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RESEARCH ARTICLE

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Precipitation instruments at Rothera Station, Antarctic Peninsula: a comparative study

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ABSTRACT

Direct measurement of precipitation in the Antarctic using ground-based instruments is important to validate the results from climate models, reanalyses and satellite observations. Quantifying precipitation in Antarctica faces many unique challenges such as wind and other technical difficulties due to the harsh environment. This study compares a variety of precipitation measurements in Antarctica, including satellite data and reanalysis fields atRothera Station, Antarctica Peninsula. The tipping bucket gauges (TBGs) were less sensitive than laser-based sensors (LBSs). The most sensitive LBS (Visibility and Present Weather Sensor, VPF-730) registered 276 precipitation days, while the most sensitive TBG (Universal Precipitation Gauge, UPG-1000) detected 152 precipitation days. Case studies of the precipitation and seasonal accumulation results show the VPF-730 to be the most reliable precipitation sensor of the evaluated instruments. The precipitation amounts given by the reanalyses were positively correlated with wind speed. The precipitation from the Japanese 55-year Reanalysis was most affected by wind speed. Case studies also show that during low wind periods, precipitation measurements from the instruments were very close to the precipitation measurement given by the Global Precipitation Climatology Project (GPCP) 1-degree-daily (1DD) data. During strong wind events, the GPCP 1DD did not fully capture the effect of wind, accounting for the relatively small precipitation amount. The Laser Precipitation Monitor (LPM) and Campbell Scientific-700 (CS700H) experienced instrumental errors during the study, which caused the precipitation readings to become exceedingly high and low, respectively. Installing multiple LBSs in different locations (in close proximity) can help identify inconsistency in the readings.

KEYWORDS

Observation; Antarctica; reanalysis; GPCP 1DD; blowing snow

ABBREVIATIONS

CFSv2: Climate Forecast System version 2; CS700H: Scientific Rain Gauge, by Campbell Scientific; ECMWF: European Centre for Medium-Range Weather Forecasts; ERA-Int: European Centre for Medium-range Weather Forecasts Interim reanalysis data set; GPCP: Global Precipitation Climatology Project data set; JRA-55: Japan Meteorological Agency 55-year Reanalysis; LBS: laser-based sensor; LPM: Laser Precipitation Monitor, by Thies; NCEP: National Centre for Environmental Prediction; PWS-100 Scientific Present Weather Sensor, by Campbell Scientific; TBG: tipping bucket gauge; UPG-1000: Universal Precipitation Gauge 1000, by Environmental Measurements Limited; VPF-730: Visibility and Present Weather Sensor 730, by Biral

Introduction

Because precipitation is an important component of Antarctic surface mass balance dynamics, obtaining robust and reliable precipitation profiles of the Antarctic is one of the main objectives of climate study of the southern continent (Agosta et al. 2015). Limited accessibility, power constraints and the harsh climate limit precipitation profiles to manned research stations. Even then, the strong winds in Antarctica, which can sometimes travel up to 20 ms^{-1}, resulting in blowing snow (Van Lipzig et al. 2004), have a profound effect on the accuracy and reliability of instrument-based precipitation measurements. Previous studies have shown that the relatively slow fall velocity of snow and the creation of flow distortions by precipitation gauges are two main causes for snow undercatch (Folland 1988). For a precipitation gauge with an open funnel, an updraft could form at the leading edge of the gauge, leading to an upward deflection of snow particles away from the gauge orifice (Kochendorfer et al. 2017). Flow distortion around the gauge will increase with increasing wind speed, deflecting more snow particles away from the gauge. Scientists also measure accumulation using stakes, ice or firn cores and acoustic depth gauges, as proxies for precipitation, but this measurement is not straightforward (Cohen & Dean 2013). In view of the logistic difficulty in obtaining reliable precipitation measurements, researchers have resorted to using other means,

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