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Assessing anemometer drift as an additional cause of the stilling phenomenon: A statistical approach to minimize biases in wind speed series

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Recent studies on wind variability have revealed an unexpected decline (termed "stilling") in observed near-surface wind speed over land in many mid-latitude regions, particularly in the Northern Hemisphere, in the last 30-50 years. The precise cause(s) of this slowdown remains uncertain and the impact of cup anemometer drift (i.e. wear on the bearings) in the artificial weakening of wind speed has not yet been quantified. Among the instrumental artefacts related to the loss of cup anemometer performance, three different issues affect the accuracy of wind speed measurements: (1) rotor damage due to severe storms, hail or lightning; (2) failure at the opto-electronic output signal system; and (3) wear and tear with the mass addition of dirt to the cups (i.e. changing its aerodynamic) and, most importantly, to the internal anemometer bearings (i.e. degrading its rotor). This latter impact of anemometer drift (i.e. bearings malfunctions) in wind speed has only partially been discussed as an additional driver of this stilling, and because its complexity no research has attempted to quantify its contribution to the phenomenon.

A 3-year field experiment (2014-2016) with paired wind speed measurements from (i) one new, against (ii) one old (i.e. old bearings after years of operation in the field) SEAC SV5 cup anemometer was developed for estimating for the first time the role of the anemometer drift as an additional cause of the stilling phenomenon. This model device is used by the Spanish Meteorological Agency in the automatic weather stations since mid-1980s. Our analyses also aim to define statistical approaches to minimize biases in wind speed series due to the artificial decline signal produced by anemometer ageing, with the ultimate goal of improving the multidecadal assessment of wind speed trends.

The results show a statistically significant impact of the anemometer drifting, with the old anemometer measuring weaker wind speeds than the new one. Clear daily and seasonal cycles in the biases are found. Also different autoregressive models are presented to minimize the weakening effect in wind speed series due to the anemometer ageing.