Trade-wind cumulus cloud feedback in the ICON large eddy model

– bridging the gap to cloud resolving models

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DKRZ DEUTSCHES KLIMARECHENZENTRUM

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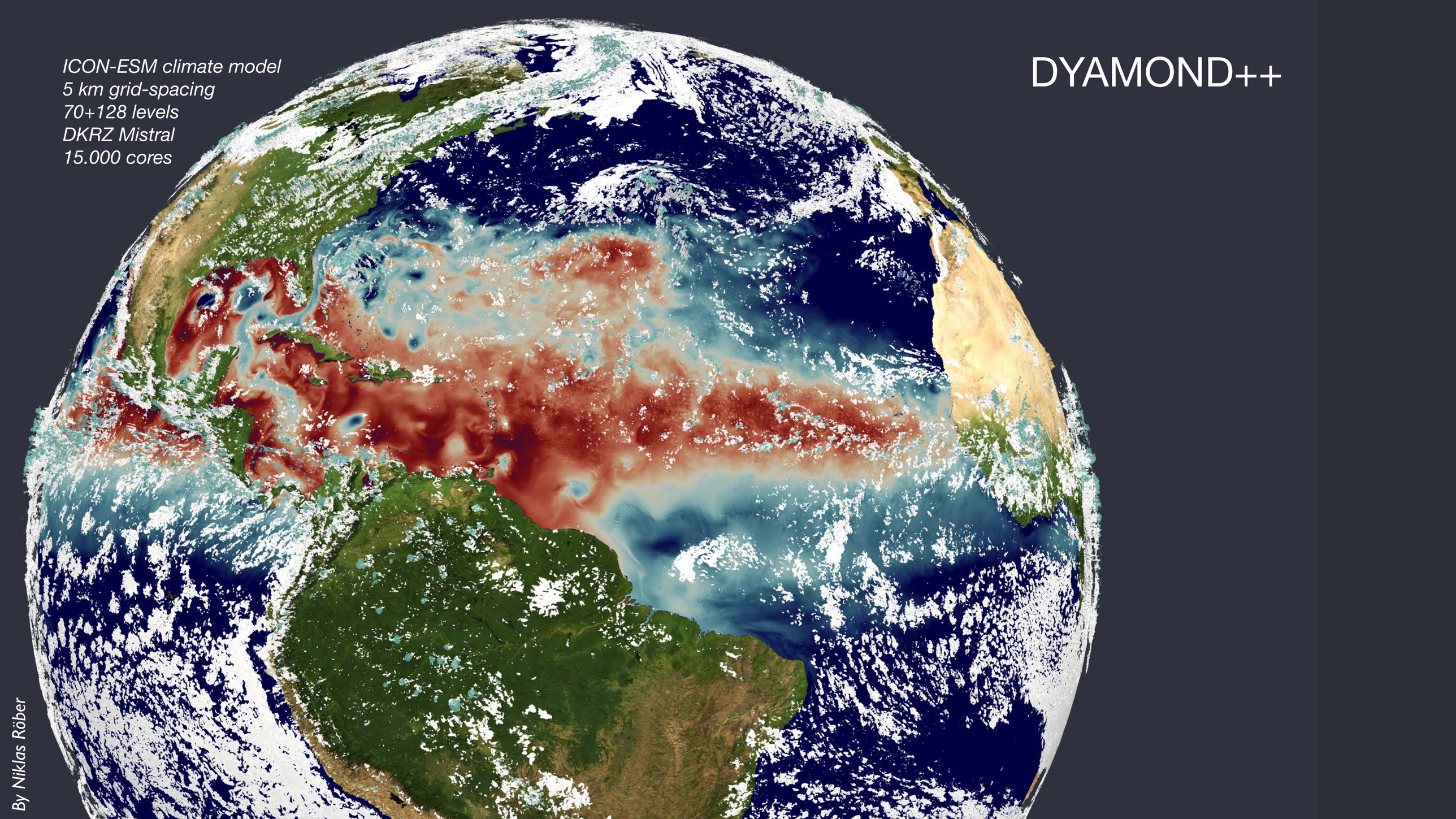
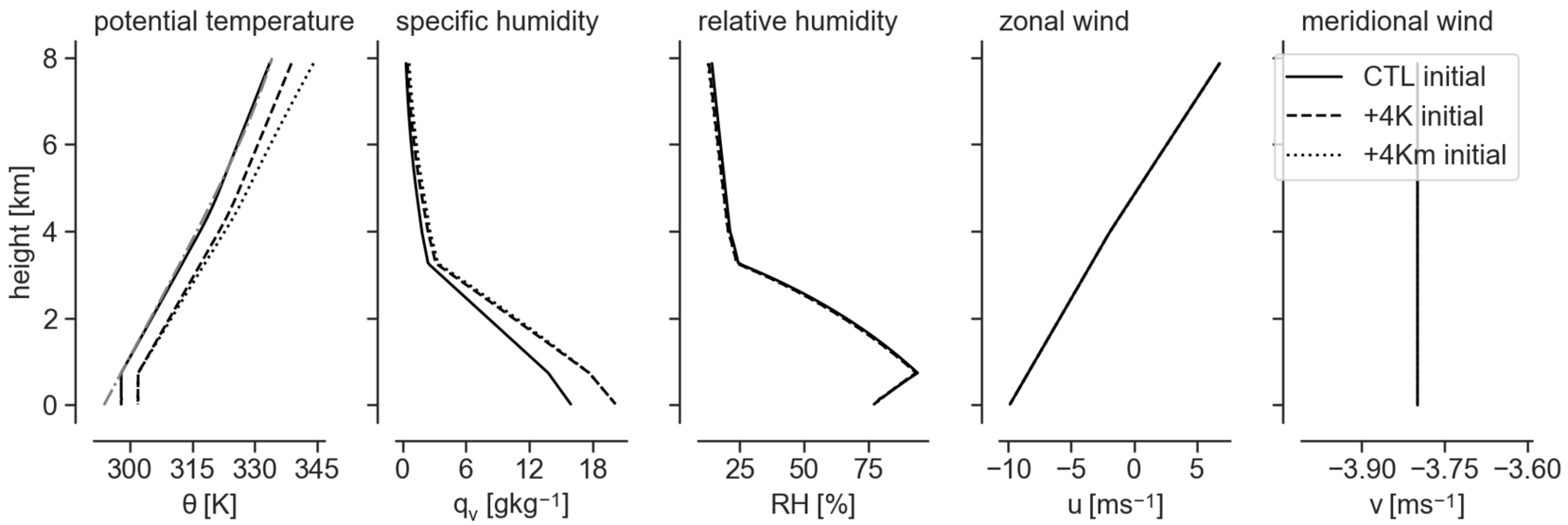

ICON-ESM climate model
5 km grid-spacing
70+128 levels
DKRZ Mistral
15.000 cores
DYAMOND++
By Niklas Röber

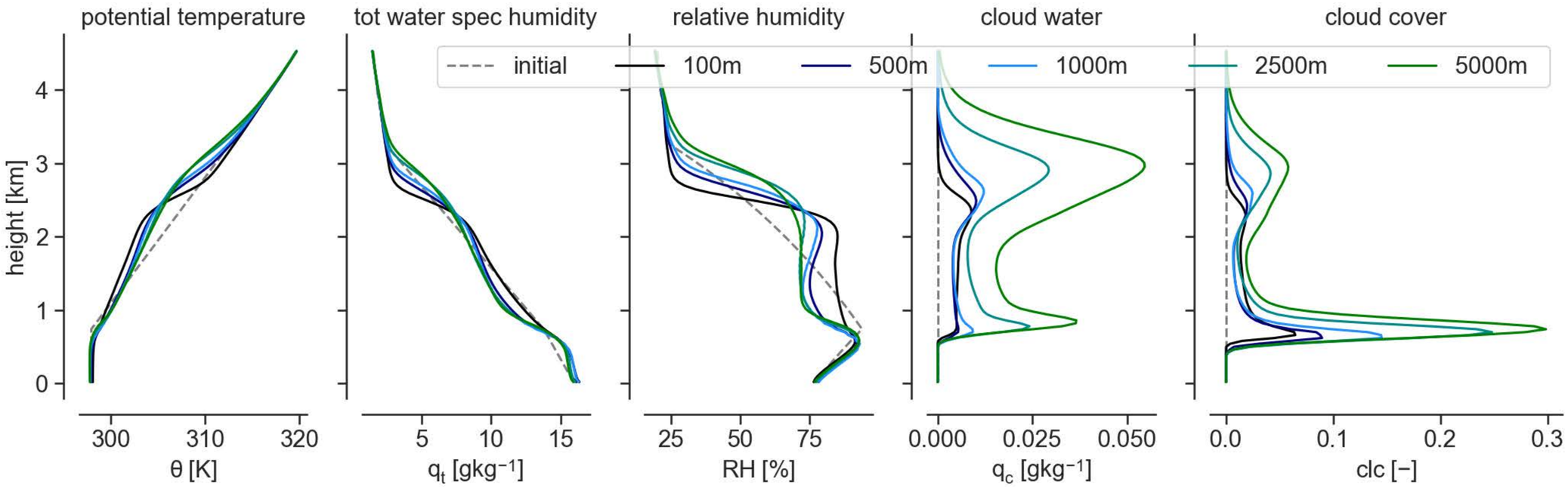
Model and setup

- Modified RICO setup – trade wind cumulus on cyclic domain
- ICON Large eddy model (LEM), Dipankar et al. (2015)
- Smagorinski/Lilly 3D turbulence
- Seifert and Beheng (2006) microphysics
- RRTM radiation
- Extended model top and profiles to 20 km
- 2 day simulations, showing statistics for second day
- Uniform vs. moist adiabatic warming, vs. precipitation

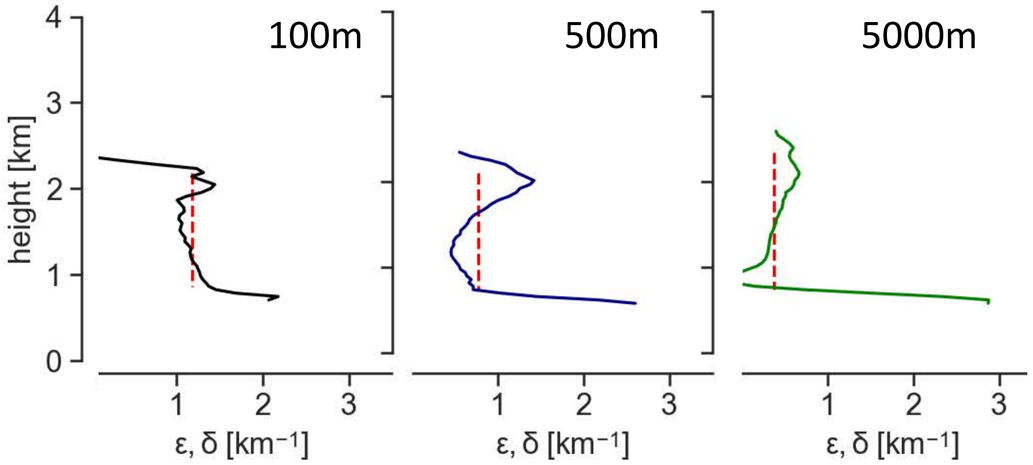
Resolution	Domain (km²)	Cases
100m	12.6 x 12.6	CTL , +4K
500m	50x50	CTL , +4K
1km	50x50	CTL , +4K
2.5km	500x500	CTL , +4K
5km	500x500	CTL , +4K



Basic state dependency on resolution



- Surprisingly similar profiles for different resolutions
- More cloudiness at low resolution, and higher cloud tops
- Lateral entrainment rate three times larger at 100 compared to 5000 m resolution



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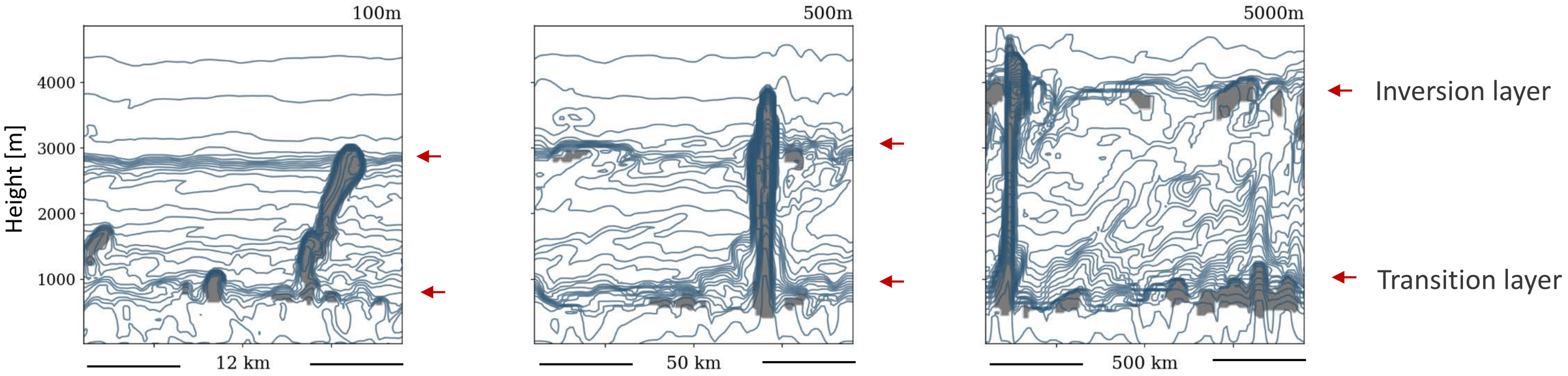
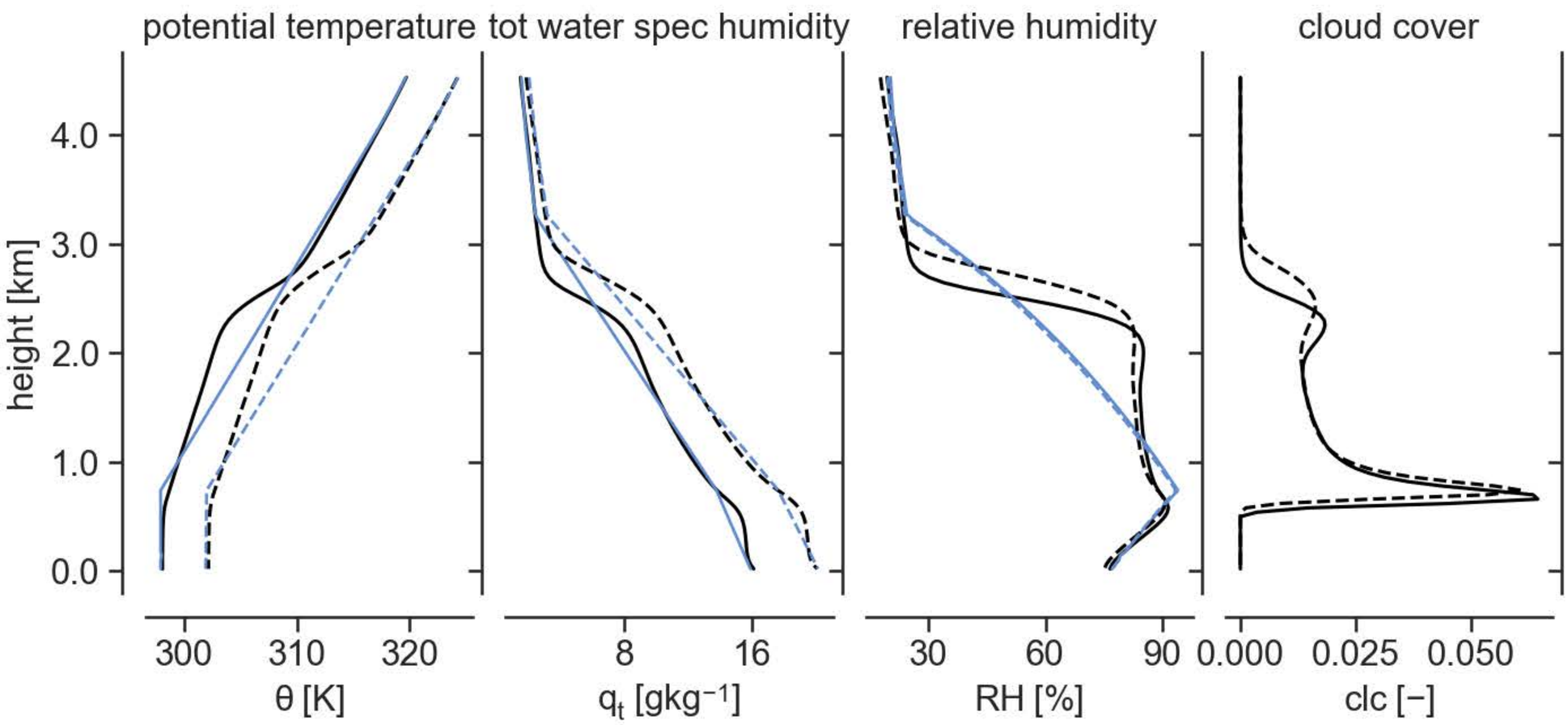
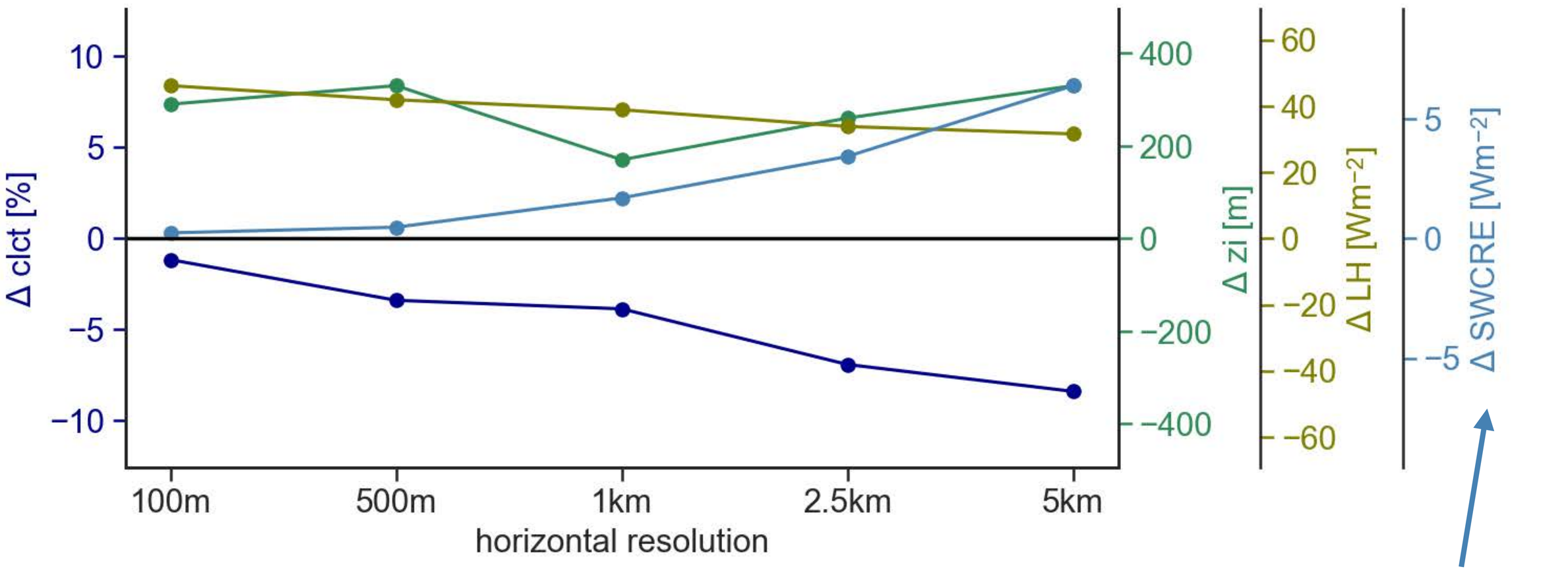


+4 K uniform warming, 100 m simulation



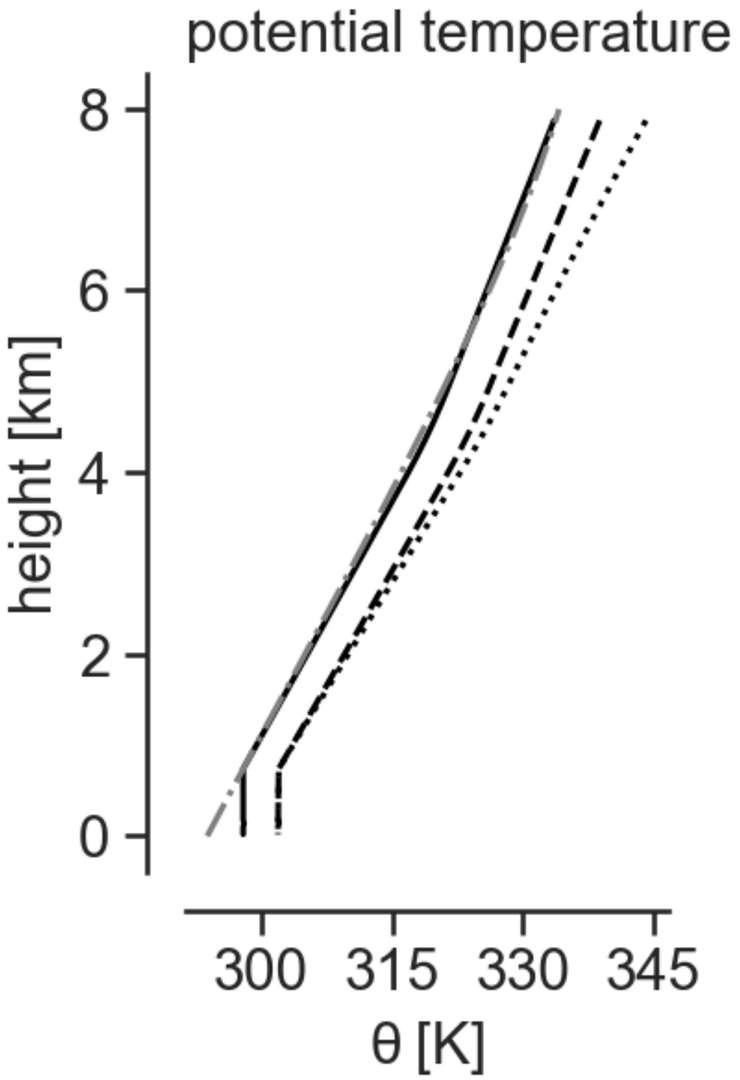
Blue: initial profiles

+4 K uniform warming, across resolutions

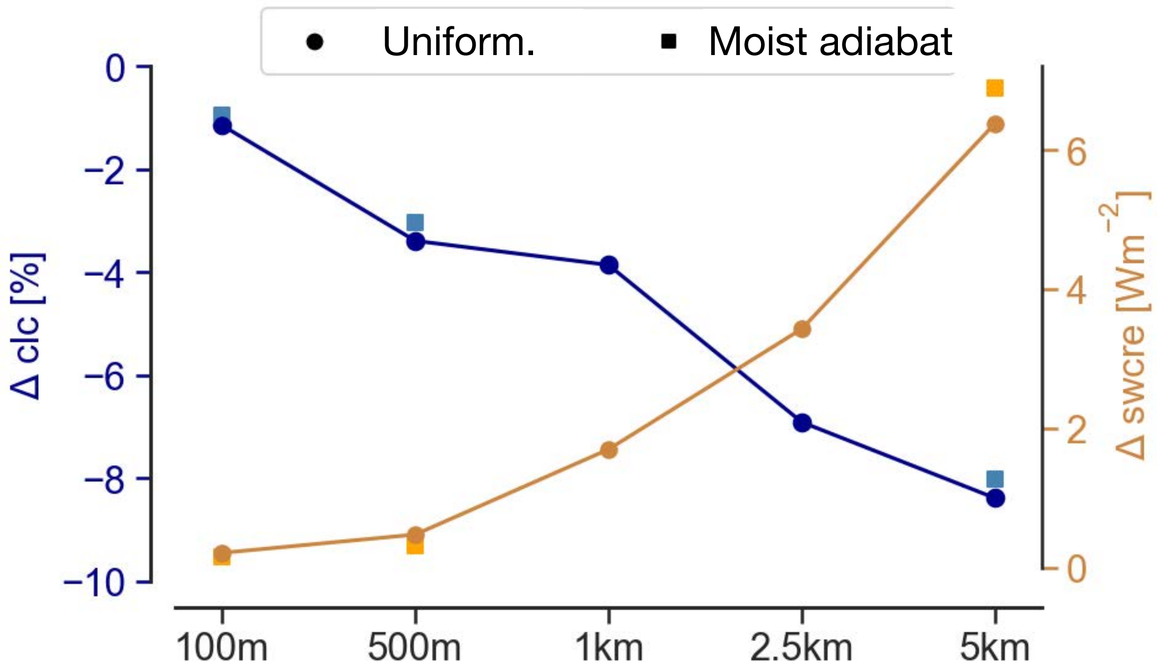


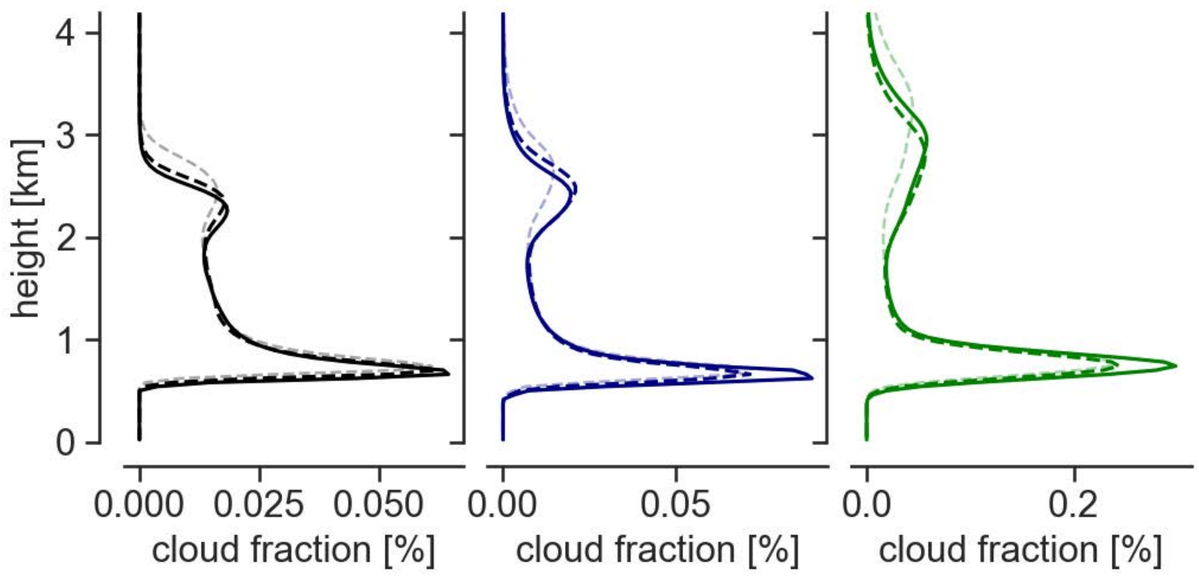
Note, this is not normalised

+4 K uniform warming *versus* moist adiabat



+4 K uniform warming *versus* moist adiabat

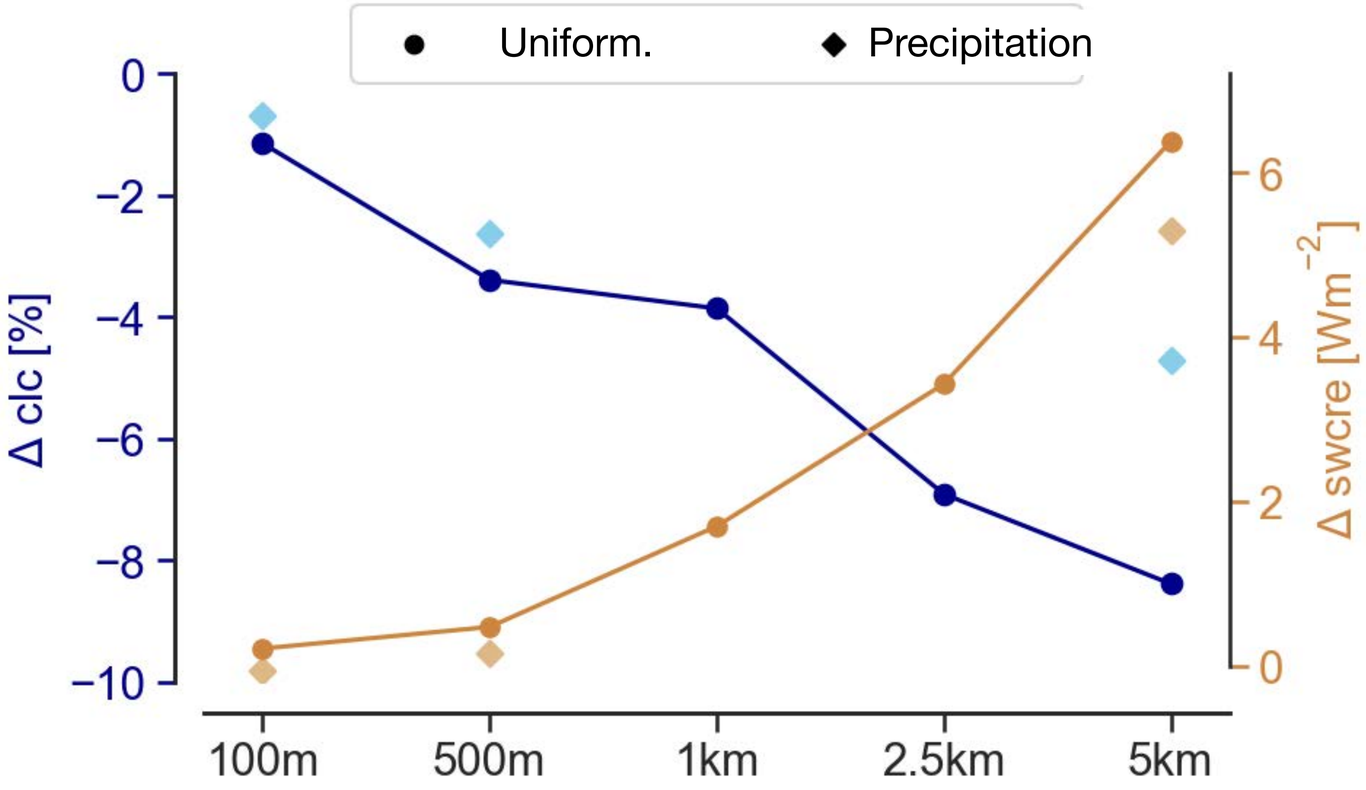




Thin dashed: uniform
Thick dashed: moist adiabat

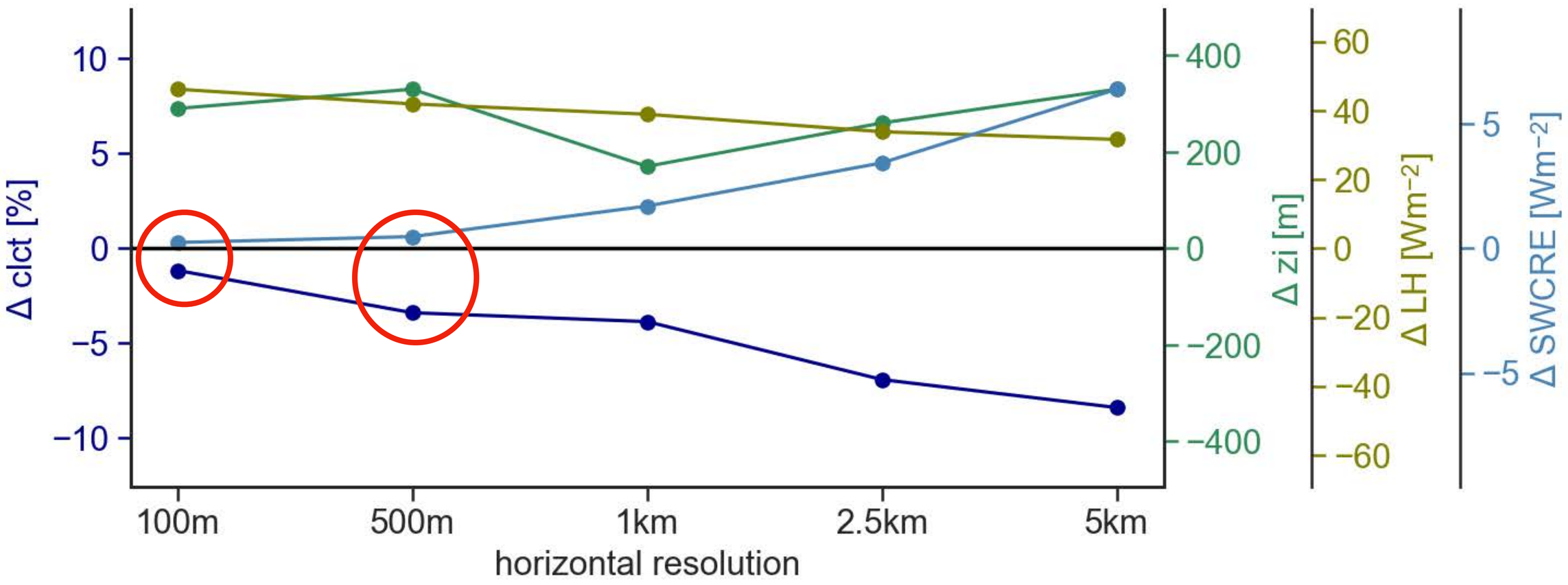
- Slight stabilisation aloft
- Reduced deepening
- Less mixing-drying
- Reduced cloud fraction decrease

+4 K uniform warming *with* precipitation



More or less same story

More juicy, brighter clouds across the board



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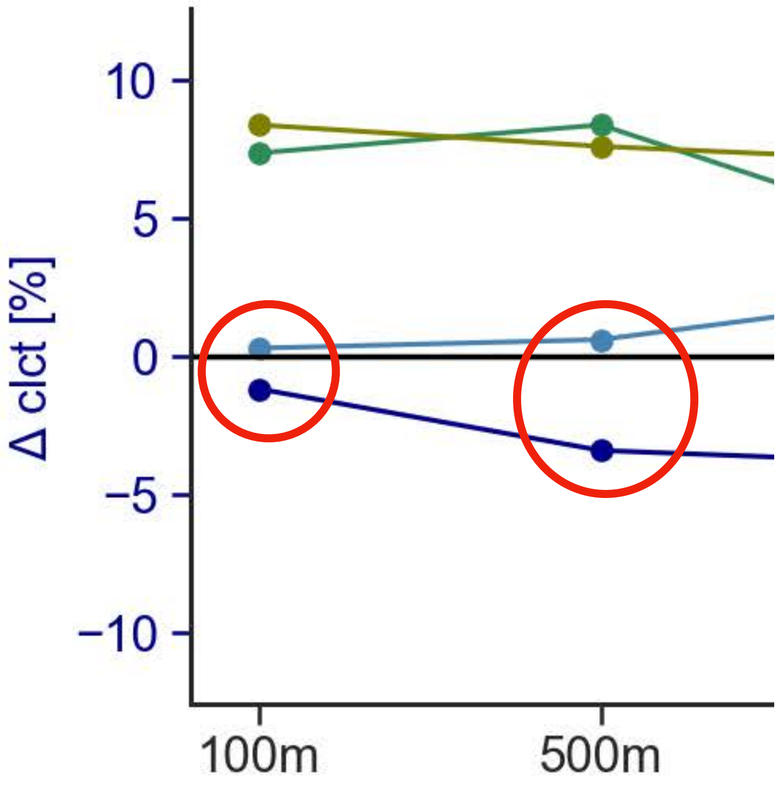

LWP/cloud cover increase (%/K)

Resolution (m)	100	500	5000
Uniform warming	4,2	9,2	11,2
Moist adiabat	3,7	8,9	6,6
Precipitation	2,9	7,7	0,6

Summary

- Surprising similarity in representation of trade wind cumulus across resolutions in ICON-LEM
- Weak lateral mixing, deeper cloud tops and more cloud-base cloudiness at low resolutions
- Reduced cloud cover with warming for all settings, but less so with higher resolution and enhanced realism
- Compensating feedback from cloud thickening (LWP) leads to convergence at **near-zero trade Cu cloud feedback**
- For comparison Blossey et al. (2016) found 1-3 Wm-2 for a +2.5 K surface warming in CGILS S6 case