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Group Meeting / Research Update

January 6, 2010

- Finishing development of PDF closure in SAM
 1. Formulation of the turbulent length scale (mixing length)
 2. Addition of countergradient terms into the diagnostic expressions for the input moments (e.g. $\overline{w' \theta'_i}$)
- Goal is have closure completed and running stable by June 2010

Turbulent Length Scale (aka Mixing Length)

- Represents the size of the large energy containing eddies
- Term used in CRMs to compute eddy diffusivity and dissipation rates

$$K = c_k L \bar{e}^{1/2} \qquad \epsilon = \frac{\bar{e}^{3/2}}{L}$$

- Many models specify this term, when it should be diagnosed
- GOAL: Develop a formulation of a unified turbulent length scale that can be used for a variety of aspect ratios

Mixing Length Formulation

- Utilizing LES, can compute the “appropriate” length scale for a variety of Δx

$$\epsilon = \frac{e^{3/2}}{L} \implies \bar{\epsilon} = \frac{e(D)^{3/2}}{L(D)} \implies L(D) = \frac{e(D)^{3/2}}{\bar{\epsilon}}$$

- Most LES benchmarks for this study did not use 1.5 closure, therefore dissipation can be computed:

$$\epsilon = -\overline{u'_i u'_j} \frac{\partial \bar{U}}{\partial x_j} + \delta_{i3} \frac{g}{\theta_v} (\overline{u'_i \theta'_v})$$

$$e(D) = 0.5(\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$$

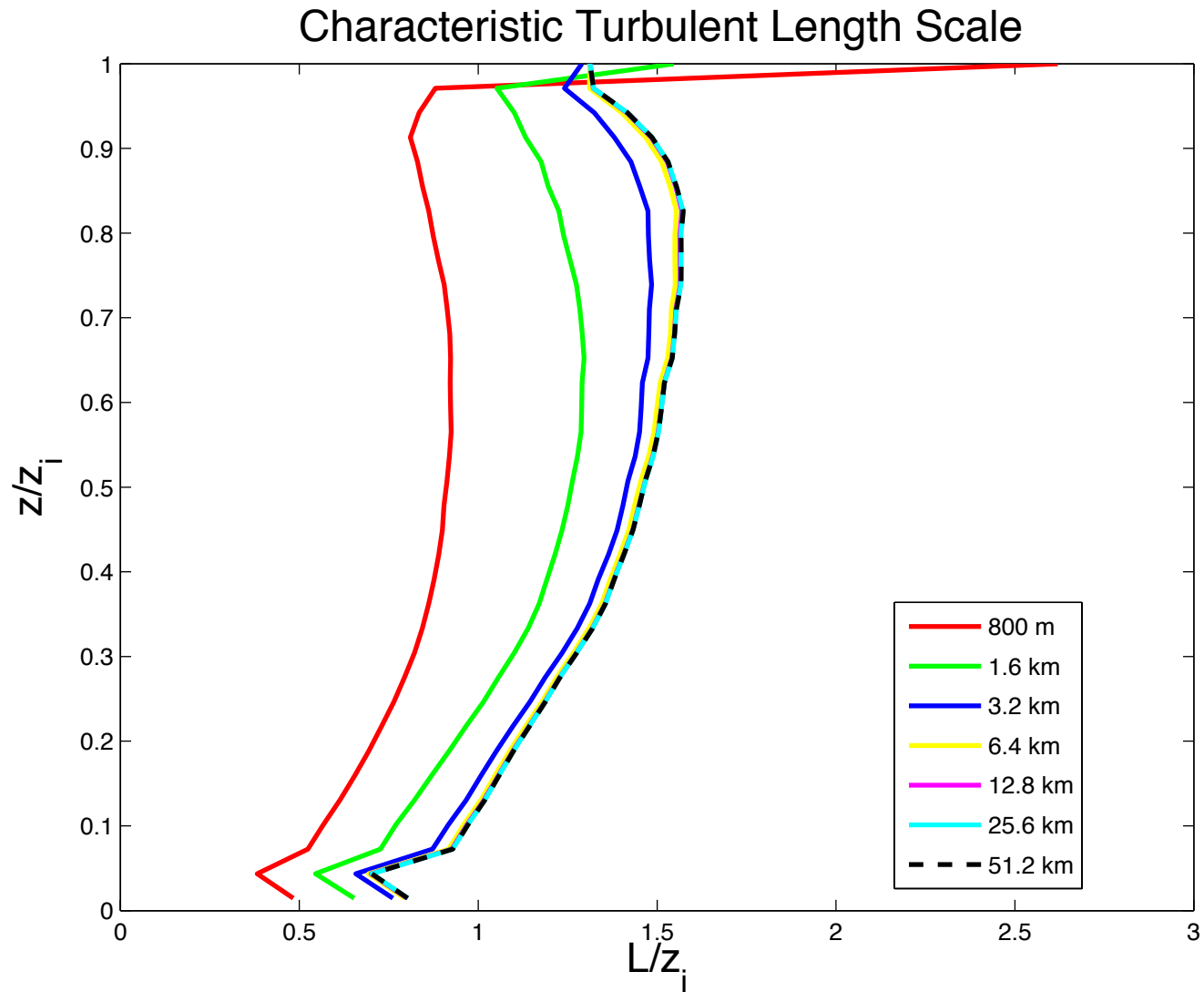
Mixing Length Formulation

- SAM currently sets $L \sim \Delta z$
- As a first step, implementing the length scale formulation described in Krueger & Xu 1991 into SAM
 - Function of Blackadar's length scale
- Testing this formulation with standard 1.5 closure, not with PDF closure
- Compare these results with the “appropriate” mixing length and examine how certain turbulent quantities are effected

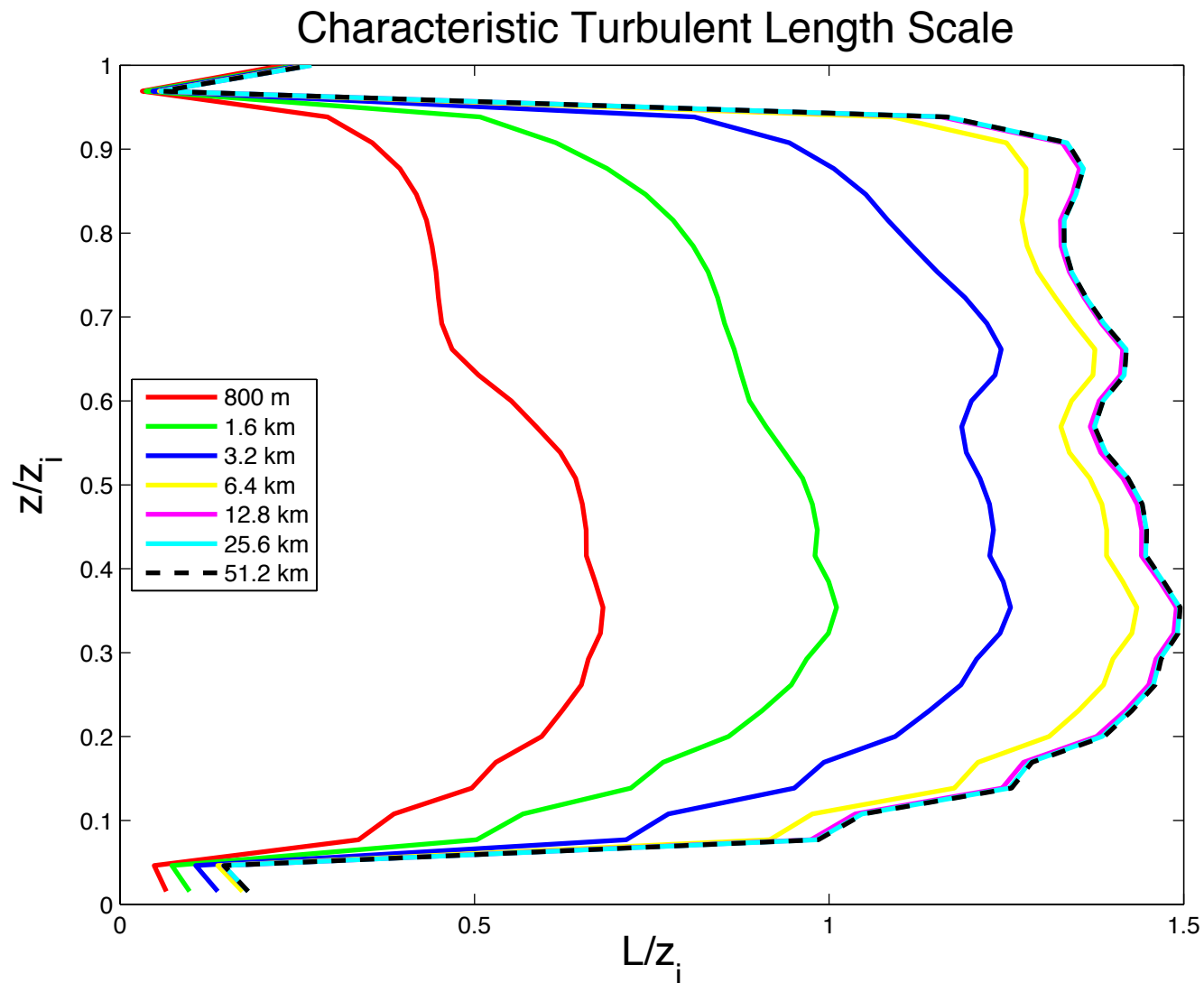
Mixing Length Formulation

- Using results of five case simulations to aide in formulation process
 - Clear Convective BL (Wangara day 33)
 - Trade Wind Cu (BOMEX)
 - Cu over land (GCSS ARM)
 - Stratocumulus (first part of SCT)
 - Deep Convection (Giga-LES)

Characteristic Mixing Lengths (Clear Convective Boundary Layer)

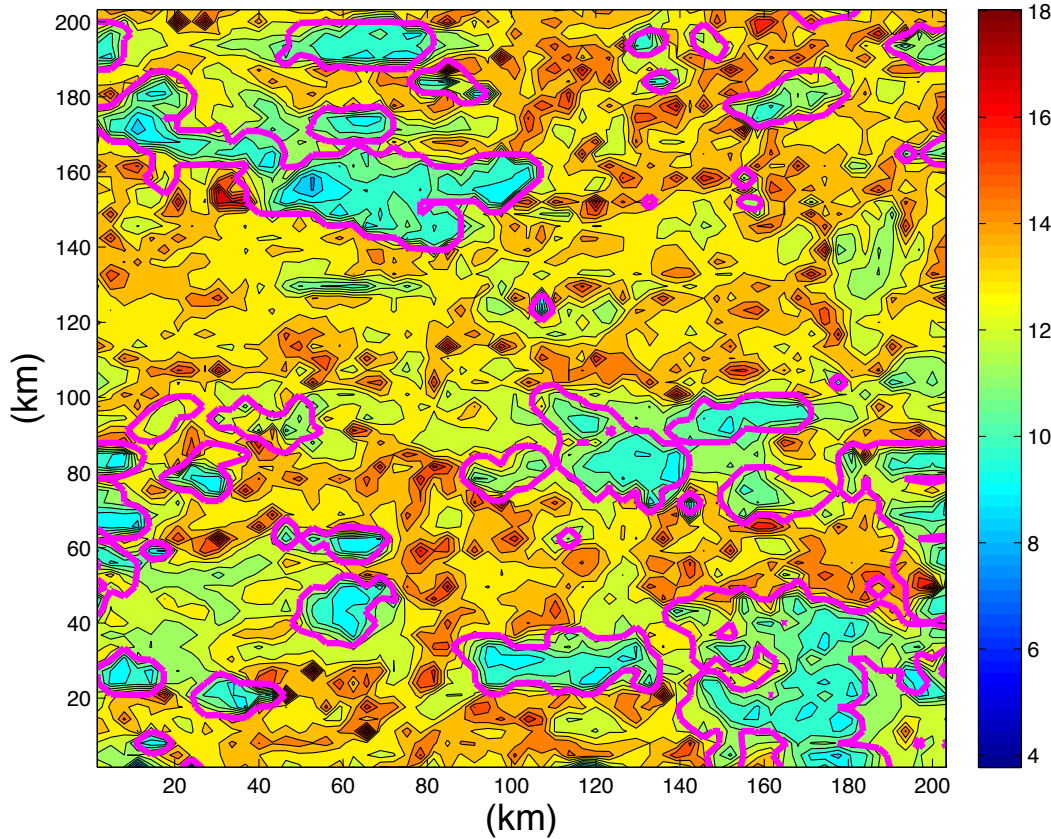


Characteristic Mixing Lengths (Stratocumulus Topped BL)

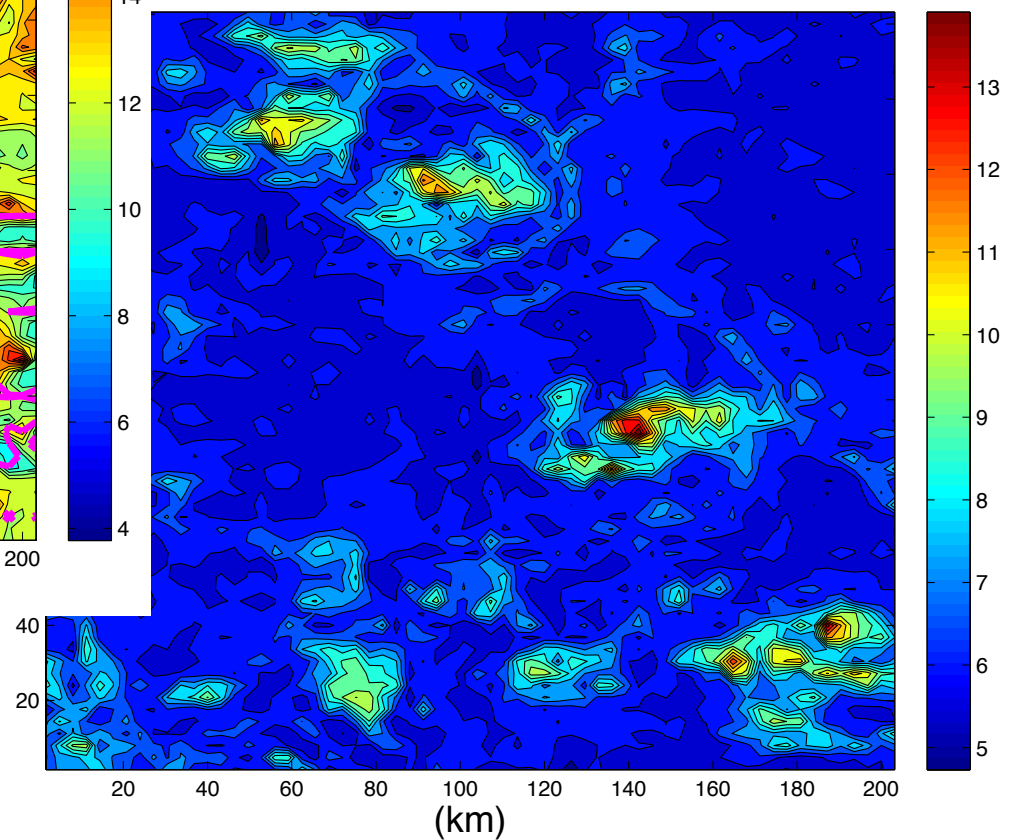


Characteristic Mixing Lengths (GATE BL)

Turbulent Length Scale at 4288.1479 m for 3200 m grid

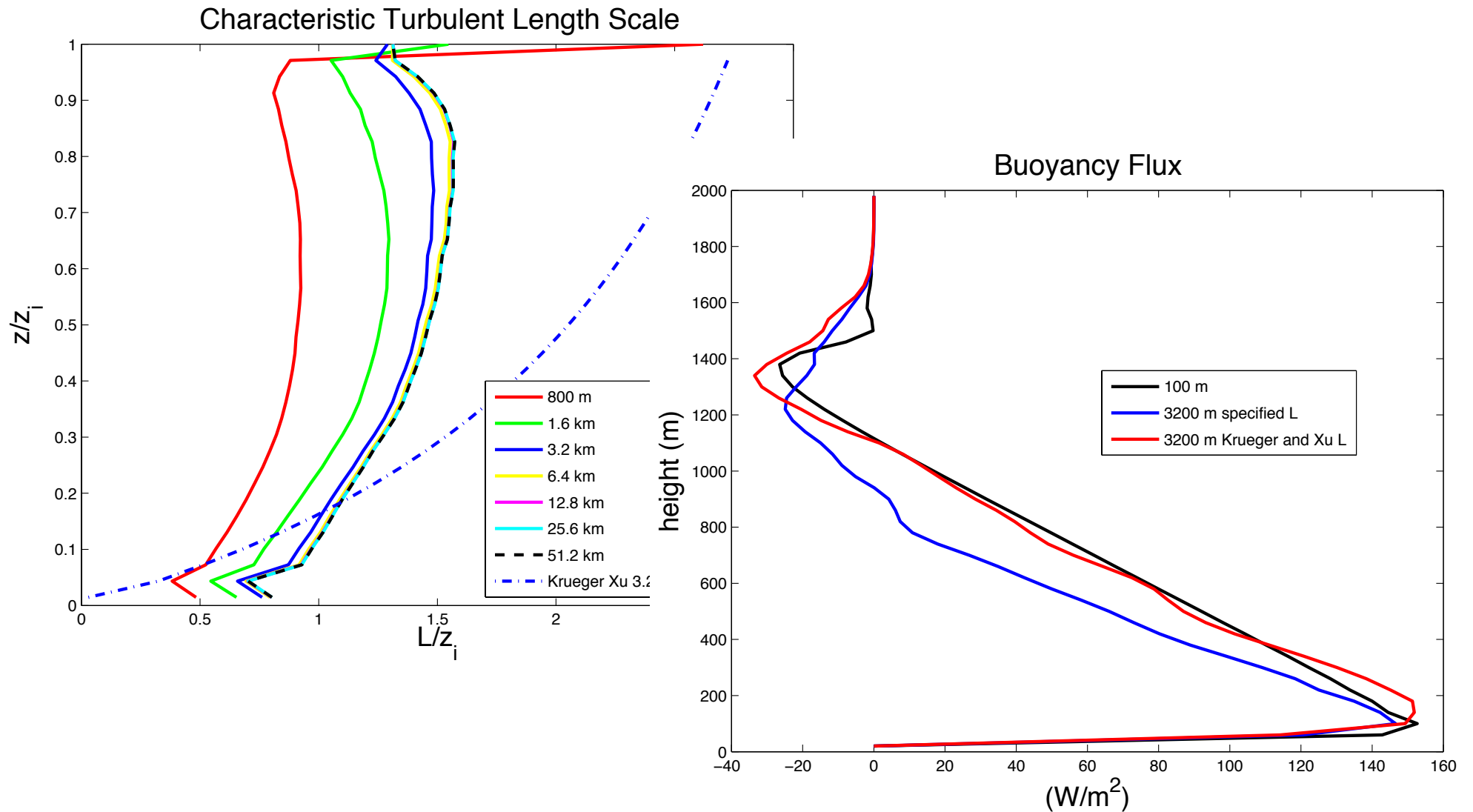


Turbulent Length Scale at 75 m for 3200 m grid

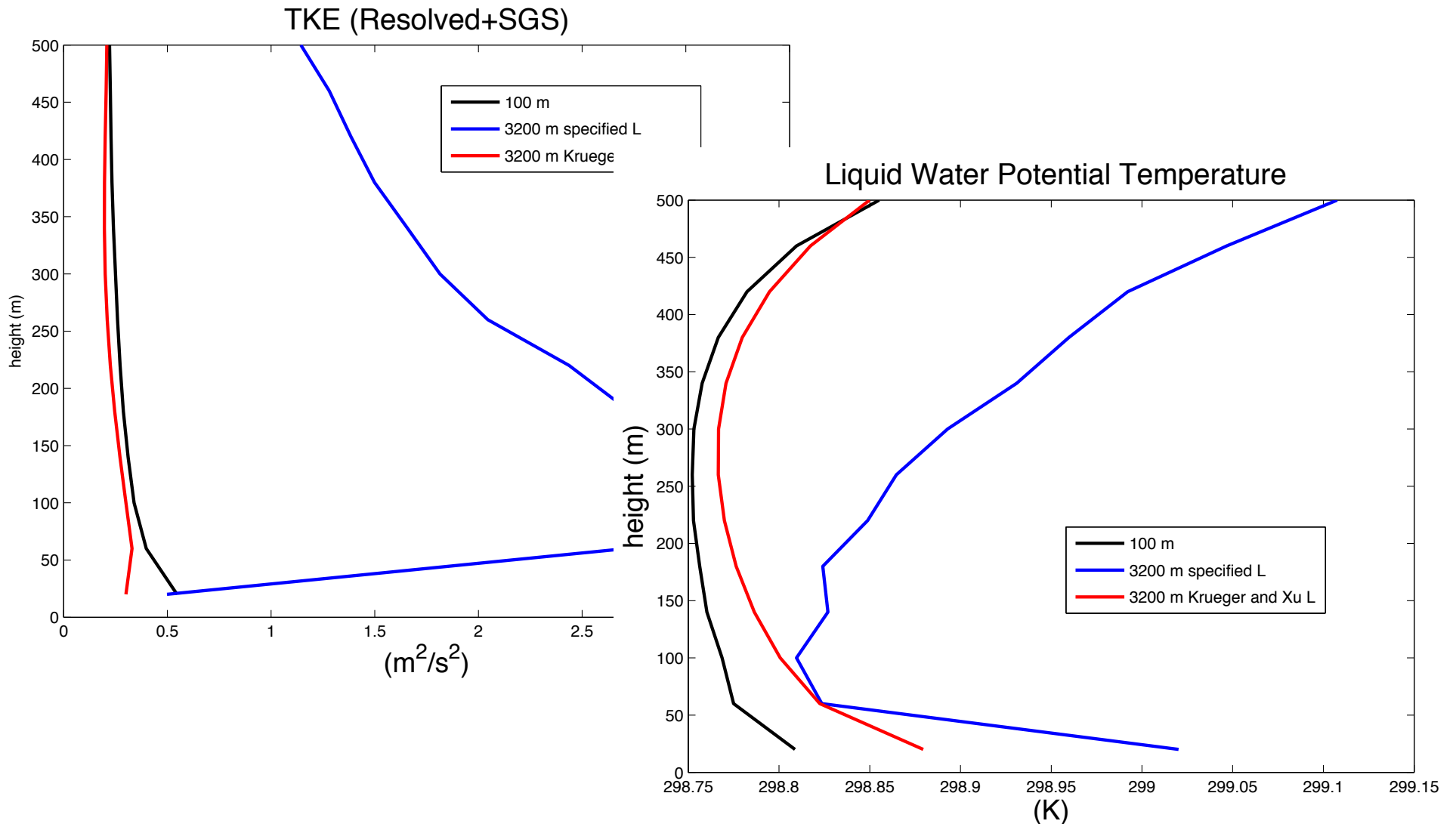


CABL

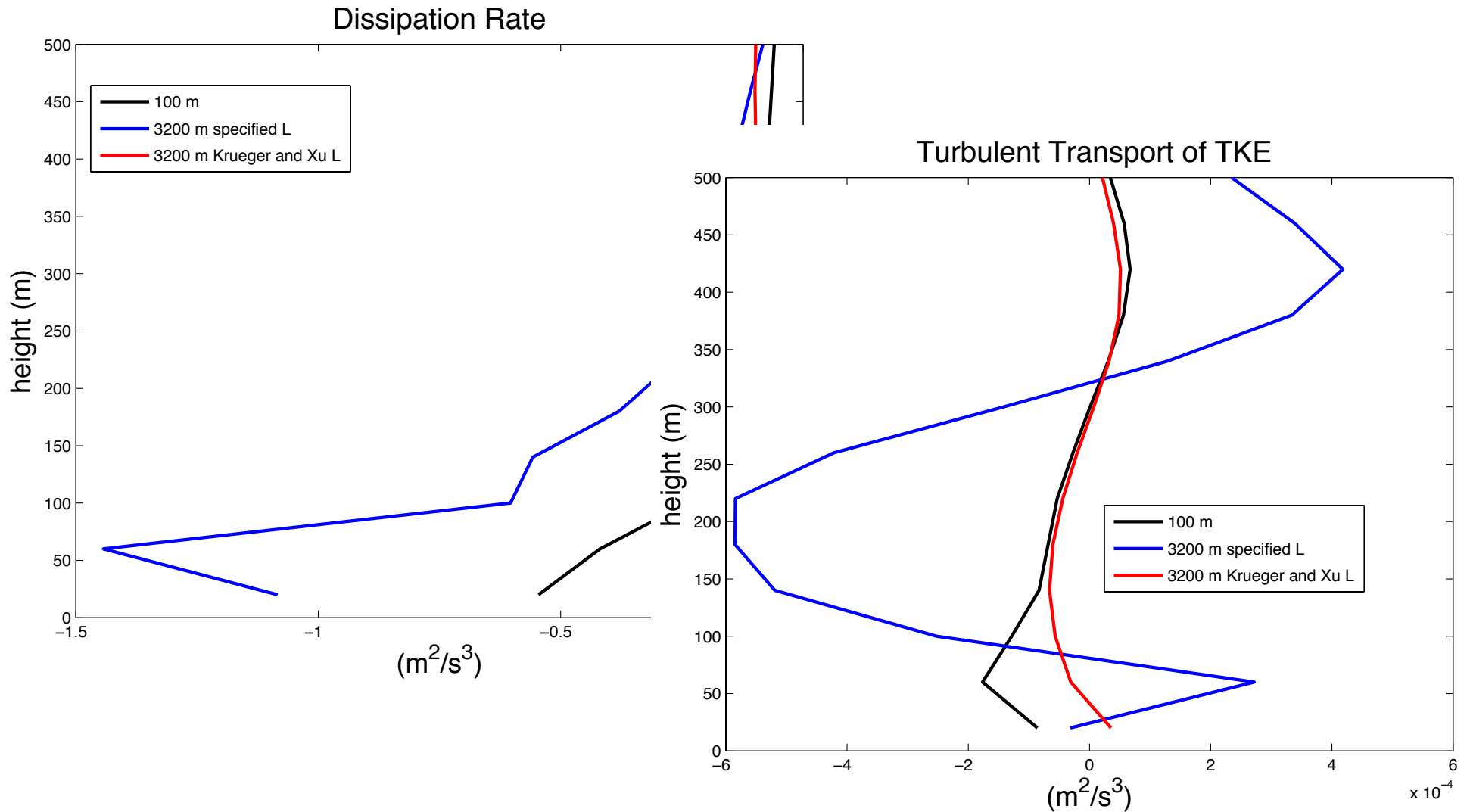
Effects of Modified Length Scale



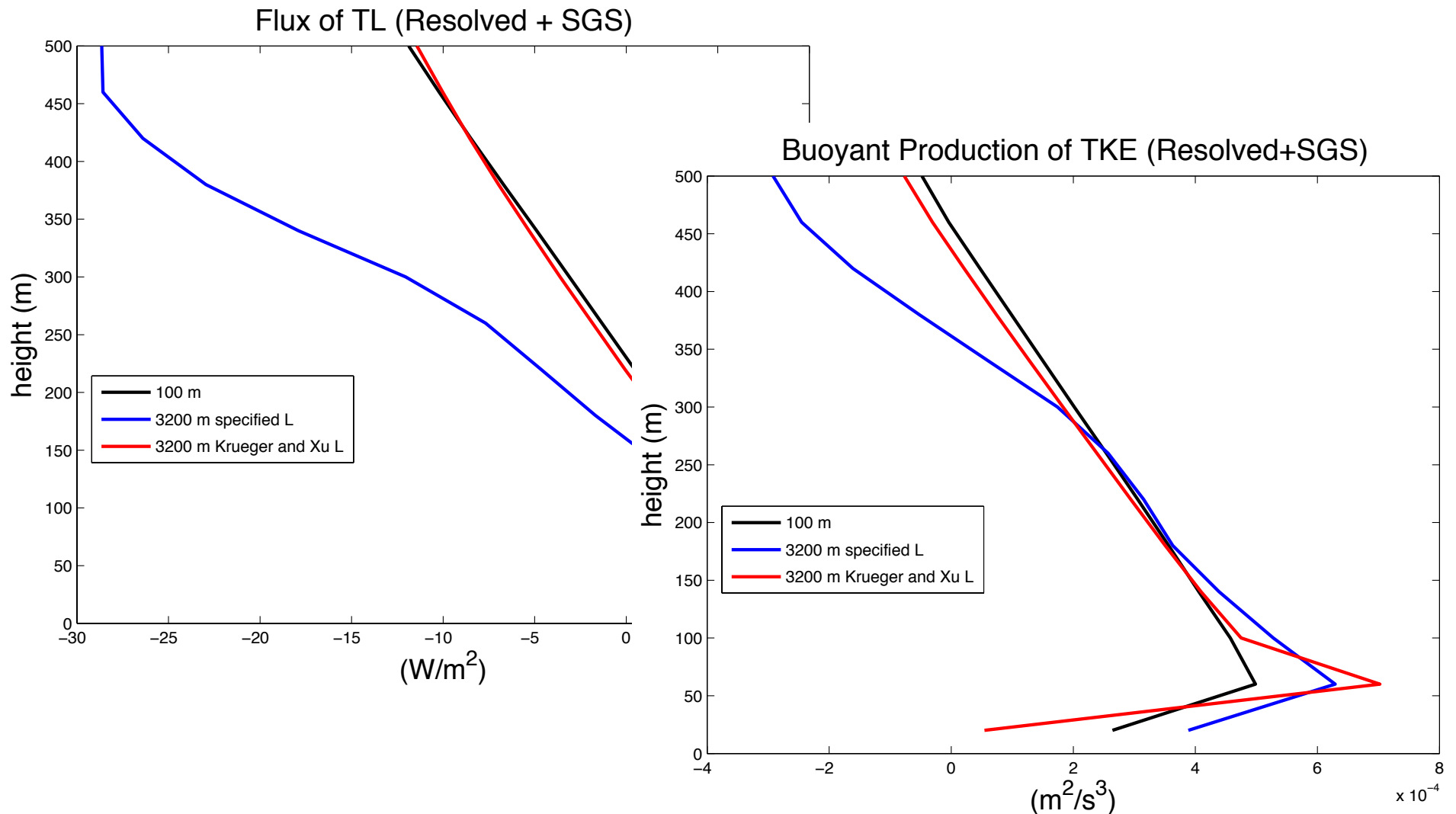
BOMEX (well mixed layer only) Effects of Modified Length Scale



BOMEX (well mixed layer only) Effects of Modified Length Scale



BOMEX (well mixed layer only) Effects of Modified Length Scale



Future Work

- Add stability correction term to modified length scale definition (near inversion layers)
- Compute characteristic length scales for remainder of cases (BOMEX & GCSS ARM) from benchmarks
- Run 3.2 km hor. res. with modified length scale for ALL five cases
- Examine length scale for clouds (GATE, BOMEX, ARM)!
- New formulation for the mixing length