

Study of Sheet Structures in Eruptive Solar Flares

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Project Summary

- ▶ Observations of high-energy emission from solar flares often reveal the presence of large sheet-like structures, sometimes extending over a space comparable to the Sun's radius. These sheets exist in a very important region where the magnetic field is expected to produce large sheets of electrical current. In this project, we will measure the physical conditions in these sheets to understand how the conditions control the magnetic reconnection and energy release in flares.



2-D Cartoon of Reconnection

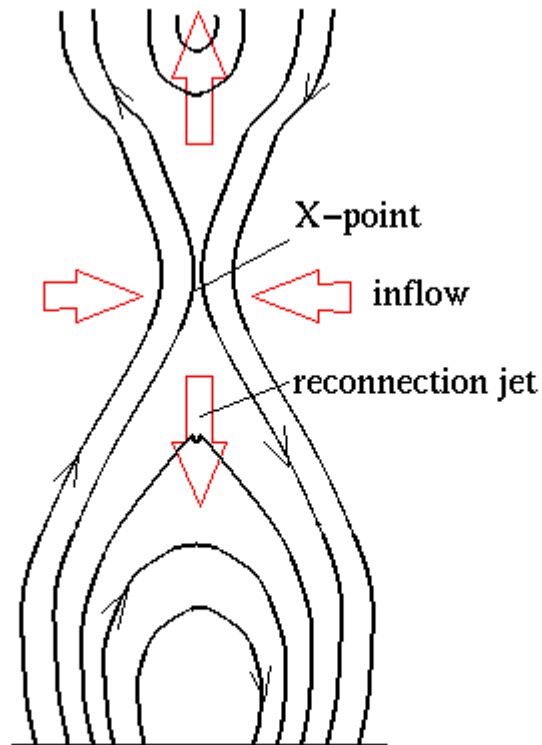


Fig. 1 : Schematic illustration of the reconnection model of a solar flare. Thick solid lines show magnetic field. Arrows indicate the plasma bulk flow.



3-D Cartoon of Reconnection

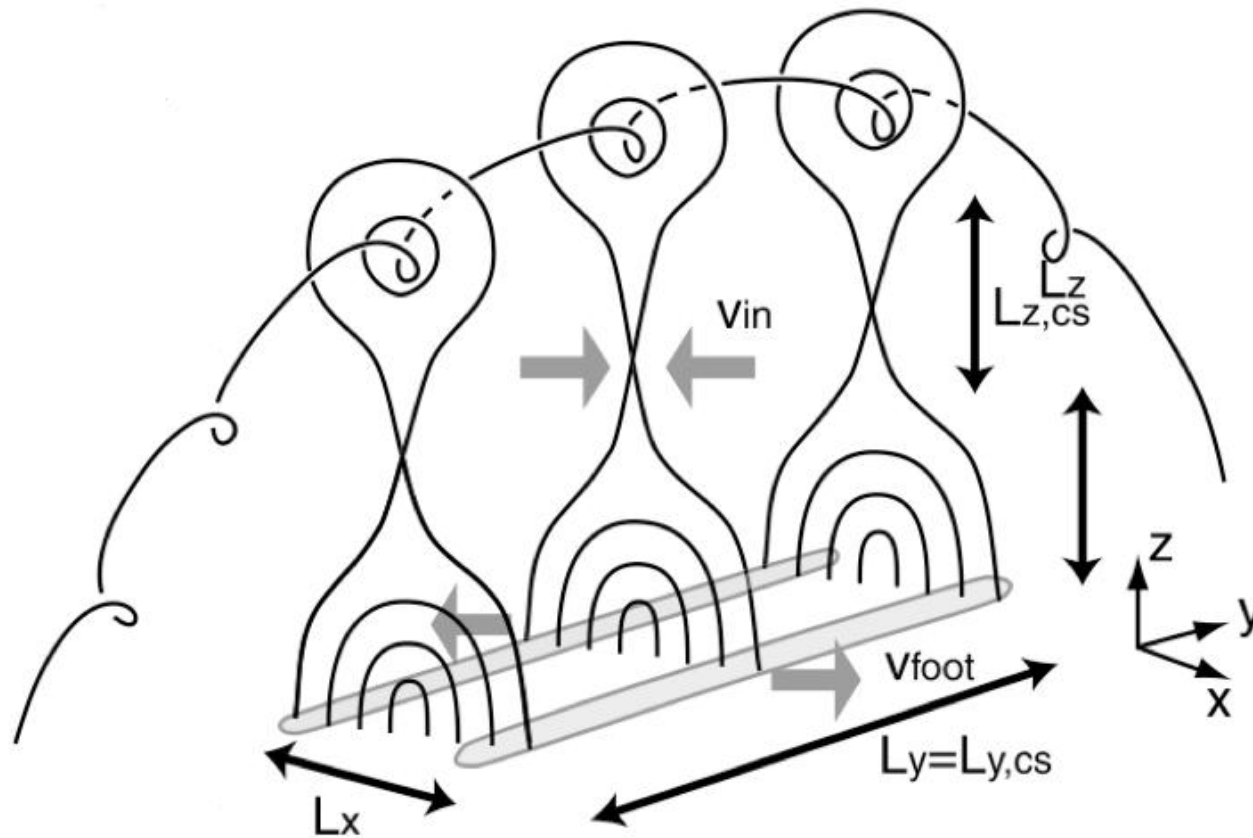
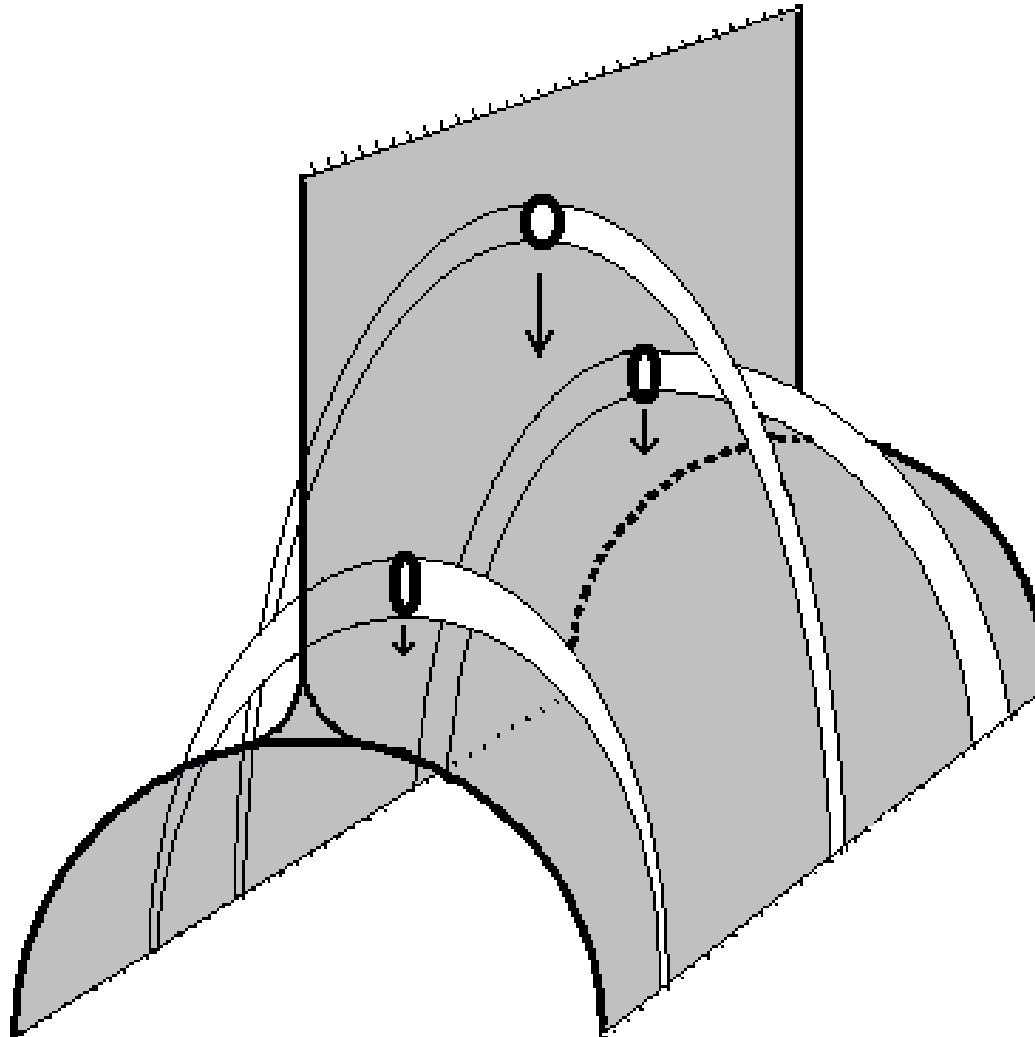
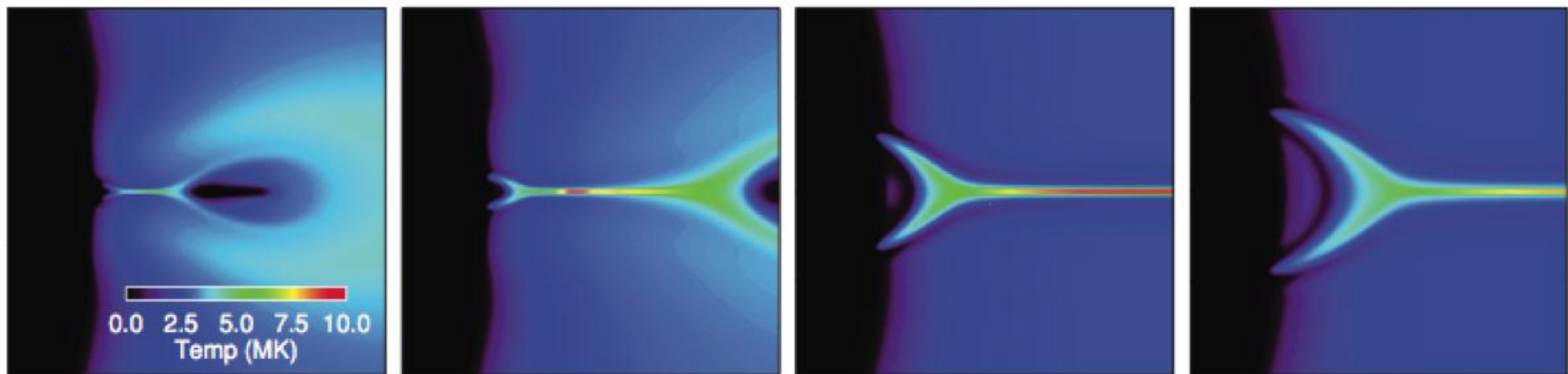
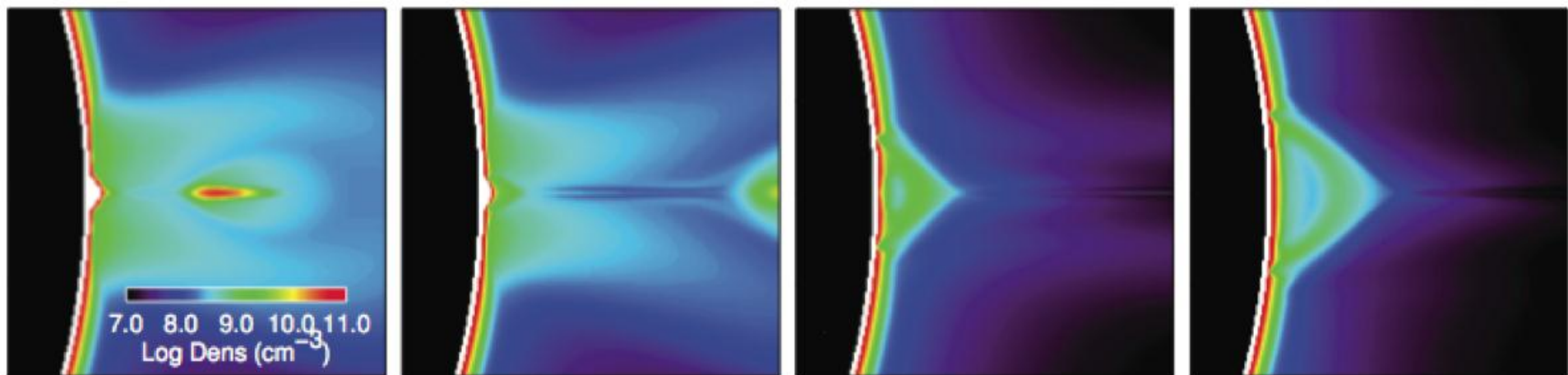
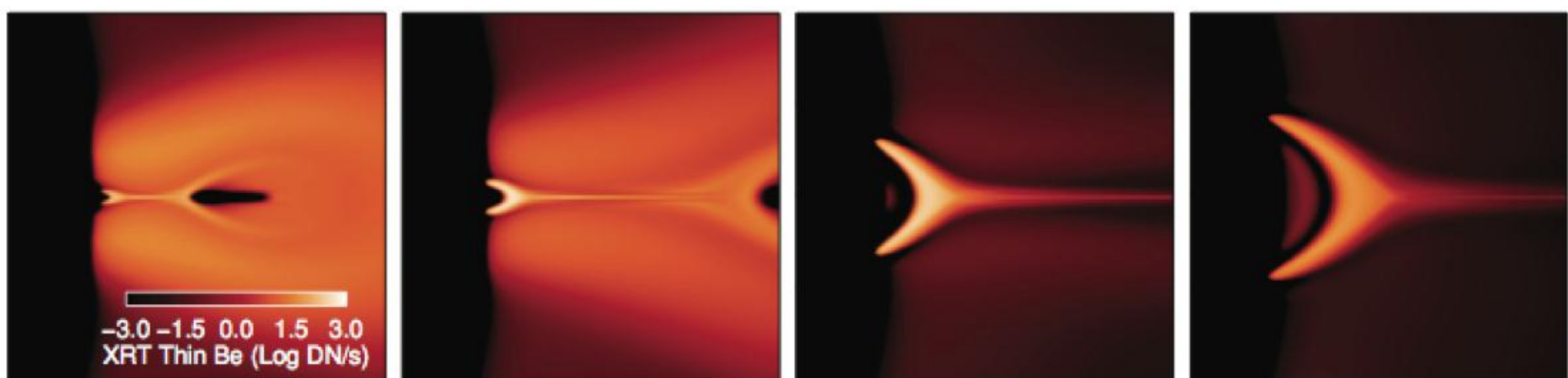


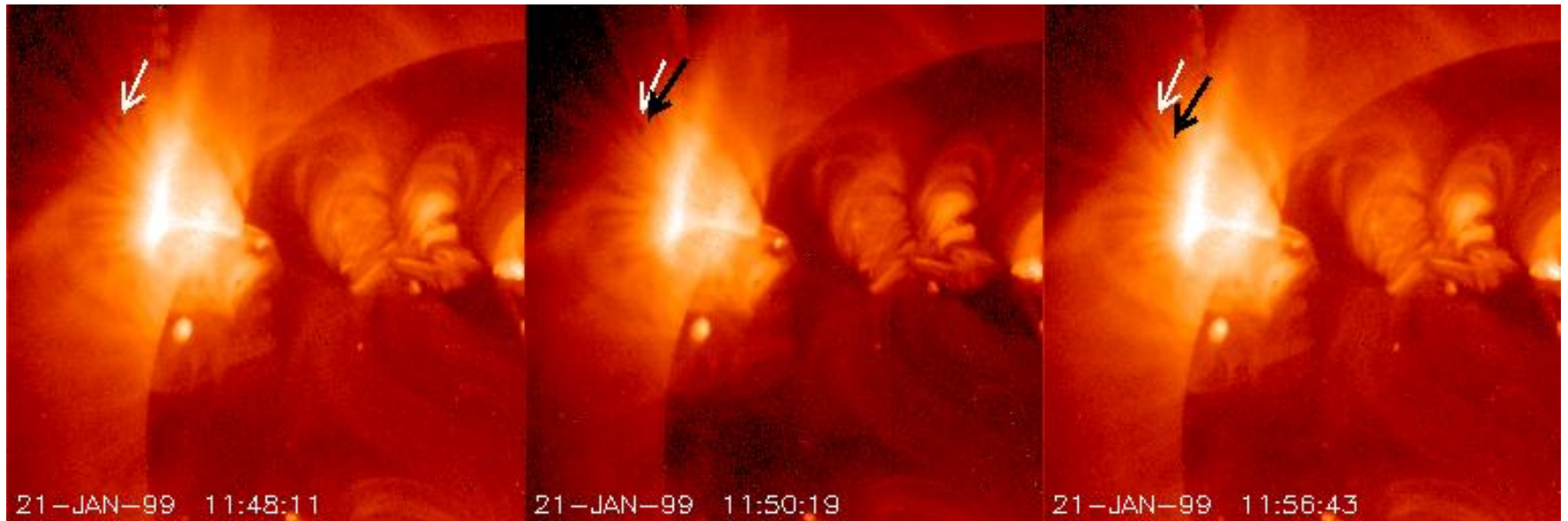
FIG. 1.—Schematic illustration of the reconnection model of a two-ribbon flare.

3-D Cartoon of Current Sheet





Visible Current Sheets



Process

1. Select Data
2. Prep Data using XRT_prep
 1. Cleans up Data
3. Align Data using XRT_align_cube
4. Ratio to create temperatures and emission measure using XRT_Teem
5. Use the temperature and emission measure to find the number density, pressure, and thermal energy



XRT Teem

- ▶ Purpose of program is to get coronal temperatures using the filter ratio method
- ▶ Different filters respond differently to X-Rays
- ▶ Relation between temperature, energy, and wavelength
- ▶ Output of the program is the emission measure and temperature



Extension of XRT Teem

- ▶ From the Temperature and Emission Measure we can also derive the Number Density, Pressure and Thermal Energy

$$\textit{Emission Measure} = \int \eta_e^2 dV \cong \eta_e^2 V$$

$$P = \frac{NkT}{V} = \eta_e kT$$

$$U_t = 3NkT = 3\eta_e V kT$$



Code

- ▶ Restrictions: Filter Combinations must be different, Images must be the same size, and Time between images must be less than 10 seconds

```
counter=0
```

```
for i=0,sz(3)-2 do begin
```

```
    if index[i].ec_fw1 ne index[i+1].ec_fw1 or index[i].ec_fw2 ne index[i+1].ec_fw2 then begin
```

```
        if image_diff[i] lt 10 then begin
```

```
            xrt_teem,index(i),data(*,*,i),index(i+1),data(*,*,i+1),te,em,et,ee,/corona, bin=4
```

```
            te1(*,*,counter)=te(*,*)
```

```
            em1(*,*,counter)=em(*,*)
```

```
            et1(*,*,counter)=et(*,*)
```

```
            ee1(*,*,counter)=ee(*,*)
```

```
            counter=counter+1
```

```
        endif
```

```
    endif
```

```
endfor
```



Flares Analyzed

- ▶ 2007/12/17 : 06:00 – 10:00
- ▶ 2007/12/18 : 06:00 – 10:00
- ▶ 2010/11/04 : 23:54 – 12:19
- ▶ 2010/11/06 : 15:00 – 17:00
- ▶ 2011/09/23 : 01:00 – 03:00
- ▶ 2011/09/24 : 12:00 – 16:00
- ▶ 2012/07/08 : 16:00 – 06:00



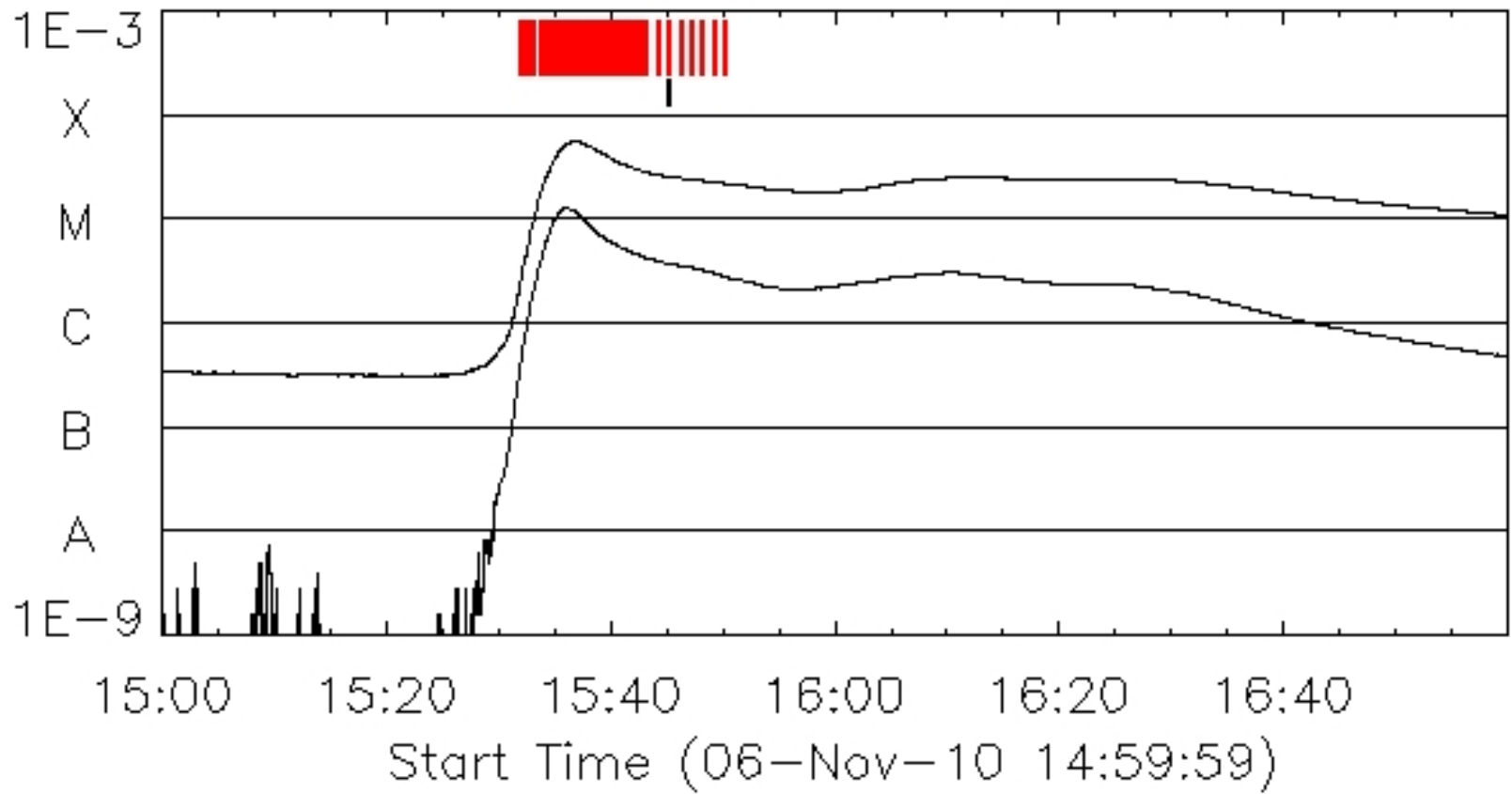
Flare 1

- ▶ Date Observed: November 6th, 2010
- ▶ Time: 15:00-17:00
 - ▶ Begin 15:27
 - ▶ Max 15:36
 - ▶ End 15:44
- ▶ Original Data Set: [384, 384, 406]
- ▶ New Data Set: [384, 384, 36] (76 images used)
- ▶ Max Height: 13.9×10^4 km (occurs at 15:45)

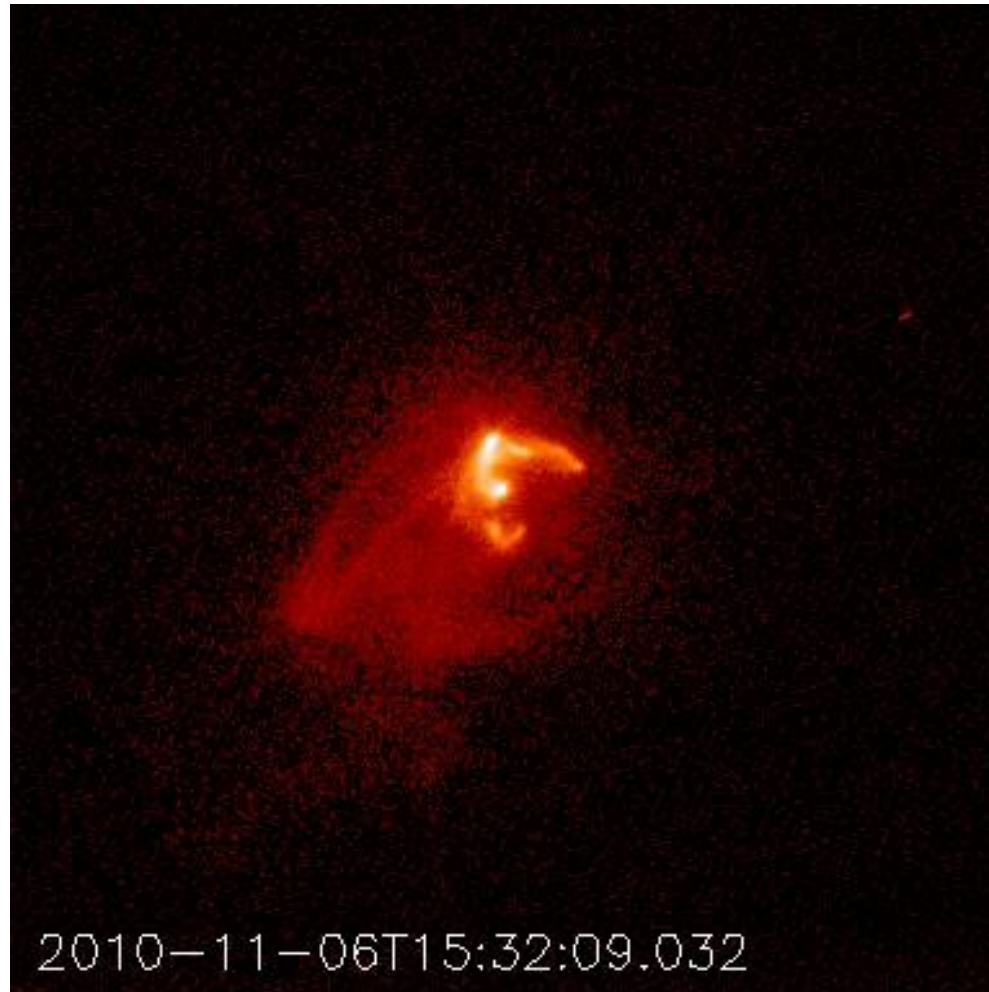


GOES Plot

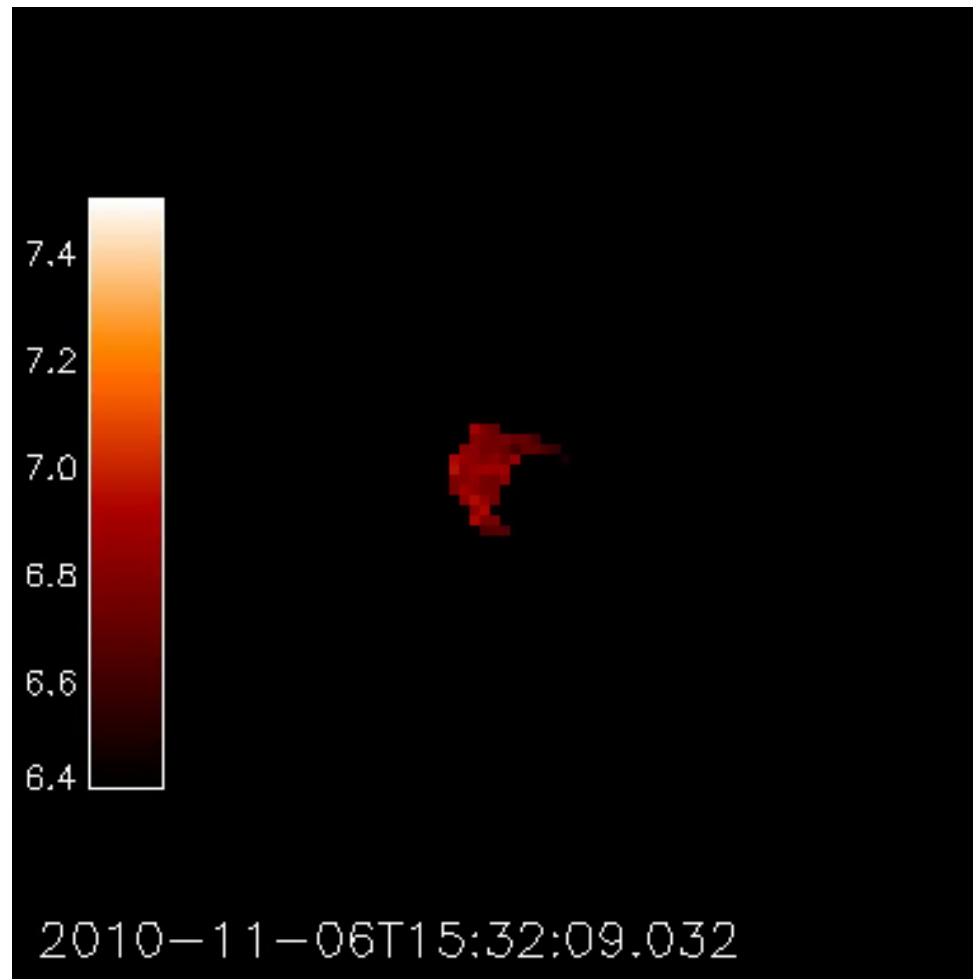
GOES 15 X-Rays:



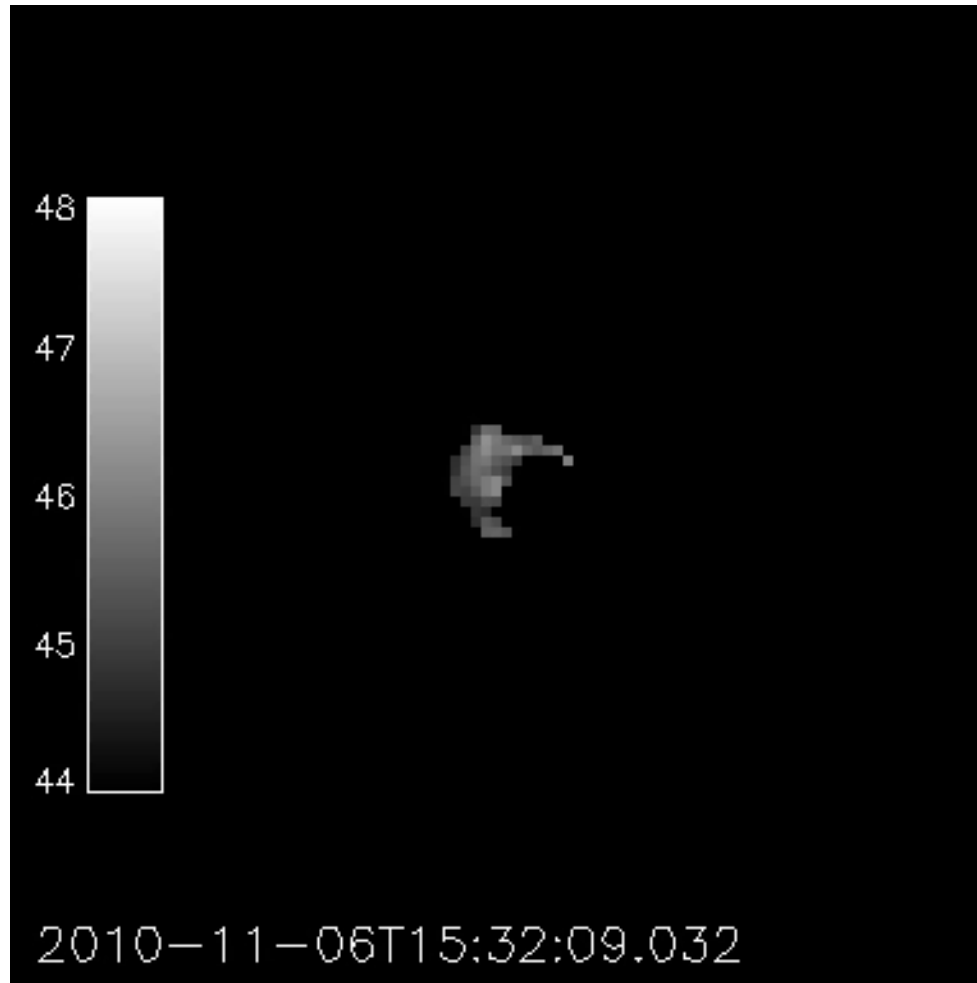
Prepped and Aligned Data



Temperatures



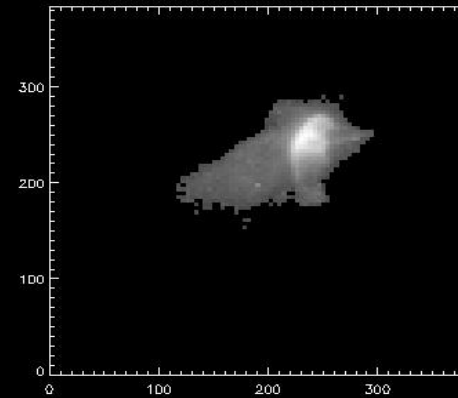
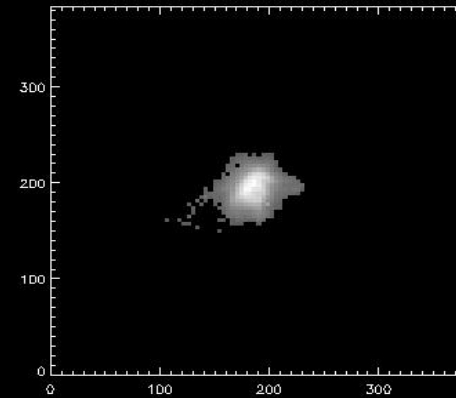
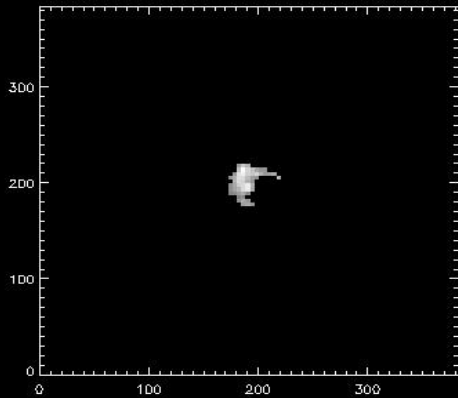
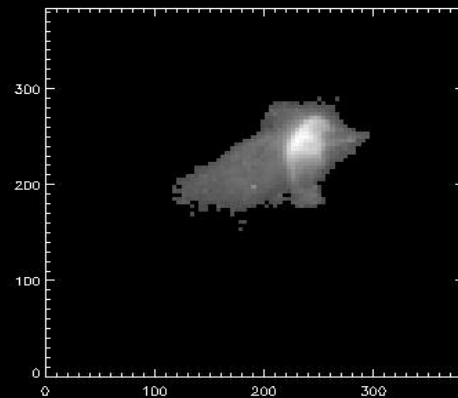
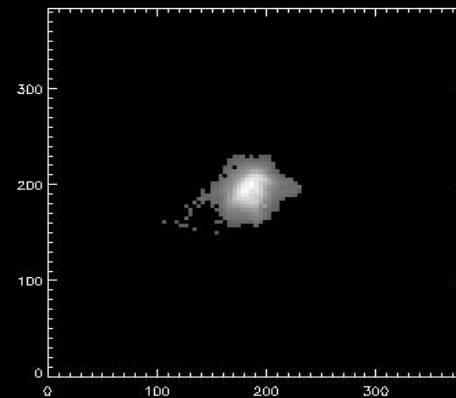
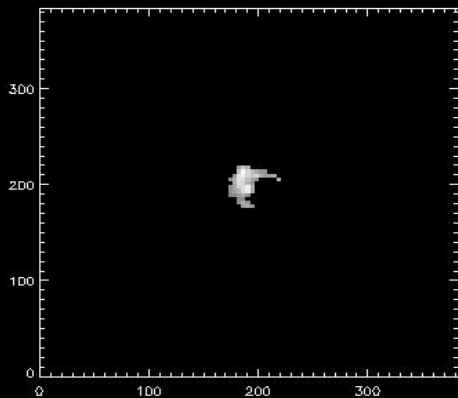
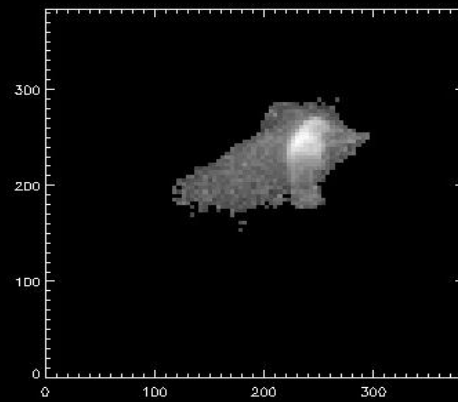
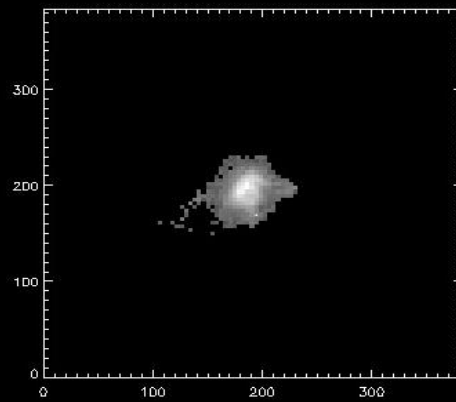
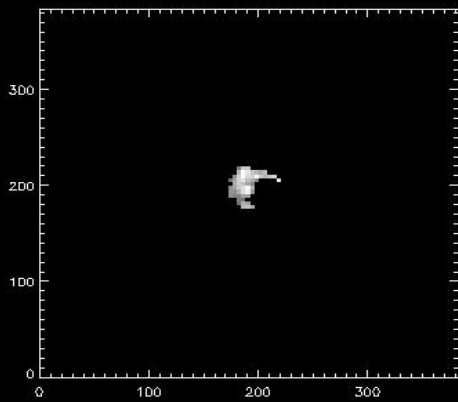
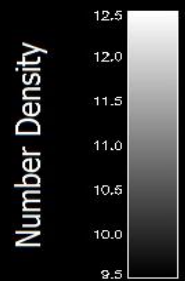
Emission Measure



15:32:09

15:37:54

15:45:22

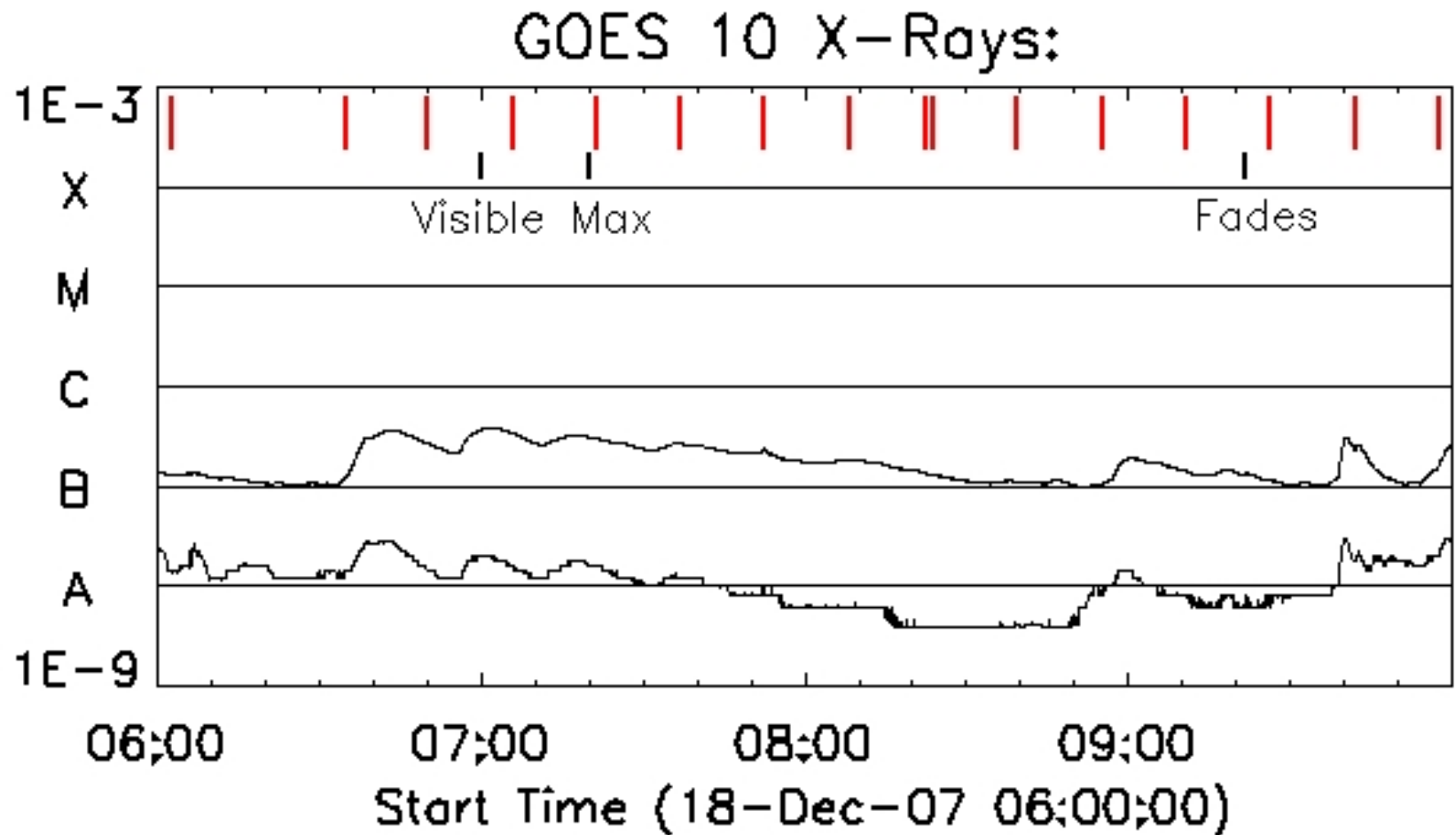


Flare 2

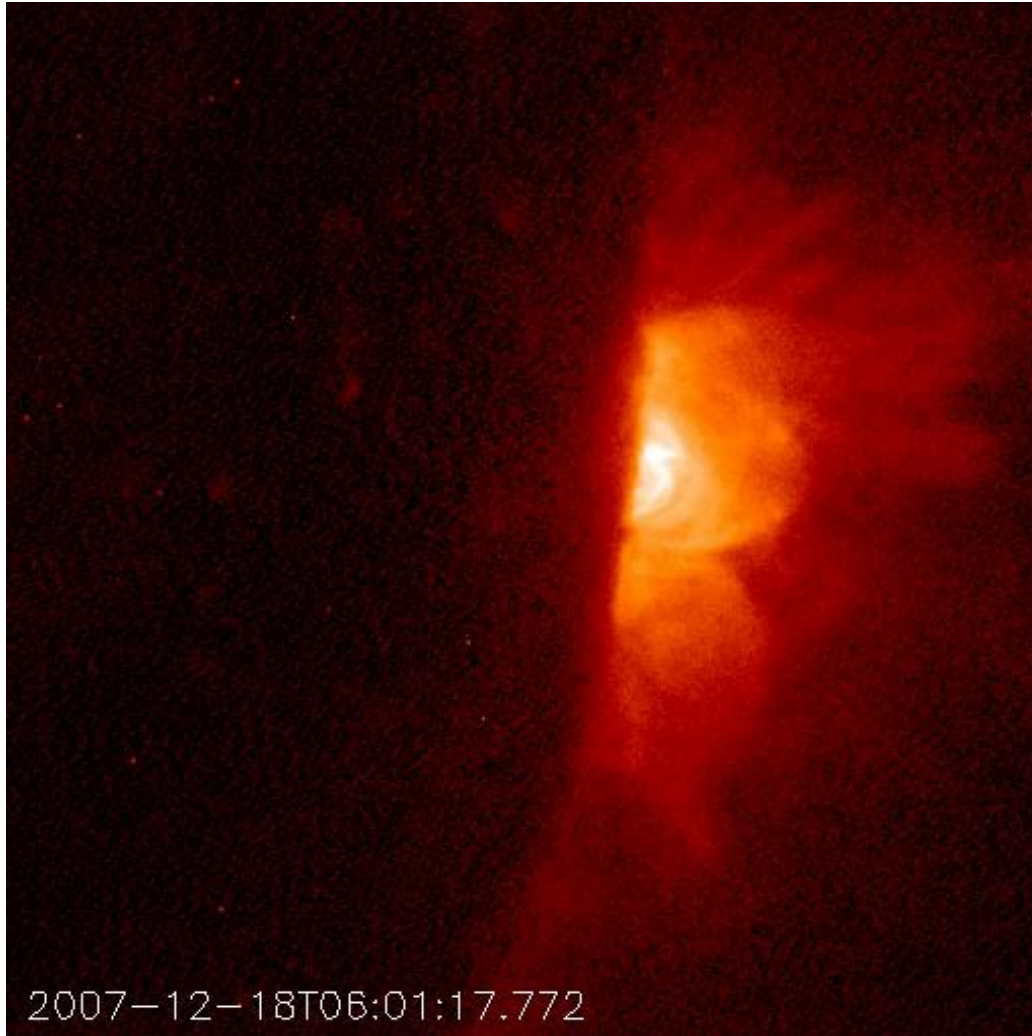
- ▶ Date Observed: December 18th, 2007
- ▶ Time Observed: 6:00-10:00
 - ▶ Four Flares occur during this time
- ▶ Original Data Set: [512, 512, 480]
- ▶ New Data Set: [512, 512, 16] (32 images used)
- ▶ Max Height: 6.4×10^4 km



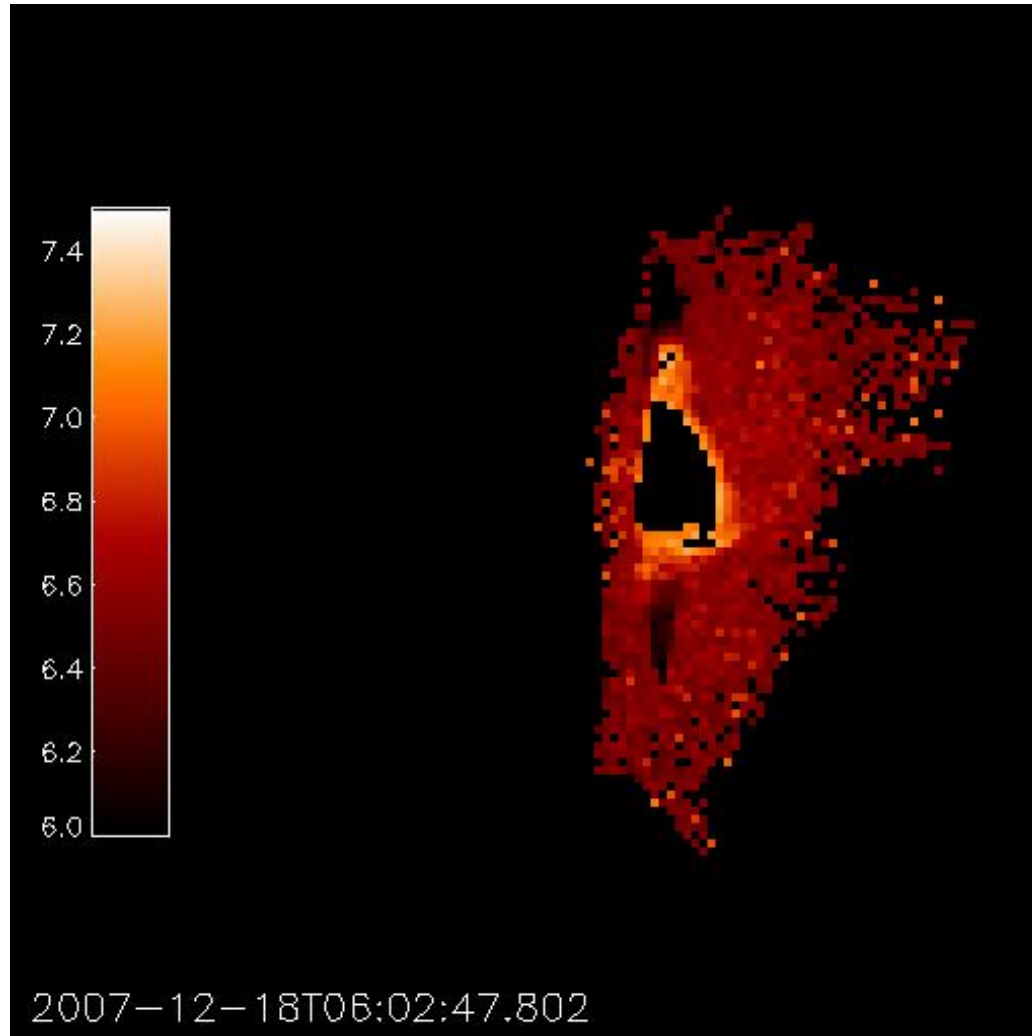
GOES Plot



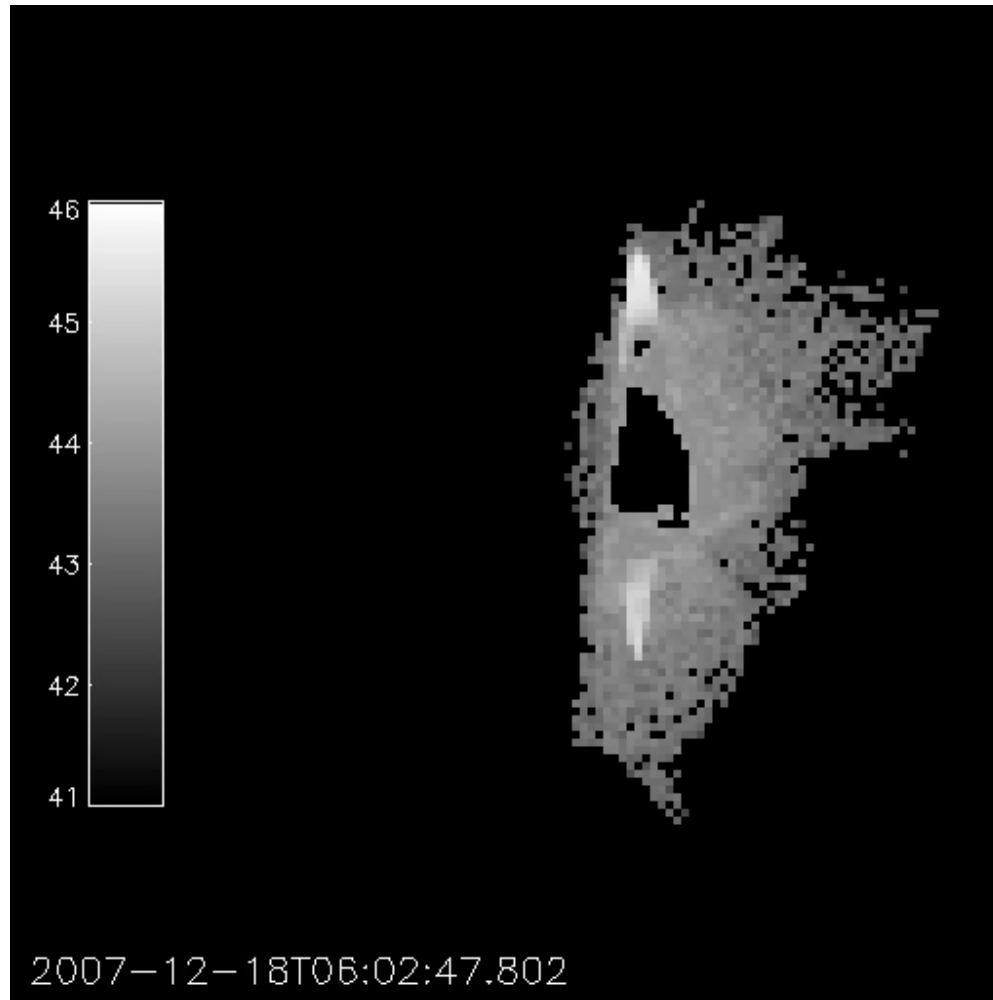
Prepped and Aligned Data



Temperature



Emission Measure



Results

Utilizes the data from 5 flares

	Average Range*	Error Range*
Temperature	6.2-7.2	5.2-6.7
Emission Measure	43.1-45.1	42.3-44.8
Number Density	9.3-10.4	8.2-9.8
Pressure	0.4-1.3	0.1-1.0
Thermal Energy	25.8-26.8	25.1-26.7

*Log Scale





TEAM DATA ANALYSIS

