Adjustment of wind induced solid precipitation undercatch in operational verification practices

Barbara Casati[1], Eva Mekis[2], Morten Køltzow[3]

1 = Meteorological Research Division, Environment and Climate Change Canada
2 = Climate Research Division, Environment and Climate Change Canada
3 = Norwegian Meteorological Institute, Oslo, Norway

Winter precipitation measurements from standard instrumentation at synoptic stations are affected by the undercatch of solid precipitation in windy conditions. Verification against these under-estimated measurements can lead to the erroneous diagnosis of solid precipitation over-forecasts, as an example. Quality control of operational verification systems then flags solid precipitation measurements in windy conditions, so that they are discarded prior to the calculation of verification scores. However, this also represents a severe problem for operational forecast verification, especially at high latitudes and in winter, since this selective screening dramatically reduces the sampled precipitation events (e.g. Casati et al. 2021 estimated a reduction of 55% in North America and up to 80% in Fennoscandia for winter 2018) and systematically eliminates major snow storms (which usually occur under windy conditions). As a result, most hit events are not scored, while false alarms dominate the verification results, preventing once again the correct diagnosis of the forecast true quality.

The WMO Solid Precipitation InterComparison Experiment (SPICE, Nitu et al. 2019) has performed a multi-site inter-comparison and evaluation of instruments for measuring solid precipitation. Comparison with collocated Double Fence Automated Reference installations enabled the estimation of the catch efficiency for different types of weighing precipitation gauges and shields (e.g. Kochendorfer et al. 2017, 2018). The solid precipitation undercatch can then be adjusted, by dividing the observed measurement by the catch efficiency. The estimated catch efficiency (and hence the adjustment) depends on the temperature and wind speed (recorded at the time of the precipitation measurement), further than on the gauge height and shielding, and on the site characteristics and local climatology.

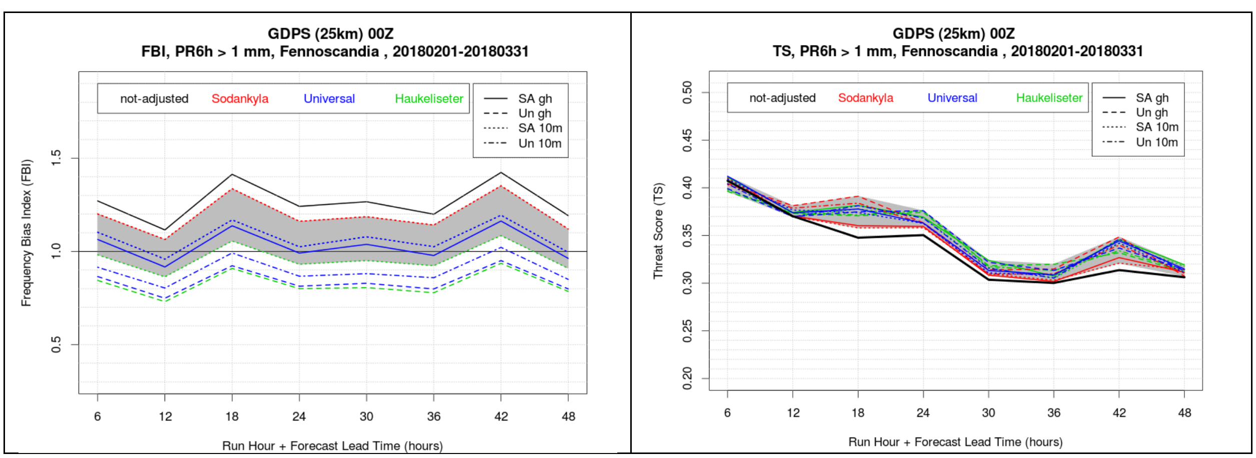

Figure 1 Frequency Bias Index (left) and Threat Score (right) for the 6h accumulated precipitation forecasts from the Canadian GDPS verified against synop measurements in Fennoscandia in February-March 2018. Black solid lines are verification statistics obtained against raw measurements, whereas colored lines are verification statistics obtained against adjusted measurements, considering the adjustment for Single Alter (SA) and unshielded gauges (Un), at 10m or gauge height (gh), for the universal adjustment (blue) as well as for the adjustments estimated for the Sodankyla (red) and Haukeliseter (green) site.

As an example, Figure 1 illustrates the effects of the SPICE adjustment on the verification results of precipitation forecasts from the Canadian Global Deterministic Prediction System (GDPS, Buehner et al. 2015). We adjust the solid precipitation undercatch by dividing the observed measurements with the catch efficiency, evaluated following Eq. 3 in Kochendorfer et al. (2017). As expected, the over-forecast is reduced (to attain almost neutral bias) and the accuracy is also improved. Similar results were found for different prediction systems and over other regions (Casati et al, 2021; Køltzow et al 2020), with the largest impact for the biases, whereas the accuracy was not always improved.

We conclude that the NWP systems systematic over-forecast of winter precipitation is artificially inflated by the undercatch of solid precipitation under windy conditions. The WMO-SPICE adjustment functions mitigate the effect of solid precipitation undercatch on the verification results, reducing the biases.

There is a large uncertainty associated with the adjustment (Buisan et al, 2020). The most significant source of uncertainty relates to the individual site characteristics and local climatology, which possibly mirrors the microphysics characteristics of the hydrometeors prevailing at the individual sites. While reducing such uncertainty is addressed by ongoing research within the SPICE community, verification results ought to be accompanied by an estimate of such uncertainty (e.g. the grey area in Figure 1).

Despite the uncertainty associated with the SPICE adjustments, verification results obtained by differently-tuned adjustments steer in a similar direction, and verification against adjusted measurements is expected to be more reliable and informative than against unadjusted measurements. Our recommendation for operational environments is to adjust the solid precipitation measurements, rather than removing the observations from the verification sample.

References

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