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Mixed cloud properties during high-intensity precipitation events over Northern Antarctic Peninsula

Anastasiia Chyhareva[1,2], Svitlana Krakovska[1,2], Lyudmyla Palamarchuk[1], and Irina Gorodetskaya[3]
[1]Ukrainian Hydrometeorological Institute, Department of applied meteorology and climatology, Ukraine
[2]National Antarctic Scientific Center of Ukraine, Kyiv, Ukraine
[3]Centre for Environmental and Marine Studies, Department of Physics, University of Aveiro, Aveiro, Portugal

Antarctic Peninsula climate is a very sensitive system that is strongly affected by the temperature increase, compared to other Antarctic regions. Moisture transport from lower latitudes influences this region indirectly through precipitation, radiative forcing, and heat advection. Our understanding of the factors responsible for the enhanced moisture transport and its impact on the surface and energy balance of the Antarctic Peninsula is incomplete, particularly, regarding cloud and precipitation microphysics and their temporal evolution.

The goal of this study is to investigate the temporal and spatial evolution of cloud properties during high-intensity precipitation events with phase transition, associated with an atmospheric river event over the Antarctic Peninsula in April 2021. Our analysis is based on PolarWRF simulations, precipitation properties derived from MRR-Pro measurements, hourly observations at Vernadsky station, ERA-5 reanalysis and GFS forecast.

We run simulations with PolarWRF forced with ERA-5 reanalysis and compare the simulation results with ground-based meteorology observations and measurements, conducted during the seasonal expedition at Vernadsky station in April 2021. Polar-WRF configuration included 3 domains with 9, 3, and 1-km spatial resolution, centered over the Vernadsky station with two double-moment cloud microphysics parameterization schemes: Morrison and Thompson. From Polar-WRF simulations we analyse the following characteristics: radar reflectivity, vertical and horizontal components of wind speed, temperature, cloud top temperature and water content, mixing ratio and number concentrations of ice, snow, and rain. We focus our analysis on two vertical cross-sections, which represent the properties of the main atmospheric river flow. “Perpendicular” to the flow cross-section passes over Anvers Island and Kyiv Peninsula. “Parallel” the flow cross-section passes over the Akademik Vernadsky station, the mountains of Antarctic Peninsula and the Larsen B ice shelf.

We analyze two cases with observed intense precipitation with phase transition during the first days of April 2021. The first intense rain event was associated with a cyclone, centered over the Amundsen Sea and reaching up to tropopause (about 10km). The second intense precipitation event with precipitation phase transition was associated with moisture intrusion from extratropical latitudes, possibly atmospheric river, in combination with a shallow cyclone centered

over 64.53° S, 76.25° W, and height up to about 3km. High precipitation intensity and temperature increase were observed during both events.

Comparison with observation and measurements at Vernadsky station shows a good agreement in precipitation phase and the timing of its transitions. Polar-WRF simulations showed development of strong updrafts and downdrafts due to the orographic effect during both precipitation events. Temperature and reflectivity profiles confirm that precipitation originated from mixed-phase clouds. High intensity of precipitation could be connected to the high intensity of the crystal growth due to the Findeisen-Bergeron process, while the temperature was -10º.. -12 ºC up to 4 km high. This information is difficult to verify due to a lack of vertical measurements such as radiosounding, etc. However, it gives some understating about atmospheric flow transformation during intense precipitation events in the Northern Antarctic Peninsula.