Surface-layer wind shear and momentum transport from clearsky to cloudy weather regimes over land

Mariska Koning

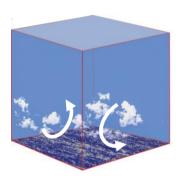
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Ruisdael Science Day 14 October 2022



Convective momentum transport (CMT) is not well understood



HOW GOOD IS THE PARAMETRIZATION?



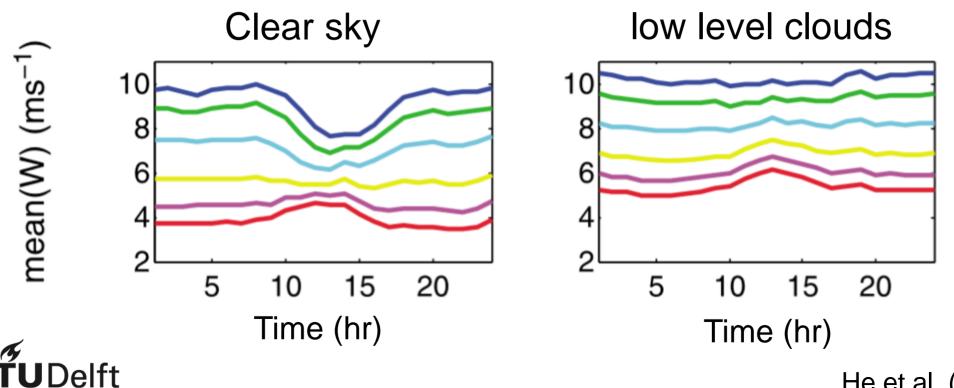
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CMT MAY BE CUMULUS FRICTION IN CLOUD LAYER



DOES CMT INFLUENCE THE SURFACE LAYER?

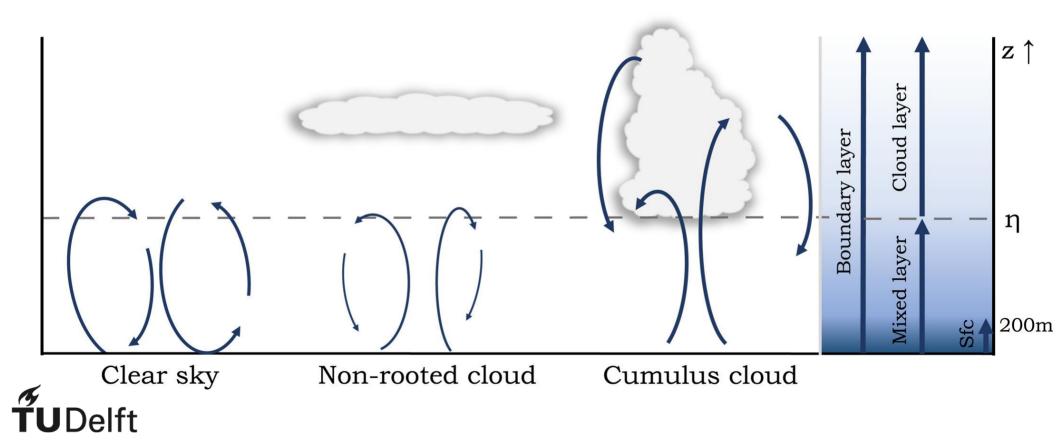
Clear sky days have better mixed winds than cloudy days



He et al. (2015)

Persistent

What are differences in the vertical wind mixing and momentum transport for different cloud regimes?



Observation data from Cabauw site



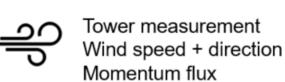
Cabauw, The Netherlands



Daily data 2009 - 2017



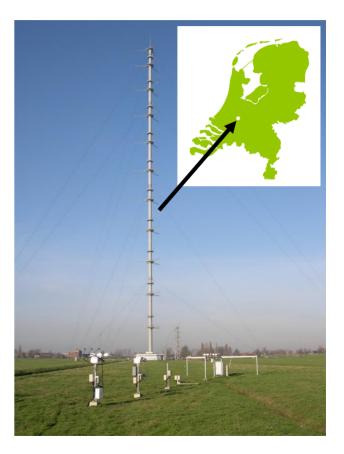
Tower measurement Temperature Temperature flux



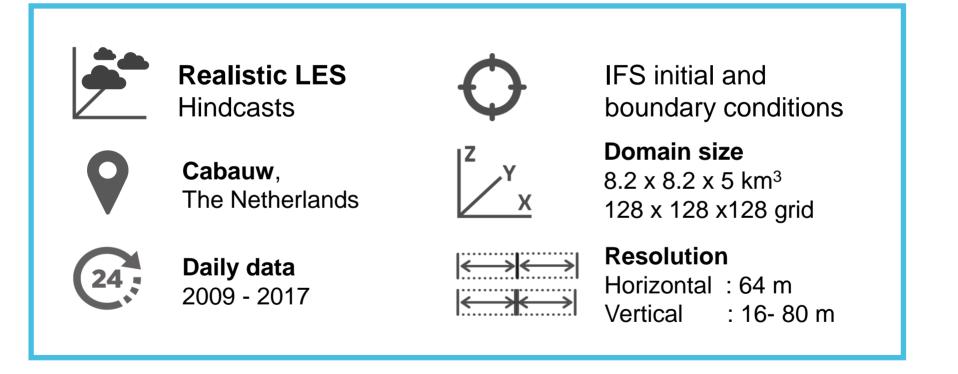
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Ceilometer: LD40 Cloud base height Cloud cover estimate Cabauw tower Height: 213m Flux: 5, 60, 100, 180m Regular: 2, 10, 20, 40, 80 , 140 & 200m

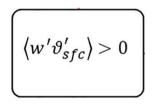


Realistic LES data over Cabauw

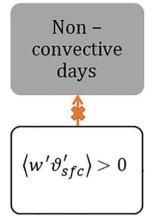




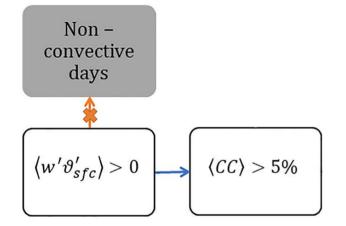




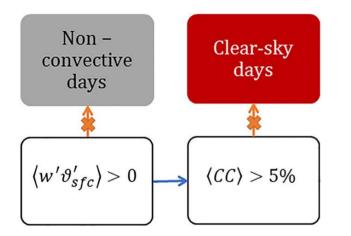




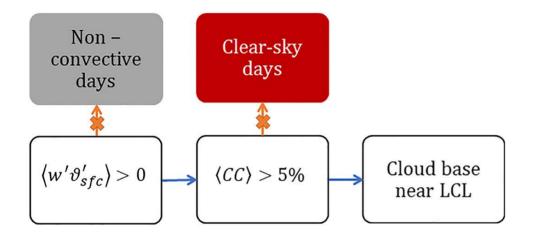




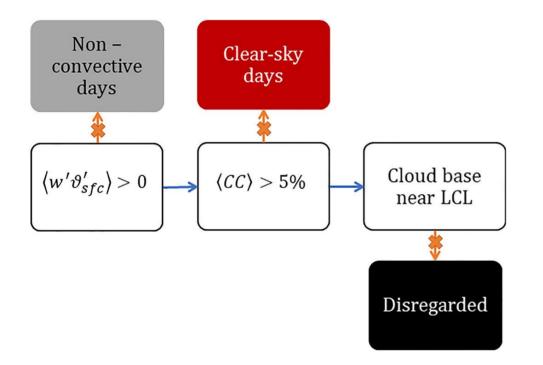




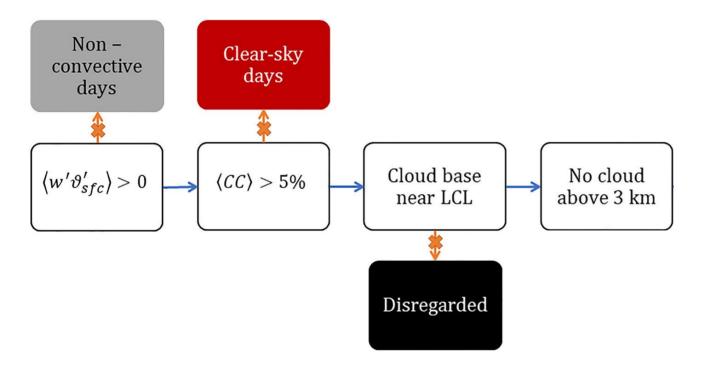




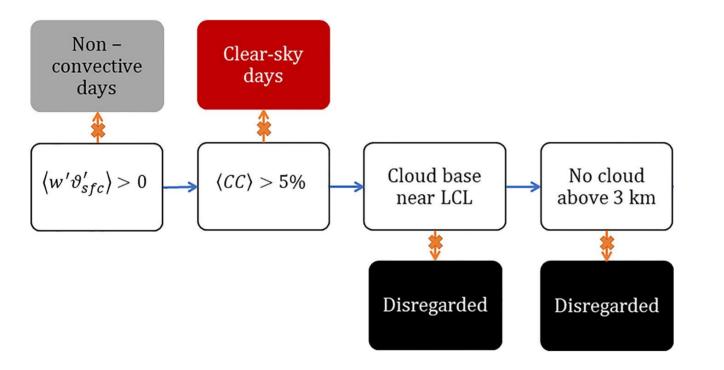




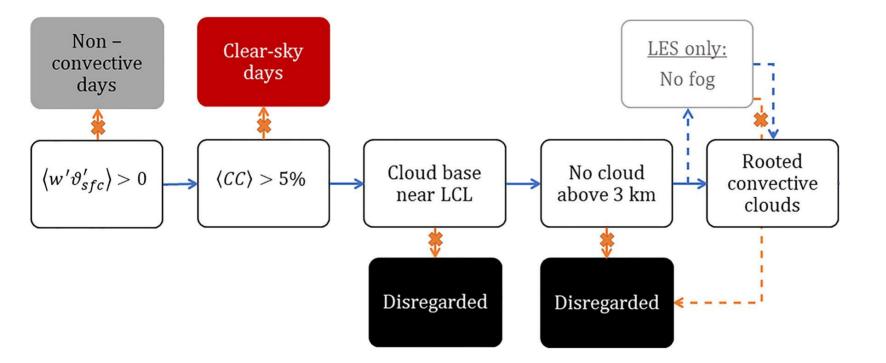




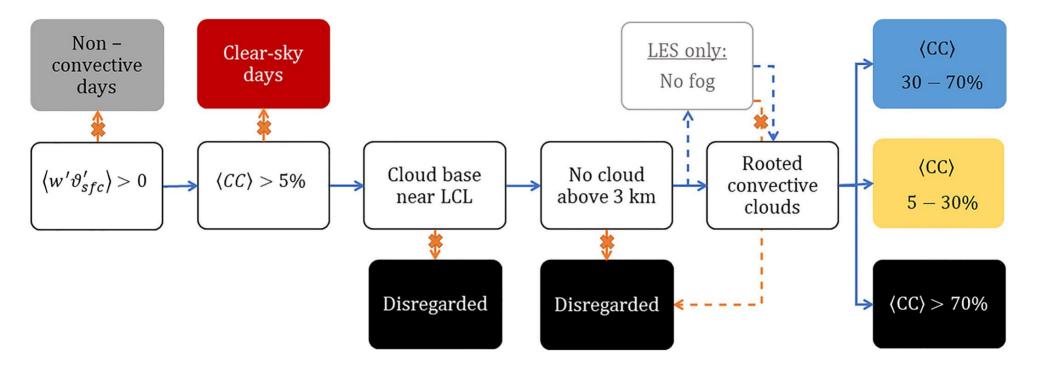






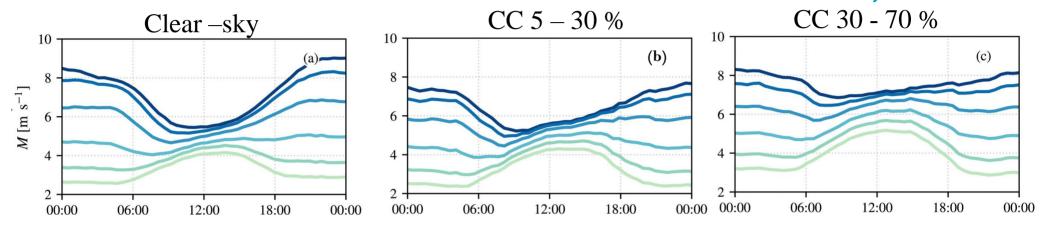


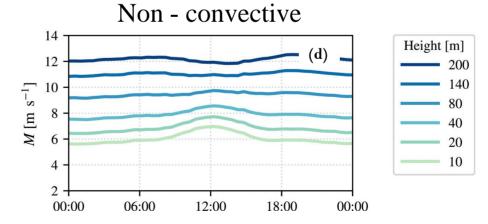






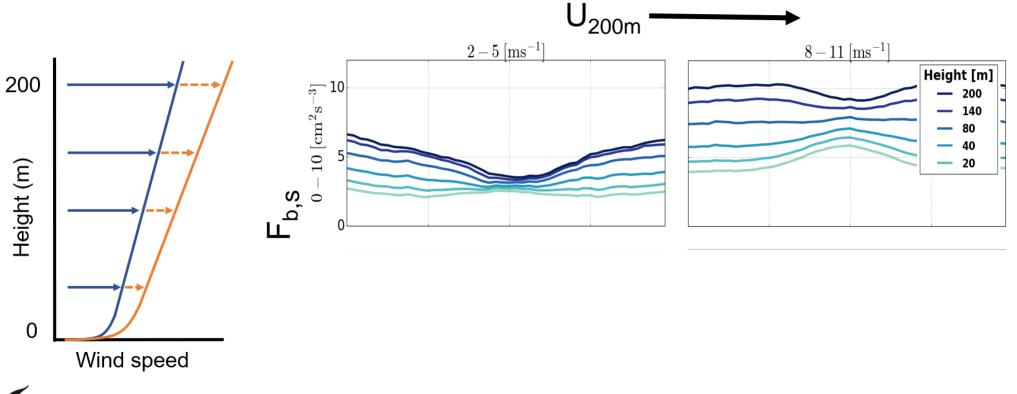
Better wind mixing in the surface layer and wind acceleration on shallow convective days





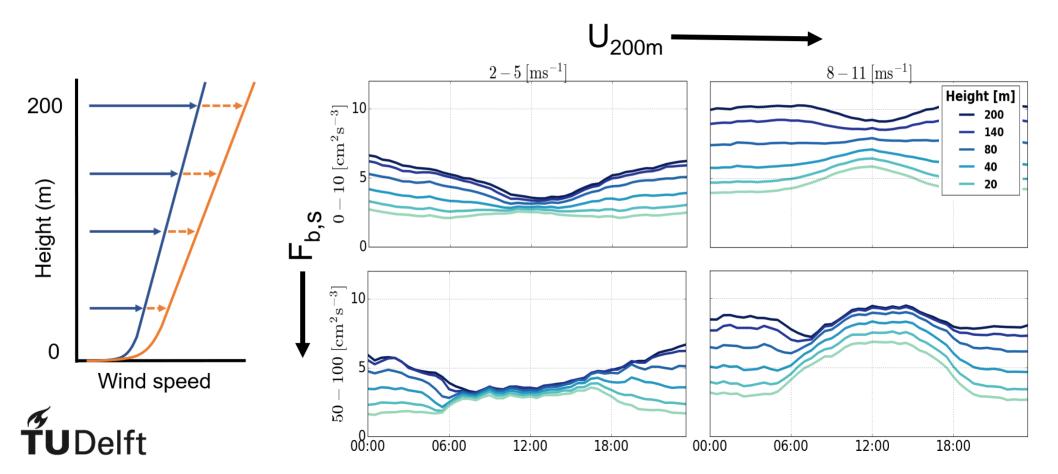


Wind mixing depends on large-scale wind and surface buoyancy flux which we need to account for



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Wind mixing depends on large-scale wind and surface buoyancy flux which we need to account for



Generally, a more unstable atmosphere has better mixed wind

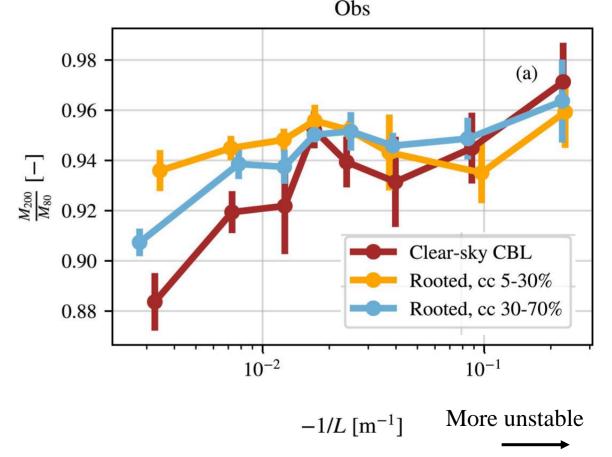
200 Height (m) 0 Wind speed

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0.98 0.96 0.94 Ξ W⁸⁰⁰ W⁸⁰⁰ W⁸⁰⁰ W⁸⁰⁰ 0.90 0.88 10^{-2} 10^{-1} More -1/L [m⁻¹] unstable

Obs

In less unstable conditions, shallow clouds appear to advance wind mixing

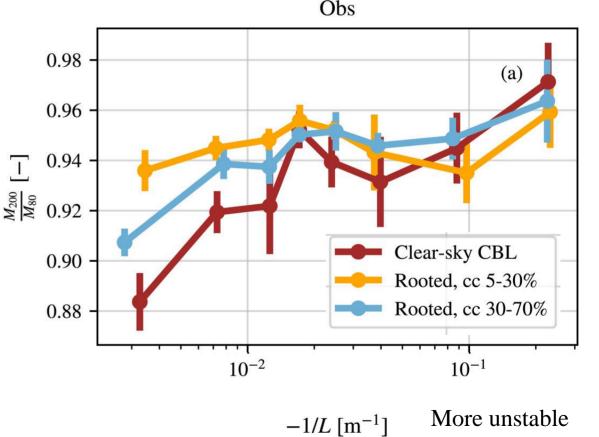




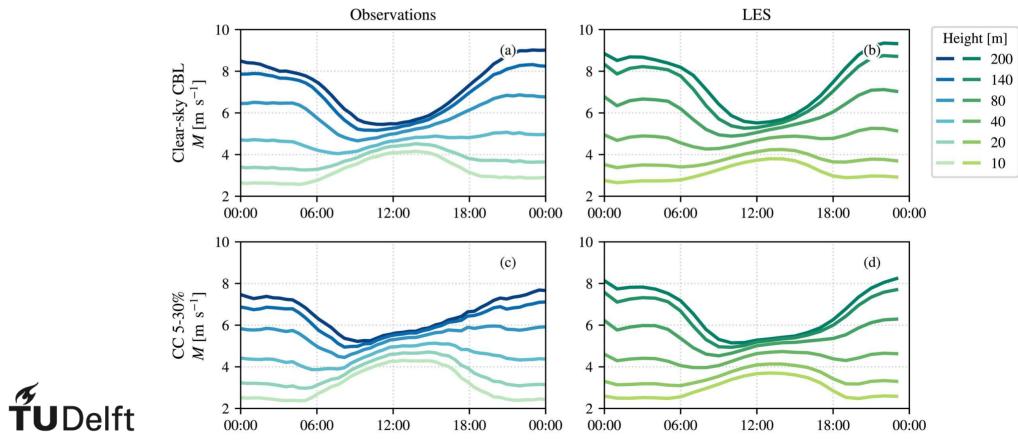
In less unstable conditions, shallow clouds appear to advance wind mixing

On cumulus days:

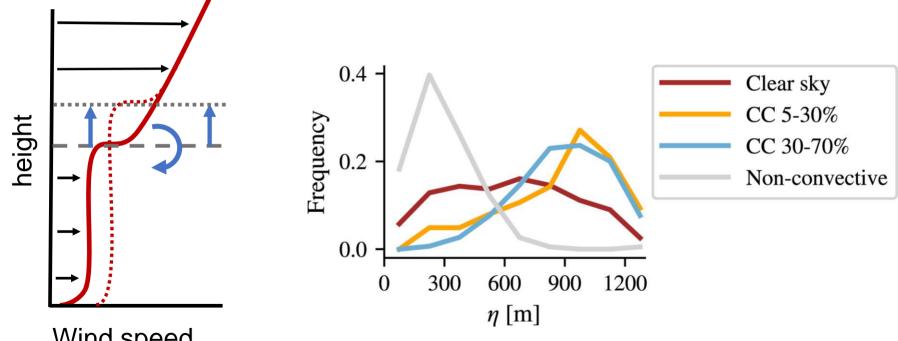
- Deeper mixed layers?
- Larger geostrophic wind above mixed layer / in cloud layer?
- More efficient CMT in mixed layer?



LES reproduces observed behavior and can be used to look at greater heights



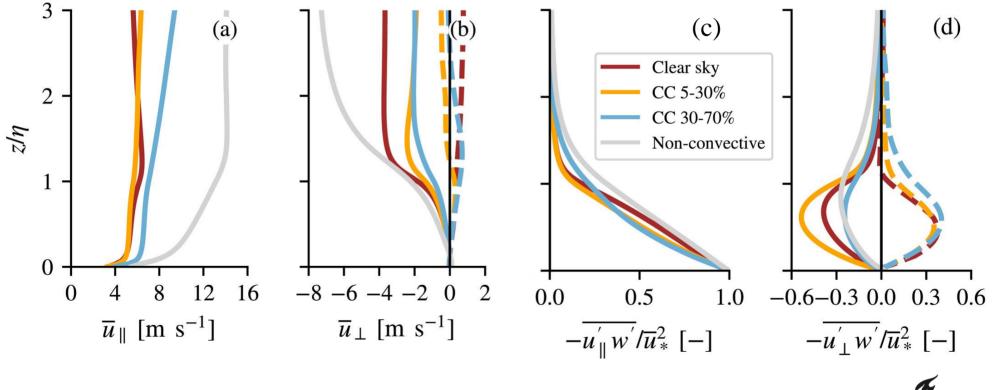
Deeper mixed layer can explain acceleration and better mixed winds on cumulus days



Wind speed

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On cumulus days wind friction is larger near cloud base



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Summary

• When correcting for surface layer stability and strength of (large-scale) wind, the surface layer winds are better mixed on days with broken cloudiness near the lifting condensation level

• Those cumulus days appear to have deeper mixed layers, but not necessarily stronger geo-winds above the mixed layer

• LES suggests more efficient CMT in the mixed layer



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Per 1 December 2022



Koninklijk Nederlands Meteorologisch Instituut Ministerie van Infrastructuur en Waterstaat

R&D Observations and Data technology



