# Polar CORDEX Annual report 2023

**Scientific highlights (including images if possible)**

Arctic:

New coordinated multi-model research activities were started. One of those activities is an evaluation of Arctic atmospheric boundary layer stability regimes, their frequency and radiative and mechanical forcing using observations from the year-long MOSAiC expedition. The approach is based on Jozef et al. (2023). A total of 12 modeling groups have indicated an interest in participating in this model intercomparison. According output from the different RCMs has been provided, results of a first model (CAFS) have been presented by Jozef and Cassano (2023), and first multi-model analysis results are expected in next spring. Another activity is the process-oriented investigation of a warm air intrusion event during mid-April 2020 that was observed during MOSAiC (Kirbus et al., 2023; Svensson et al., 2023). This study has its focus on the atmospheric boundary layer, air mass transformation, surface energy budget, and aerosol-cloud-radiation interactions. This multi-model activity is a joint effort of Polar CORDEX and the EU-funded project PolarRES (https://polarres.eu/).

To quantify possible climate change effects, wind energy potentials from a multi-RCM ensemble of Arctic-CORDEX were calculated for future scenarios (Akperov et al., 2023). The seasonal wind power density over the Arctic is estimated to increase in the 21st century under a high emission scenario (RCP8.5). Surface roughness through sea-ice and vegetation changes may significantly impact on the variability of future wind energy potentials in the Arctic.

Antarctic:

To determine which ice shelves are vulnerable to melt-induced hydrofracture, Orr et al. (2023) used near-surface temperature output from 1979/80 to 2018/19 from two Antarctic CORDEX simulations (MetUM and HIRHAM5) to calculate a regional surface “melt potential” index (MPI) over Antarctic ice shelves that describes the frequency (MPI-freq, %) and intensity (MPI-int, K) of daily maximum summer temperatures exceeding a melt threshold of 273.15 (0°C), which is the melting point of snow/ice. Results are based on output from two models to enable model-dependence and consistency to be assessed. Hansen et al. (2023) examined the representation of an extensive melt event that occurred over the Ross Ice Shelf during January 2016 by the MetUM and HIRHAM5 Antarctic CORDEX simulations, as well as a physically-based, multi-layer, offline coupled firn model forced by both HIRHAM5 and MetUM output. The results show that both the HIRHAM5 and MetUM simulations considerably underestimated the number of melt days that occurred during the event, which is likely due to both limitations in their own ice/snow surface schemes and an absence of spin-up. However, using HIRHAM5 and MetUM output to force the offline coupled firn model resulted in a considerable improvement in modelled melt. However, despite its sophistication, the offline coupled firn model was unable to realistically represent the complete melt pattern over the RIS, which they suggest is due to deficiencies in the representation of cloud phase partitioning in models.

**Summary of each workshop/activity held during the year**

| Title, date, short description, location, website, links | Responsible person/-s | Funder |
|---|---|---|
| Annual Polar Cordex meeting, 4-6 October 2023, Utrecht University, Netherlands | A. Rinke, J. Cassano, A. Orr, W. J. van de Berg | Cordex, CliC |
| D2 session on “Regional Climate Modelling in the Polar Regions: Applications and the road ahead” at ICRC-CORDEX 2023, 25-29 September 2023, Trieste, Italy, https://icrc-cordex2023.cordex.org/ | P.A. Mooney, A. Rinke, J. Cassano | |
| Session M15 on “Polar Modelling” at IUGG, Berlin, Germany, 11-20 July 2023, https://www.iugg2023berlin.org/ | J. Cassano, A. Rinke, A. Orr | |

| **Domain related publications during the year** | | |
|---|---|---|
| Title, journal and link to publication | Author/-s | Date |
| An Overview of the Vertical Structure of the Atmospheric Boundary Layer in the Central Arctic during MOSAiC, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-780 | Jozef, G.C., Cassano, J.J., Dahlke, S., Dice, M., Cox, C. J., and de Boer, G. | 2023 |
| Thermodynamic and kinematic drivers of atmospheric boundary layer stability in the central Arctic during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC). *Atmospheric Chemistry and Physics,* **23,** 13087-13106, doi:10.5194/acp-23-13087-2023. | Jozef, G.C., J.J. Cassano, S. Dahlke, M. Dice, C.J. Cox and G. de Boer | 2023 |
| Surface impacts and associated mechanisms of a moisture intrusion into the Arctic observed in mid-April 2020 during MOSAiC, Front. Earth Sci., https://doi.org/10.3389/feart.2023.1147848 | Kirbus et al. | 2023 |
| Warm air intrusions reaching the MOSAiC expedition in April 2020—The YOPP targeted observing period (TOP). Elementa: Science of the Anthropocene, https://doi.org/10.1525/elementa.2023.00016 | Svensson et al. | 2023 |
| Future projections of wind energy potentials in the Arctic for the 21st century under the RCP8.5 scenario from regional climate models (Arctic-CORDEX), Anthropocene, https://doi.org/10.1016/j.ancene.2023.100402 | Akperov et al. | 2023 |
| Policy-relevant science highlights from the Antarctic CORDEX project, World Meteorological Organisation Antarctic Treaty Paper, https://www.ats.aq/devAS/Meetings/Documents/95 | Orr | 2023 |
| Characteristics of surface melt potential over Antarctic ice shelves based on regional atmospheric model simulations of summer air temperature extremes from 1979/80 to 2018/19, J. Clim., https://doi.org/10.1175/JCLI-D-22-0386.1 | Orr et al. | 2023 |
| Variable temperature thresholds of melt pond formation on Antarctic ice shelves. *Nature Climate Change*, *13*(2), 161-166, https://doi.org/10.1038/s41558-022-01577-1 | van Wessem et al. | 2023 |
| Higher Antarctic ice sheet accumulation and surface melt rates revealed at 2 km resolution. *Nature Communications*, *14*(1), 7949, https://doi.org/10.1038/s41467-023-43584-6 | Noël et al. | 2023 |
| Deep learning regional climate model emulators: A comparison of two downscaling training frameworks. *Journal of Advances in Modeling Earth Systems*, *15*(6), e2022MS003593, https://doi.org/10.1029/2022MS003593 | van der Meer et al. | 2023 |
| The importance of cloud phase when assessing surface melting in an offline coupled firn model over Ross Ice shelf, West Antarctica, *The Cryosphere Discuss.*, https://doi.org/10.5194/tc-2023-145. | Hansen et al. | 2023 |

**Planned activities for next year**

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| Annual Polar Cordex meeting, autumn 2024, Potsdam, Germany |