Project: **474,** Project title: **Laptev**
Project lead: **Günther Heinemann,** Report period: **2023-01-01 to 2023-10-31**

The project focuses on simulations with the atmospheric climate model COSMO-CLM (CCLM) adapted for the polar regions (Heinemann et al. 2022a) with 15km (C15), 5km (C05) and 1km (C01) for the Arctic (C15 being part of Arctic CORDEX).

In the report period, we used the data of the MOSAiC drift of Polarstern for the period 2019-2020 to evaluate C15 for the simulation of the atmospheric boundary layer (ABL, Heinemann et al. 2023). Simulations for the domain of the whole MOSAiC drift with 5km resolution nested in ERA5 were performed for different configurations and parameterizations. Furthermore, C01 was nested in C05 for the winter 2019/20 using 1km sea ice data to investigate the impact of sea ice leads on the atmospheric boundary layer for the MOSAiC winter. Another focus was the study of topographic flows. Here we performed simulations for the Siberian Arctic extending the data set of Heinemann et al. (2022b) with C15 and C05 and Greenland (Kohnemann and Heinemann 2021) with C05 and C01 for case studies covering periods of field experiments (Heinemann et al. 2021, Heinemann 2018). CCLM data were also used to study sea ice leads and their relation to winds (Willmes et al. 2023).

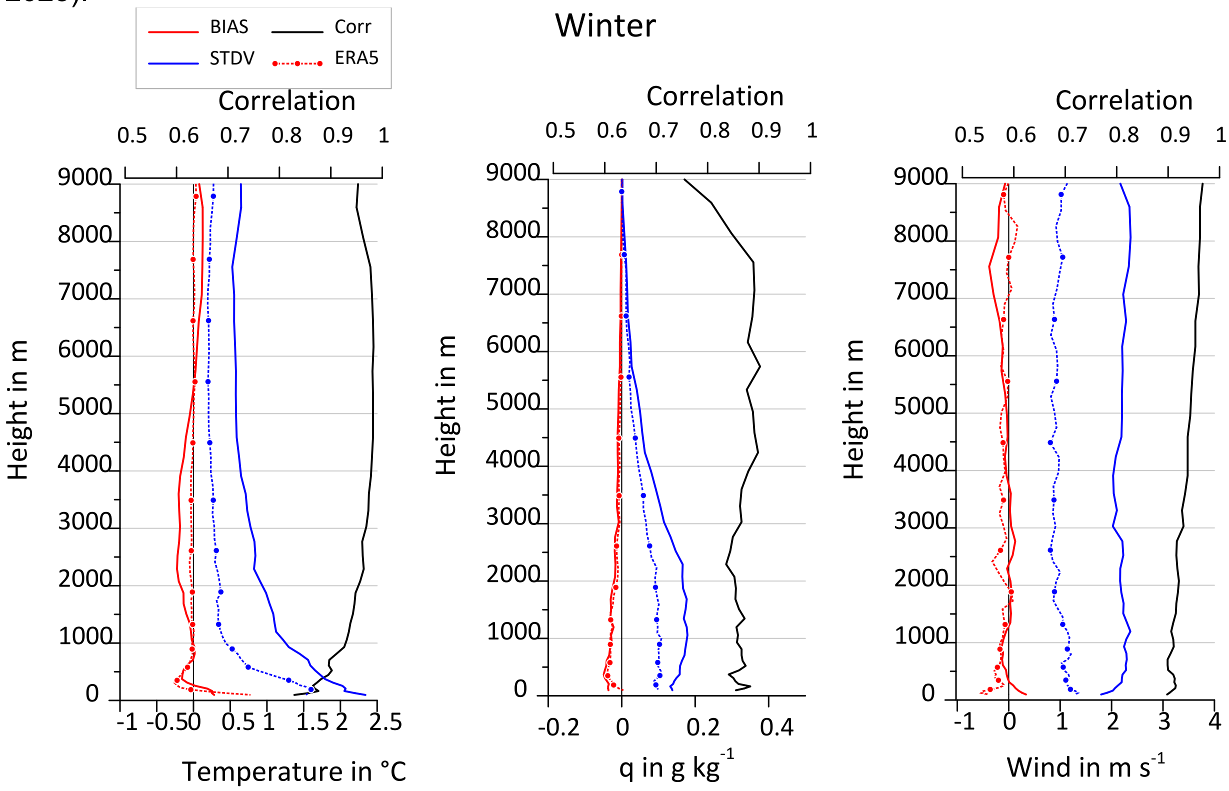

Fig.1: Profiles of bias (red lines), STDV (blue lines) and correlation (black lines) for the comparison of CCLM simulations with radiosondes for temperature (left), specific humidity (middle) and wind speed (right) for November 2019 -April 2020 (715 profiles). Bias and STDV for the comparison of ERA5 with radiosonde data are shown as dotted lines with symbols. From Heinemann et al. (2023).

Fig.1 shows the results of the comparison of C15 simulations and radiosondes of Polarstern during the MOSAiC winter 2019/20. Altogether, 715 profiles are available. For this comparison, radiosonde data were interpolated to the model levels of the simulated profile closest to the time of the ascent. Data on each model level were linearly detrended for the calculation of correlations. Since radiosonde data are not reliable in the lowest decameters, because of flow distortion around the ship, and its influence on temperature and humidity, the lowest level for the comparison was chosen as 80 m. Temperature shows very small biases of less than ±0.3°C for all levels, the STDV (standard deviation of the difference between model and observation) is about 2.0°C in the lowest 500 m and less than 1.0°C above 1000 m. The correlation is very high for all levels, with r = 0.83-0.90 in the lowest 500 m and typically 0.97 above 1000 m. The biases for wind speed are extremely small, while the STDV has values of about 2 m/s. The correlation exceeds 0.9 at all levels. For specific humidity, there is a small negative bias of 0.05 to 0.03 g/kg in the lowest 2000 m. The STDV is smaller than 0.18 g/kg and the correlation is 0.85-0.90 below 8000 m. The decrease of the correlation above 8000 m is due to the extremely low humidity in the upper troposphere. Figure 1 also shows bias and STDV for the comparison of ERA5 data with radiosonde data, which are assimilated in ERA5. As expected, STDVs for ERA5 are smaller than for CCLM. The temperature bias for ERA5 is almost zero above 1000 m, but is larger than for CCLM in the ABL.

Wind profiles for the ABL were evaluated using wind lidar data (Heinemann et al. 2023). The wind speed bias is largest at 87 m (1.1 m/s) and decreases to 0.2 m/s at higher levels (Fig.2a). At the same time the number of available lidar data decreases substantially with height. The number of hourly CCLM data is 4368. While at 87 m the availability of lidar data is 65%, this value decreases to 30% at about 400m and to 18% at about 600 m. The STDV increases with height from 1.7 m/s at lower levels to 2.4 m/s at about 600 m. While the radiosonde comparisons show almost the same values for the STDV, the bias is much lower. Fig.2b shows the bias and STDV for the wind direction. The mean wind direction of the simulations has a small positive bias in the lowest 300 m, and is almost zero above that level. The STDV lies between 30 and 40°. The bias for the mean wind components (Fig.2c) is negative for the u component and slightly positive for the v component.

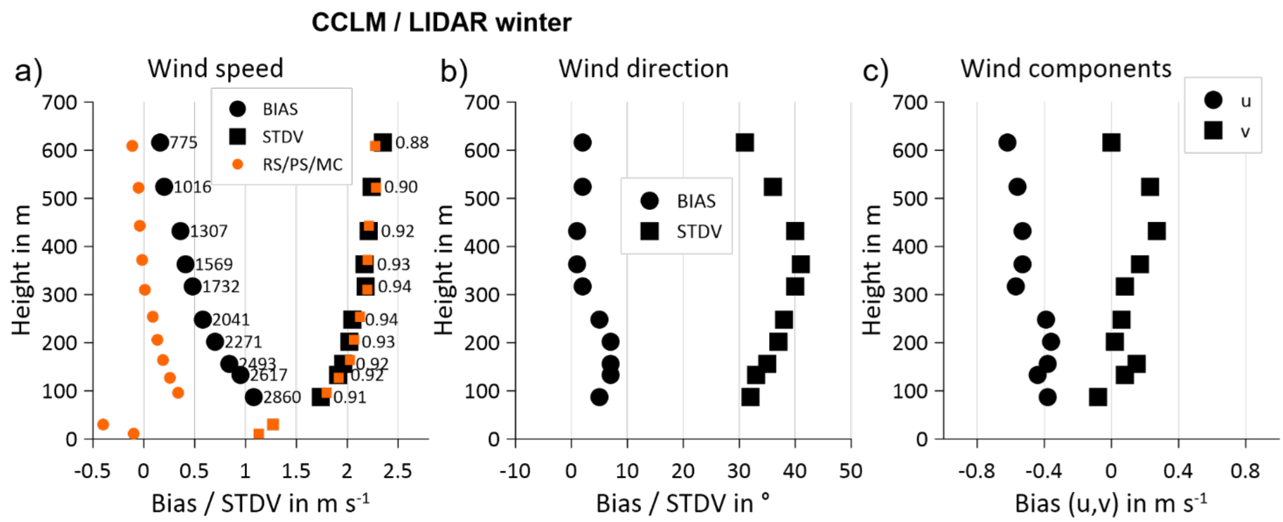

Fig.2: Bias (CCLM-OBS) and STDV for the comparison of wind from the Galion lidar (black symbols) and CCLM simulations at different heights for the winter based on hourly data. a) Bias (black dots) and STDV (black squares) for the wind speed (correlation coefficients (detrended data) are shown as labels at the STDV data, numbers of data points as labels at the bias data). The bias and STDV for the comparison with radiosondes (RS), the wind at 30 m from Polarstern (PS) measurements and the 10m-wind at Met City (MC) are shown as orange symbols. b) Bias (black dots) and STDV (black squares) for the wind direction, and c) biases for the wind components (dots for u, squares for v). From Heinemann et al. (2023).

Literature

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