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How do driving time scales effect energy release in the solar corona?

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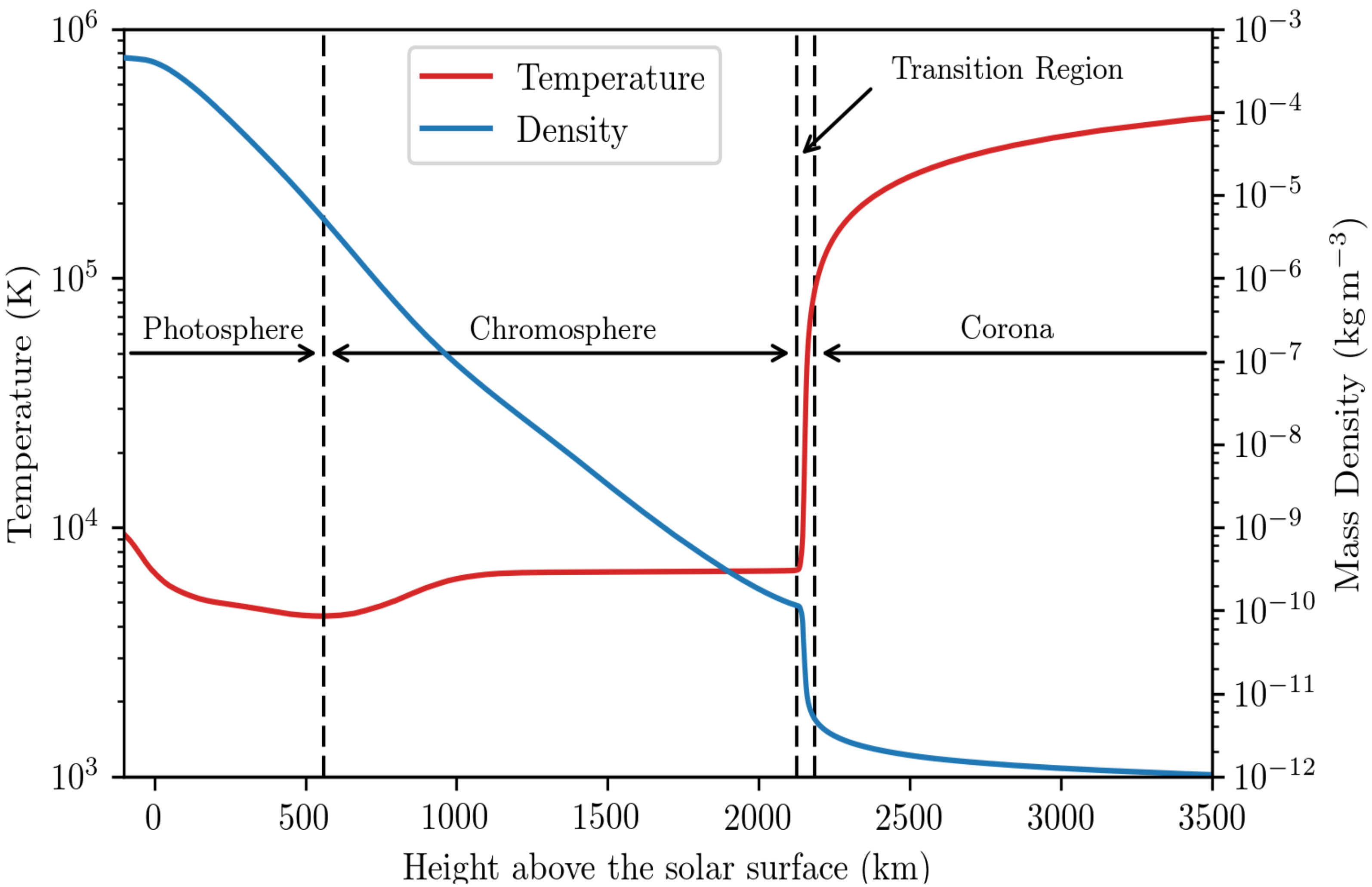
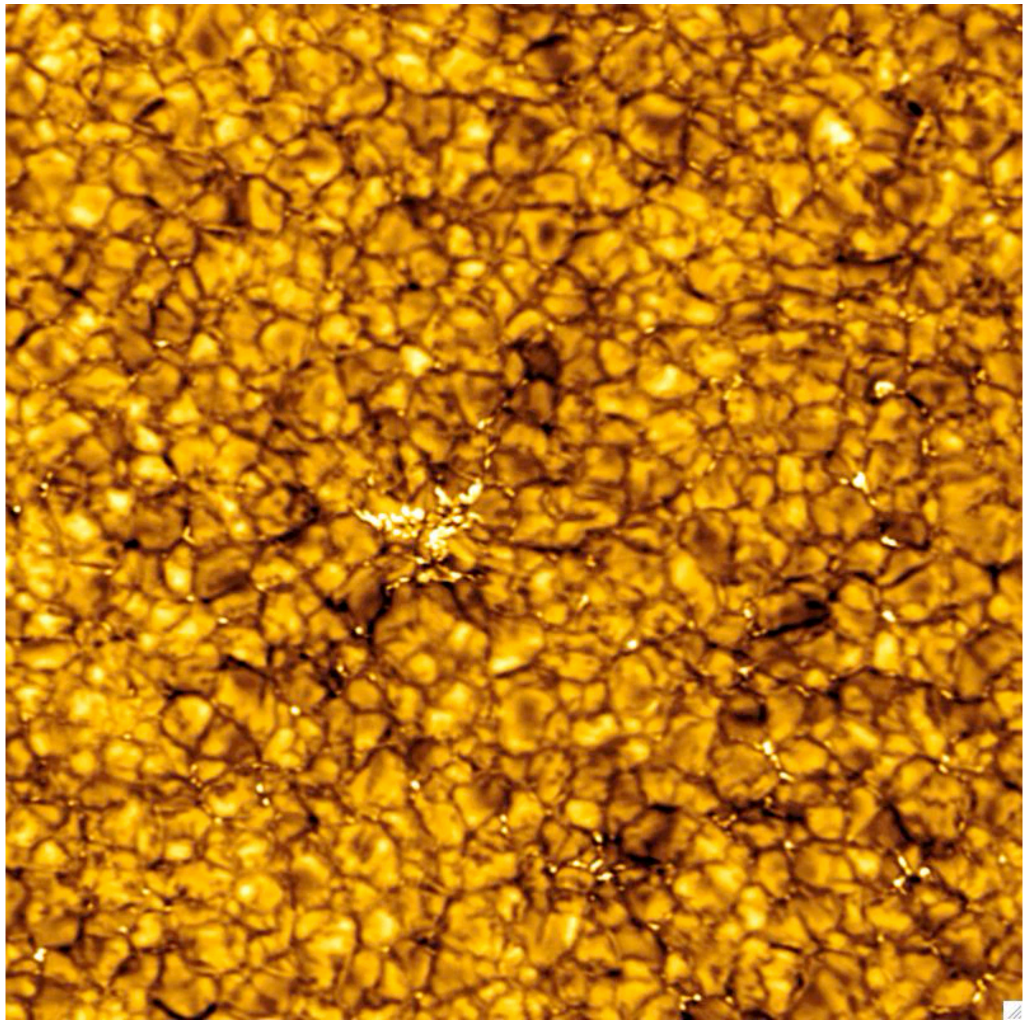
European Research Council
Established by the European Commission

Coronal Heating Problem



Avrett & Loeser (2008)



Quiet Sun - Observed 18/06/2006 SST
Rouppe van der Voort

What are the effects of driving timescales on energy injection and energy dissipation?

A Closer Look: AC vs DC heating

Two broad categories:

$\tau_{\rm driver} < \tau_A$ → **AC heating models**

$\tau_{\rm driver} > \tau_A$ → **DC heating models**

Velocity Driver

$$v_x = \sum_{i=1}^{N} v_i \cos\theta_i \exp\left\{\frac{-(r - r_{0,i})^2}{l_i^2}\right\} \exp\left\{\frac{-(t - t_{0,i})^2}{\tau_i^2}\right\}$$

$$v_y = \sum_{i=1}^{N} v_i \sin\theta_i \exp\left\{\frac{-(r - r_{0,i})^2}{l_i^2}\right\} \exp\left\{\frac{-(t - t_{0,i})^2}{\tau_i^2}\right\}$$

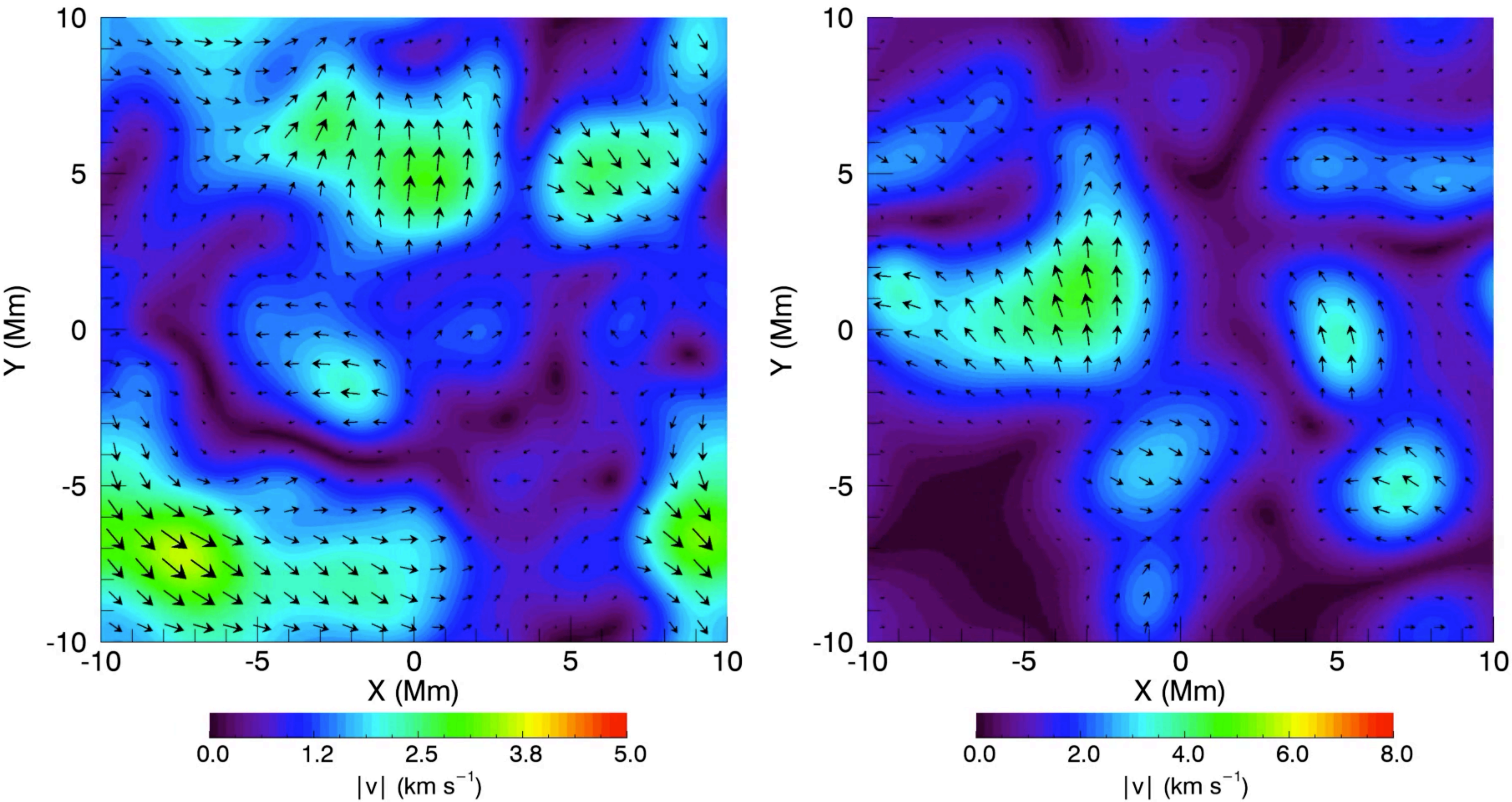
Impose a **random** 2-D velocity **v** = (v_x, v_y) profile

Can change **amplitude**, **time scales**, length scales, direction, complexity.

Imposed Velocity Driver

DC Driving

AC Driving

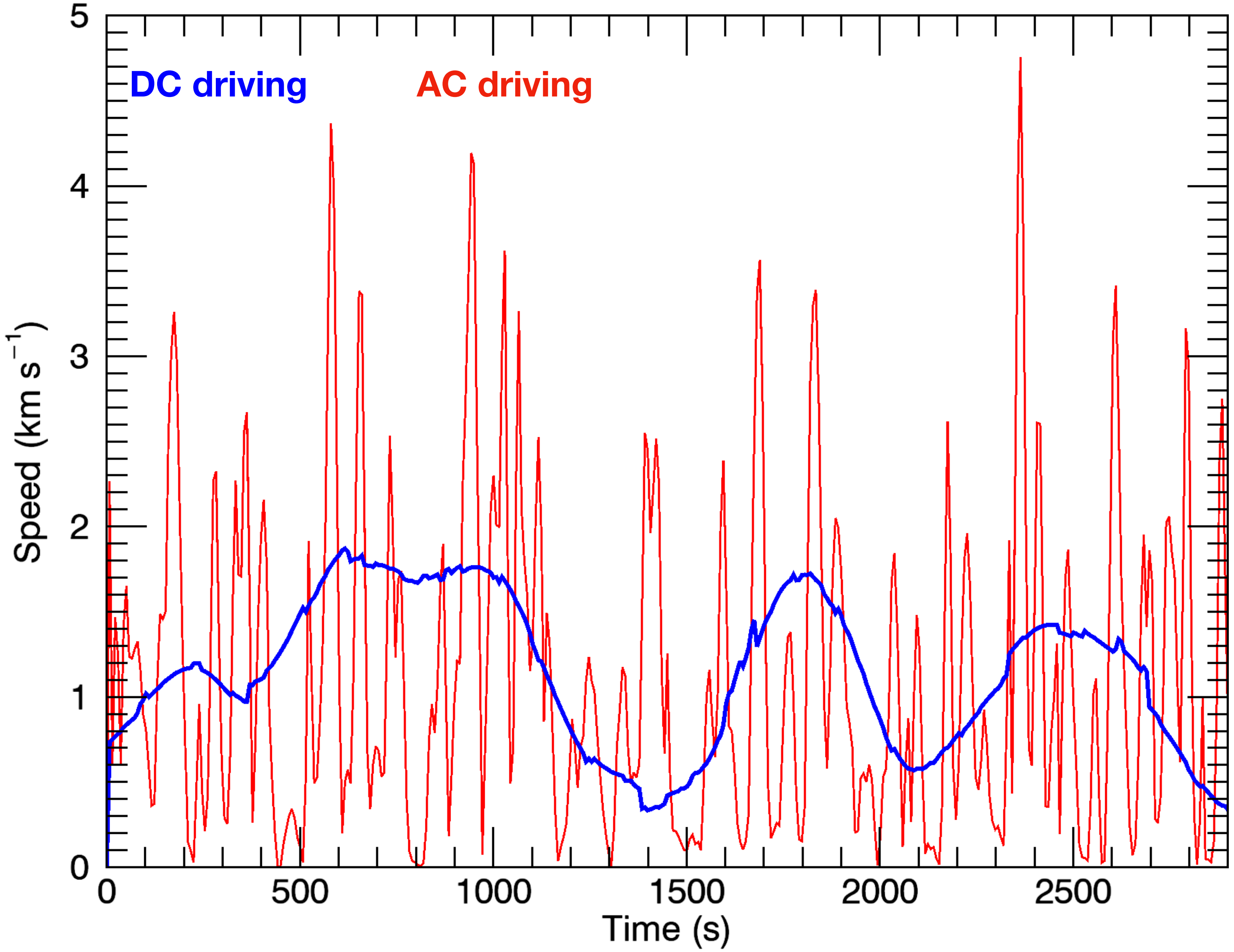


We choose velocity amplitude so mean kinetic energies are equal

Driver Energy

What should be constant between simulations - driver velocity? Poynting flux?

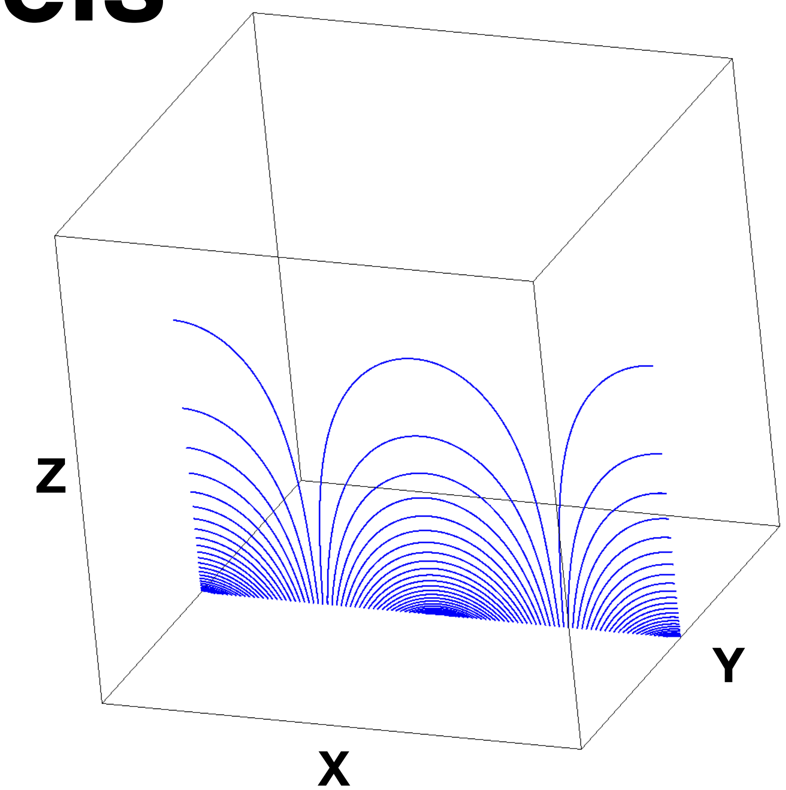
Set driver amplitude and N to ensure **mean kinetic energy and driver complexity** are approximately the same



Injected Poynting flux is not forced to be constant between simulations.

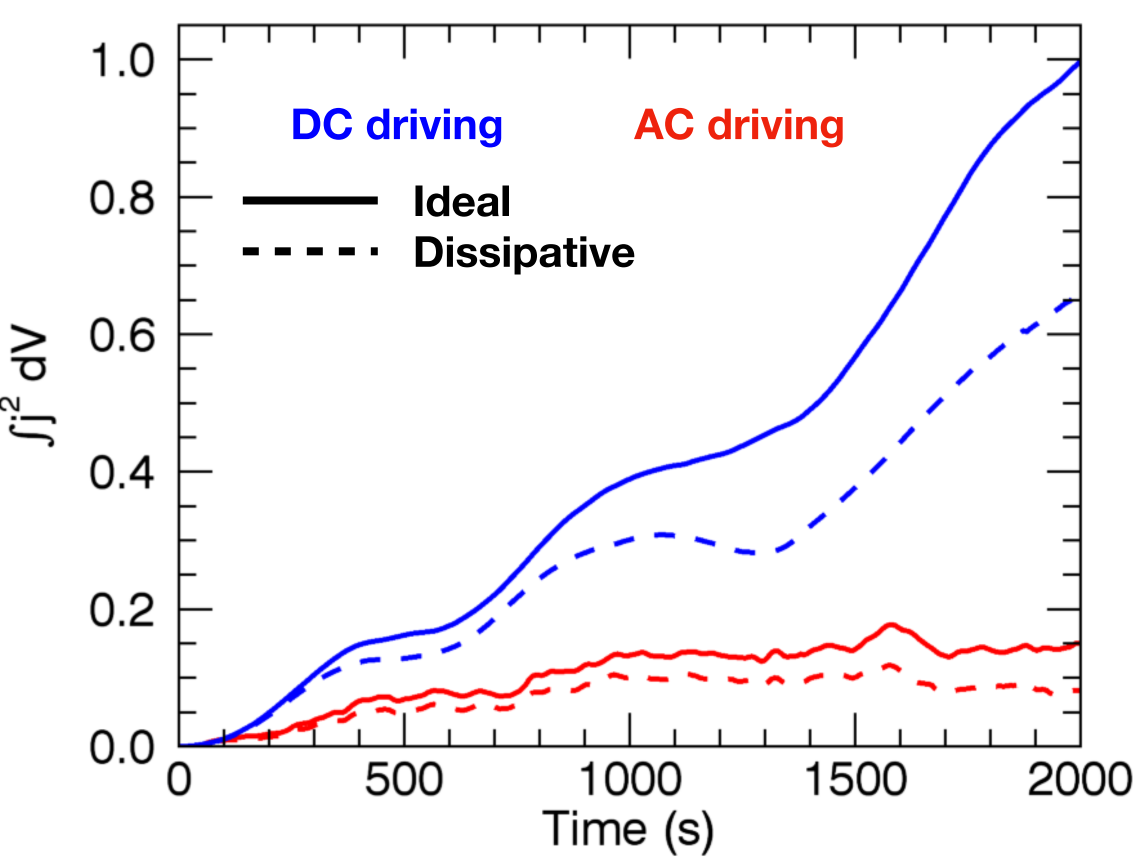
Models

1. Coronal Arcade
(Howson et al. 2020)

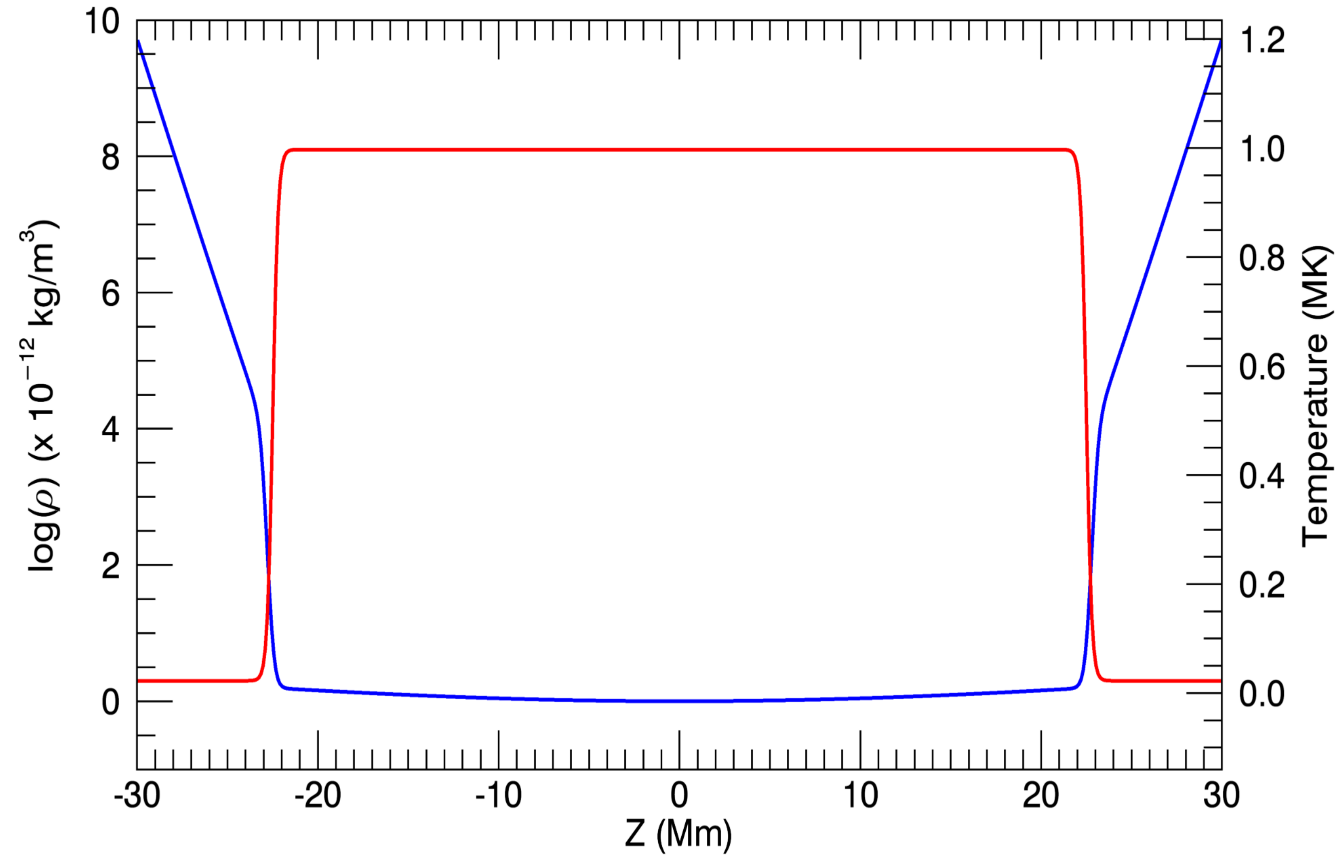


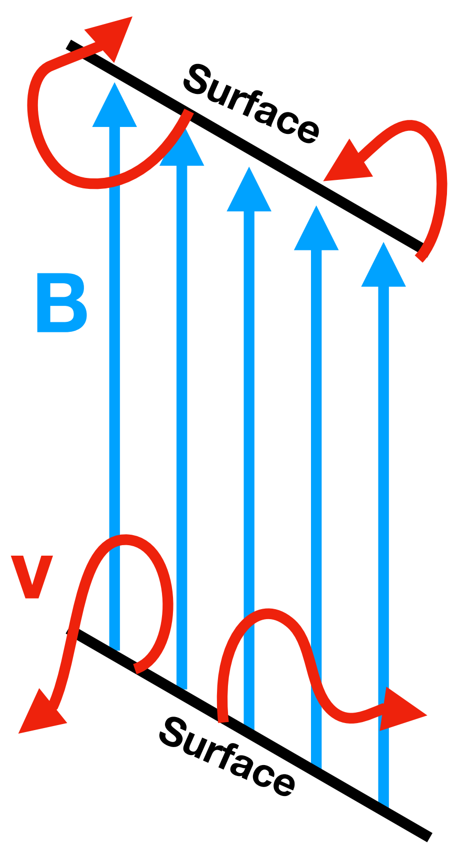
Potential arcade, uniform plasma.

Current



2. Stratified Atmosphere
(Howson et al. 2021 - in prep.)





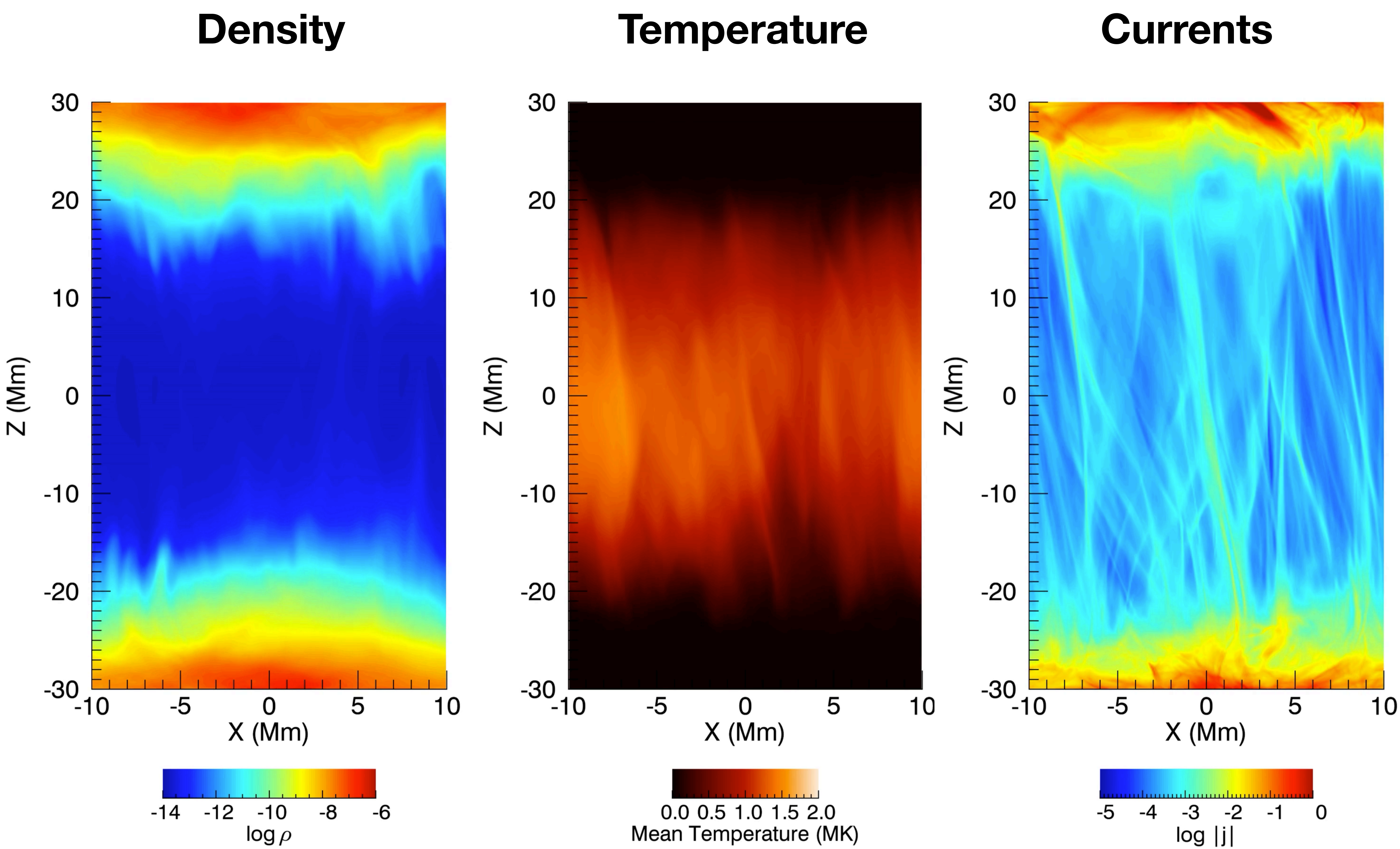
Field - uniform

Plasma - stratified atmosphere with field-aligned gravity.

Drive both boundaries.

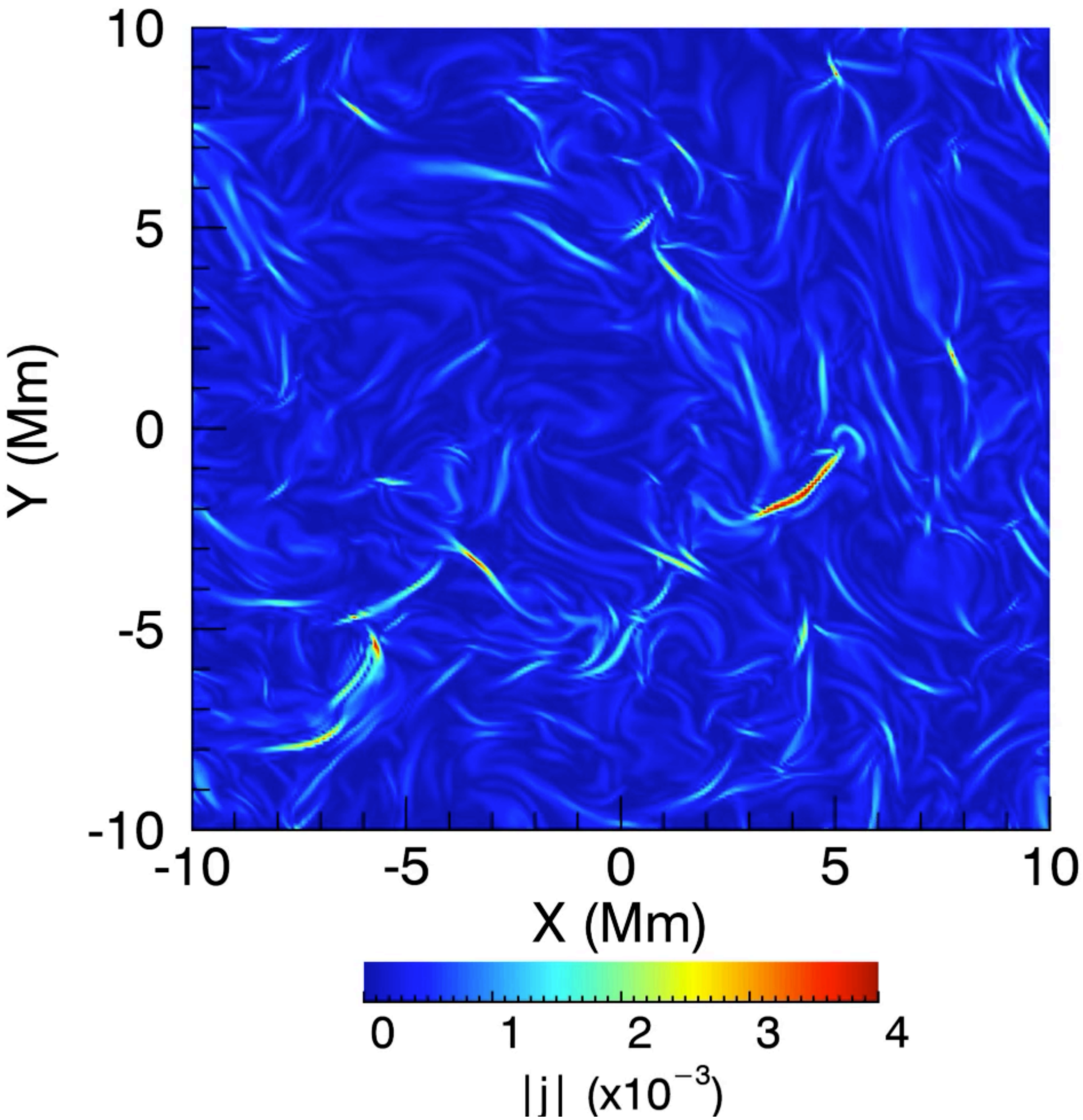
Conduction + radiation.

Atmosphere: Evolution

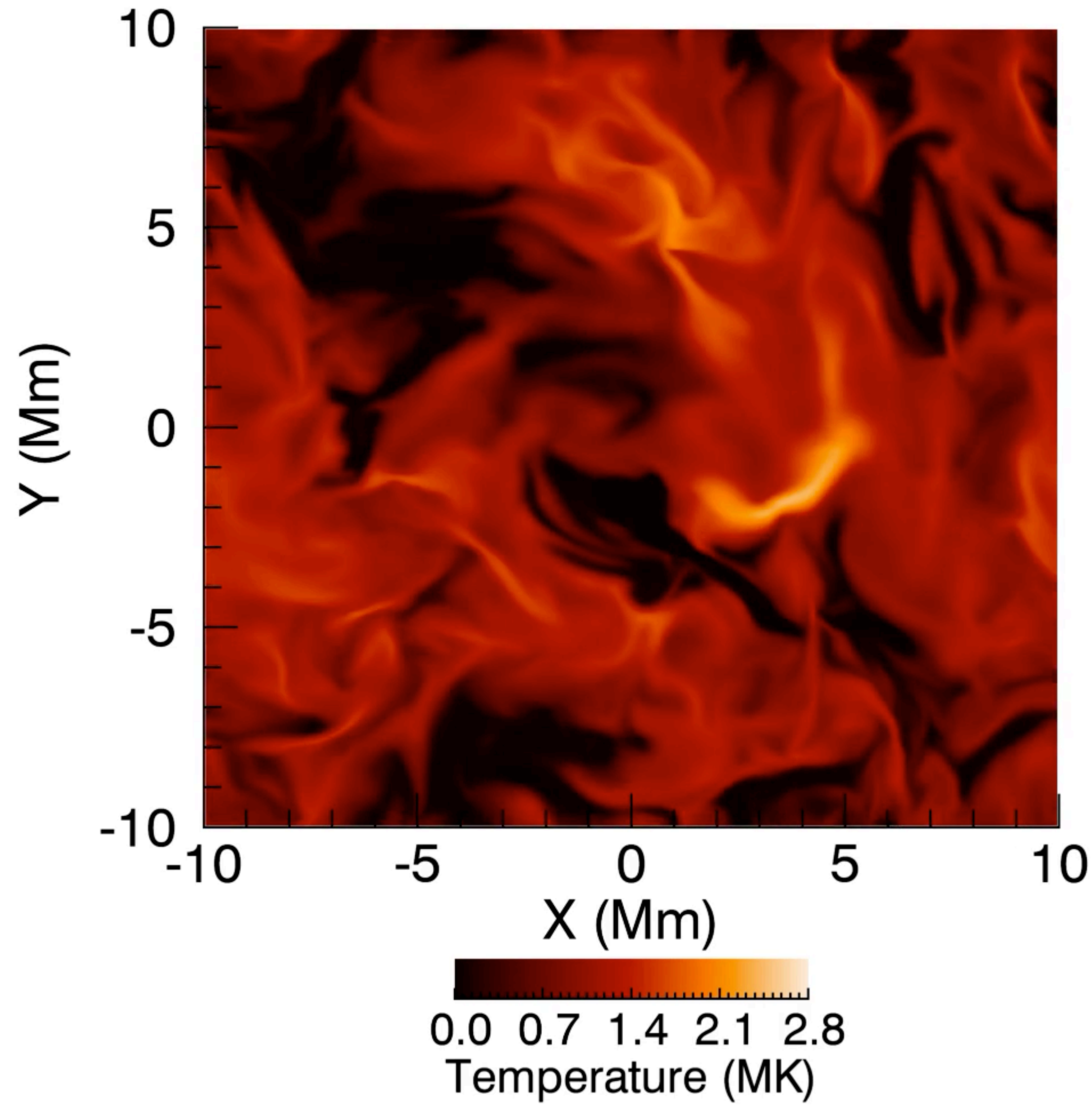


Atmosphere: Evolution

Currents

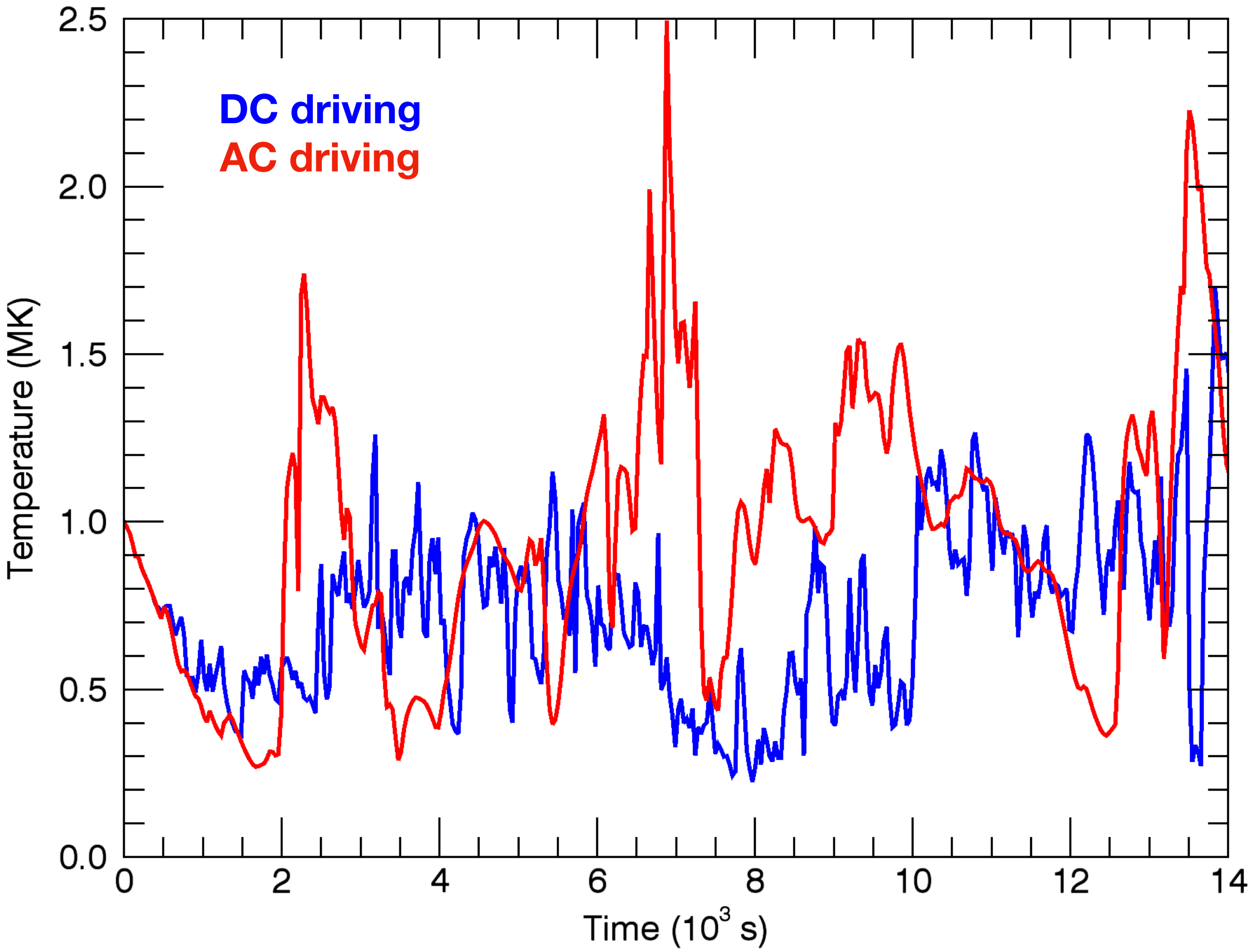


Temperature

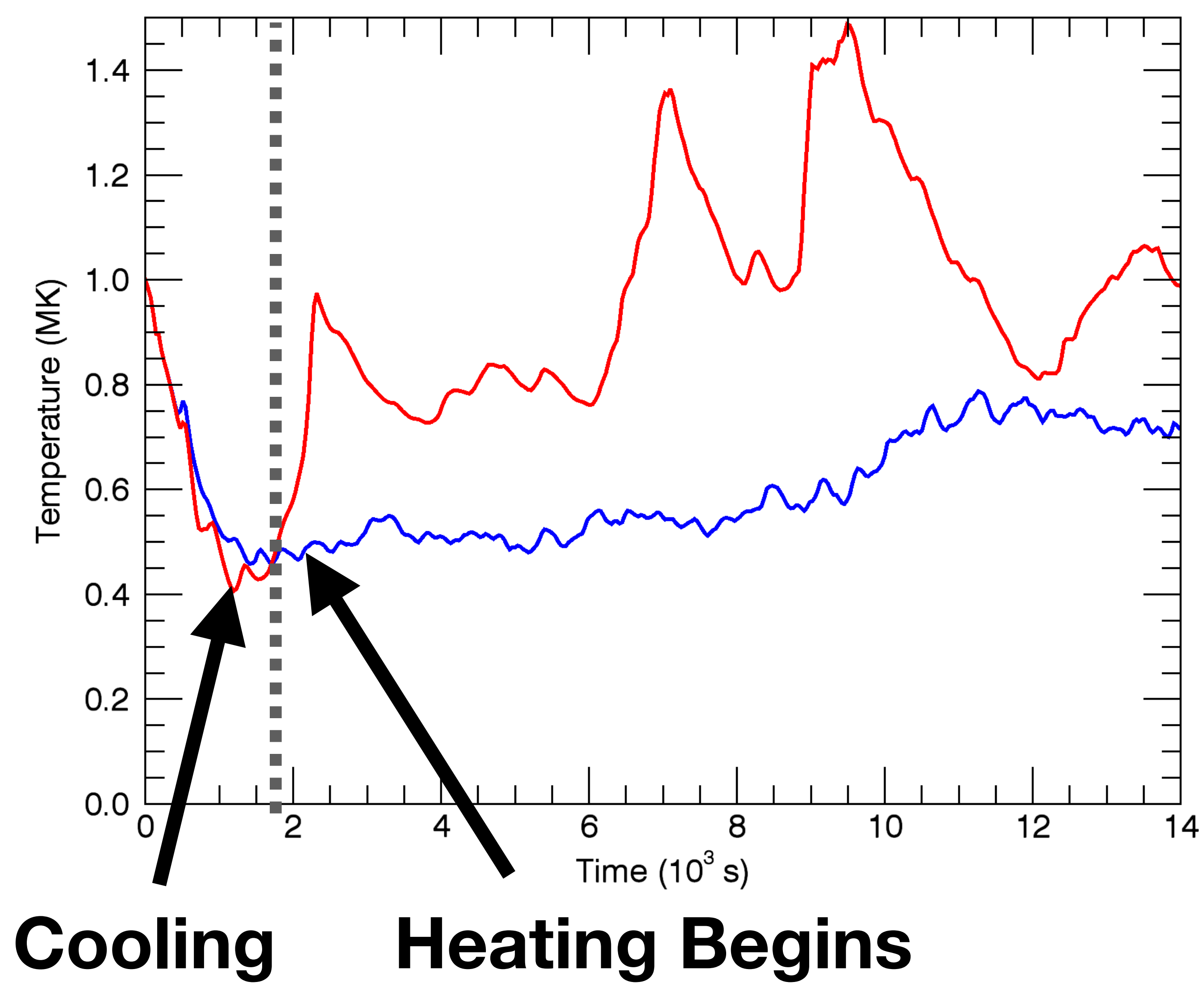


Atmosphere: Heating

Localised Apex Temperature



Mean Apex Temperature



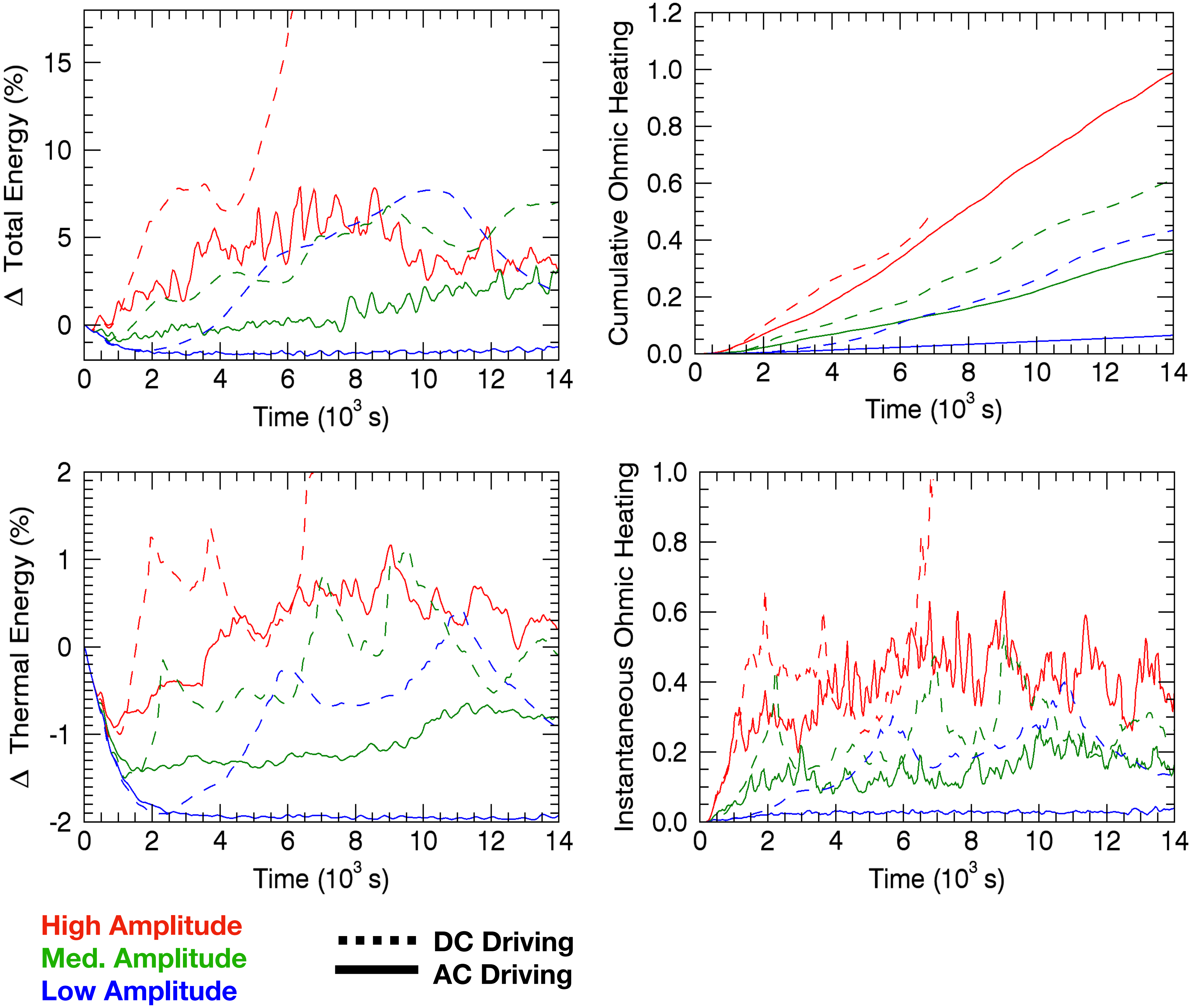
Both AC and DC heating impulsive locally (e.g. on single field line).

DC heating typically less frequent but larger energy release events.

Greater variation in temperature for DC cases.

Atmosphere: Energetics

Volume Integrated Energy Diagnostics



More energy injected for DC driving - mainly magnetic.

This allows higher Ohmic heating rates and ultimately higher temperatures.

Naturally, higher amplitude driving produces greater heating

Conclusions

Enhanced Poynting flux and heating for DC drivers.

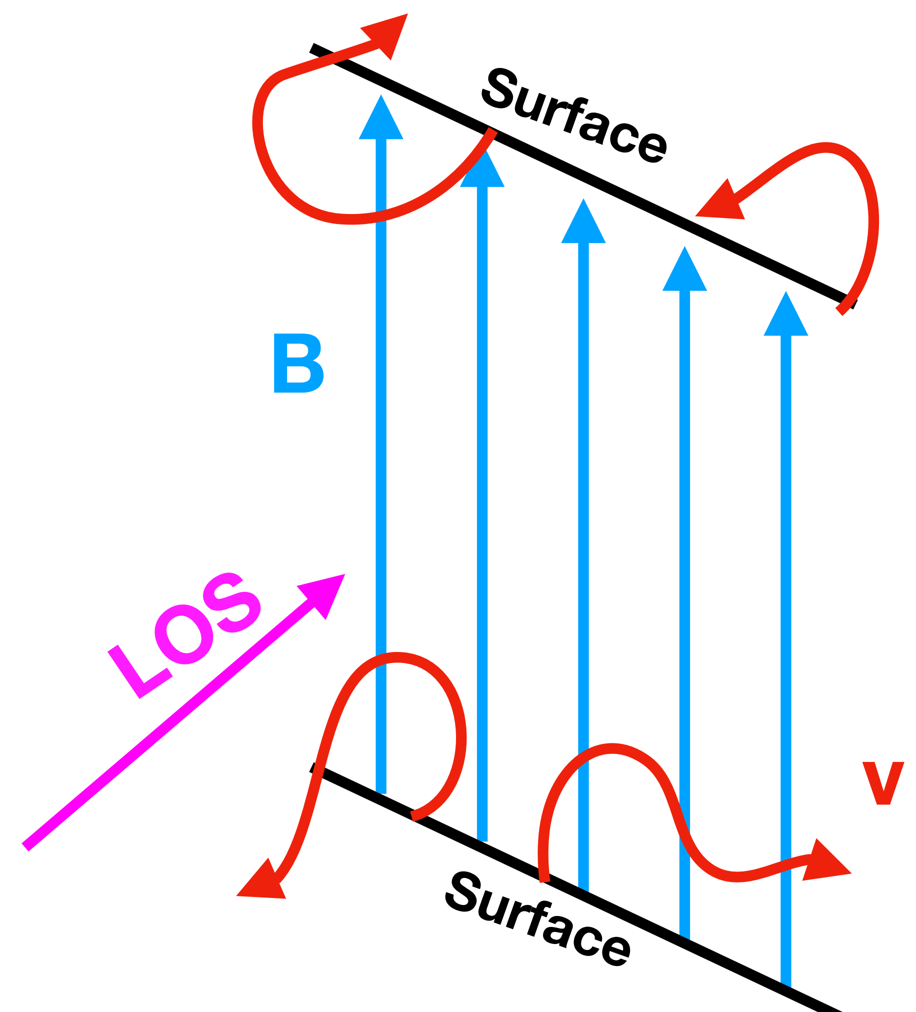
When AC drivers **inject complexity into the magnetic field**, they can maintain coronal conditions for driver amplitudes of approx 10 km/s (and artificially large dissipation).

Future Questions

How does heating **scale with transport coefficients?**

Are there any defining characteristics for AC/DC heating events?

Can we differentiate between models using synthetic observables?



This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 647214).