EllipSys3D forest extension validation

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February 29, 2012

DTU

Overview

1. Introduction
2. Validation of forest implementation in Ellipsys3D against SCADIS with simple boundary conditions
3. Effect of LAI and PAD on the solution
4. Test comparison: "Spruce Forest" canopy

Introduction

- Use of the $k - \epsilon$ model w/h modified constants
- Modification of the transport equations to account for forest presence

Extension: Sogachev (2009)

Momentum:

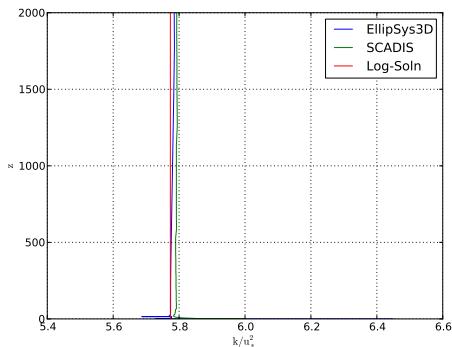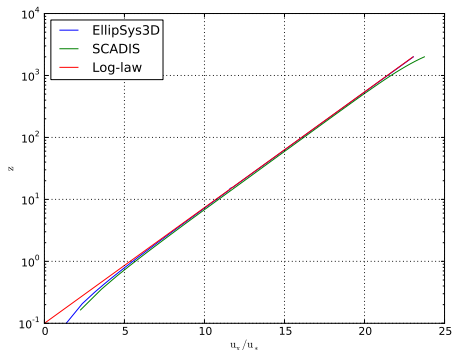$$\frac{\partial u_i}{\partial t} = ... - c_d a(z) u_i |U|$$

Dissipation:

$$\frac{\partial \epsilon}{\partial t} = ... - 12 C_\mu^{1/2} c_d a(z) |U| (C_{\epsilon 1} - C_{\epsilon 2}) \epsilon$$
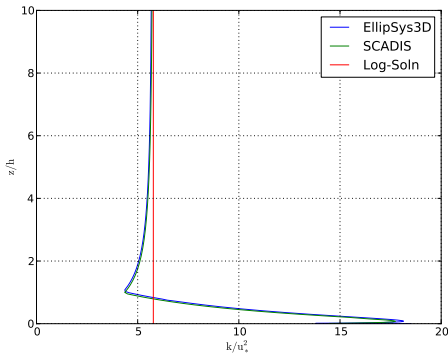
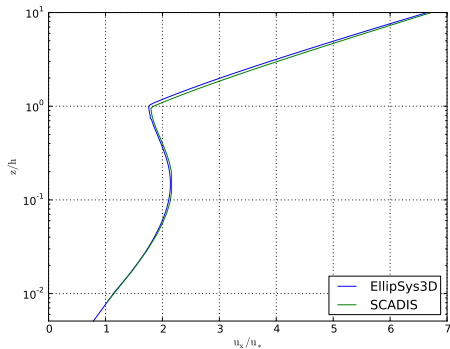- Length-scale limitation (Apsley and Castro, 1997)

EllipSys vs SCADIS
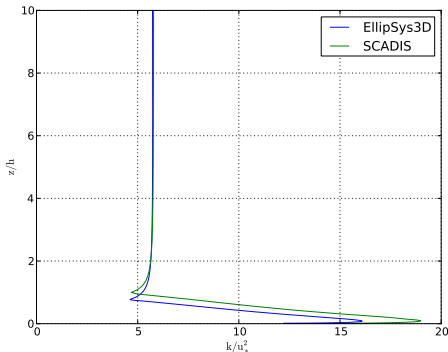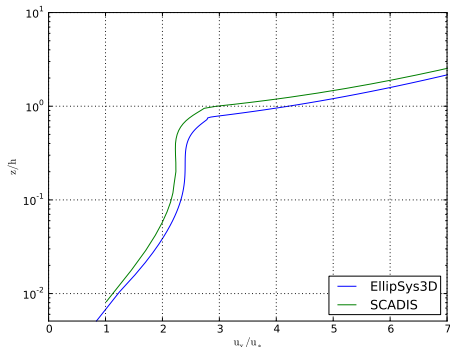
No forest, periodic inlet-outlet, fixed values BC on top.

EllipSys vs SCADIS

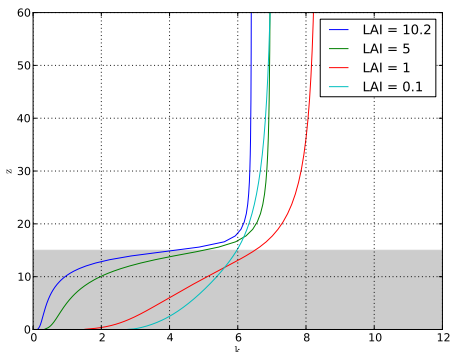With forest, periodic inlet-outlet, fixed values BC on top, **without** sink term in the ϵ equation
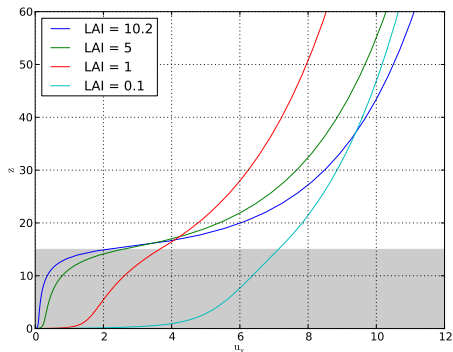
EllipSys vs SCADIS

With forest, periodic inlet-outlet, fixed values on top, **with** sink term in the ϵ equation
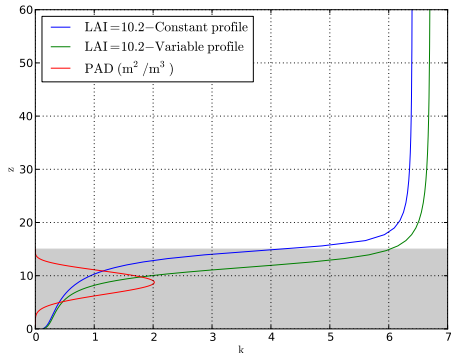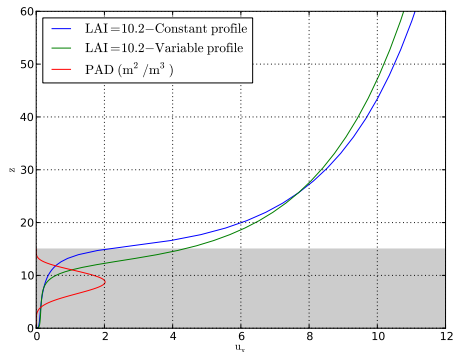
Varying LAI

Coriolis forcing (without length scale limitation): rough effect of a varying LAI (constant PAD)
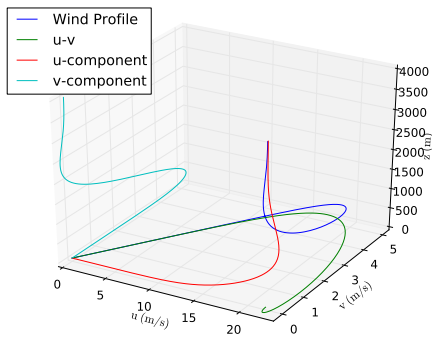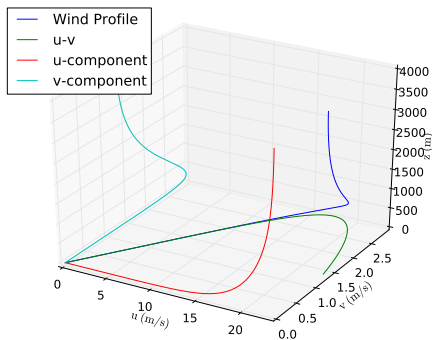
Non-uniform vs uniform PAD

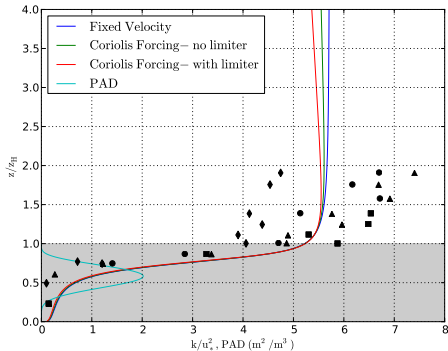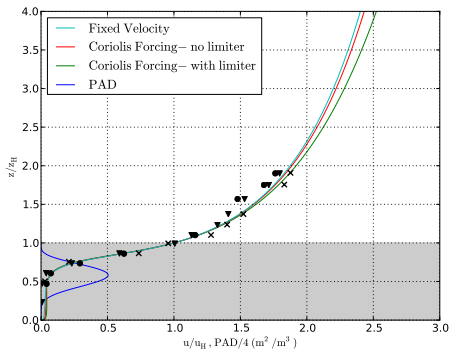Coriolis forcing (without length scale limitation): non-uniform vs uniform PAD

"Spruce forest canopy" - 1

Coriolis forcing, **no forest**, **without** length scale limitation (left), **with** length scale limiter (right): effect of turning of the wind

"Spruce forest canopy" - 2

Coriolis forcing vs fixed values at top boundary: comparison with measurements

Thank you for your attention!

References:

- Sogachev, A (2009) A note on two-equation closure modelling of canopy flow. Boundary-Layer Meteorol. 130:423-435.
- Apsley DD and Castro IP (1997) A limited-length-scale $k - \epsilon$ model for the neutral and stably-stratified atmospheric boundary layer. Boundary-Layer Meteorol. 83:75-98.

Supplements

- LAI leaf area per unit ground surface

  e.g.: LAI = ratio canopy-sky

- a(z) leaf area per unit volume of space: $LAI = \int_0^{h_c} a(z)dz$