Project: **1358**
Project title: **HErZ: Marine Boundary-Layer Cloud Physics in ICON (MBL-ICON)**
Principal investigator: **Anna Possner**
Report period: **2024-07-01 to 2025-04-15**

Resource Utilisation

Resources requested	28
Resources consumed	21
Resources expired (incl. in consumed)	6
Resources remaining	6

Table 1: Overview of resources during the 01.07.2024 – 15.04.2025 reporting period. All entries are given in kNode hours [kNh].

Around 7 kNh were used for configuring idealised simulations for 10 stratocumulus-cumulus (St-Cu) transects observed during the MAGIC campaign between California and Hawaii (section 1). An additional 6 kNh were used in experiments investigating the St-Cu transition in mesoscale regional climate simulations testing different treatments of the shallow convection parameterisation (section 2). And finally 2 kNh were used for the "*Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE)*" model-intercomparison in the North Atlantic (section 3), as well as analyses contributing to Feingold et al. (2024) and Sauerland et al. (2024). Publications from section 1 and 2 are delayed due the 7-month absence of the PI for maternity and parental leave during the allocation period.

Section 1: Large-eddy simulations of the stratocumulus to cumulus transition in the Northeast Pacific using ICON

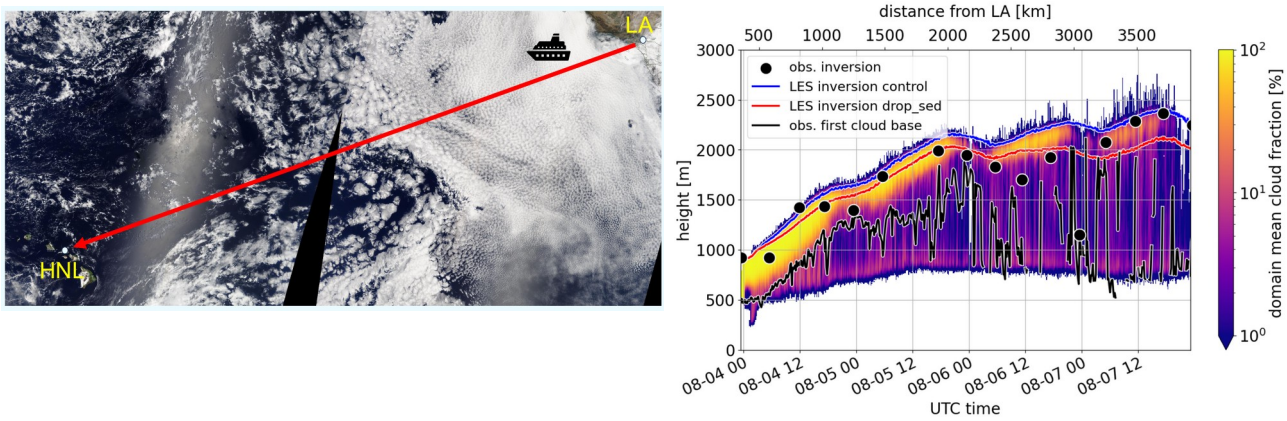

Figure 1: left: ship path of the SPIRIT (ship) during Leg 15A on the 20-07-13. The St-Cu transition is clearly visible along the ship transect. right: Simulated cloud fraction of Leg15A over the course of the ship-following idealised LES domain (see text for details).

Following fixes in the large-scale forcing in the previous reporting period, sensitivity experiments were conducted with respect to the impact of droplet sedimentation on boundary layer growth for all 9 selected MAGIC transects. Simulations were conducted at a horizontal (vertical) resolution of 60m (9m in the boundary layer) for the entire 3-4 day period. Different experiments including/excluding droplet sedimentation and/or warm-rain processes were conducted requiring a total of 7 kNh. Analysing the statistics over all 10 legs we find, that droplet sedimentation results in slower boundary layer growth in most simulated legs. This is seen in Figure 1 showing the inversion height in the control run (blue) and a run including droplet sedimentation (red). The impact on the simulated stratocumulus-cumulus transition is small. However, this needs to be substantiated in larger-domain simulations allowing the organisation of shallow convection as it develops. Resources for these experiments will be applied for in the following resource allocation period. The remainder of this allocation period will be used to disentangle the physical mechanisms at play and final publication figures for a a first draft.

Section 2: Cloud-radiative bias in fully parametrised subtropical clouds in ICON

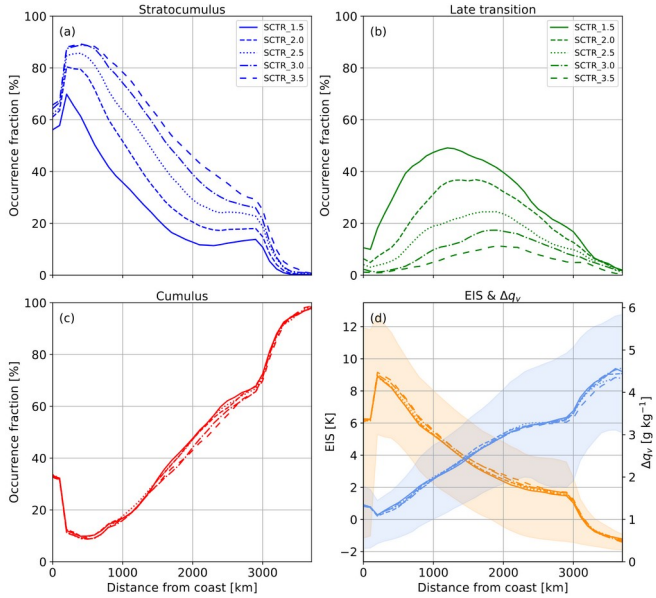

Figure 2: Summertime averaged occurrence fraction of the (a) stratocumulus, (b) late transition, and (c) cumulus regimes within each distance bin for the SCTR simulations with different $\Delta qv_{,crit}$ values.

During the allocation period we focussed on the proposed 3-month experiments and the CSET-based evaluation in individual cases. This was neccessary as we adjusted our methodolgy and criteria for the treatment of shallow convection. Previously, we tested an implementation where 1K is used as the critical estimated inversion strength (EIS) parameter, but only in boundary layers with a depth of up to 1.5km. The second criterion can be climatologically motivated, but has no direct physical meaning. We thus introduced a new criterion in addition to the EIS parameter considering a critical moisture jump ($\Delta qv_{,crit}$) in the sub-cloud layer, which is indicative for decoupling and the formation of cumuli initially detraining into the still existing stratiform cloud deck. Figure 2 demonstrates the impact of different $\Delta qv_{,crit}$ thresholds (spanning the entire physical range) on the relative stratocumulus, transition region, and cumulus occurrence. In addition to CERES, a new forward simulated radiance operator was tested for GOES. This allowed us to assess the impact on cloud morphology for CSET research flights in individual case studies in addition to vertical cloud and rain distribution analysed in PAMTRA forward simulated and observed radar reflectivities.

Simulations were performed at 10km horizontal resolution, 90 vertical levels with a 60s time step over a domain of 6000x3000 km^2. A total of 6 kNh were consumed on all conducted sensitivity experiments. A first paper draft is in internal review.

Section 3: COMBLE LES simulations

Following the COMBLE simulation protocol (https://arm-development.github.io/comble-mip/timeline.html), five different scientific experiments were run on a small (25x25km domain, 100m horizontal resolution) differing in assumptions with respect to droplet activation and immersion freezing along the advected air mass. Simulations are submitted to the intercomparison and ICON results look reasonable in comparison to other models and observations. Further explorations are planned on larger domains and different model physics in the coming allocation period.

Publications/Presentations:

- Ramadoss, V., Pfannkuch, K., Protat, A., Huang, Y., Siems, S., & Possner, A. (2024). An evaluation of cloud-precipitation structures in mixed-phase stratocumuli over the Southern Ocean in kilometer-scale ICON simulations during CAPRICORN. Journal of Geophysical Research: Atmospheres, 129, e2022JD038251.
- Sauerland F. , N. Souverijns, **A. Possner**, H. Wex, P. Van Overmeiren, A. Mangold, K. Van Weverberg, N. van Lipzig (2024): Ice-nucleating particle concentration impacts cloud properties over Dronning Maud Land, East Antarctica, in COSMO-CLM2, Atm. Chem. and Phys., doi:10.5194/acp-24-13751-2024.
- Feingold G. et al. [inkl. **A. Possner**] (2024): Physical science research needed to evaluate the viability and risks of marine cloud brightening, Sci. Adv., doi:10.1126/sciadv.adi8594.
- Pfannkuch, K.; Ahlgrimm, M.; Possner, A. "Reducing the cloud-radiative bias in fully parametrised subtropical clouds in ICON during CSET", International Conference on Clouds and Precipitation (ICCP) 2024, Jeju, South Korea (poster).
- Possner A. “Exploring the impact of mixed-phase cloud (MPC) processes on cloud dynamics and cloud radiative effects in marine stratocumuli”, ICCP Journal Club.
- Schnelke, M. , M. Ahlgrimm, A. Possner:”Exploring the influence of cloud droplet sedimentation on the stratocumulus to cumulus transition in high-resolution ICON simulations”, ICCARUS 2025.

Expected Resource Utilisation remaining quarter (16.04. - 31.06.2025):

We expect a full resource utilisation during the remaining quarter of this allocation.