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Impact of assimilation of radiosonde and UAV observations on numerical weather prediction analyses and forecasts in the Arctic and Antarctic

Timo Vihma[1], Tuomas Naakka[1], Qizhen Sun[2], Tiina Nygård[1], Michael Tjernström[3], Marius Jonassen[4,5], Roberta Pirazzini[1], and Ian Brooks[6]

[1]Finnish Meteorological Institute, Meteorological Research, Helsinki, Finland (timo.vihma@fmi.fi)
[2]National Marine Environmental Forecasting Center, Beijing, China
[3]Department of Meteorology and Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden
[4]The University Centre in Svalbard, Longyearbyen, Norway
[5]University of Bergen, Norway
[6]School of Earth and Environment, University of Leeds, Leeds, UK

Weather forecasting in the Arctic and Antarctic is a challenge above all due to rarity of observations to be assimilated in numerical weather prediction (NWP) models. As observations are expensive and logistically challenging, it is important to evaluate the benefit that additional observations could bring to NWP.

Considering the Arctic, in this study the effects of the spatial coverage of the network on numerical weather prediction were evaluated by comparing radiosonde observations from land station taken from Integrated Global Radiosonde Archive (IGRA) and radiosonde observations from expeditions in the Arctic Ocean with operational analyses and background fields (12 hr forecasts) of the European Centre for Medium Range Weather Forecasts (ECMWF). The focus was on 850 hPa level temperature for the period January 2016 – September 2018. Comparison of the analyses and background fields showed that radiosoundings had a remarkable impact on improving operational analyses but the impact had a large geographical variation. In particular, radiosonde observations from islands (Jan Mayen and Bear Island) in the northern North Atlantic and from Arctic expeditions substantially improved analyses suggesting that those observations were critical for the quality of analyses and forecasts. Comparison of two cases with and without assimilation of radiosonde sounding data from expeditions of Icebreaker Oden in 2016 and 2018 in the central Artic Ocean showed that satellite observations were not able to compensate for the large spatial gap in the radiosounding network. In the areas where the network is reasonably dense, the density of the sounding network was not the most critical factor for the quality of background fields. Instead, the quality of background field was more related to how radiosonde observations were utilized in the assimilation and to the quality of those observations.

Considering the Antarctic, we applied radiosonde sounding and Unmanned Aerial Vehicles (UAV) observations from an RV Polarstern cruise in the ice-covered Weddell Sea in austral winter 2013 to

evaluate the impact of their assimilation in the Polar version of the Weather Research and Forecasting (Polar WRF) model. Our experiments revealed small or moderate impacts of radiosonde and UAV data assimilation. In any case, the assimilation of sounding data from both radiosondes and UAVs improved the analyses of air temperature, wind speed, and humidity at the observation site for most of the time. Further, the impact on the results of 5-day long Polar WRF experiments was often felt over distances of at least 300 km from the observation site. All experiments succeeded in capturing the main features of the evolution of near-surface variables, but the effects of data assimilation varied between different cases. Due to the limited vertical extent of the UAV observations, the impact of their assimilation was limited to the lowermost 1-2 km layer, and assimilation of radiosonde data was more beneficial for modelled sea level pressure and near-surface wind speed. Considering the perspectives for technological advance, atmospheric soundings applying UAV have a large potential to supplement conventional radiosonde sounding observations.

The differences in the results obtained for the Arctic and Antarctic are discussed.