Project: **474,** Project title: **Laptev**
Project lead: **Günther Heinemann,** Report period: **2025-11-01 to 2026-10-31**

The project focuses on simulations with the atmospheric climate model COSMO-CLM (CCLM) adapted for the polar regions (Heinemann et al. 2022) with 15km (C15), 5km and 1km for the Arctic (C15 being part of Arctic CORDEX).

In the report period, we used 5km simulations for a six-years climatology of low-level jets (LLJs) in the Laptev Sea area (Heinemann and Schefczyk 2026). These data were further evaluated with respect to wind extremes and downslope windstorms in the Laptev Sea area. A paper on the evaluation of simulated wind profiles and LLJs compared to SODAR-measured data for one year was published (Heinemann et al. 2025). Additional runs with 1km resolution for the MOSAiC drift of Polarstern for the period 2019-2020 were made. Results were compared to the LES model PALM (publication submitted).

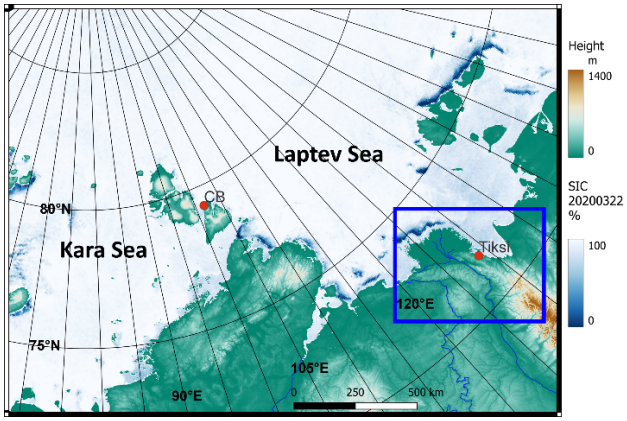


Fig.1: Model domain for CCLM with 5 km resolution for the Laptev Sea (L05) with topography and sea ice concentration for 22 March 2020. The Russian observatories Cape Baranova (CB) and Tiksi are marked by red dots. Modified from Heinemann and Schefczyk (2026).

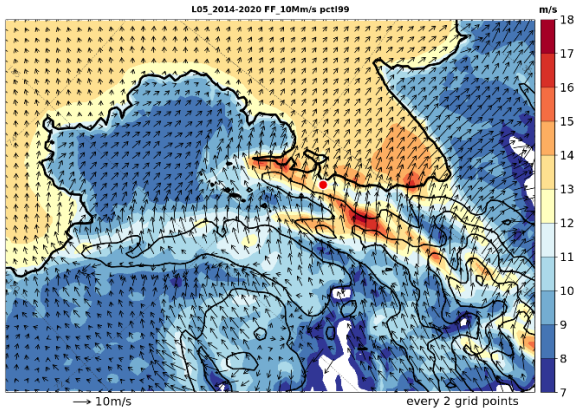


Fig.2: 99%-tile of the 10m-wind (2014-2020) for the Tiksi area (topography every 500m as isolines). Mean wind vectors for wind speeds exceeding 10m/s are shown for every second grid point. The red point marks Tiksi.

The simulations of CCLM for 2014-2020 with 5 km resolution for the Laptev Sea area (Fig.1) were evaluated with respect to wind field structure with a focus on downslope winds, turbulence and wind energy in the Tiksi area. Fig.2 shows the 99%-tile of the 10m-wind for the Tiksi area based on 1h values. The highest wind extremes exceed 16m/s and are located at the eastern slope of the main mountain ridge. The study of Heinemann and Schefczyk (2026) showed that at Tiksi most low-level jets were associated with downslope windstorms and high turbulence intensity in the lower boundary layer (Fig.3). The distribution of the TKE extremes at 50m (Fig.4) shows that very large TKE occurs associated with the downslope winds, which can be hazardous for light aircraft (Shestakova 2021).

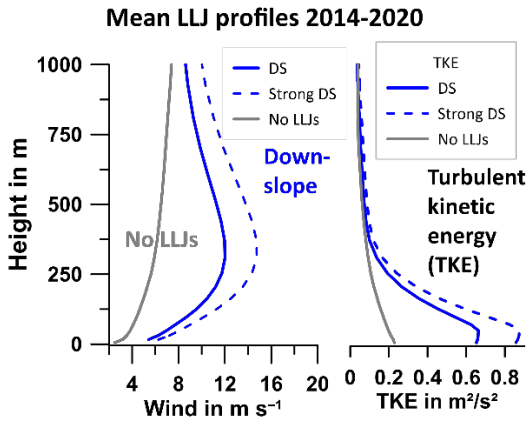


Fig.3: Mean vertical profiles for all and strong downslope LLJs (jet speed ≥ 10 m/s) and profiles without LLJs (gray line). Modified from Heinemann and Schefczyk (2026).

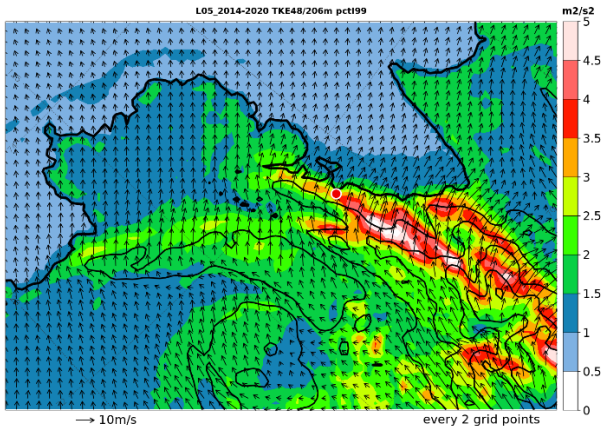


Fig.4: As Fig.2, but for the 99%-tile of the TKE at 50m.

CCLM simulations were performed for the MOSAiC period 2019-2020 with 15km horizontal resolution for the whole Arctic (C15) and with 5km horizontal resolution for a domain covering the whole drift (M05). In addition, runs with 1km resolution (M01) were made for case studies. Sea ice concentration (SIC) is taken from AMSR microwave data and Moderate Resolution Imaging Spectroradiometer (MODIS) data. The latter yield sea ice lead information with a resolution of 1km. At 1km resolution for 21 March 2020 (Fig.5a) leads are represented at their native resolution and the SIC is smaller than 70% for many pixels. For M05 and C15, leads are sub-grid features and have SIC of more than 90% in general. Accordingly, the daily mean of the sensible heat flux over leads in M01 is much higher than for M05 and C15 (Fig.5b). The differences get relatively small, if M05 and M01 are upscaled to C15 resolution (Fig.5c). In conclusion, the sea ice lead parameterization yields consistent results from the convection-resolving scale to the scale of regional climate models.

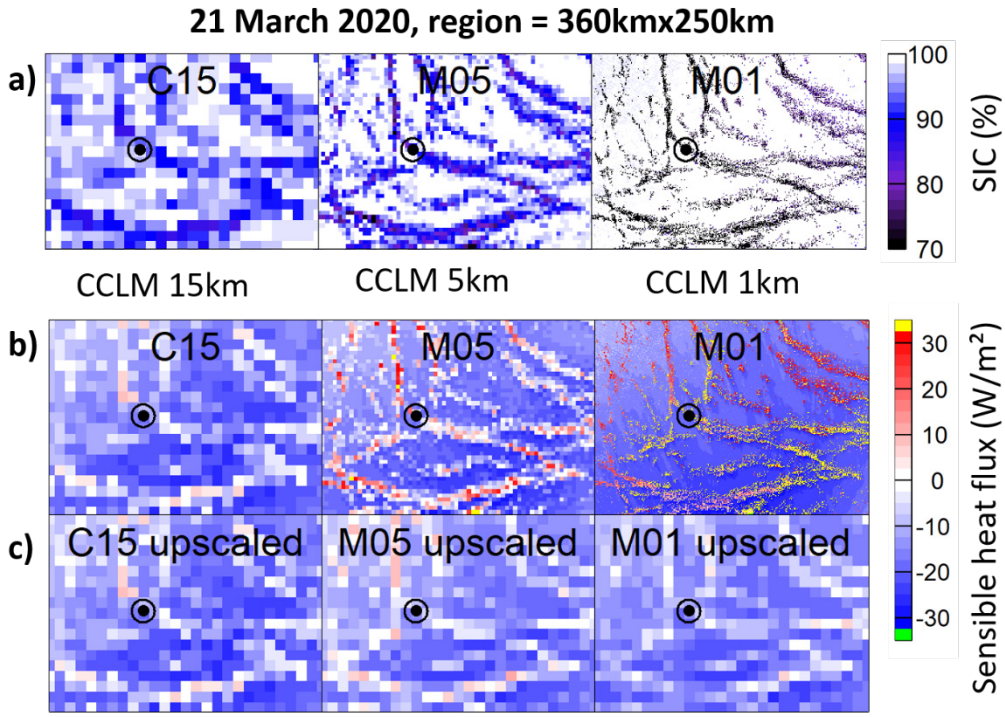


Fig.5: Comparison of CCLM simulations for MOSAiC (dot = position of the icebreaker Polarstern) with resolutions of 15km, 5km and 1km for 21 March 2020. a) sea ice concentration, b) and c): sensible heat flux (daily mean) at the native model resolution and upscaled to 15km, respectively.

In the report period, the following CCLM data with 15km resolution for Polar CORDEX were transferred to DKRZ Doku:

Arctic Climate CMIP6 forcing SSP370 2070-2100 (**19TB**), DKRZ_LTA_474_dsg0003

Antarctic Climate CMIP6 forcing – 3D data 2000-2014 (**14TB**), DKRZ_LTA_958_ds00023-25

Literature

Heinemann, G., Schefczyk, L., Willmes, S., Shupe, M., 2022: Evaluation of simulations of near-surface variables using the regional climate model CCLM for the MOSAiC winter period. Elem. Sci. Anth., 10 (1). DOI: 10.1525/elementa.2022.00033.

Heinemann, G., Drüe, C., Makshtas, A., 2025: Simulations of low-level jets at the Tiksi observatory (Laptev Sea, Siberia) using the regional climate model CCLM and evaluation using SODAR observations for the winter 2014/15. Journal of the European Meteorological Society 3 100027. https://doi.org/10.1016/j.jemets.2025.100027.

Heinemann, G., Schefczyk, L., 2026: A climatology of low-level jets at the Tiksi observatory (Laptev Sea, Siberia) using high-resolution regional climate model simulations. Atmosphere 17, https://doi.org/10.3390/atmos17020218.

Shestakova, A.A. Assessing the Risks of Vessel Icing and Aviation Hazards during Downslope Windstorms in the Russian Arctic. Atmosphere 2021, 12, 760, doi:10.3390/atmos12060760.