2.5D simulation of coronal rain in randomly heated arcades

Xiaohong Li

Collaborators: Rony Keppens, Yuhao Zhou

Centre for mathematical Plasma Astrophysics, Department of Mathematics,
KU Leuven

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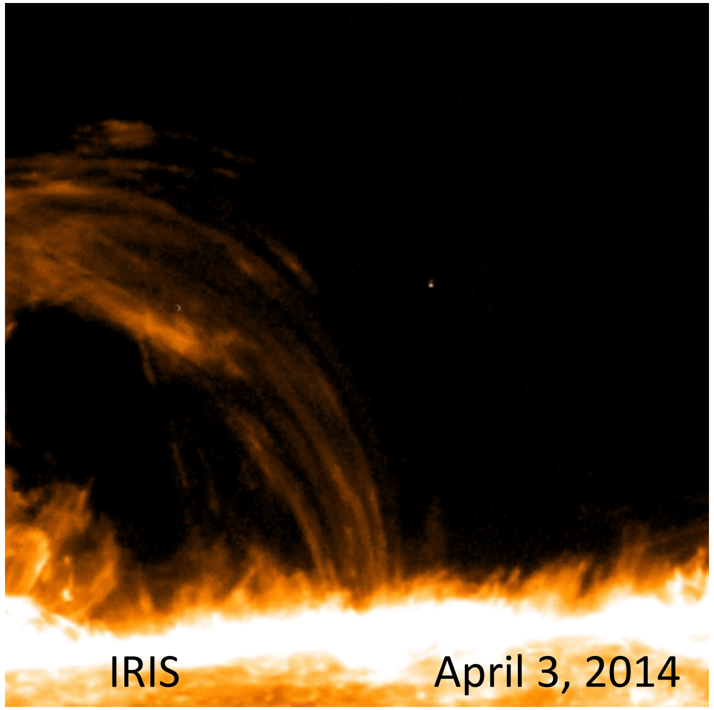
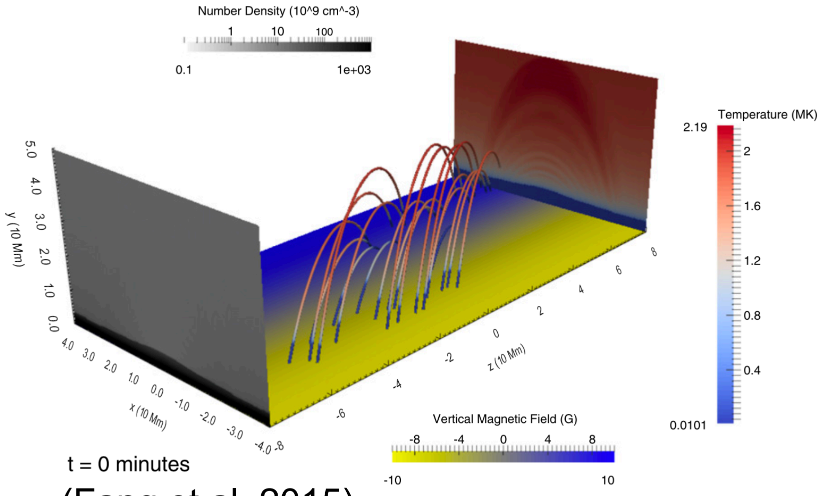
Numerical setup: 2.5D evaporation-condensation model



- Code: MPI-AMRVAC (http://amrvac.org)
- Include gravity, field-aligned heat conduction, and radiative cooling and parameterized heating terms:

$$\frac{\partial E}{\partial t} + \nabla \cdot \left(E\boldsymbol{v} + p_{\rm tot}\boldsymbol{v} - \frac{\boldsymbol{BB}}{\mu_0} \cdot \boldsymbol{v} \right) = \rho \boldsymbol{g} \cdot \boldsymbol{v} + H - R + \nabla \cdot (\boldsymbol{\kappa} \cdot \nabla T)$$

- Cartesian geometry, x: (-30, 30) Mm, y: (0, 60) Mm, ignoring the curvature of the solar surface.
- 5-level AMR, 1536×1536, 39 km per cell



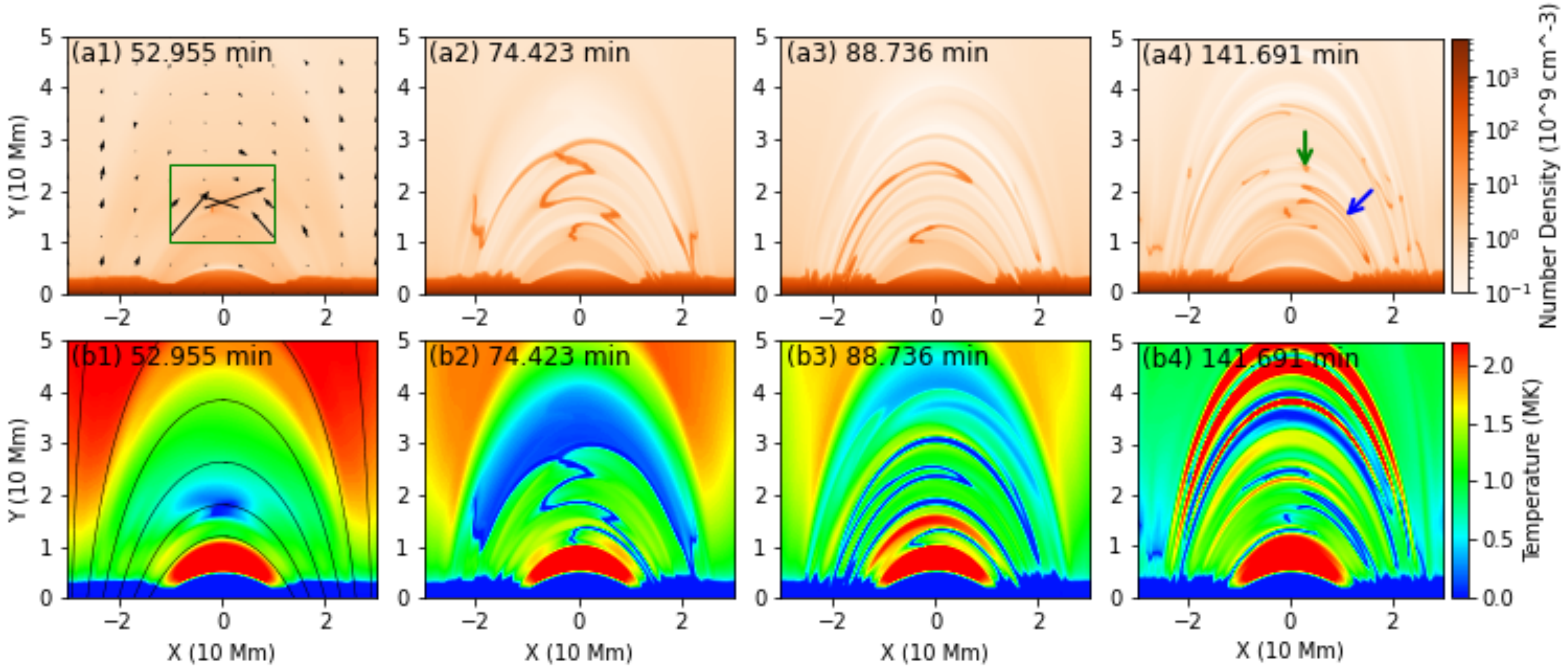
(Fang et al. 2015)

- Linear force-free magnetic arcades, stratified atmosphere
- $H = H_{bgr} + H_{loc}$

H_{bgr} : vertical exponentially decaying background heating

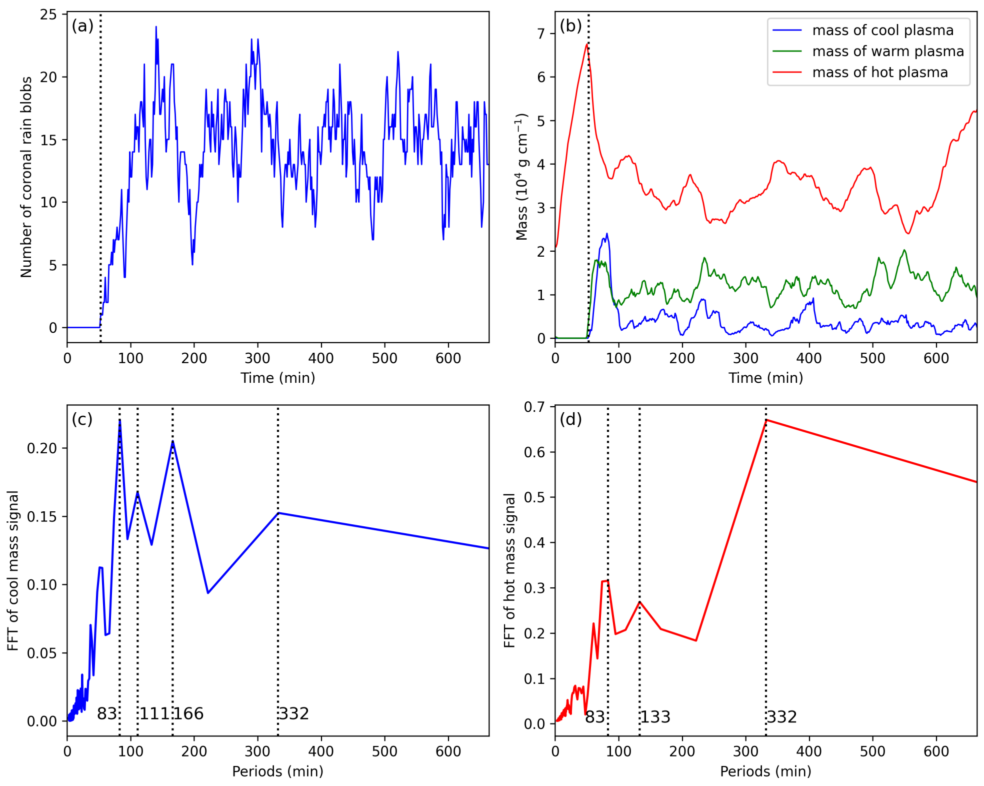
H_{loc} : localized heating randomly distributed both spatially and temporally

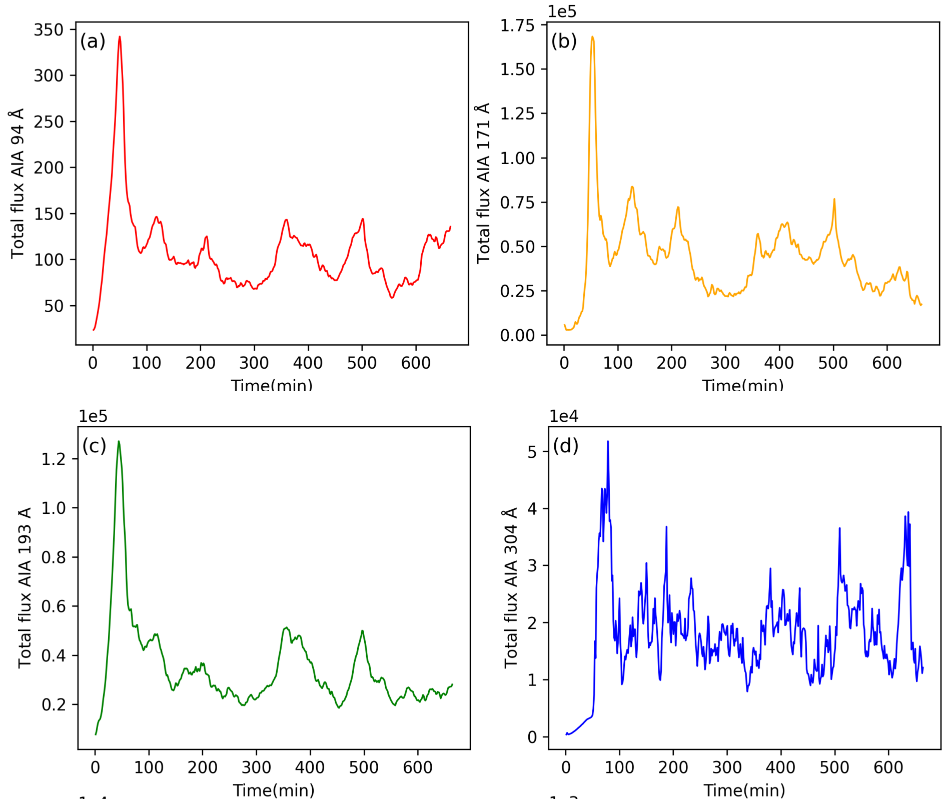
Results: overall evolution



localized heating → evaporation → density increase, temperature first increases but then starts to reduce → thermal instability → condensations

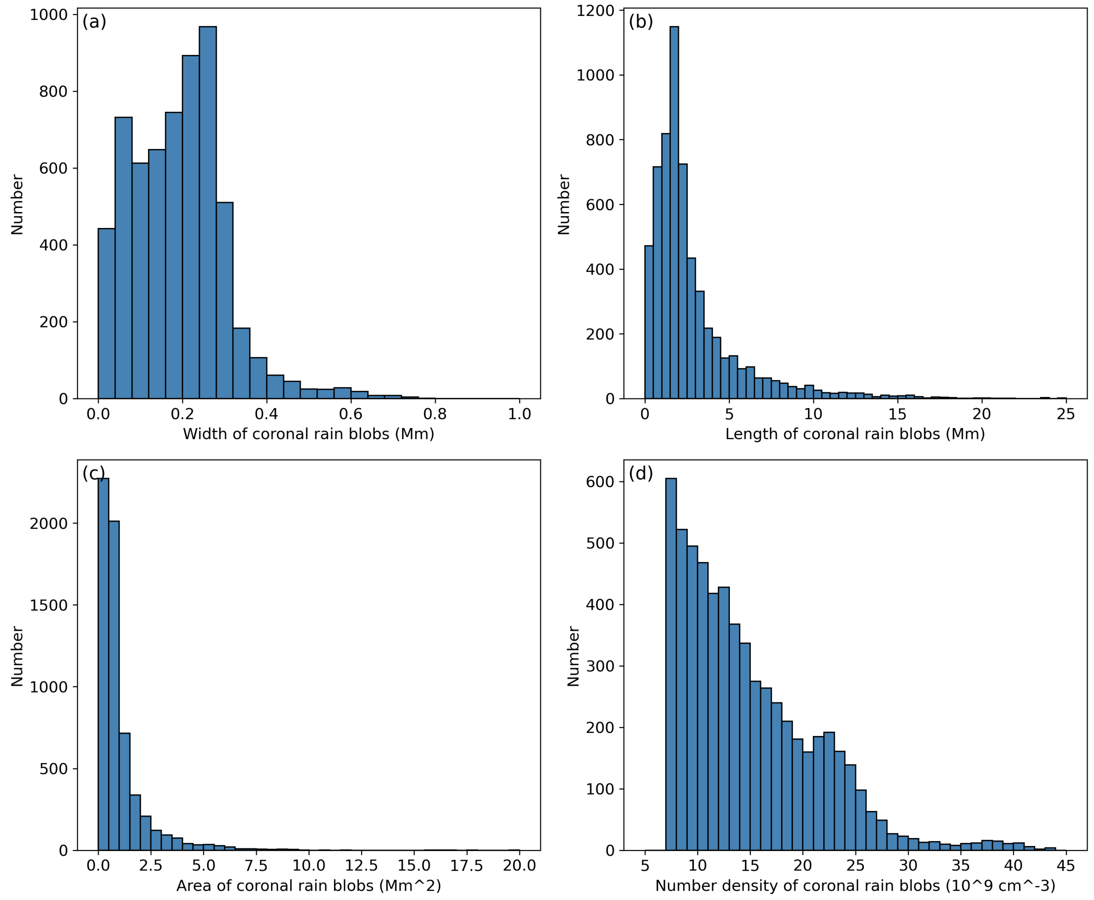
Statistical analysis: continuous cycles

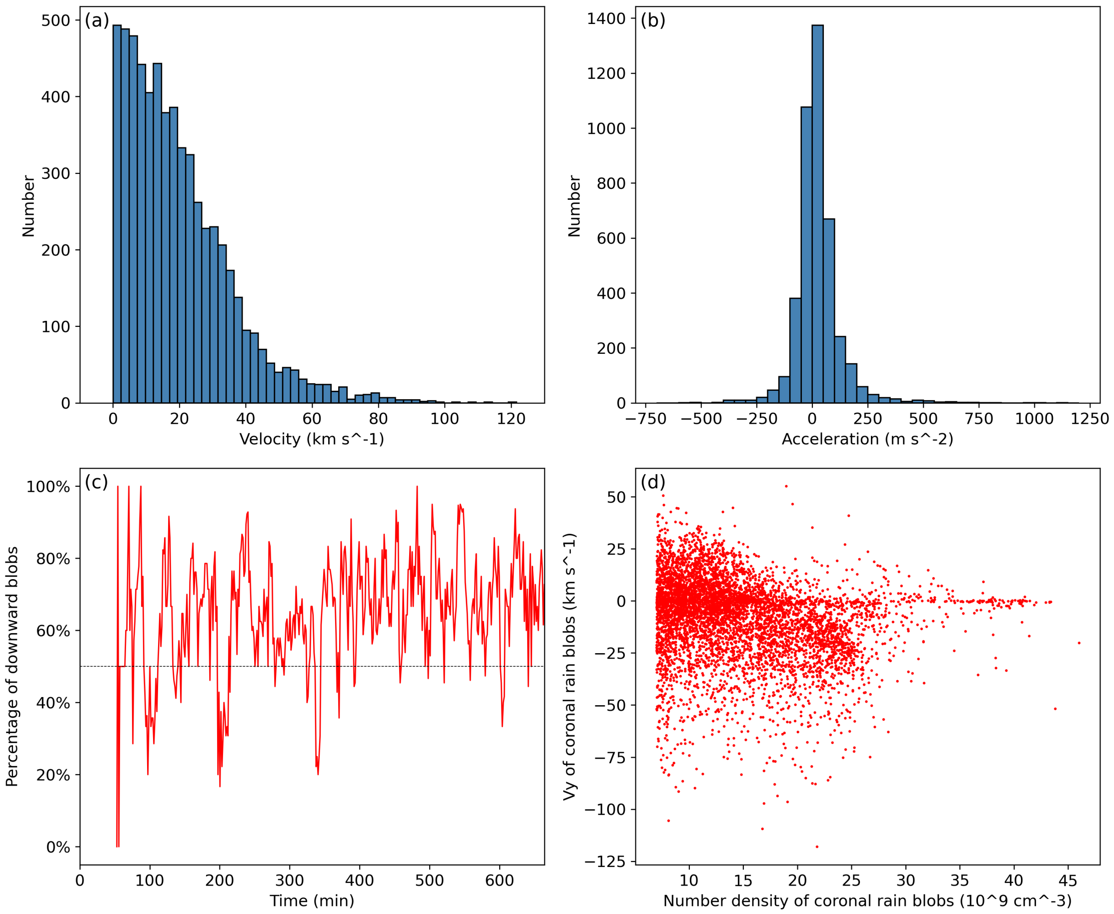




- ➢ The number and mass curves of the coronal rain blobs, as well as the total flux of the synthetic EUV channels, display cycles with similar periods.
- ➢ The coronal rain and the EUV pulsations both correspond to recurrent heating−cooling cycles in the corona, and they may occur together.

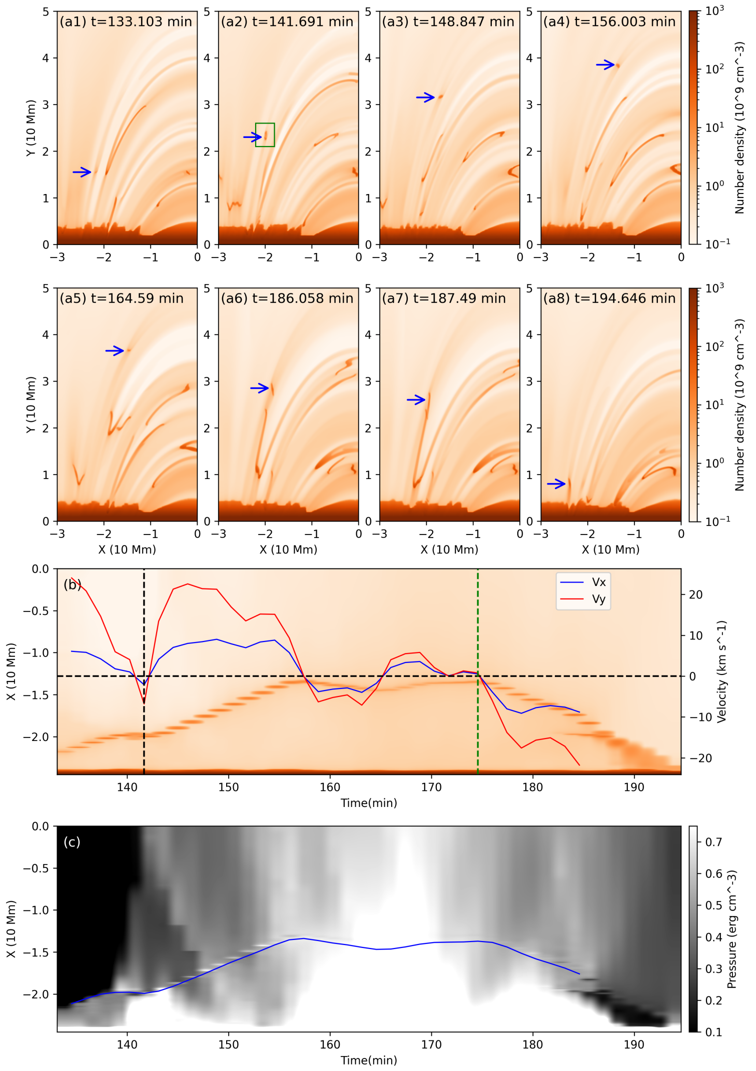
Statistical analysis: morphology and kinematic characteristics

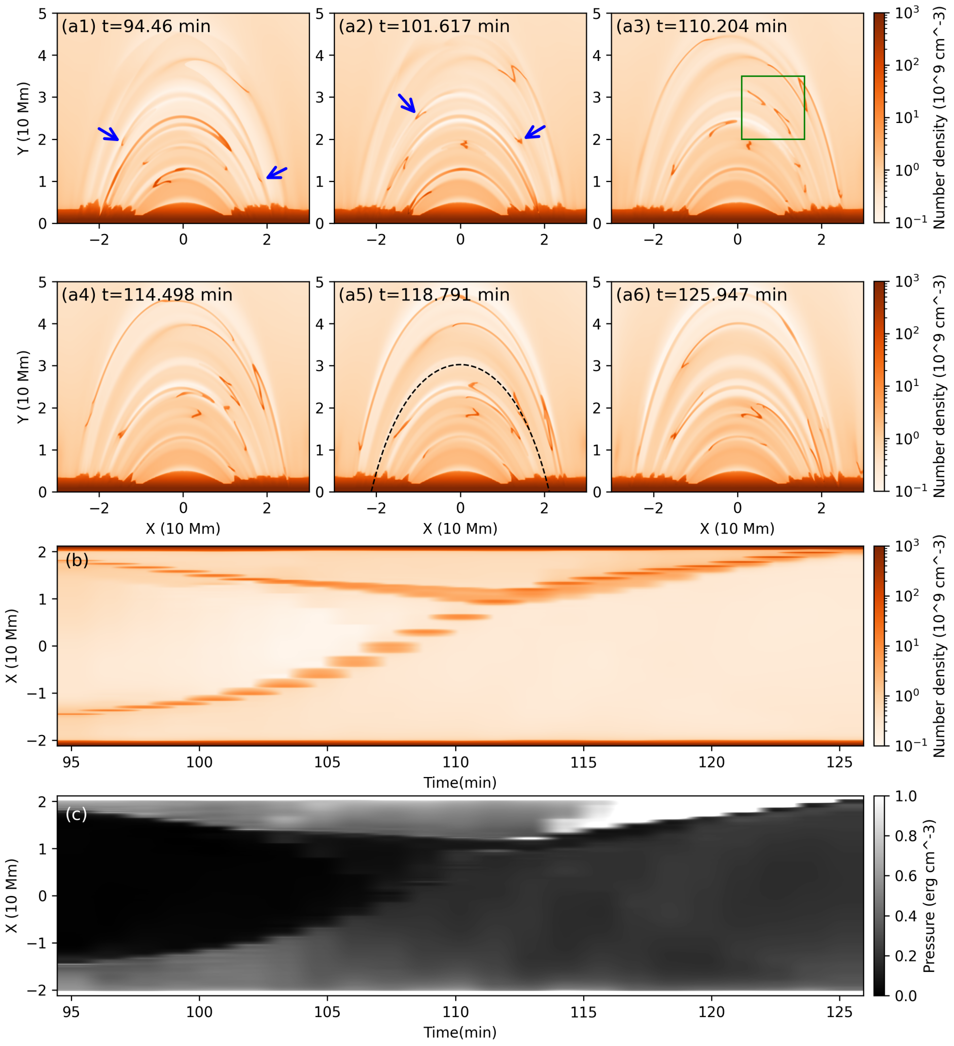




- Most blobs have widths less than 800 km, lengths from a few hundred km to 25 Mm, and areas under 0.5 Mm^2, in good agreement with observational results.
- Sub-ballistic motion and upward motion

Results: dynamics of Individual Blobs





Local changes of pressure in the loop have a greater influence on the dynamics of the condensations than gravity => sub-ballistic fall accelerations and the upward motions of the coronal rain blobs

Conclusion

We performed a 2.5D simulation of coronal rain where a power-law distribution of Gaussian heating events centered in both space and time is adopted.

- Due to thermal instability, the temperature and gas pressure in the perturbed area decline significantly, therefore ambient plasma is inhaled from the surroundings, and condensations continue to form.
- The coronal rain and the EUV pulsations both correspond to recurrent heating−cooling cycles in the corona.
- The gas pressure gradient in the magnetic loop is the primary candidate to explain the descent slower than freefall and the upward motion of the coronal rain blobs.
- For more details see 2022, *ApJ,* **926,** 216.