

How large is large enough?

Large-eddy simulation of clear and cloudy convective boundary layers

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Simulation of the clear convective boundary layer

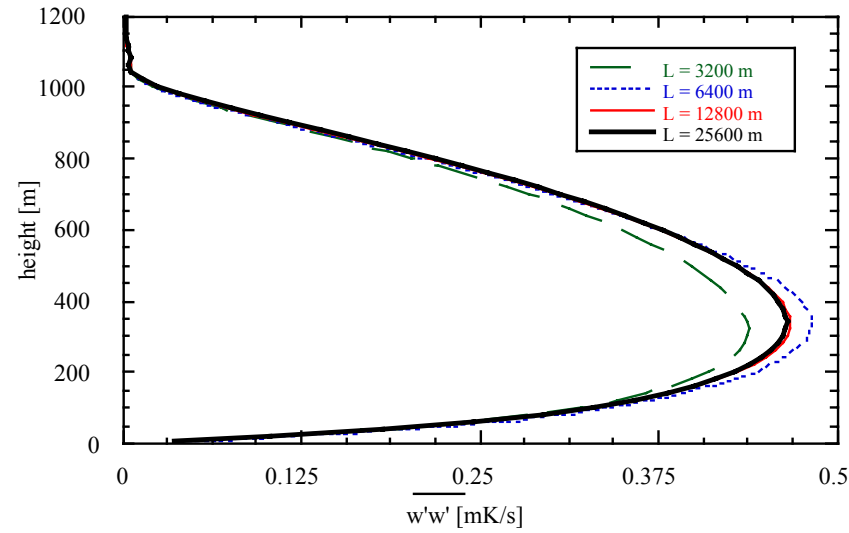
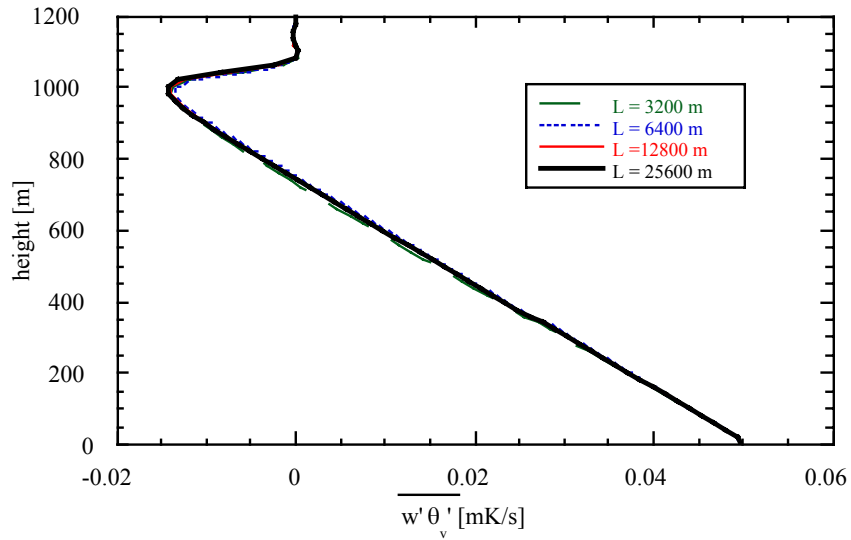
4 different horizontal domain sizes L

$L = 3200$ m

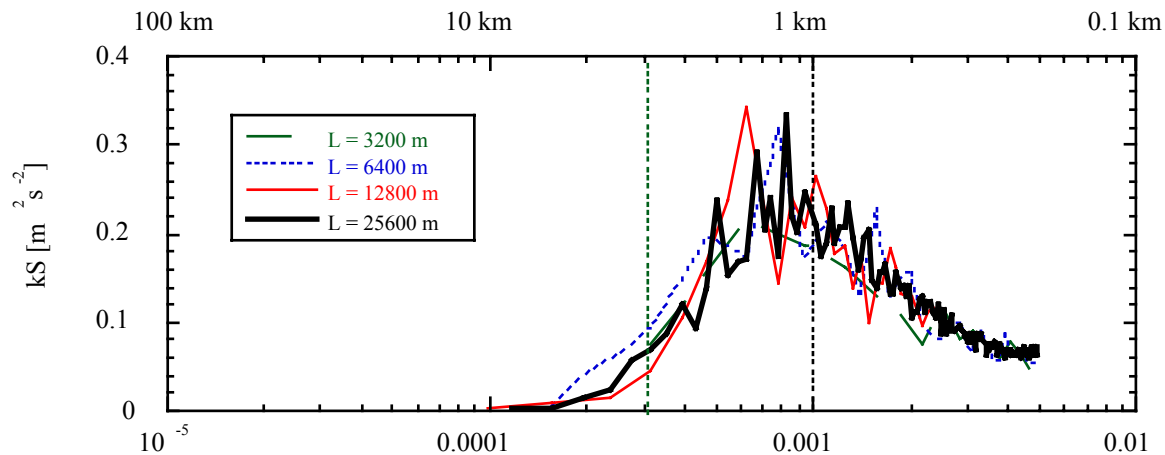
$L = 6400$ m

$L = 12800$ m

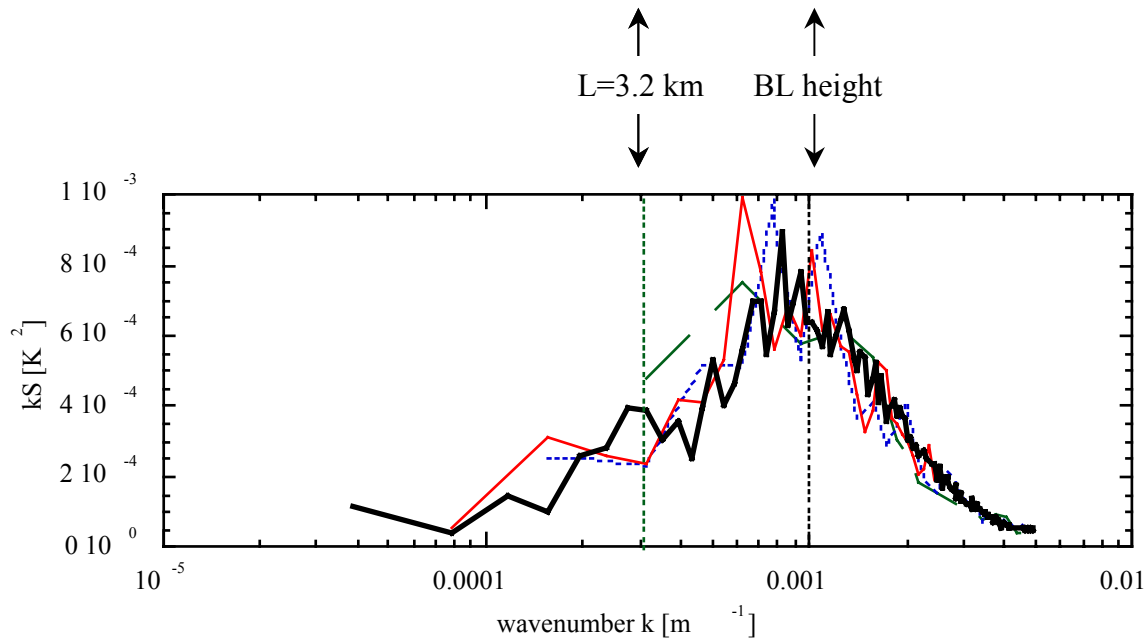
$L = 25600$ m



Variance spectra in the middle of the boundary layer at t=8h

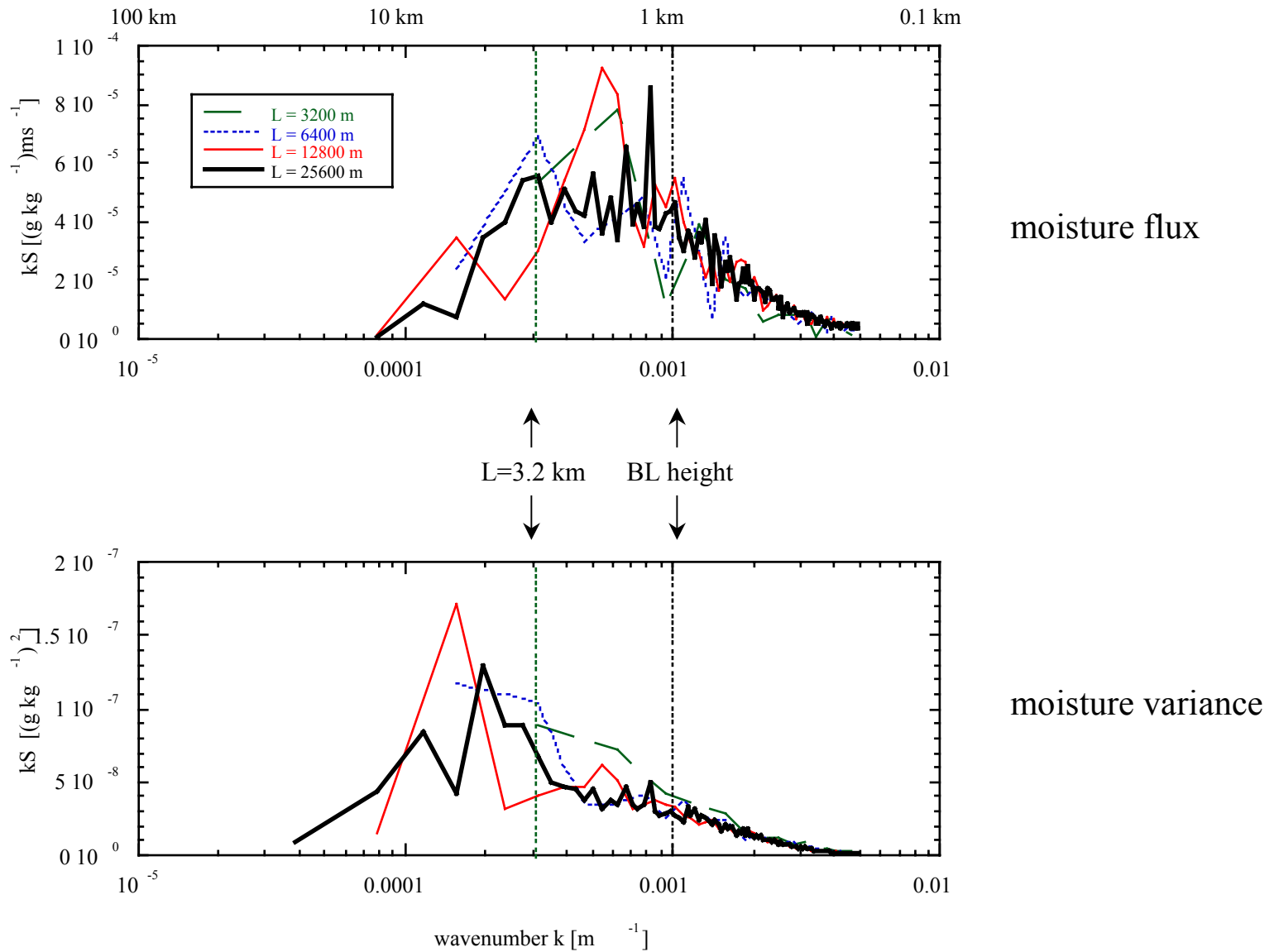


vertical velocity

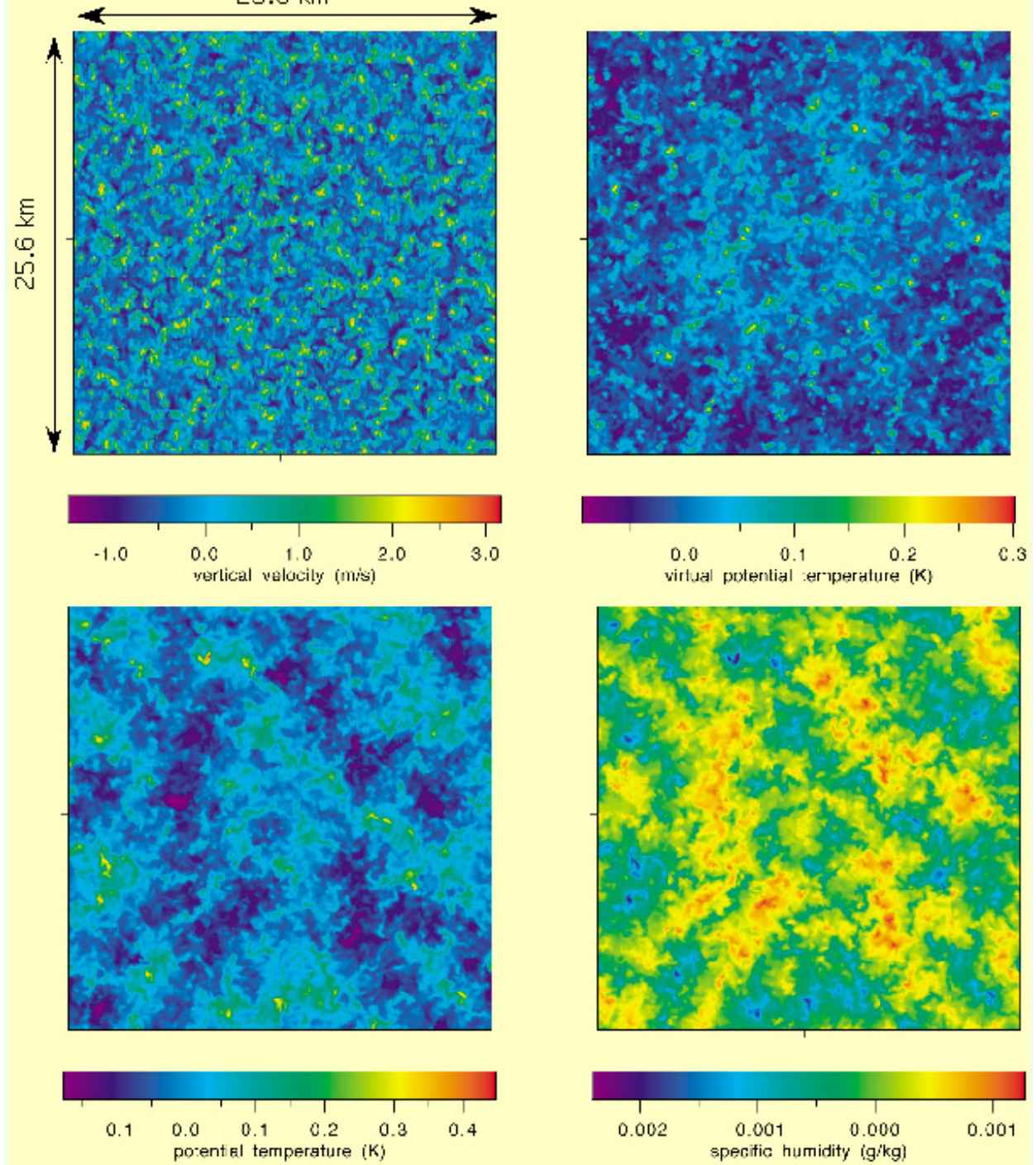


virtual potential temperature

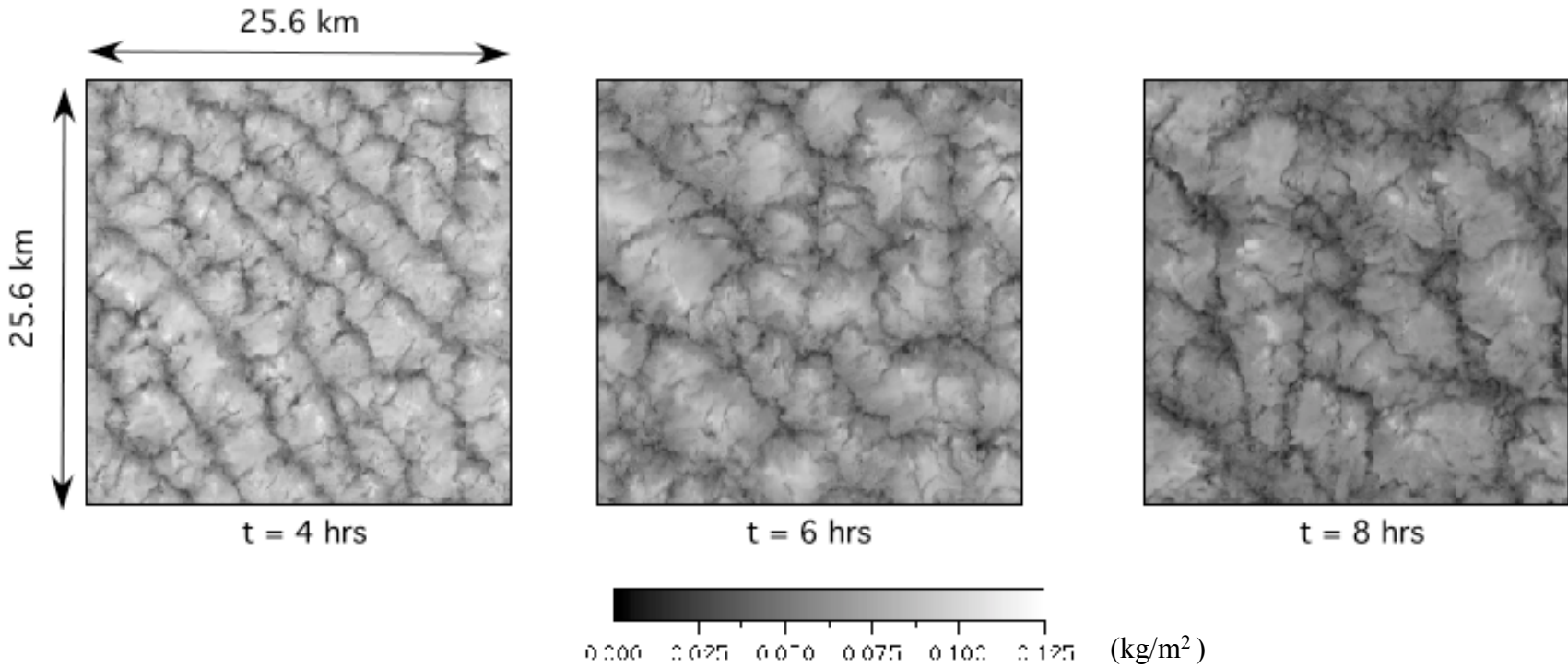
(Co)-variance spectra in the middle of the boundary layer



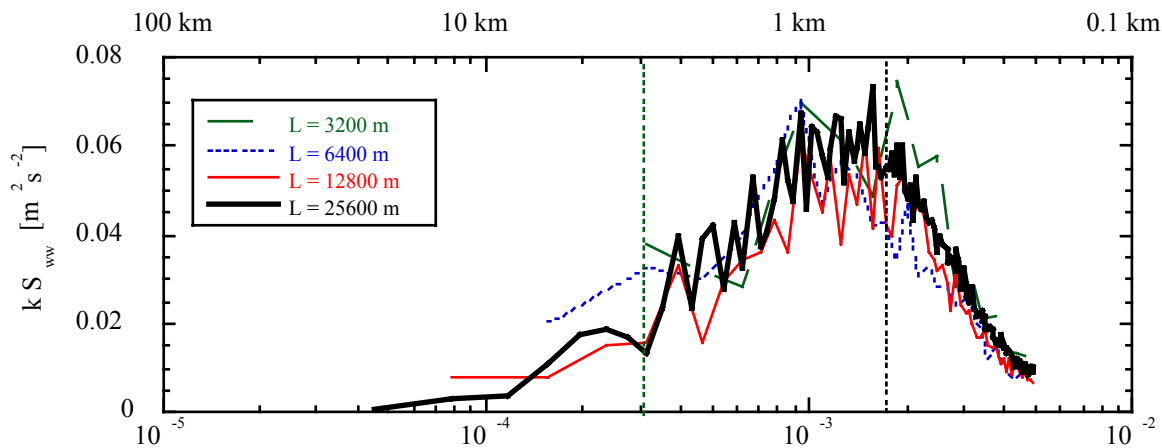
Structures in the middle of
the clear convective BL



Liquid water path evolution in stratocumulus simulation during the night



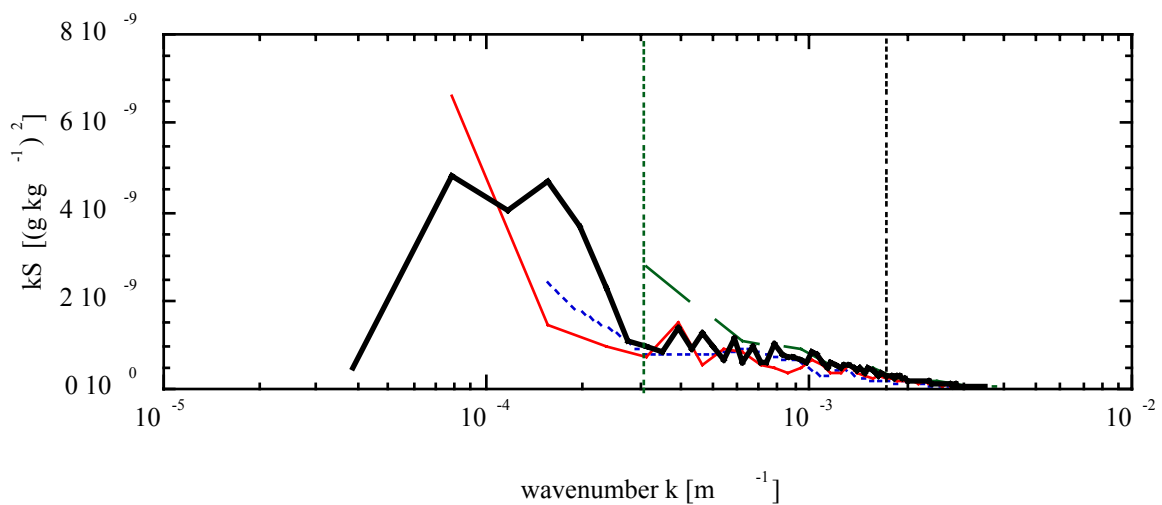
(Co)-variance spectra in the middle of the stratocumulus layer



vertical velocity
variance

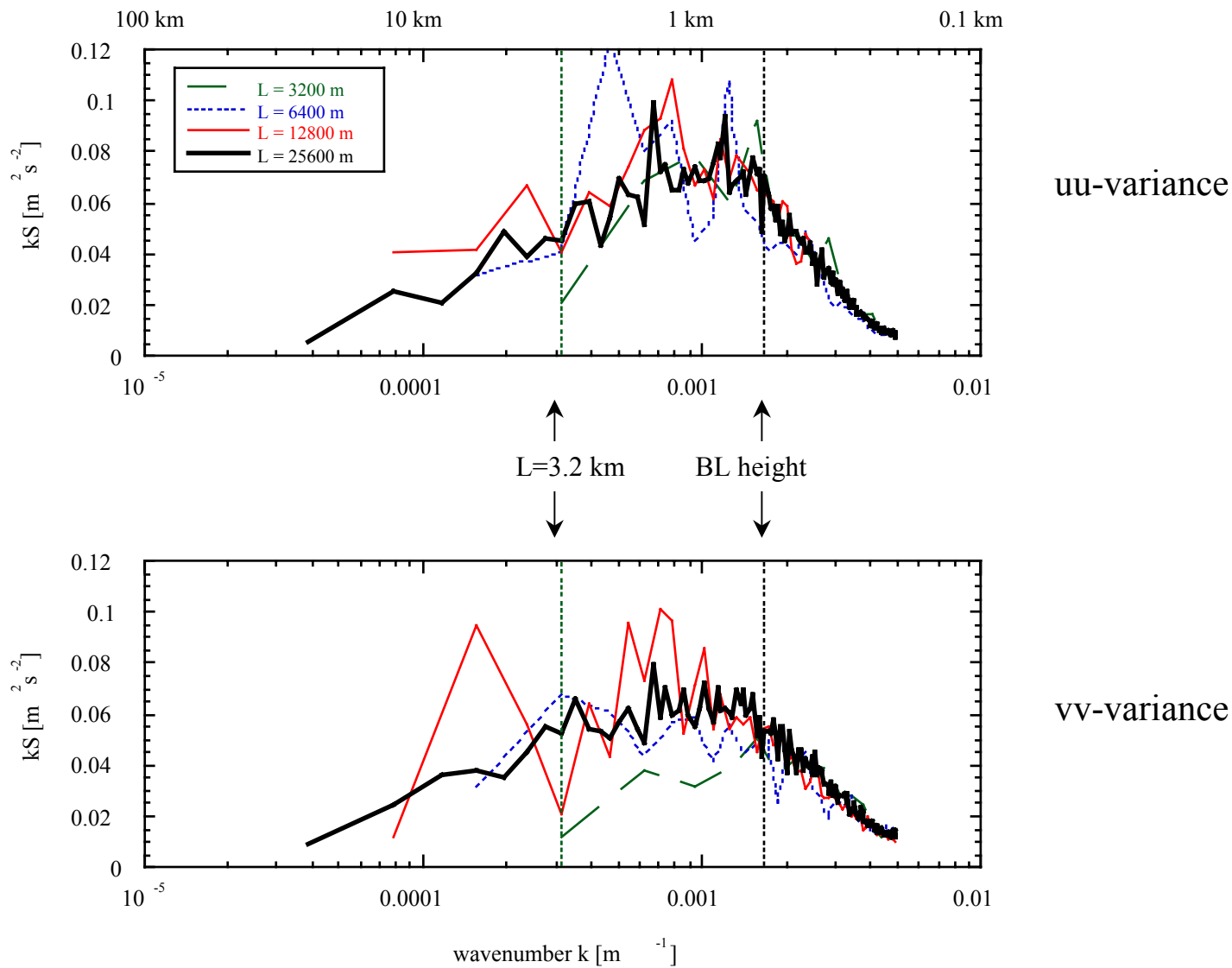
\uparrow
 $L=3.2 \text{ km}$
 \downarrow

\uparrow
BL height
 \downarrow



moisture variance

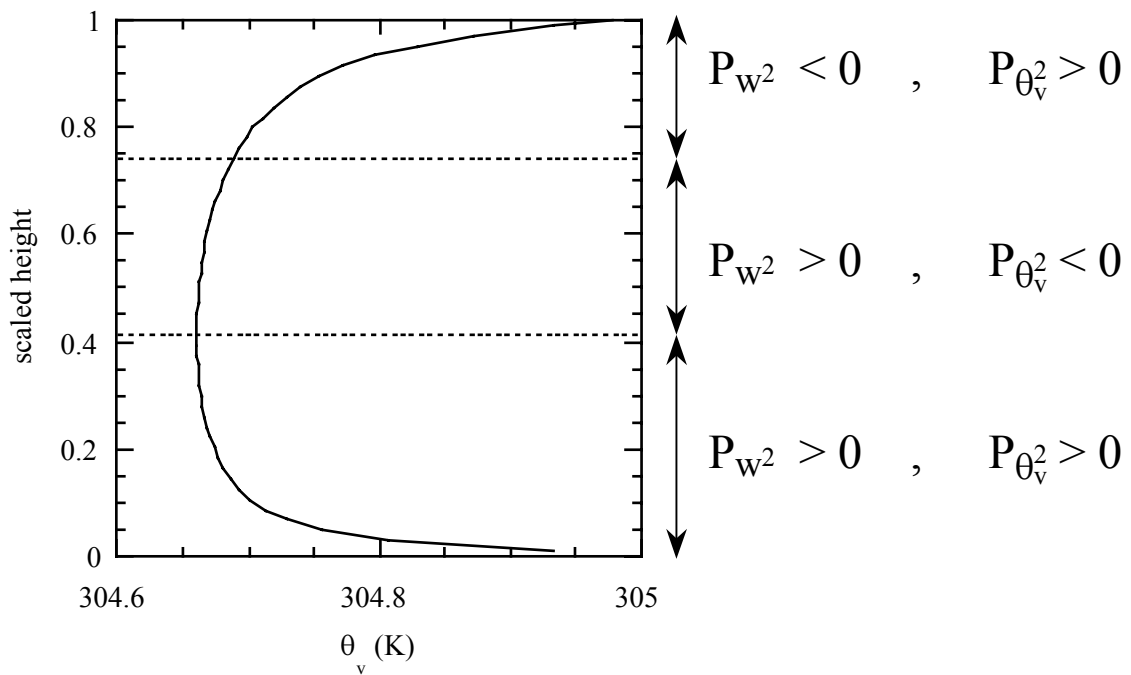
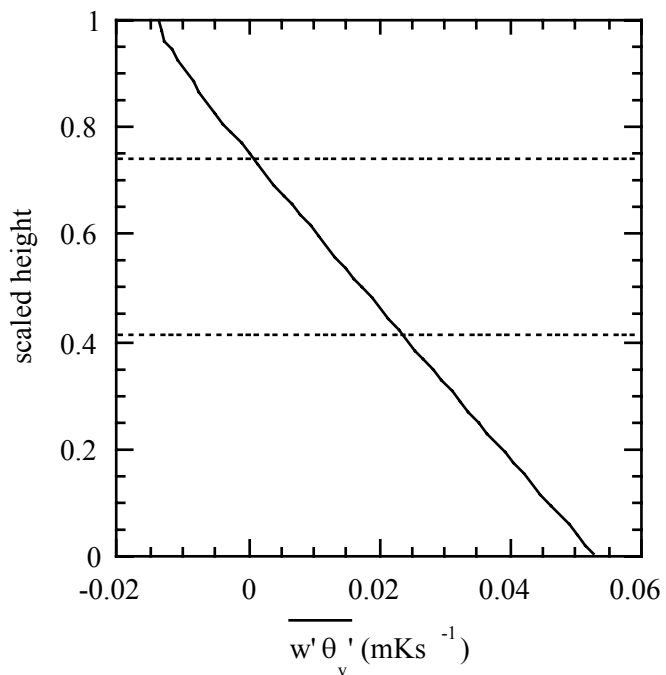
(Co)-variance spectra in the middle of the stratocumulus layer



Production of variance in the clear CBL

$$\left(\frac{\overline{\check{Z}w'w'}}{\check{Z}t} \right)_P = P_{w^2} = 2 \frac{g}{\theta_0} \overline{w'\theta_v'}$$

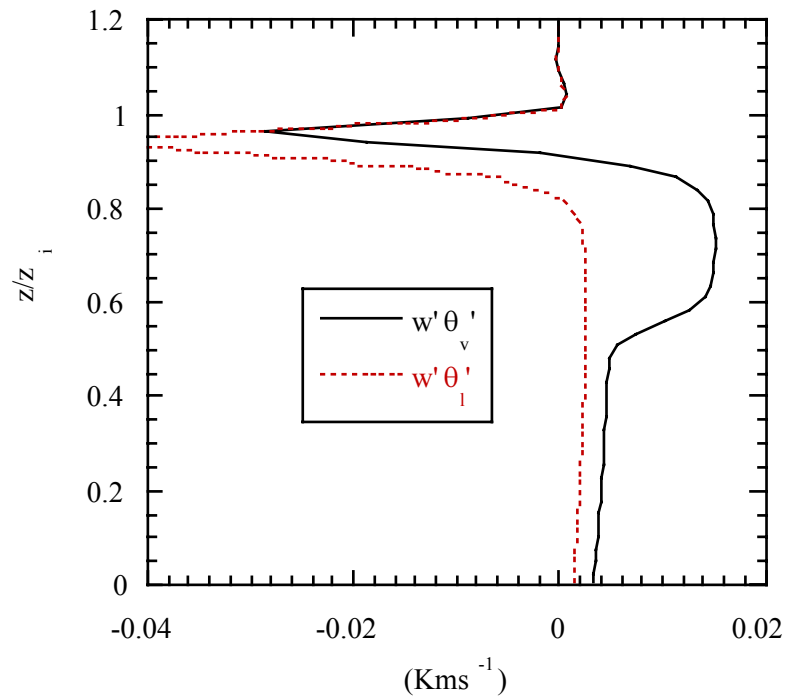
$$\left(\frac{\overline{\check{Z}\theta_v'\theta_v'}}{\check{Z}t} \right)_P = P_{\theta_v^2} = -2 \overline{w'\theta_v'} \frac{\check{Z}\theta_v}{\check{Z}Z}$$



Length scale in stratocumulus

$$\overline{w'\theta'_v} = A \overline{w'\theta'_l} + B \overline{w'q'_t}$$

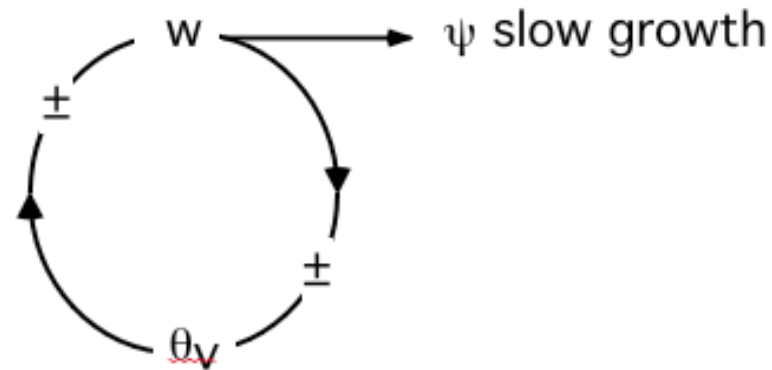
$A = 1$, $B = 0.61\theta \approx 180$ (subcloud)
 $A \approx 0.6$, $B \approx 1200$ (cloud)



Turbulence production of scalar (ψ) mesoscale fluctuations

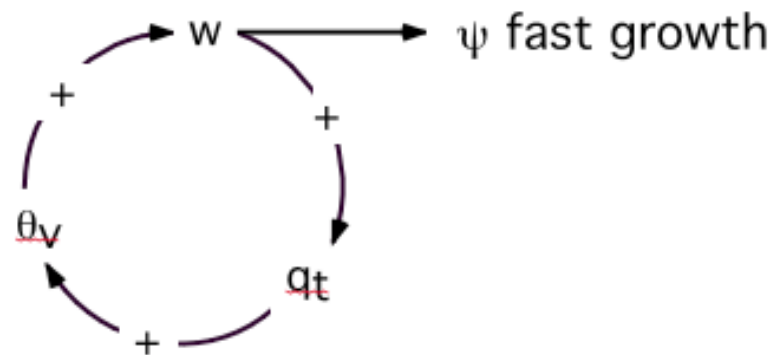
CBL

- + surface heating
- entrainment warming



Stratocumulus

- + latent heat release
- + radiative cooling



How large is large enough?

Conclusions

- larger w-fluctuations at mesoscales, more production of mesoscale scalar variance
- Scalar variance at mesoscales may grow with time -> longer duration of simulation requires larger horizontal domain

This talk: <http://www.phys.uu.nl/~roode/presentations.html>

Paper: <http://www.phys.uu.nl/~roode/publications.html>

S. R. de Roode, P. G. Duynkerke and H. J. J. Jonker, 2002: Large Eddy Simulation: How large is large enough? Submitted to the J. Atmos. Sci.