The wind profile in large eddy simulations of the neutral and near-neutral atmospheric boundary layer

The effect of the free atmosphere Brunt Vaisala frequency and the surface heat flux

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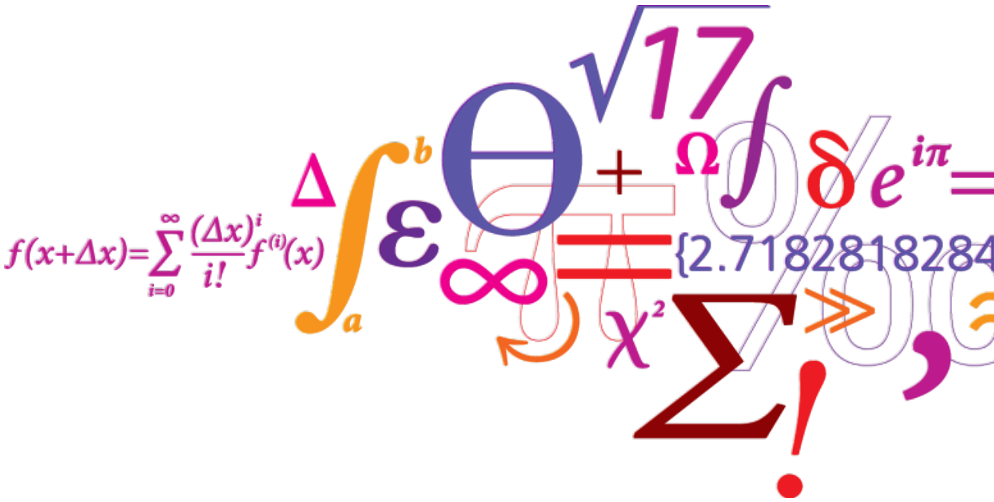
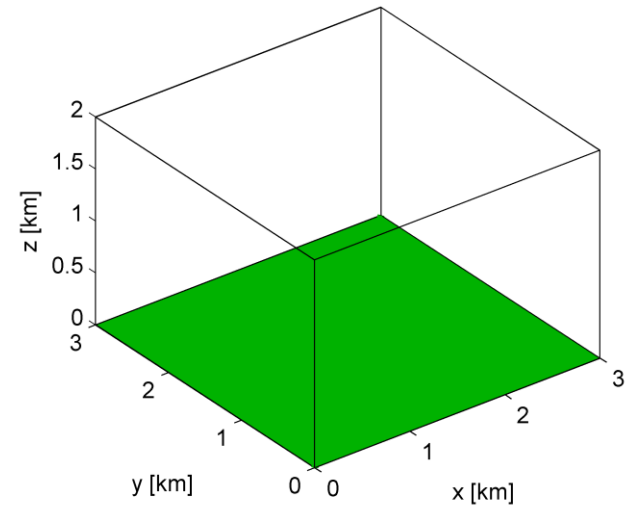
Mark Kelly



DTU Wind Energy
Department of Wind Energy

Simulations

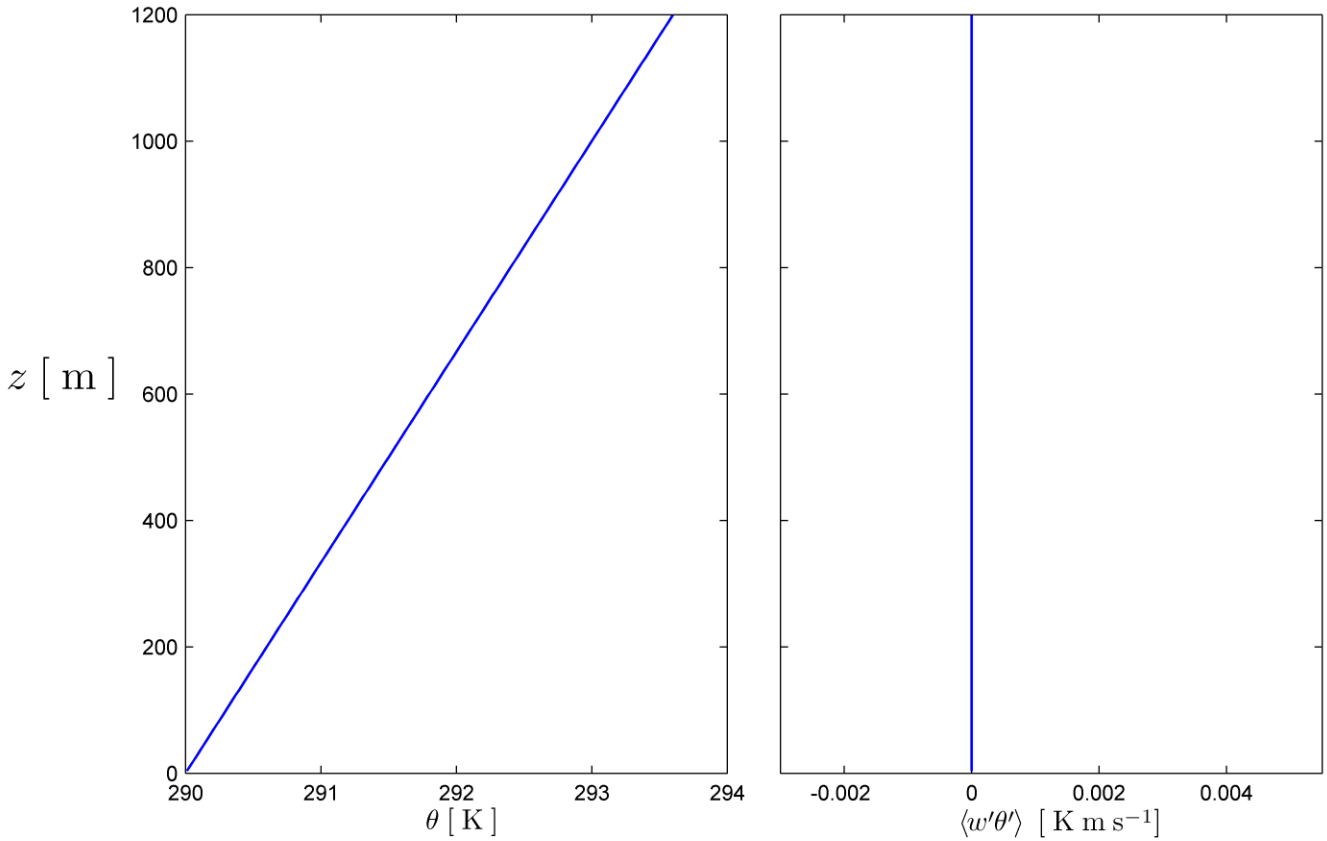
#	$N = \left(\frac{d\theta}{dz}\frac{g}{\theta}\right)^{0.5}$ $[\mathrm{s}^{-1}]$	$\overline{w'\theta'}_s$ $[\mathrm{k\,m\,s^{-1}}]$
1	0.006	0
2	0.010	0
3	0.014	0
4	0.018	0
5	0.010	0.001
6	0.010	0.003
7	0.010	0.005



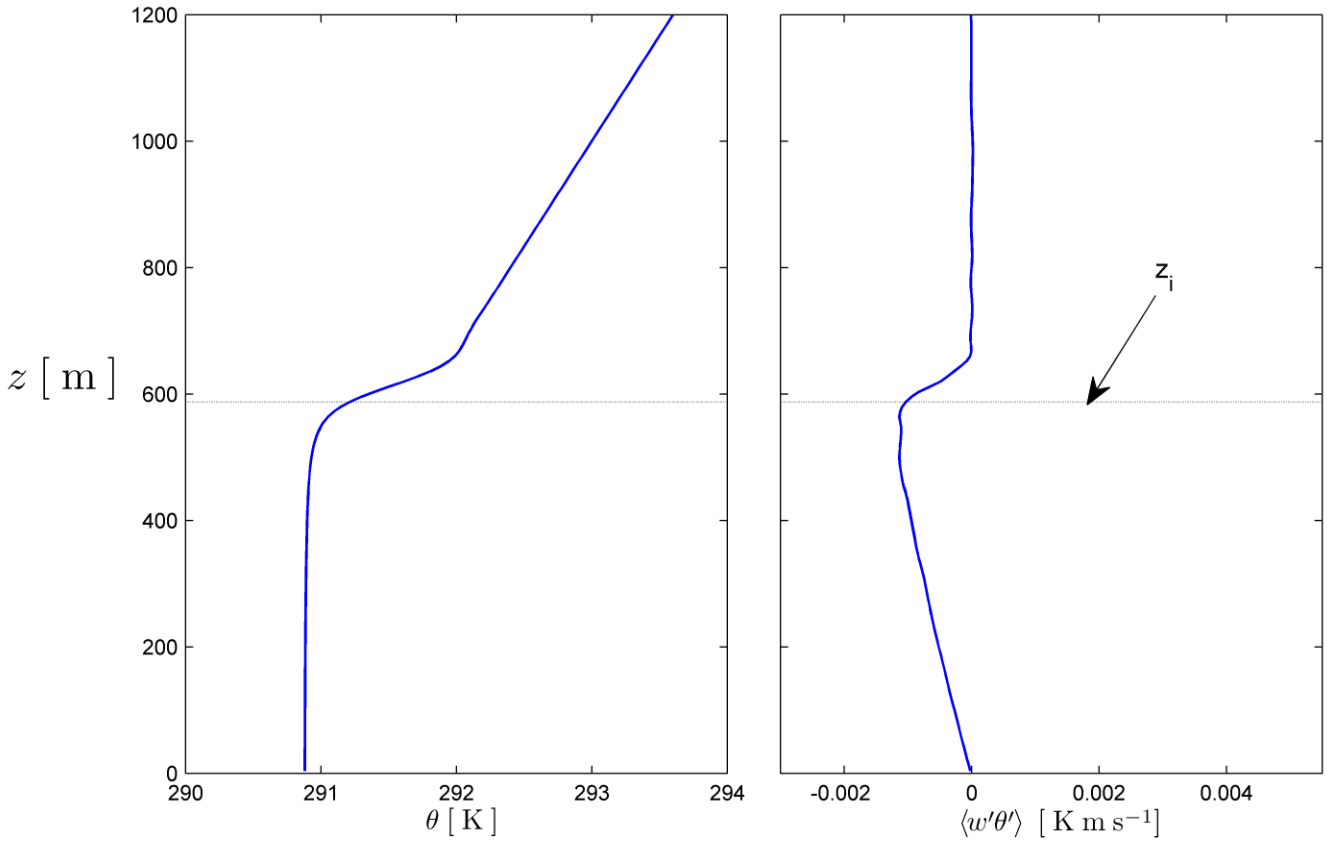
$$U_g = -\frac{1}{\rho f}\frac{dp}{dy} = 10\ \mathrm{m\ s^{-1}}$$

$$V_g = \frac{1}{\rho f}\frac{dp}{dx} = 0\ \mathrm{m\ s^{-1}}$$

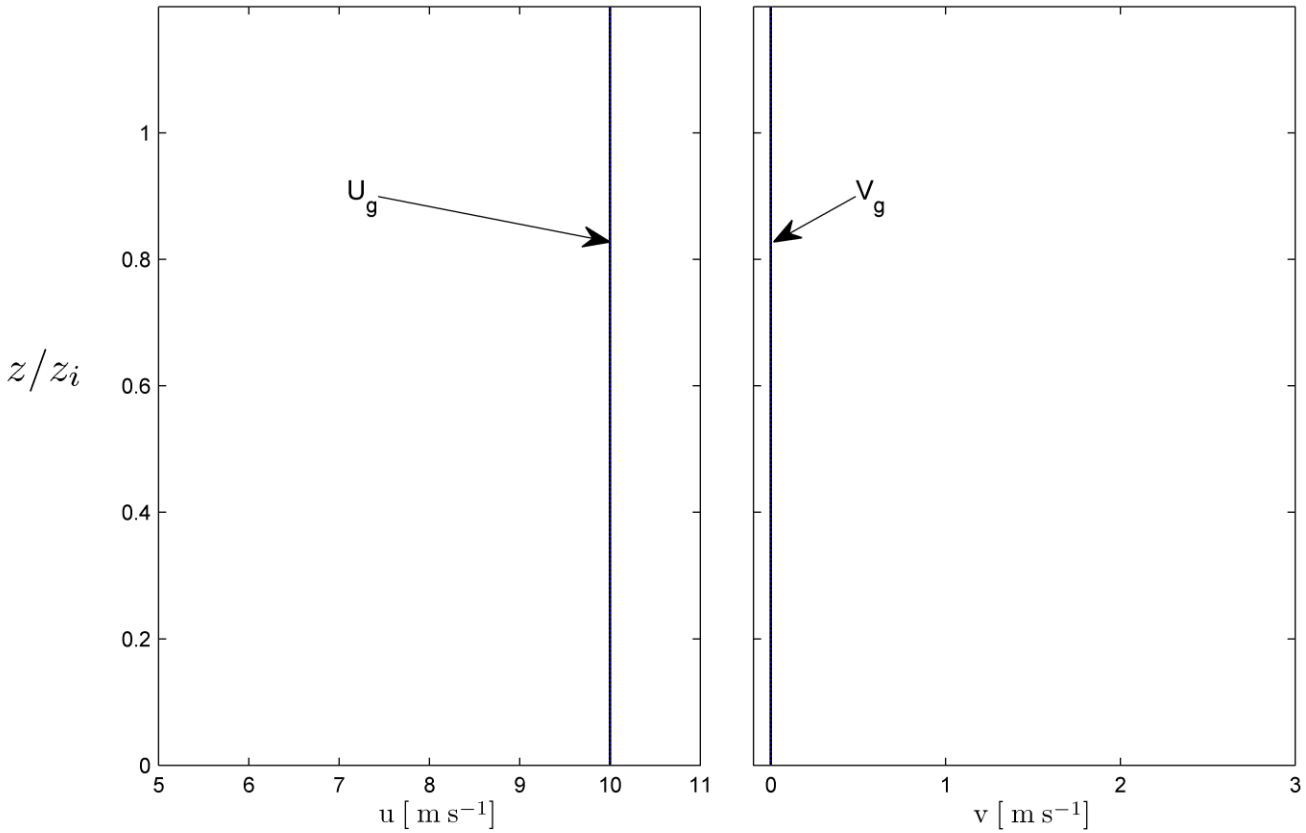
Potential temperature and heat flux



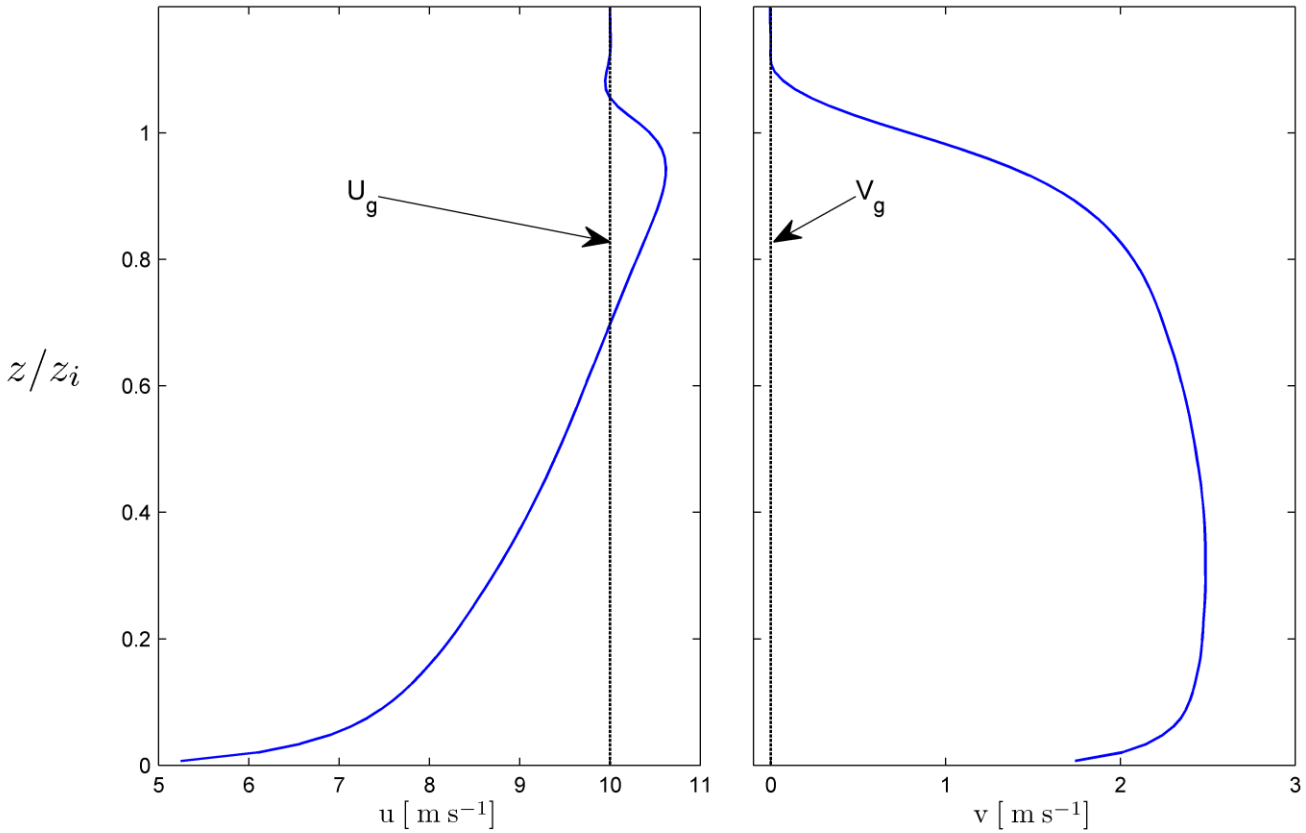
Potential temperature and heat flux



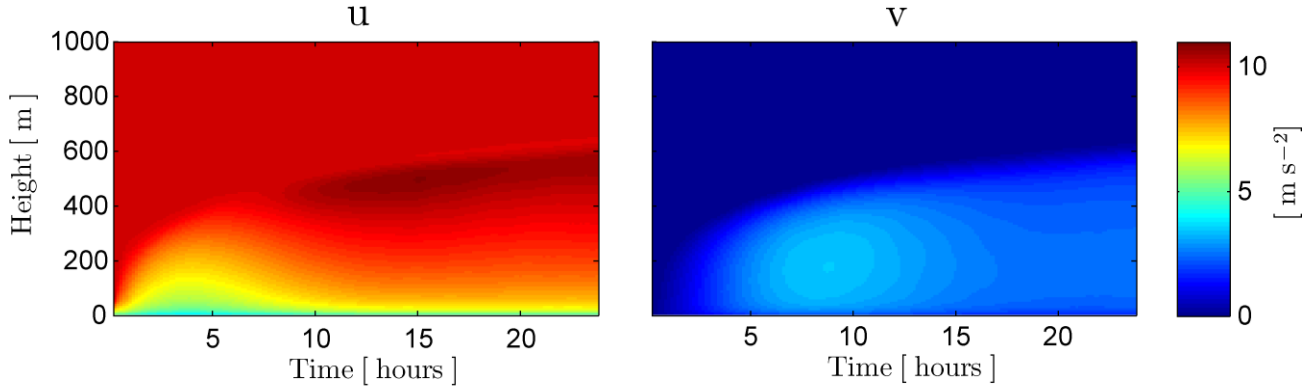
Wind profiles



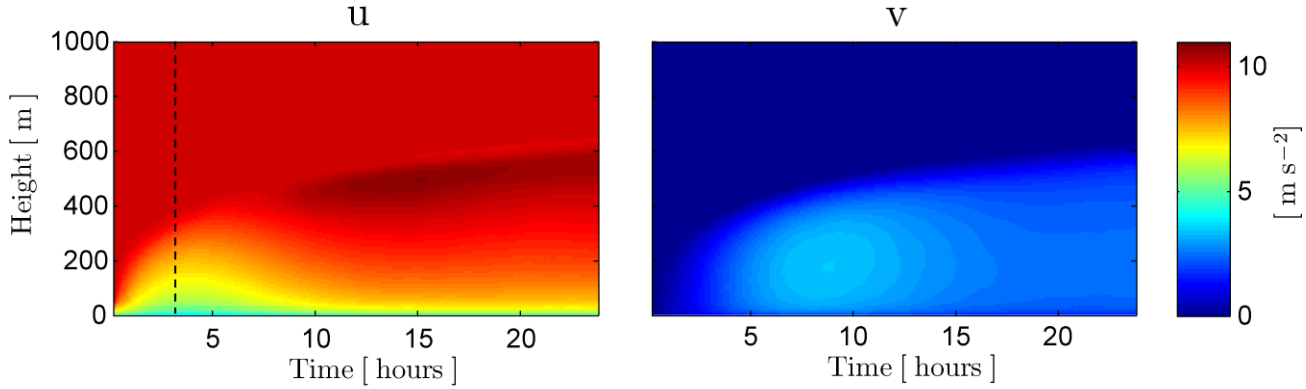
Wind profiles



The neutral ABL

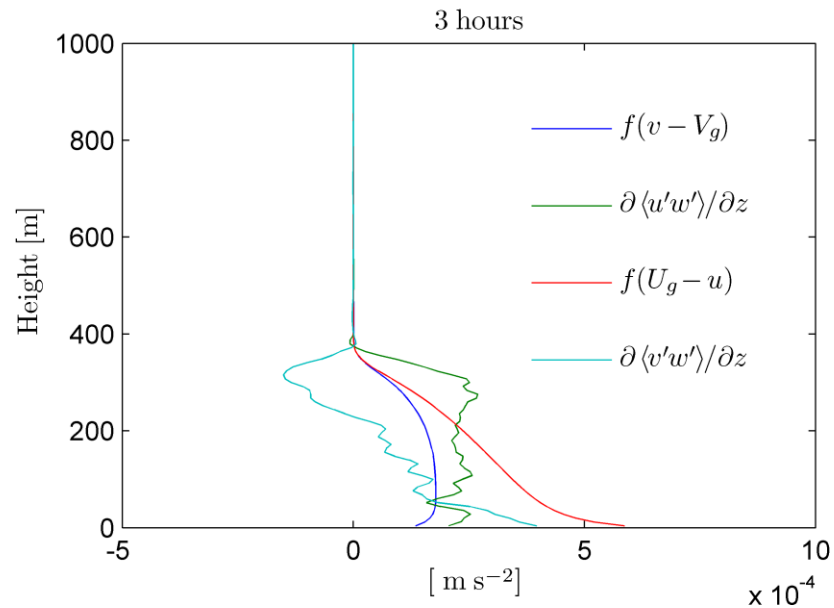


The neutral ABL

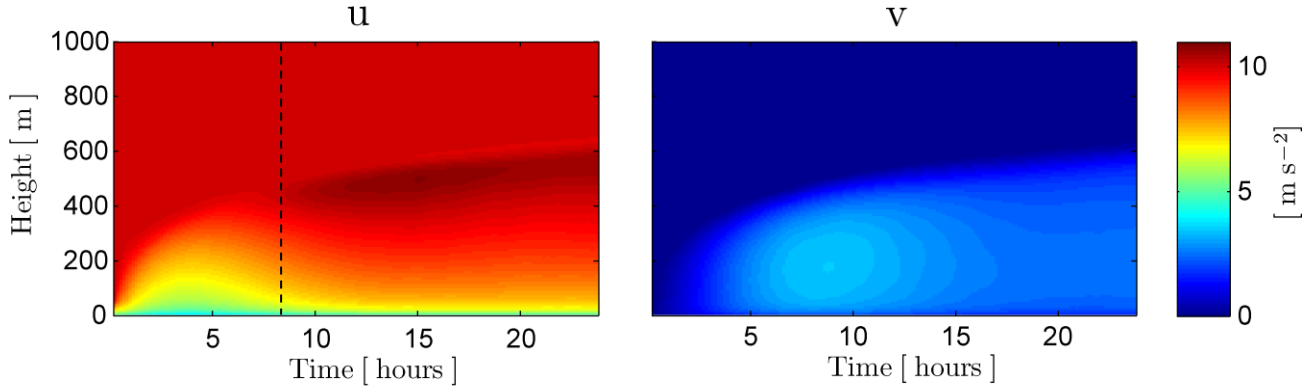


$$\frac{\partial u}{\partial t} = f\left(v - V_g\right) - \frac{\partial \langle u'w' \rangle}{\partial z}$$

$$\frac{\partial v}{\partial t} = f\left(U_g - u\right) - \frac{\partial \langle v'w' \rangle}{\partial z}$$



The neutral ABL



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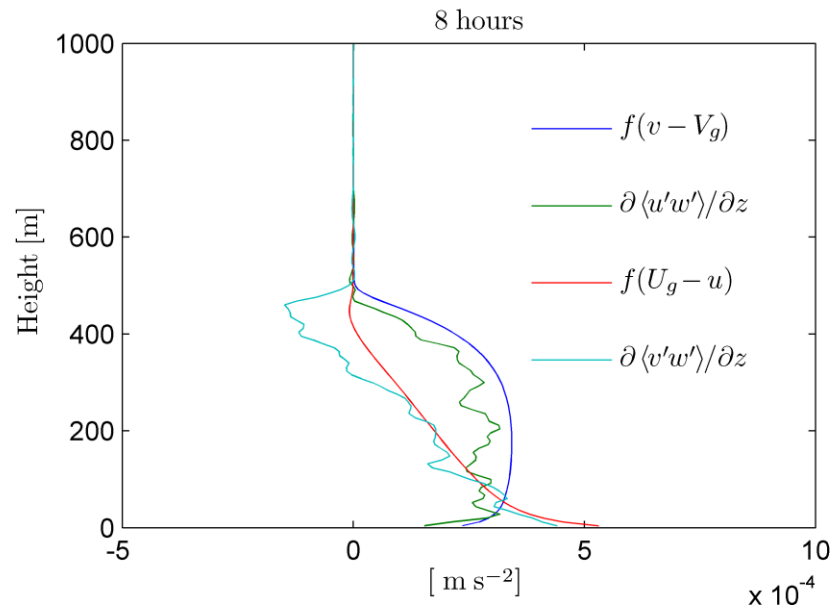
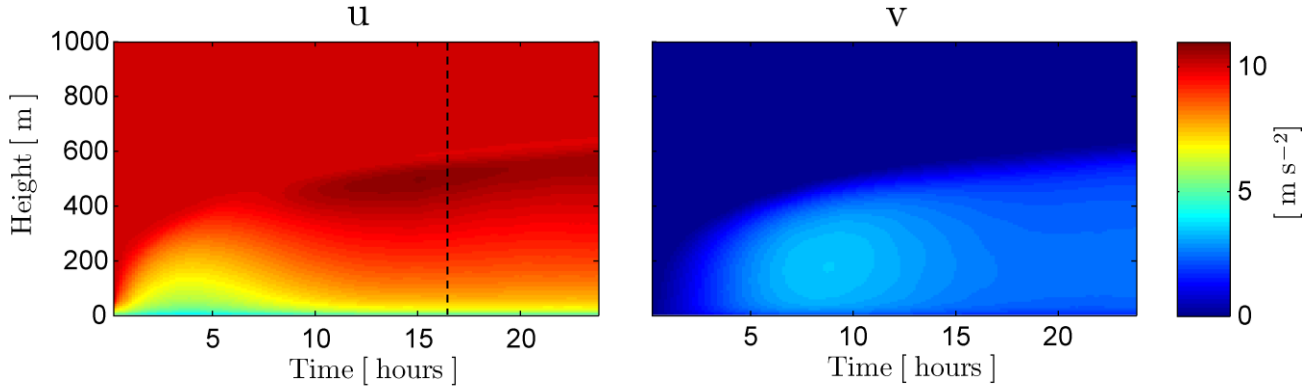


The neutral ABL



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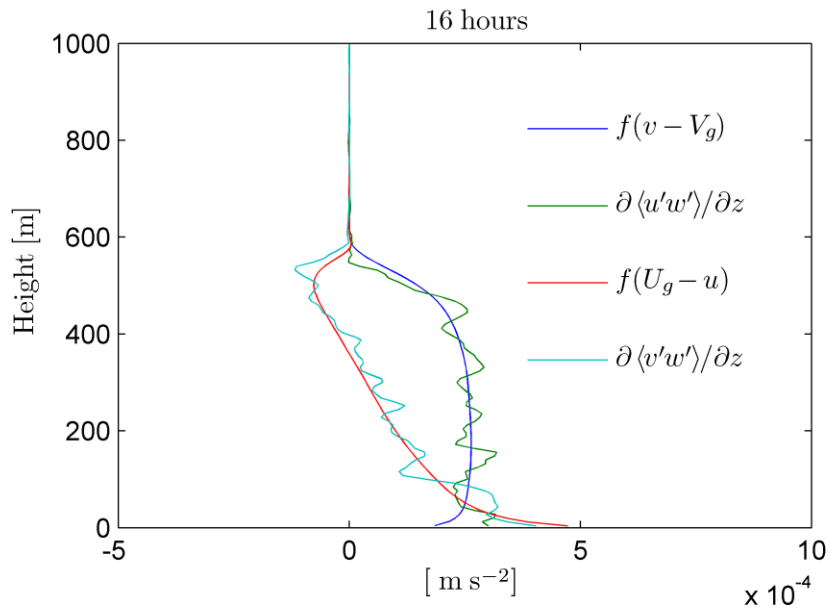
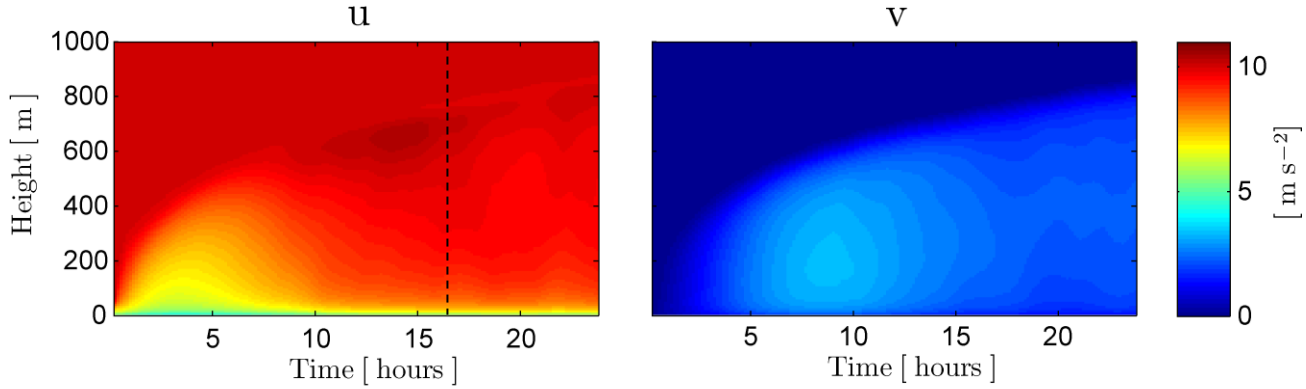


The near-neutral ABL



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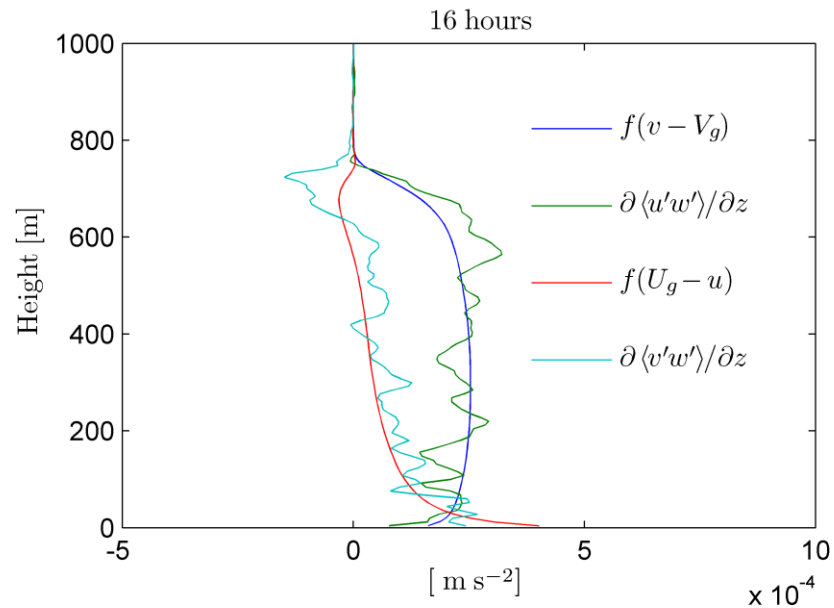
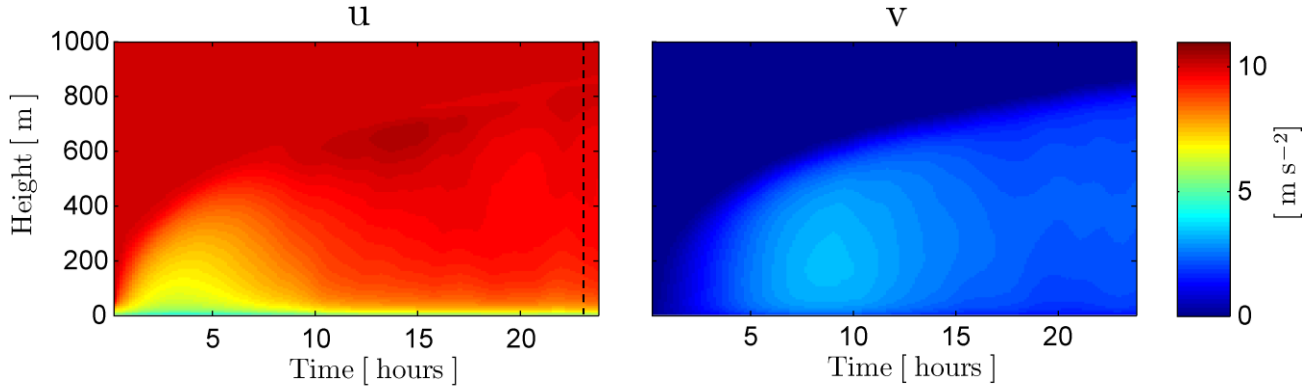


The near-neutral ABL



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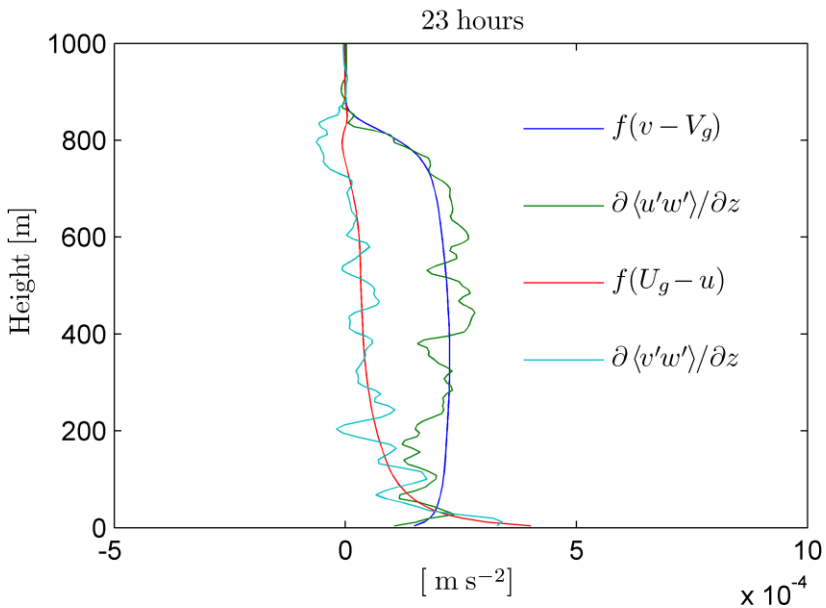
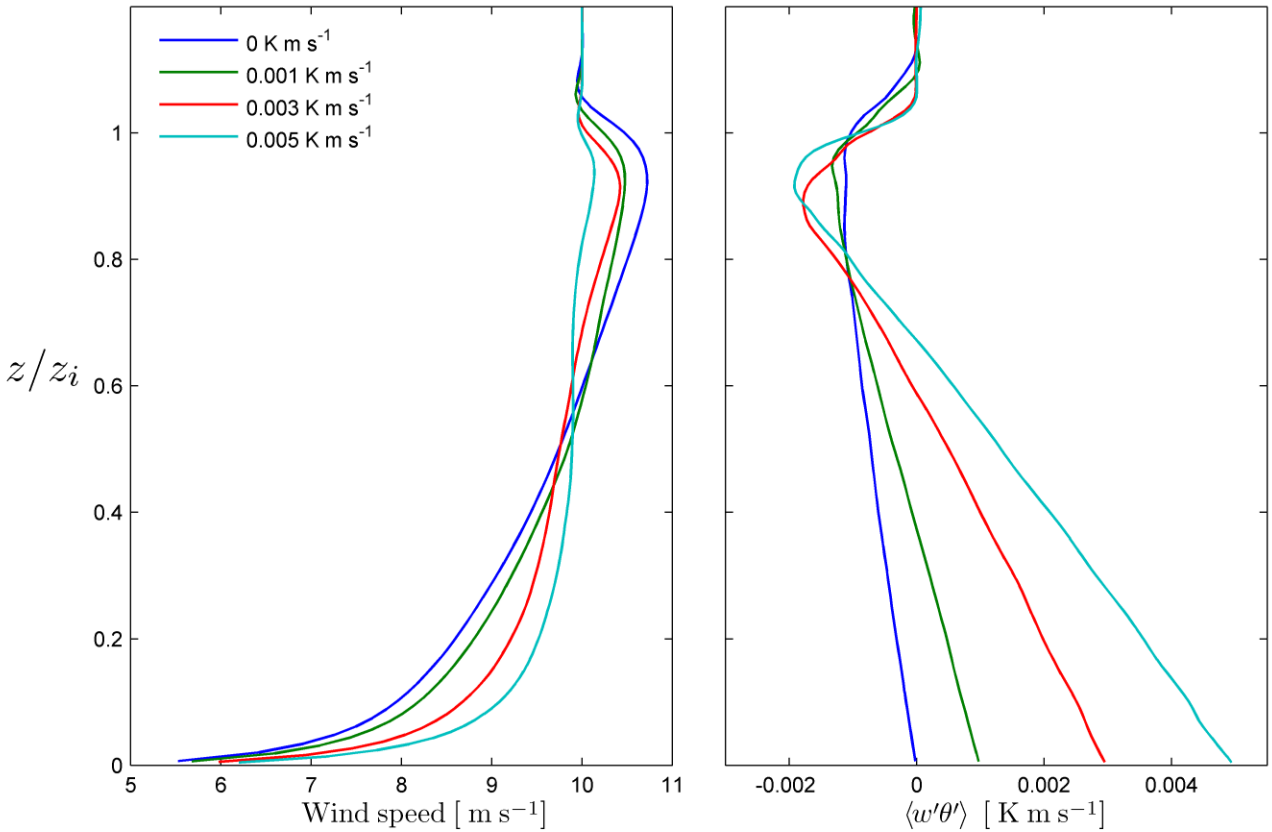


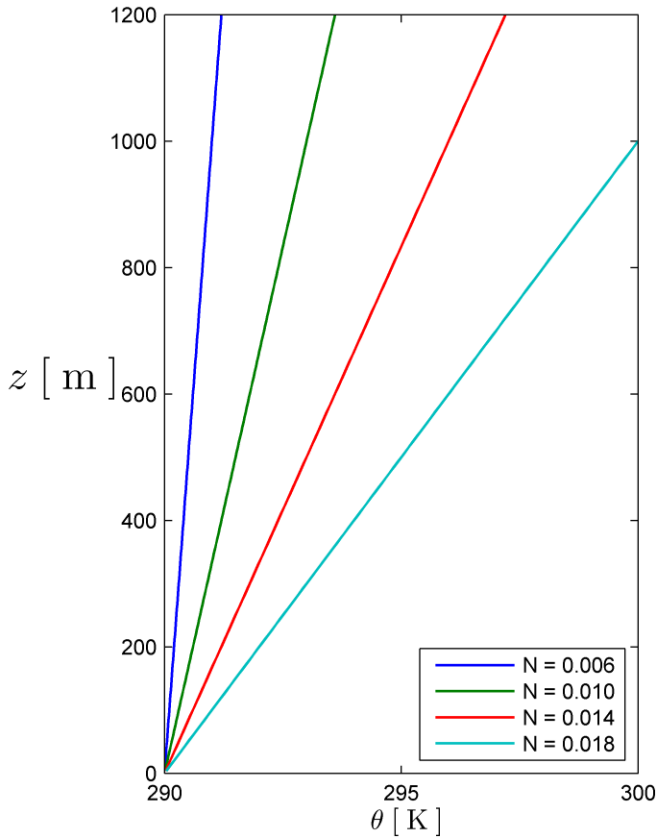
Profiles of wind speed and heat flux

$N = 0.01\ \mathrm{s}^{-1}$



Profiles of temperature and wind speed

$\overline{w'\theta'}_s = 0$



Profiles of temperature and wind speed

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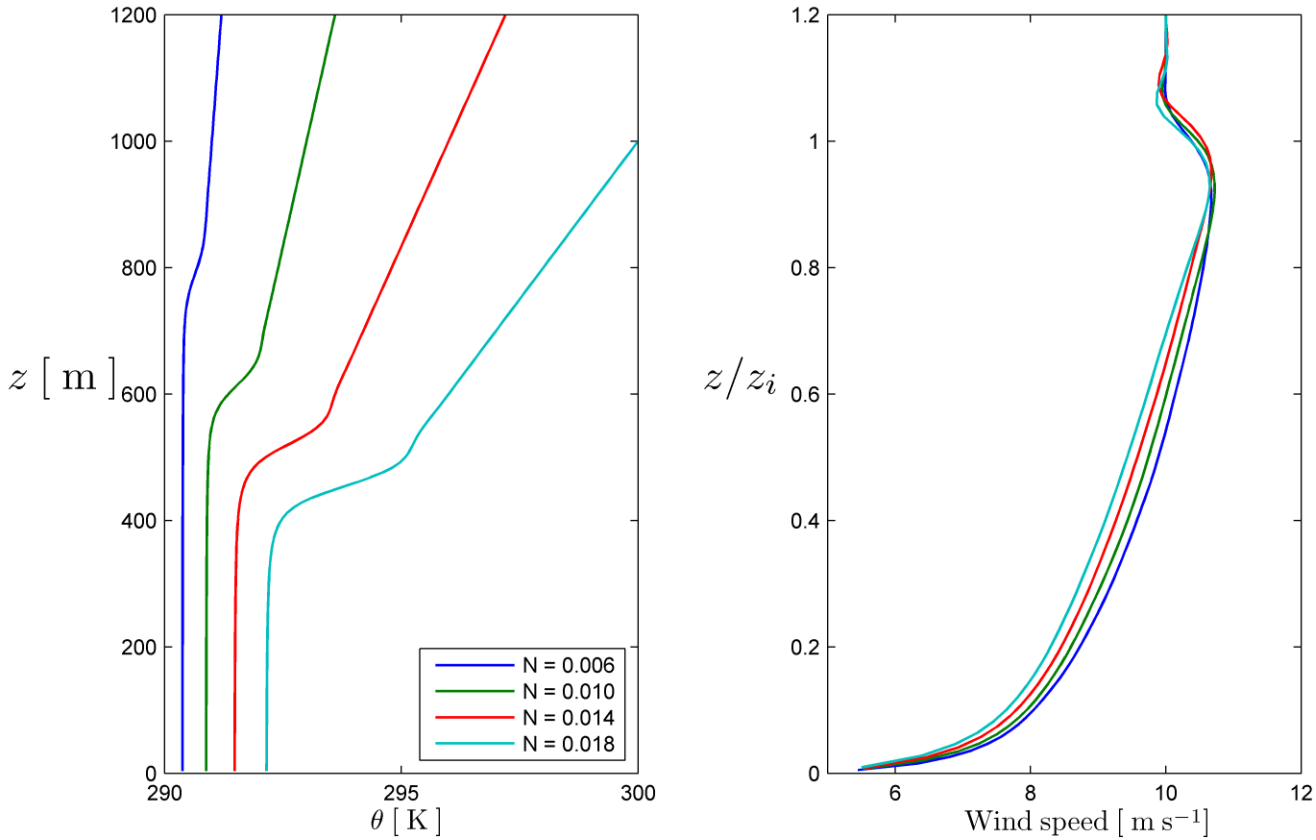

Summary

- ”Spin-up” time for LES of the neutral/near-neutral ABL ~17 hours
- In neutral conditions a super-geostrophic jet forms after ~8 hours
- Small increments of the surface heat flux decreases the size of the jet and the wind shear throughout the ABL
- Increasing *N* decreases the wind speed in the middle of the ABL
- The maximum wind speed (peak of the jet) is independent of *N*