Impulsive coronal heating from large-scale magnetic rearrangements: MHD modeling

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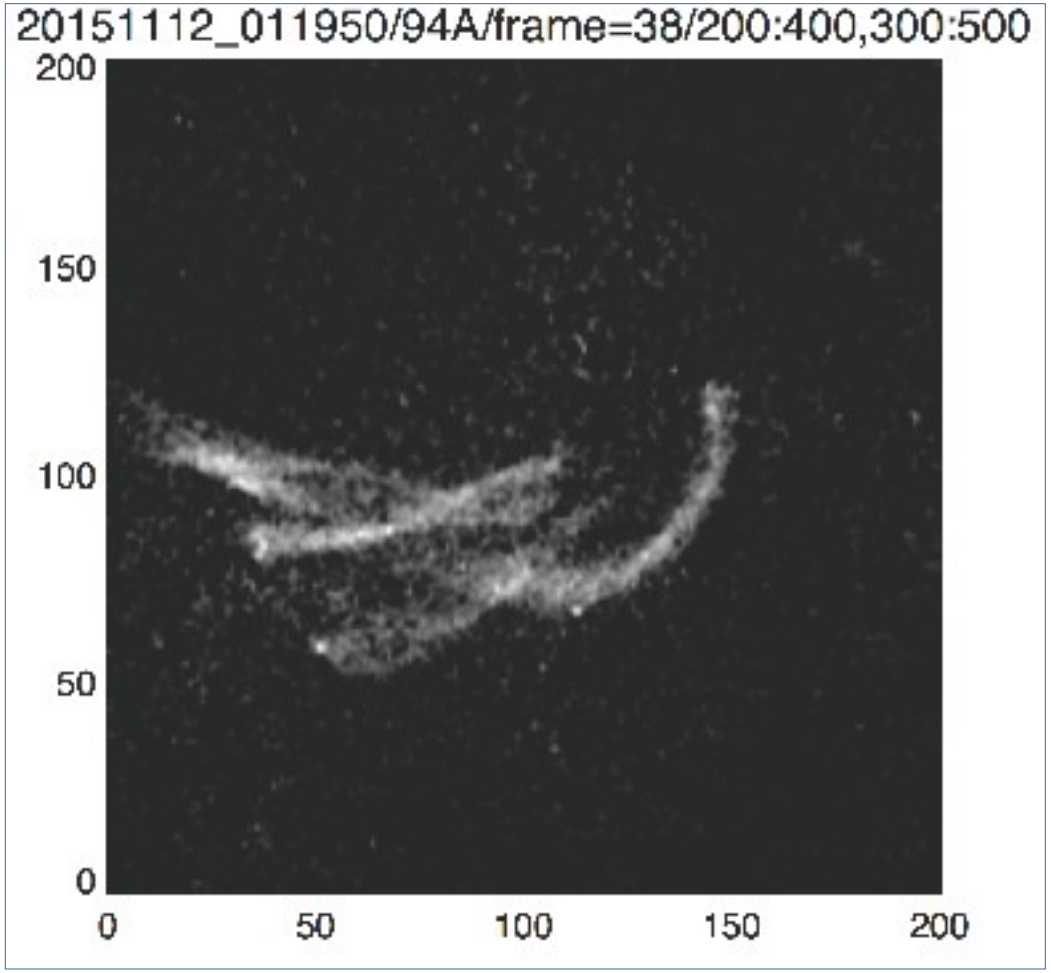
Observational evidences



(Did you see F.Reale's talk?)

Issues:

- Loops tangle
  - large scale effect;
  - changing morphology;
- Loops brighten
  - structured in EUV HOT channels;

Rationale

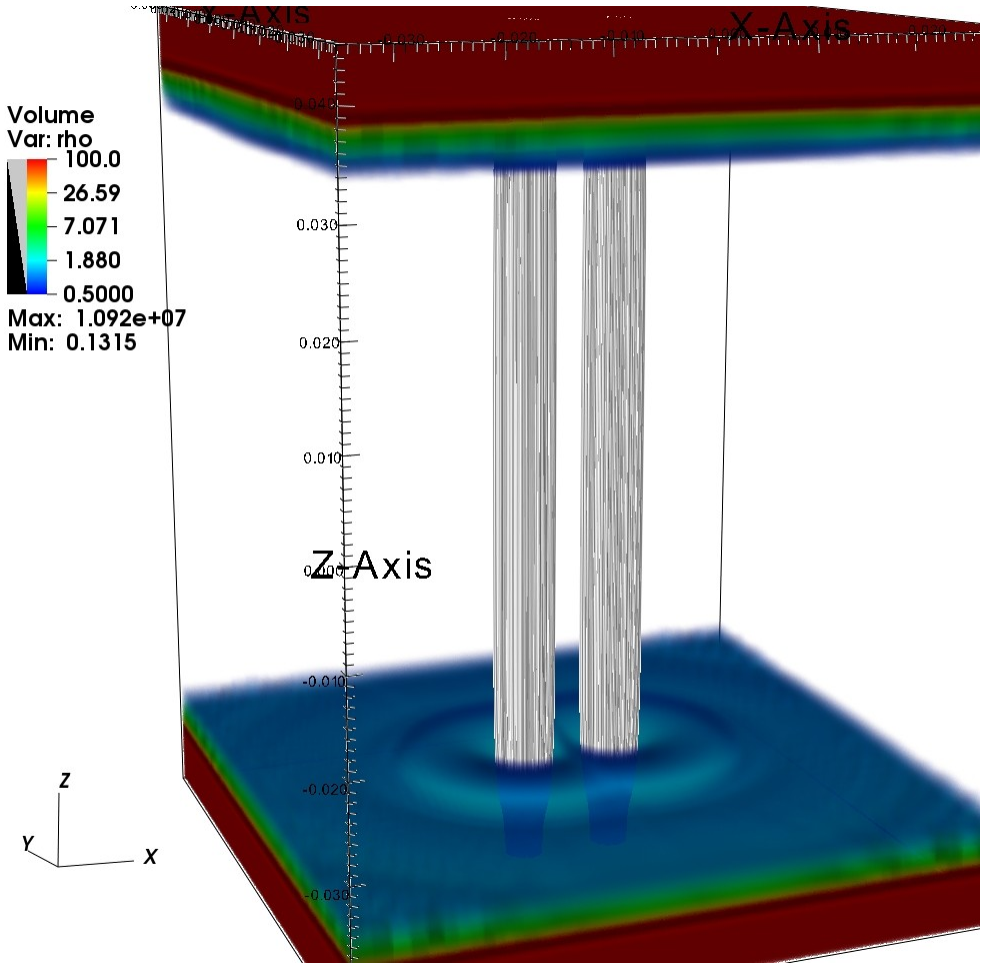
- Are brightenings really linked to magnetic rearrangements and loop tangling?

- MHD modeling powerfull tool to answer the question.

Approach

- Simplified but still realistic scenario: two loops tangling;
- Full 3D MHD modelling, including:
  - Complete atmosphere, from chromosphere to corona
  - Loop expansion in the transition region;
  - Photospheric driver;
  - Magnetic dissipation.
- Forward modeling: producing observables

Initial condition



Atmosphere:

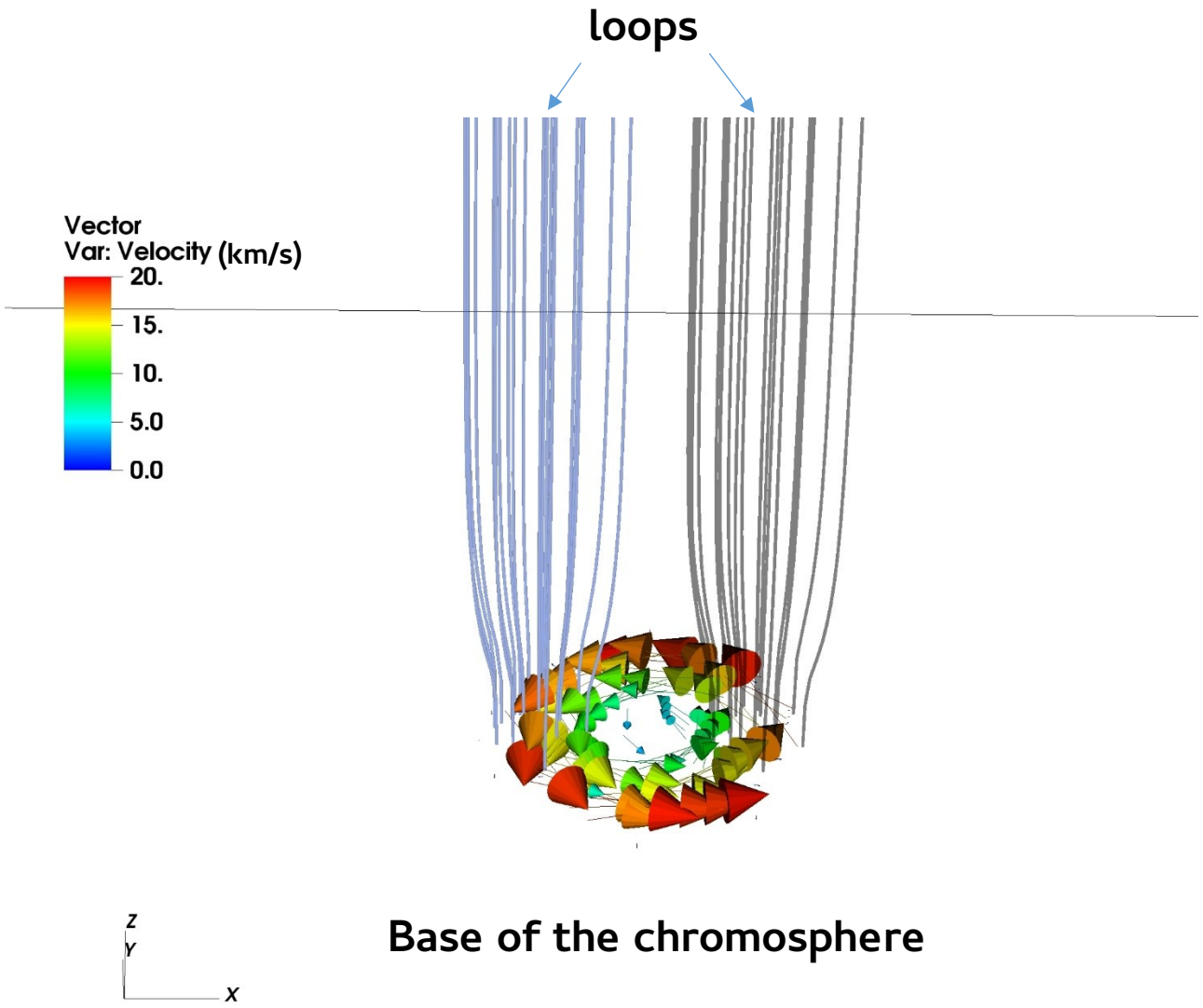
- plane parallel with Z perpendicular to the chromosphere
- $T_{cor} = 8x10^{5}$ K
- $n_{cor} = 2x10^{8}$ cm-3
- $T_{chr} = 10^{4}$ K

Magnetic field:

- two parallel magnetic tubes (loops)
- varying with the height (35G at the top of the chromosphere, 15G in the corona)

Photospheric driver

- Tubes dragged by a rotation of a circle including the footpoints of both tubes (opposite at the top and bottom);



MHD equations

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

$$\frac{\partial \rho \mathbf{v}}{\partial t} + \nabla \cdot (\rho \mathbf{v}\mathbf{v} - \mathbf{B}\mathbf{B} + p_t \mathbf{I}) = \rho \mathbf{g}$$

$$\frac{\partial E}{\partial t} + \nabla \cdot ((E + p_t)\mathbf{v} - \mathbf{B}(\mathbf{v} \cdot \mathbf{B})) = \rho \mathbf{v} \cdot \mathbf{g} - n_e n_H \Lambda(T) + H - \nabla \cdot \mathbf{F}_c - \nabla \cdot [(\eta \cdot \boldsymbol{J}) \times \boldsymbol{B}]$$

$$\frac{\partial \boldsymbol{B}}{\partial t} + \nabla \times (-\boldsymbol{v} \times \boldsymbol{B}) = -\nabla \times (\eta \cdot \boldsymbol{J})$$

$$p = (\gamma - 1)\rho\epsilon$$

radiative losses

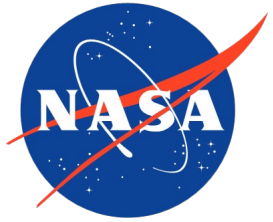
Thermal conduction along field lines

Heating through turbulent current dissipation (>250A/cm$^{2)}$

Hood et al. 2009

3D MHD simulation

- **Pluto** astrophysical code – Mignone et al. 2007, 2012
- **Pleiades** Supercomputer – NASA HPC facility



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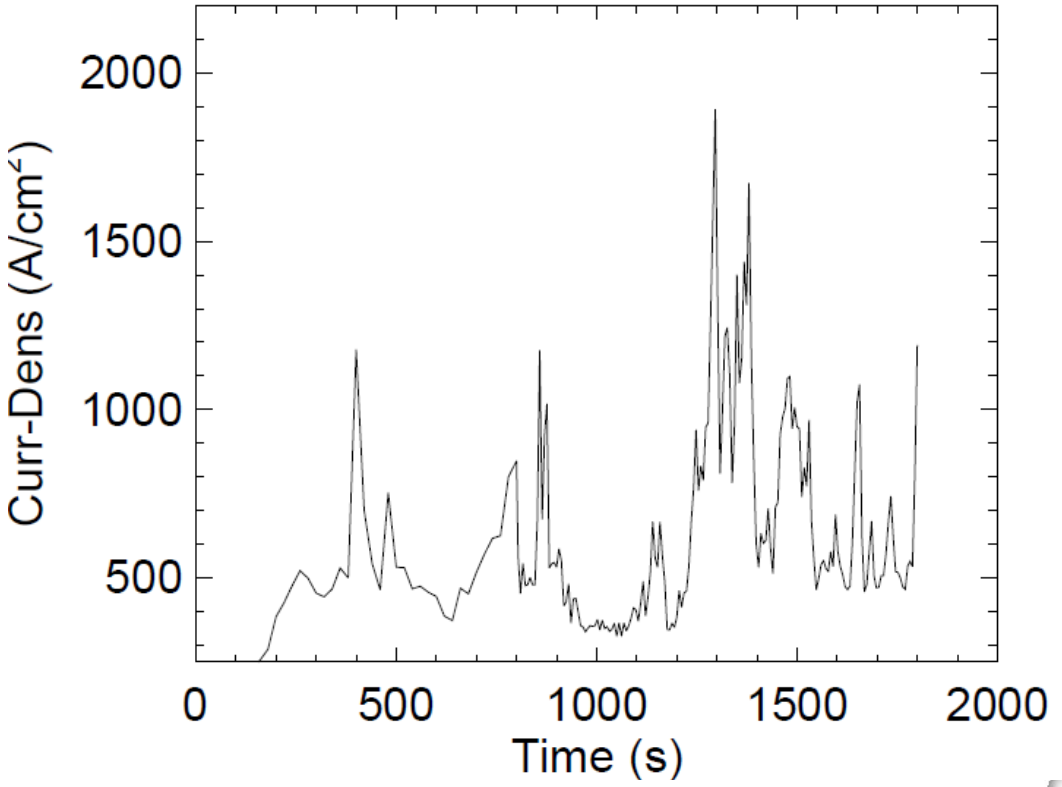
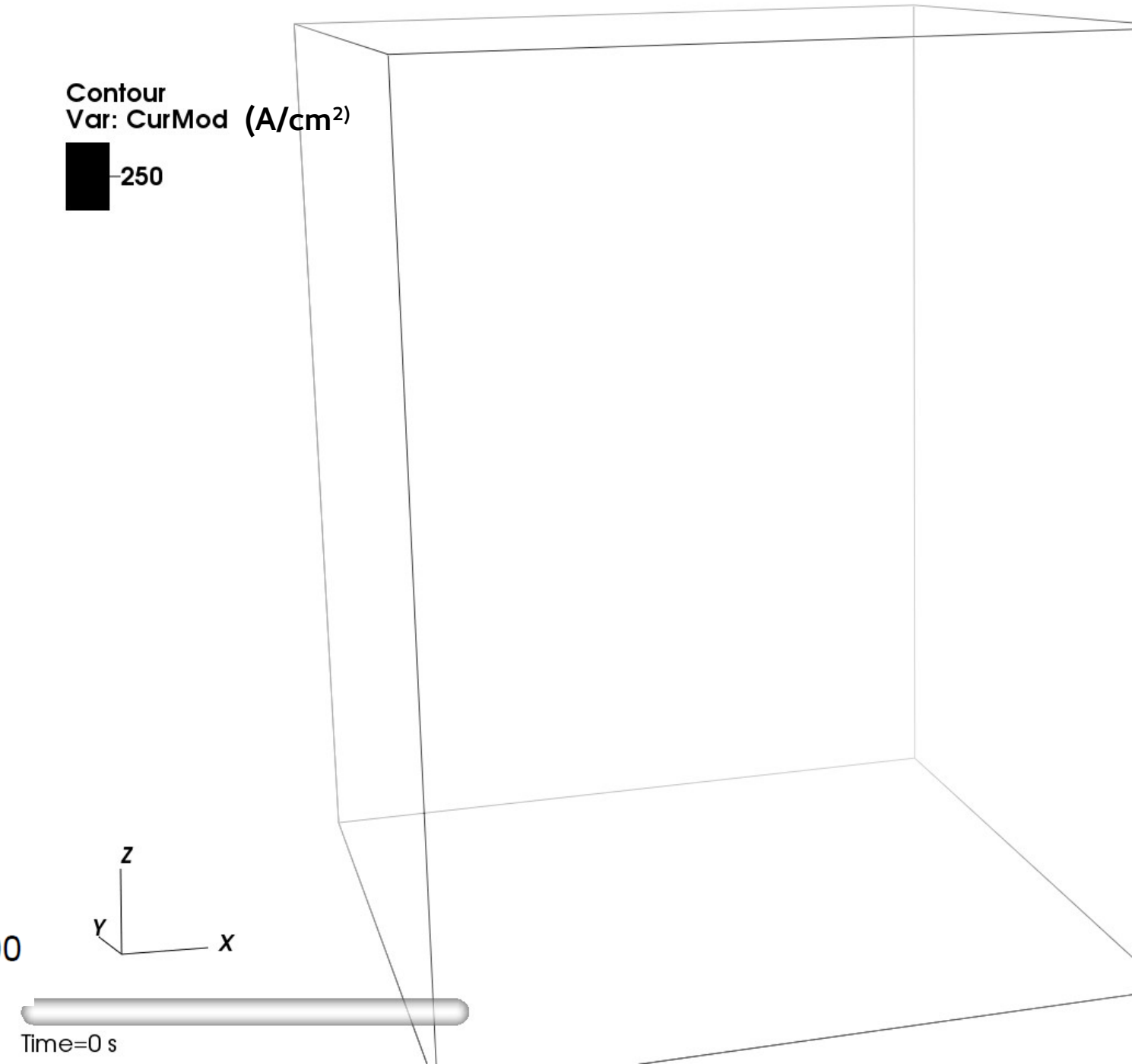
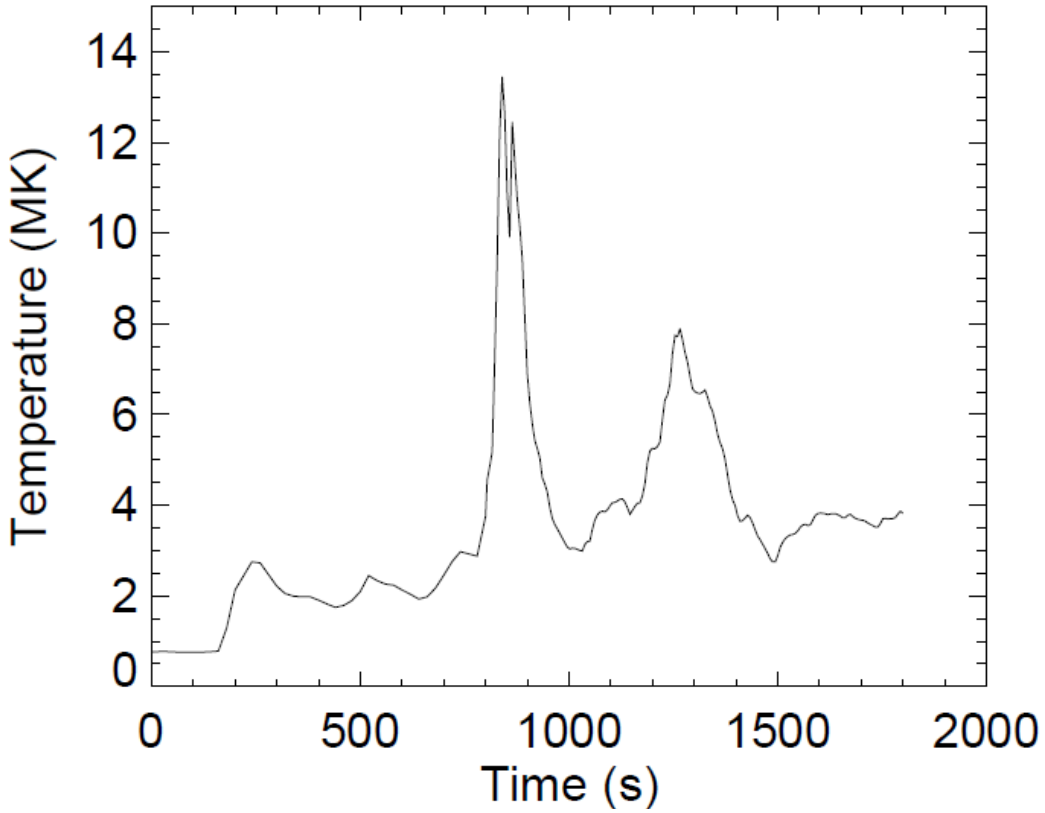
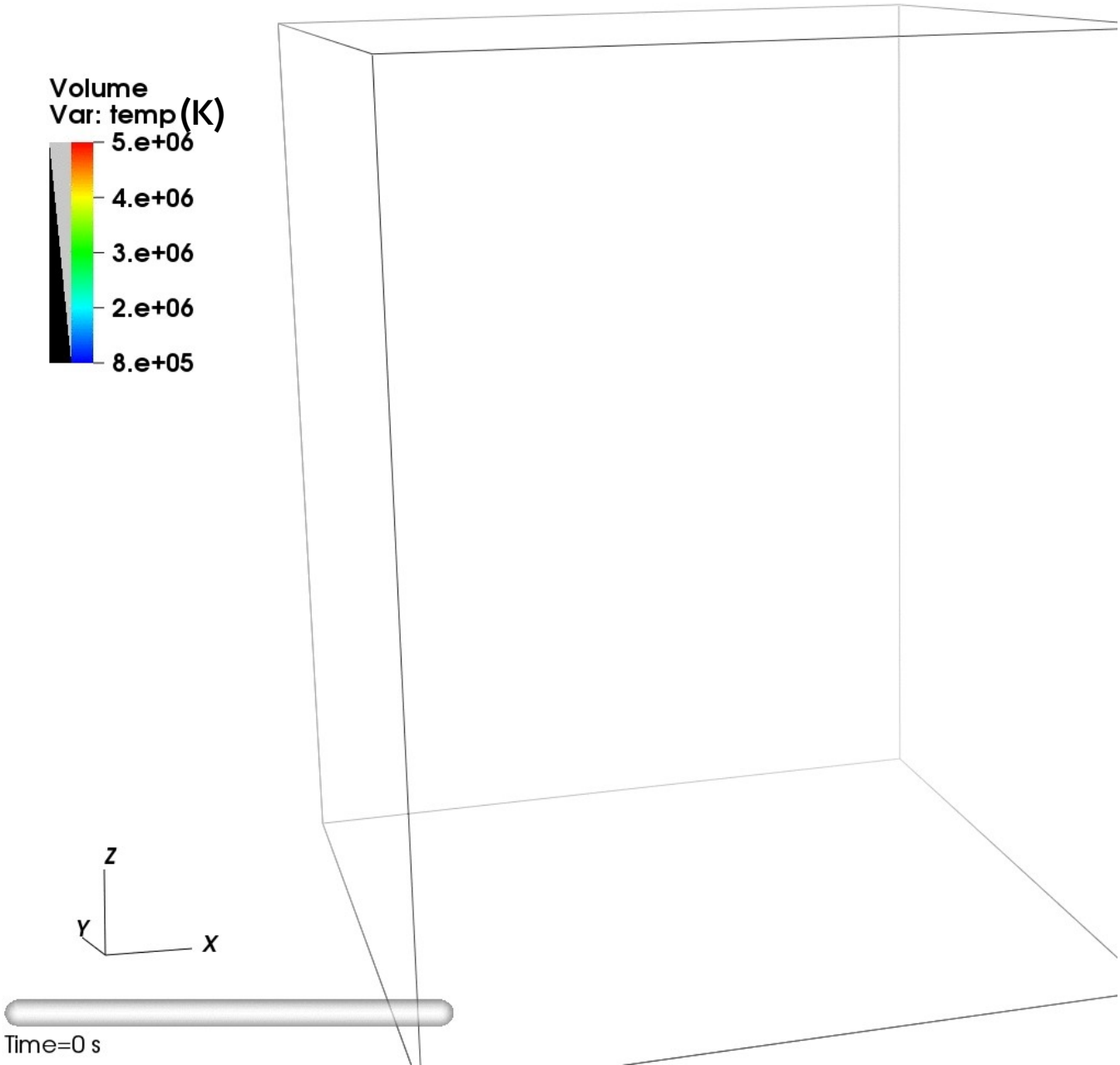
Currents: (heating)



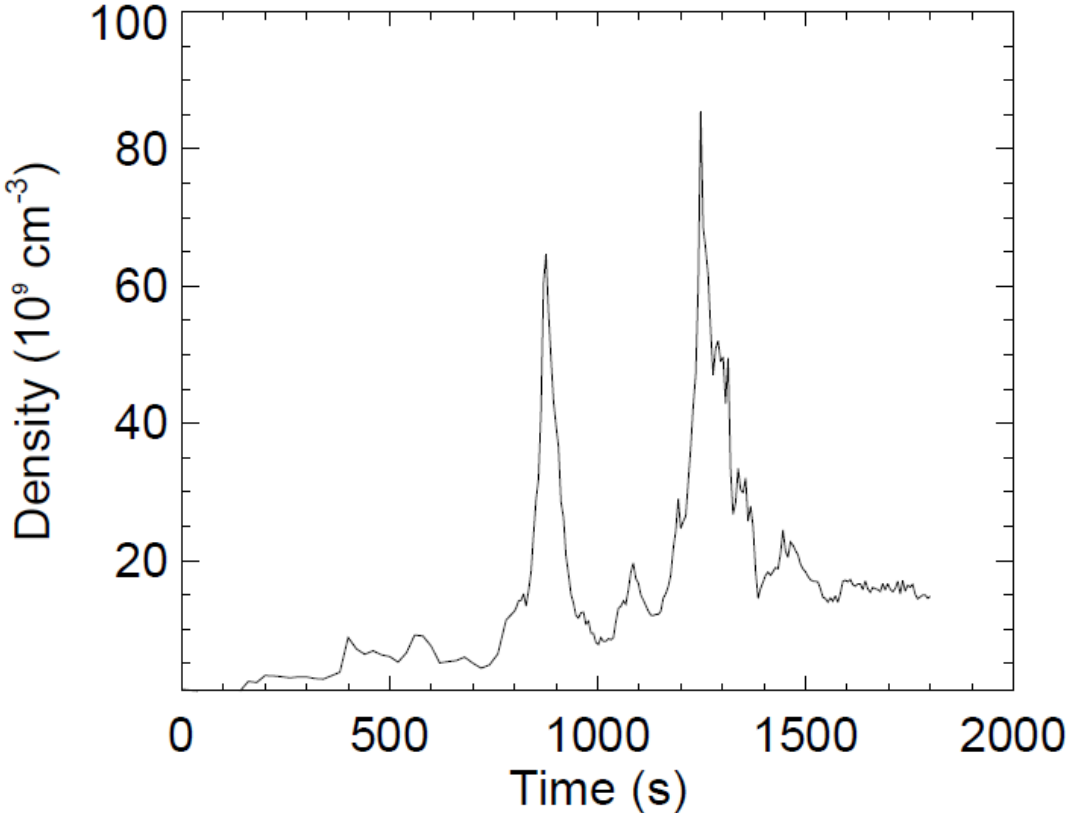


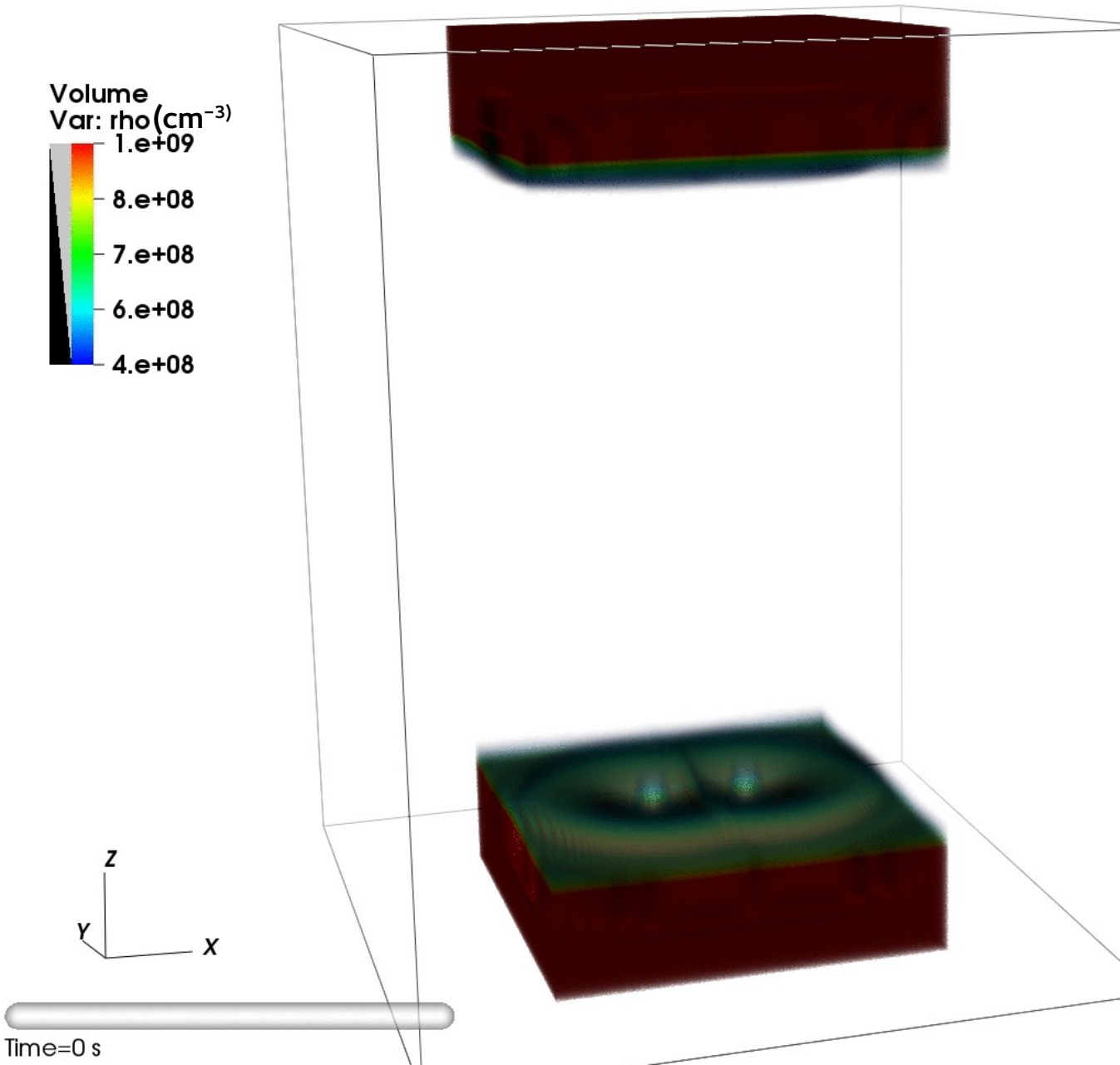
Temperature:



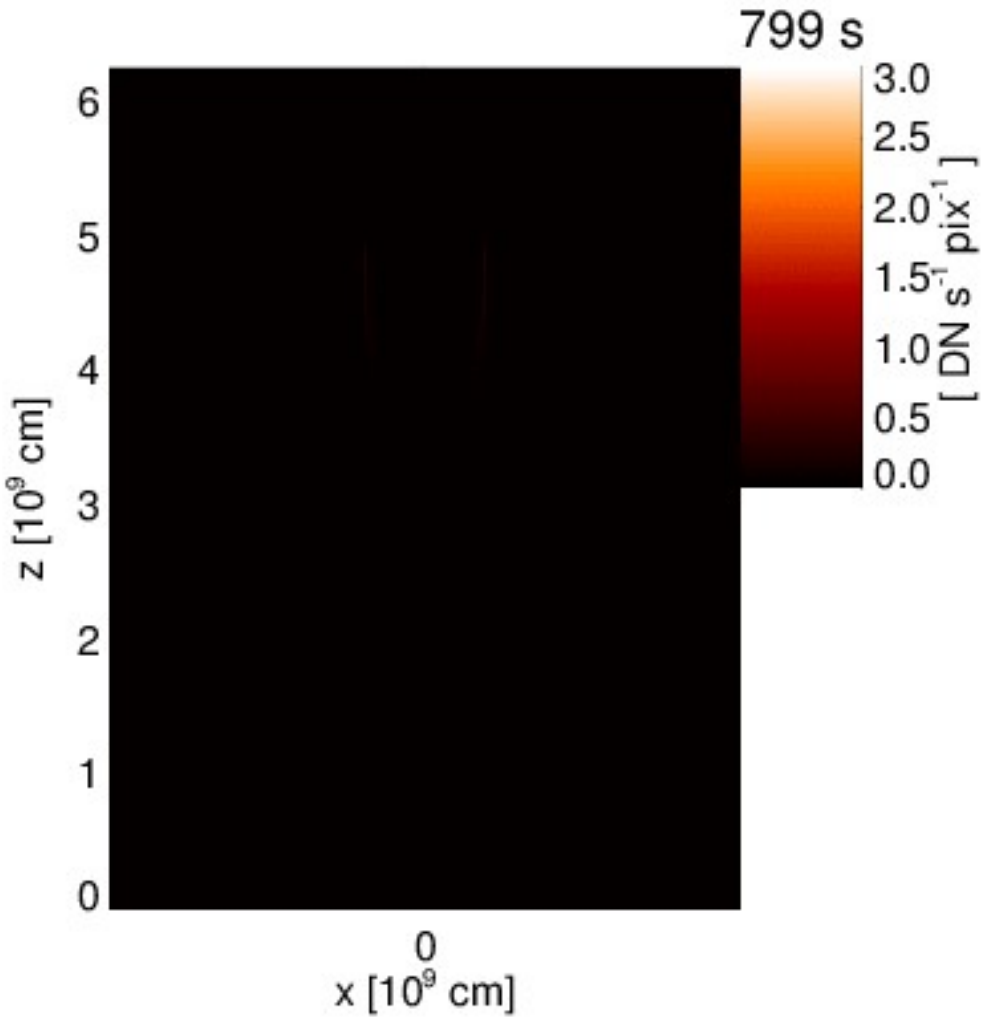


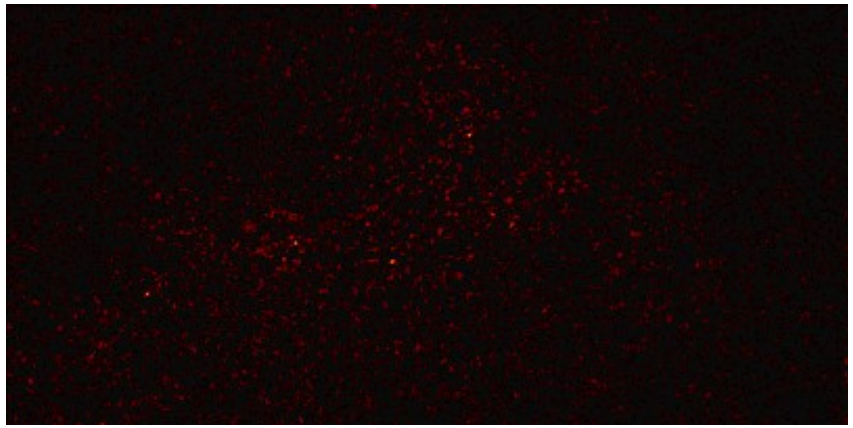
Density:


100
80
60
40
20
Density (10^9 cm^{-3})
0
500
1000
1500
2000
Time (s)


Volume
Var: rho(cm^{-3})
1.e+09
8.e+08
7.e+08
6.e+08
4.e+08
Z
Y
X
Time=0 s

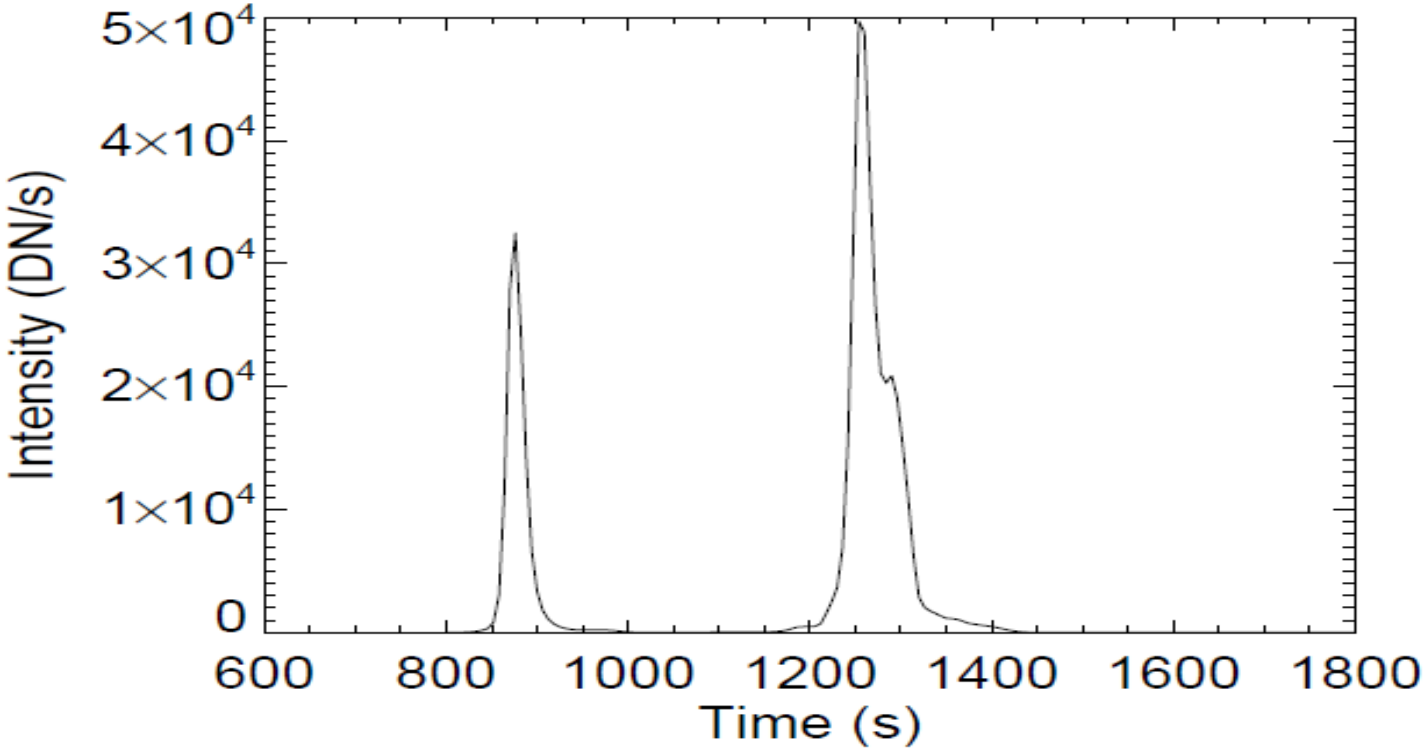
Synthetic emission vs observation (94A - AIA/SDO)





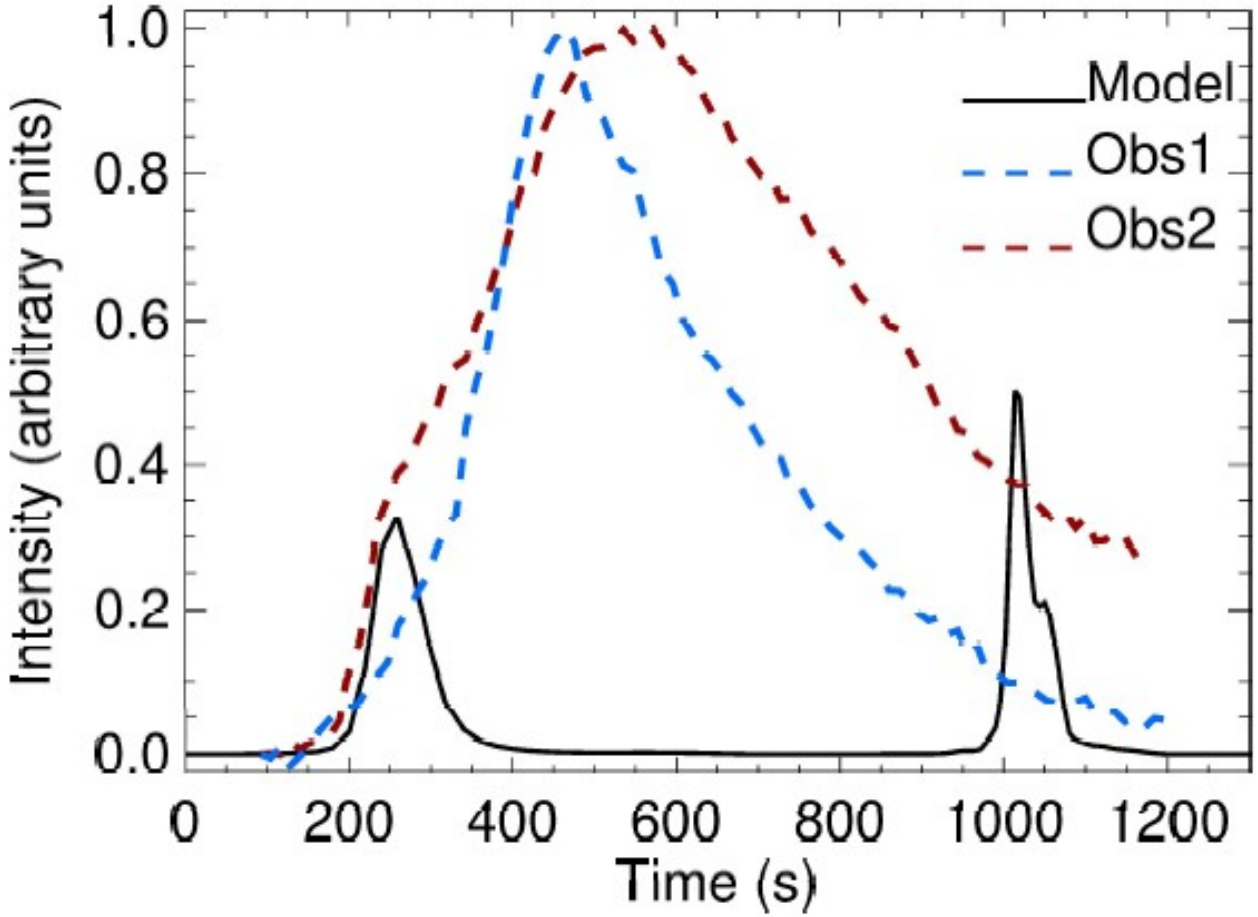
Light curve (94A - AIA/SDO)

- Two short brightenings (1-2min) --> cooling through narrow band
- Time separated (~400s)



Preliminary comparison with the observed light curves

- Longer time scales in the observation (500s vs 100s)
- Conglomeration of events? Work in progress



Conclusion

- Are brightenings really linked to magnetic rearrangements and loop tangling? Yes, they are:
  - Strong currents sheets generated by the tangling;
  - Impulsive heat deposition in the corona;
  - Dynamics determined by currents dissipation;

- Our impulsive magnetic diffusion implies a kind of fast magnetic reconnection;
- More to be done…

Thanks for the attention