Impact of tall vegetation on turbulent flow over orography

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Normalized surface pressure

- Specified roughness
- Resolved canopy

\[ \frac{p}{\rho U_{Sc}^2} \]

Max Slope = 0.2
Normalized momentum flux

\[ \langle u''w'' \rangle_{y,z} / U_{Sc}^2 \]

Mean wind

surface roughness

resolved canopy
Influence of variations in plant area index (PAI)
Expected PAI influence on separation

Finnigan and Belcher (2004): \[
\frac{Z_s}{h_c} = \frac{1}{2\beta h_c} \ln \left( \frac{U_o^2}{U_h^2} \frac{H}{2k^2 L_c} \right) < 1
\]
sparse canopy

dense canopy
Mean wind

sparse canopy

dense canopy
Kinematic Pressure

Mean wind

sparse canopy
dense canopy
Normalized Turbulent Kinetic Energy

Mean wind

sparse canopy
dense canopy
Summary

• Specified roughness ≠ Resolved canopy

• Finnigan and Belcher (2004) theory accurately predicts separation for canopy density variations

• Increase in PAI mimics the shift from specified roughness to a resolved canopy

• 10-fold increase in PAI increases the orographic pressure drag by about 15%

• Turbulence levels increased up to heights equaling a hill half-length ($L$) and above