Project: **1358**
Project title: **HErZ: Marine Boundary-Layer Cloud Physics in ICON (MBL-ICON)**
Principal investigator: **Anna Possner**
Report period: **2023-07-01 to 2024-03-31**

Resource Utilisation

Resources requested	17
Resources consumed	13
Resources expired (incl. in consumed)	6
Resources remaining	4

Table 1: Overview of resources during the 01.07.2023 – 31.03.2024 reporting period. All entries are given in kNode hours [kNh].

Around 2 kNh were used for configuring idealised simulations for 9 stratocumulus-cumulus (St-Cu) transects observed during the MAGIC campaign between California and Hawaii (section 1). An additional 4 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 0.3kNh were used for satellite retrieval processing from the GOES satellite investigating cloud-radiative effects in the South American stratocumulus deck in multi-year climatologies (section 3).

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

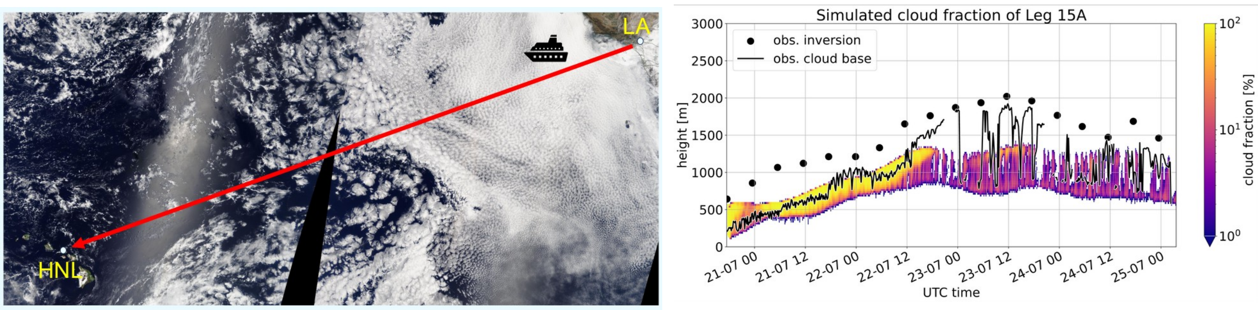

Figure 1: left: ship path of the SPIRIT (ship) during Leg 15A on the 20-07-13. The St-Cu transition is clearly visible along the ship transect. right: Simulated cloud fraction of Leg15A over the course of the ship-following idealised LES domain (see text for details). The first solid black line separates the St state from the Cu under St state, while the second solid line marks the St breakup. The dashed line highlights the beginning of the St thinning.

From the 20 observational trips 9 were selected which featured a good transition and idealised LES simulations were setup for these transects in small test domains. For all 9 legs, test domains (32x32 grid points at a resolution of 108m in horizontal and at most 25m in vertical up to 3km) were run for all cases. These runs were performed to check first transition characteristics and fine tune the NUDGING setup. Coarser (300m) resolution were performed on larger domains (50x50km2) to check the impact of domain size, which did not resolve the insufficient boundary layer deepening in the beginning (Fig. 1). Meanwhile, the observed decline in boundary layer depth at the end is now captured, which was not the case in initial test simulations and required a correction of the vertical updraft speed in the external forcing file for the run.
Tests investigating ways to improve initial boundary layer growth are ongoing, before continuing to production runs in the next proposal.

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

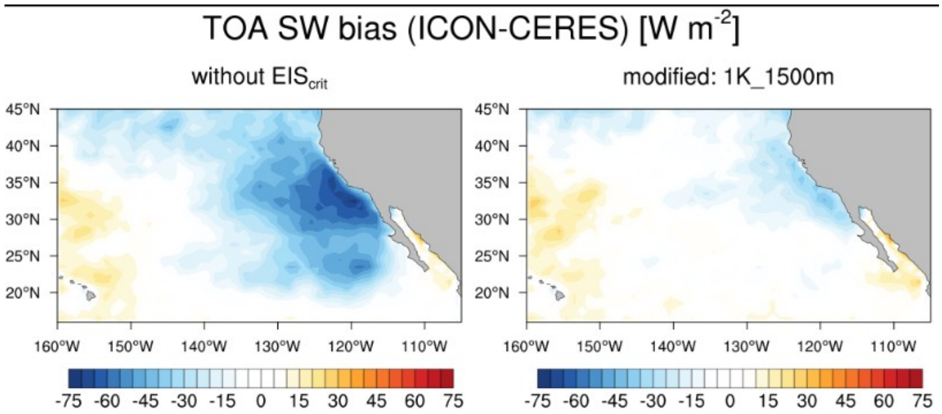

Figure 2: TIme averaged top-of-the-atmosphere (TOA) shortwave (SW) bias (ICON – CERES-EBAF) for simulations with left: no critical estimated inversion strength (EIS) parameter and right: critical EIS parameter reduced to 1K and a maximum boundary layer depth of 1500m as trigger limiter for modified shallow convection treatment.

We investigated newly implemented adjustments to the triggering of shallow convection and subgrid-scale (SGS) cloud cover in regional ICON simulations in the Northeast Pacific. Results are shown for a climatological mean between June-August 2015 including the CSET field campaign period. Simulations were performed at 10km horizontal resolution, 90 vertical levels with a 60s time step over a domain of 6000x3000 km^2.

As shown in Figure 2 the cloud-radiative bias is reduced drastically by suppressing the triggering of shallow convection in shallow and stable boundary layers. The default implementation by the German weather service proposes a critical EIS parameter of 7K. Here we test an alternate implementation where 1K is used as the critical EIS parameter, but only in boundary layers with a depth of up to 1.5km. In addition we also turn of mid-level convection.
We use the 2-moment microphysics scheme and change the effective radius used SGS clouds to more realistic values, which greatly improves the representation of SGS clouds and renders the additional adjustment of SGS cloud cover implemented at DWD, which is tuned for single-moment microphysics, unnecessary. These modifications drastically increase the simulated grid-scale cloud fraction, which is of particular importance investigations of aerosol-cloud interactions. We have finished testing, and are now developing further analysis metrics for the CSET campaign and will move to multiyear production runs during the next phase.

Section 3: Cloud Albedo susceptibility in marine stratocumulus in GOES

We processed 3 years of GOES-16 retrievals to investigate the joined or independent changes in cloud optical depth and cloud fraction as a function of aerosol concentration on stratocumulus scene albedo. We are currently extending our analysis incorporating information on cloud morphology for publication.

Publications/Presentations:

Schnelke, M. , M. Ahlgrimm, A. Possner: ”Large-eddy simulations of the stratocumulus to cumulus transition in the Northeast Pacific using ICON”. Poster presentations at ICCARUS 2024 and EGU 2024.

Pfannkuch, K., M. Ahlgrimm, A. Possner: “ Reducing the cloud-radiative bias in fully parametrised subtropical clouds in ICON during CSET”, poster presentation at ICCARUS 2024.

Vieira-Fischer, F. and A. Possner: “Exploring cloud fraction adjustments in the South Pacific marine stratocumulus cloud deck using 3 years of GOES 16 retrievals”, poster presentation at EGU 2024.

Expected Resource Utilisation remaining quarter (01.04. - 31.06.2024):

We expect a full resource utilisation during the remaining two quarters of this allocation. This will include testing of our setups on the new Levante computing system.