Eruptive events

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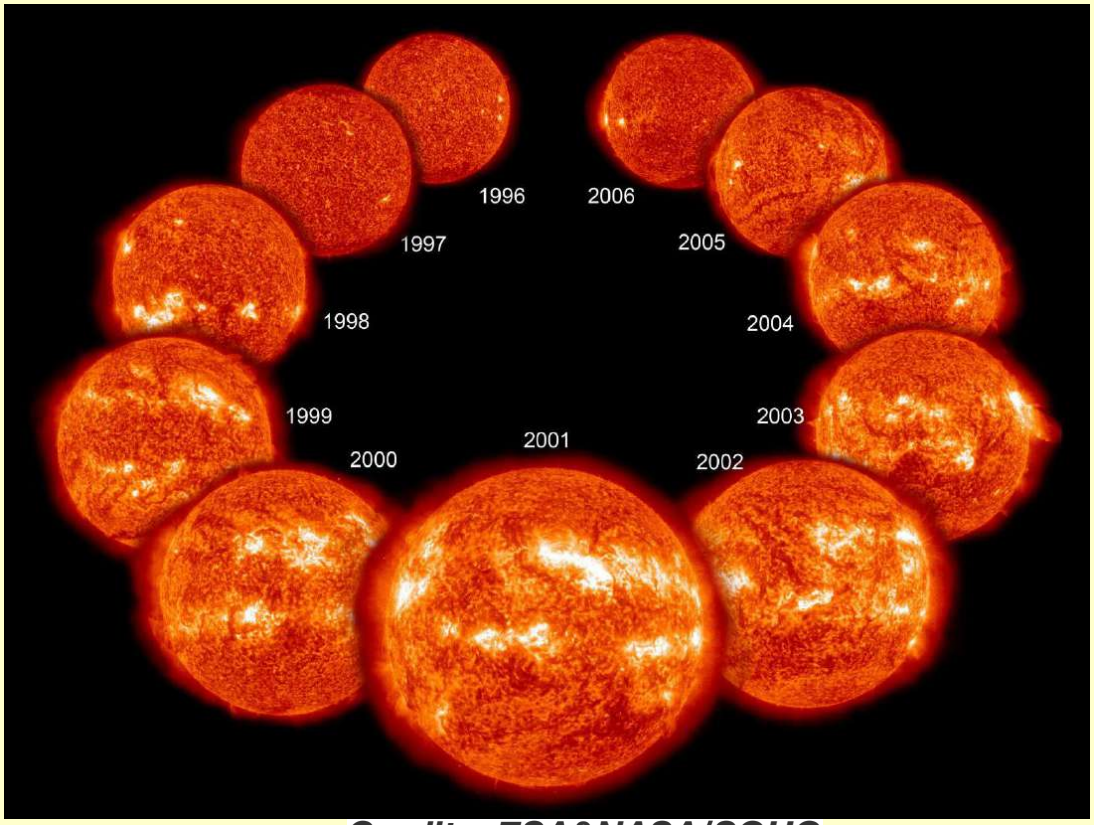
ETH zürich

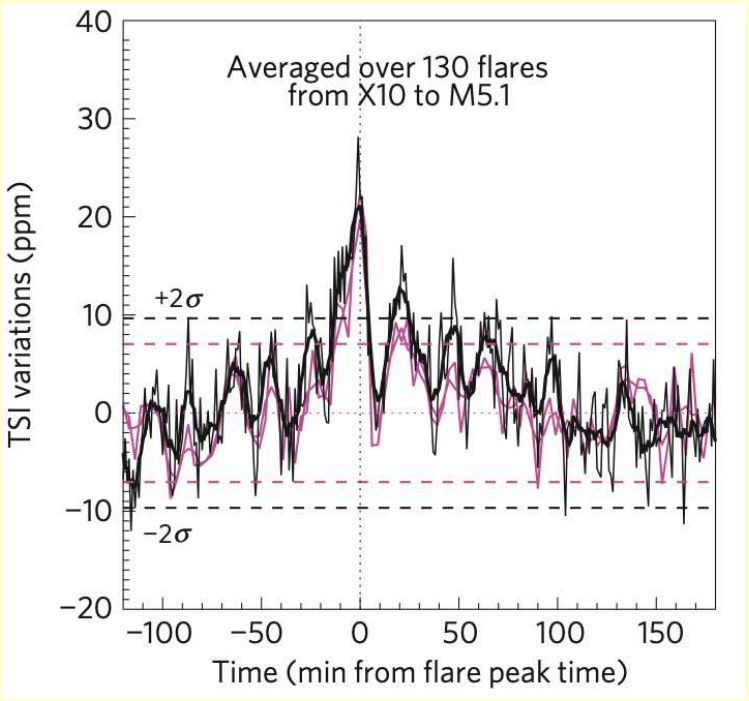
Davos, 05.10.2021

pmod wrc

The solar activity



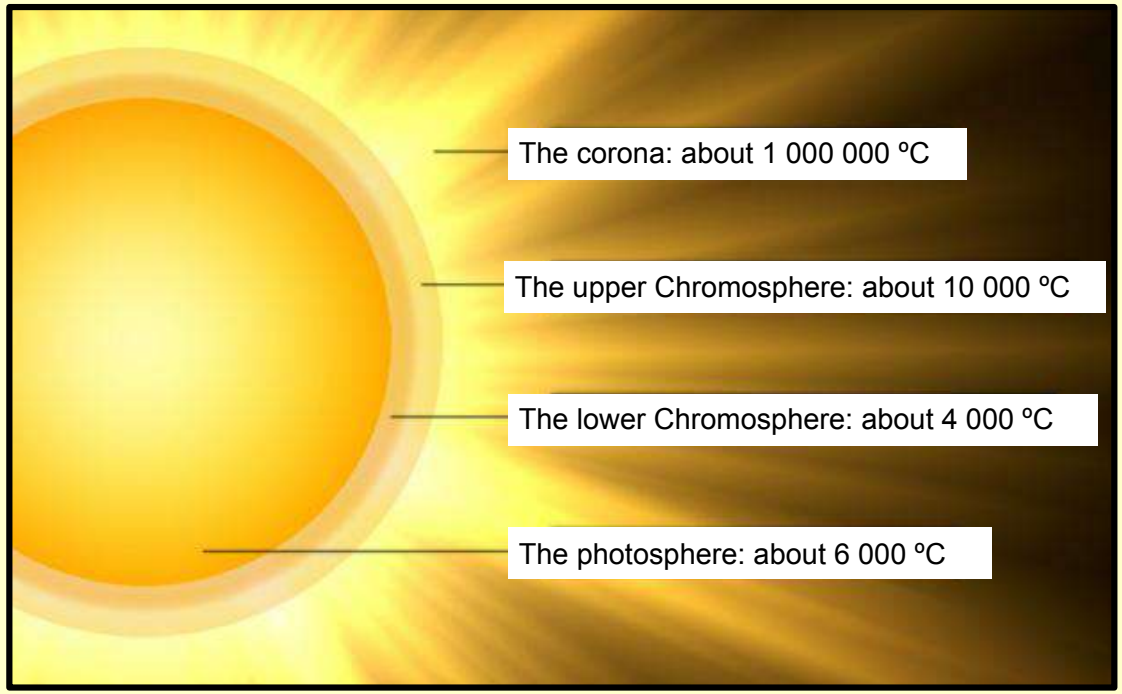
Credits: ESA&NASA/SOHO

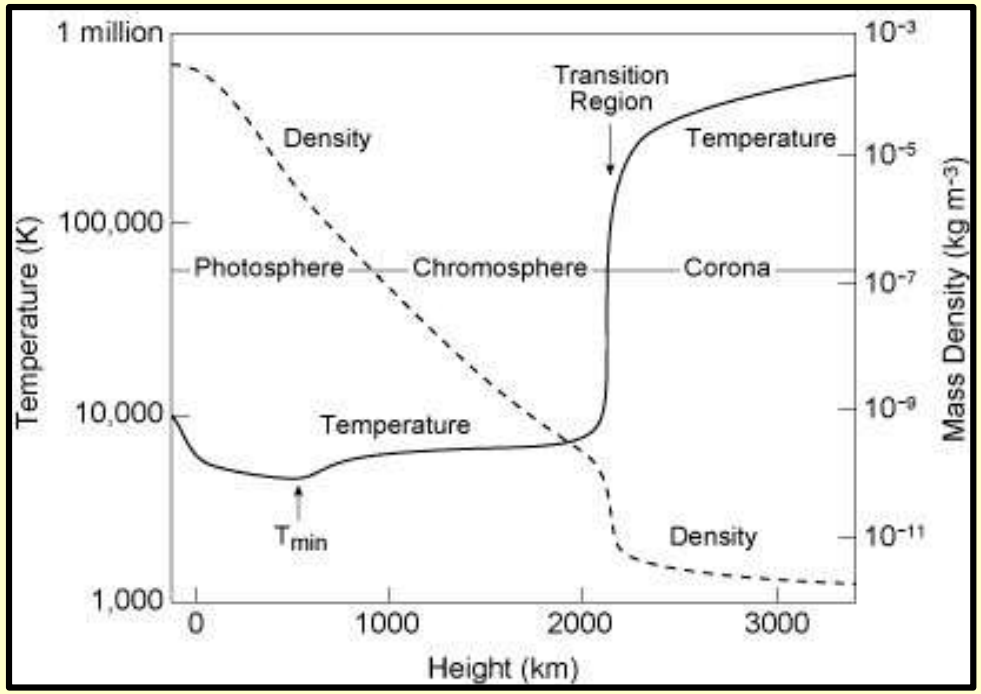


Kretzschmar et al. 2010

- What are the eruptive events and why we investigate them?
- What are the type of eruptive events (CME, flare, campfires)?
- Why has a new era of eruptive events research begun?

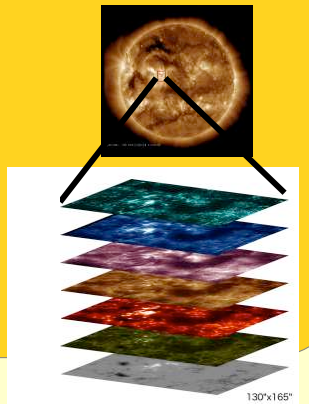
The solar atmosphere





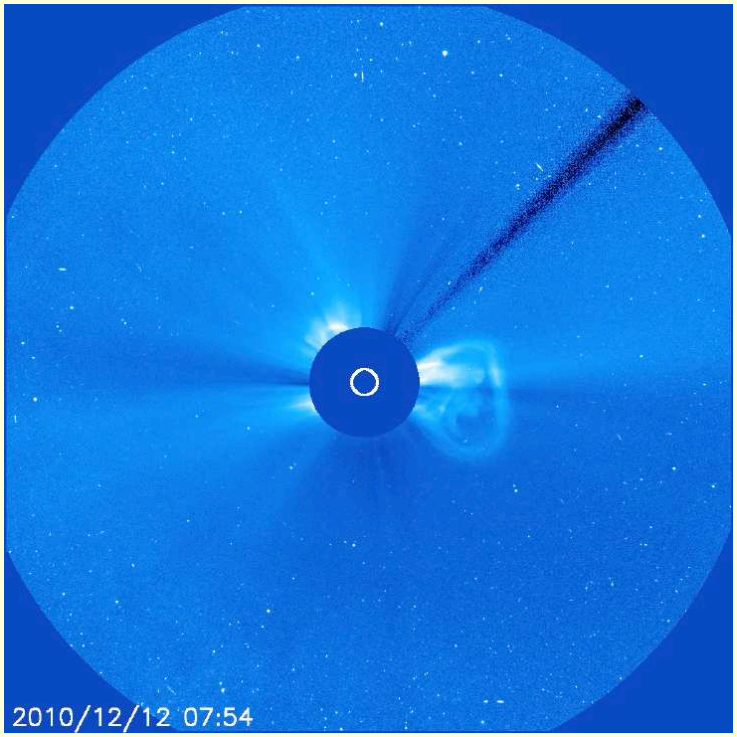
1) Illustration: Per Byhring; 2) Eugene Avrett, Smithsonian Astrophysical Observatory

- Solar atmosphere is spatially structured (1 Mm – hundreds Mm)
- How evolve the structures in the solar atmosphere?
- **Focus on large scale structures and phenomena**



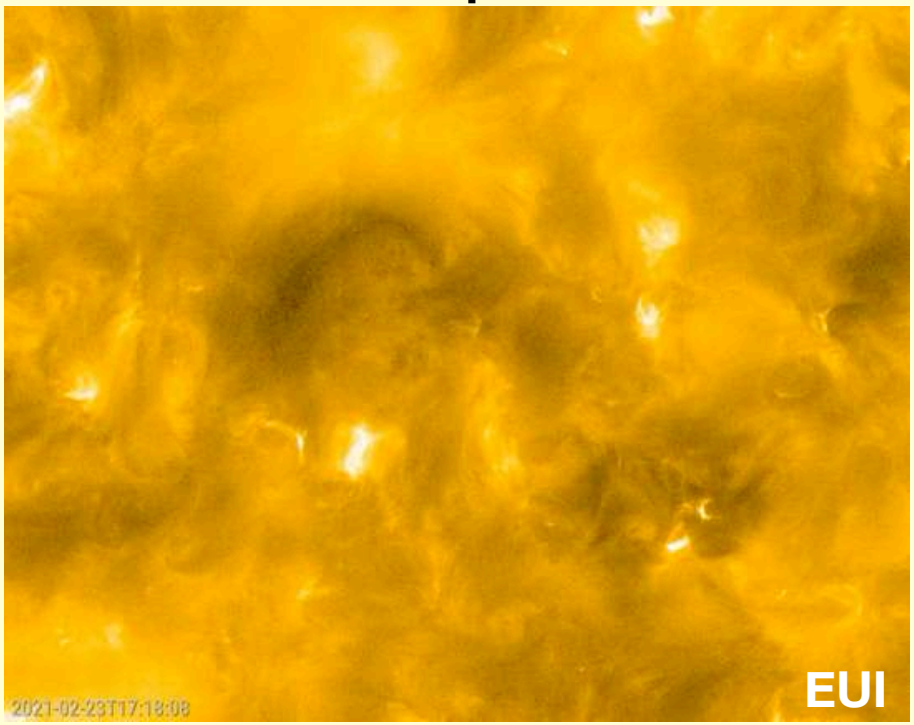
Eruptive events

Coronal Mass Ejection (CME)

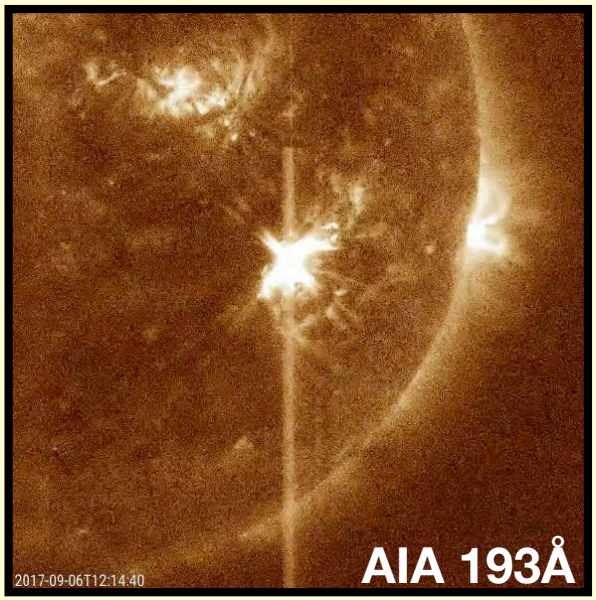


NASA, ESA /
Solar and Heliospheric Observatory

Campfires

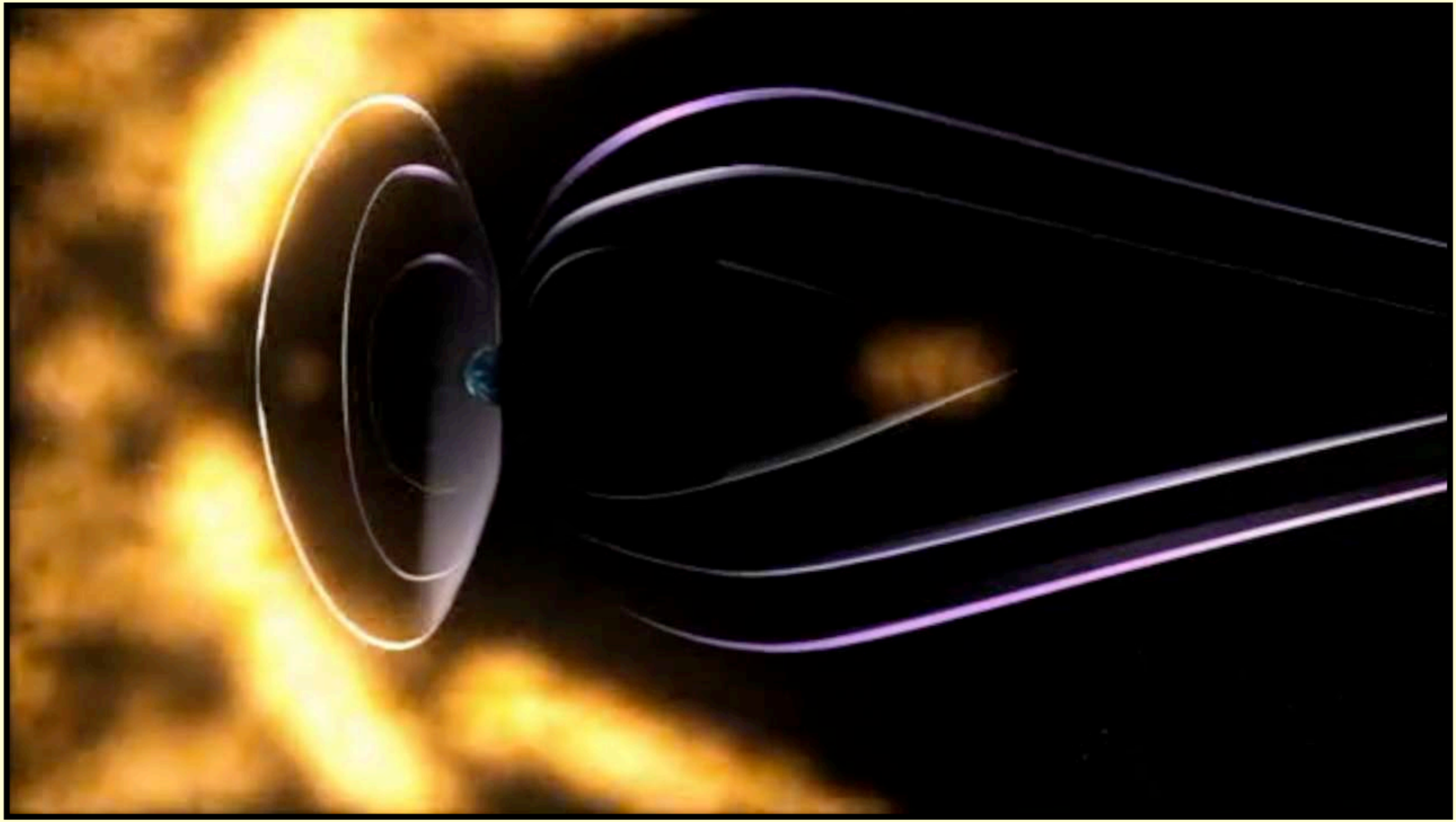


Solar flare



NASA/GSFC/ Solar Dynamics Observatory

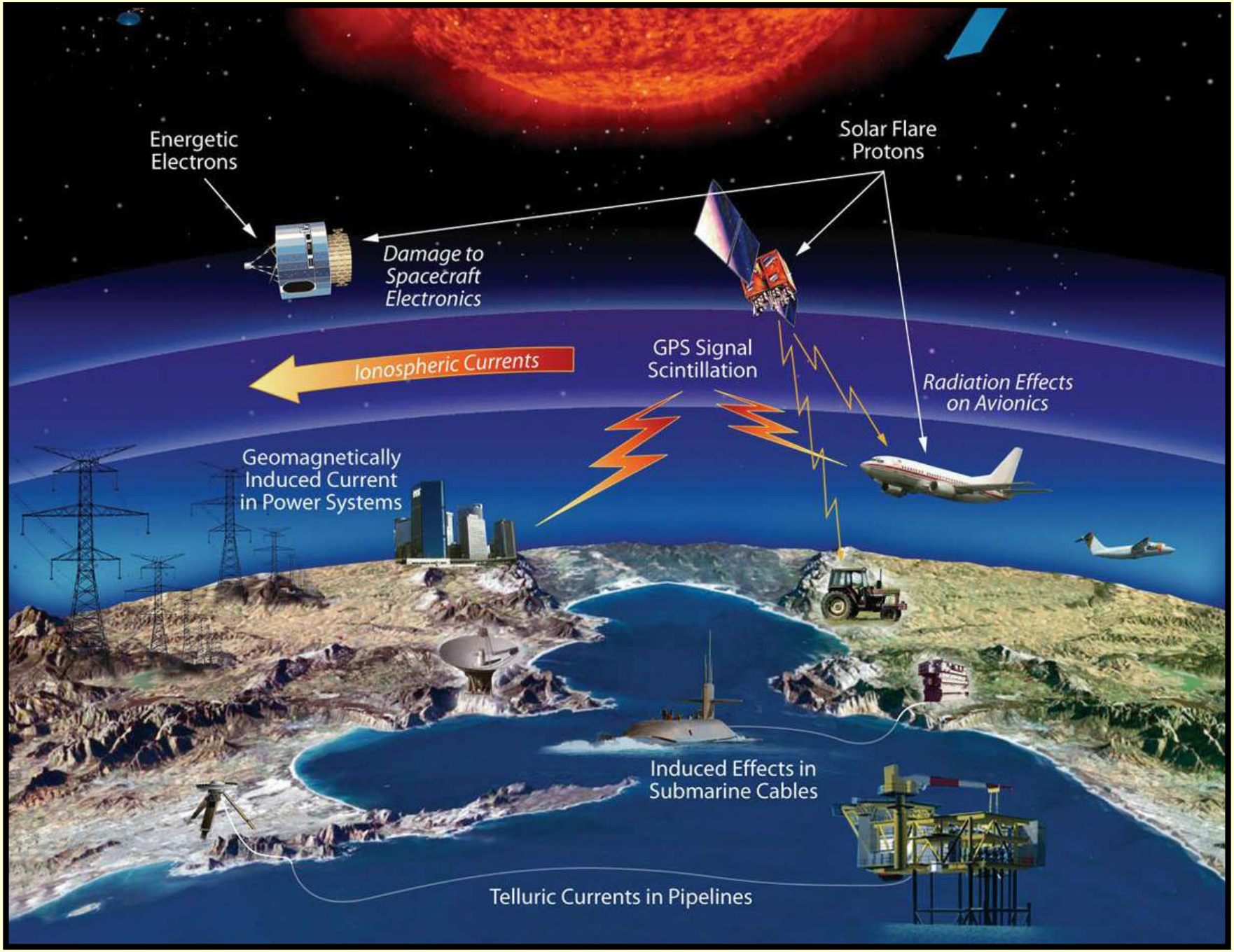
Space weather



NASA

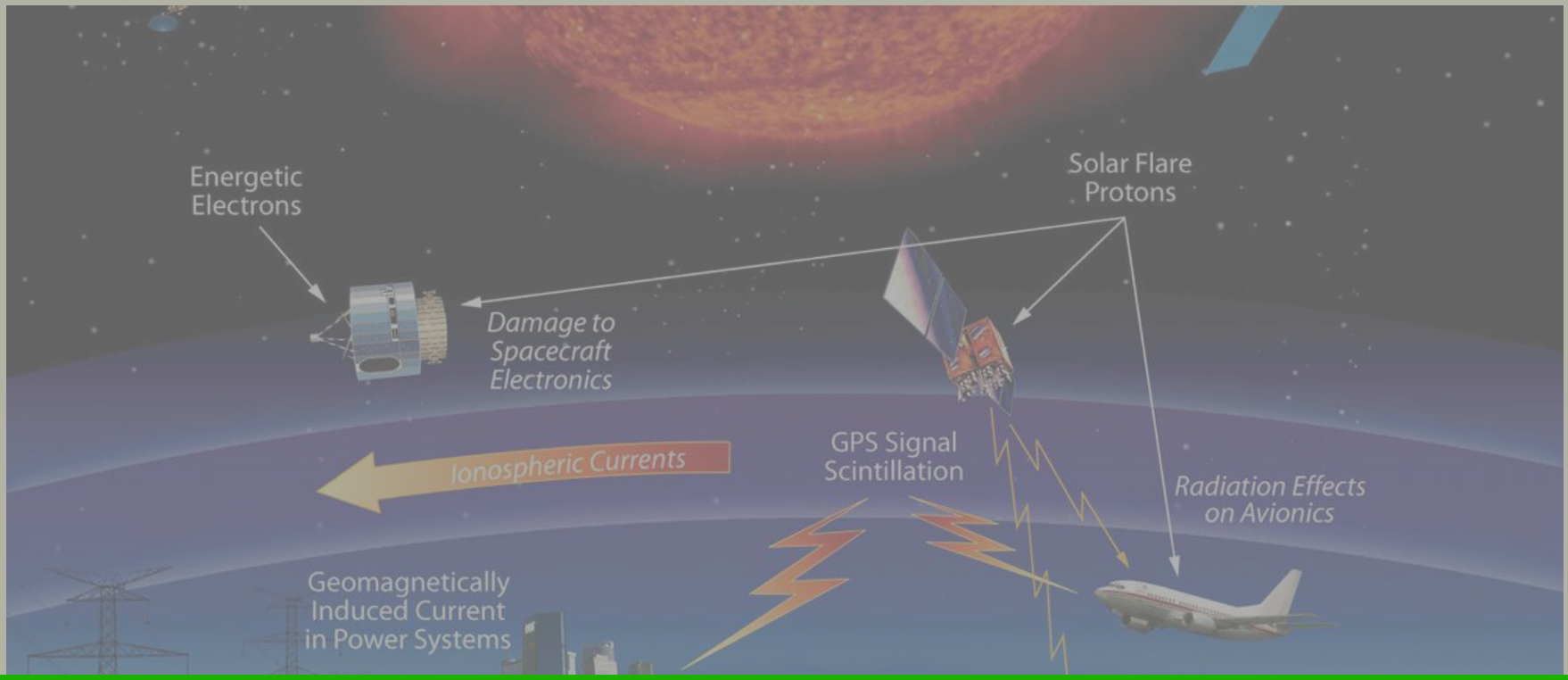
-magnetic fields
-particles (ion, proton, electron, alpha)

Geomagnetic storm



NASA

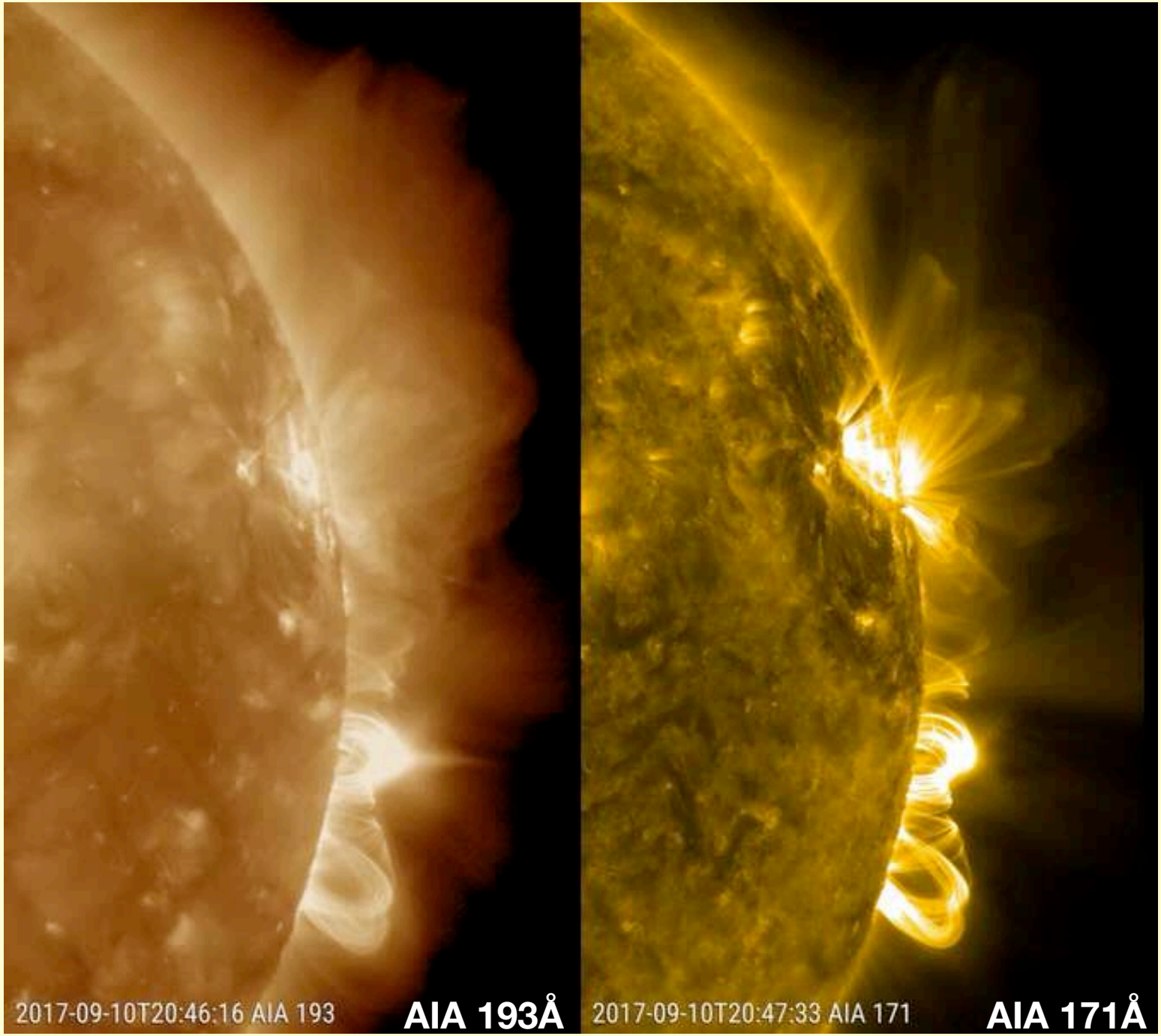
Aim



AIM:

Eruptive events → **Observations + Simulations + in situ** → **Understand the Solar Physics** → **Space Weather Forecast**

Solar flares



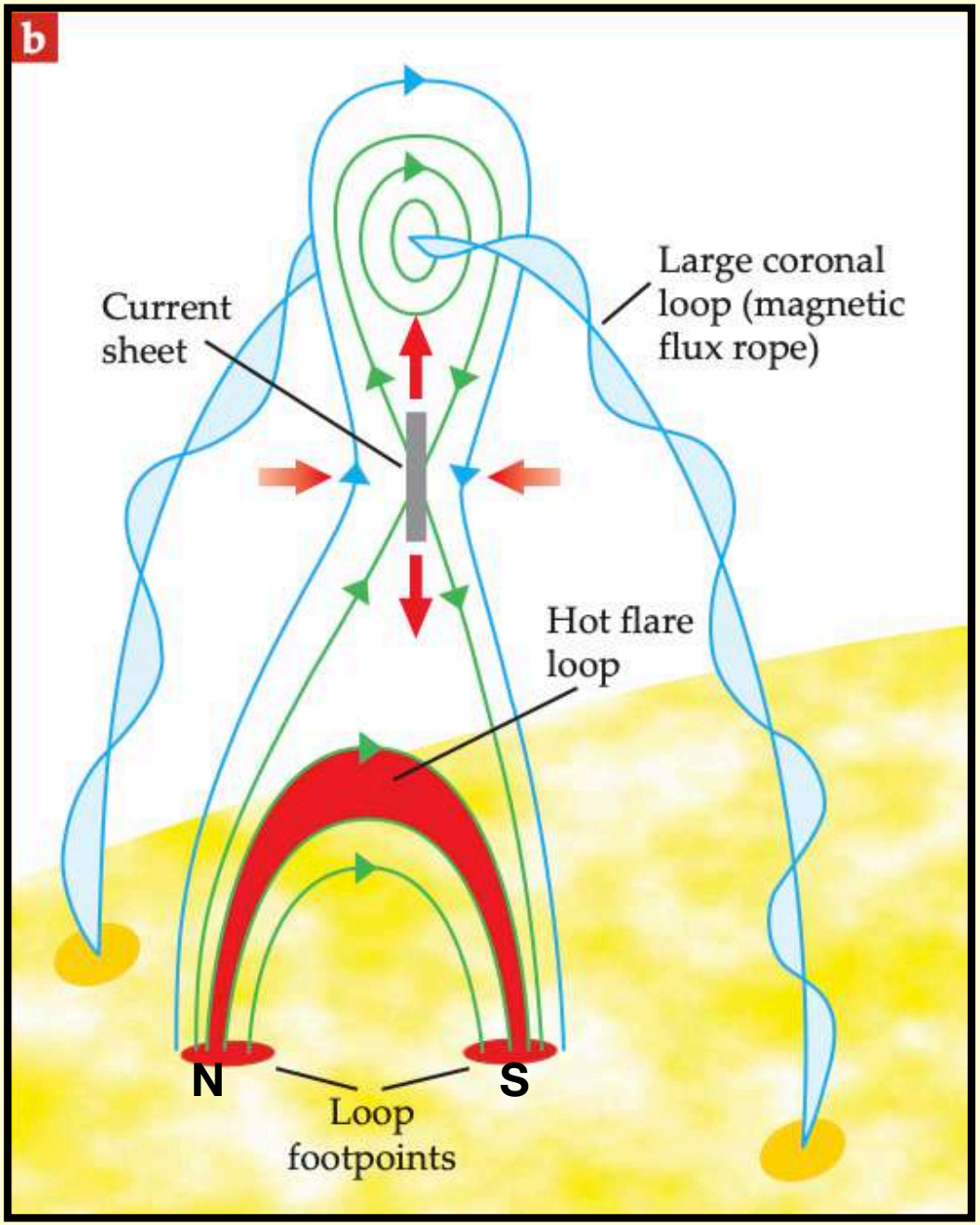
NASA/GSFC/ Solar Dynamics Observatory

Energy: $<10^{32}$ erg

Duration:
minutes-hours

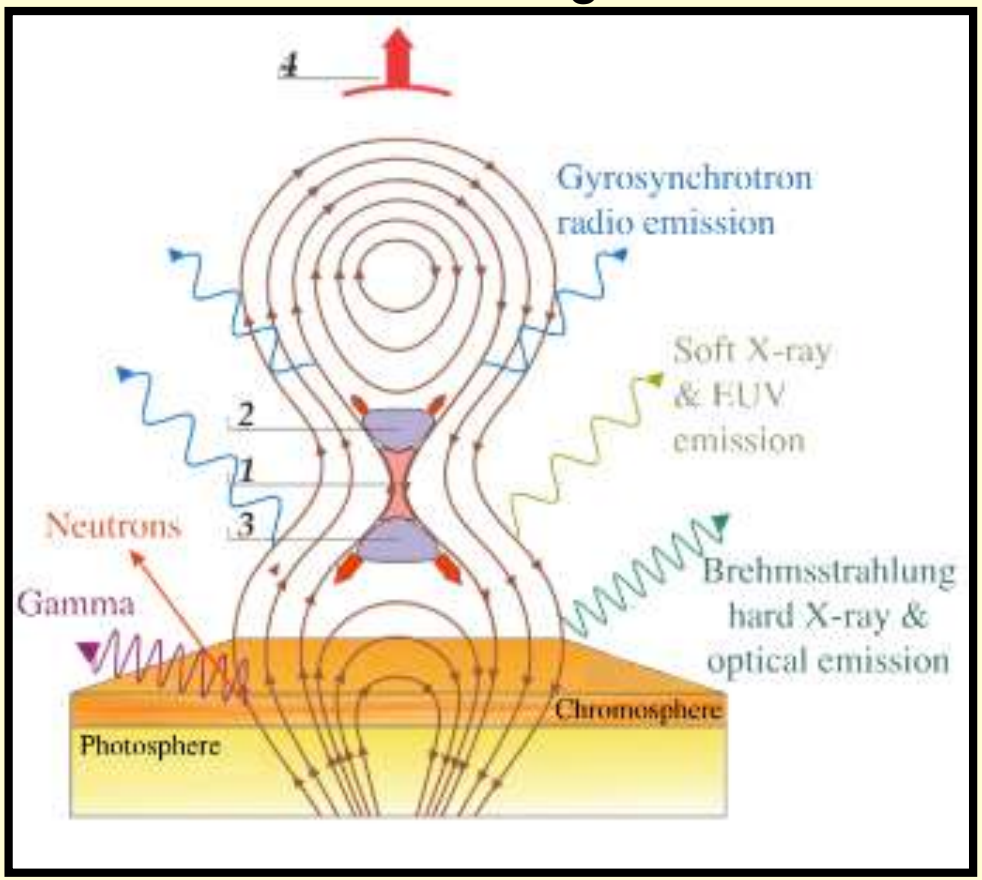
Solar flare 2D model

CSHKP 2D flare model



Holman at al. 2012

Emission during a flare



Bazilevskaya (2017)

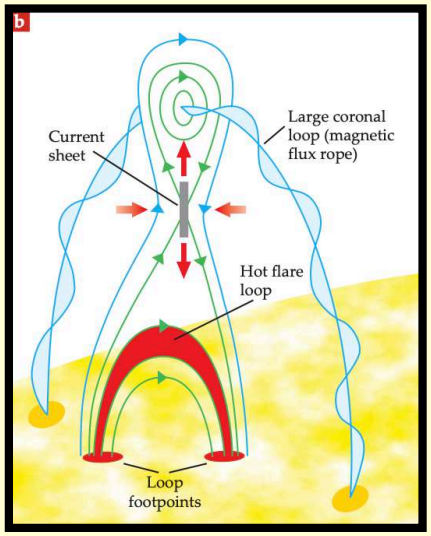
Solar flare 2D → 3D model

Grand Archive of Flare and CME Cartoons (H. Hudson)

More and more flare cartoons!!!

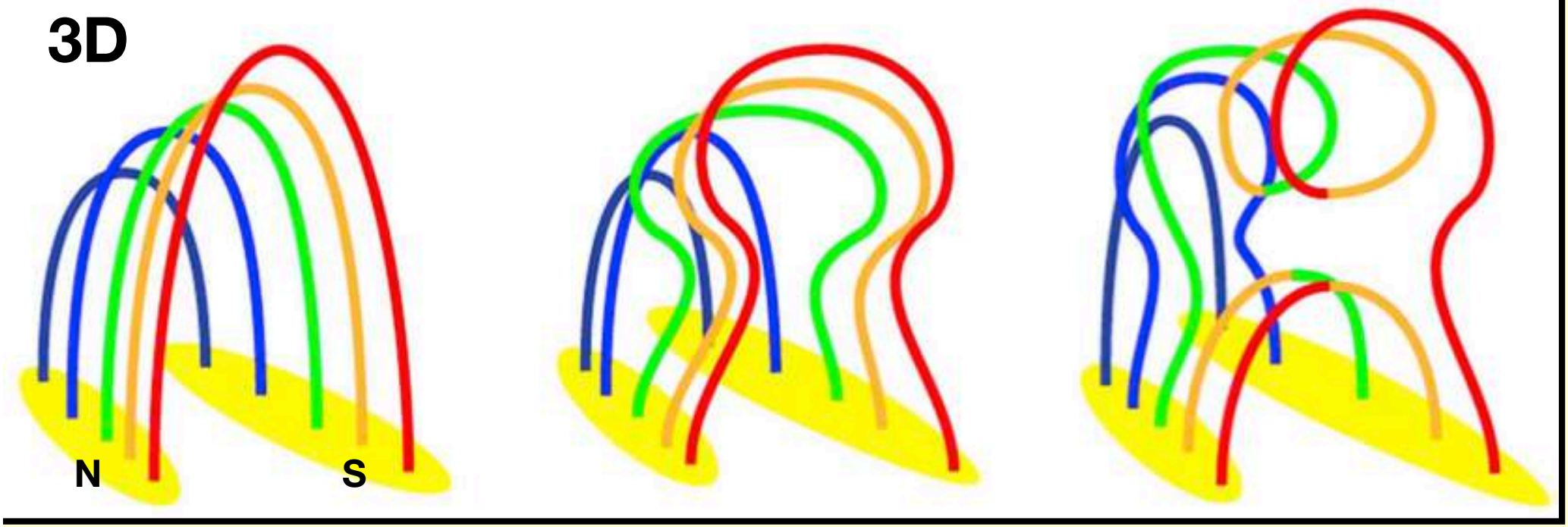
http://solarmuri.ssl.berkeley.edu/~hhudson/cartoons/

2D



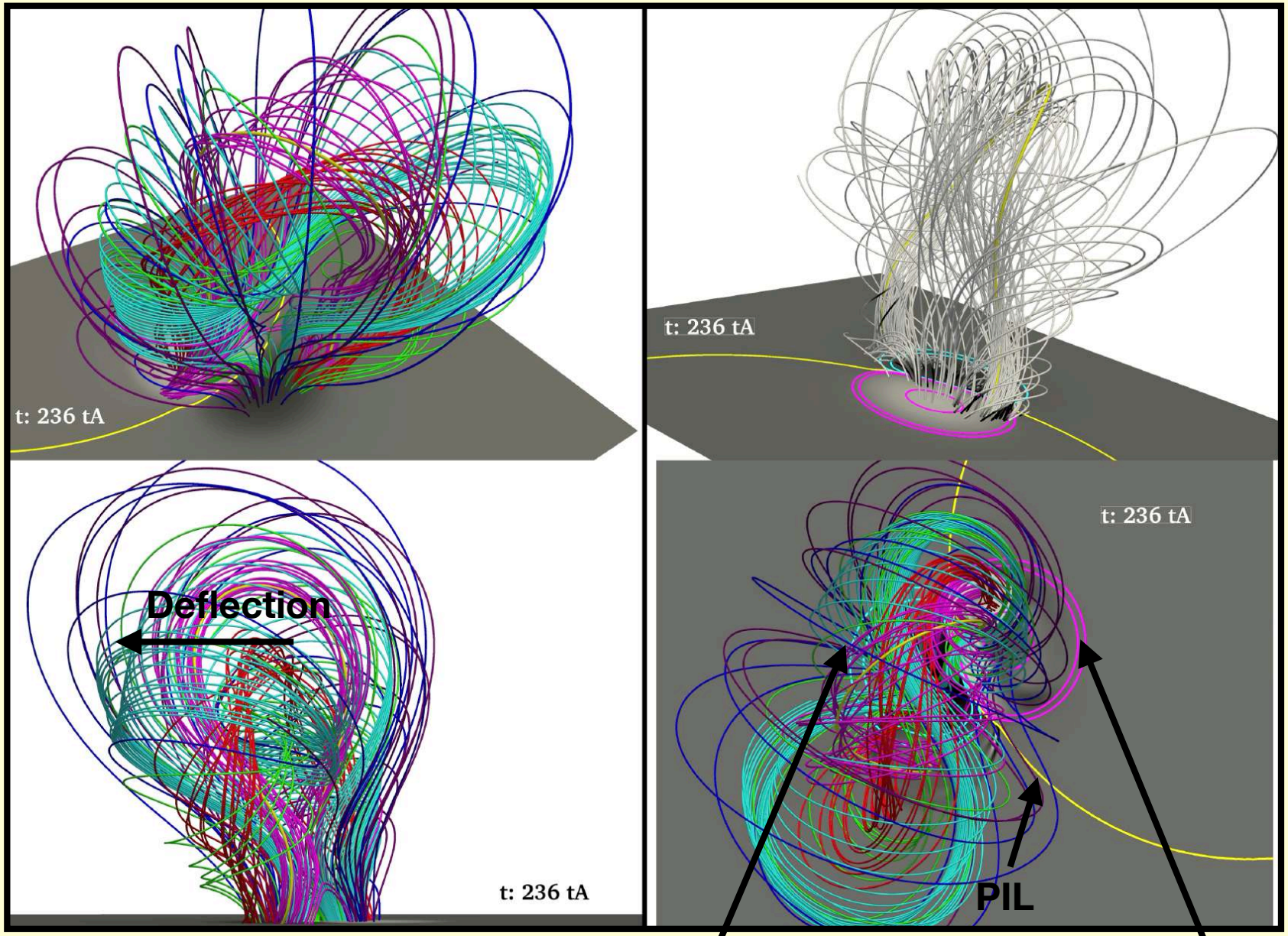
Holman at al. 2012

3D



Holman at al. 2016

Solar flare 3D MHD model

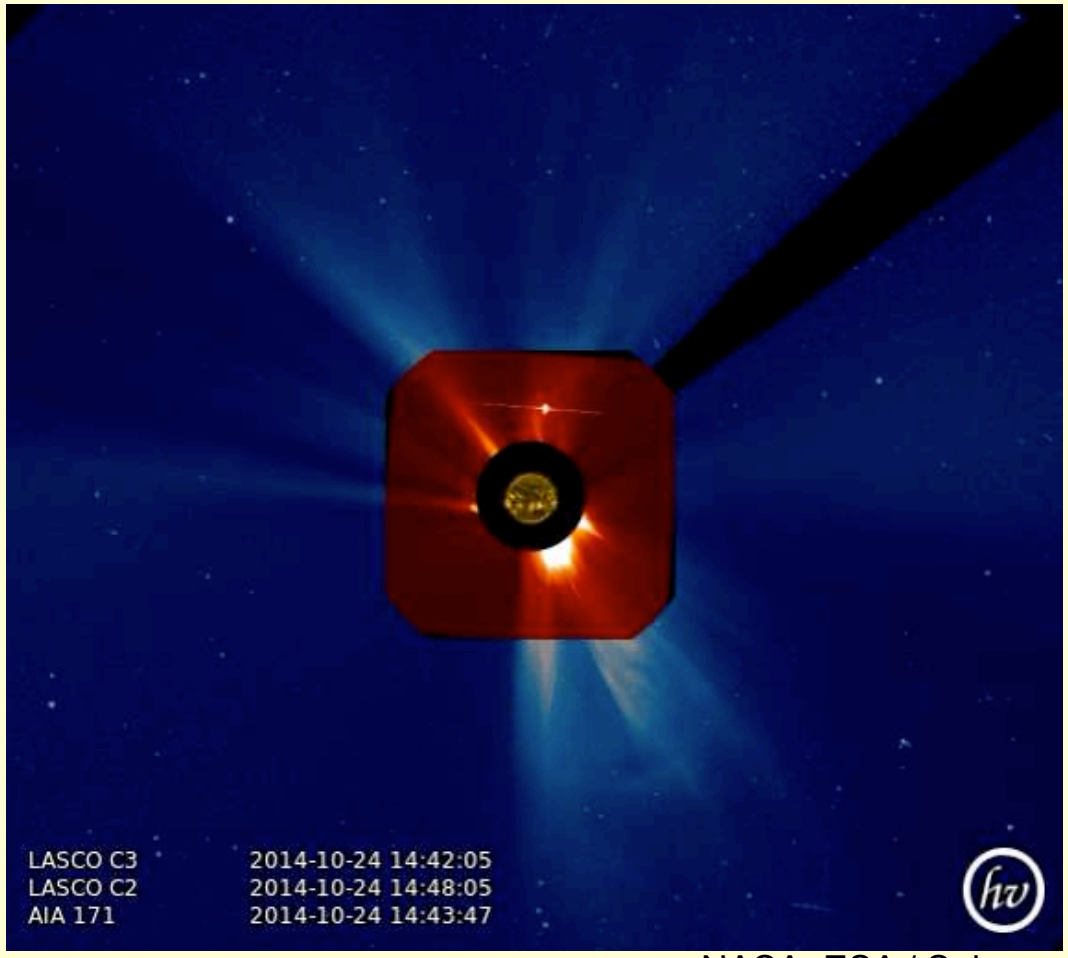


Zuccarello et al. 2015 (ApJ, 814, 126)

negative magnetic field positive

Coronal Mass Ejection (CME)

CME



Halo CME

NASA, ESA / Solar and Heliospheric Observatory

Energy: ~10^{32} erg

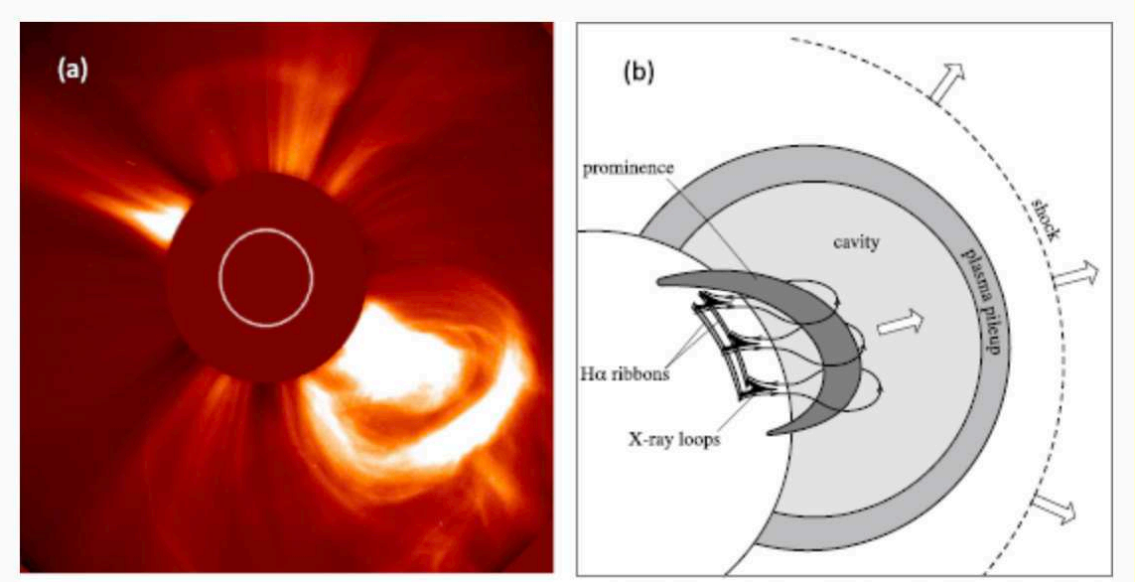
Mass: 10^{11} - 10^{14} kg

Speed: 10 - 3000 km/s

Duration: hours - days

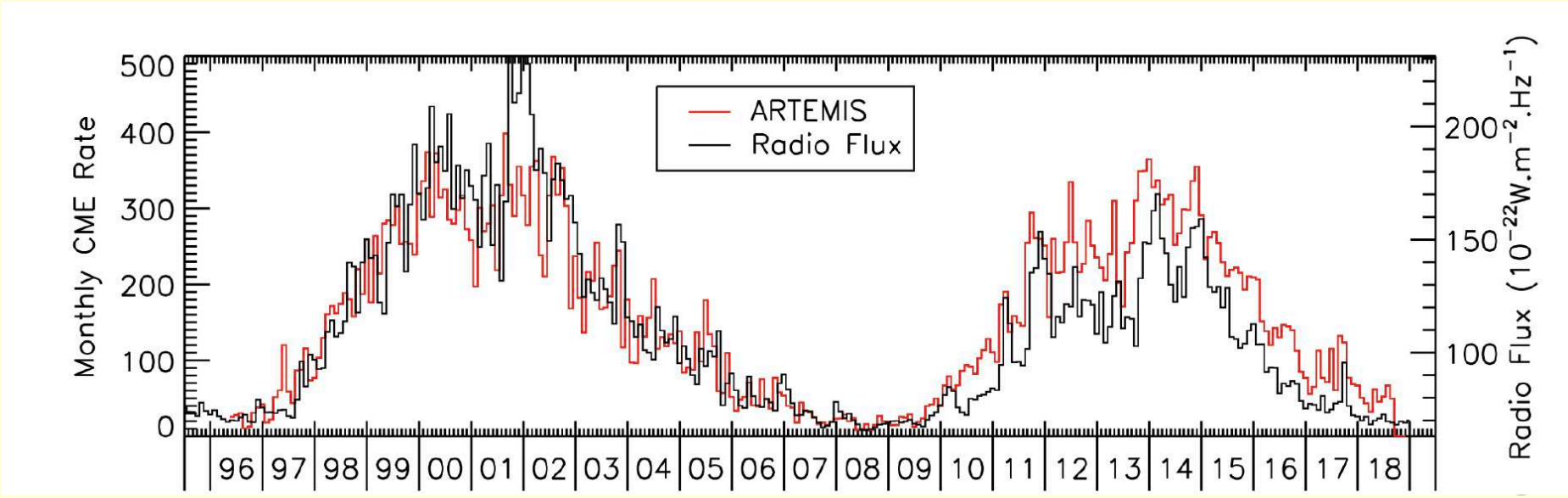
Coronal Mass Ejection (CME)

CME structure



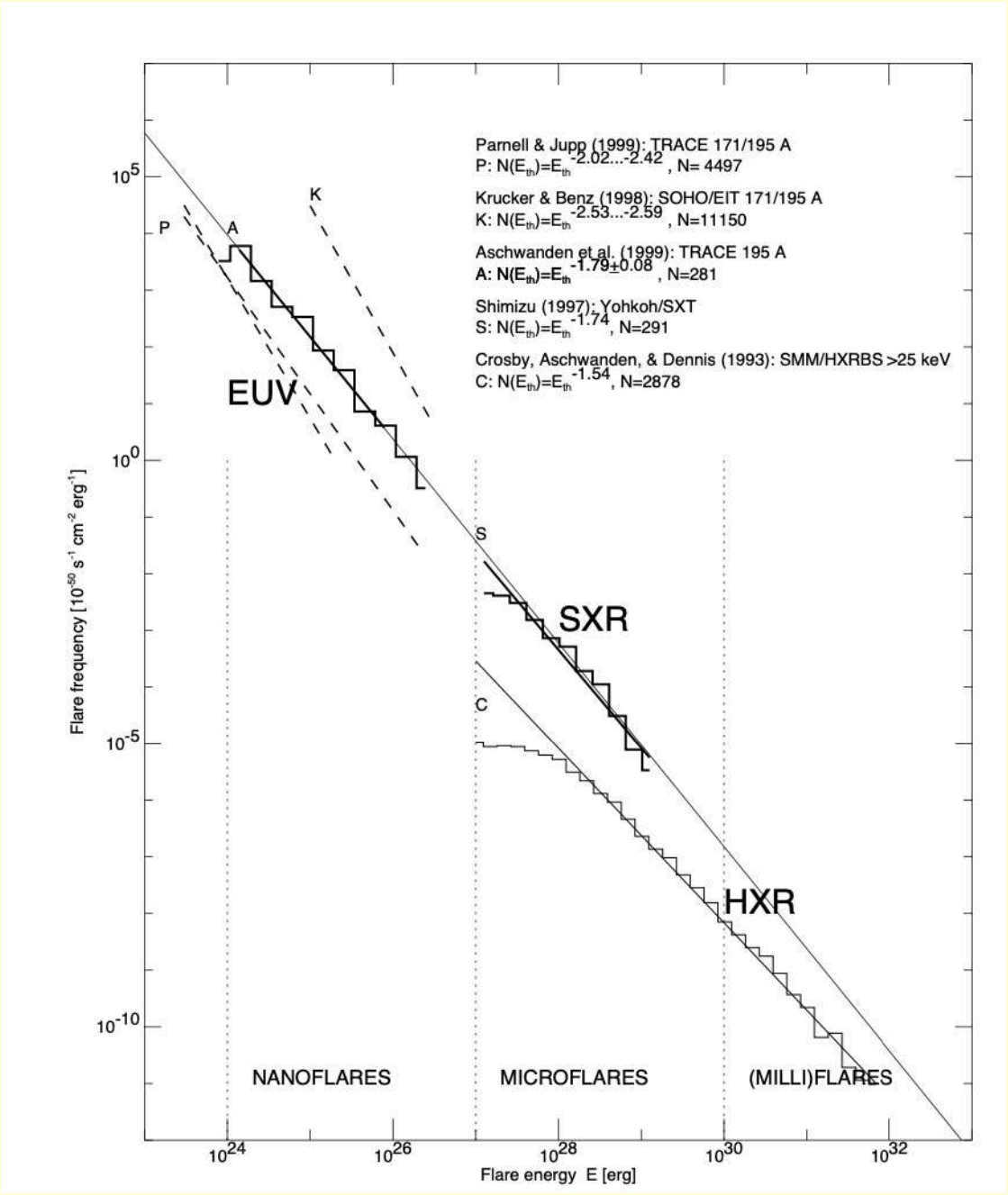
Forbes, 2000

How often we observe CME?



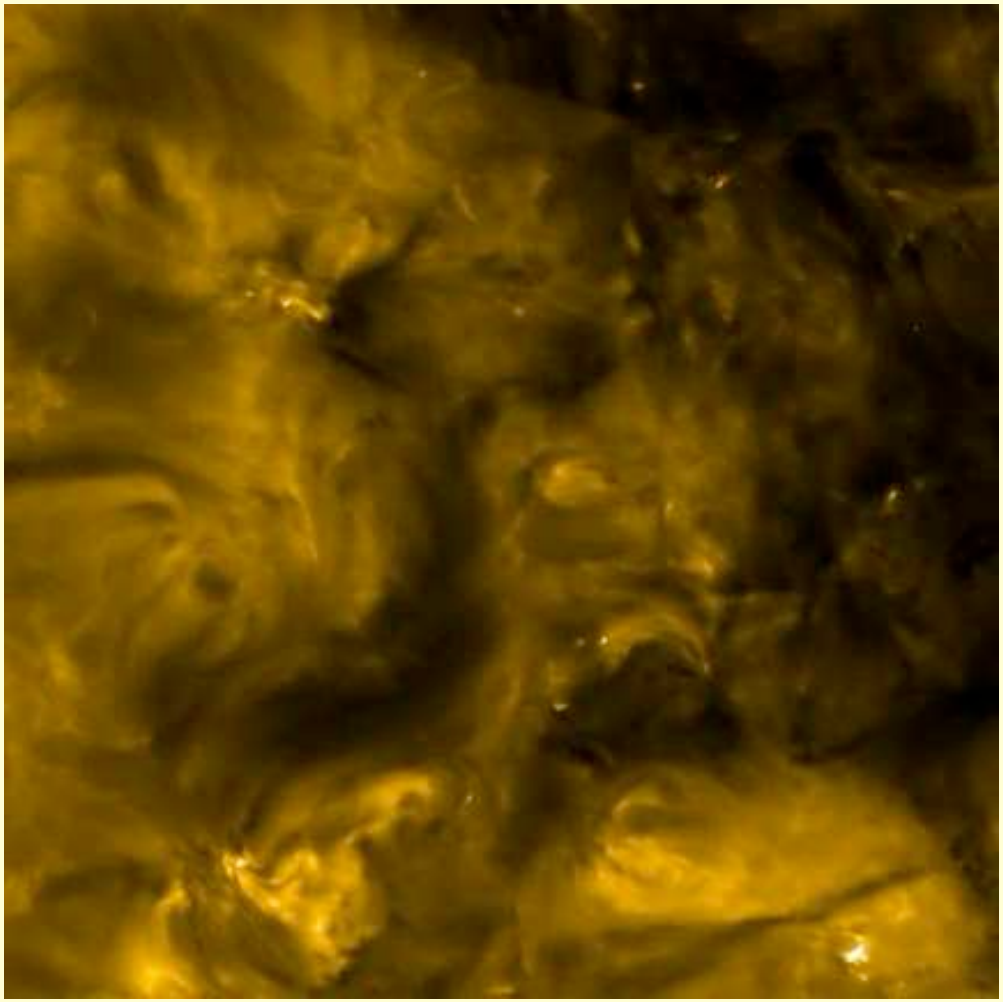
Lamy et al. 2019 (Space Sci Rev (2019) 215:39)

Euruptive events: energy vs. occurance

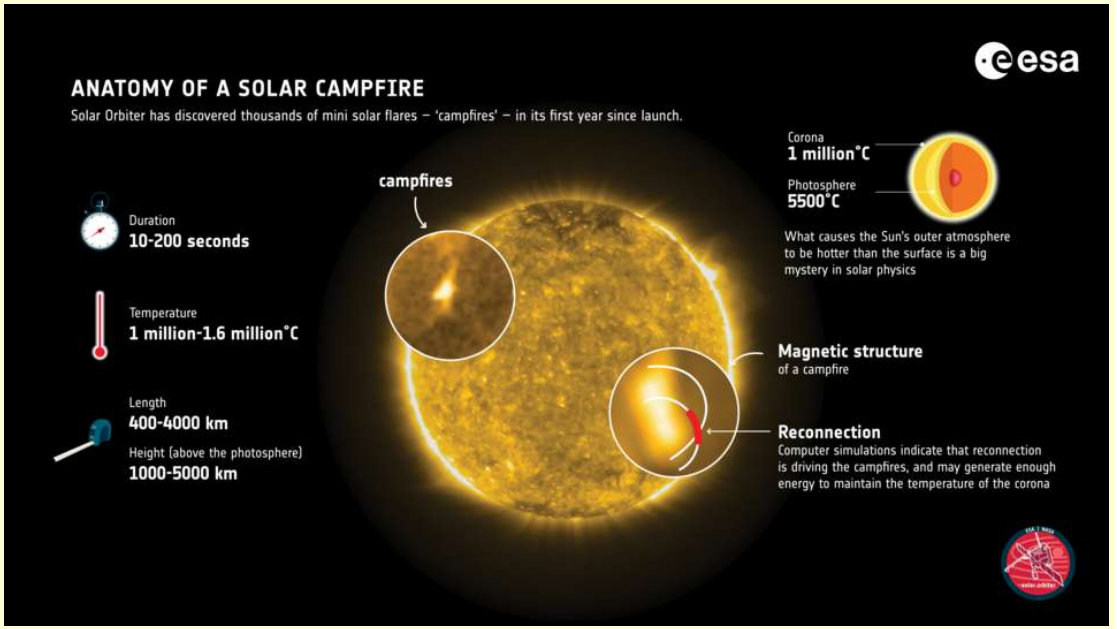


Aschwanden et al. 1999

Campfires

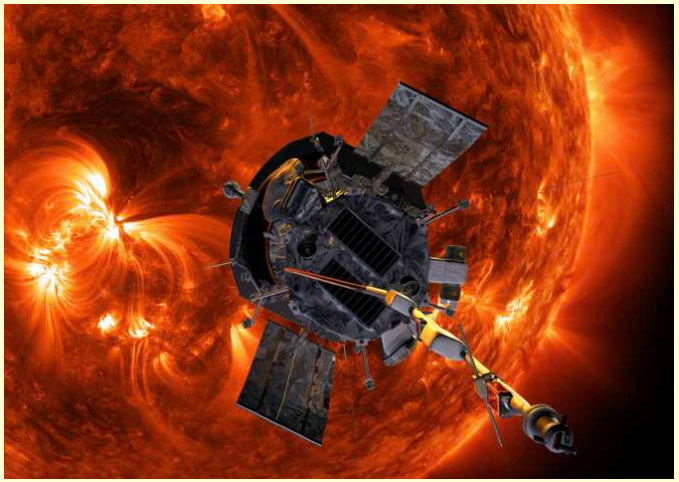


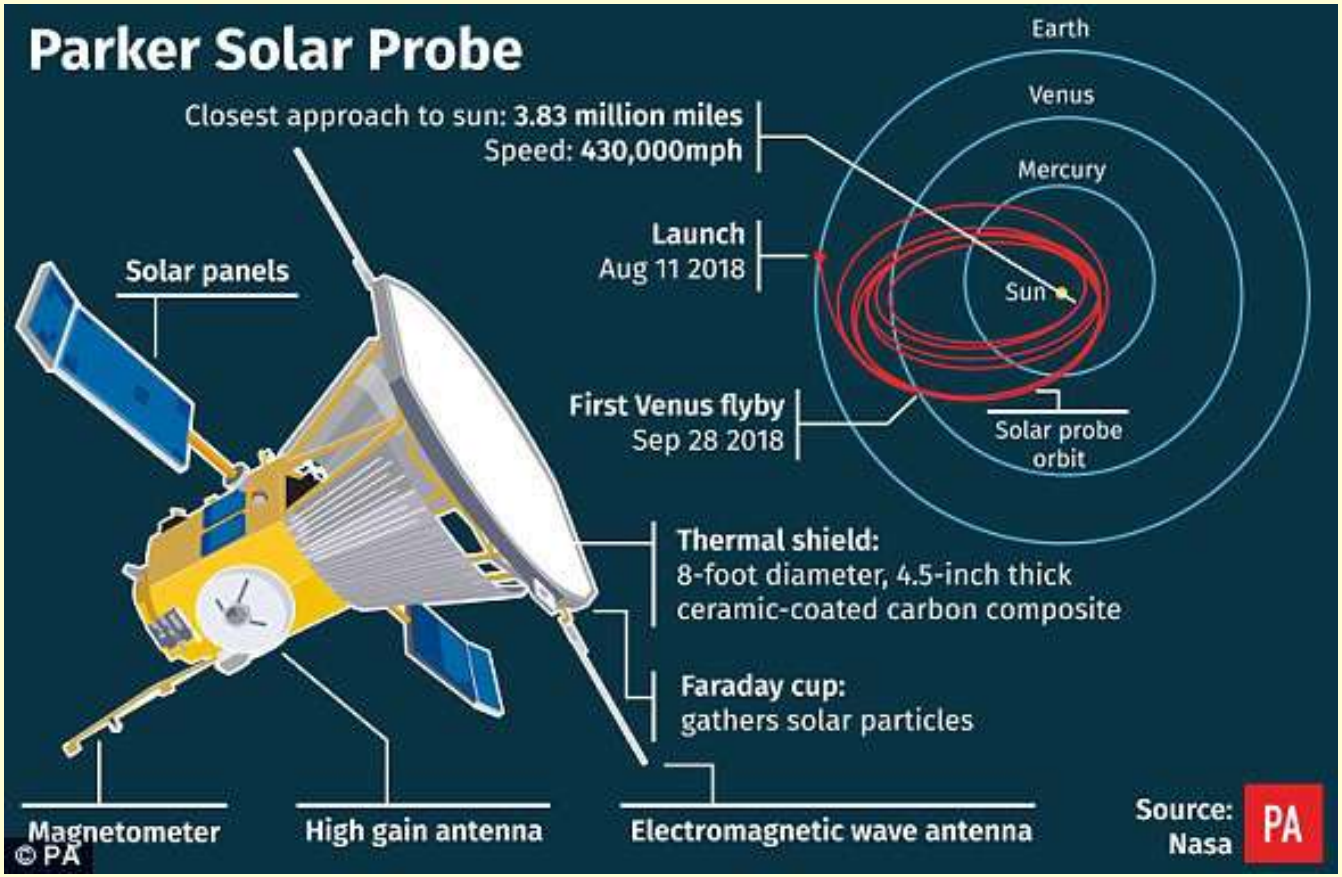
ESA/ Solar Orbiter



ESA/ Solar Orbiter

Parker Solar Probe





-Launch: 11 August 2018

-Orbit: around the Sun

-Distance: 0.046 - 0.73 AU

-plasma in-situ measurements

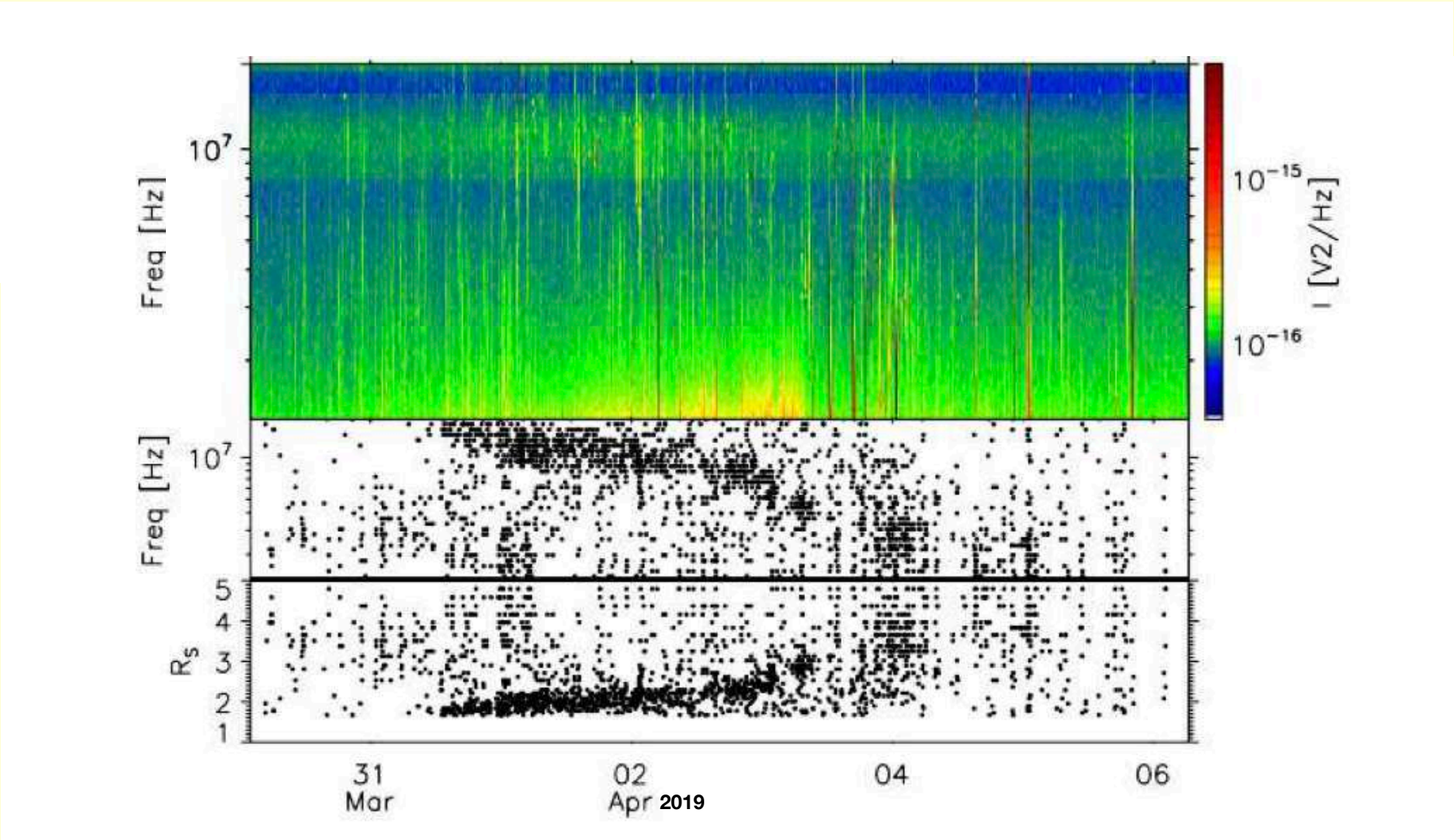
-magnetic field

-solar energetic particles

-electromagnetic wave

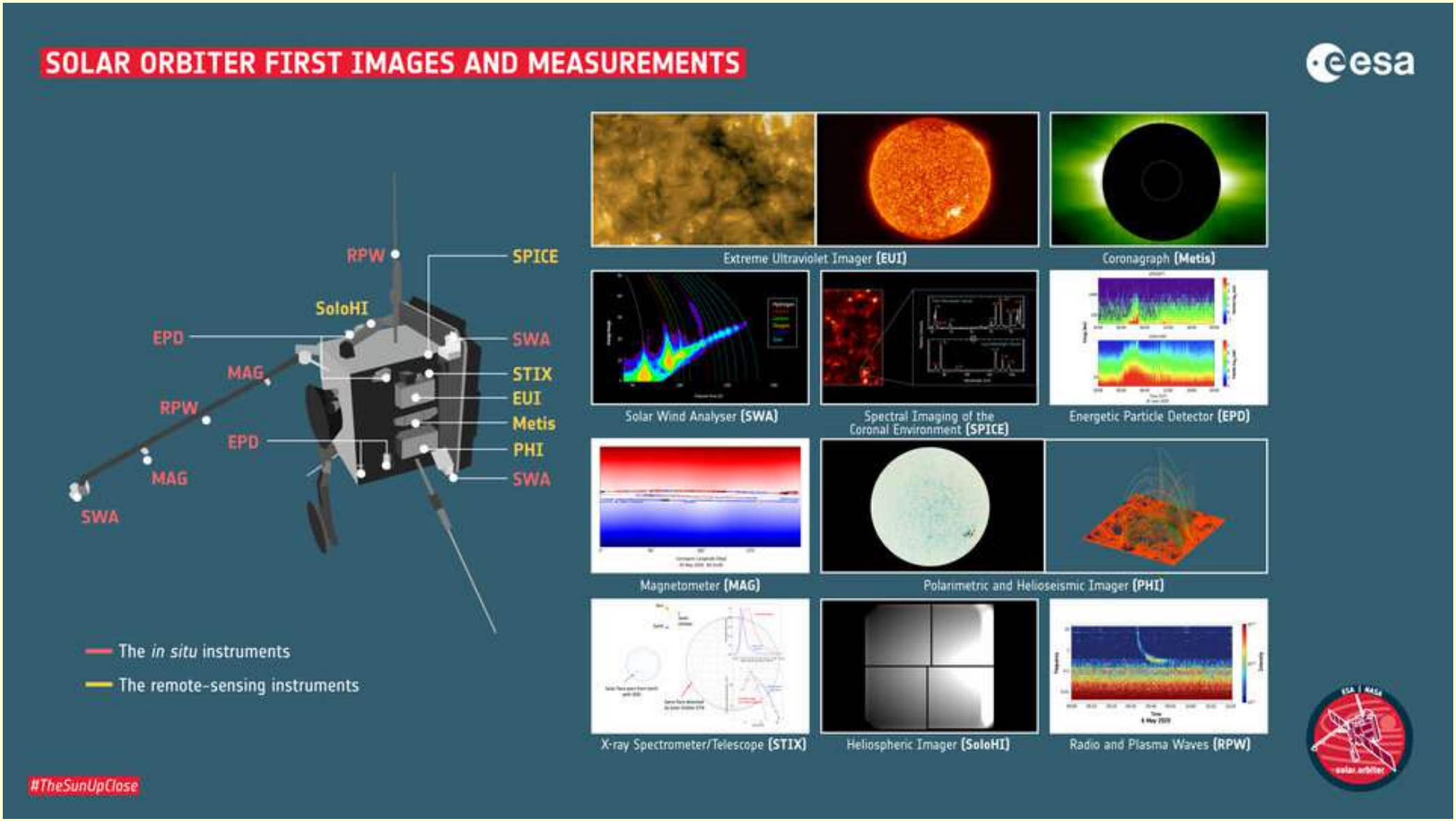
Parker Solar Probe

The active region sources of radio storm



Harra et al. 2021

Solar Orbiter

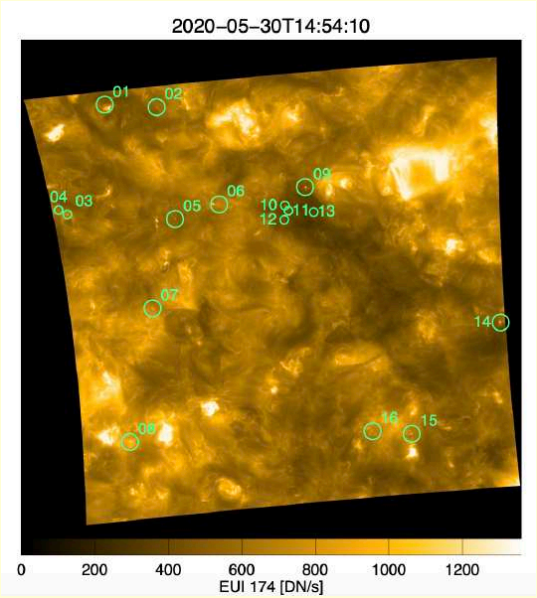


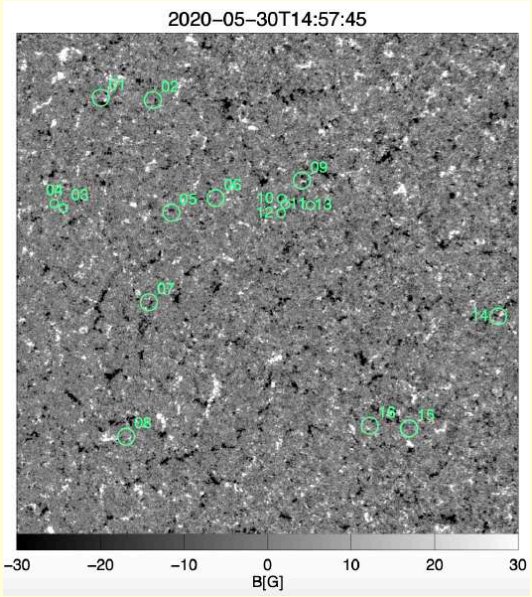
-Launch: 10 February 2020
-Orbit: around the Sun
-Distance: 0.28 - 1.2 AU
-Inclination: 24 deg.

ESA

-imaging, spectrograph,
-magnetic field
-plasma in-situ measurements

Solar Orbiter

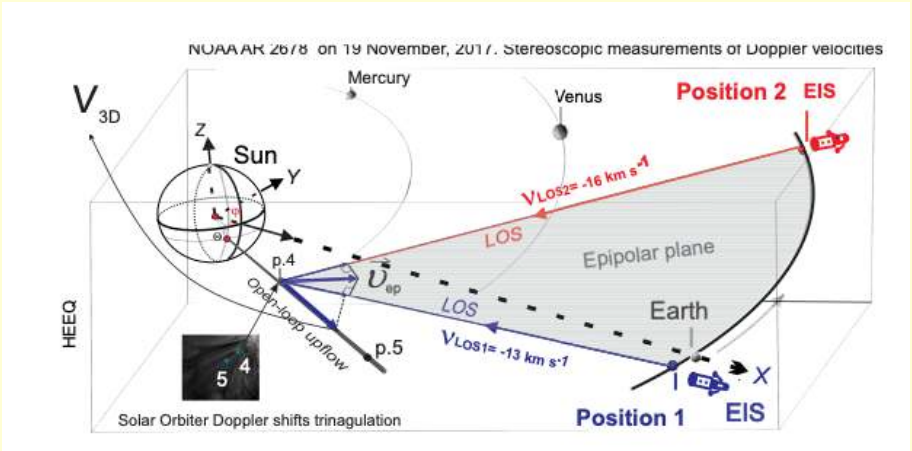


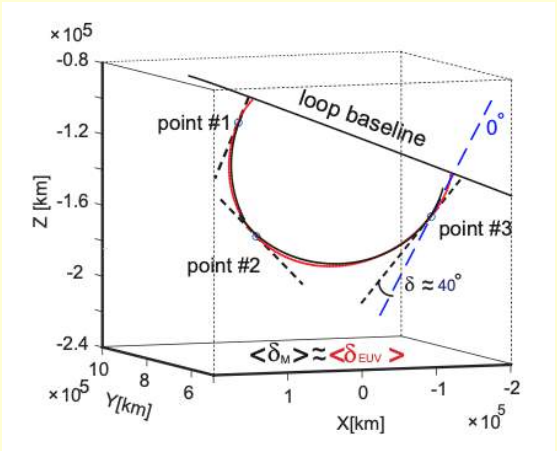


Campfires properties

Berghmans et al. 2021

Zhukov et al. 2021





Stereo-spectroscopy

Podladchikova et. al 2021

Thank you for your attention!

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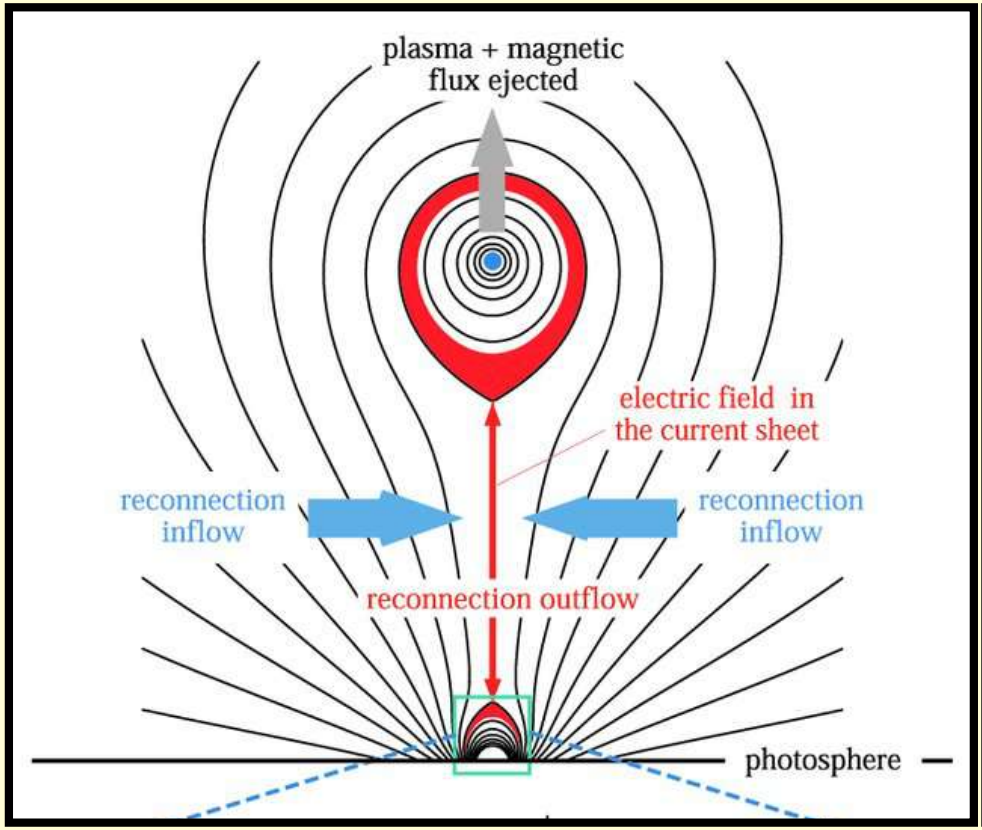
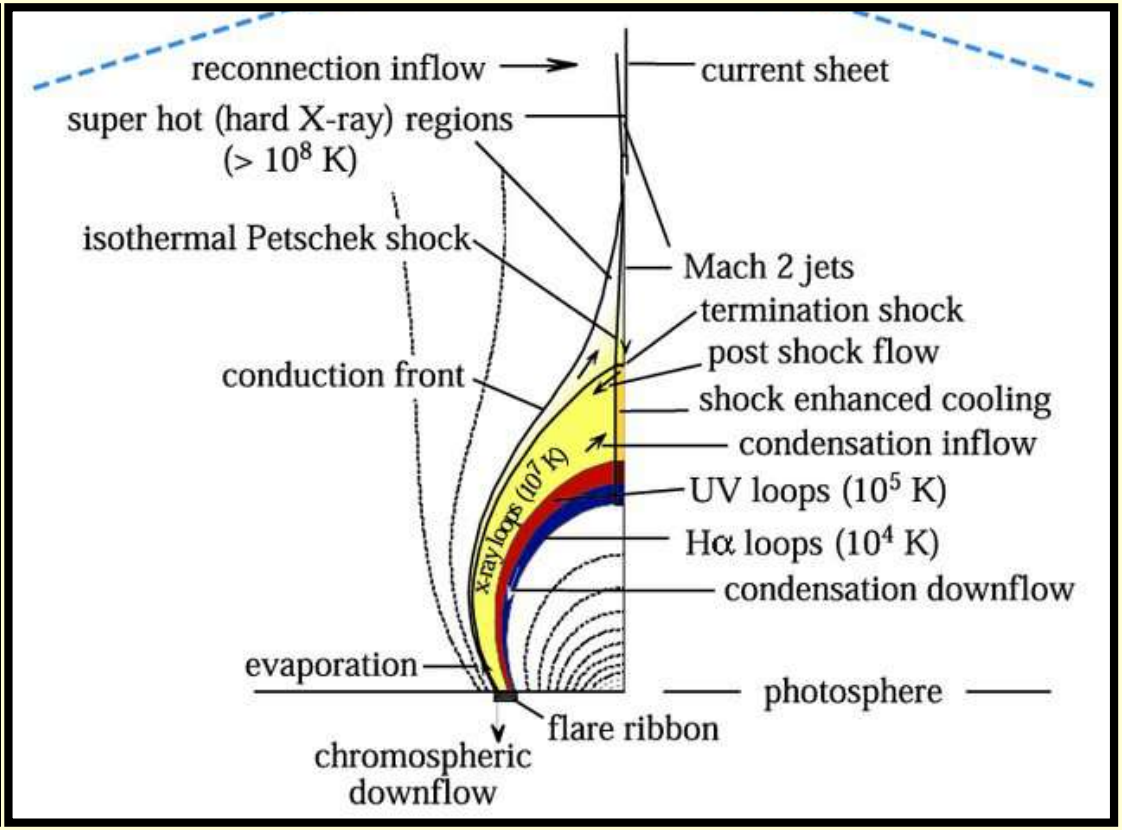
Appendix

Solar flare 2D model

CSHKP 2D flare model





Lin & Forbes 2002, (JGR 105, 2375)

Flares classification

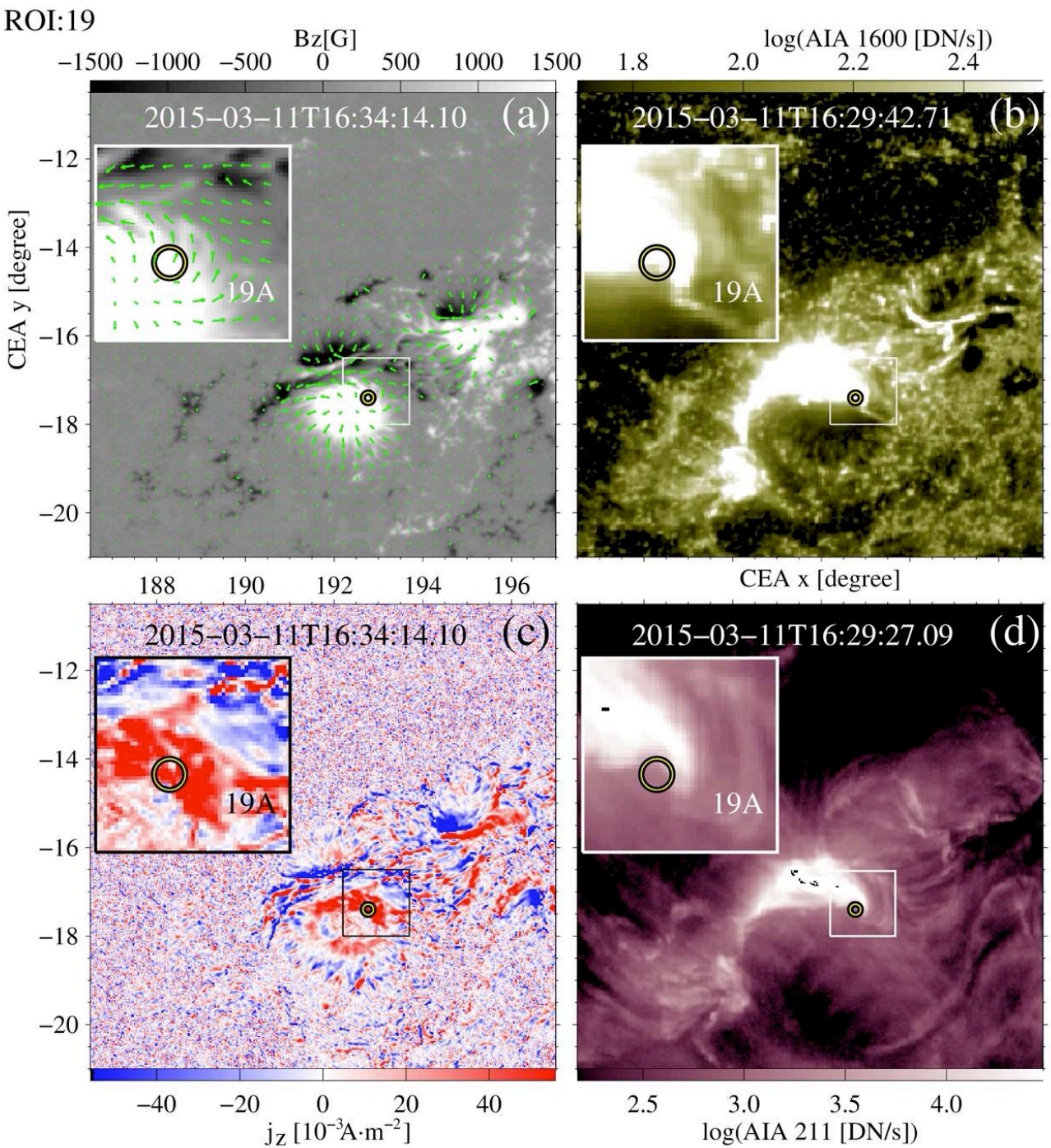
After Bhatnagar & Livingston 2005

Hα classification			Radio flux at 5000 MHz in s.f.u.	Soft X-ray class	
Importance Class	Area (Sq. Deg.)	Area 10^{-6} solar disk		Importance class	Peak flux in 1-8 Å w/m^2
S	2.0	200	5	A	10^{-8} to 10^{-7}
1	2.0–5.1	200–500	30	B	10^{-7} to 10^{-6}
2	5.2–12.4	500–1200	300	C	10^{-6} to 10^{-5}
3	12.5–24.7	1200–2400	3000	M	10^{-5} to 10^{-4}
4	>24.7	>2400	3000	X	>10^{-4}

Hα sub-classification by brightness: F – faint, N – normal, B – bright

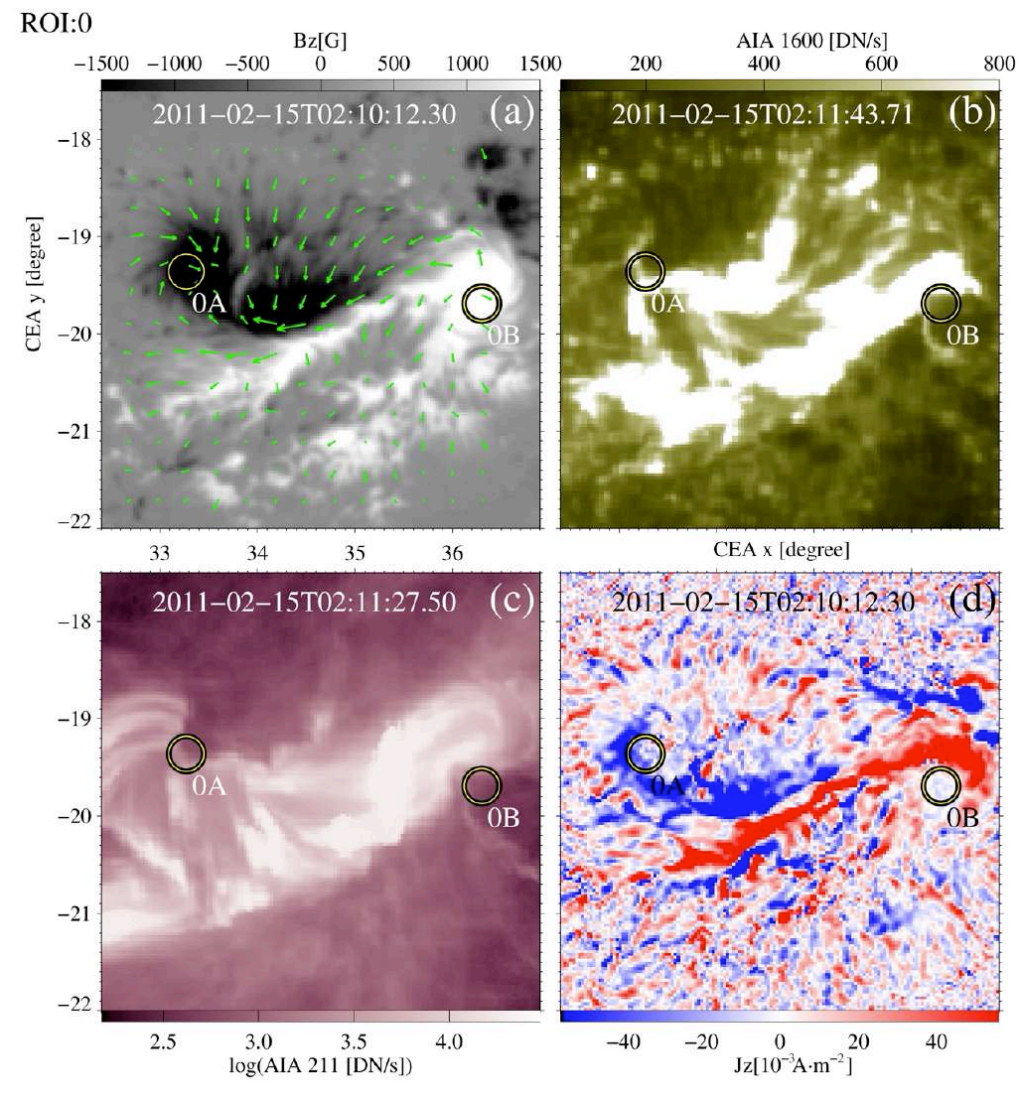
1 s.f.u. = 10^4 jansky = 10^{-2} W m^{-2} Hz^{-1}

ROI-19

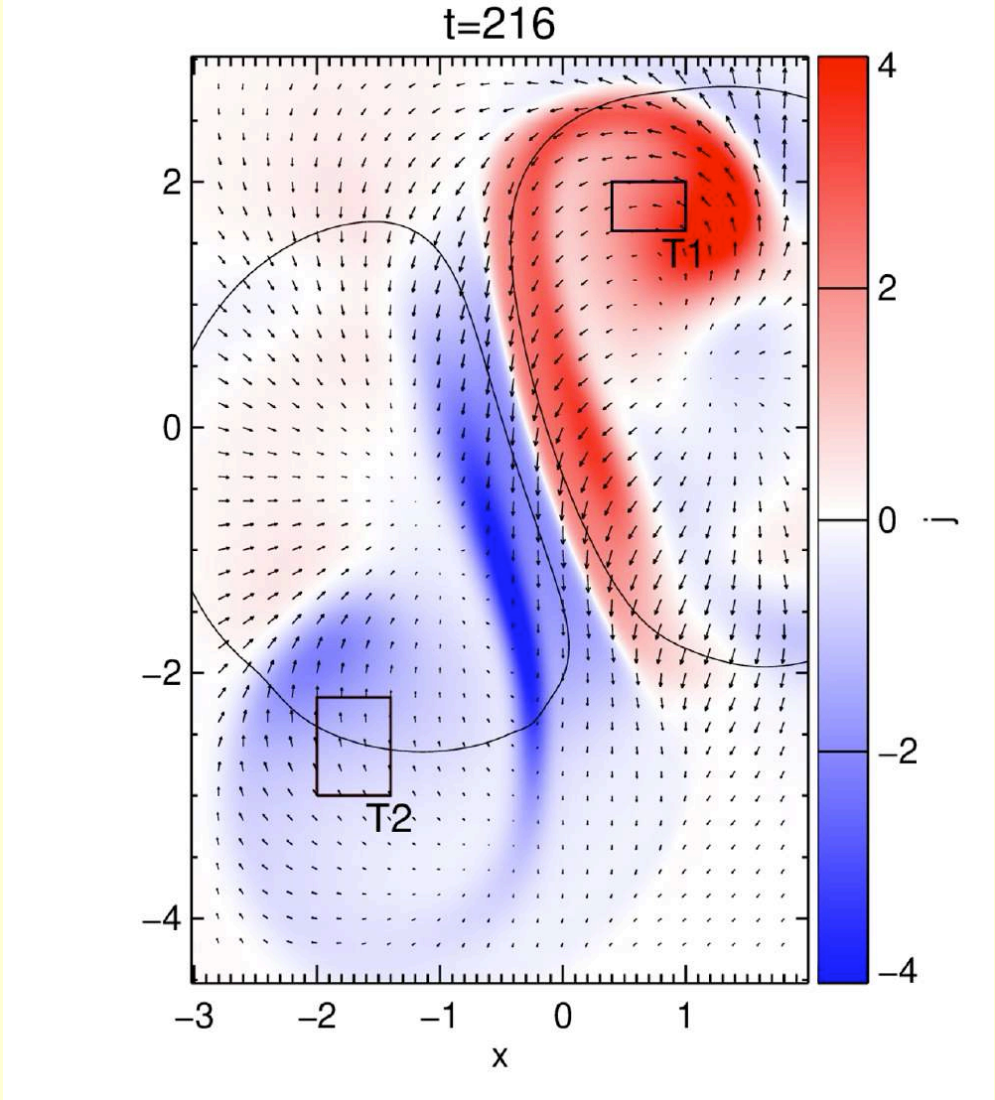


Barczynski et al. 2020

Observation vs. Simulation



Barczynski et al. 2020



Barczynski et al. 2020