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Balloon drift estimation and improved position estimates for radiosondes

Ulrich Voggenberger[1], Leopold Haimberger[1], Federico Amgrogi[1], and Paul Poli[2]
[1]Department of Meteorology and Geophysics, University of Vienna, Vienna, 1090, Austria (img-wien@univie.ac.at)
[2]European Centre for Medium-Range Weather Forecasts, Bonn, Germany

When comparing model output to historical radiosonde observations, it is typically assumed that the radiosonde has ascended directly above its launch site and has not been moved by the wind. The introduction of Global Navigation Satellite System (GNSS) receivers on radiosondes in the late 1990s has led to a recent change in the availability of balloon trajectory data. However, this information was still not always transmitted, despite being the basis for estimating wind. Radiosondes can drift a few hundred kilometres, especially in mid-latitudes during winter months, depending on conditions and time of year. Position errors may result in significant representation errors when assimilating corresponding observations.We have developed a methodology to calculate changes in balloon position during vertical ascent using limited information, such as the vertical wind profile in historical observation reports. The investigation analysed the method's sensitivity to various parameters, including the vertical resolution of the input data, the assumption about the vertical ascent speed of the balloon, and the departure of the Earth's surface from a sphere. To validate the method, modern GNSS sonde data reports were considered, which provided the full trajectory of the balloon and the estimated wind. The evaluation was conducted by comparing the results with ERA5 and conducting low-resolution data assimilation experiments. The study evaluated the accuracy of reconstructing the trajectory of radiosonde using original data of varying vertical resolution. The results indicate that the accuracy of the reconstructed trajectory can be improved by using more accurate balloon positions, which reduces both representation and systematic errors.Radiosonde measurements have a wide range of applications, including near-real-time use by forecasters and Numerical Weather Prediction (NWP), as well as for air pollution and other scientific investigations, such as climate monitoring. The production of climate reanalyses that directly assimilate radiosonde observations, such as ERA5, is expected to benefit from more accurate historical balloon position data, similar to NWP.