Diurnal warm layers appear in the ocean, but the **clouds** are not very impressed*

*at least on short timescales

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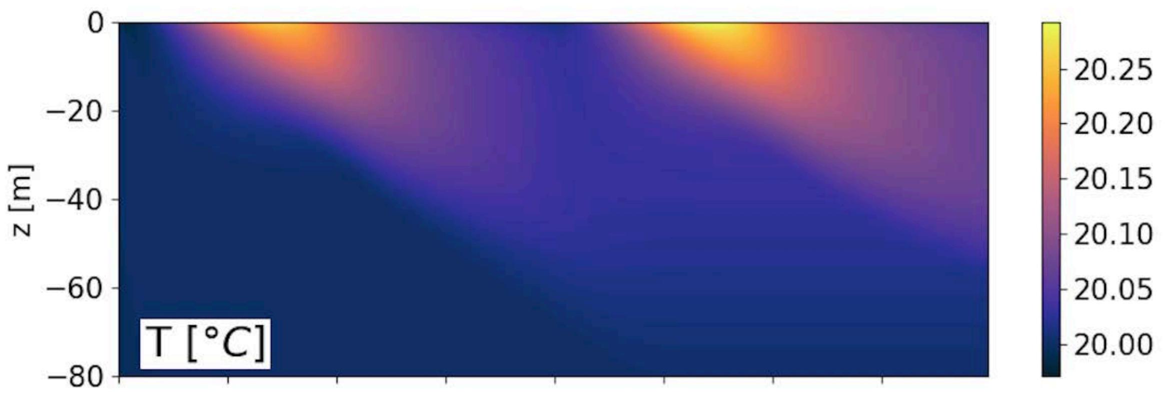
Motivation and background

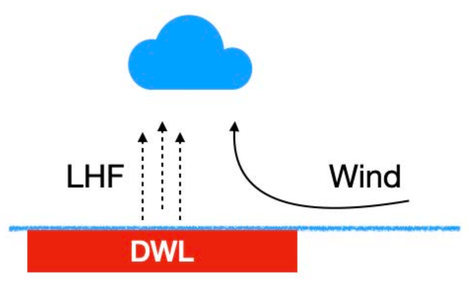
What are diurnal warm layers (DWL)?

- Upper-ocean areas that heat up during the day and decouple from the mixed layers —> SST fluctuations of up to 5 K
- Horizontal extent: several 100 km, thickness: O(10 m)
- Mechanism: **high incoming shortwave radiation** warms up the surface, **weak wind**: low turbulent mixing; heat accumulation during the day
- "Relaxation" at nighttime



How can they influence the atmosphere?

- "Sea breeze" due to differential heating (J. Malkus (1957))
- More evaporation, more atmospheric moisture (A. Voldoire (2022), S. P. de Szoeke (2021))
- Impact on convection (tropics), more clouds
- Influence on climate through a change in outgoing longwave radiation
- Changes in the diurnal cycle of clouds
- Feedback mechanisms?



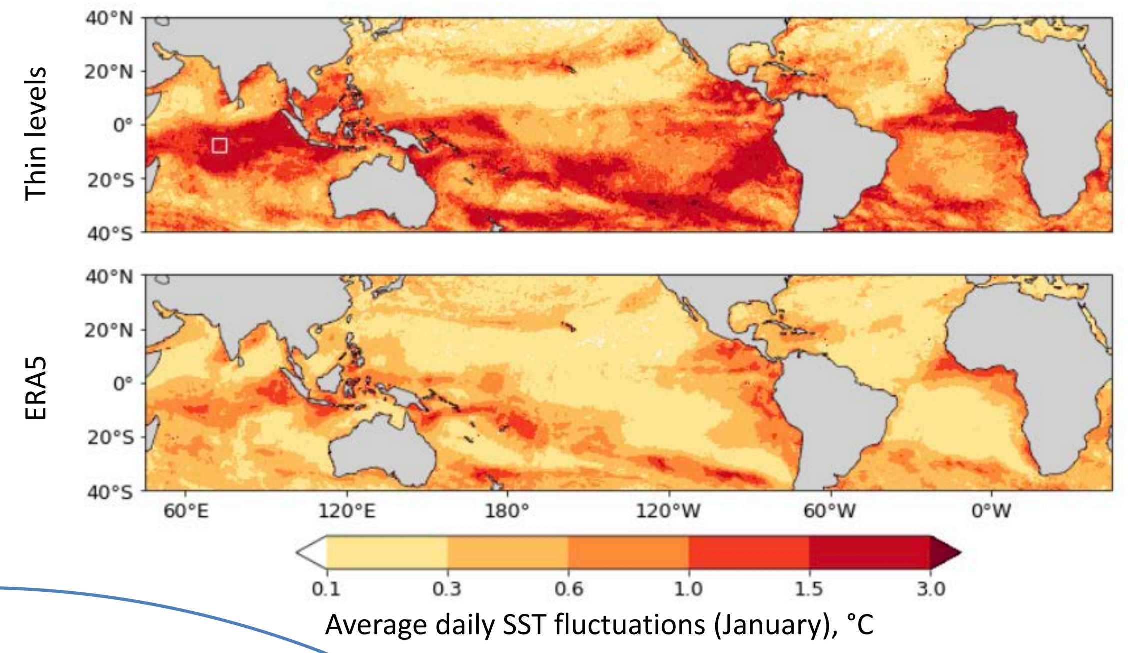
What do we want to do?

Study and quantify these influences in a global simulation

Simulation setup

- Coupled, global simulations: ICON Sapphire (C. Hohenegger et al. (2023))
- 5 km horizontal resolution: convection not parameterised
- To obtain physical DWLs: thin vertical levels (0.5m near the surface, determined with a 1 column model GOTM)
- Control simulation: thicker vertical levels, same initial condition
- Measure differences during the first 4 days (low error due to variability)

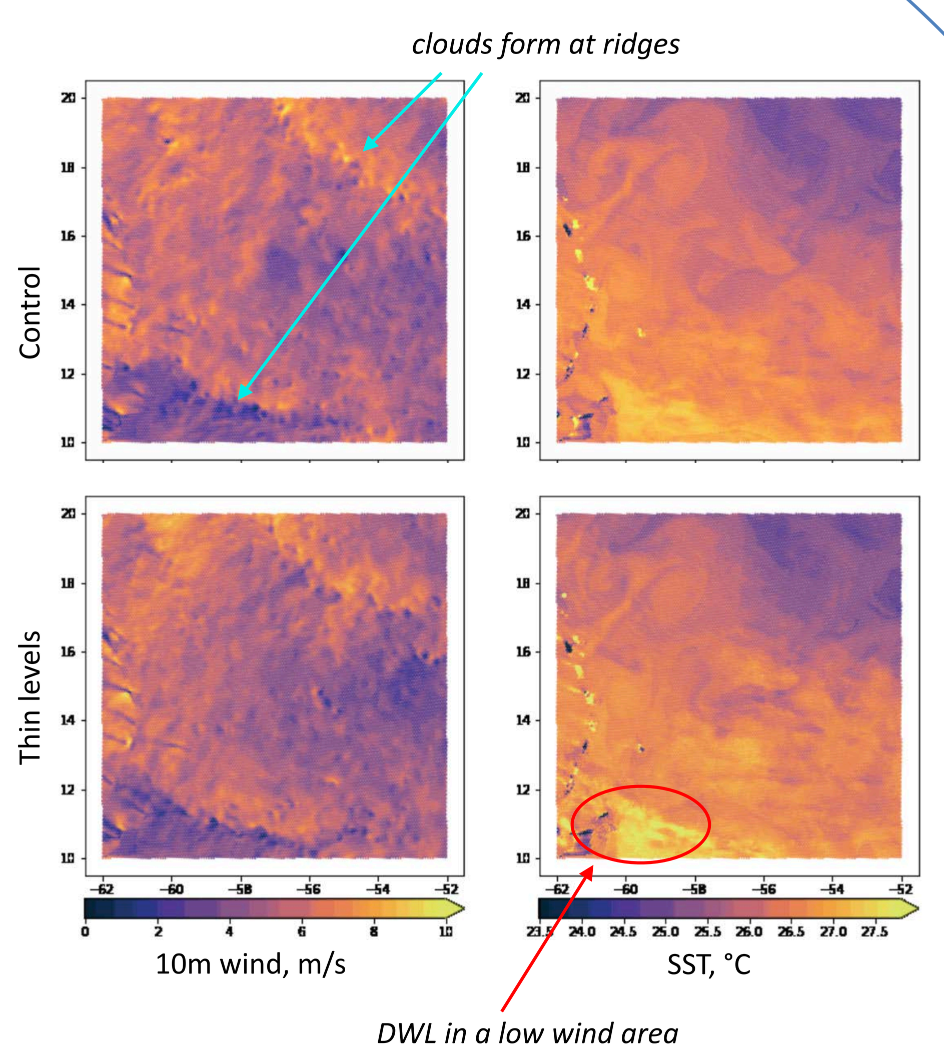
DWLs in an ICON simulation



- Accurate spatial distribution
- Magnitude of daily SST fluctuations: 2x reanalysis (ERA5) and observations
- Too shallow and too strong DWLs
- Large clusters, but short individual lifetimes
- Correctly reproduced dependencies on near-surface wind and shortwave radiation at the surface

Preprint: Impact of Diurnal Warm Layers on Atmospheric Convection

Results at first glance: Barbados region



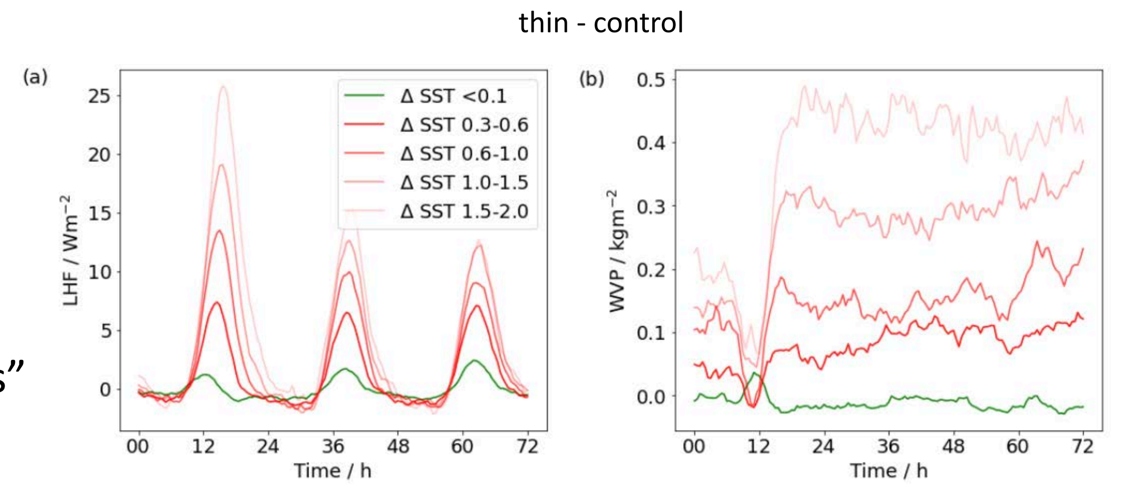
DWLs do not cause the appearance of cloud patterns, though their locations are related because of wind patterns.

...do DWLs at least enhance the cloud amount?

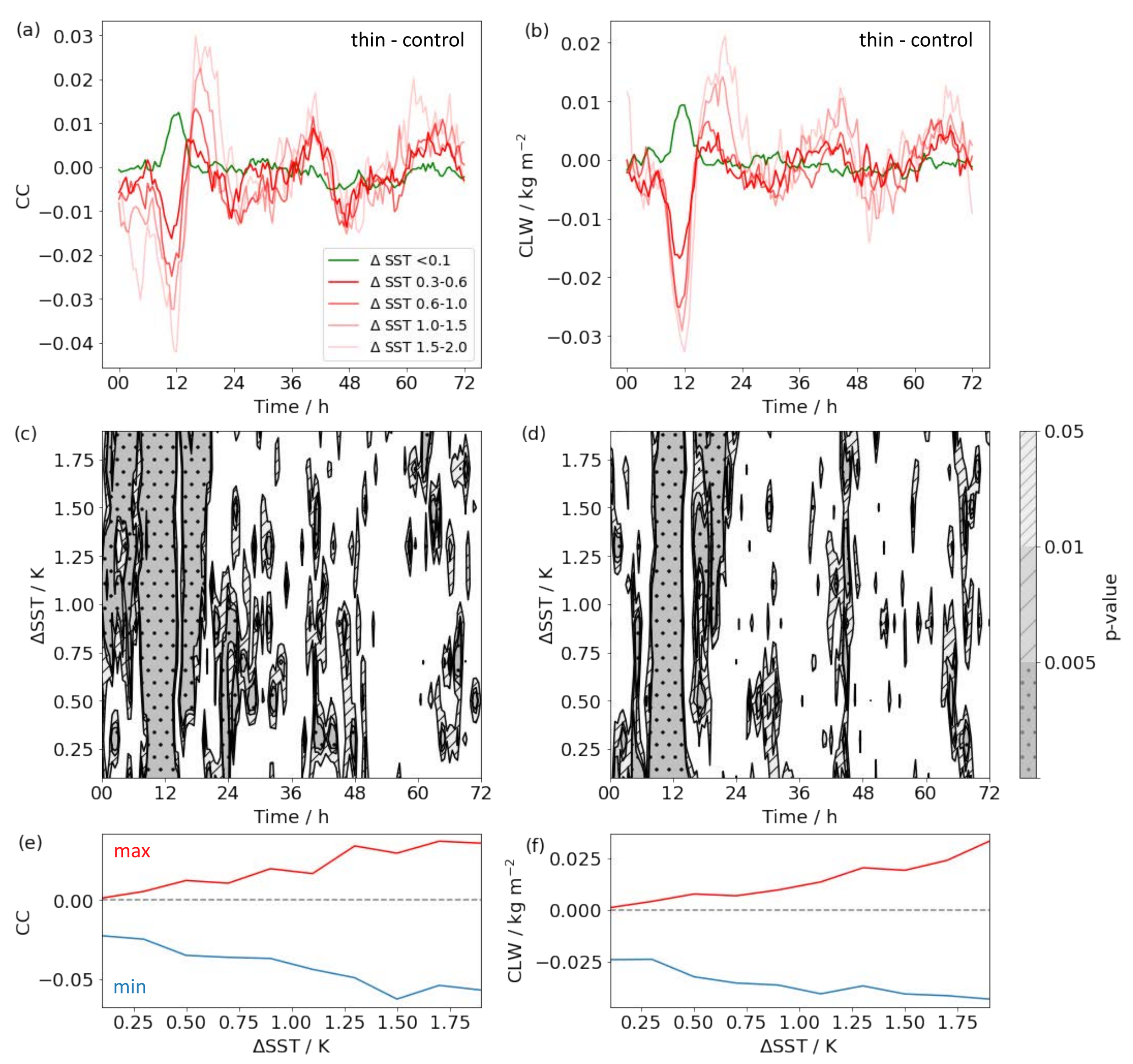
In-depth results: global quantitative analysis

- Divide the tropical ocean into 0.25°x0.25° squares
- Move all squares to the same time zone
- Divide them into groups depending on the maximal SST difference on a given day (detection day)
- Observe how atmospheric variables differ between "thin levels" and "control" in different groups over three days

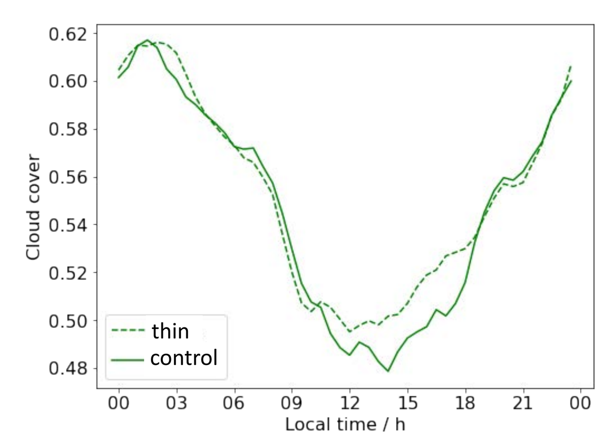
Impact on latent heat (LH) and water vapour path (WVP):



Impact on cloud cover (CC) and cloud liquid water (CLW):



Diurnal cycle of cloud cover:



No difference in daily CC averages

Conclusions

- Visible but small effects on cloud cover and liquid water path
- Might play a role in places with high SST fluctuations
- Very small and short-lived global impact
- Possible reasons: insufficient increase of moisture, lack of persistence

J.S. Malkus (1957) *Trade Cumulus Cloud Groups: Some Observations Suggesting a Mechanism of Their Origin.* Tellus 9(1):33–44

A. Voldoire et al. (2022) *Assessment of the sea surface temperature diurnal cycle in CNRM-CM6-1 based on its 1D coupled configuration.* GMD 15(8):3347-3370

S.P. de Szoeke et al. (2021) *Diurnal Ocean Surface Warming Drives Convective Turbulence and Clouds in the Atmosphere.* Geophysical Research Letters 48(4):1-8

C. Hohenegger et al. (2023) *ICON Sapphire: simulating Earth System's components and their interactions at kilometer and subkilometer scales.* GMD 16(2):779-811

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