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Exploring satellite-derived relationships between N_d and LWP using a large-domain large-eddy simulation

May 26, 2022

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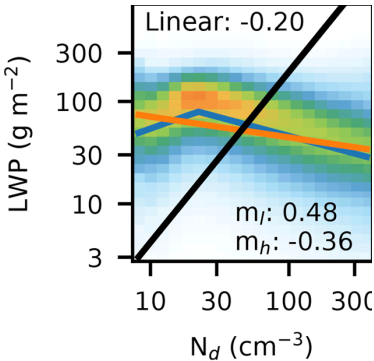
Outline

Interpreting N_d-LWP relationships

- A positive N_d-LWP relation implies precipitation suppression
- A negative N_d-LWP relation illustrates:
- The sedimentation-entrainment feedback
- Evaporation-entrainment feedback
- Wet scavenging feedback
- Warm cloud invigoration



Here each column normalised so that it sums to 1

Gryspeerdt et al., 2019

N_{Ad}-LWP relationship in the ICON model

- $N_{Ad} = 1.37e^{-5} \times \cot^{0.5} \times ref^{-2.5}$
- Here, N_{Ad} is calculated using the above equation instead of the default N_d from the ICON model.

N_{Ad}-LWP relationship in the ICON model

Cloud Selection:

- Selected single layer of non-precipitating clouds.
- The cloud top N_d is filtered for cloud fraction greater than 90%
- cloud optical depth greater than 2
- the cloud top temperature is greater than 268 K
- similar to Gryspeerdt et al., 2019.

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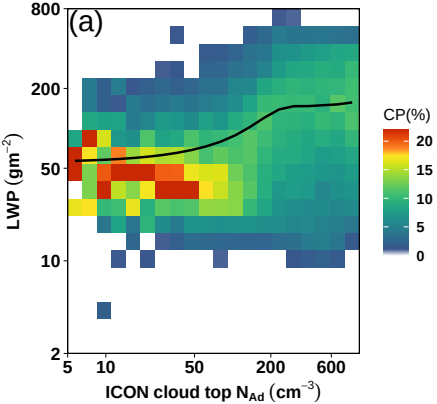

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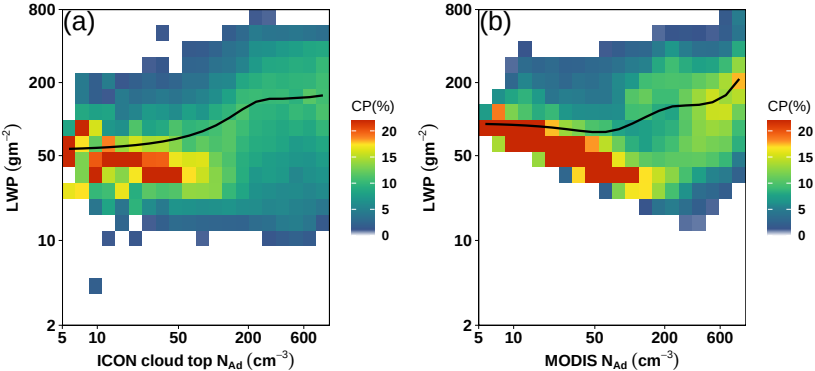
N_d-LWP relationship in the ICON model & Satellite observation



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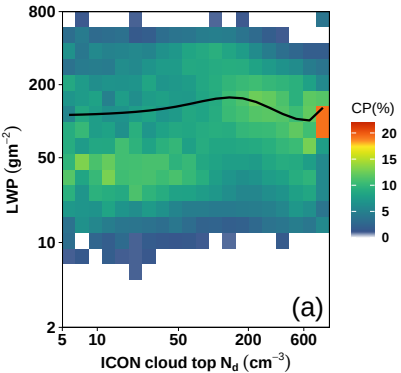
- MODIS Level 2
- 1 km horizontal resolution

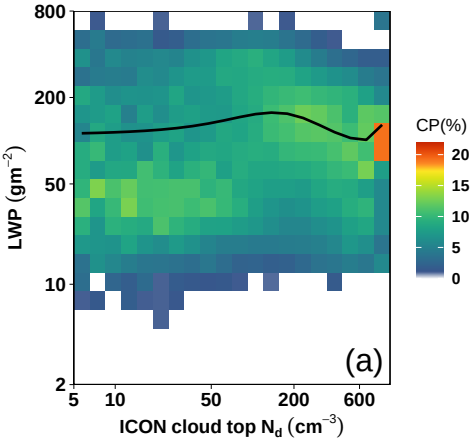
N_d-LWP relationship in the ICON model

· ICON-LES simulation over Germany

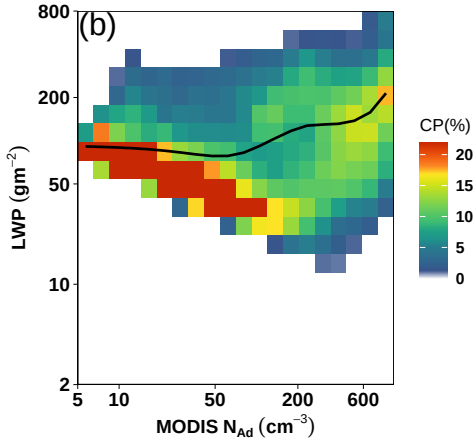


N_d-LWP relationship in the ICON model & Satellite observation

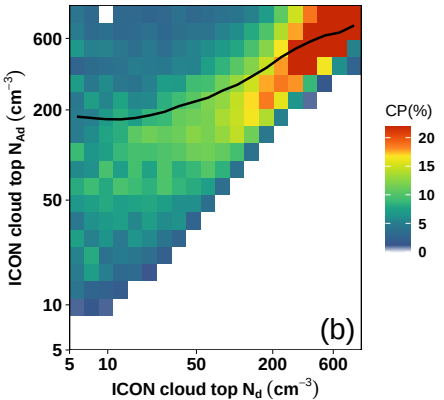
· ICON-LES simulation



· MODIS Satellite

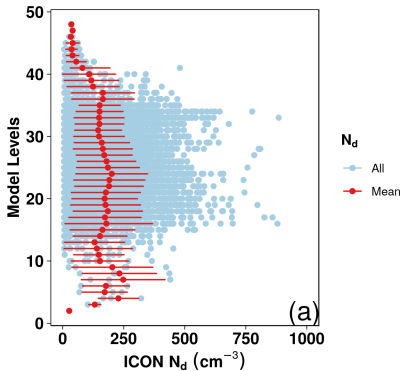


Comparison between the ICON simulated N_d and N_{Ad}



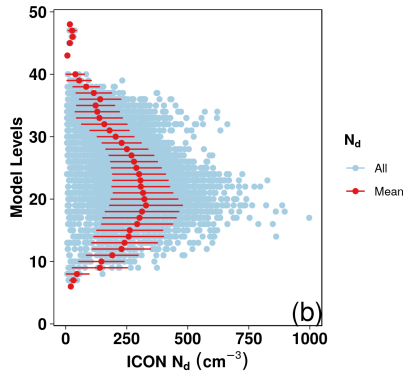
Cloud regimes based on N_d profile

Shallow Clouds



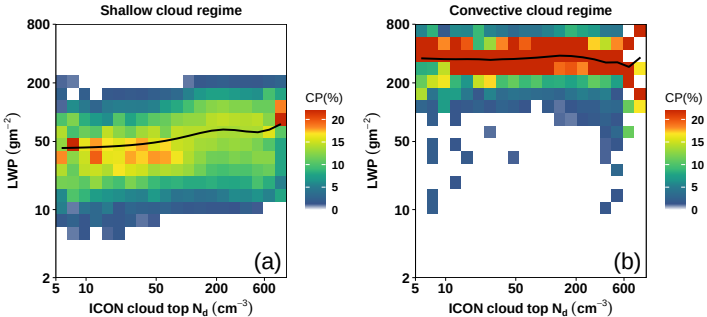
- For cloud depth $>$ 100 & $<$ 600 meters
- Cloud cores with RH>100%
- Cloud cores with w $>$0

Convective Clouds



- For cloud depth $>$ 1000 meters
- Cloud cores with RH>100%
- Cloud cores with w $>$0

Shallow and Convective cloud regime



- For cloud depth > 1000 meters
- Cloud cores (w > 0 & RH>100%)
- Cloud cores CDNC = cdnc at max w)
- For cloud base > 300 meter
- Non-precipitating Single layer clouds

- For cloud depth > 100 & < 600 meters
- Cloud cores (w > 0 & RH>100%)
- Cloud cores CDNC = cdnc at max w)
- For cloud base > 300 meter
- Non-precipitating Single layer clouds

Summary

- A joint probability histogram is used to investigate the $N_{d/Ad}$-LWP sensitivity.
- The ICON-LES derived N_{Ad}-LWP relationship is comparable with satellite retrievals.
- However, the ICON-LES derived N_d-LWP relationship shows a nonlinear relationship.
- The model and the satellite failed to explain the negative sensitivities when suing the adiabatic N_{Ad}-LWP relation.
- The diverse N_d-LWP relationship in adiabatic and sub-adiabatic cloud regimes suggests that the regime-based analysis would be more relevant when compared to the satellite retrievals, especially in the warm continental clouds.

Thank you for your attention!

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