Convective structure in the photosphere after removing the 5-min oscillations with SOT/ Hinode

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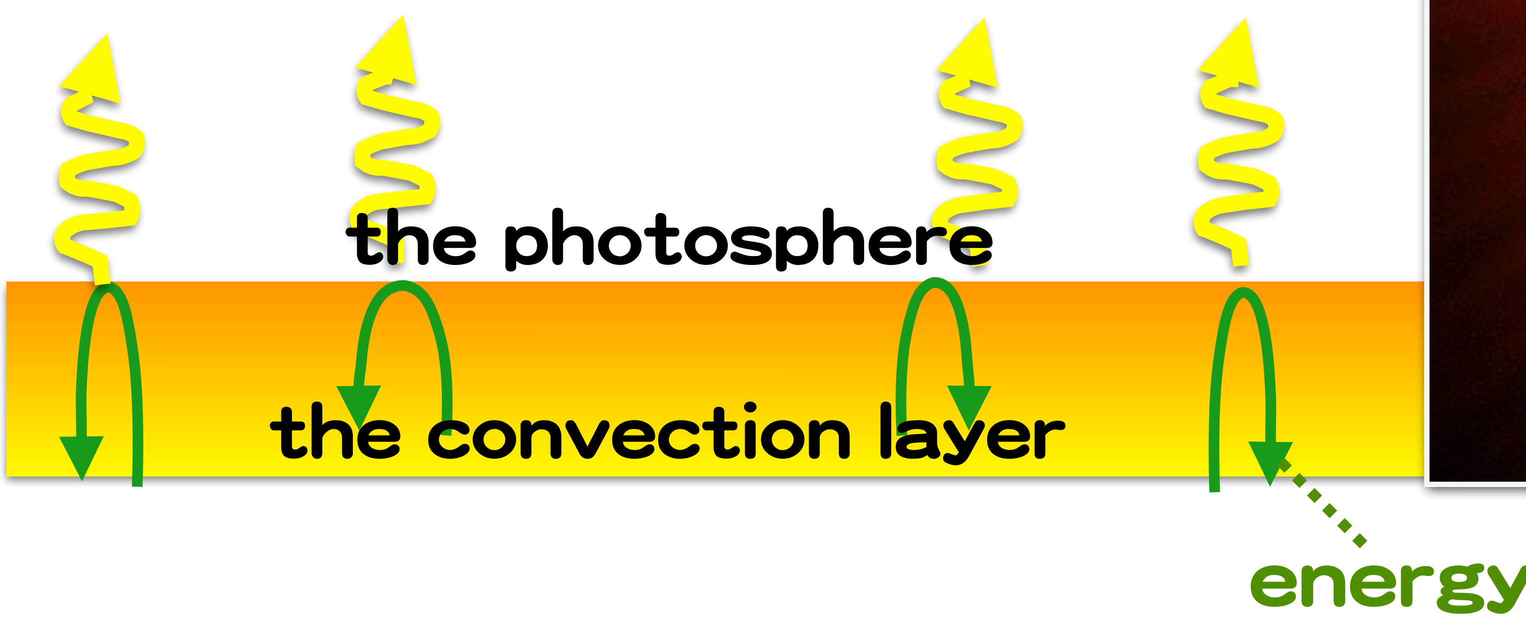
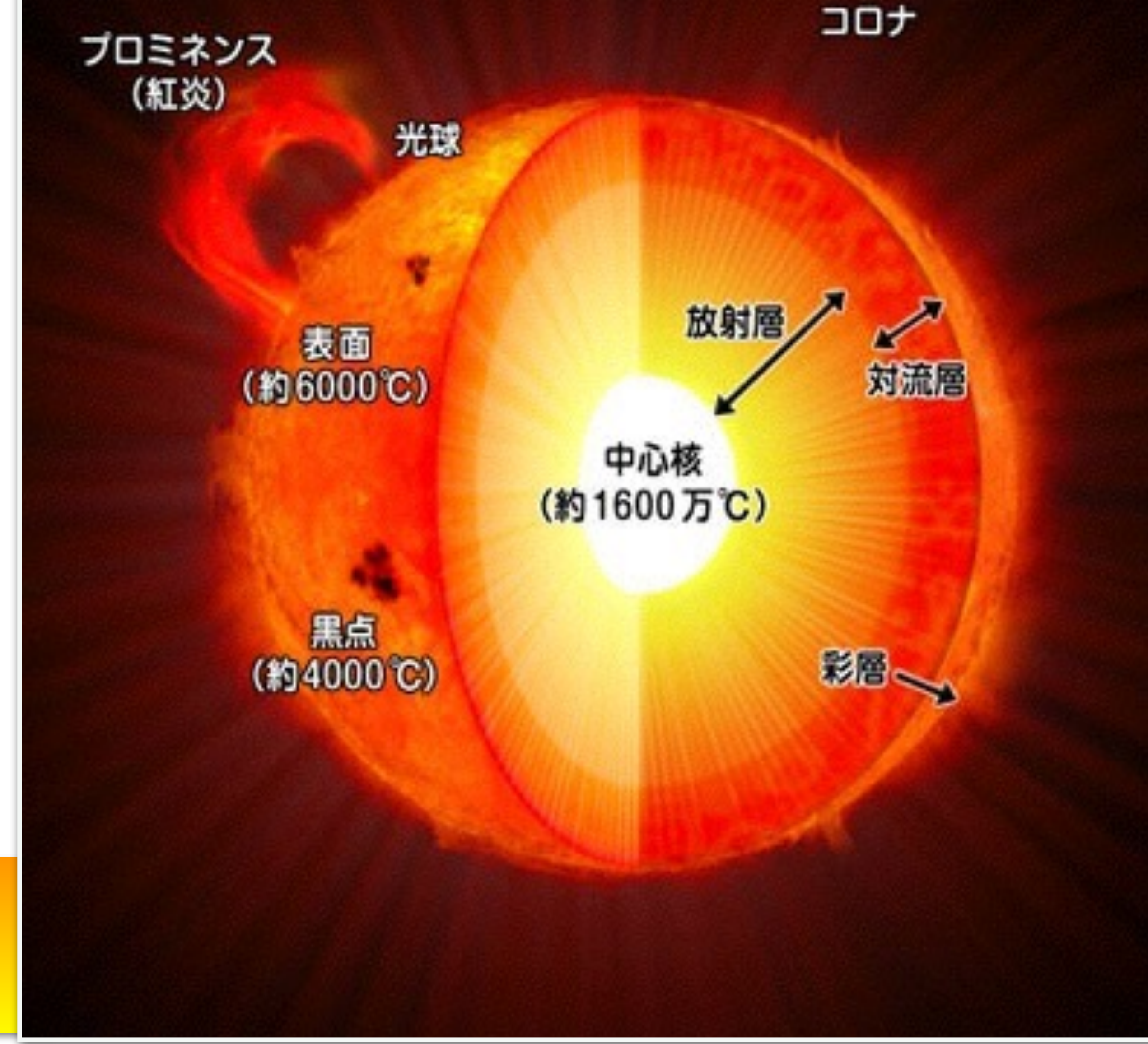
The photosphere

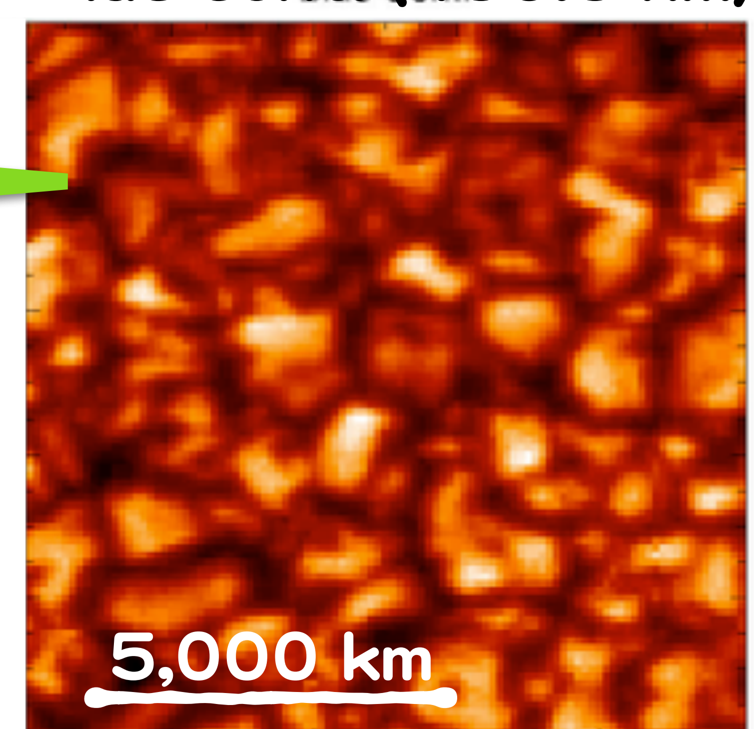
The energy

The energy coming from interior is released by radiation





Blue cont. (450.5 nm)



Bright granules and dark intergranular lanes

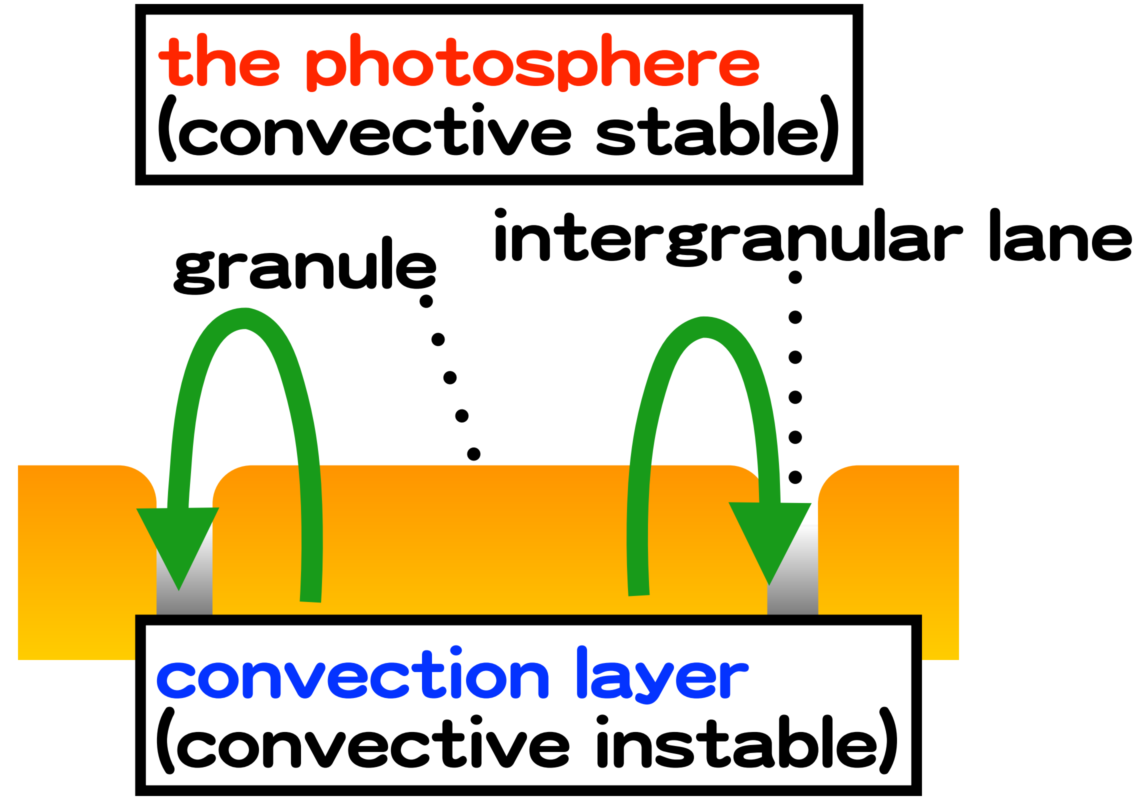
The photosphere is governed by convection

Physical picture of photospheric convection

1) Gas parcels come from the convection layer and ascend to the photosphere

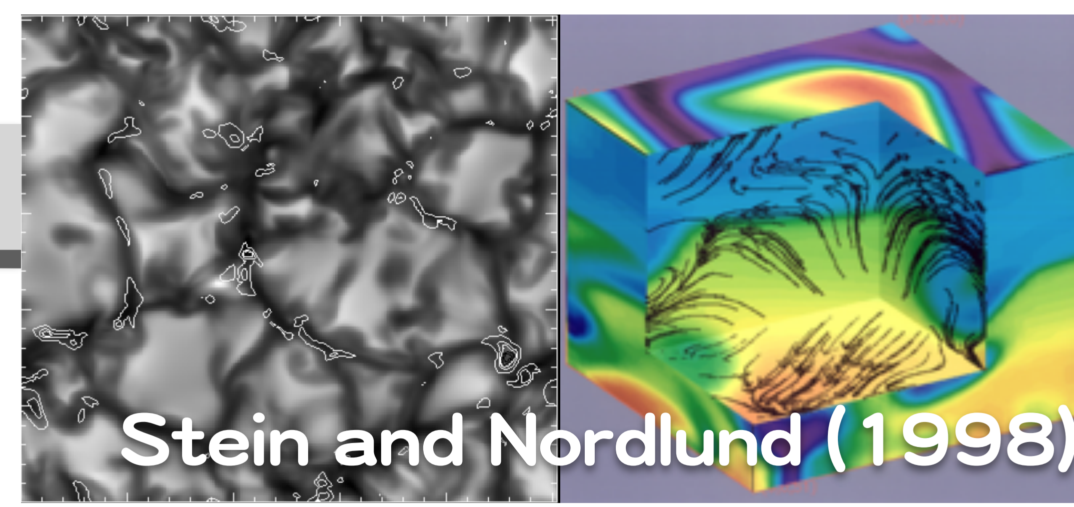
2) Hot gas parcels ascend and pushed away horizontally **(making granules)**

3) Cooled gasses submerge to the subsurface **(making intergranular lanes)**



RMHD numerical simulation

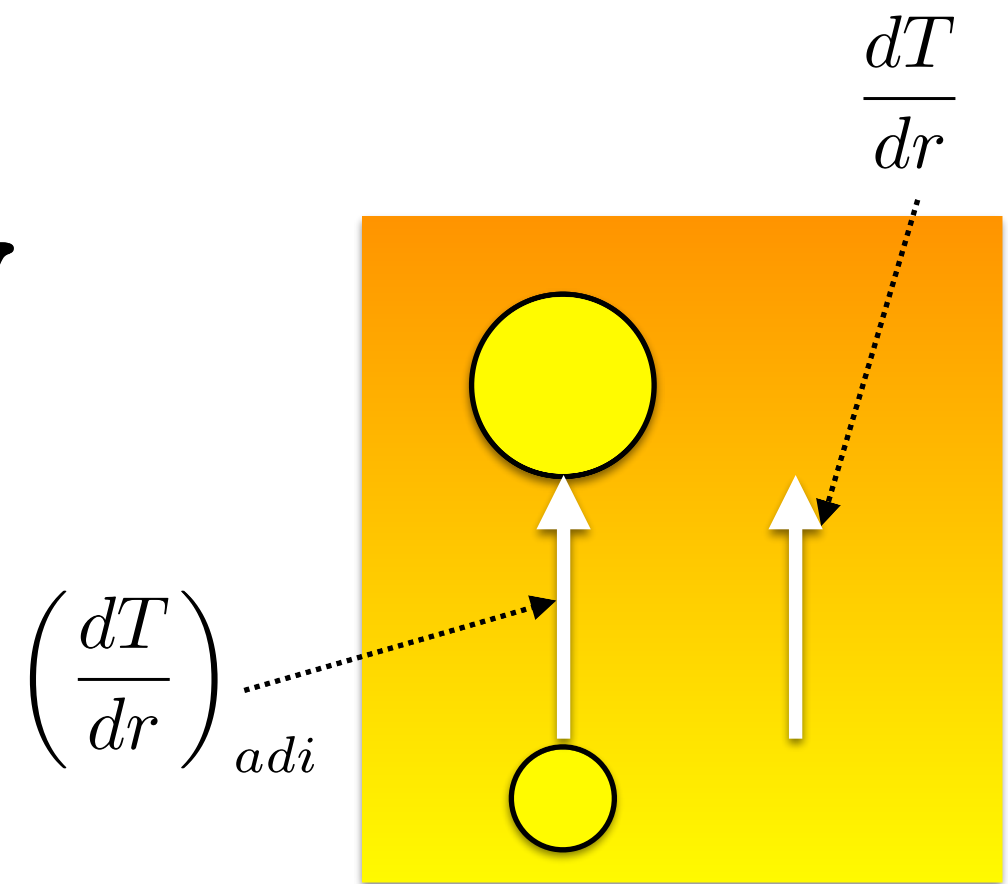
Succeed to reproduce the granules



Height structure is critical for convection

Convective instability

$$\left(\frac{dT}{dr}\right)_{adi} > \frac{dT}{dr}$$



When a gas parcel ascends adiabatically..

A) dT/dr is **smaller** than (dT/dr)adi

→ **convective stable**

B) dT/dr is **larger** than (dT/dr)adi

→ **convective instable**

Height structure is unclear observationally

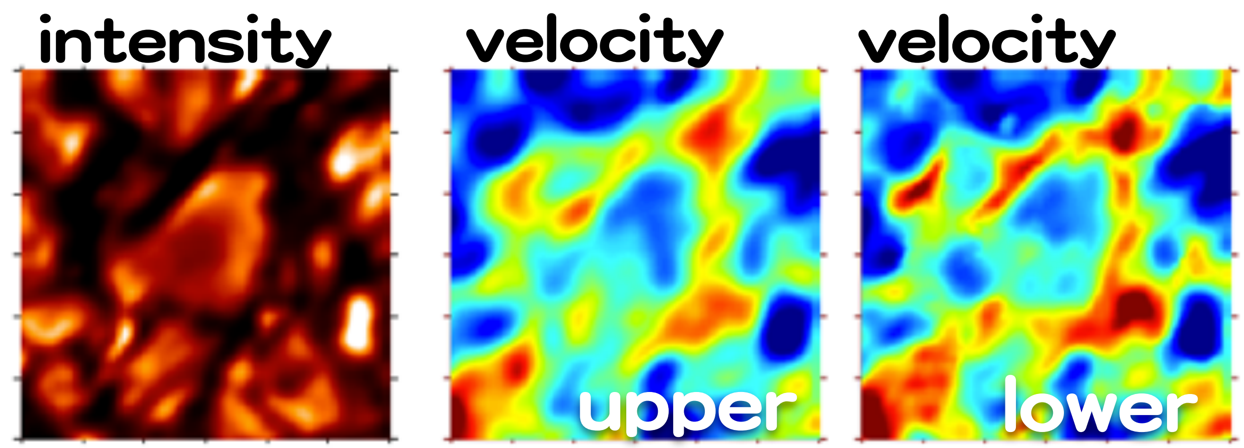
Difficulties to derive a height structure

1. Method

A) Multiple line analysis

B) Bisector analysis

Hirzberger et al. (2001)



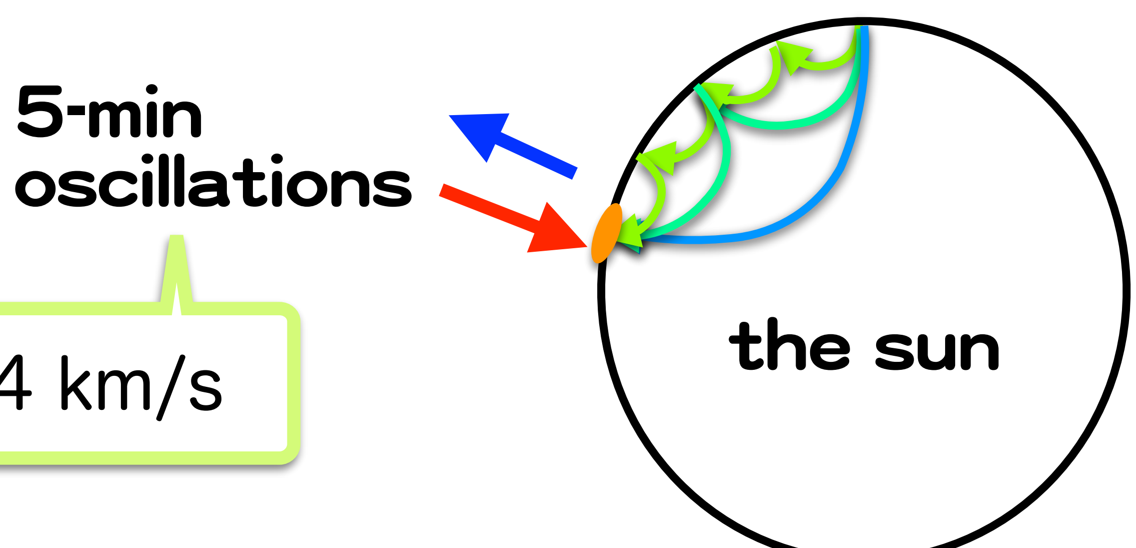
2. Spatial resolution

(< 0.3-0.5 arcsec)

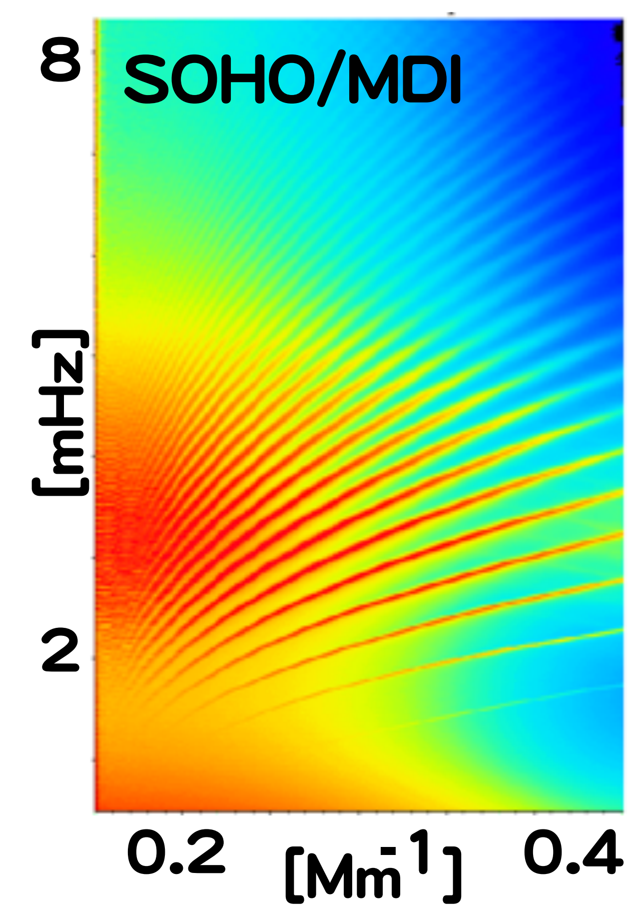
Doppler signals are mixed from granules and intergranular lanes

3. 5-min oscillations

The amplitude is comparable to that of convection



0.3 - 0.4 km/s



Purpose of this study

The height structure of convective velocity in granular region and intergranular lane

- Bisector analysis to high S/N spectral data with high spatial resolution

  → Hinode/SOT is the best instrument

- Removal of 5-min oscillations

Dateset

SP+ FG (blue continuum)

Duration: 45 min (2014/07/06 22:56-23:41)

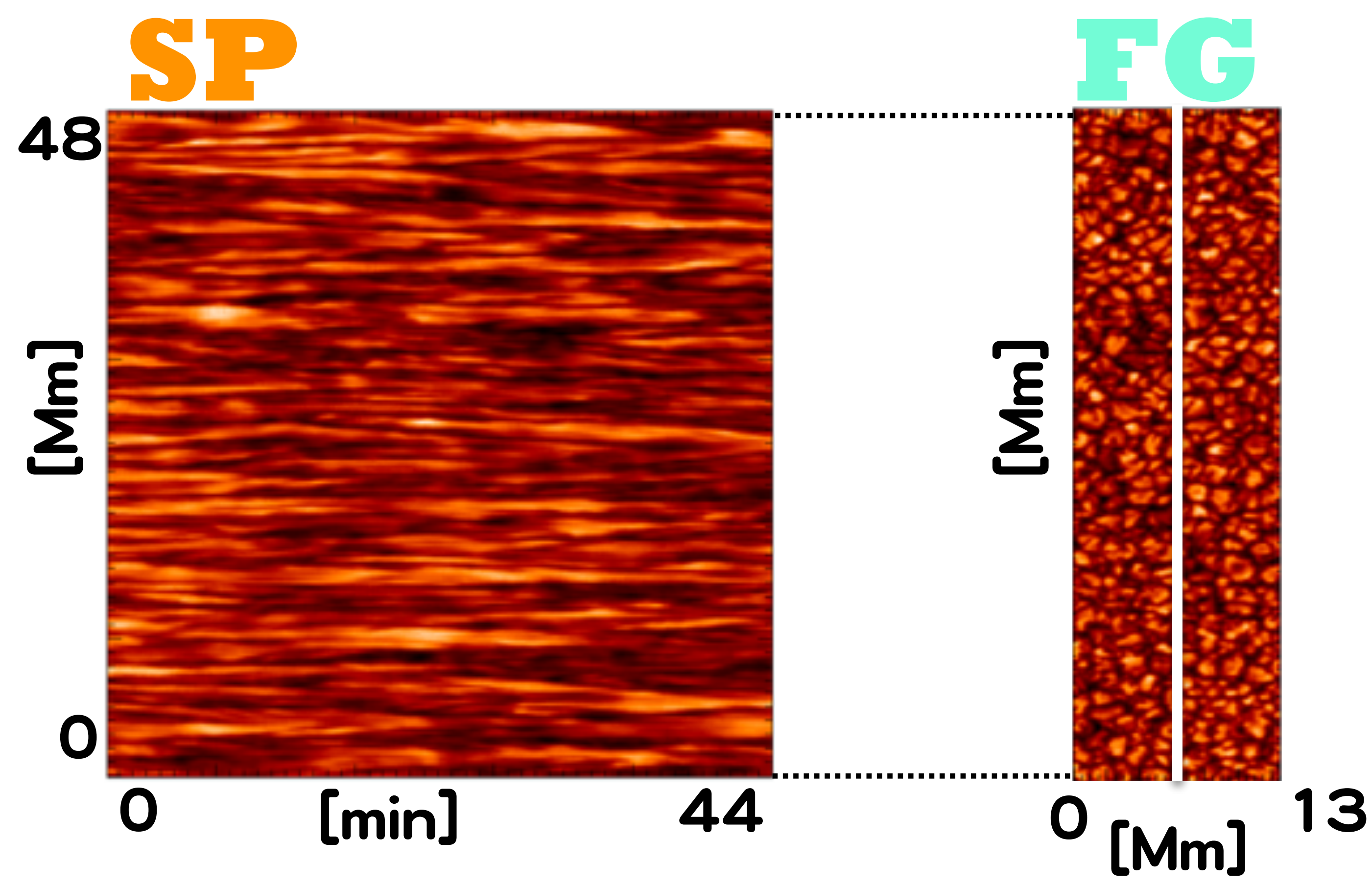
Quiet region on disk center for fixed position

Time cadence:

SP: 2 sec
FG: 30 sec

Spatial resolution:

SP: 0.15, 0.16 arcsec
FG: 0.10, 0.10 arcsec

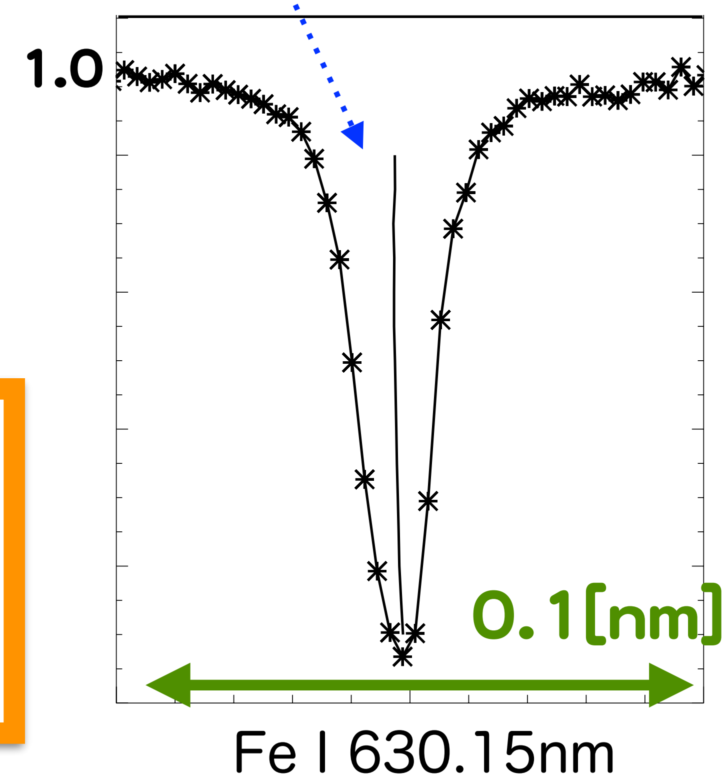


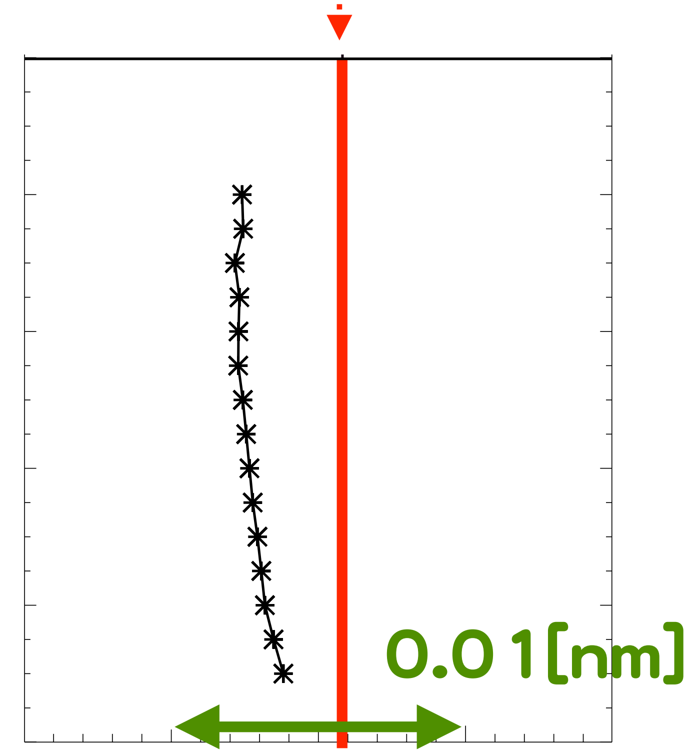
Bisector analysis

Calculate the Doppler velocity at each intensity level

Doppler velocity

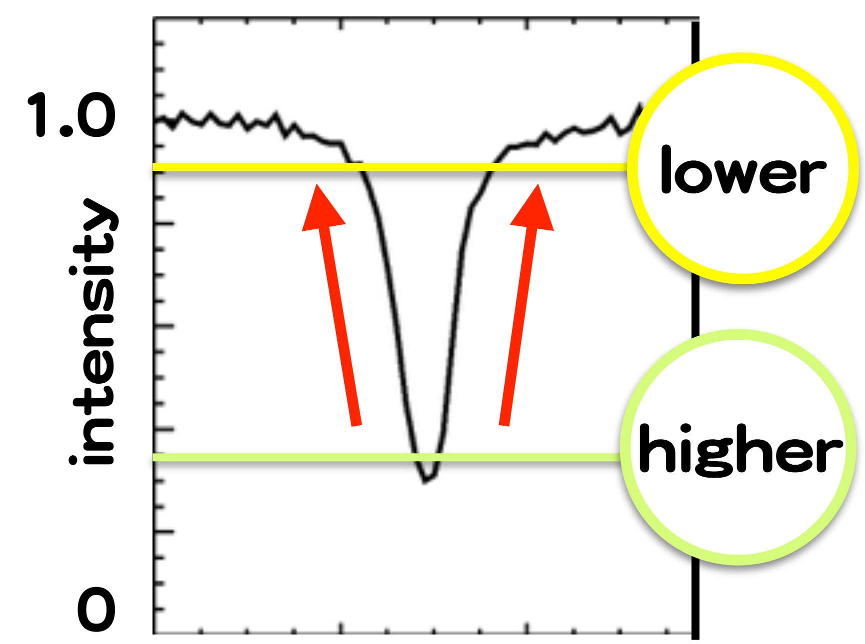
$$v = c\frac{\Delta\lambda}{\lambda}$$



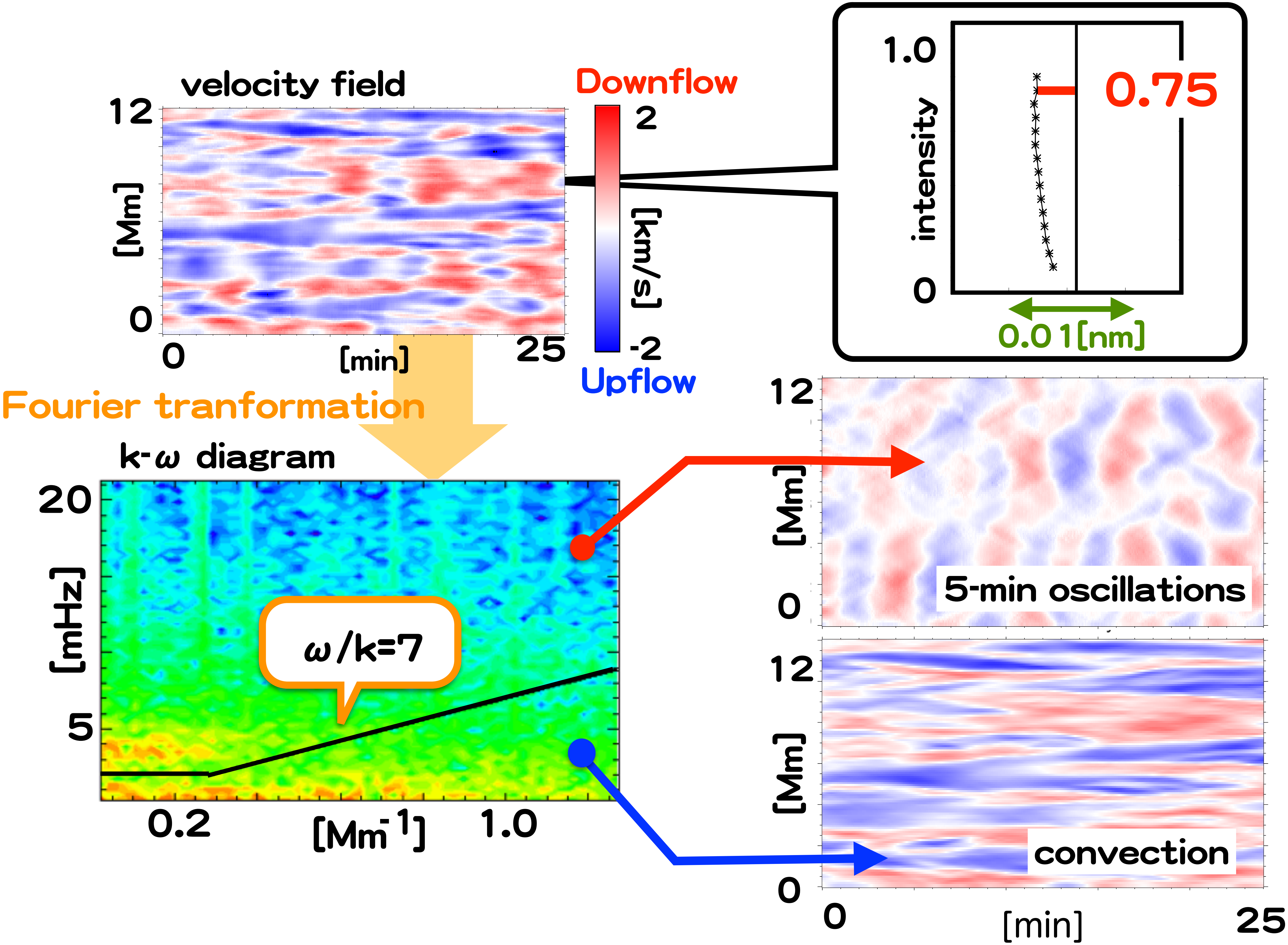


Absorption line reflects a height structure

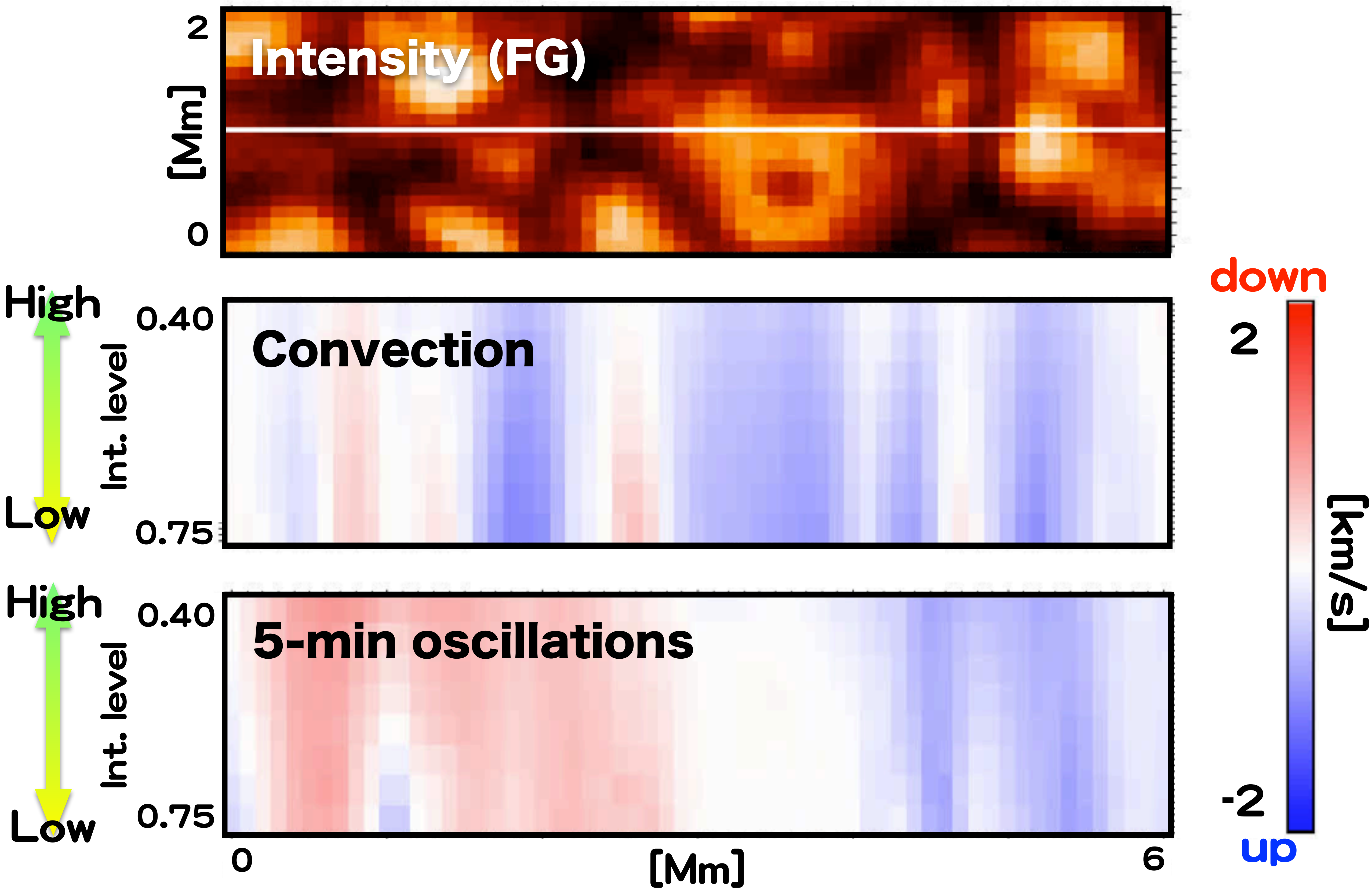
higher **Line core** lower intensity	⟷	lower **Wing** higher intensity



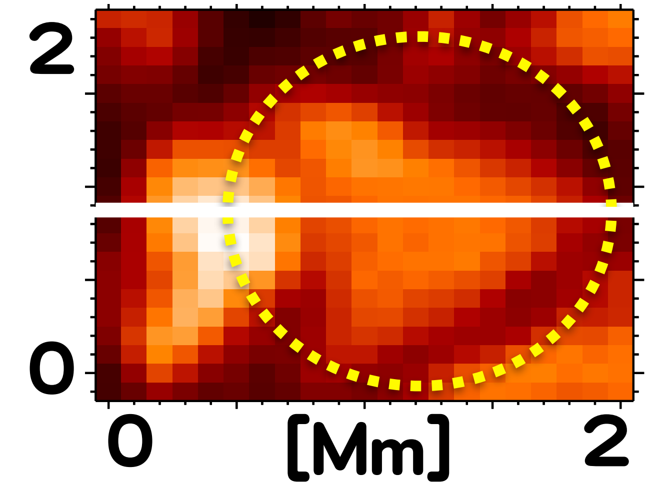
Removal of 5-min oscillations



Result: Time evolution



Results: Time evolution

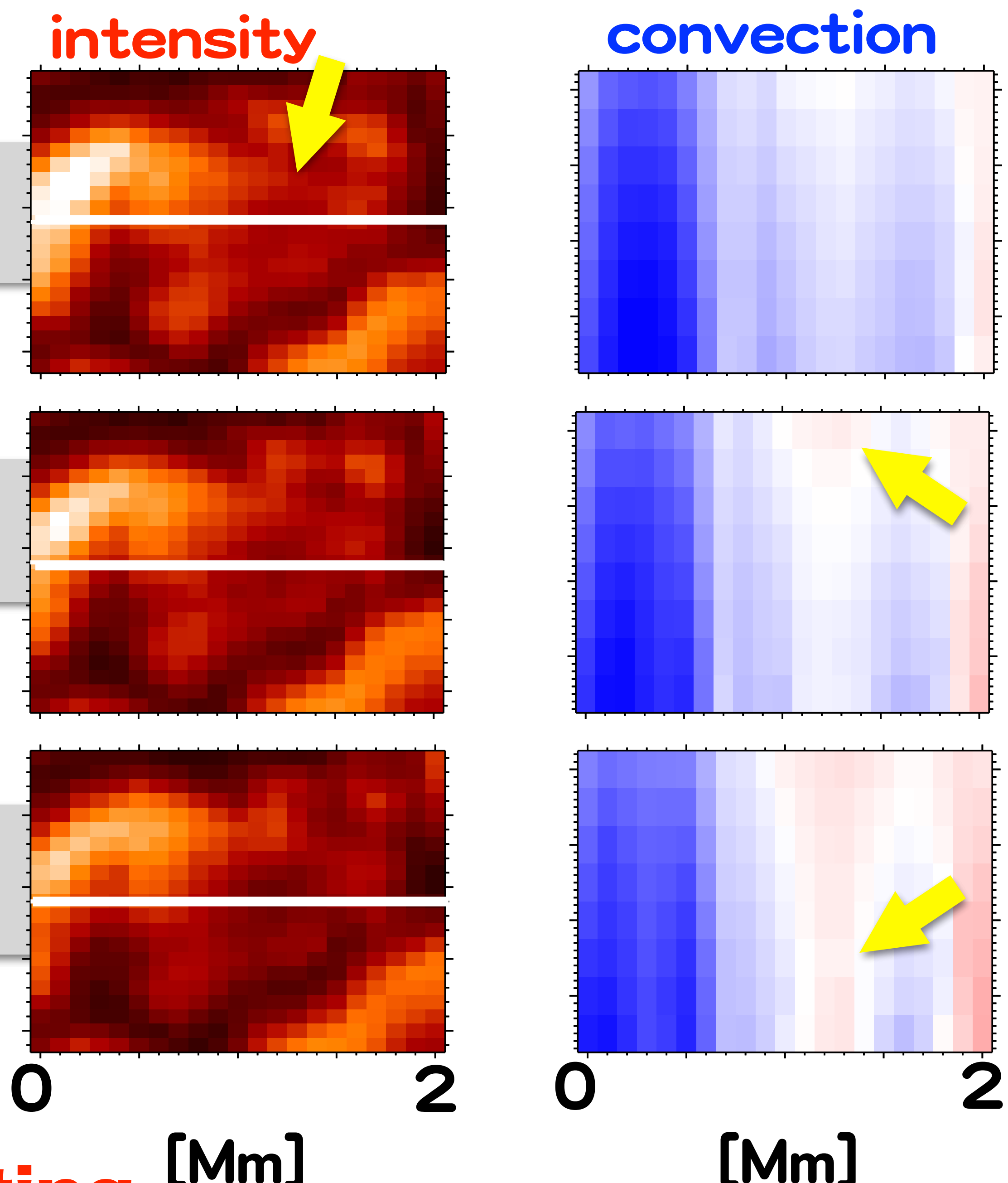


Scnerio:

t=0.0 [min]
Intensity begin to decrease

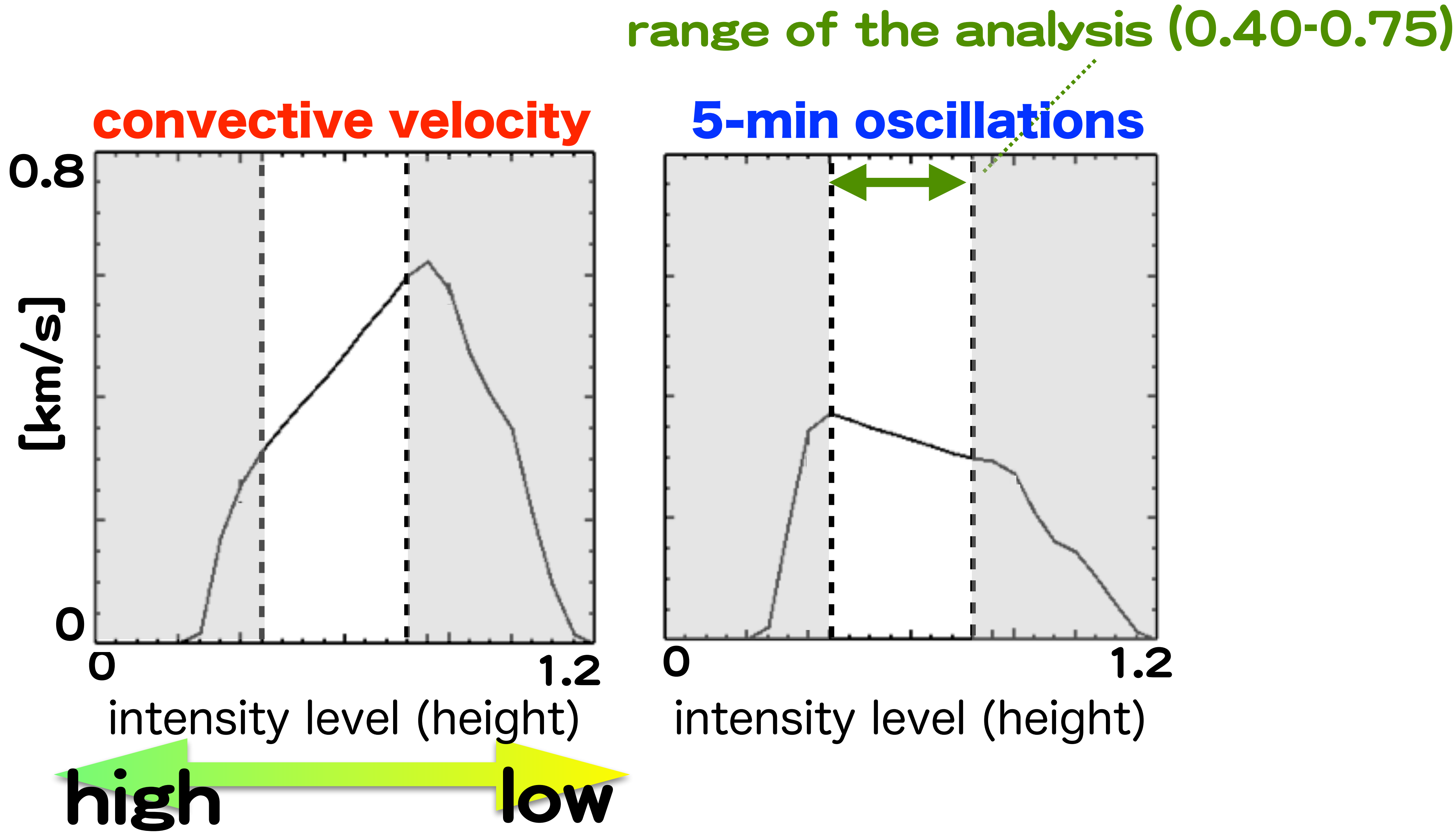
t=0.5 [min]
Downflow appears at the higher layer

t=1.0 [min]
Downflow descends to the bottom layer



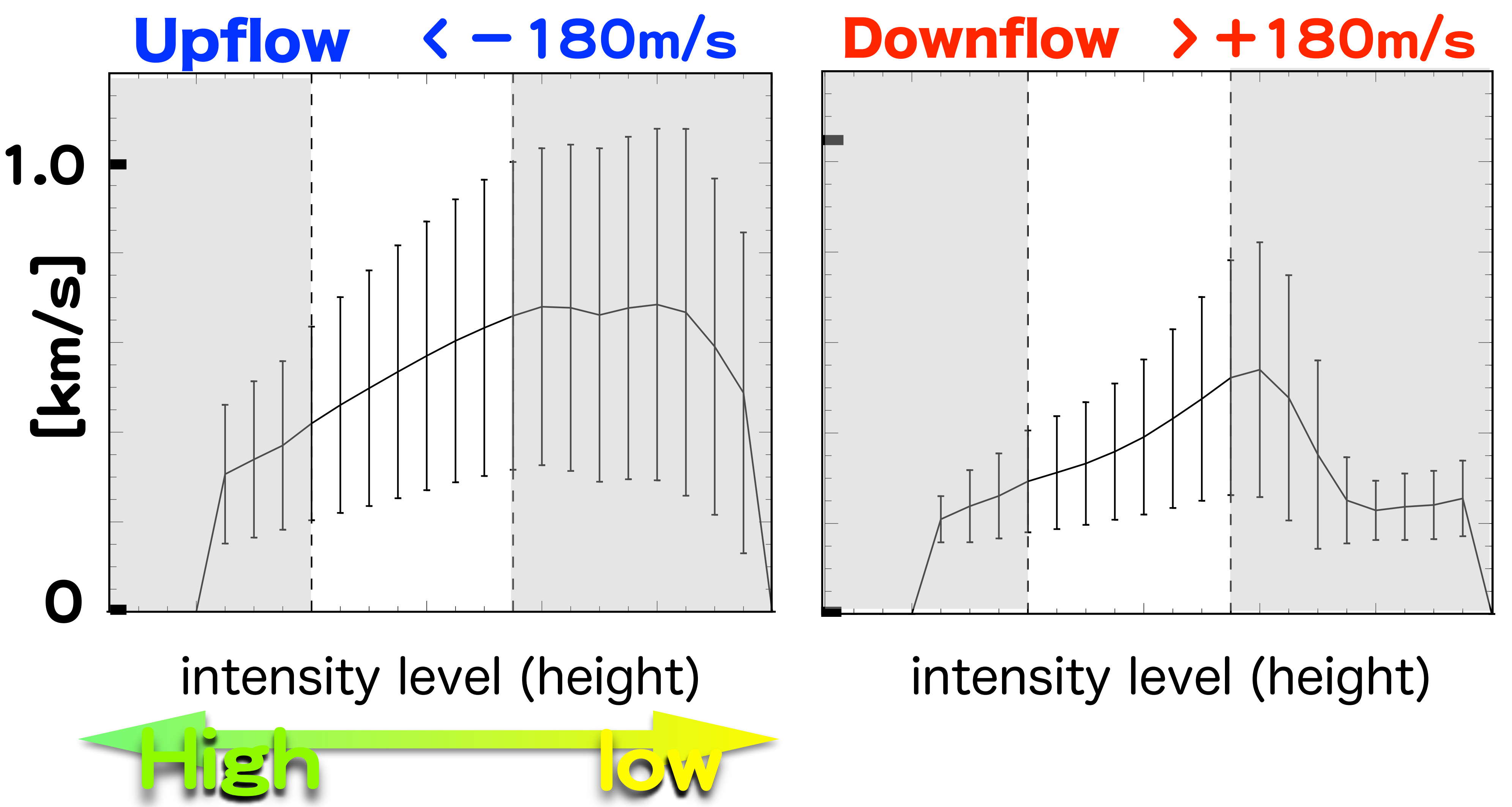
Find a time evolution of height structure during granular splitting

Result:
Height dependence of RMS velocity



convective velocity decreases (0.6 → 0.3 km/s)
5-min oscillations increases (0.3 → 0.4 km/s) with height

Height dependence of averaged convective velocity



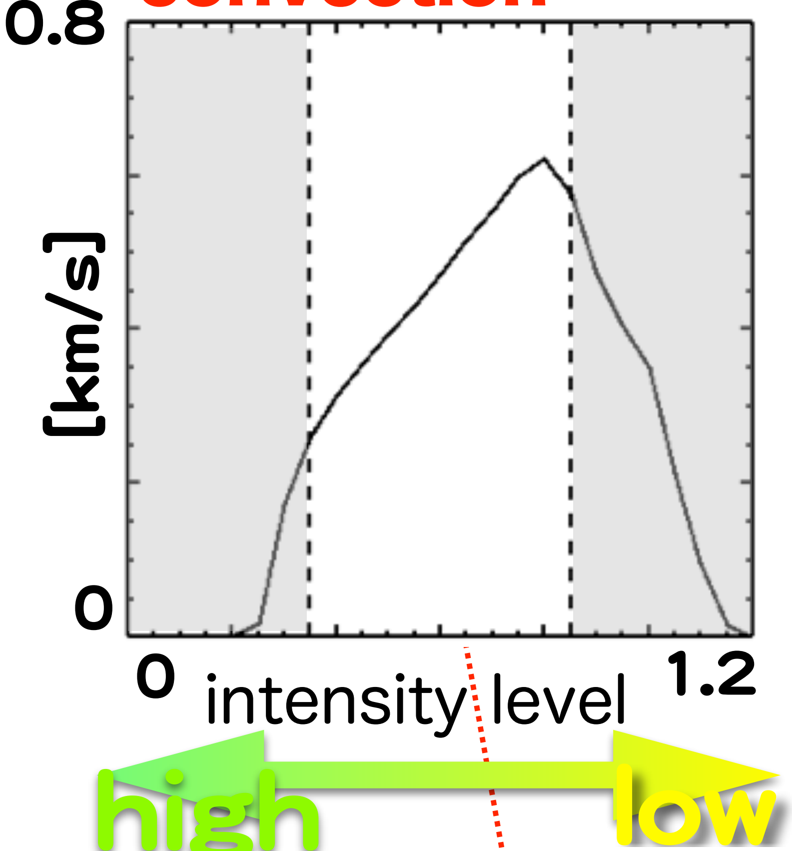
Upflow decelerates with height (0.65 → 0.40 km/s)
Downflow accelerates with depth (0.30 → 0.50 km/s)

Discussion: comparison with past work

Stronger velocity amplitude

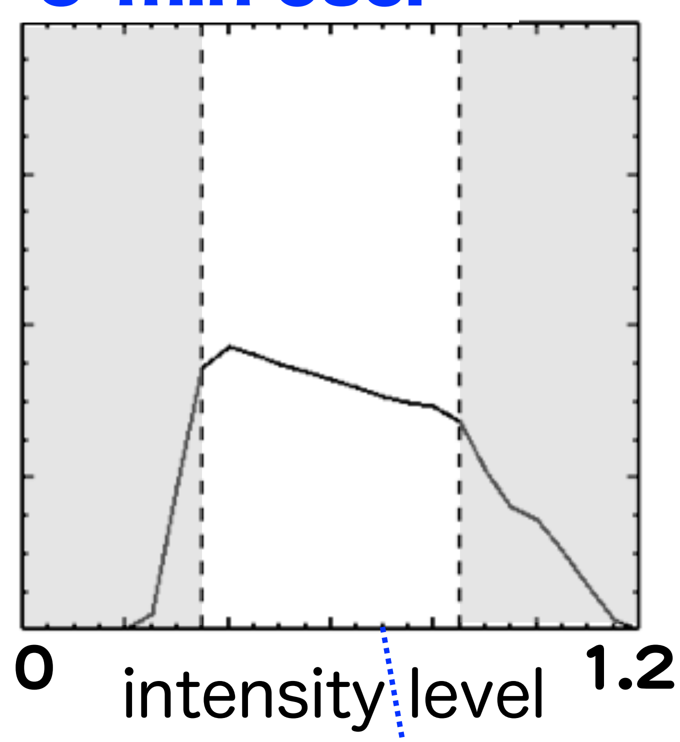
0.20 → 0.35 km/s

convection

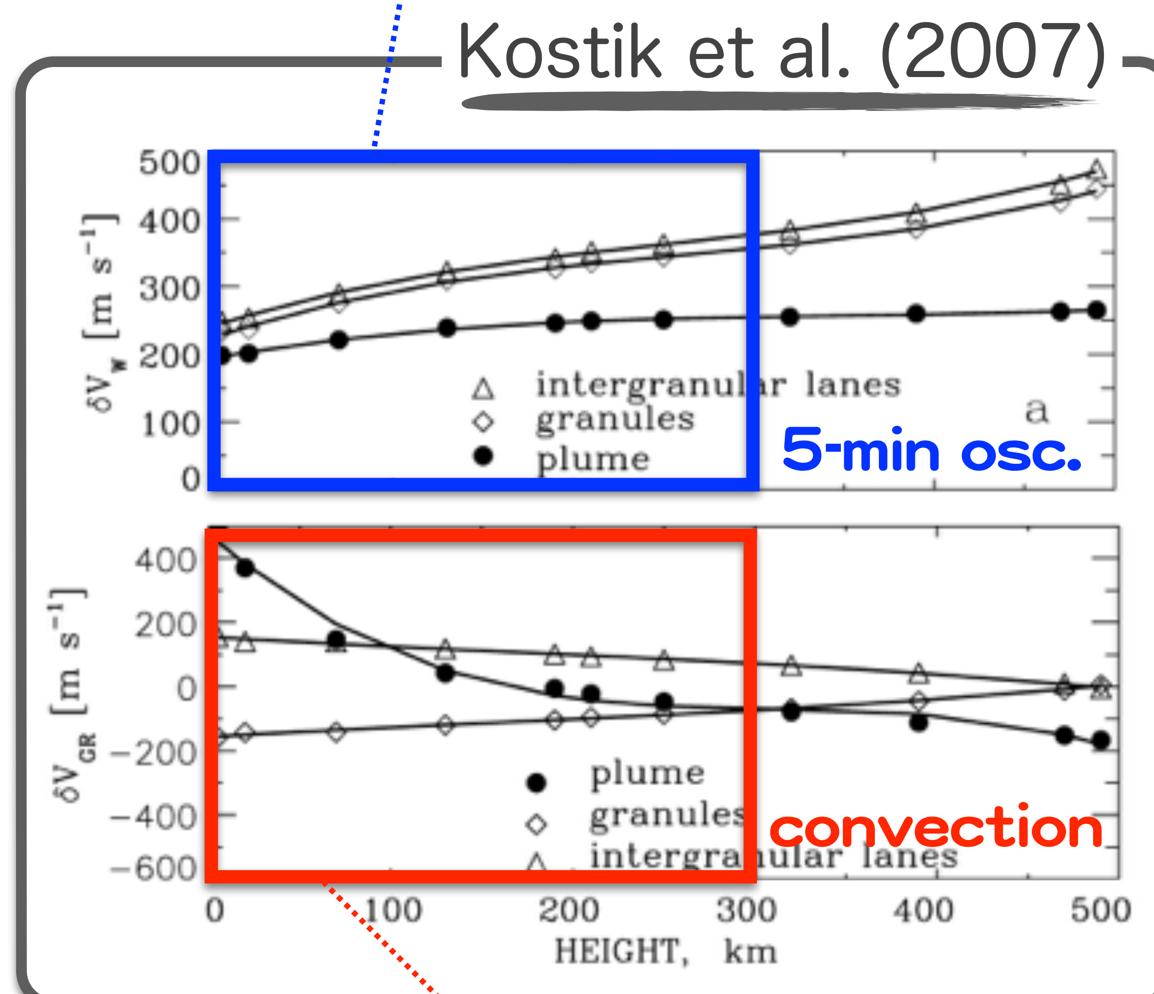


0.60 → 0.30 km/s

5-min osc.



0.20 → 0.35k m/s



0.20 → 0.10 m/s

This is because granules and intergranular lanes are spatially resolved

Discussion: height structure of convective velocity

The photosphere is thought to be convective stable from 1D model

↓

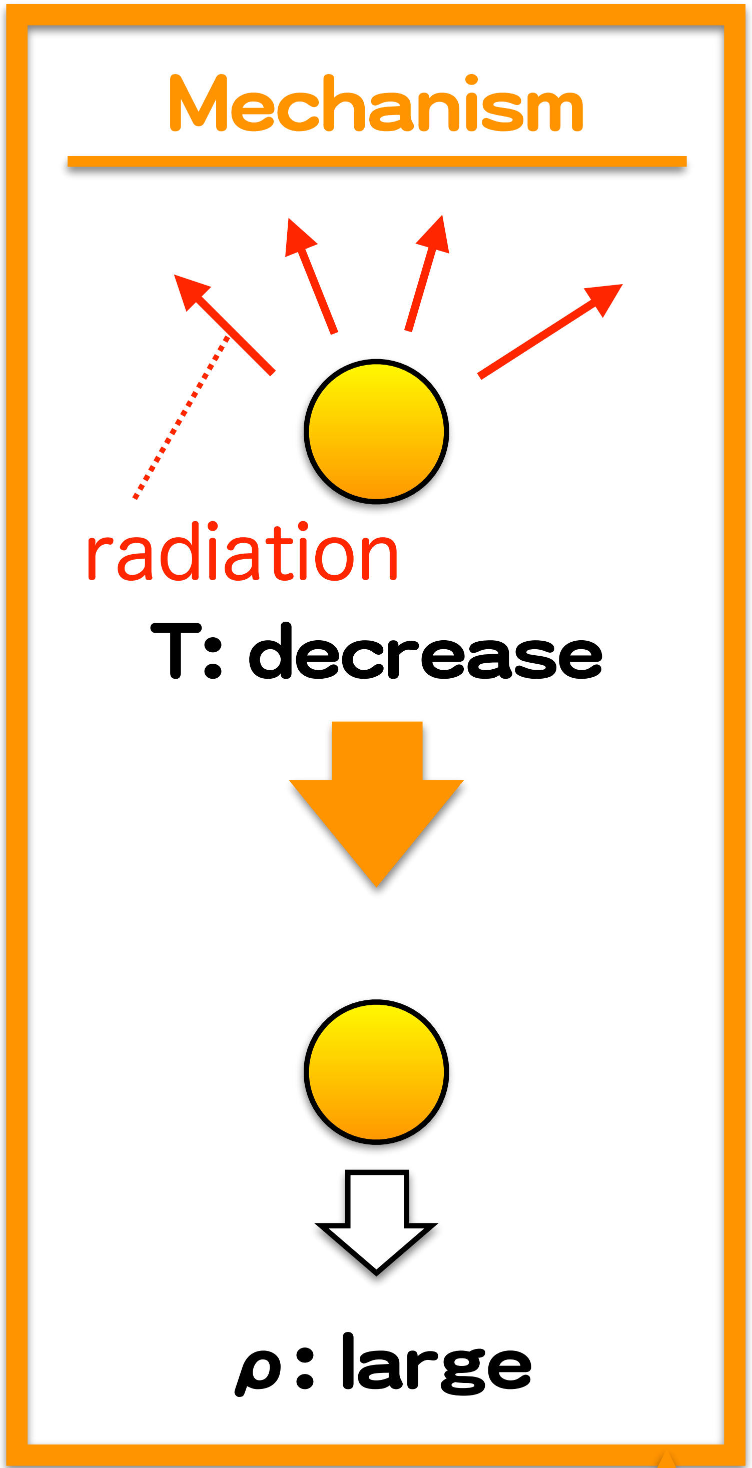
Both upflow and downflow decelerates

Our result

Upflow: decelerations ⟶ **stable**

Downflow: accelerations ⟶ **unstable?**

This character at the downflow cannot be explained by 1D model



We found..

The radiation effects is enough to make the convective unstable condition at the downflow region

Summary

We analyzed the height dependence of the photospheric convection by applying bisector analysis to data with Hinode/SOT

Upflow decelerates with height and downflow accelerates with depth

Upflow: 0.65 → 0.40 km/s	Deceleration
Downflow: 0.30 → 0.50 km/s	Acceleration

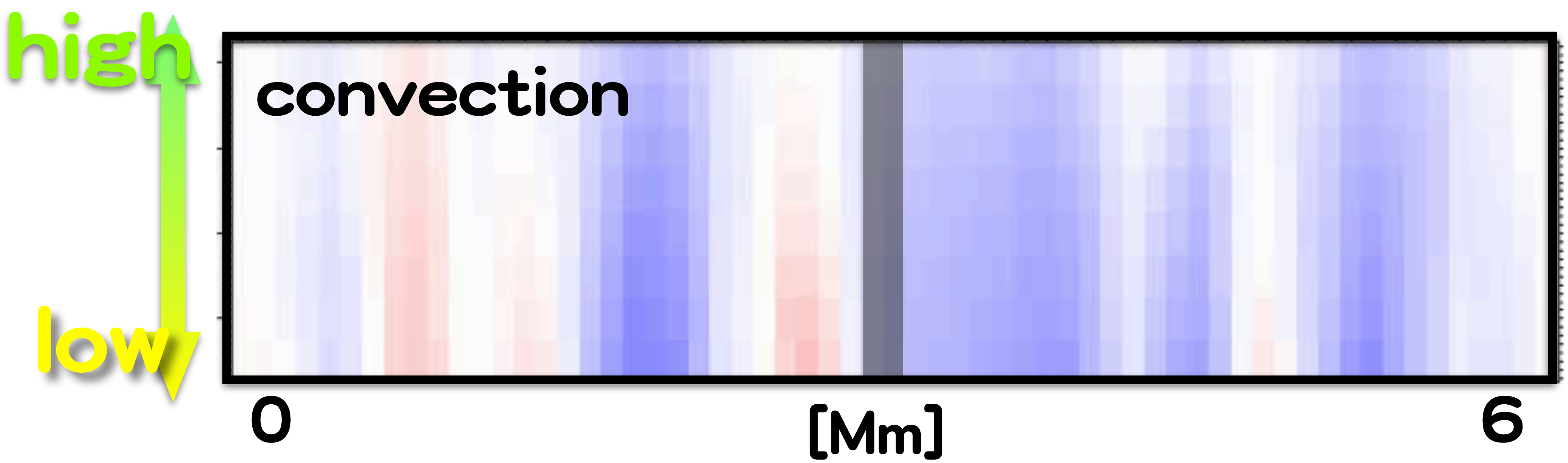
1D model cannot explain the accelerating downflow

Radiative energy loss maybe very effective to cause a convective instable condition at the intergranular lane

Future work

Try to detect the MHD waves enhancement

→ interaction between convection and magnetic field



Difficulties: We must separate the absorption line profile from Zeeman effect

Verify and test our method by using RMHD simulation

at MPS (Jan-Mar 2016)