The afternoon transition phenomenology during BLLAST

Preliminary analysis of Doppler lidar measurements

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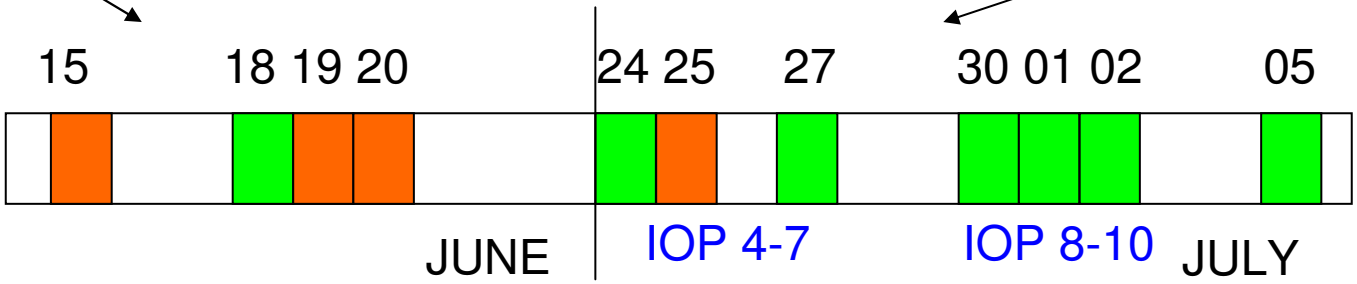
Instrument & operation during BLLAST
14 June – 8 July 2011, Lannemezan

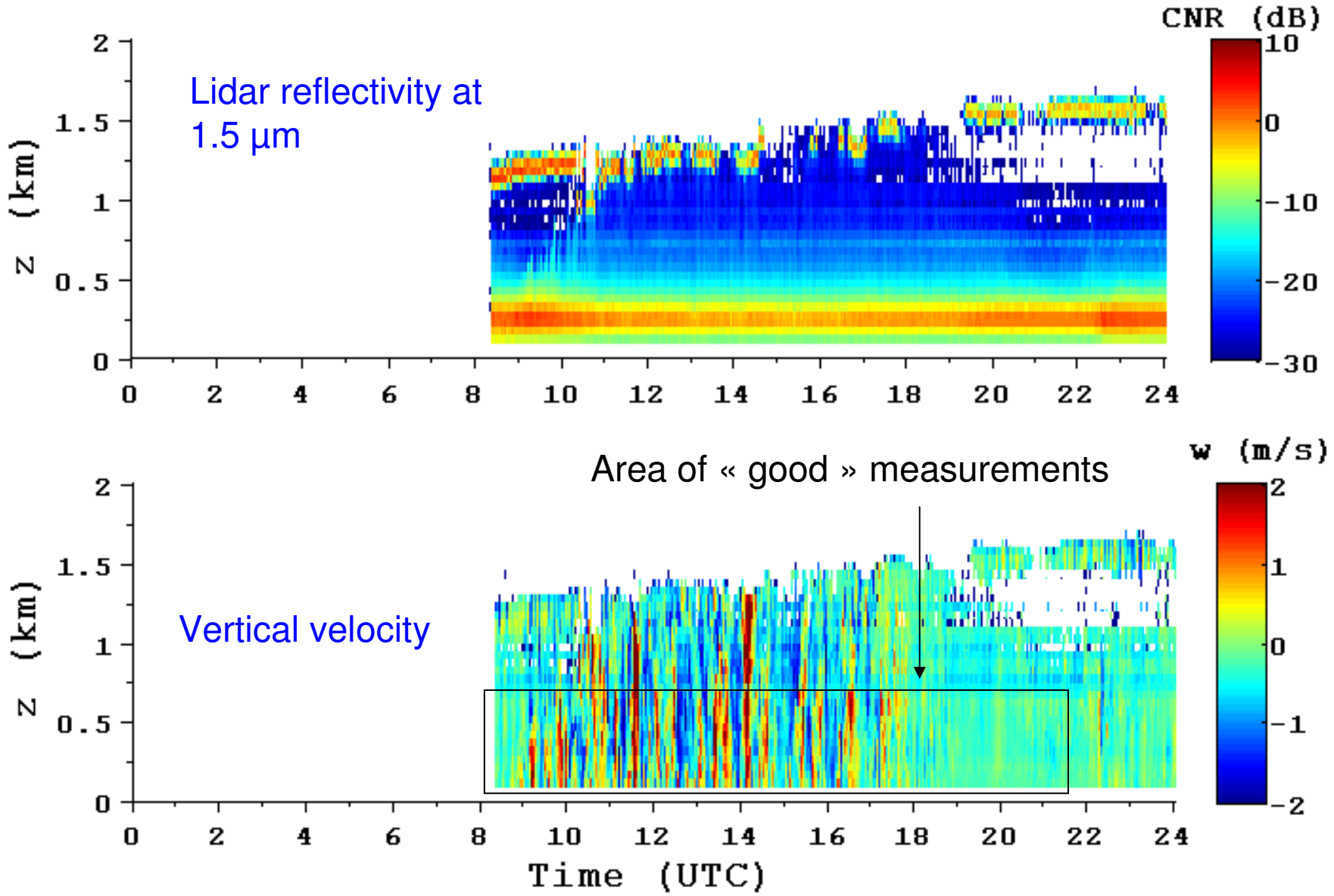
Doppler Lidar:
WindCube 200 (Leosphere)
1.5 µm pulsed fiber laser (100 µJ/ 20 kHz)

Products
Lidar reflectivity & vertical velocity profiles
Range & Time resolution: 50 m / 3 s

Operation semi-automatic
(problem of temperature regulating during the day)

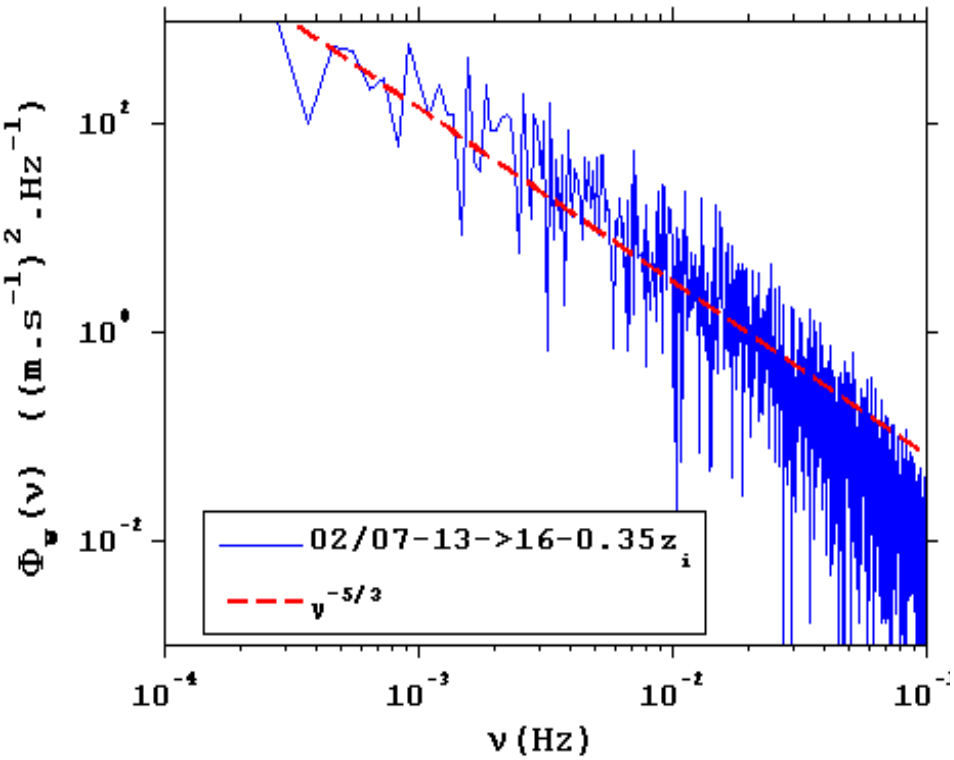


Case study: 30 June 2011

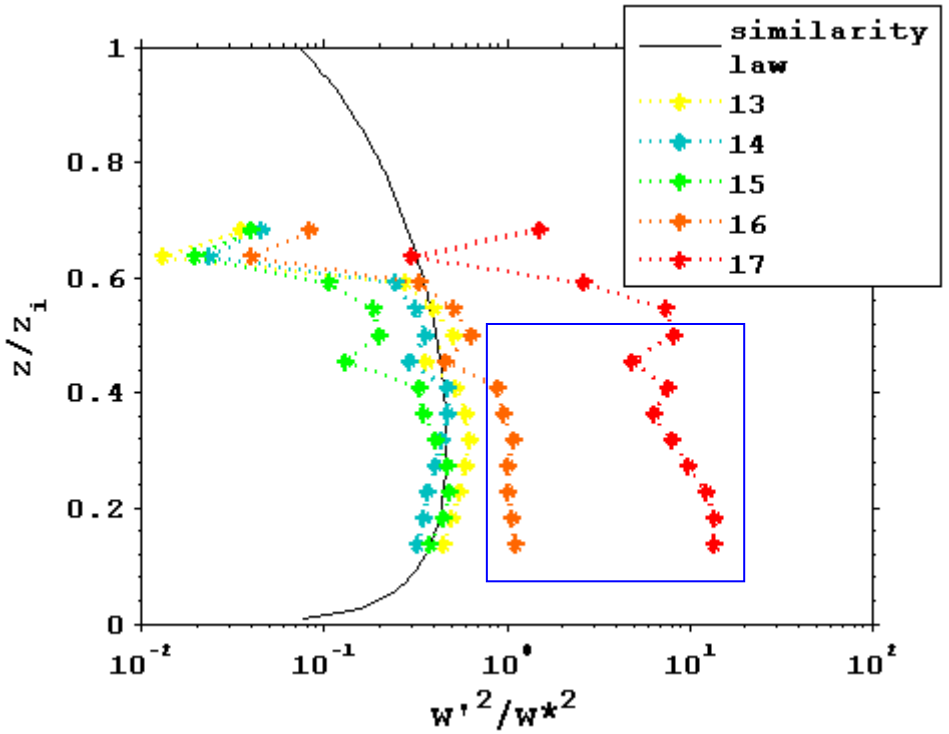


Preliminary analysis of vertical velocity

Typical velocity power spectrum in the inertial subrange (Friedlich, BLM, 98, Gibert et al. BLM, 07)



Vertical velocity variance profile vs similarity law in the CBL



→ w'^{2} does not follow the similarity law after 1530 UTC

Scientific goals/ analysis

-**TKE decay during the afternoon transition**

- **Changes in turbulence lenght scales**

Comparison with LES / analytic model results

Comparison with previous field experiments at different sites

- Scalars horizontal and vertical distribution and transport during the afternoon transition.

How can they be used (tracers or reactive) to answer the questions relative to the dynamics ?

TKE budget

$$\bar{e} = \frac{1}{2}\left(\overline{u'^2} + \overline{v'^2} + \overline{w'^2}\right)$$

TKE budget equation (Stull,88)

$$\frac{\partial \bar{e}}{\partial t} + \bar{u}_j \frac{\partial \bar{e}}{\partial x_j} = \delta_{i3} \frac{g}{\bar{\theta}_v} \overline{u_i'\theta_v'} - \overline{u_i'u_j'} \frac{\partial \bar{u}_i}{\partial x_j} - \frac{\partial \overline{u_i'e}}{\partial x_j} - \frac{1}{\bar{\rho}} \frac{\partial \overline{u_i'p'}}{\partial x_i} - \varepsilon$$

Buoyancy

Shear production

Transport of TKE

Subsidence Pressure fluctuation

Loss due to viscous dissipation

Following Nieuswstadt and Brost (1986), Fernando et al. (2003), Nadeau et al. (2011): horizontal homogeneous flow, neglecting subsidence, shear, vertical gradient and transport of TKE

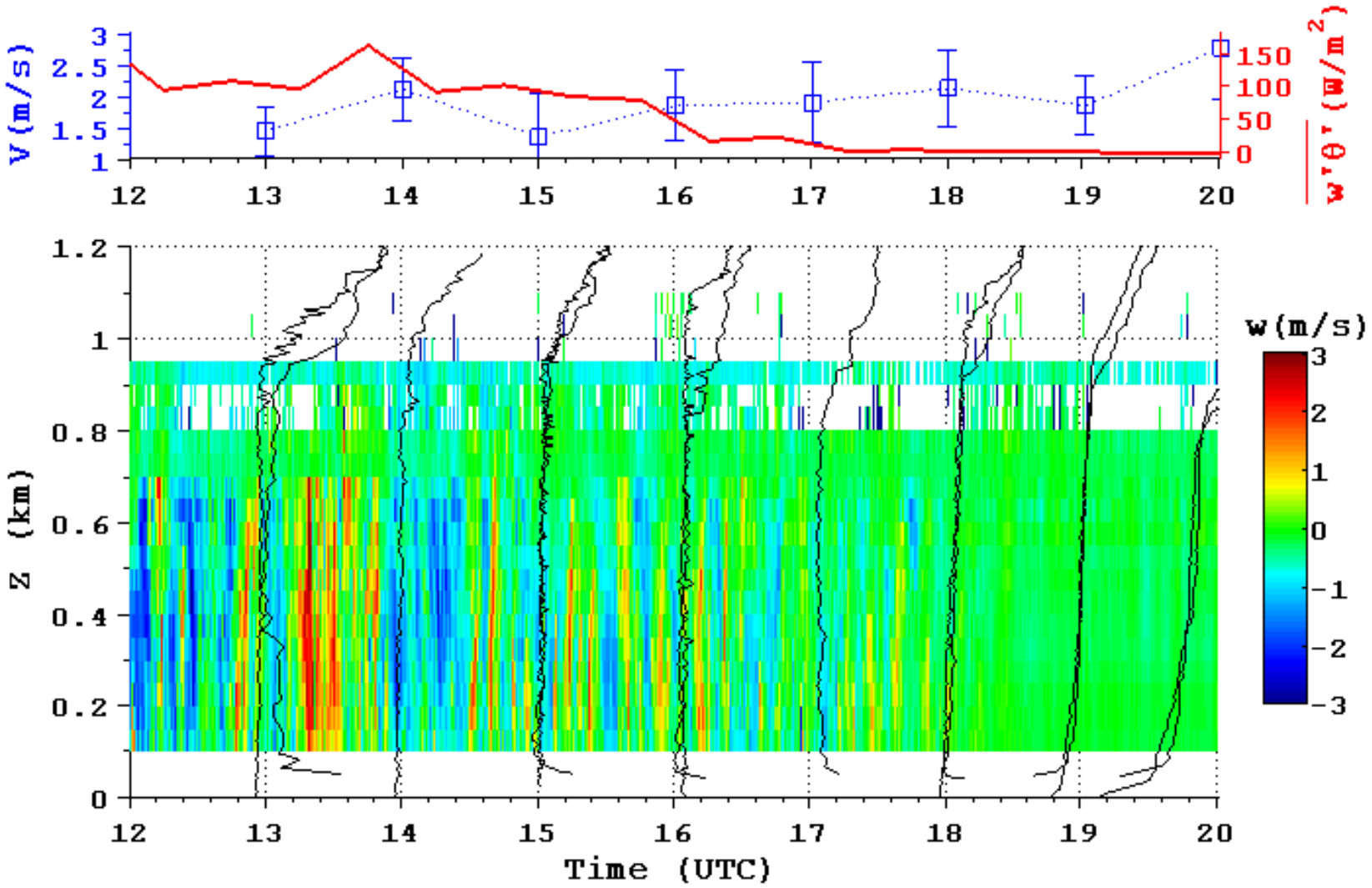
$$\frac{\partial \overline{e(t,z)}^*}{\partial t^*} + C_\varepsilon \overline{e(t,z)}^{*3/2} = \frac{g z_i}{\bar{\theta}_v w_*^3} \overline{\left(u_i'\theta_v'\right)_s}(t) f(z)$$

$$\bar{e}^* = \bar{e}/w_*^2$$

$$t^* = t w_*/z_i$$

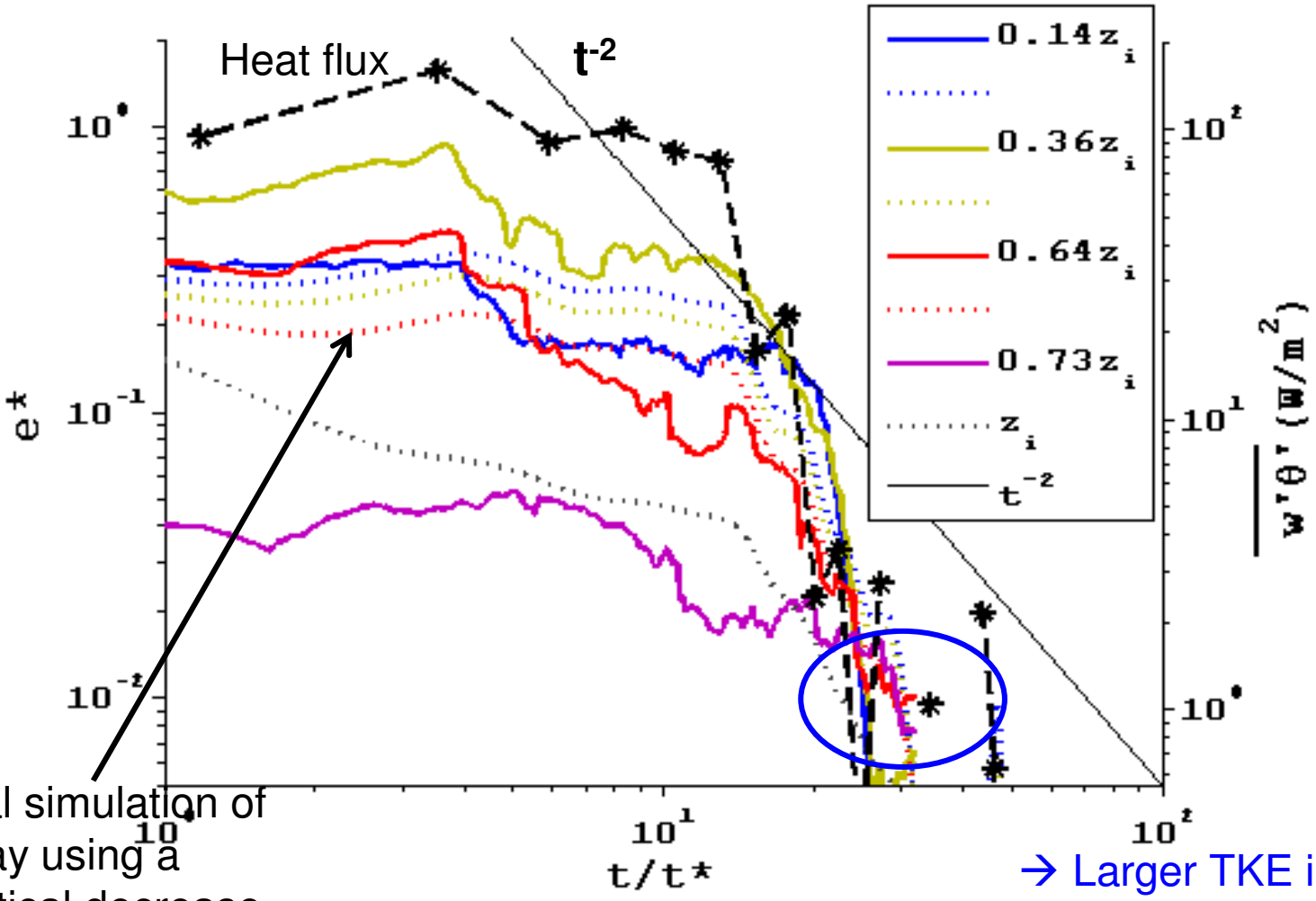
And using only the variance of vertical velocity as a proxy for TKE

Application - July 02 case



TKE decay – July 02

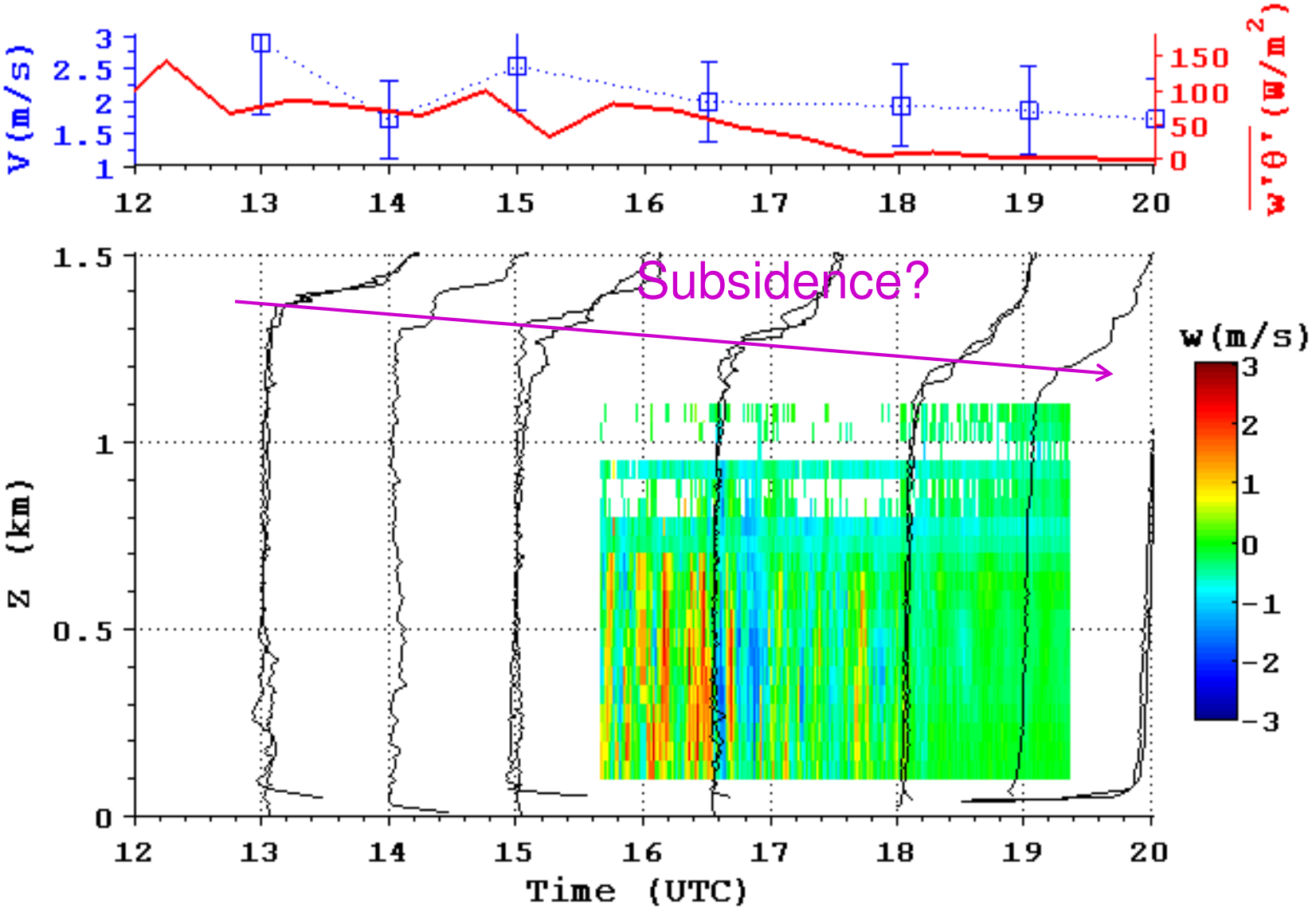
z_i=1100m, w^*_0=1.44 m/s, t^*=0.21h, t_0=13h (UTC)



Numerical simulation of TKE decay using a linear vertical decrease of surface heat flux

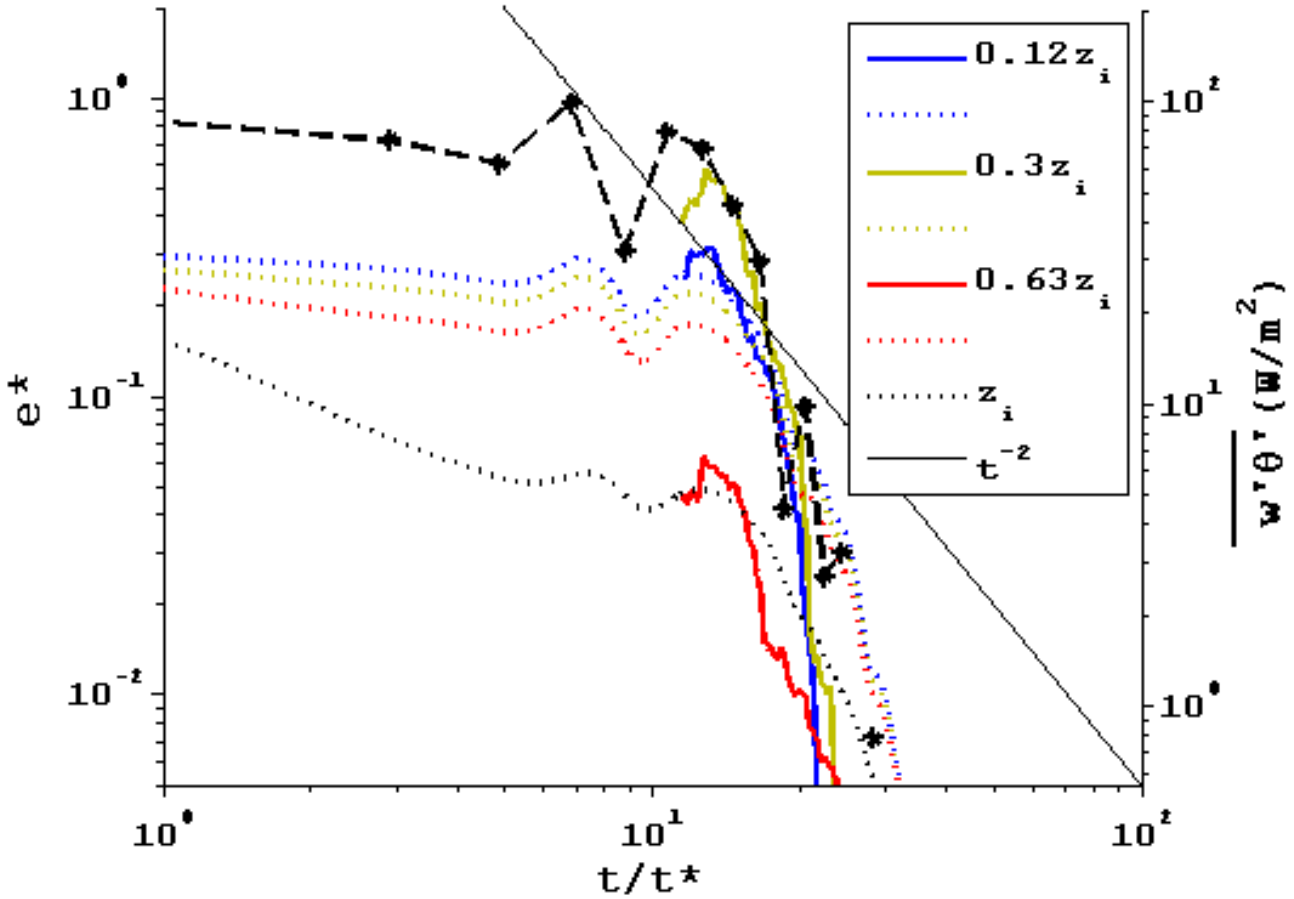
→ Larger TKE in the middle of the CBL than at the bottom

July 01 case


V (m/s)
3
2.5
2
1.5
1
150
100
50
0
w'θ' (W/m²)
12
13
14
15
16
17
18
19
20
Subsidence?
1.5
1
0.5
0
Z (km)
w (m/s)
3
2
1
0
−1
−2
−3
Time (UTC)

TKE decay – July 01

z_i=1280m, w^*_0=1.39 m/s, t^*=0.26h, t_0=13h (UTC)

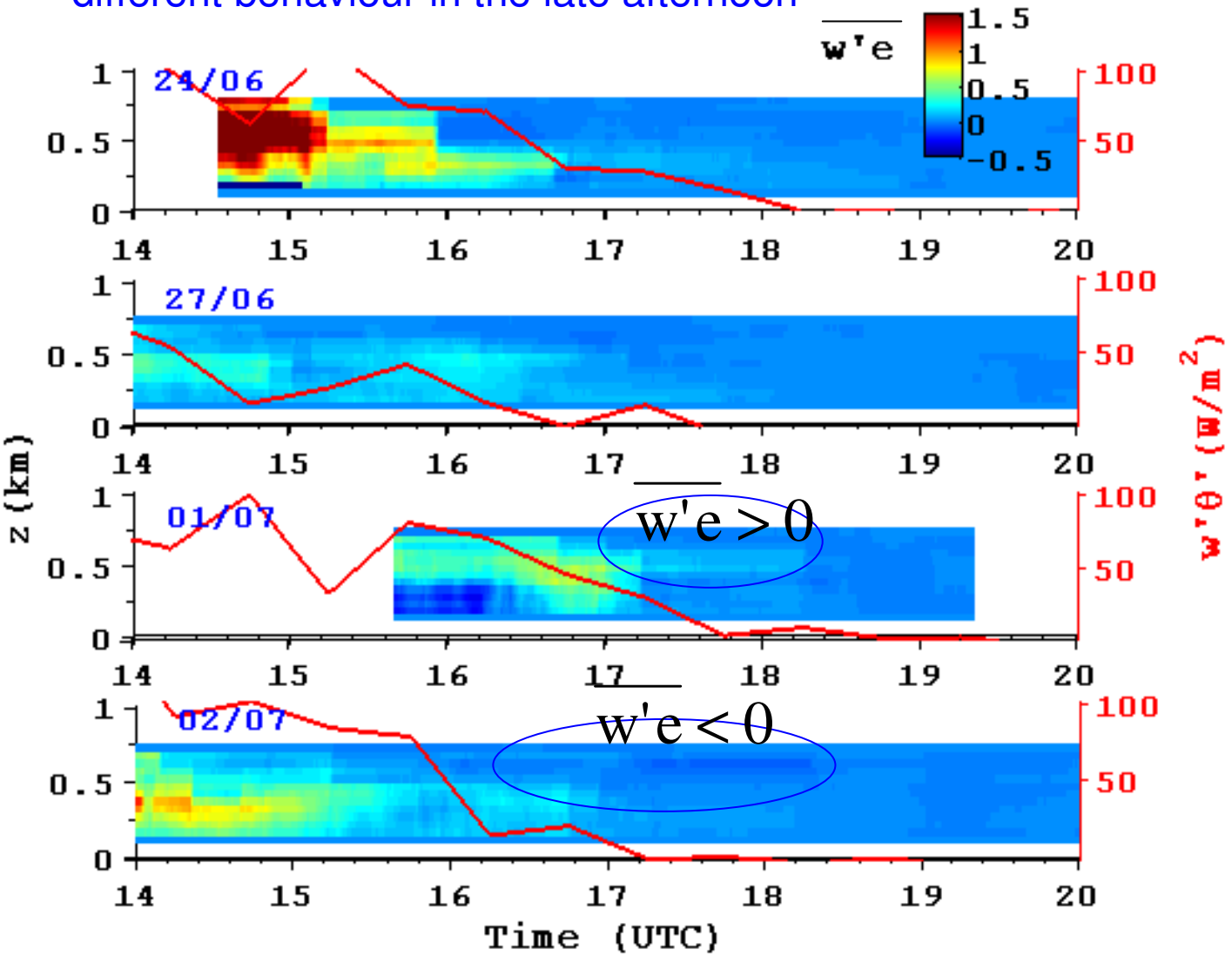


→ Observations show a steapier decreases of TKE than simulations but a similar decrease with surface heat flux – The slope decreases when z increases

TKE transport $\frac{\partial \overline{w'e}}{\partial z}$

$\overline{w'e}$ is usually maximal in the mid-CBL

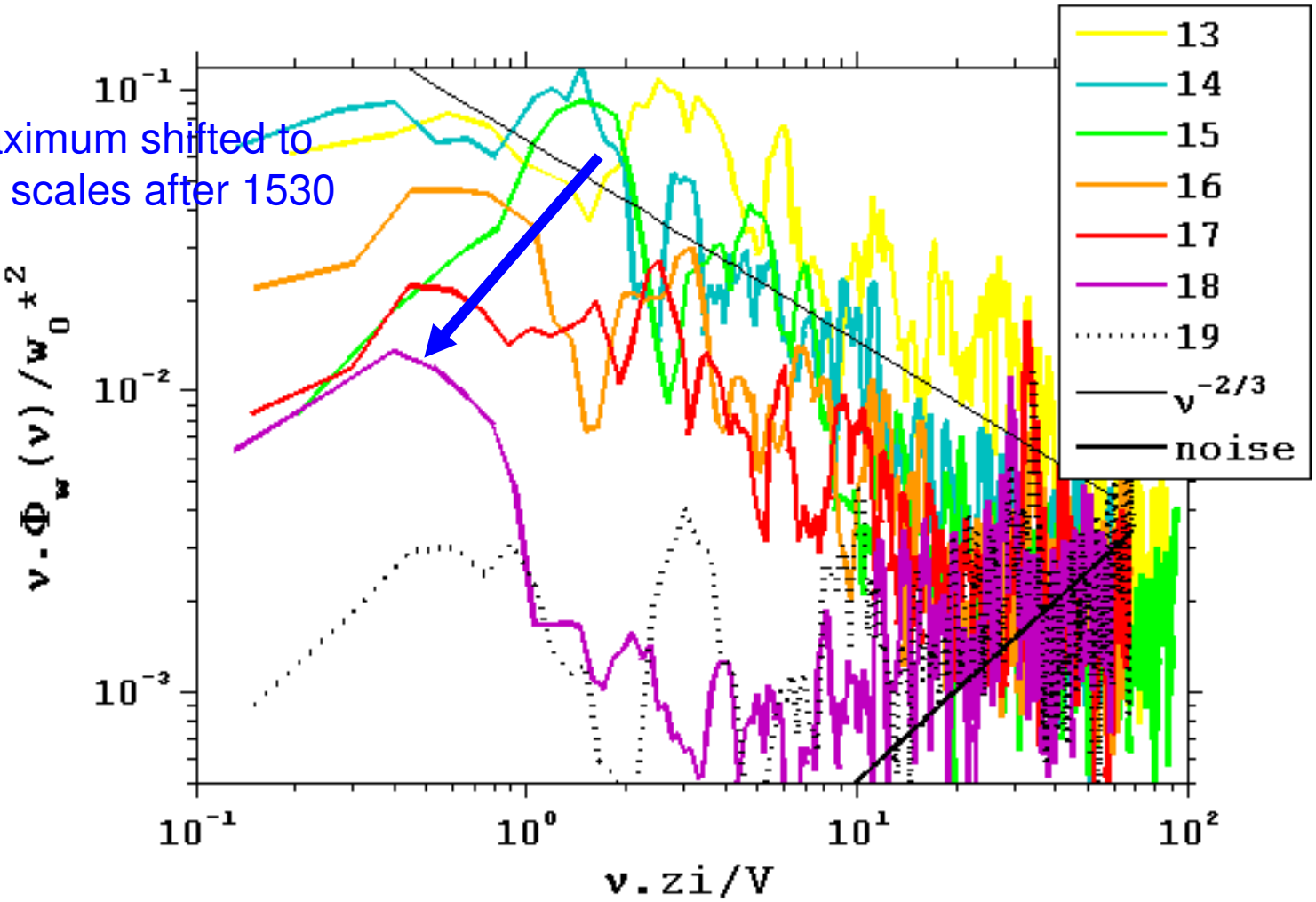
different behaviour in the late afternoon



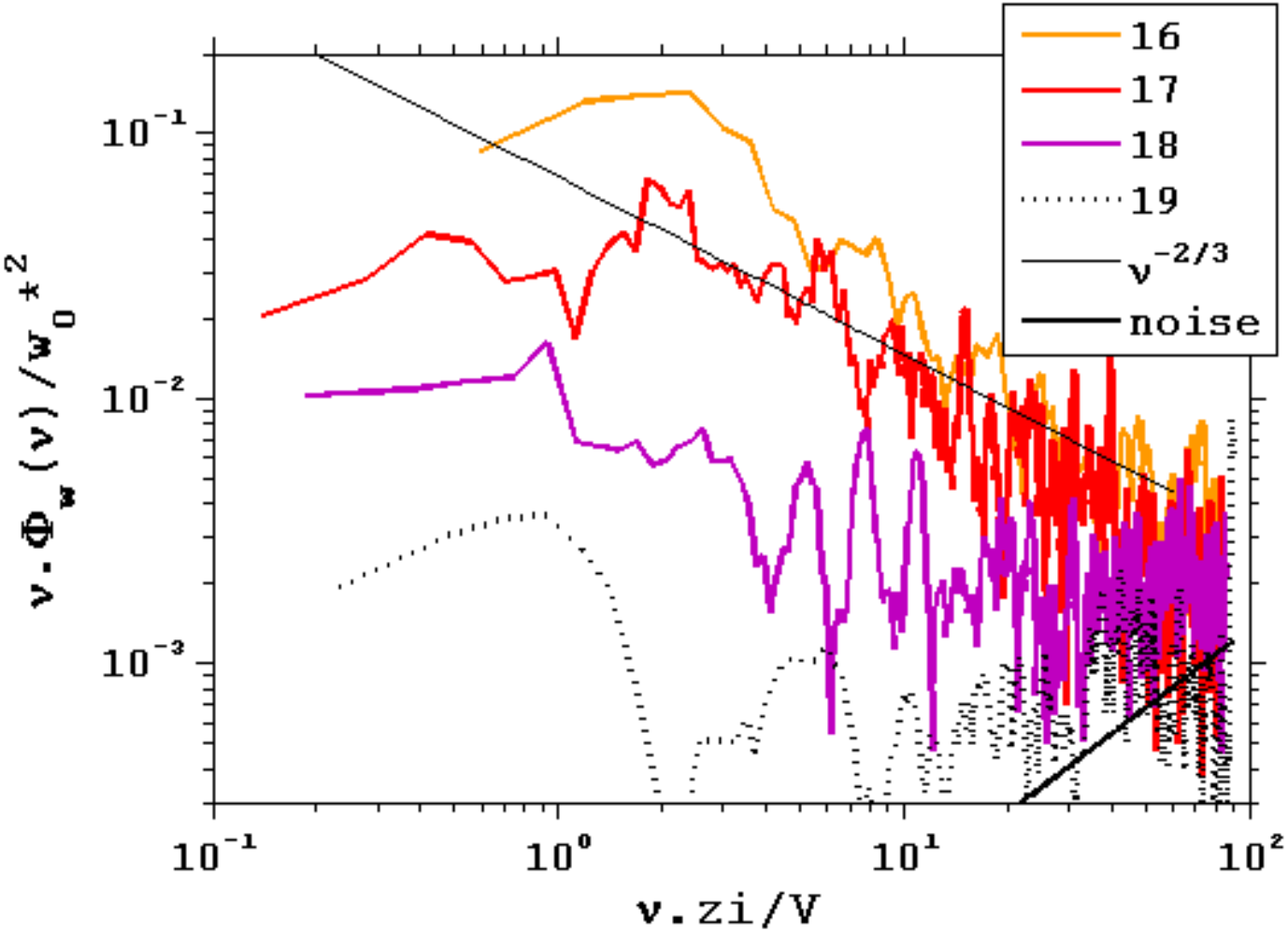
Length scales - July 02 case

Following Goulart et al. 2003
1-D energy density spectrum using temporal series of vertical velocity $\phi_w = \frac{\Delta t}{N}\left|DFT(w')\right|^2$
(Friedlich, BLM,98, Gibert et al.,BLM, 07)

→ Maximum shifted to larger scales after 1530 UTC



Length scales - July 01 case



→Shift to larger scales less marked but still apparent

Future work

-Trying to estimate other terms in TKE budget

- Profiles of enery viscous dissipation using profiles of velocity variance? (Frielhich, BLM,98)

- Heat flux profiles using TKE vertical gradient in the Late afternoon CBL

- Comparison with LES simulations

- Comparison with previous field experiments

- M1 student will continue this work in April 2012