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Comparison of time series using entropy and mutual correlation

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The potential for redundant time series to reduce uncertainty in atmospheric variables has not been investigated comprehensively for climate observations. Moreover, comparison among time series of in situ and ground based remote sensing measurements have been performed using several methods, but quite often relying on linear models.
In this work, the concepts of entropy (H) and mutual correlation (MC), defined in the frame of the information theory, are applied to the study of essential climate variables with the aim of characterizing the uncertainty of a time series and the redundancy of collocated measurements provided by different surface-based techniques.
In particular, integrated water vapor (IWV) and water vapour mixing ratio times series obtained at five highly instrumented GRUAN (GCOS, Global Climate Observing System, Reference Upper-Air Network) stations with several sensors (e.g radiosondes, GPS, microwave and infrared radiometers, Raman lidar), in the period from 2010–2012, are analyzed in terms of H and MC. The comparison between the probability density functions of the time series shows that caution in using linear assumptions is needed and the use of statistics, like entropy, that are robust to outliers, is recommended to investigate measurements time series.
Results reveals that the random uncertainties on the IWV measured with radiosondes, global positioning system, microwave and infrared radiometers, and Raman lidar measurements differed by less than 8 % over the considered time period. Comparisons of the time series of IWV content from ground-based remote sensing instruments with in situ soundings showed that microwave radiometers have the highest redundancy with the IWV time series measured by radiosondes and therefore the highest potential to reduce the random uncertainty of the radiosondes time series. Moreover, the random uncertainty of a time series from one instrument can be reduced by 60% by constraining the measurements with those from another instrument. The best reduction of random uncertainty is achieved by conditioning Raman lidar measurements with microwave radiometer measurements.
The proposed methodology also allows to recommend specific instruments for measuring atmospheric water vapour measurements at the ground-based atmospheric observatories. This approach can be also applied to the study of redundant measurements for other climate variables.