Comparison of wind profiles and WRF at Høvsøre

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flow center meeting

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Introduction

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- Leosphere Windcube 70
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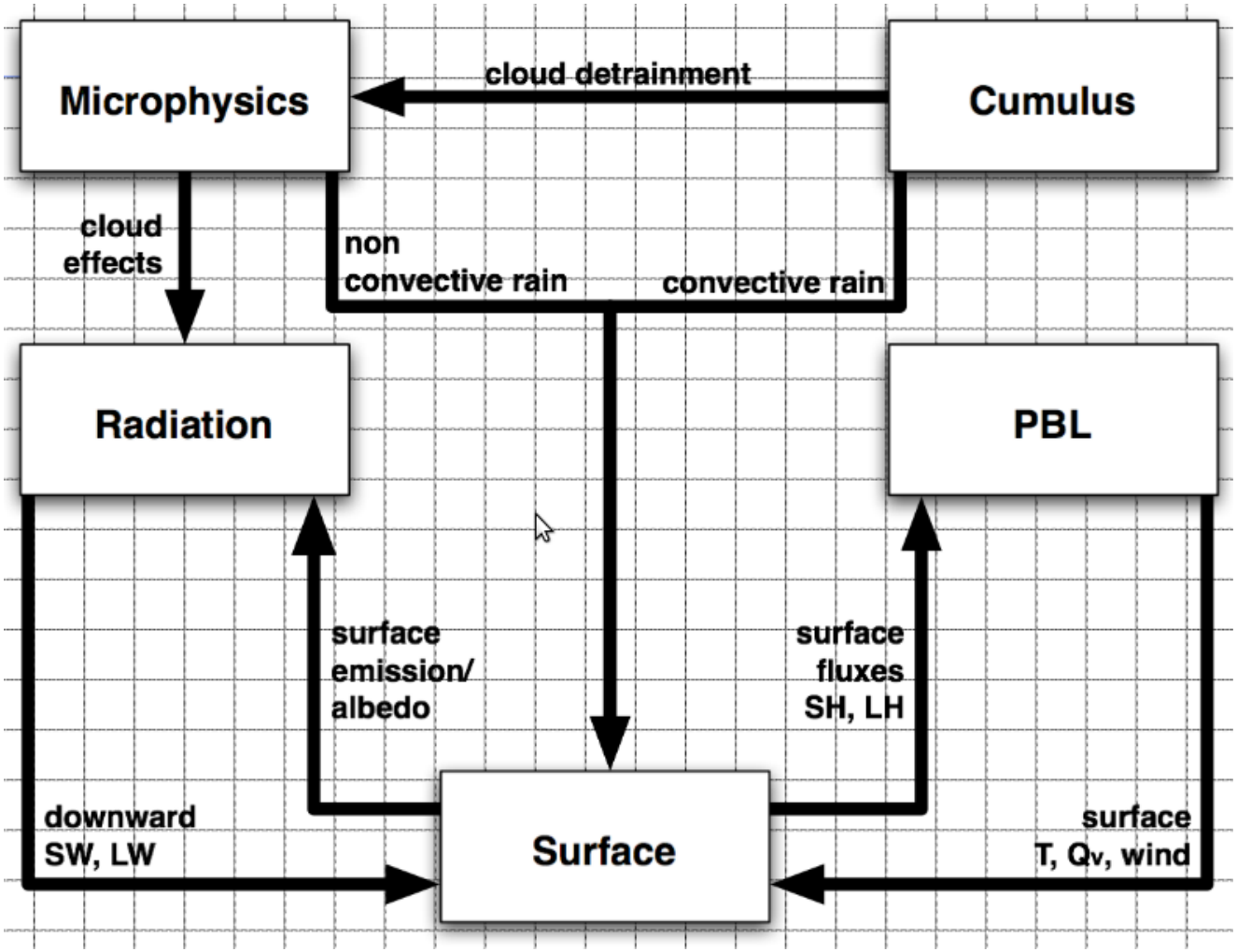
WRF v3.3 - Physics



WRF v3.3 - Physics

- Noah land surface scheme
- Thompson microphysics scheme
- RRTM longwave radiation
- Dudhia shortwave radiation
- New Kain-Fritsch cumulus scheme

WRF v3.3 - PBL schemes

Inputs:

- Mean profiles
- Surface fluxes

Outputs:

- Tendencies of T, Q_V, Q_C, Q_i, U, V
- Energy variable (TKE)
- Diagnostic variables

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WRF v3.3 - PBL schemes

$$\frac{\partial U}{\partial t} + \ldots = -\frac{\partial}{\partial z}\overline{u'w'} = \frac{\partial}{\partial z}\left(K_m \frac{\partial U}{\partial z}\right)$$

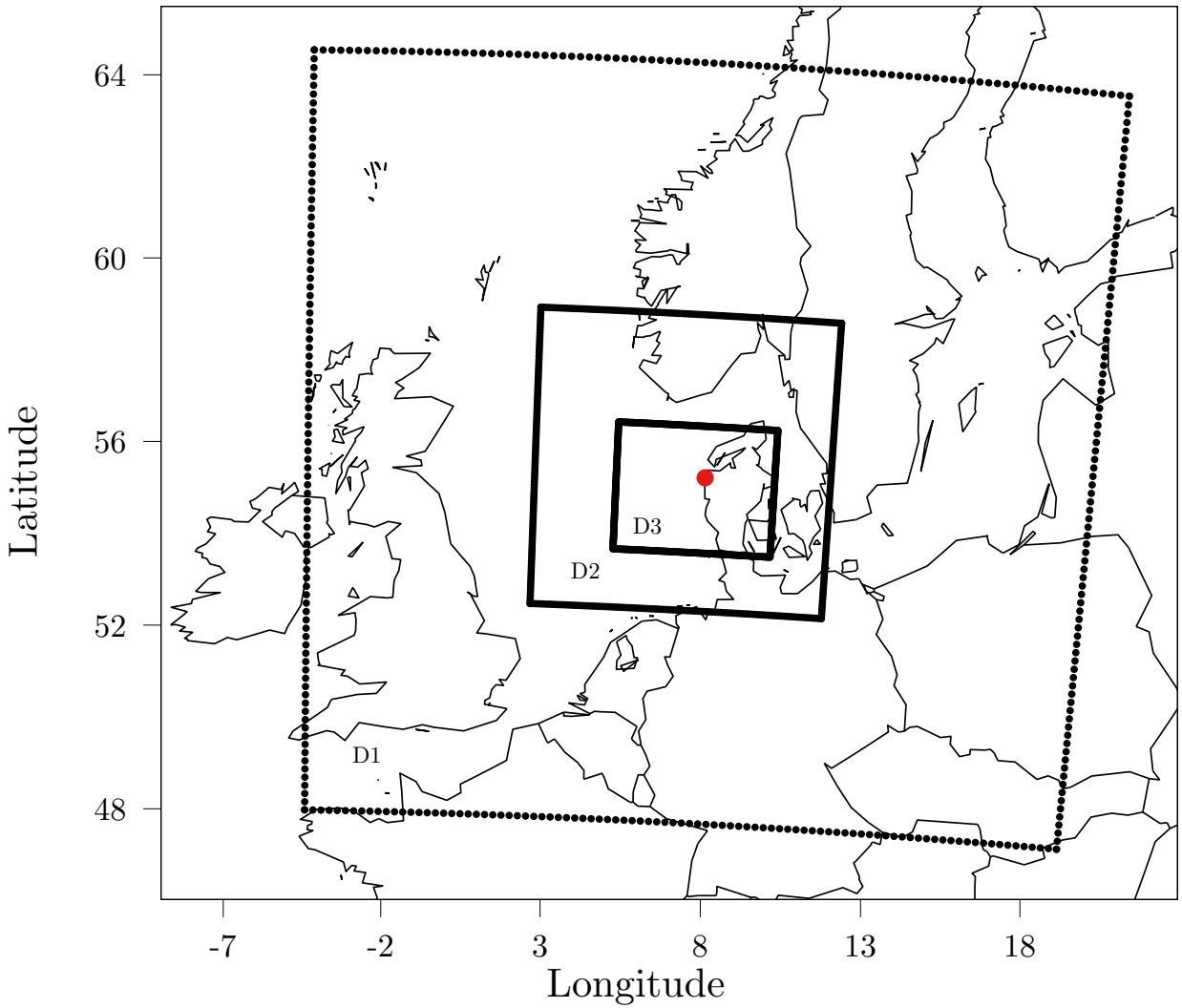
YSU (first order)

- $\frac{\partial}{\partial z}\left[K_m\left(\frac{\partial U}{\partial z} - \gamma_c\right) - \overline{u'w'}_h\left(\frac{z}{h}\right)^3\right]$
- $K_m = \kappa w_s z\left(1 - \frac{z}{h}\right)^2$
- $w_s = (u_*^3 + \phi_m \kappa w_{*b}^3 z/h)^{1/3}$

MYNN (1.5 order)

- $K_m = l\sqrt{e}S_c$
- e is given by a prognostic TKE equation
- l is a master length scale for the entire boundary layer

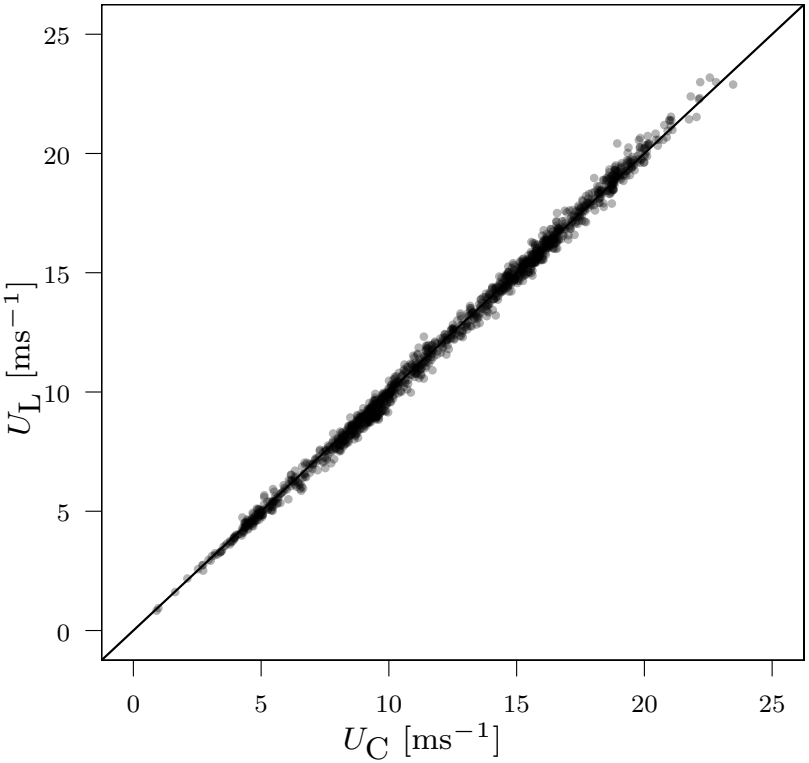
WRF v3.3 - Domain



Horizontal resolution: 18, 6, 2 km

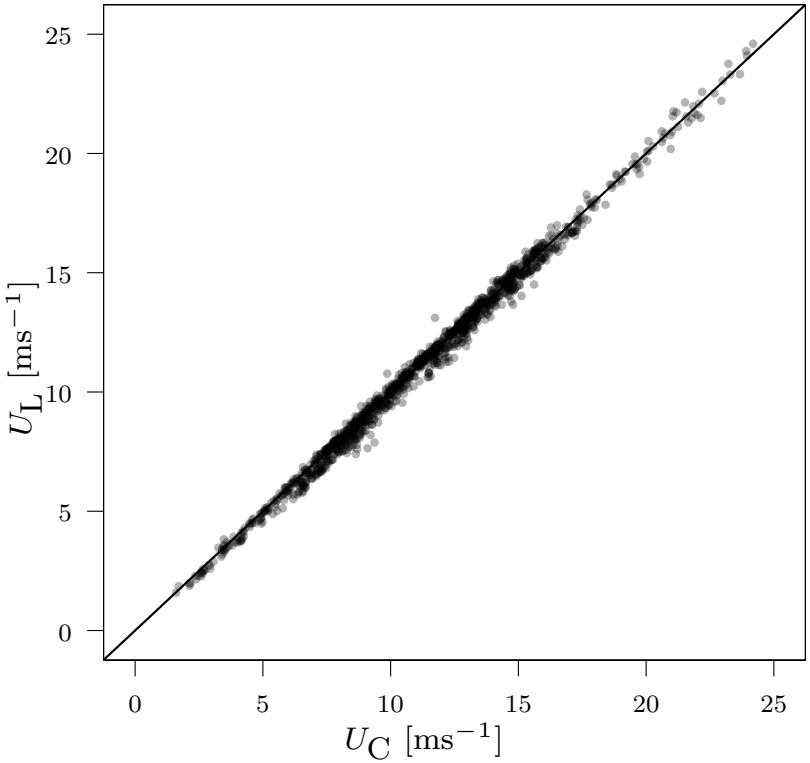
Leosphere WindCube 70

Wind speed at 100 m



15 – 30 September

$N = 2277$, $R^2 = 0.9995$

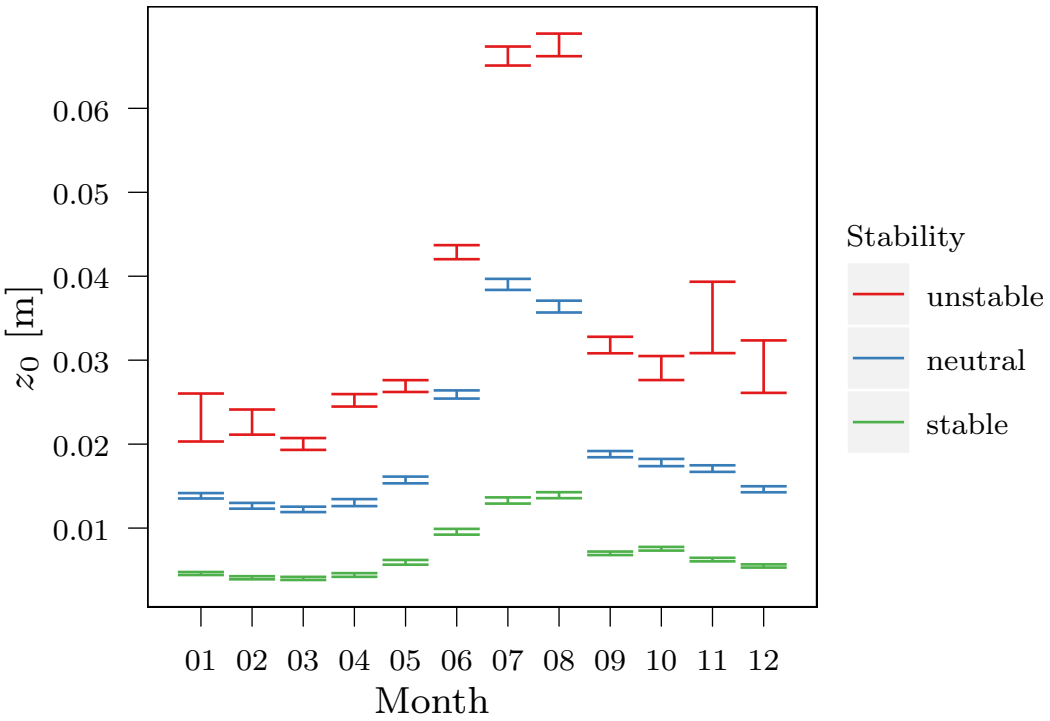


15 – 31 October

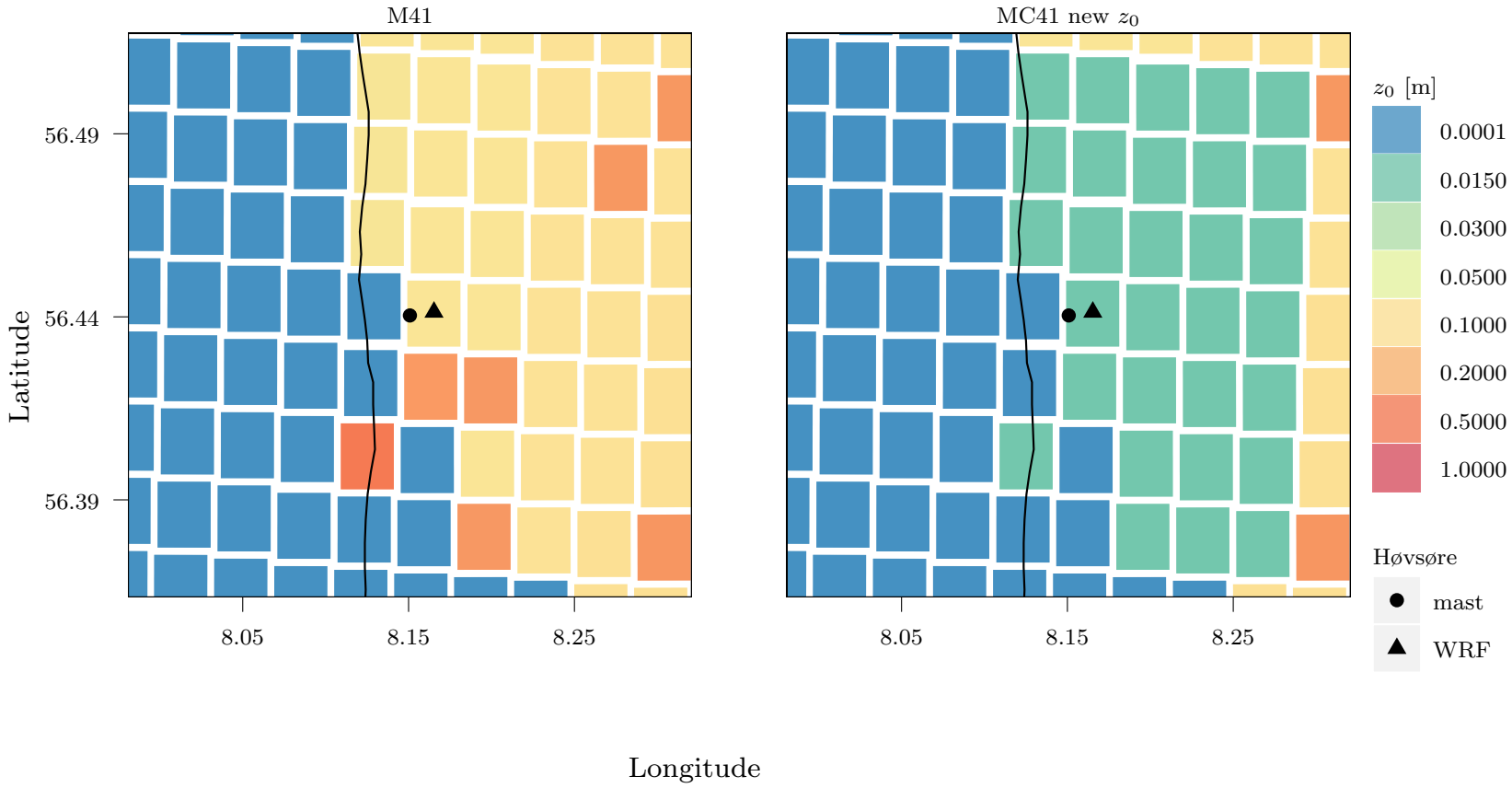
$N = 2310$, $R^2 = 0.9993$

Roughness calculated based on Monin-Obukhov similarity theory

- $\frac{U}{u_*} = \frac{1}{\varkappa}\ln\left(\frac{z}{z_0}\right) - \psi\left(\frac{z}{L}\right)$
- All measured at Høvsøre at 10 m, except for z_0
- Climatological mean for 2004-2011



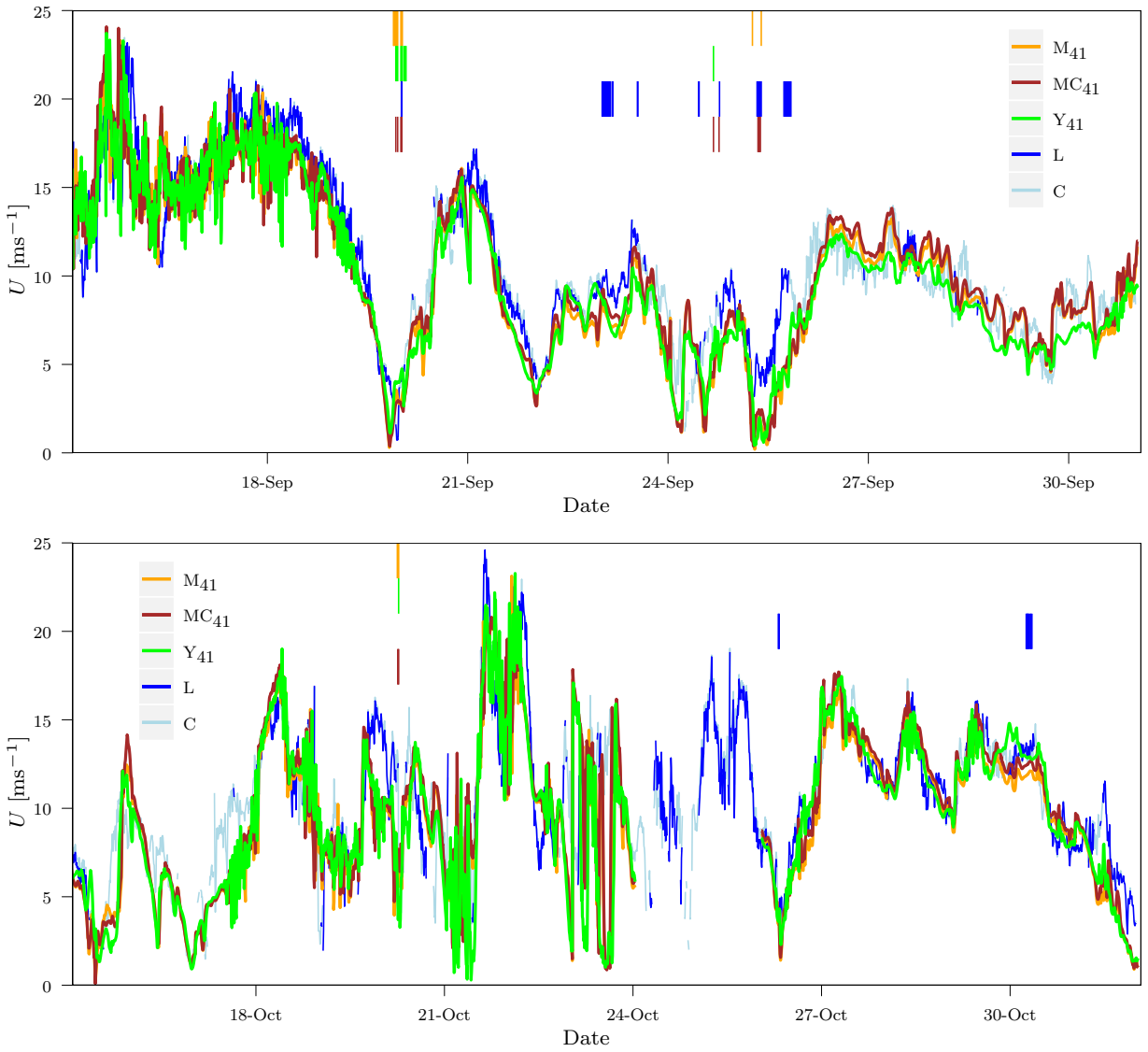
Roughness in WRF



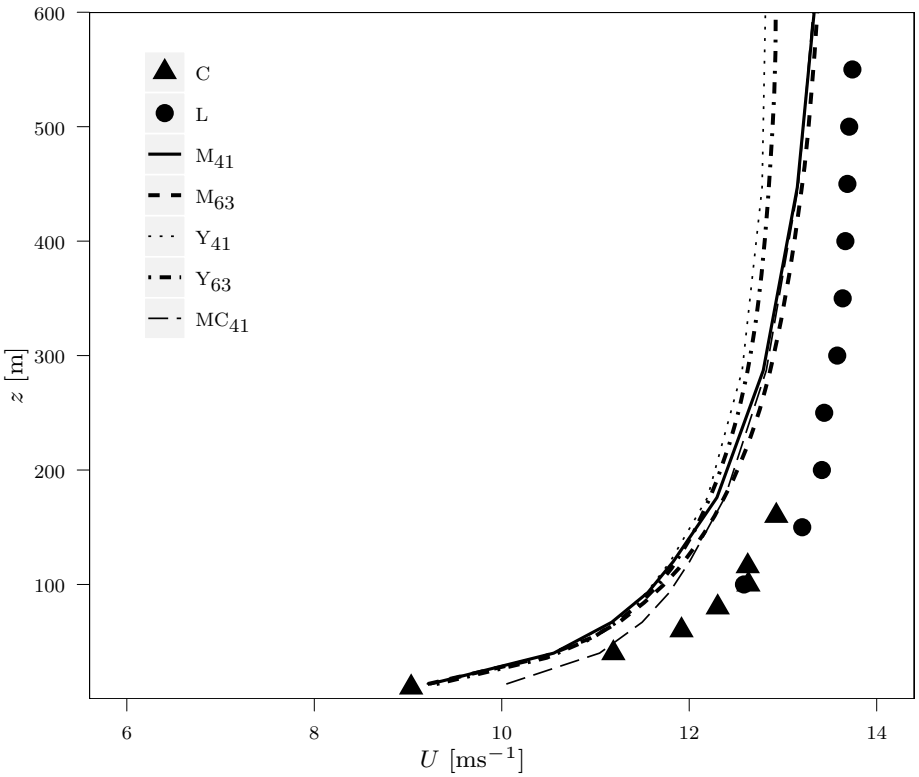
WRF v3.3 - Model runs

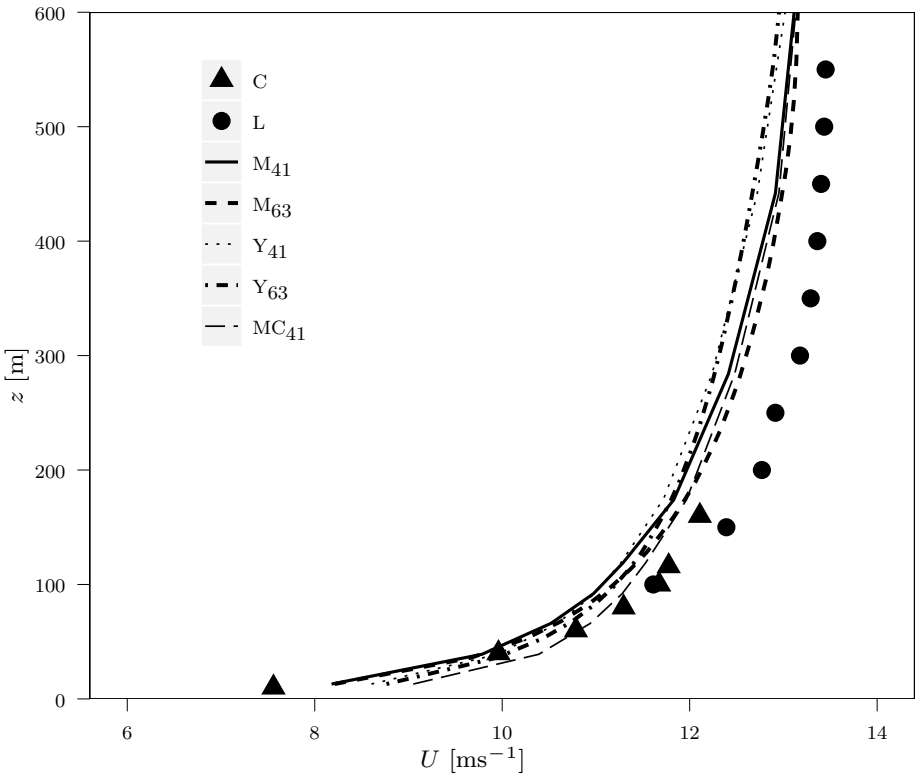
WRF		
Model run	Abbreviation	No. vertical levels (within range of lidar)
MYNN	M_{41}	41 (8)
MYNN	M_{63}	63 (22)
YSU	Y_{41}	41 (8)
YSU	Y_{63}	63 (22)
MYNN	MC_{41}	41 (8)
Observations		
Data source		Vertical levels
Cup	C	10, 40, 60, 80 100, 116.5, 160
Sonic	S	10
Lidar	L	100 – 600 (50 m interval)

Time series for Sep - Oct

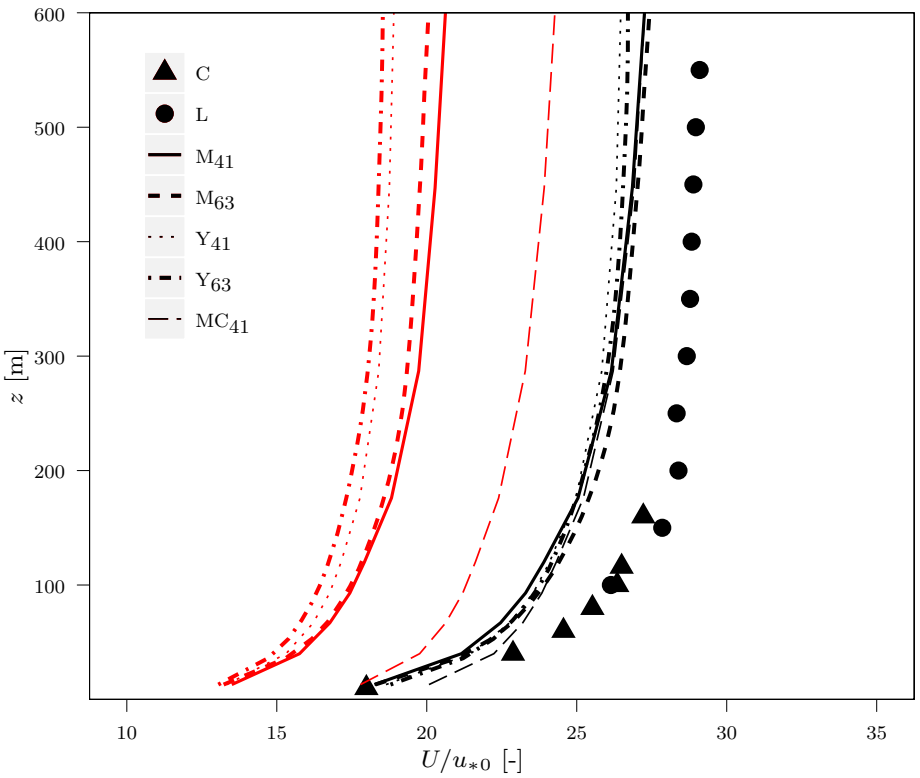


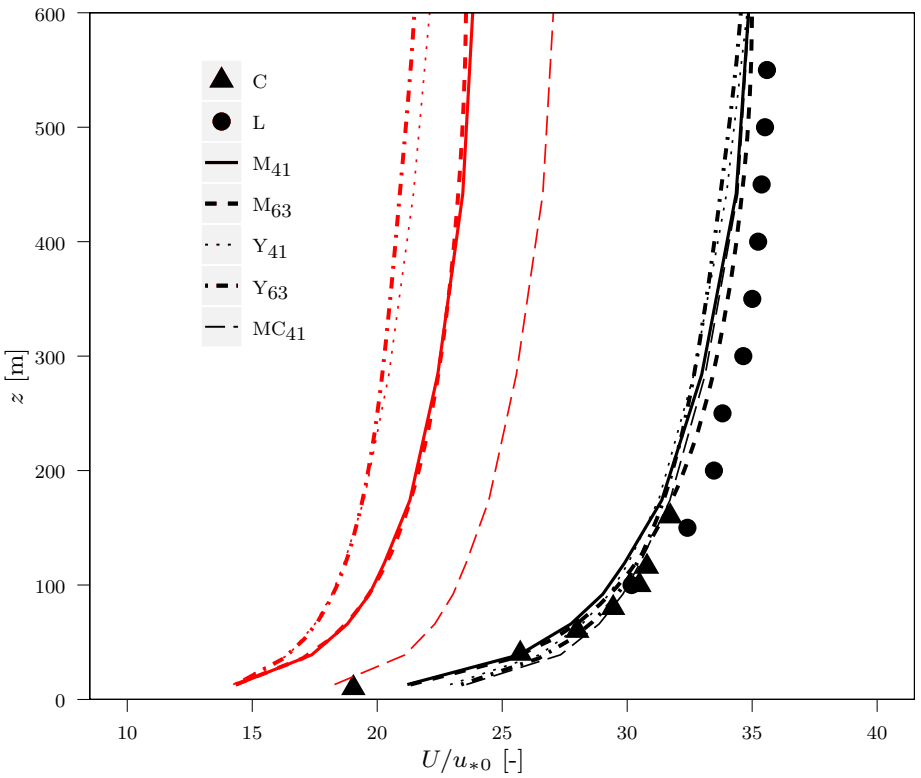
Wind profiles Sep - Oct





Dimensionless wind profiles Sep - Oct





- surface wind relatively accurate, large under prediction higher up
- u_* very high (factor 1.5)
- resolution has little effect, YSU less shear at higher levels

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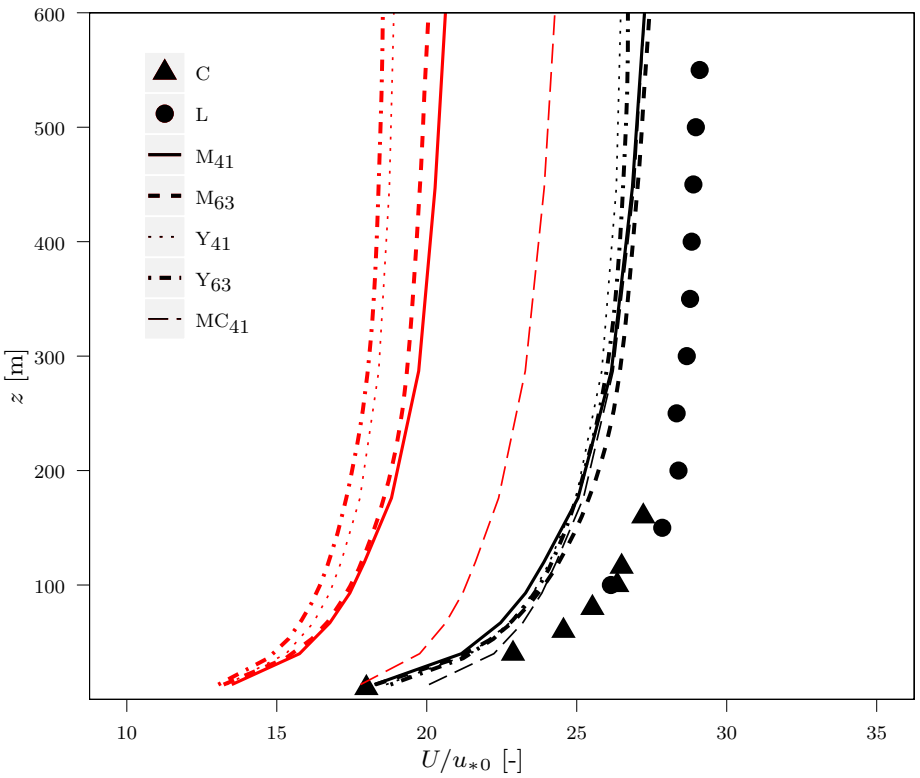

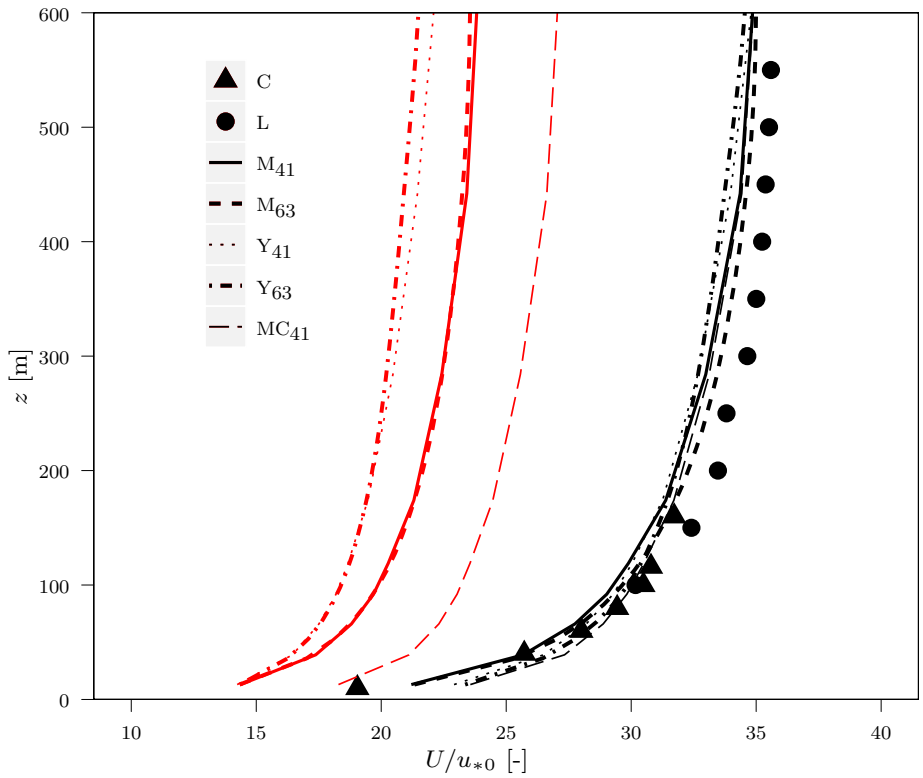

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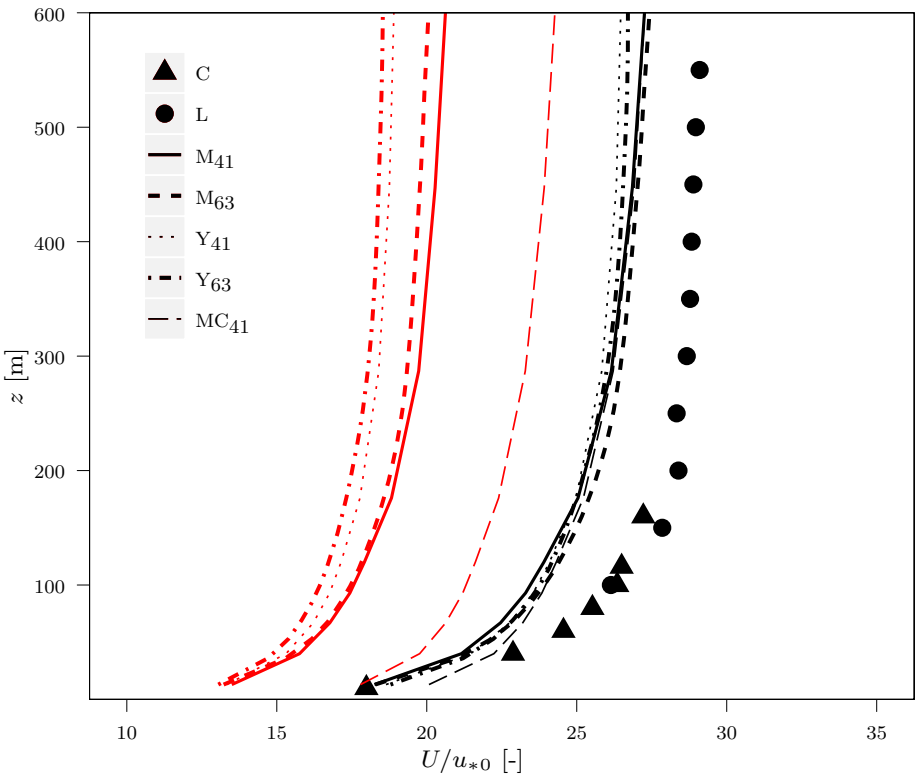

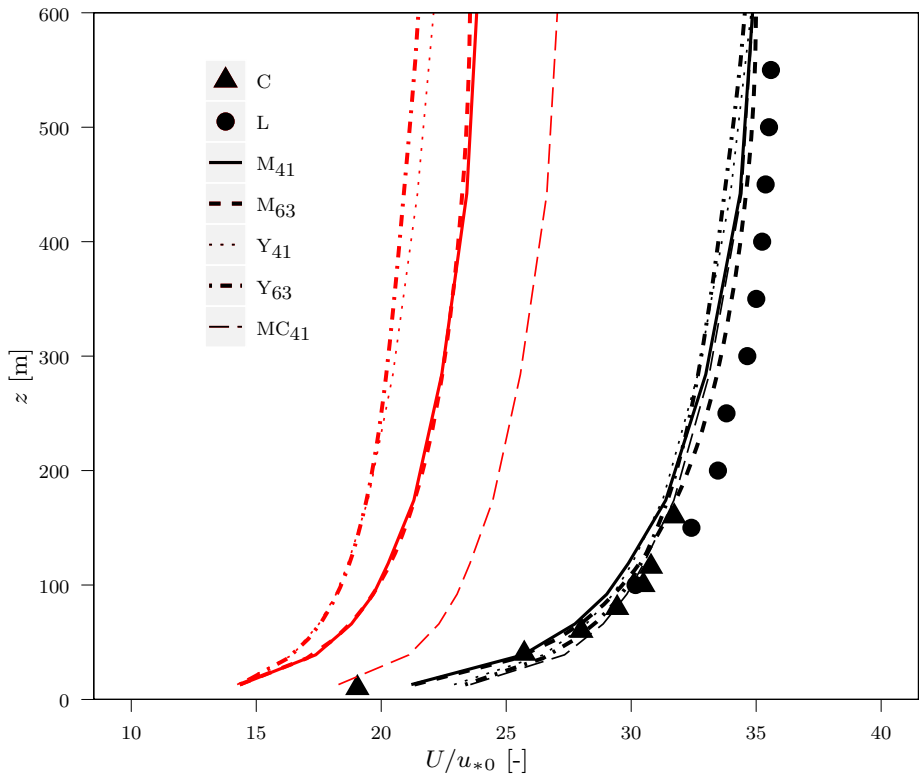

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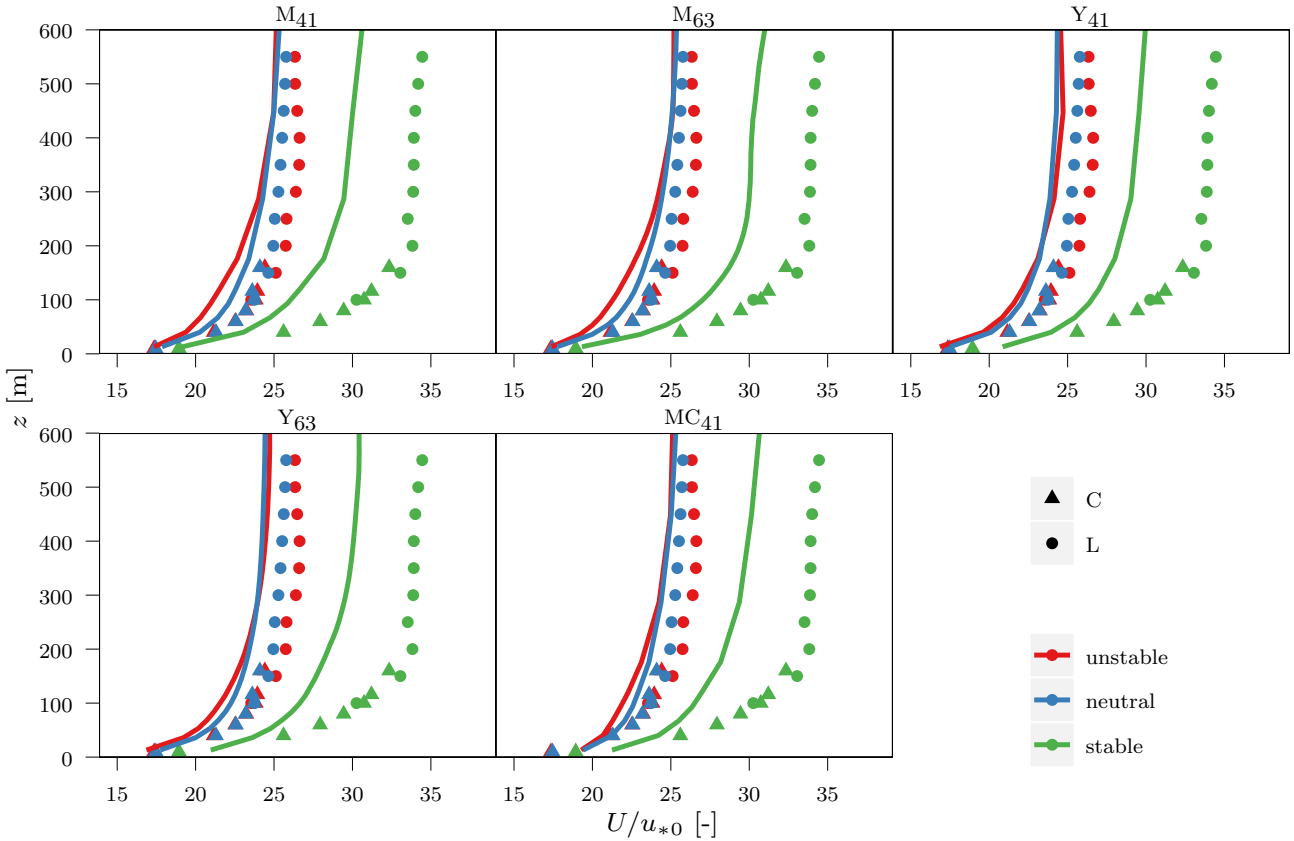

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- NWPs enhance mixing in stable conditions

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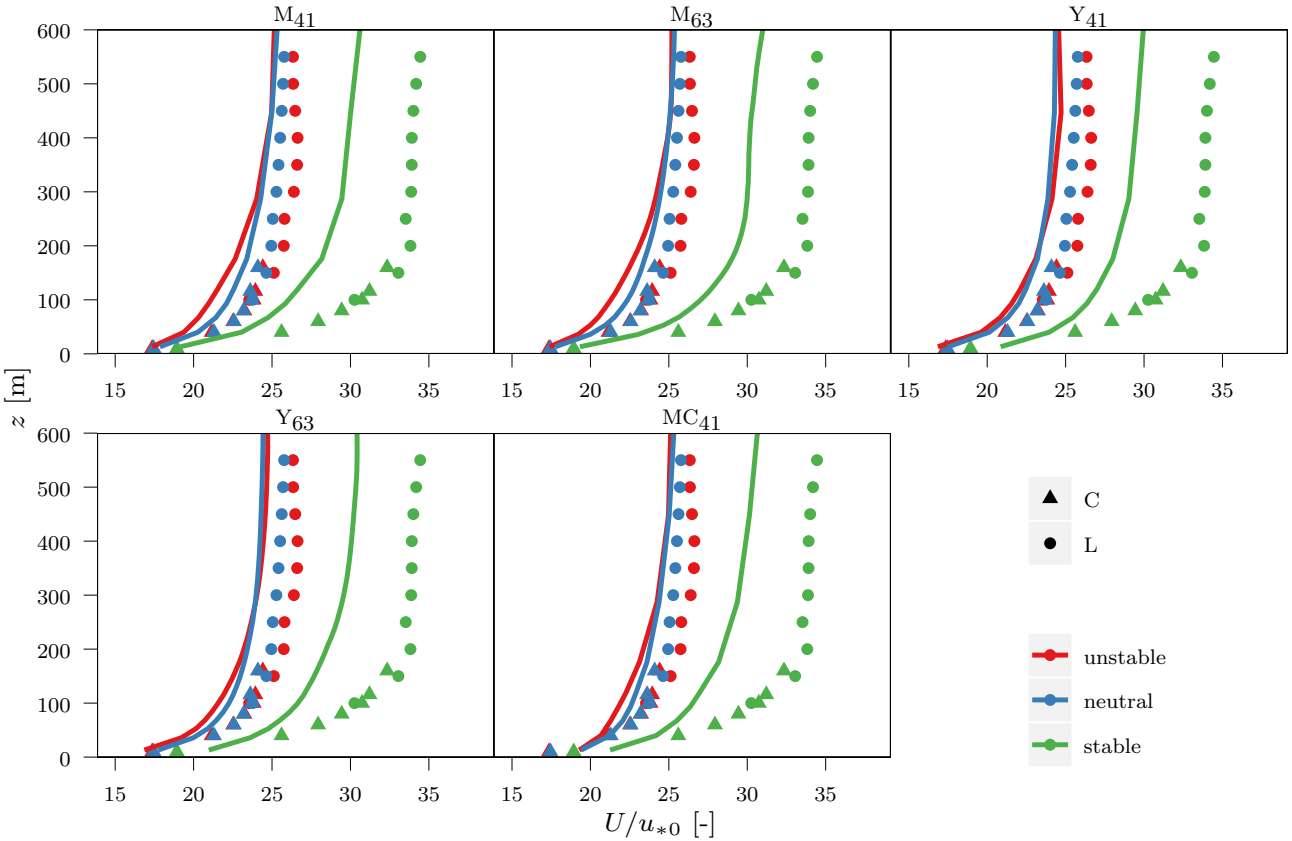

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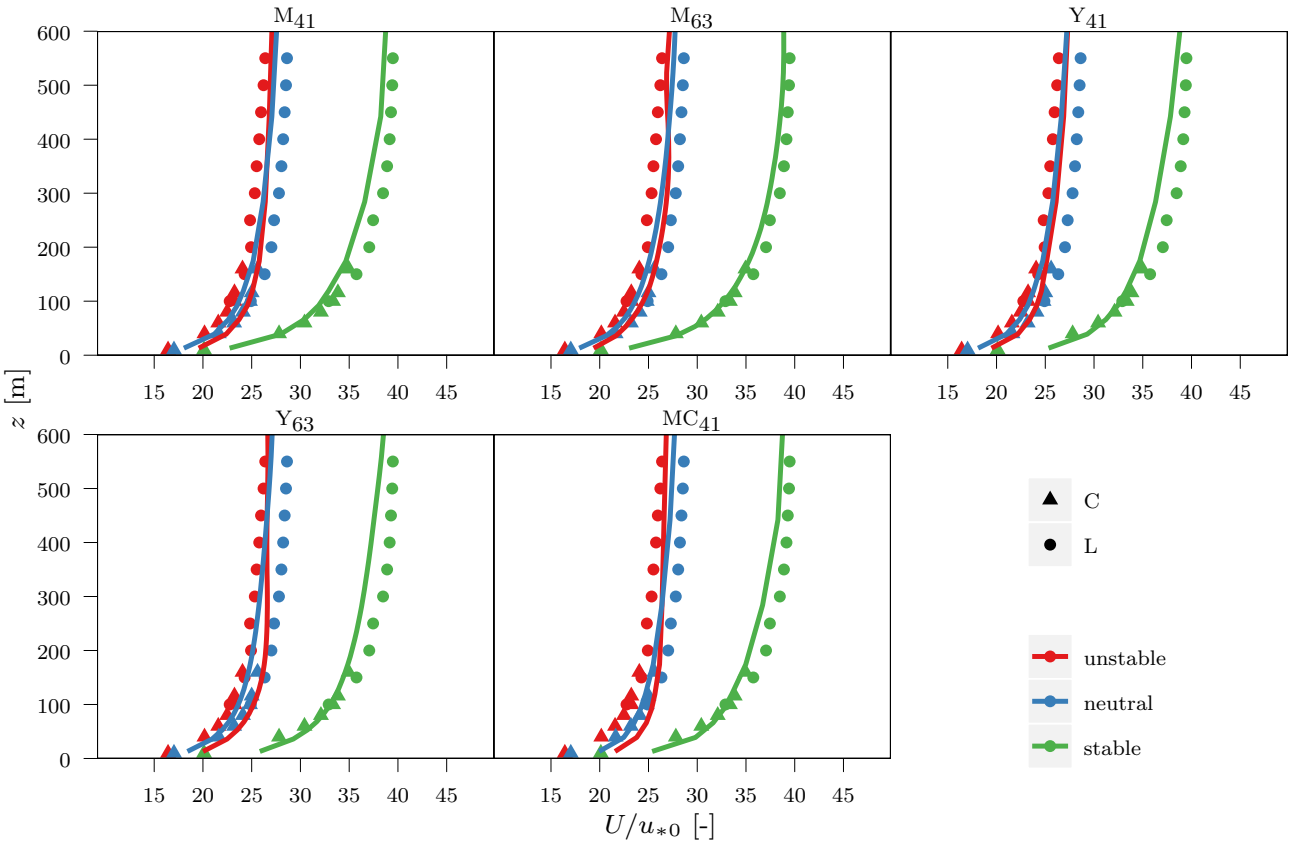

- Westerly winds in October: warm air advection over colder land causes stable conditions at surface.

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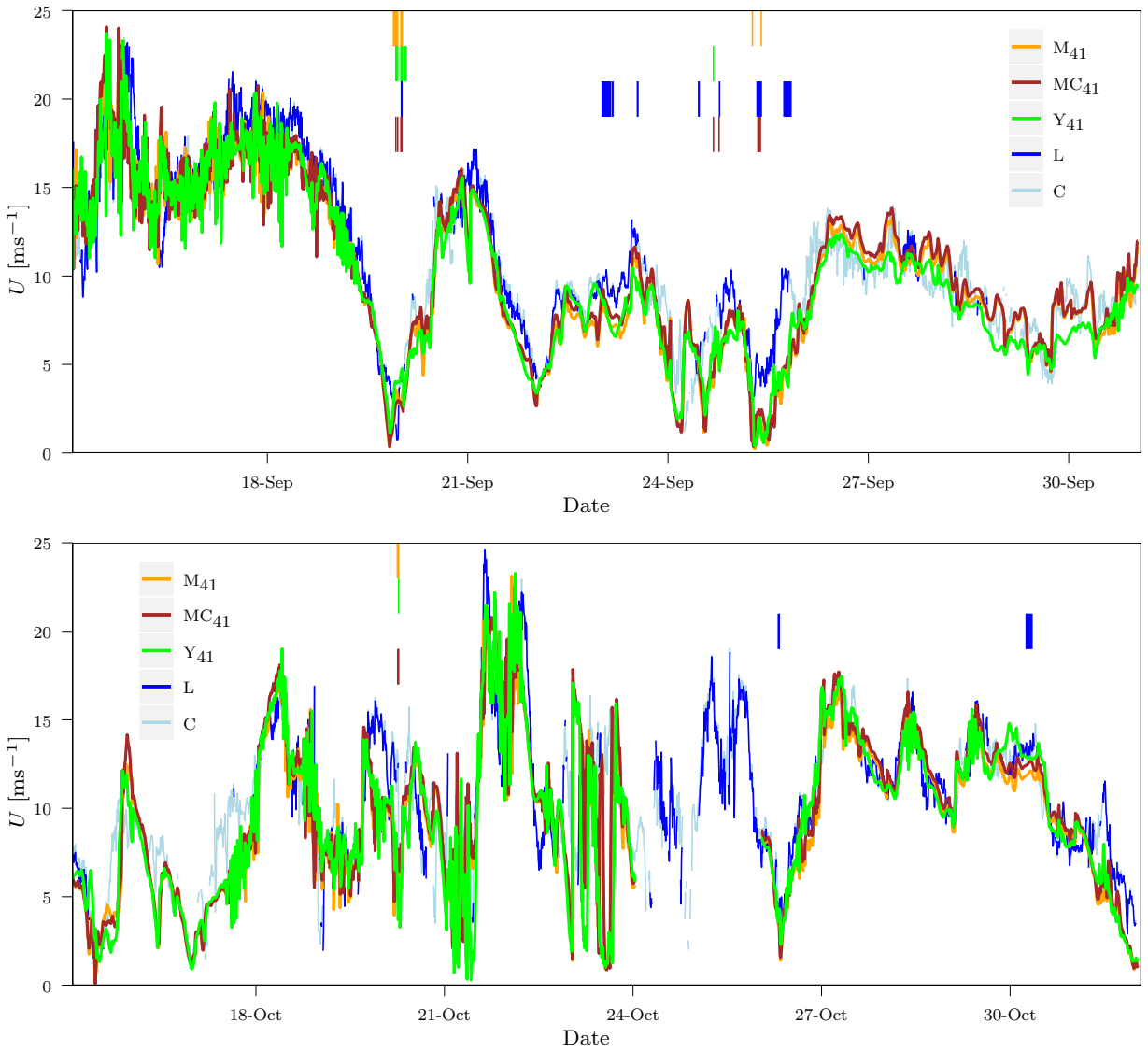
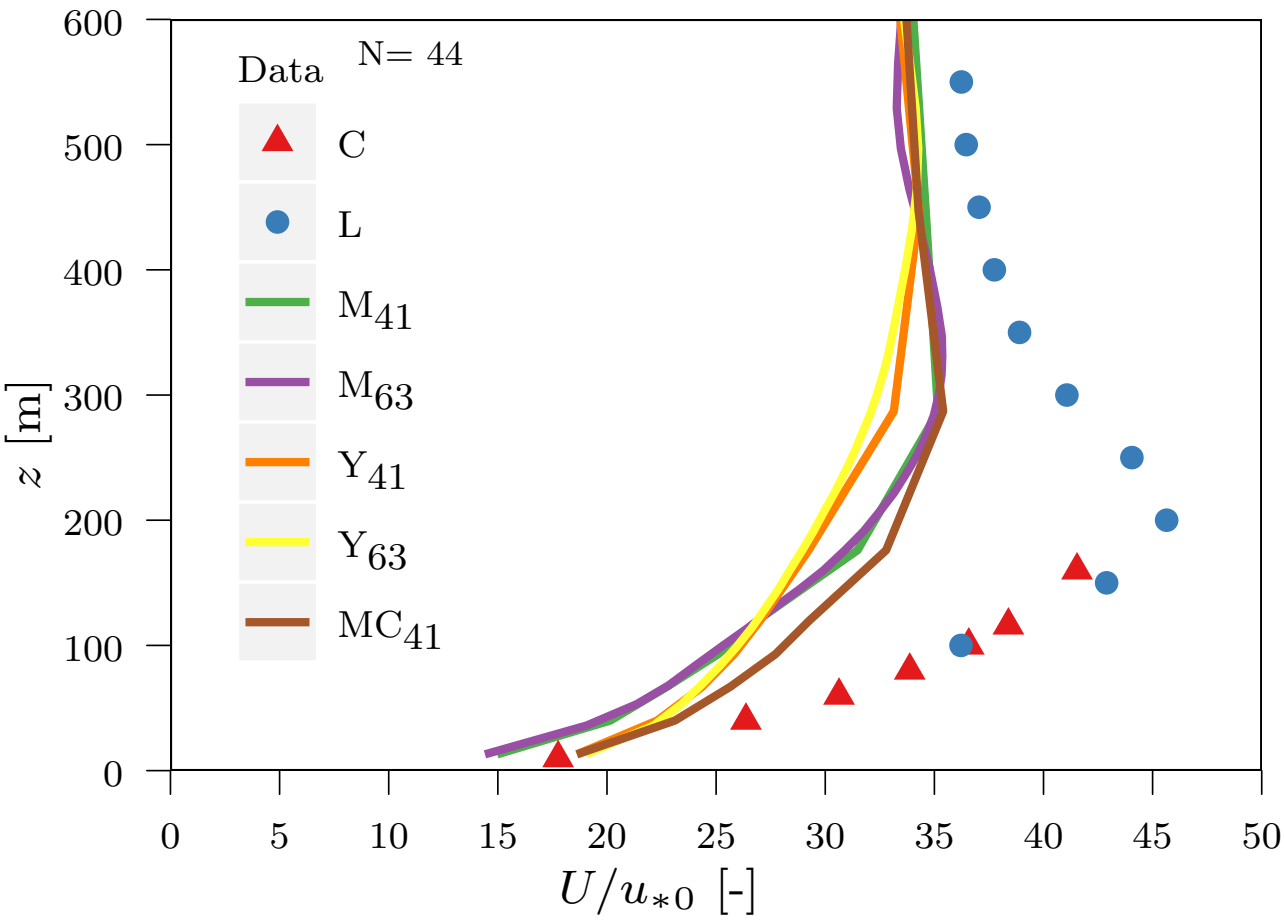


Low Level Jets in September



Mean dimensionless wind profiles at times with a low-level jet in the observations.

Conclusion

- WRF models surface winds relatively well, but shows large bias at larger heights
- Reducing roughness improves slightly improves results between 40 - 200 m
- Most of the under prediction result of predominant stable condition: enhanced mixing prevents WRF from modelling LLJ's
- Stable conditions in second period have different cause: bias lower

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