Supergranulation Scale Convection Simulations

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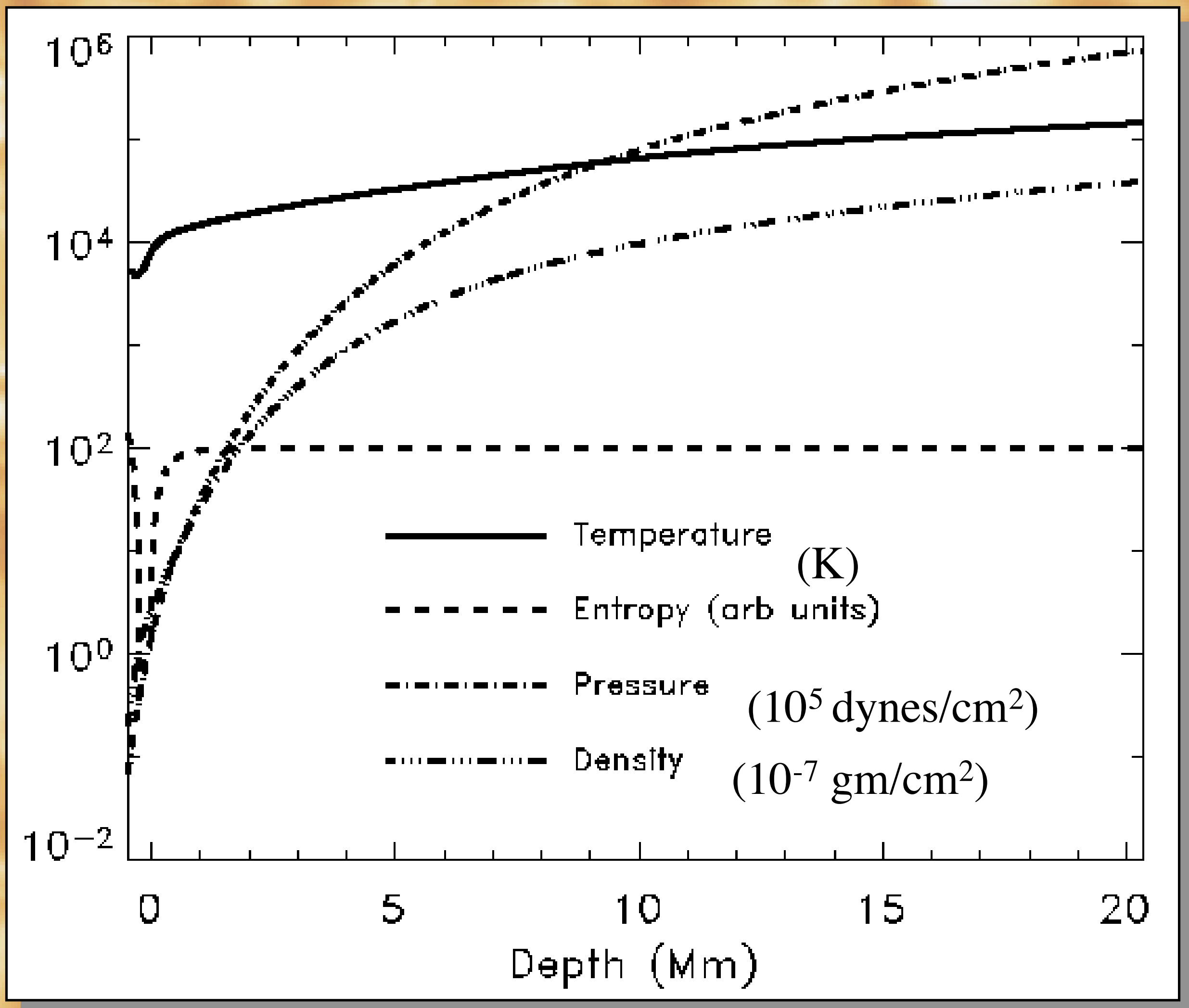
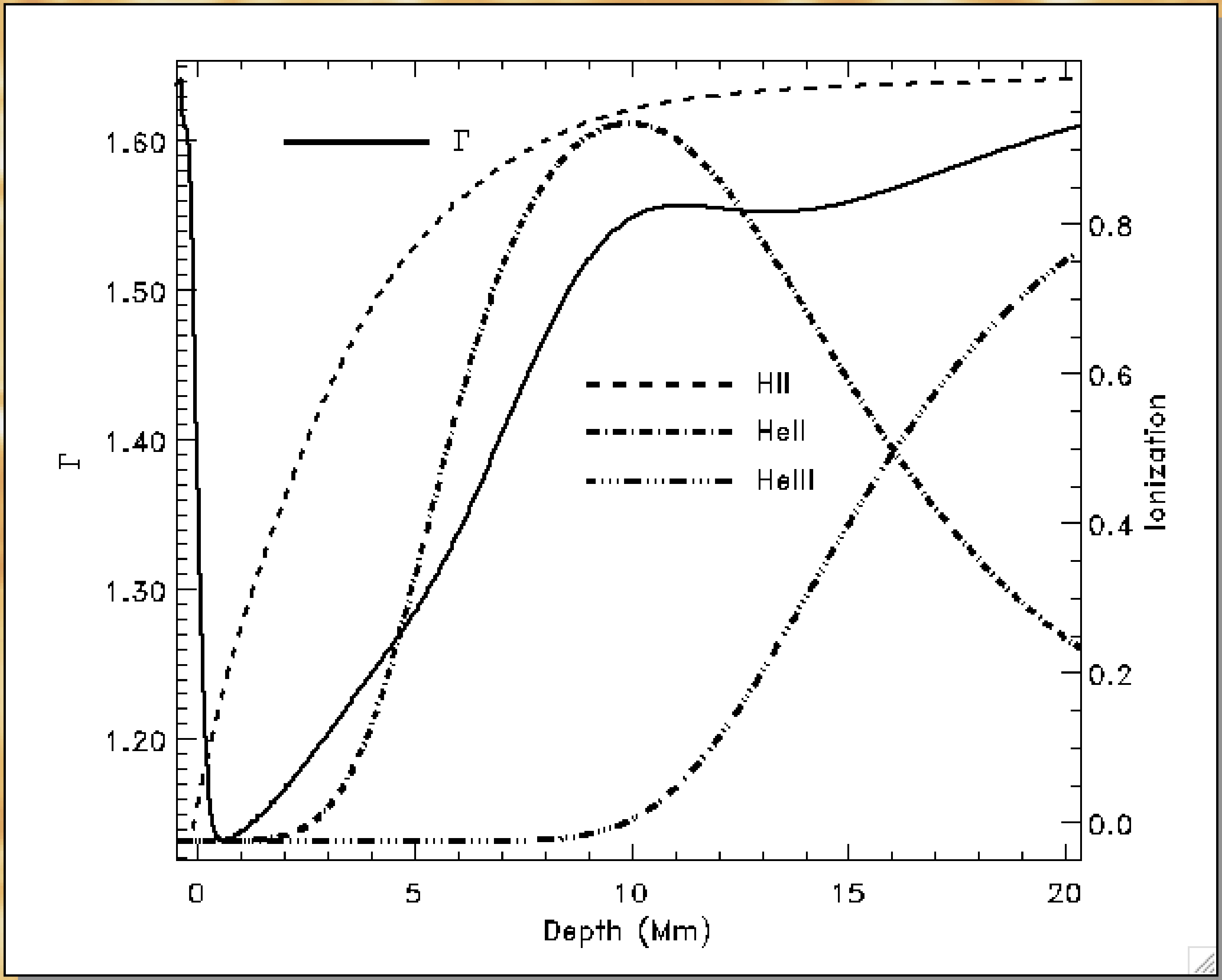
Mean Atmosphere

Temperature, Density and Pressure



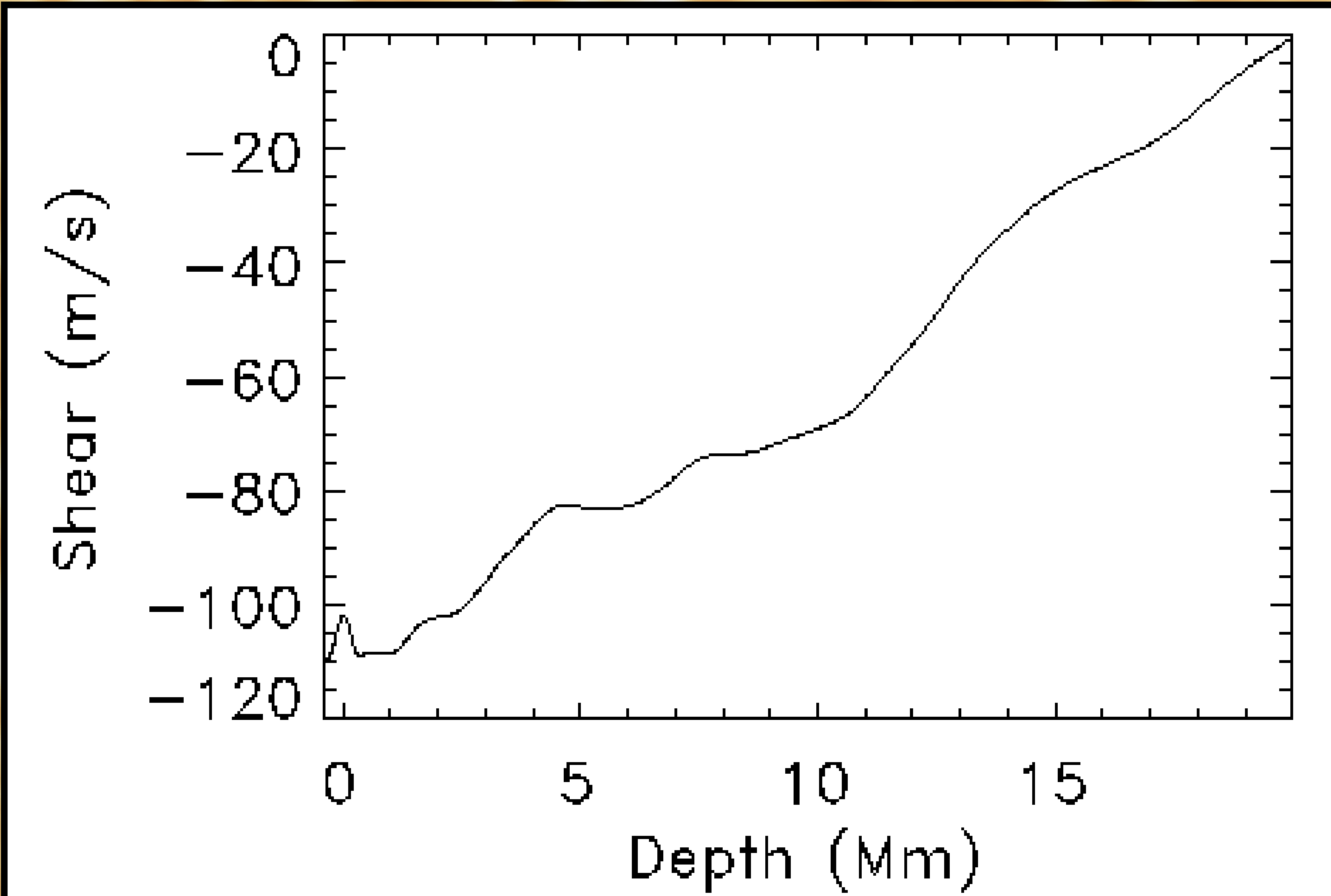
Mean Atmosphere

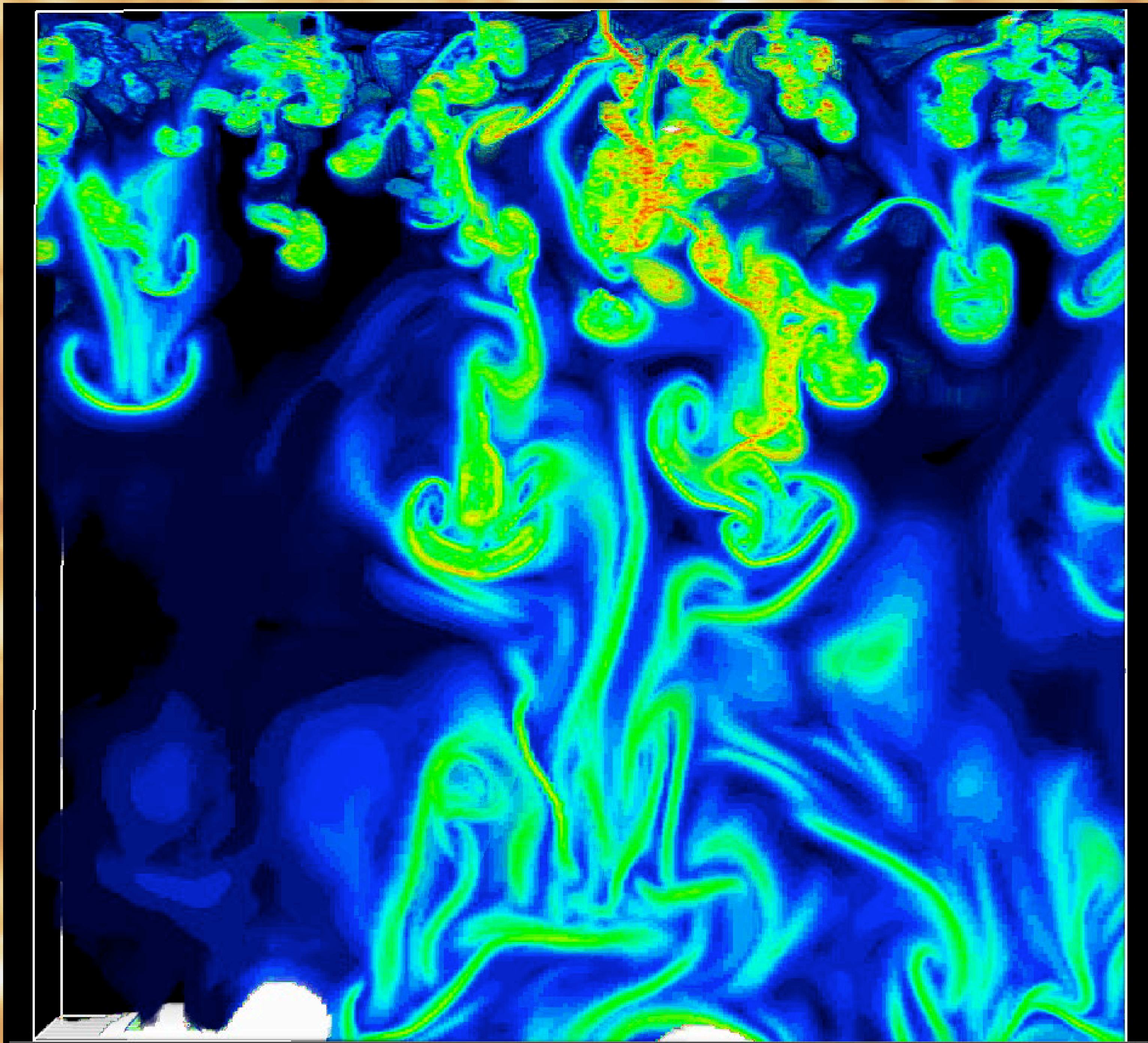
Ionization of He, He I and He II



Surface shear layer

f-plane rotation





Vorticity

11.75 hours, Finite Time Lyapunov Exponent Field, subdomain 21 Mm wide x 19 Mm high x 0.5 Mm thick, (from 48x 20 Mm simulation)

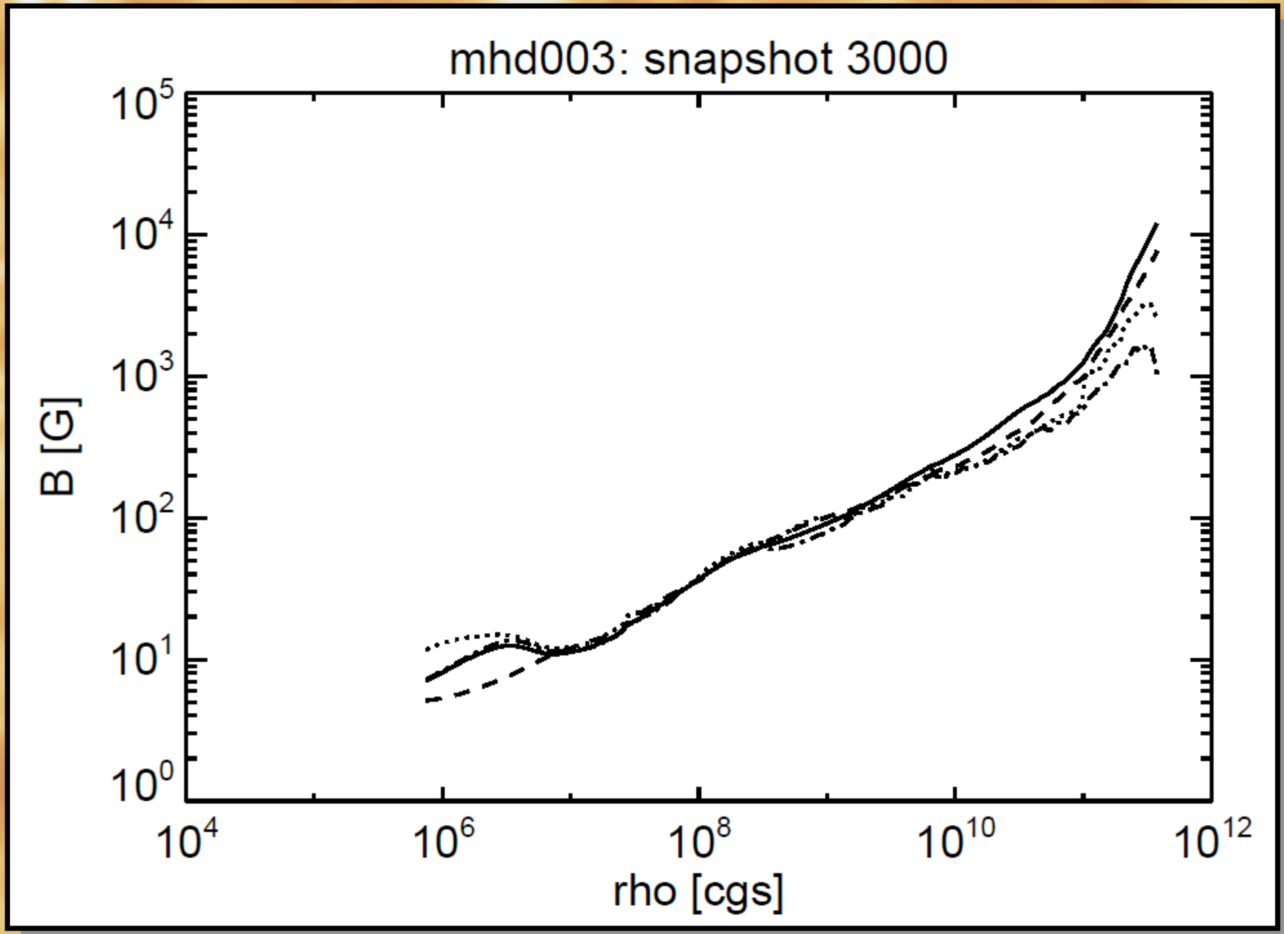
Magneto-Convection

Ininitial state B=0, B_x advected into domain from bottom.

$\langle B \rangle$, $\langle B^2 \rangle^{1/2}$ relax to $\rho^{\sim 0.5}$

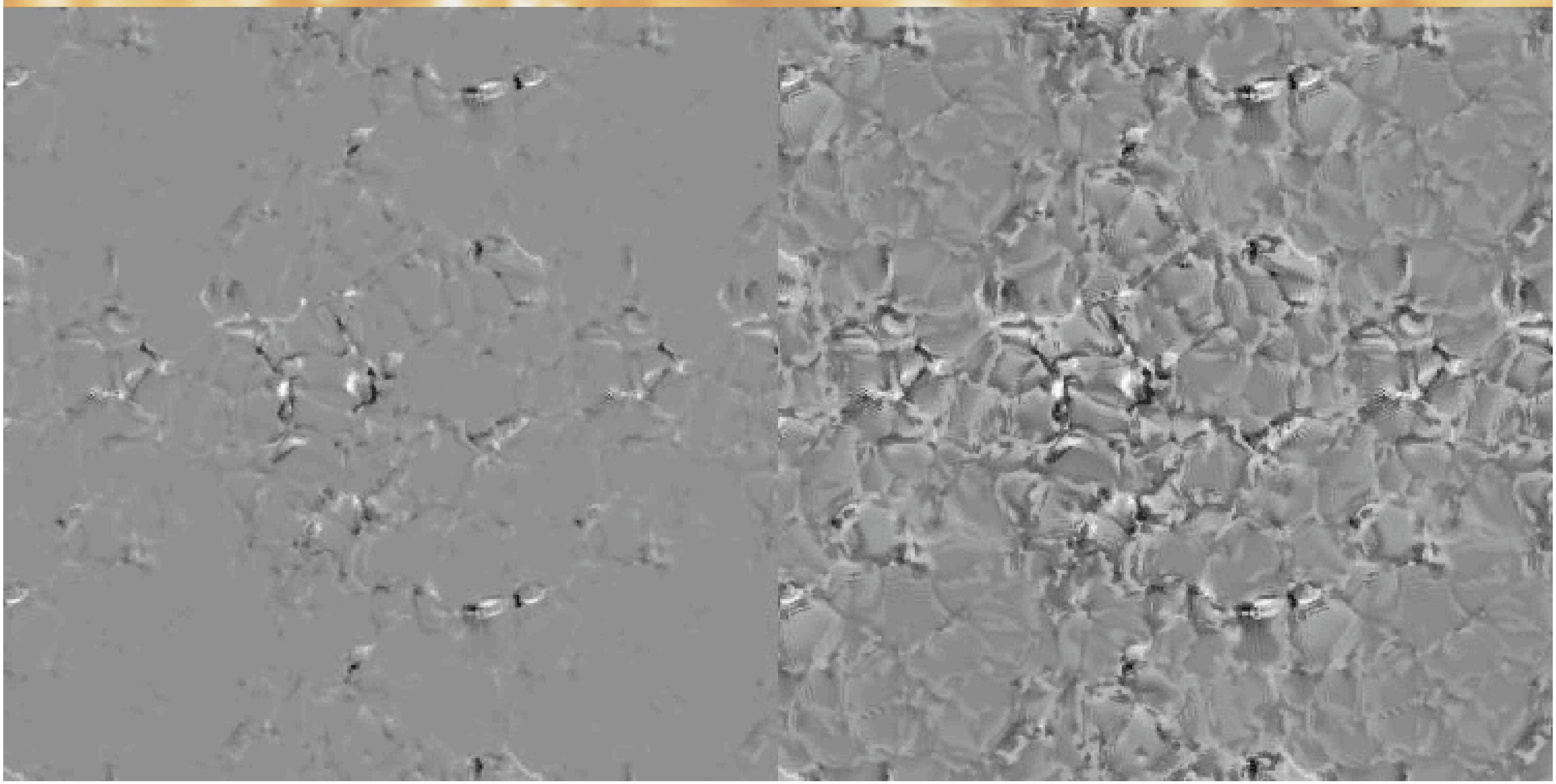
The scaling of average B (full drawn) & fluctuating B components (x:dotted, y:dashed, z:dot-dashed) after 25 solar hours.

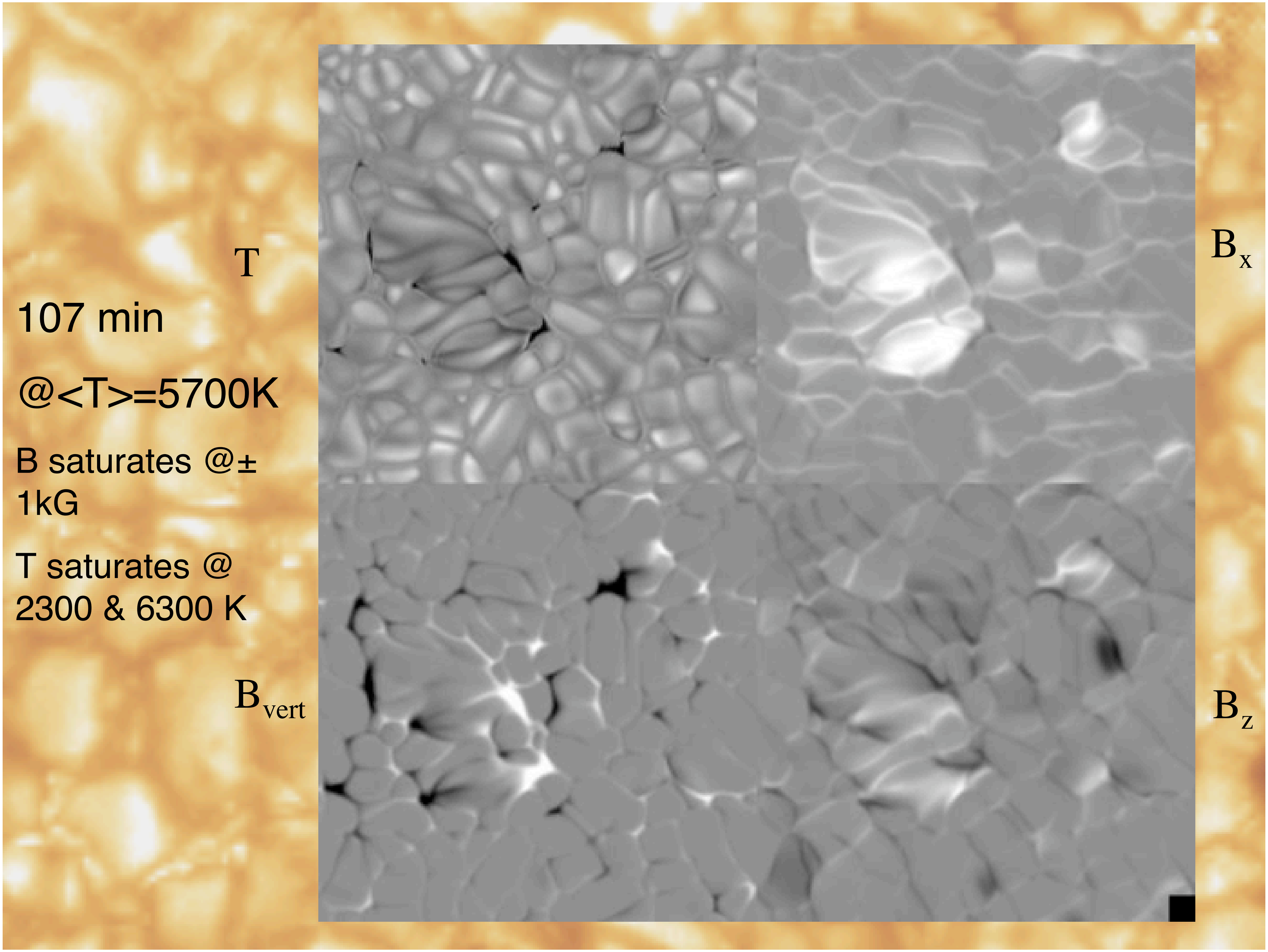
(see poster P3-11)

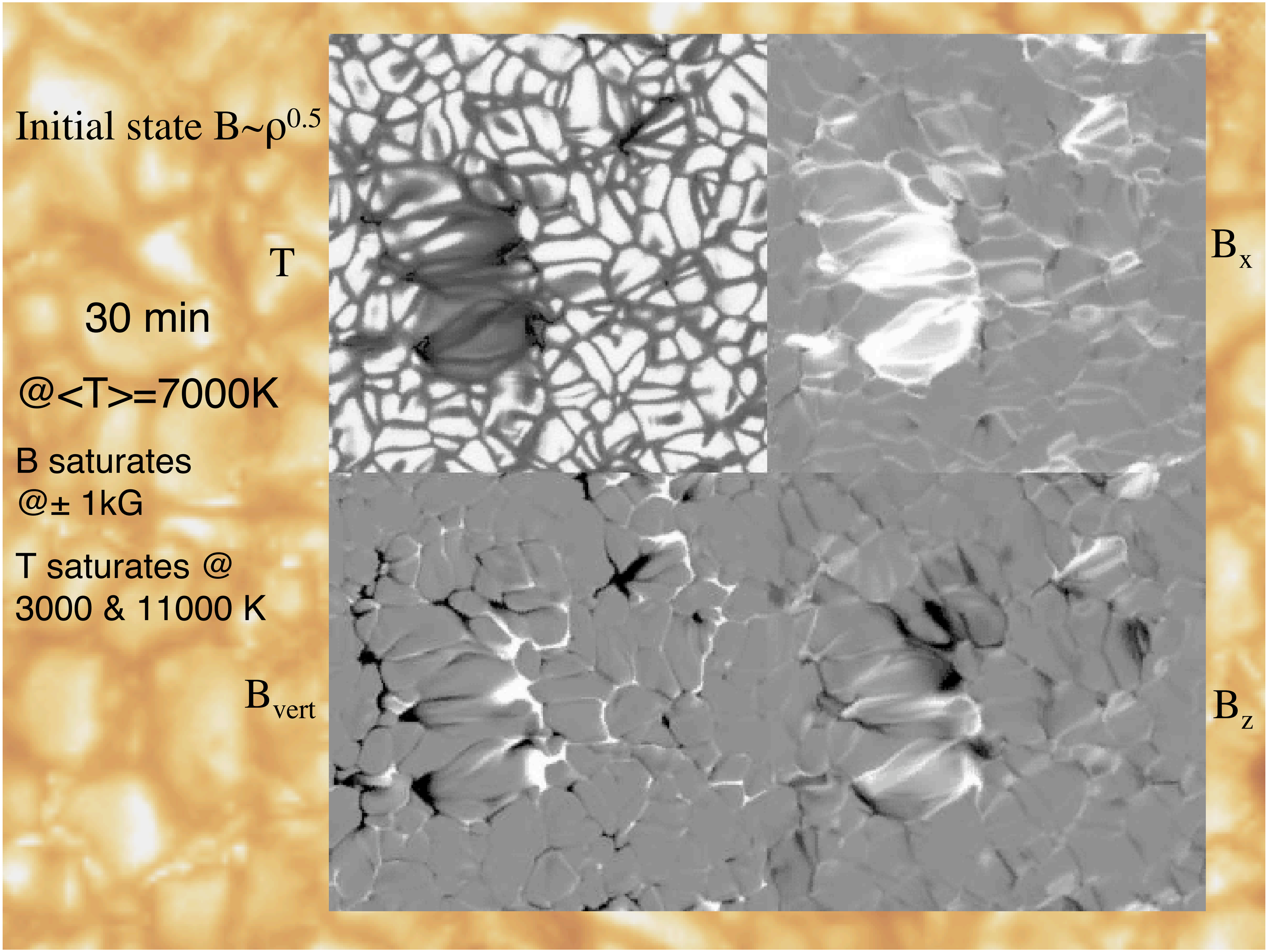


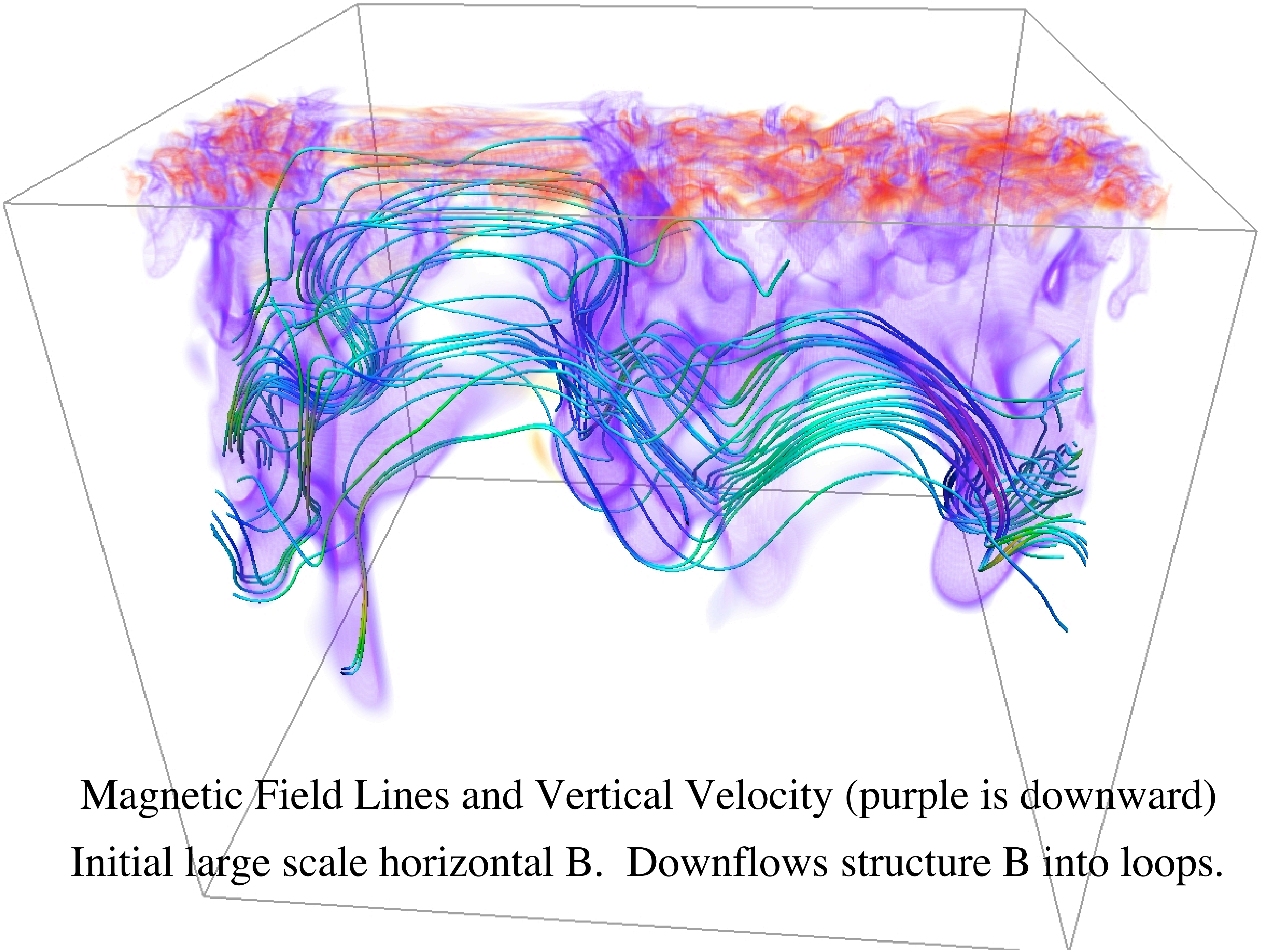
Domain 24 Mm wide x 20 Mm deep, 1 hour sequence

Initial state: B=0. Horizontal field advected into domain at bottom



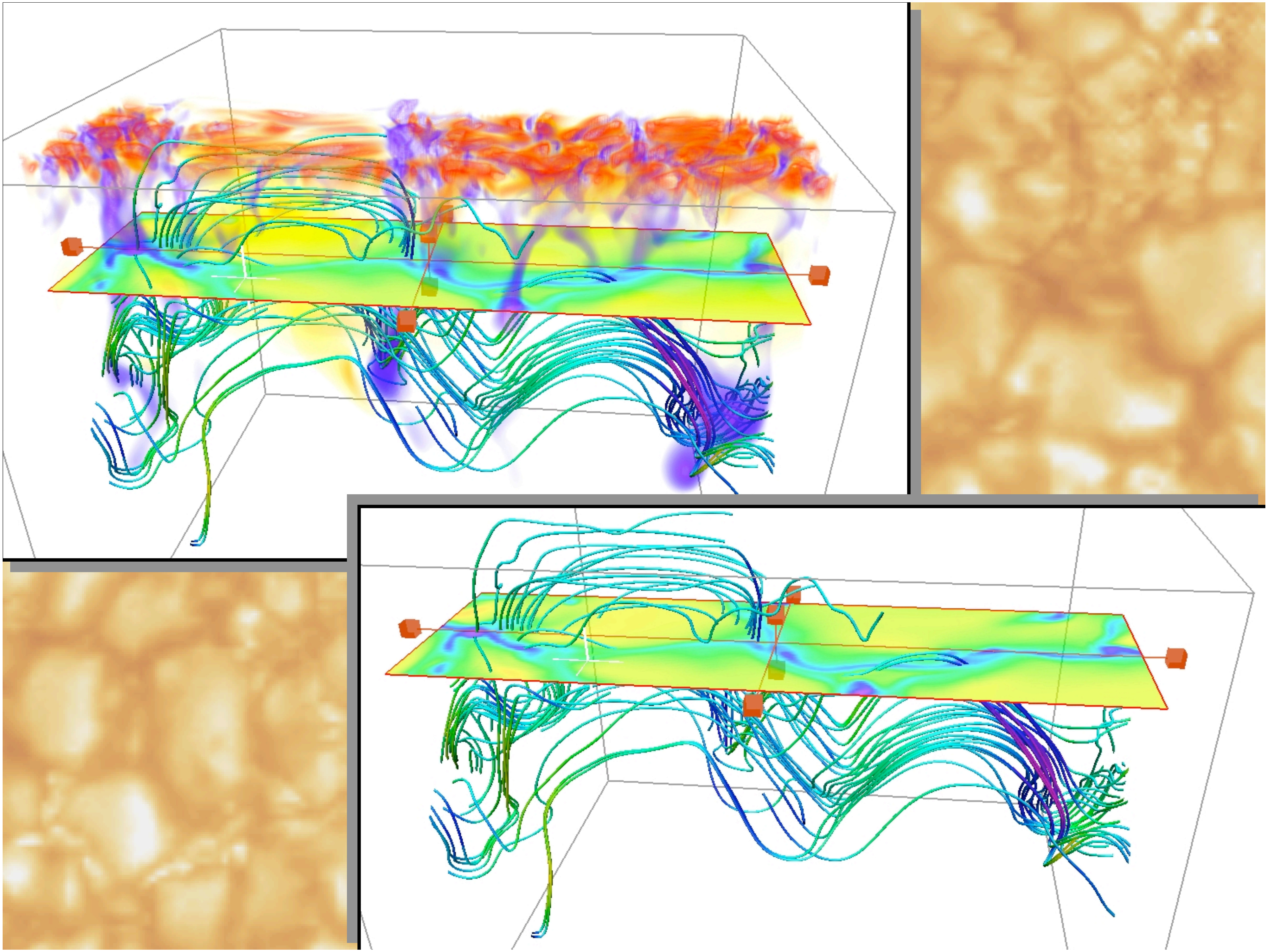

T
107 min
@<T>=5700K
B saturates @± 1kG
T saturates @ 2300 & 6300 K
B_x
B_{vert}
B_z


Initial state B~ρ^0.5
T
30 min
@<T>=7000K
B saturates
@± 1kG
T saturates @
3000 & 11000 K
B_vert
B_x
B_z

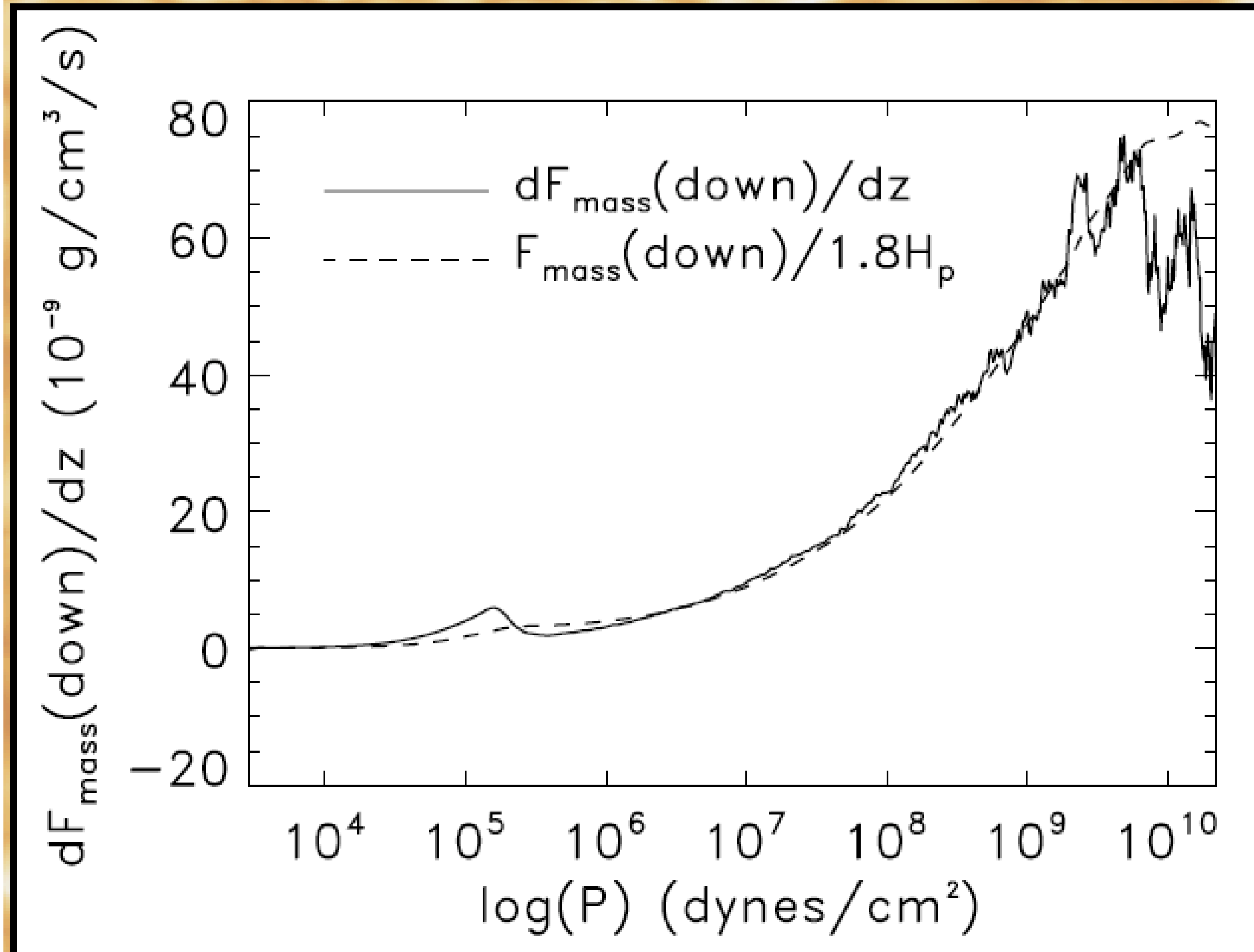


Magnetic Field Lines and Vertical Velocity (purple is downward)

Initial large scale horizontal B. Downflows structure B into loops.

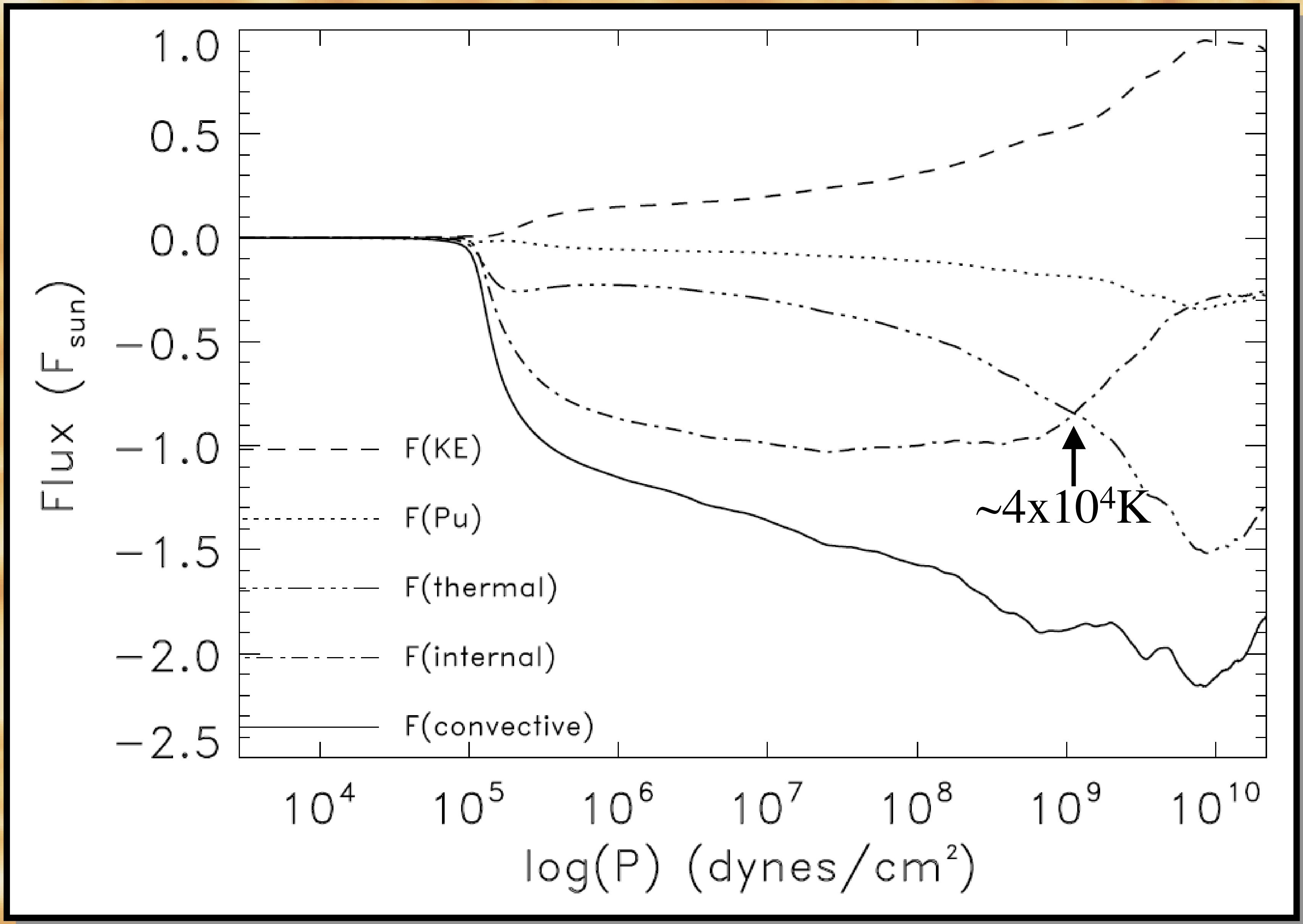


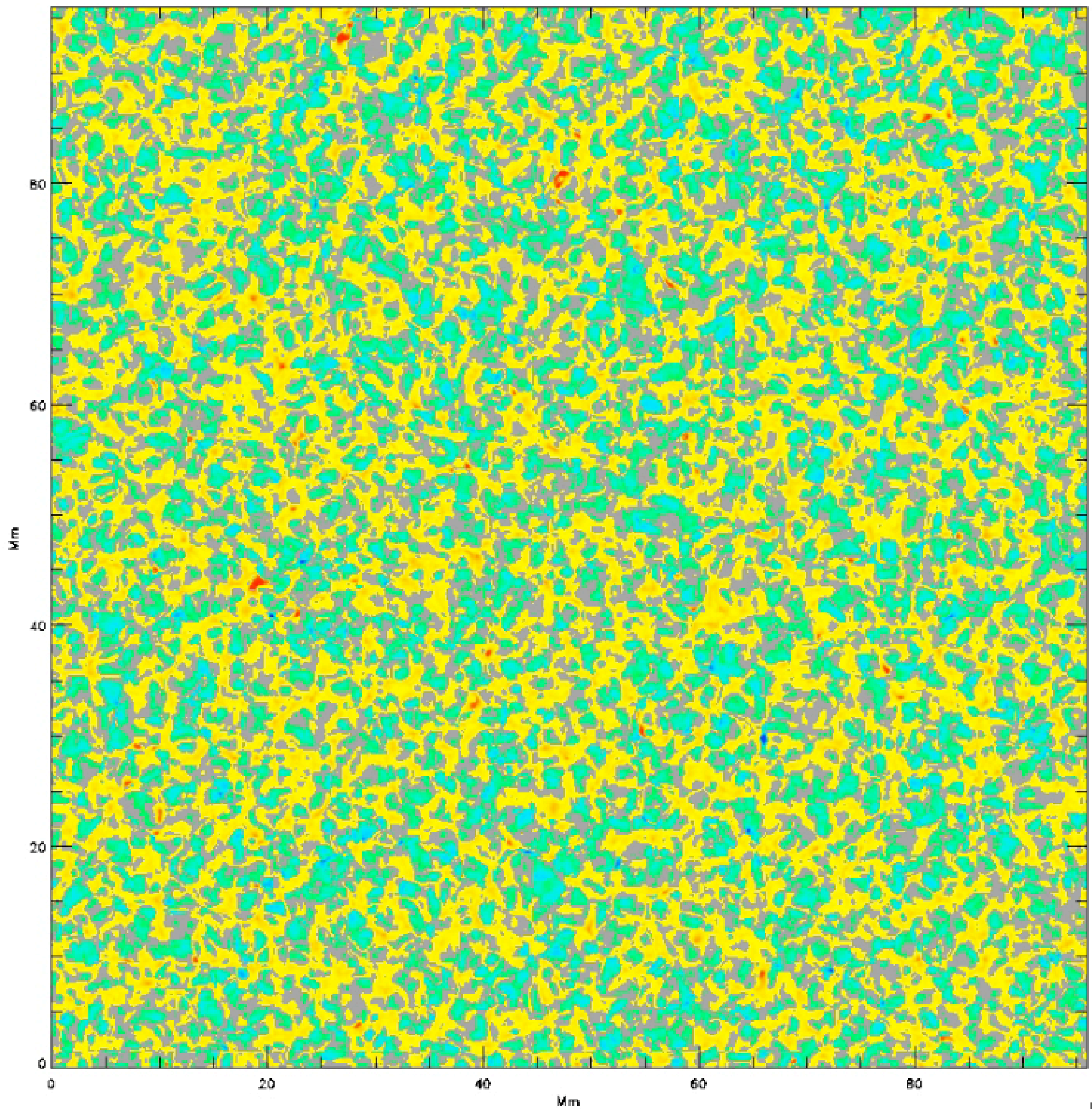
Convection Properties, 96x20 Mm: Mixing Length



Rising fluid must turn over and descend within about a scale height to conserve mass. The actual mixing (entrainment) length in the simulation is **1.8 H_P**.

Energy Fluxes

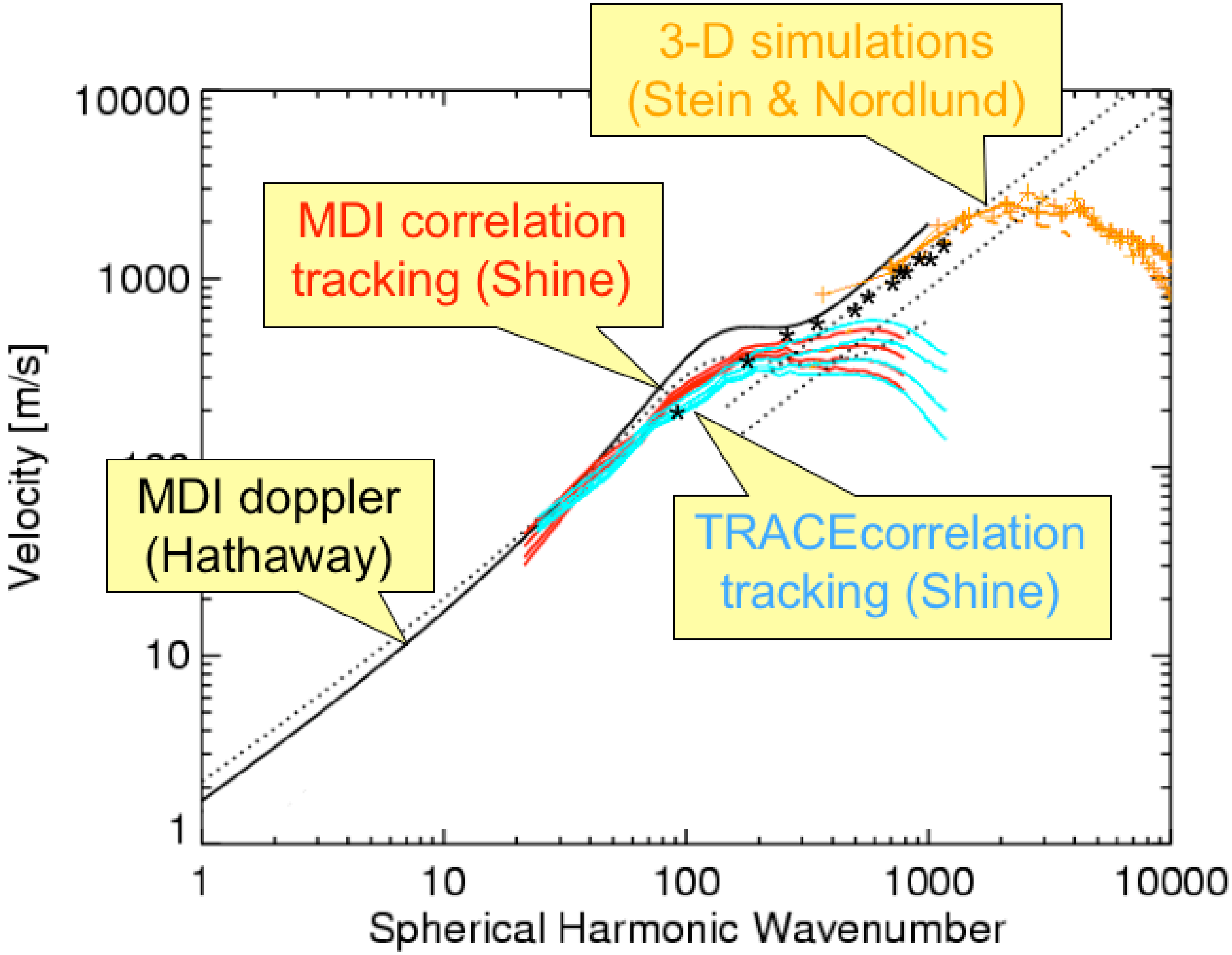




Vertical velocity: scan from temperature minimum to 20 Mm depth

size of cellular structures increases with depth

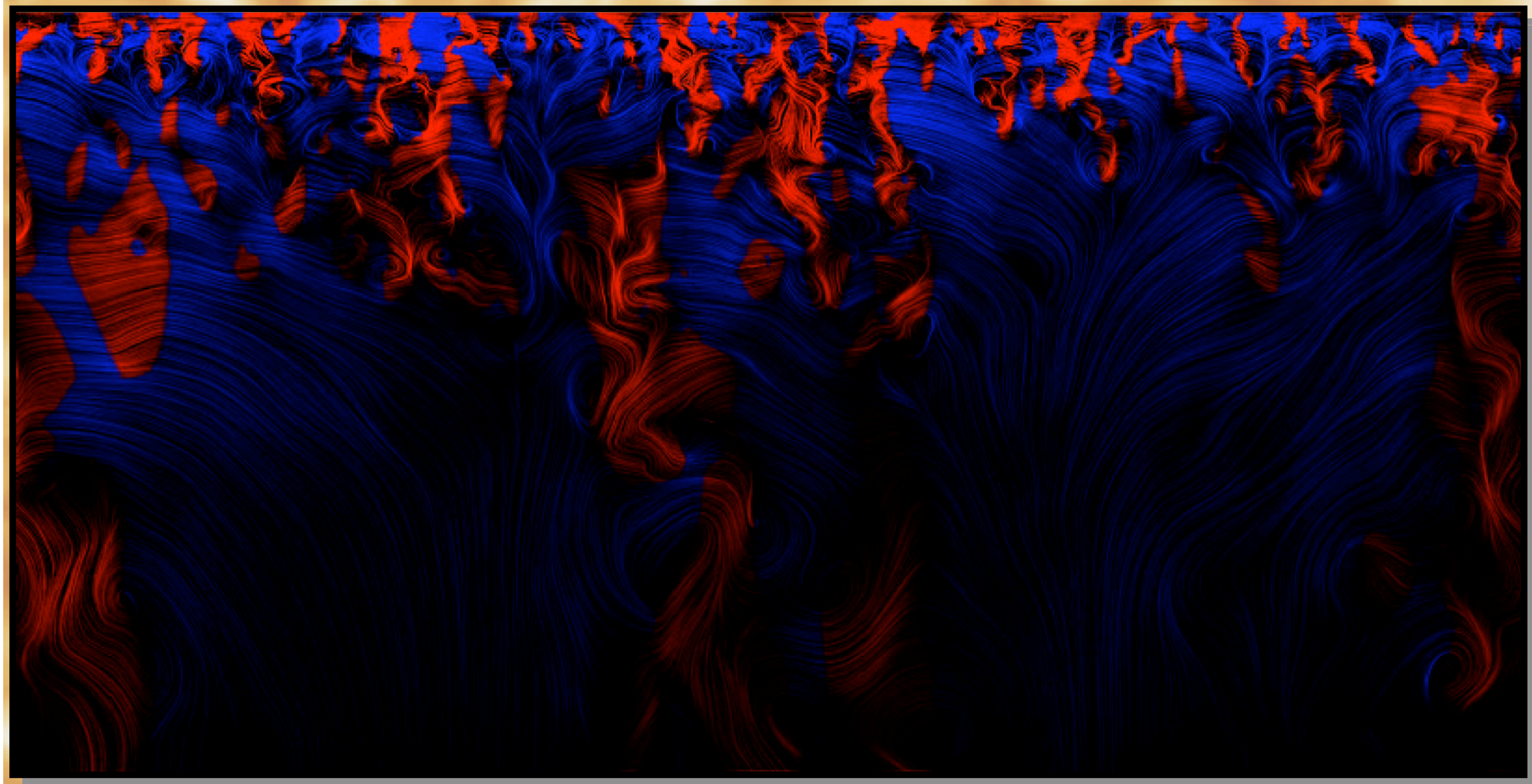
Velocity spectrum $[kP(k)]^{1/2}$



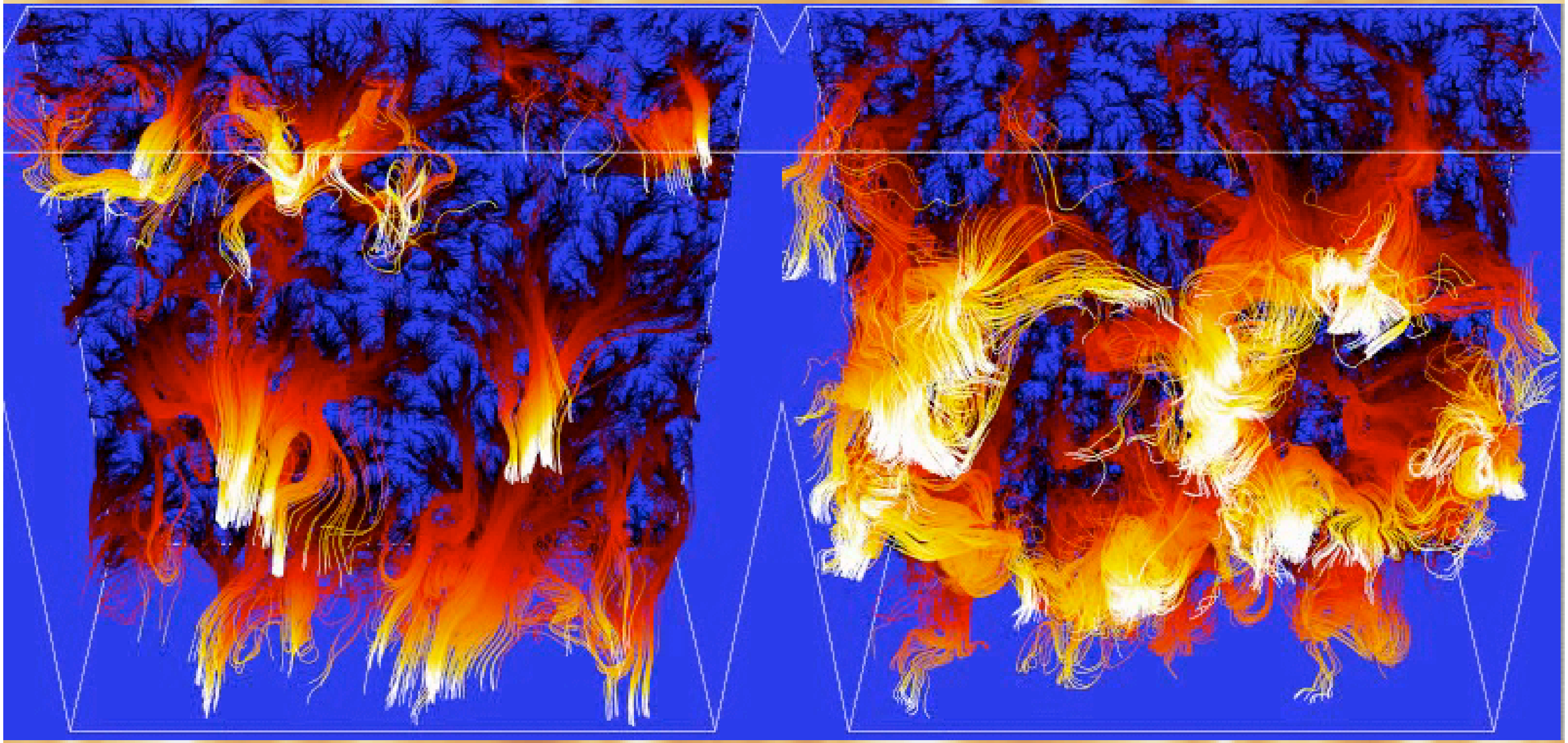
Streamlines: red down, blue up;15 hours;

48 x 20 Mm, vertical scale is depth

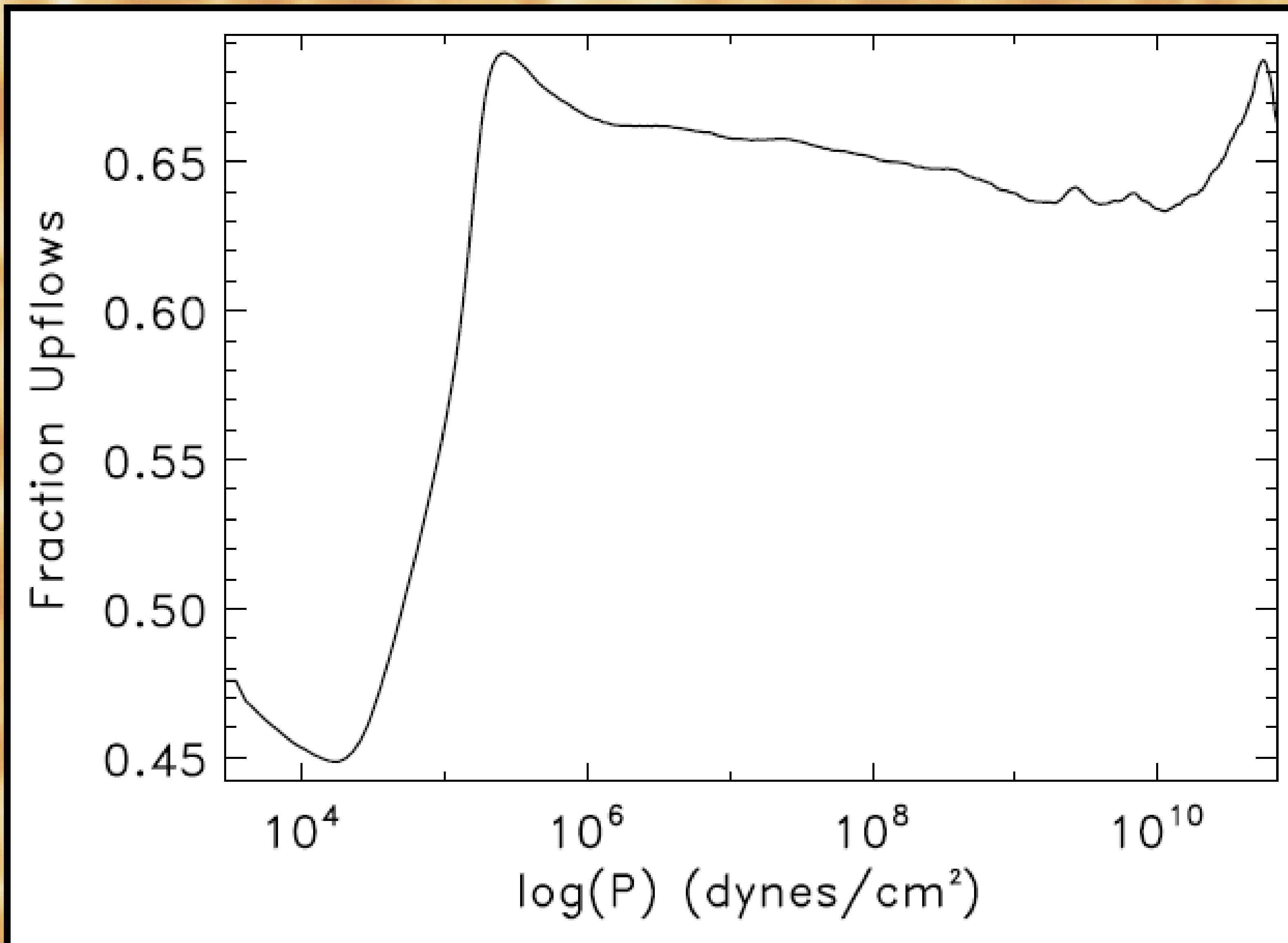
some downflows are halted, others merge into larger structures



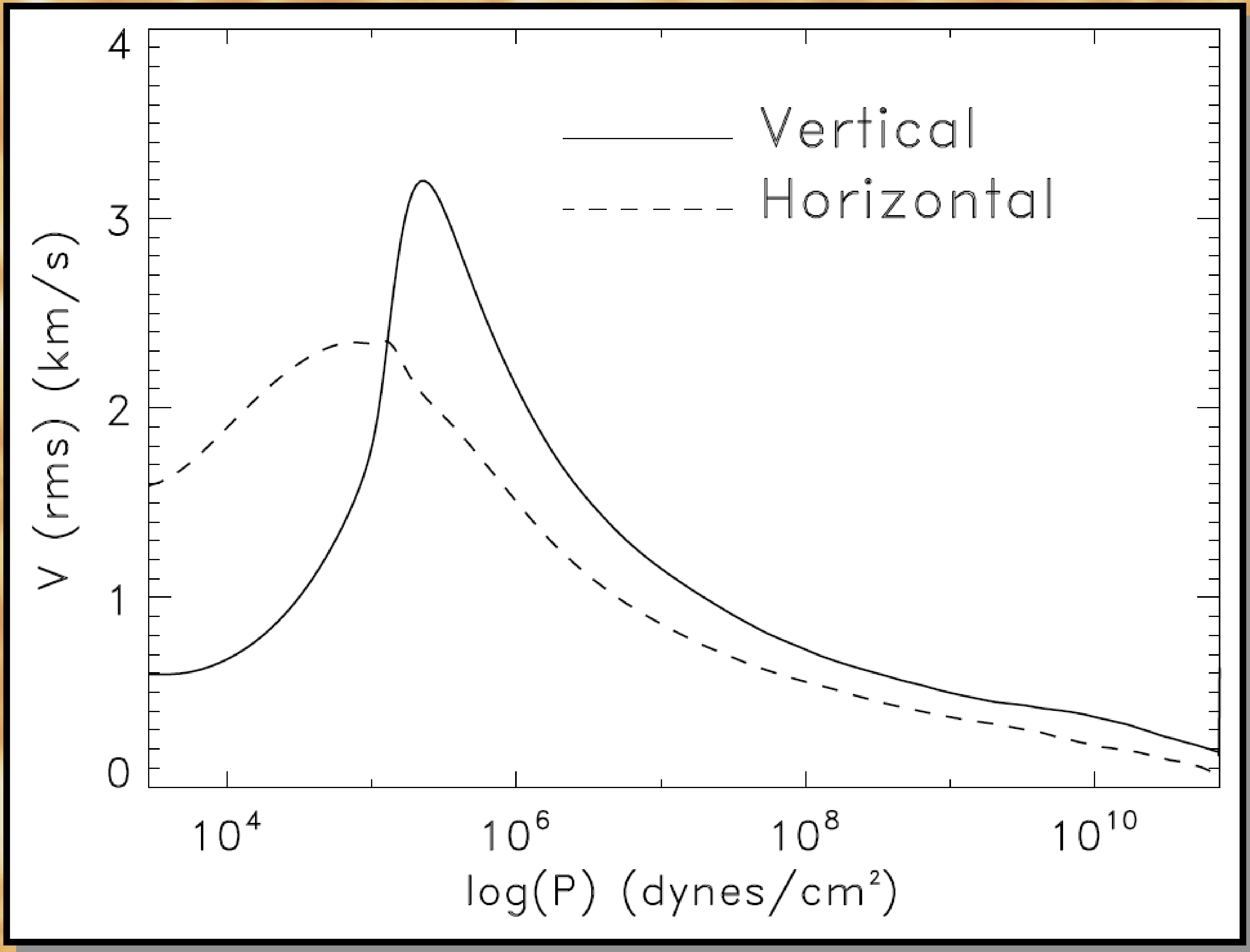
Upflows at surface come from small area at bottom (left)
Downflows at surface converge to supergranule boundaries (right)



Fractional area in Upflows



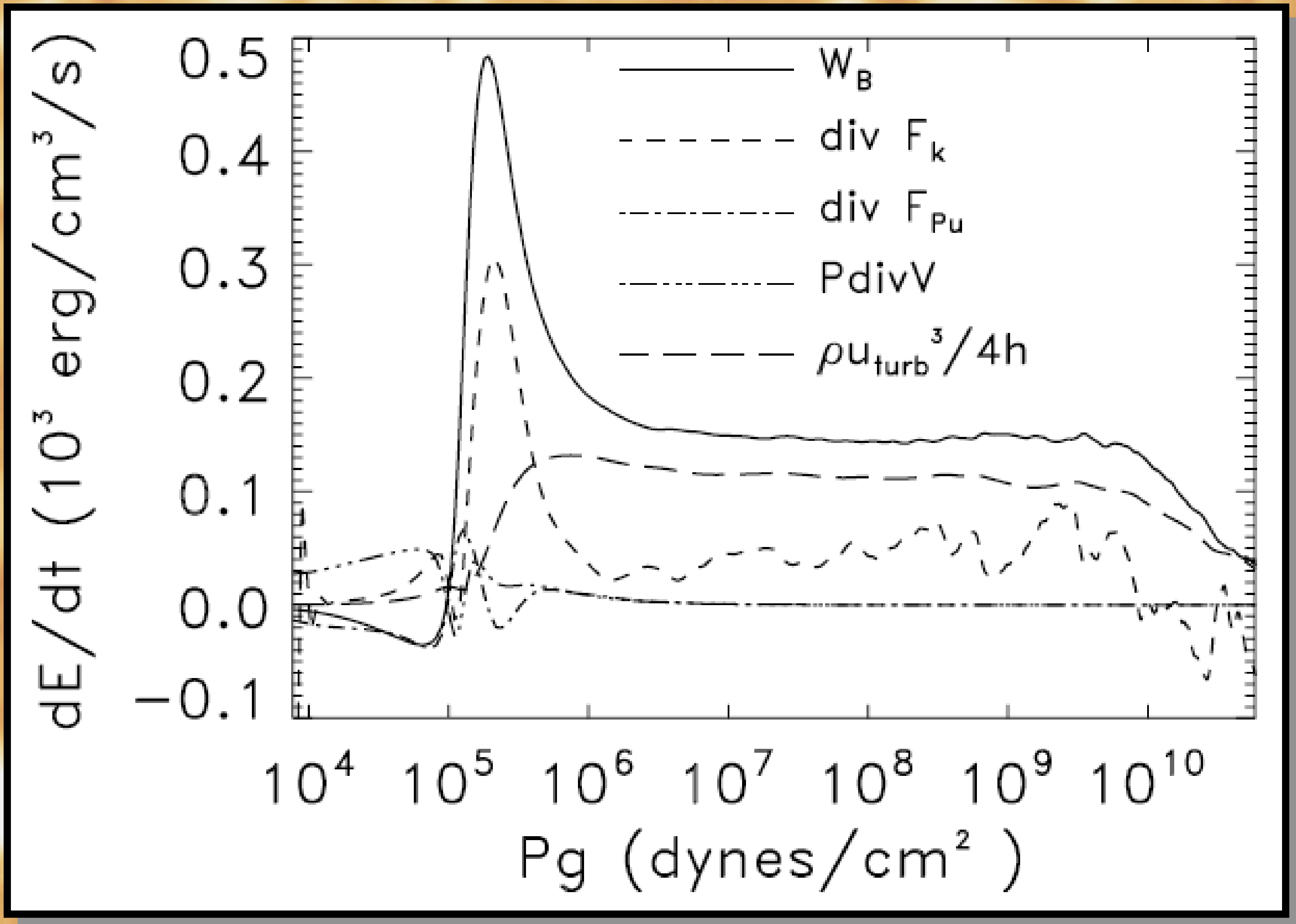
rms Velocity



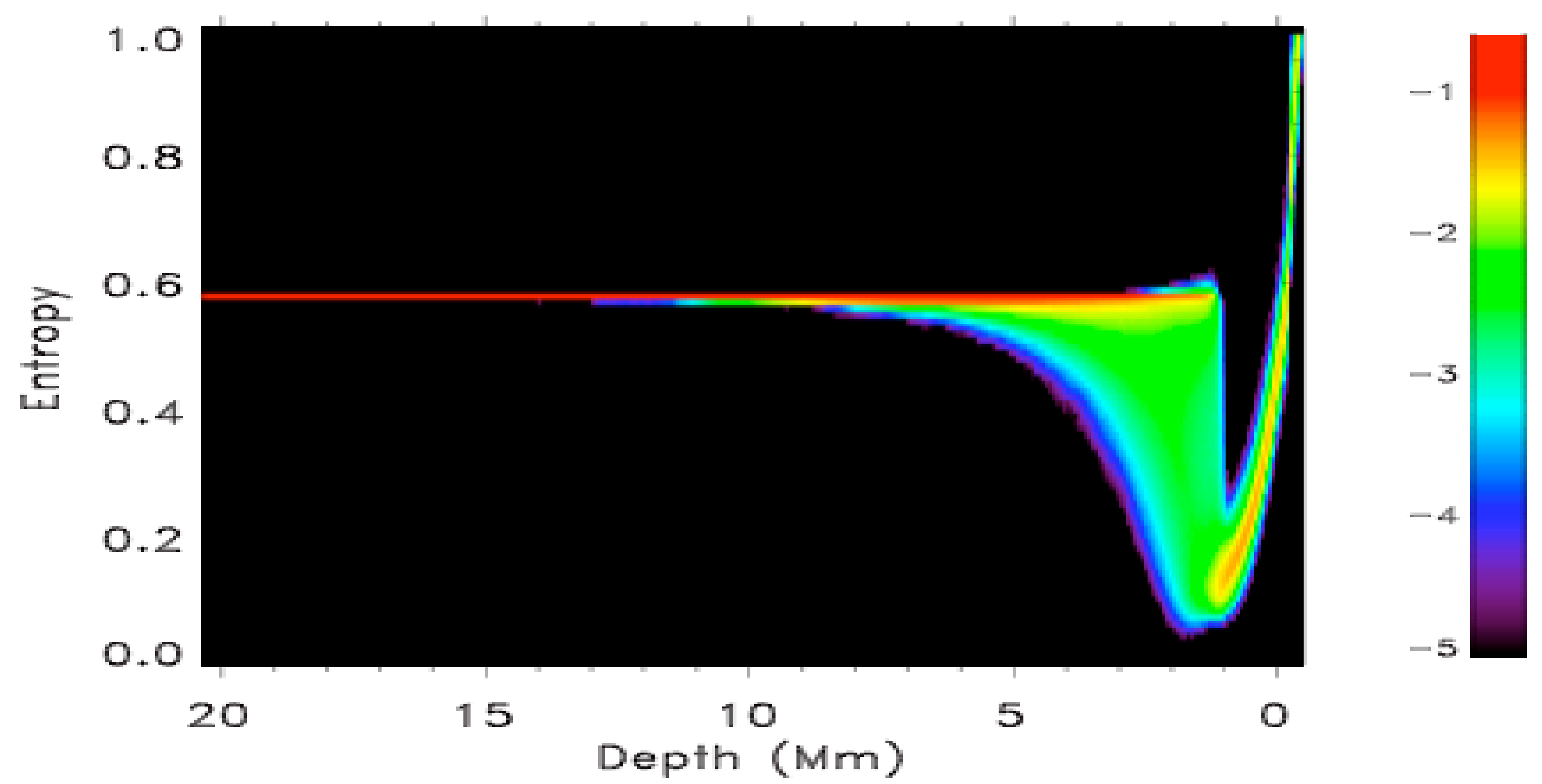
Energy balance

buoyancy work ~ dissipation

(~ div F_{KE} @ surface)

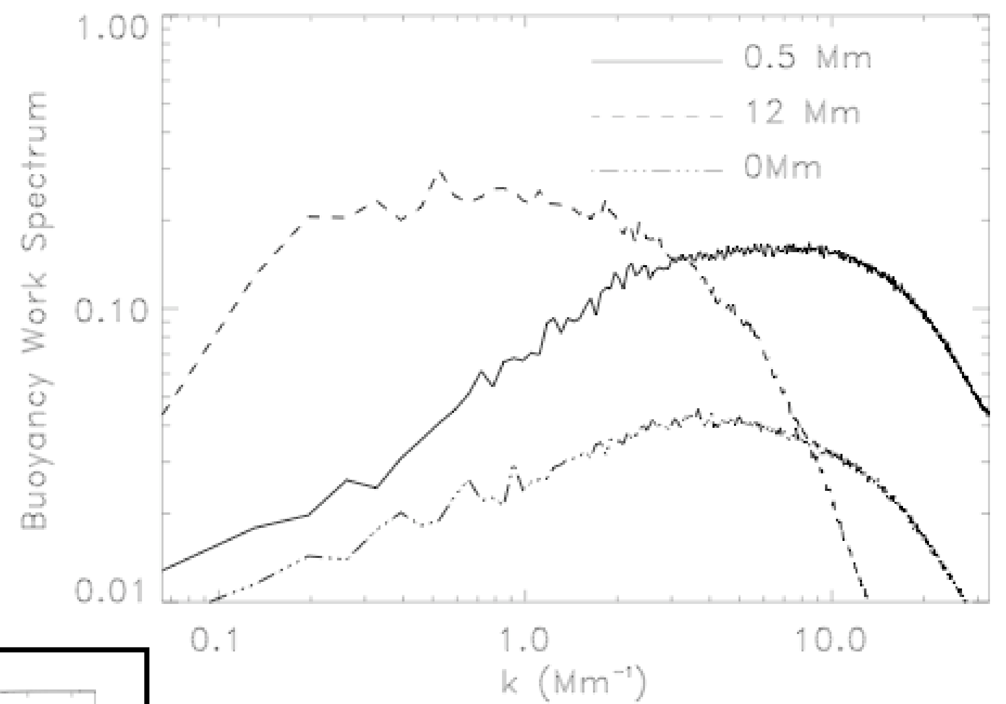


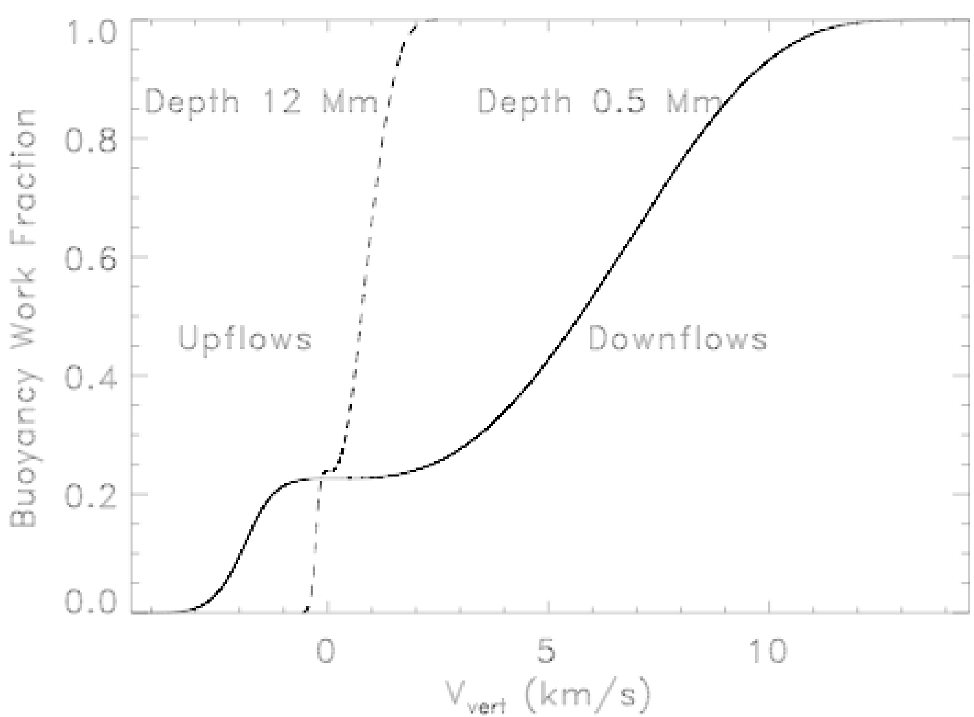
Entropy Histogram

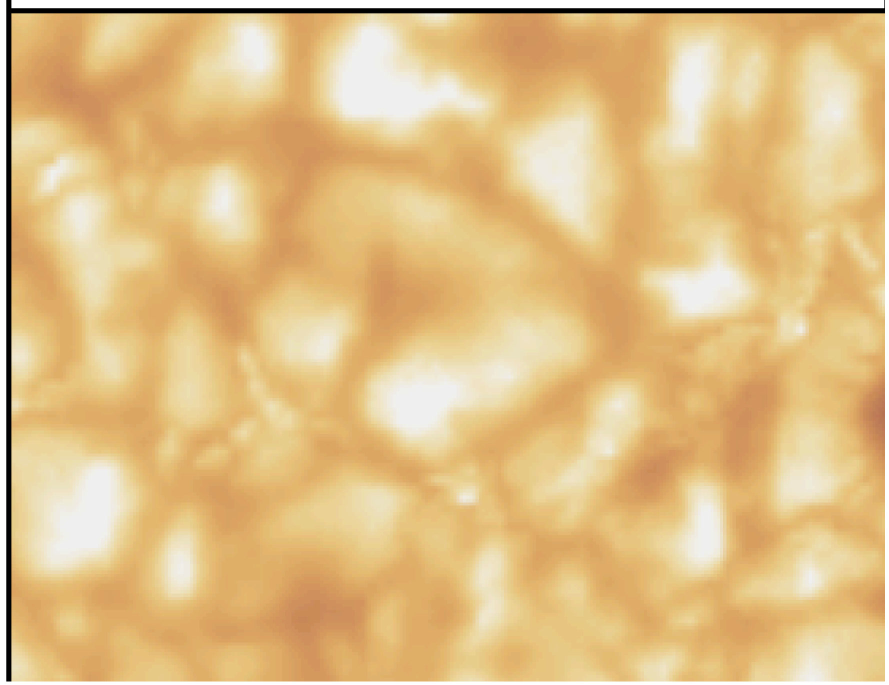


Buoyancy Work

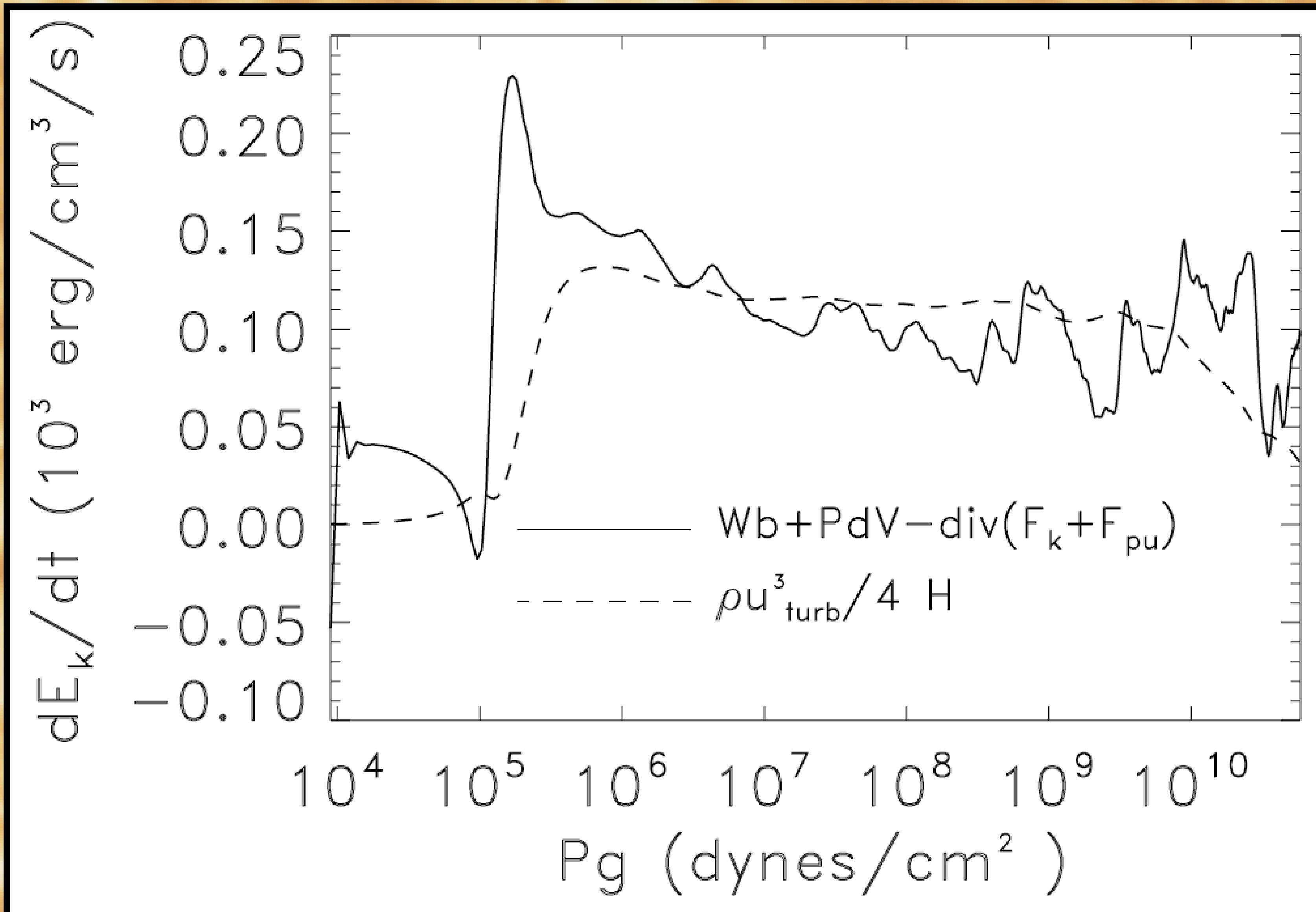
3/4 is in downflows
Largest at locally dominant scale of convection



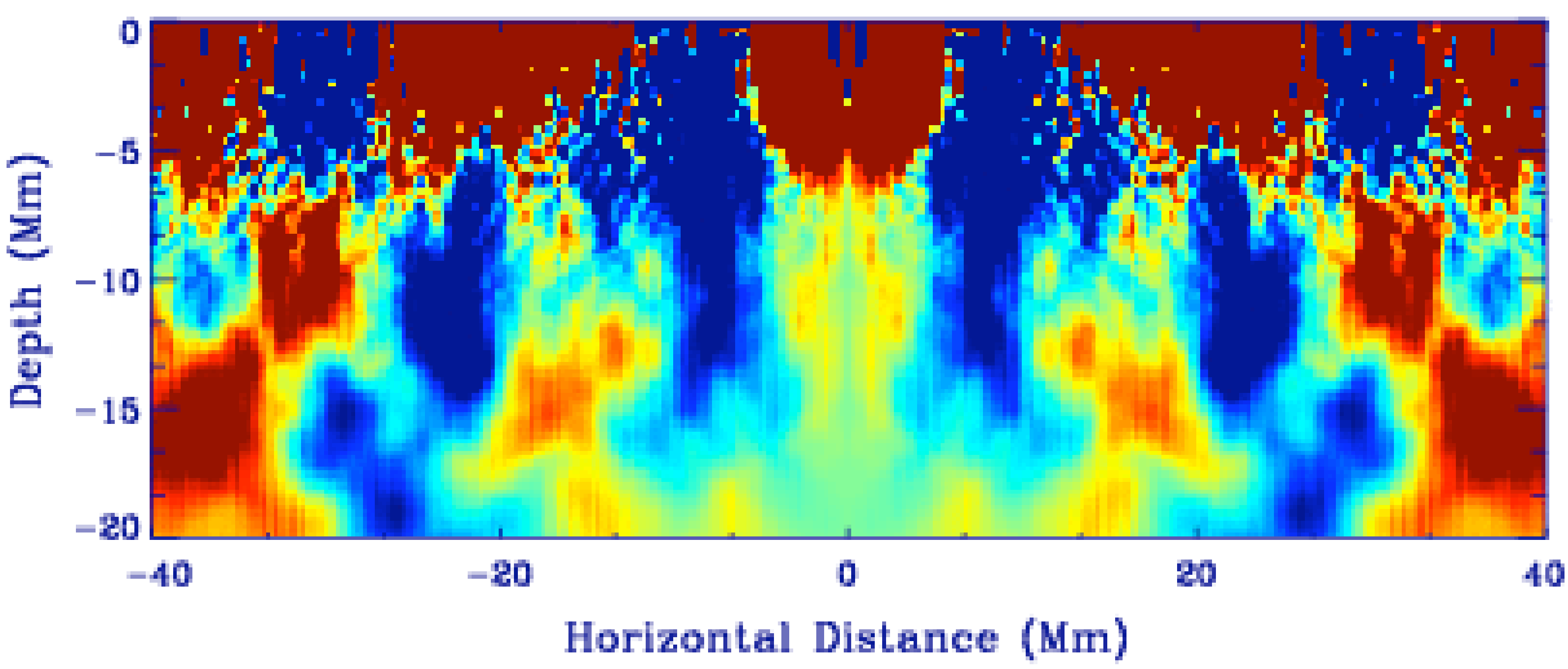




Dissipation length ~ 4 H_P



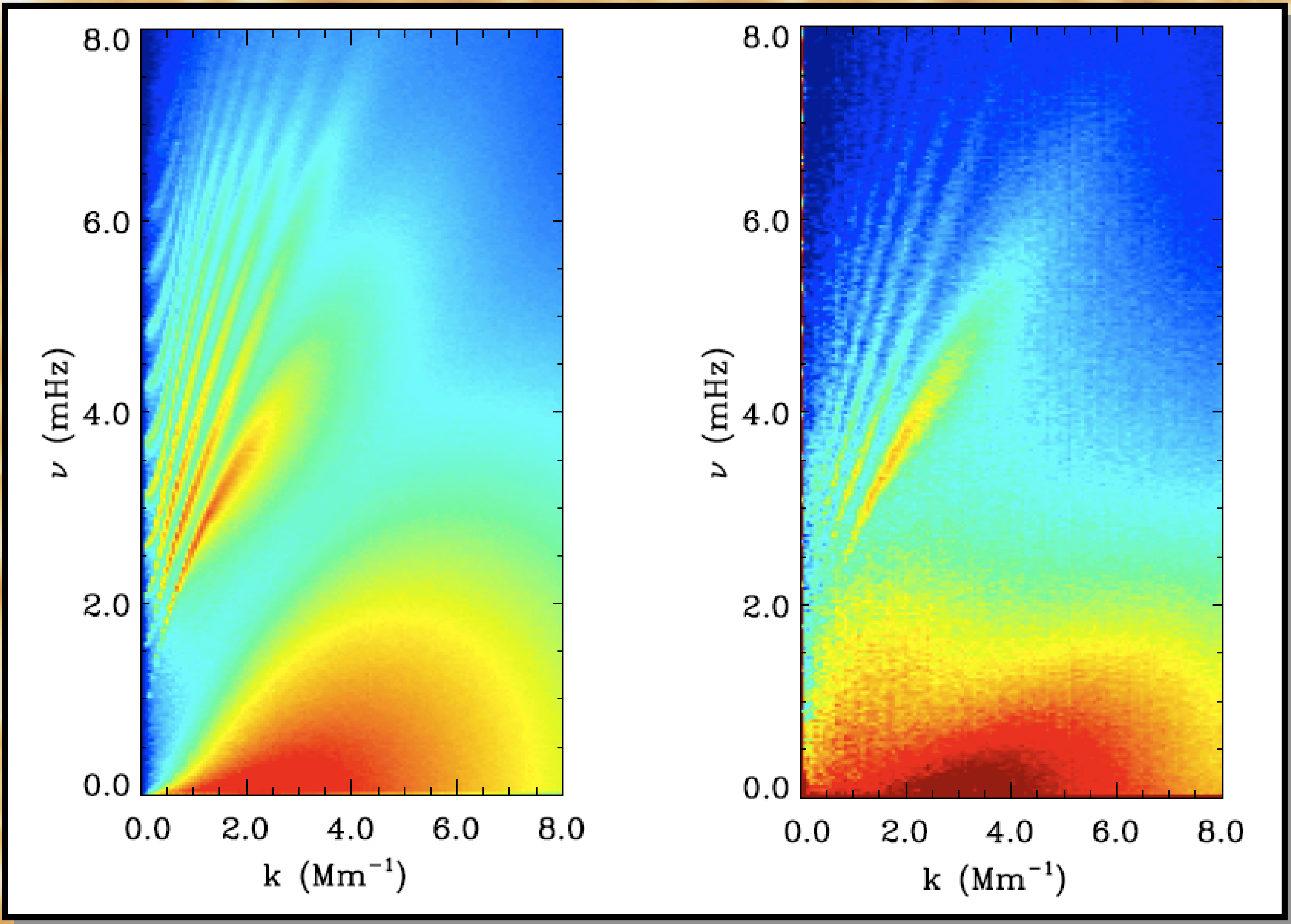
Wave generation & propagation



Courtesy Junwei Zhao

Vertical Velocity Simulation (left) Hinode G-band intensity (right)

see poster p8-1 (upstairs)



Summary

- Horizontal scale increases smoothly with depth
- Horizontal velocity decreases smoothly with increasing size
- Magnetic field fluctuations have universal scaling with density
- Mass mixing length = 1.8 H