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State of the Art in Cup Anemometry

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Despite the great development of more accurate and sophisticated wind-measurement instruments, cup anemometers remain today the most widely used and popular anemometer in measuring wind speeds at meteorological stations and wind farms. In addition, almost all the available long-term wind speed time series across the world have been recorded by cup anemometers. Studying the response of cup anemometers and errors associated with their measurements, and also how the cup anemometer measurements are comparable with modern sensors, is of great importance, and can affect meteorological and climatological studies of long-term wind speed trends, and also wind energy estimations.

Although cup anemometers are known for being robust and reliable, long-term field measurements of wind speeds by these wind sensors can be associated with errors and uncertainties affecting the quality of recorded data and subsequent analyses. When analysing wind speed data, it is essential to understand these errors and compensate for them and distinguish them from the real climate signals.

A comprehensive review on various aspects of anemometry, particularly cup anemometers, is presented in this paper. This review includes the different designs and theory developed from the invention of this wind-speed measuring system to very recent works, the response characteristics of anemometers, anemometer calibration procedures, field and wind-tunnel experiments on anemometers, etc. In addition, the different sources of errors and uncertainties are introduced and methods, including statistical, mathematical and experimental approaches, proposed to quantify and remedy the effects of these errors are presented. Lastly, several comparative studies that investigated the response characteristics of different types of cup anemometers and other anemometers are reviewed.