Final Report for Project **1253**

Project title: **Investigating feedbacks between atmospheric convection and near surface processes in the ocean**

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In the project « Investigating feedbacks between atmospheric convection and near surface processes in the ocean » we investigated the interaction between diurnal warm layers (DWLs) in the ocean and convection in the tropics. DWLs are warm water layers near the surface of the ocean that appear under low wind conditions on days with high radiation.

In the publication Shevchenko et al. (2023) we show that the appearance of DWLs leads to an increase in latent heat flux and in the cloud cover over the warming patches, but the average effect on the cloud is small.

To accomplish this analysis , we ran, after a round of preparatory experiments, a global simulation with a 5 km horizontal resolution and a very high vertical resolution in the ocean, starting from 0.5 m at the surface. This allowed to resolve the physics behind diurnal warm layers and simulate them in an interactive and physically consistent way. Although the amplitude of the diurnal warming seems to be overestimated with respect to ERA5, the dependence on wind and solar radiation is in good agreement with theoretical considerations and available measurements (see Figure 1).

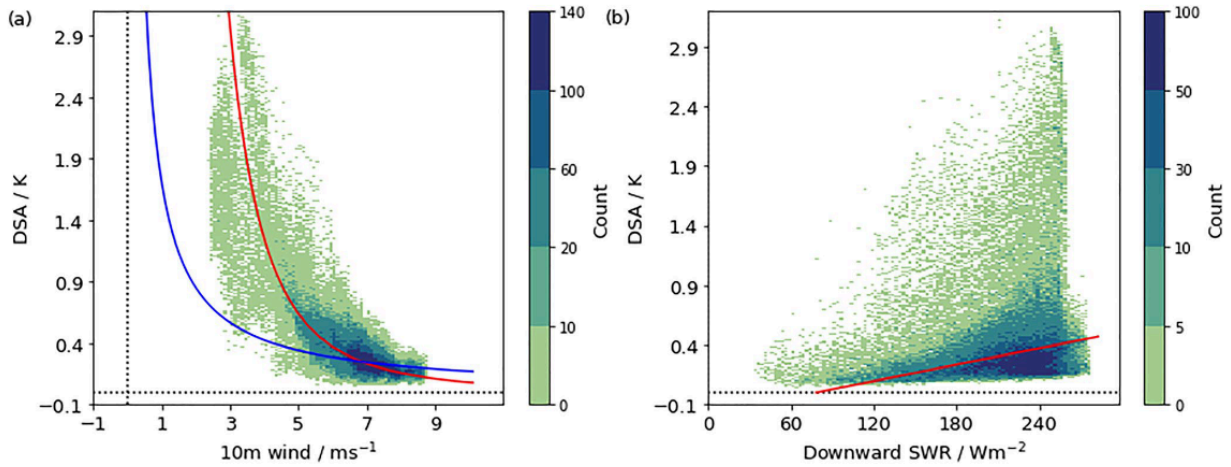

Figure 1. Histograms and fits of diurnal SST fluctuation amplitude vs. (a) 10 m wind, (b) downward shortwave radiation

We also conducted a control simulation having identical initial conditions but fewer layer in the ocean. In the control simulation, the DWLs are not as strong, and one can compare the relative effect of the warming depending on the temperature increase. We found that DWLs cause an increase of the latent heat flux: The sea surface temperature (SST) increase of 1-1.5K results in a latent heat flux difference of up to 17 W / m^2 in the afternoon. The effects on the cloud cover (CC) and cloud liquid water (CLW) are also clearly distinguishable, but an SST increase of 1-1.5K only produces a CC rise of 0.02 and a CLW rise of 0.01 kg / m^2 in the global average (see Figure 2).

In the subsequent part of the project we aimed to understand why the effect on convection is small compared to the effects caused, for instance, by a surface warming of a similar magnitude in other circumstances. For example, Acquistapace et al. (2022) have found that over more persistent warm patches the difference in latent heat flux is about 5 times stronger than in our experiments. One hypothesis was that the influence of the low wind conditions that prevail when DWLs are formed. To test this, we ran idealized atmosphere-only simulations of RCE type on a torus domain and implemented SST fluctuations as well as the possibility to impose high near-surface winds. Preliminary results show that an increase in wind does indeed change the amount

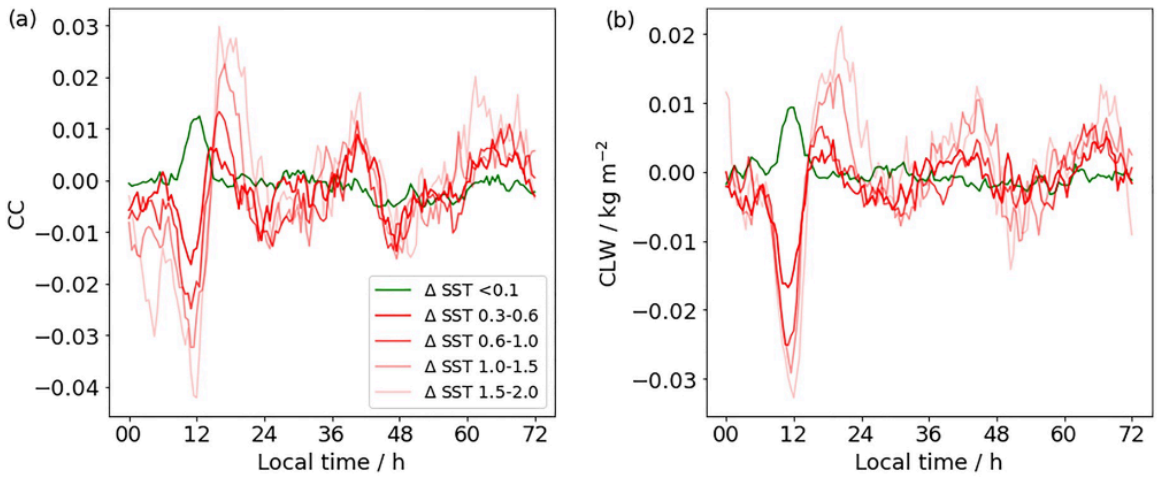

Figure 2. The differences in (a) cloud cover and (b) cloud liquid water between the simulation with DWLs and a control run. The colours refer to different magnitudes of daily SST fluctuations.

of CC compared to low-wind simulations, but its average contribution only amounts to a difference of 0.03. The investigation is ongoing, with a plan of completing it in 2024.

References

Acquistapace, C., Meroni, A. N., Labbri, G., Lange, D., Späth, F., Abbas, S., & Bellender, H. (2022). Fast atmospheric response to a cold oceanic mesoscale patch in the north-western tropical Atlantic. *Journal of Geophysical Research: Atmospheres*, 127, e2022JD036799, https://doi.org/10.1029/2022JD036799

Shevchenko, R., Hohenegger, C., & Schmitt, M. (2023). Impact of diurnal warm layers on atmospheric convection. *Journal of Geophysical Research: Atmospheres*, 128, e2022JD038473. https://doi.org/10.1029/2022JD038473