Variational Bias Correction for Radiosonde Data

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Due to various causes artificial biases can be found in meteorological observations. The use of biased observations in the analysis leads to systematic errors in the resulting analysis unless special measures are taken during the data assimilation. This is especially important in case of reanalysis.

One such measure is variational bias correction (VarBC), which is used successfully within the European Centre for Medium-range Weather Forecasts (ECMWF) operational system mainly for estimating biases in satellite radiance data. VarBC is also an integral part of the multi-decadal reanalysis ERA-Interim.

In VarBC the bias of the given observation is computed using a linear predictor model based on a small number of predefined predictors and the corresponding unknown bias parameters. These are estimated together with the model state by including a bias term in the cost function of the variational analysis. Hence VarBC adjusts single observation groups using the whole state of the atmosphere described by the analysis given from a 4D-Var assimilation system. The produced corrections are consistent with all assimilated observations and the model physics.

In this work a variational bias correction method is applied to radiosonde temperature and wind data. Radiosonde data have especially great value in reanalysis work since they reach back to pre-satellite eras. Before the introduction of meteorological satellite in the 1970s radiosondes are the main sources for upper-air information. Therefore the analysis quality in the pre-satellite era is more sensitive to biases in the radiosonde observations than in later periods.

Our fist candidate for bias correction is radiosonde wind direction. Erroneous north alignments at observation sites lead to a constant bias throughout the whole radiosonde profile. About 200 stations have been found containing such a wind direction bias during the time interval of 1960-2000. Systematic model errors in wind direction are expected to be small; therefore VarBC can be safely applied in this case. The main challenge is, however, that relatively few observations are available during an assimilation interval because every station bias needs to be assessed individually.

Radiosonde temperatures tend to have a warm bias relative to the satellite data in the stratosphere and upper troposphere. This motivated us to apply VarBC also to radiosonde temperatures. In this case stations with the same radiosonde equipment can be grouped together, thereby increasing the sample size. Unlike the wind direction bias the temperature biases are pressure dependent and therefore the correction requires only one predictor, the solar elevation, but different parameters for different pressure levels. Even more importantly we cannot assume that the assimilating model is free of systematic temperature errors. Thus we expect that not all radiosonde types can be subject to VarBC but must serve as an “anchor” that constrains the assimilation system. Extensive testing and intercomparison with independent data sources and bias estimation methods will be needed.

This work is part of the ERA-CLIM project, which has the aim to develop a reanalysis of the whole 20^{th} century. One of the main goals of ERA-CLIM is to have the best possible bias corrected input data. The bias corrected radiosonde data will reduce the uncertainties in reanalysis and improve the overall quality of the dataset. A lot of information about observation quality and recent climate variability and change are expected from this project.

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