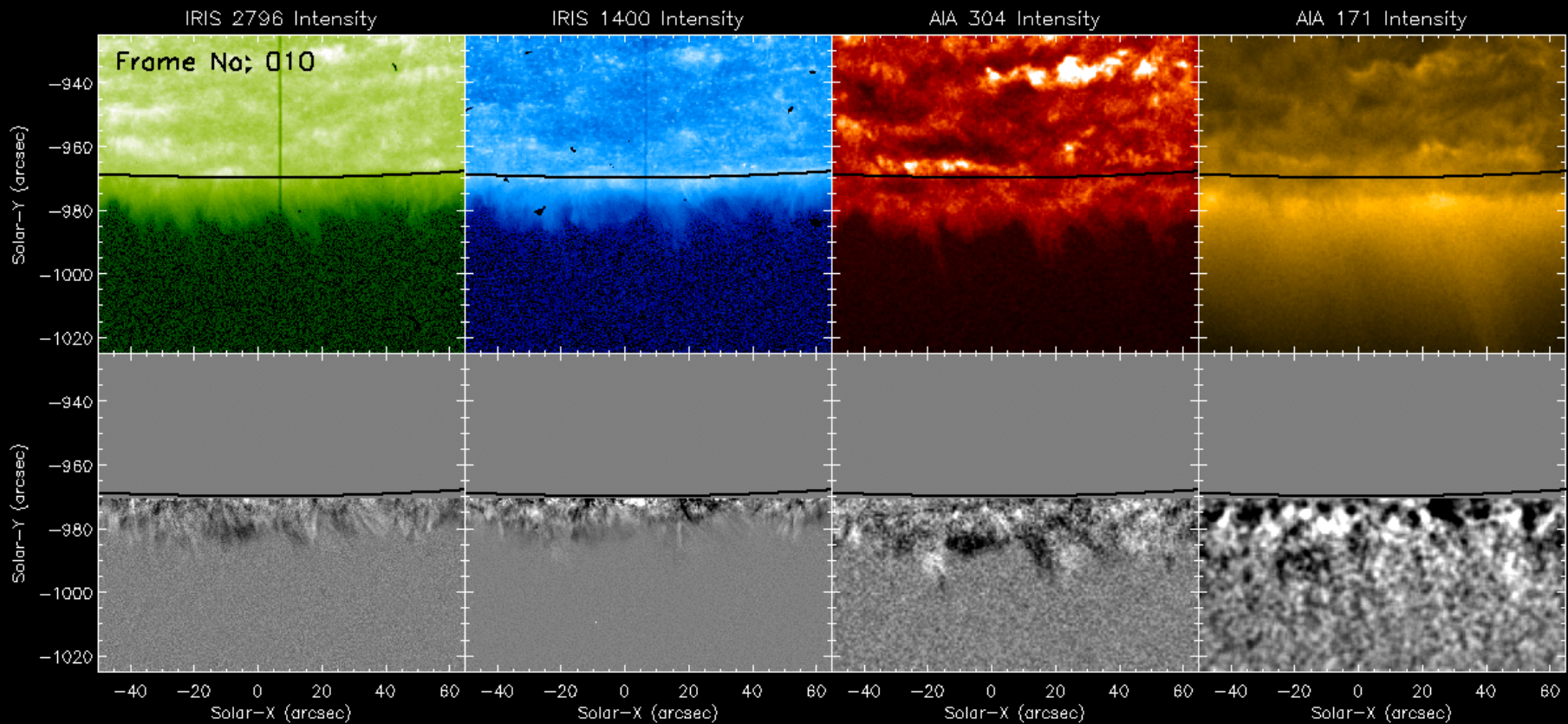
Can flows generate waves?

- High resolution observations (AIA/SDO) revealed jet-like features at the base of plumes (Raouafi & Stenborg, 2014)
- Source of these jet-like features is still unknown
- Our aim is to combine chromospheric, TR dynamics and dynamics at coronal heights while combining data from IRIS and AIA

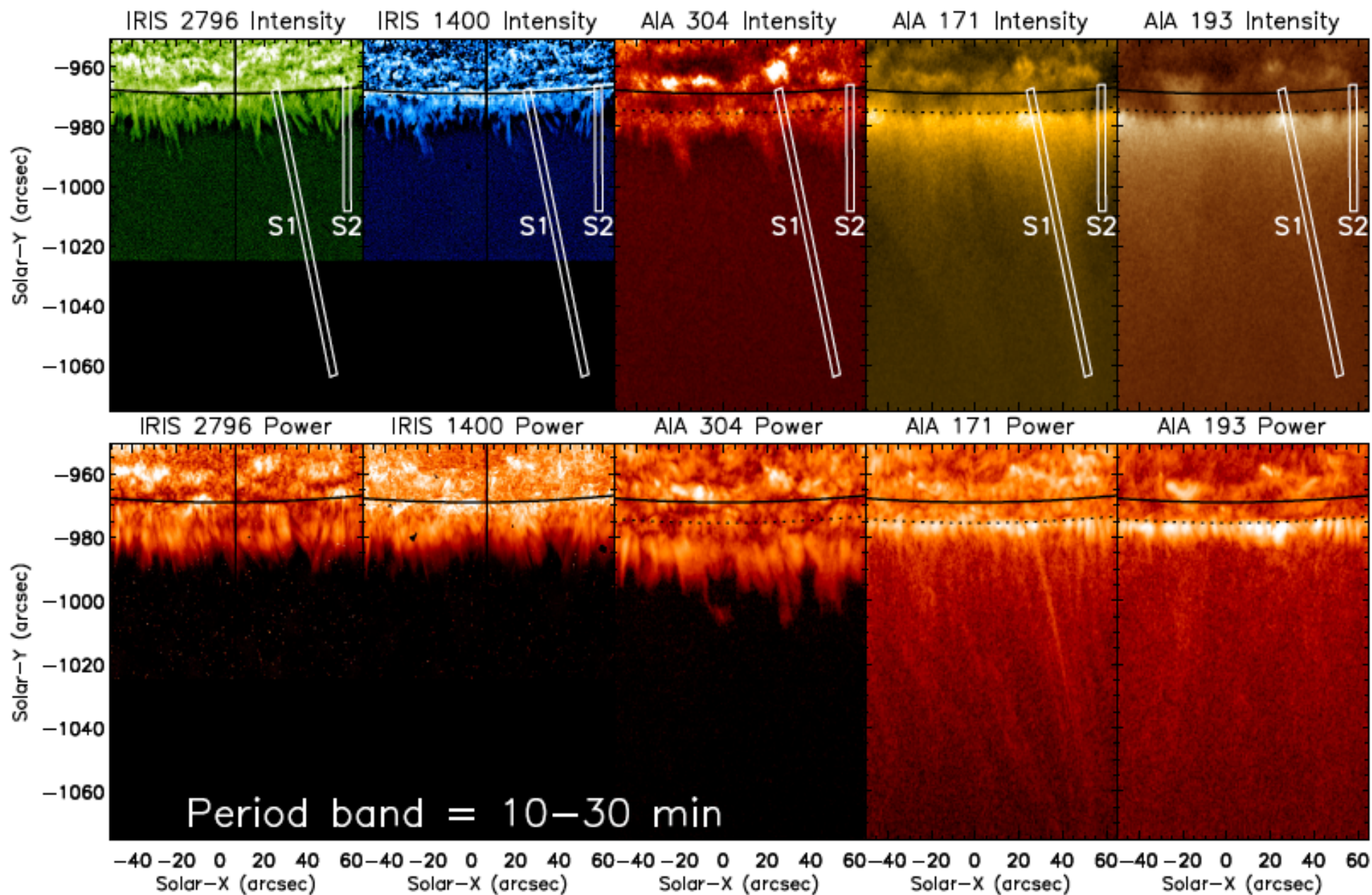
Coronal PDs and spicular connections

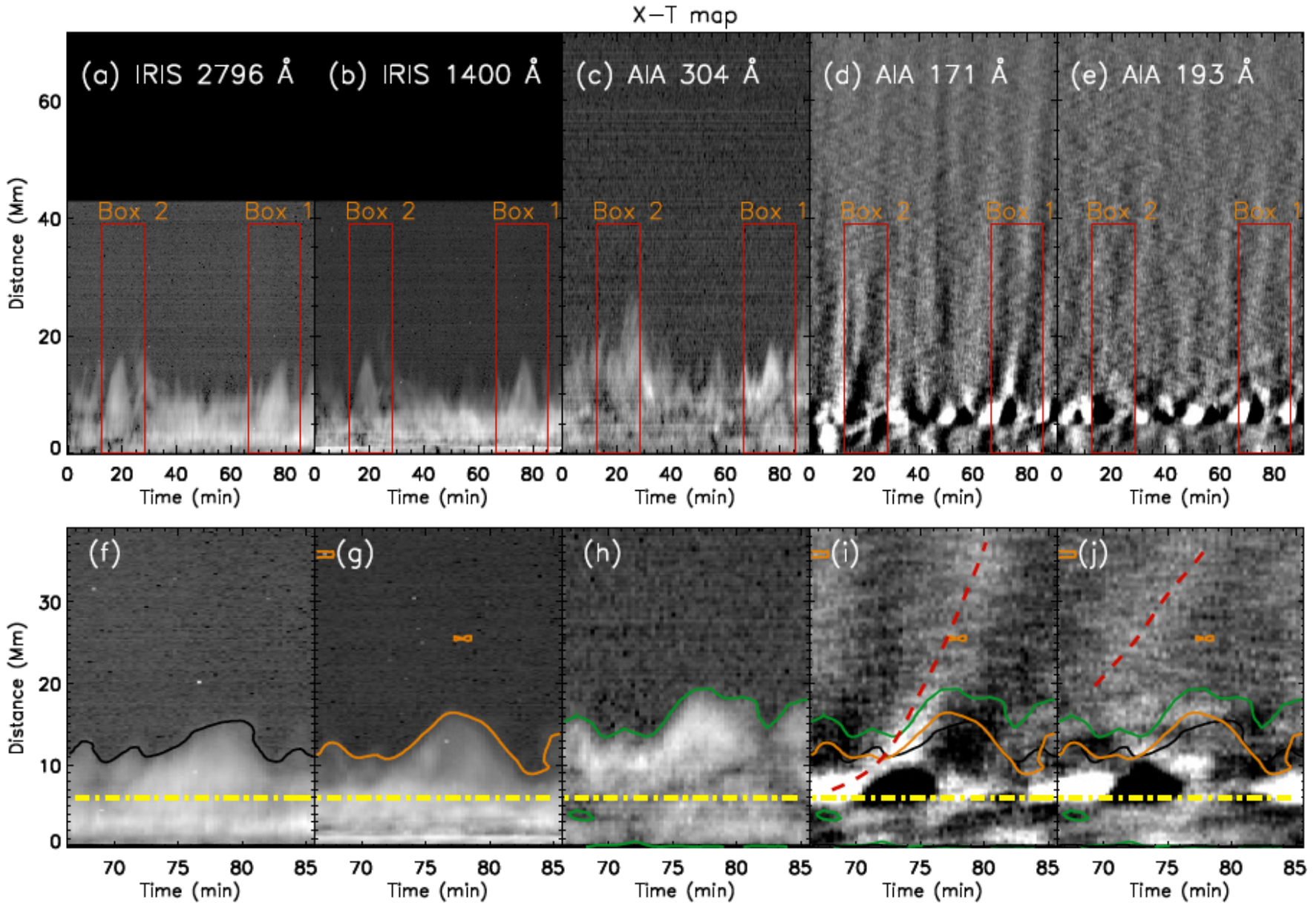


South Polar limb simultaneous observations of IRIS and AIA

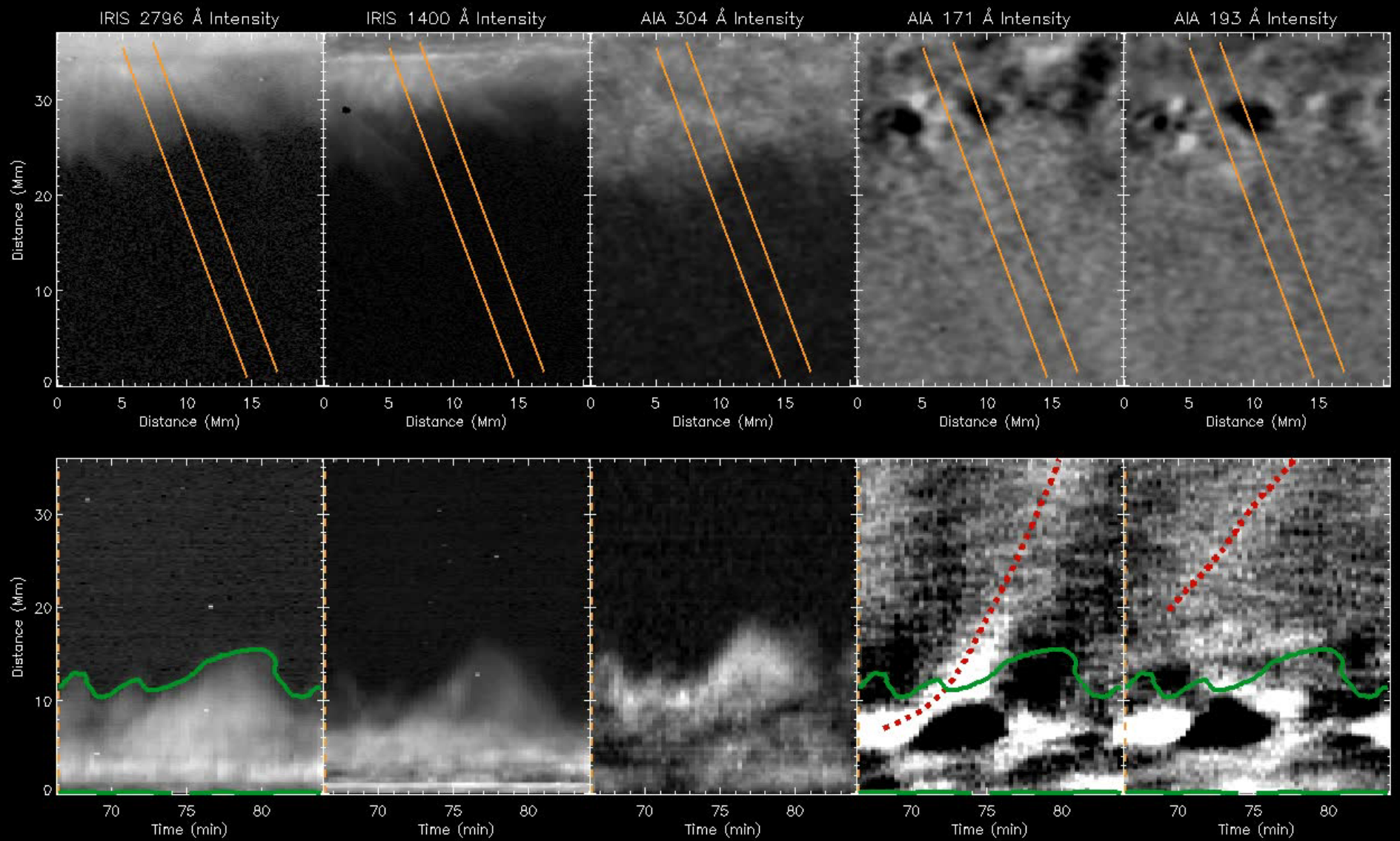


IRIS 2796 A 10,000 to 15,000 K and IRIS 1400 A is sensitive to temperatures 60,000 to 80,000 K. The AIA 304 A, AIA 171 A and AIA 193 A filters response function peaks at 0.05 MK, 0.8 MK and 1.25 MK respectively

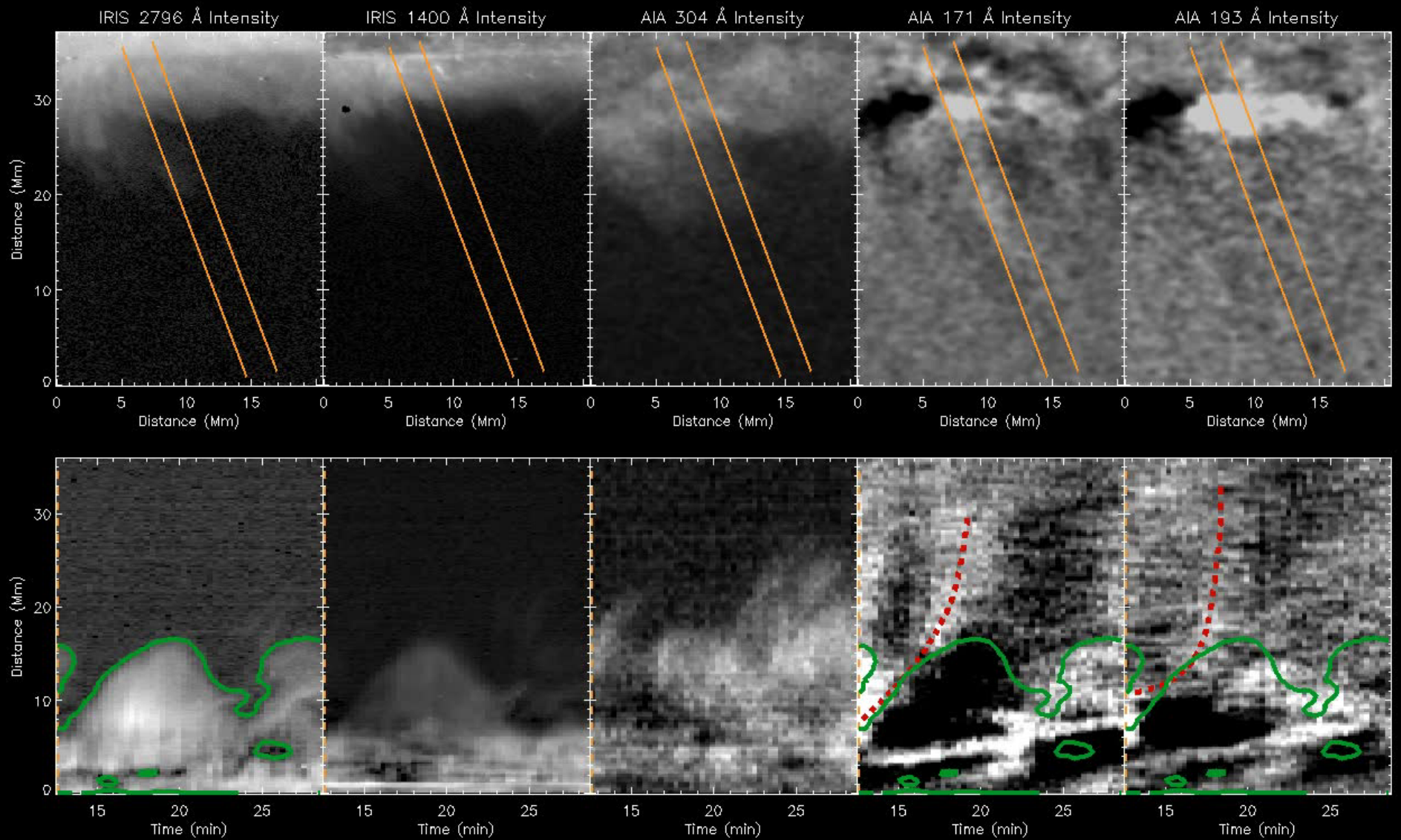




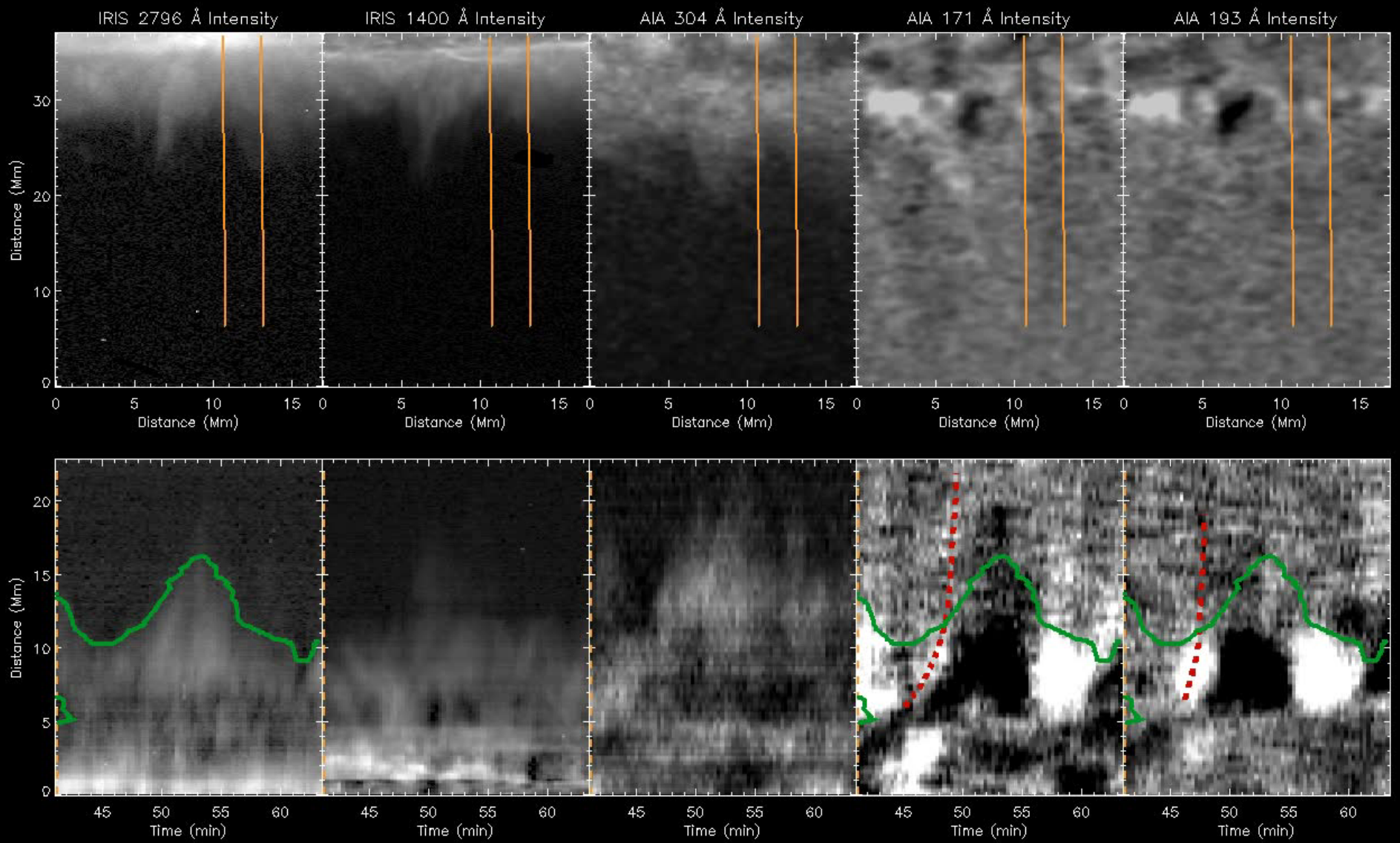
Black, orange and green contours show the envelopes of the spicular temporal evolution as seen in the IRIS 2796 Å SJI, IRIS 1400 Å SJI and AIA 304 Å channels. These contours are overplotted in the AIA 171 Å and AIA 193 Å X-T map for comparison. Dot-dashed horizontal line in yellow represents the limb of Sun as seen in AIA 171 Å and 193 Å. Dashed red lines tracks the PDs observed in AIA 171 Å and 193 Å.



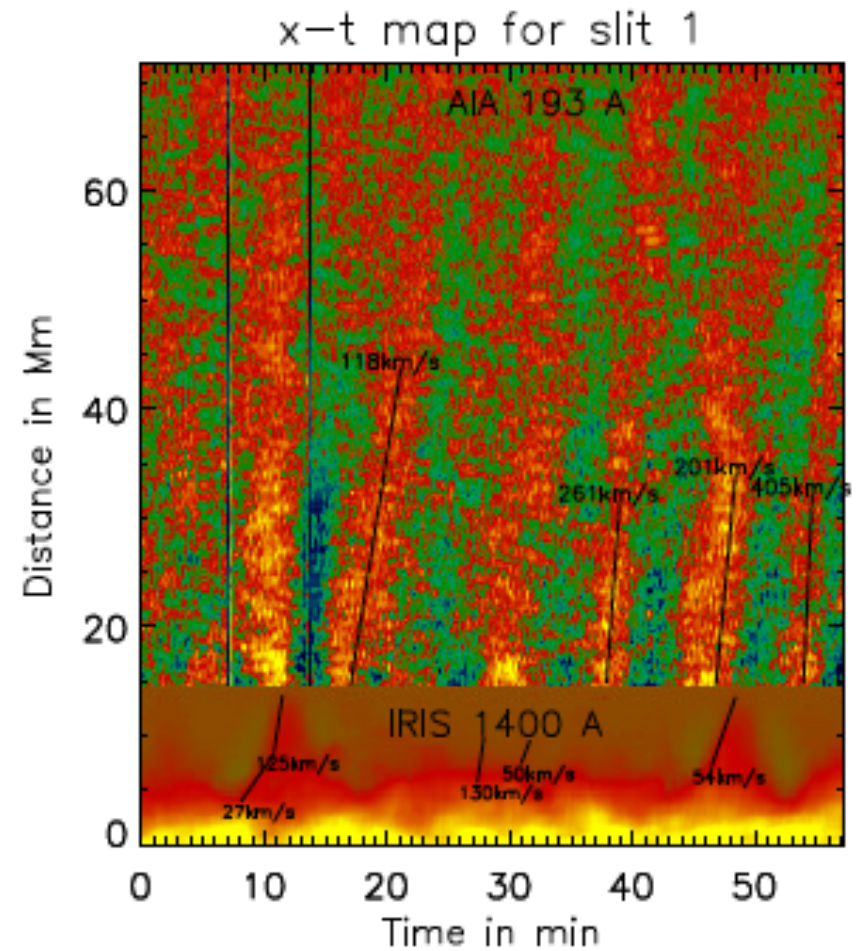
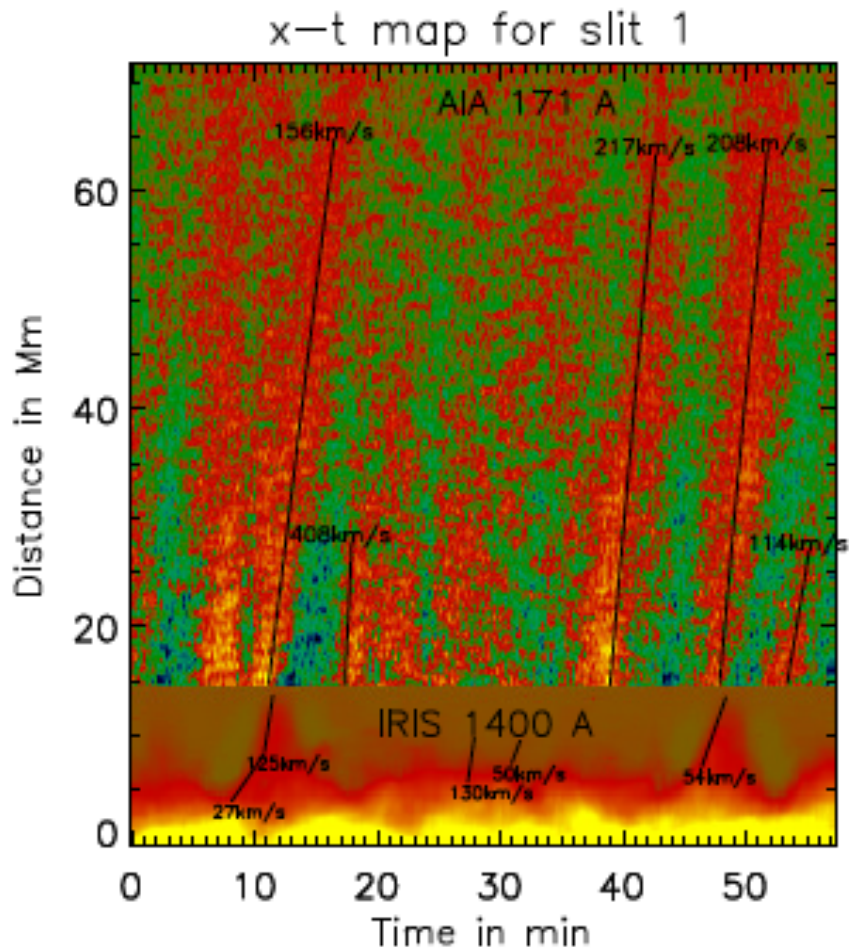
BOX 1



BOX 2



BOX 3



Space-time maps corresponding to slit location S1 (along a plume like structure) showing connection between spicular activities as seen by IRIS channels (bottom) and PDs as seen by coronal AIA channels (top). The slanted black lines are used to measure the speeds.

Summary

- PDs are ubiquitous in the solar atmosphere and spicules can trigger coronal PDs.
- We point out a possible connection between the small scale, short lived cool spicular structures with the very large scale long lived hot plume structures
- We find that time of the start of trajectory of PDs is almost co-temporal with the time of the rise of the spicular envelope and the spicular material fall cause brightenings followed by the generation of another PD in AIA 171 and 193 ° A.
- We propose that reconnection like processes generate the spicules and waves simultaneously
- The PDs as seen have a mixed signature of waves and flows at lower heights while at the extended coronal heights the wave signature is dominant. There is also a signature of acceleration of these PDs as represented by the curved red dashed lines

Thank you for your attention



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PROPAGATING DISTURBANCES IN THE SOLAR CORONA AND SPICULAR CONNECTION

TANMOY SAMANTA¹, VAIBHAV PANT¹, AND DIPANKAR BANERJEE^{1,2}

¹ Indian Institute of Astrophysics, Koramangala, Bangalore 560034, India; tsamanta@iiap.res.in

² Center of Excellence in Space Sciences, IISER Kolkata, India

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