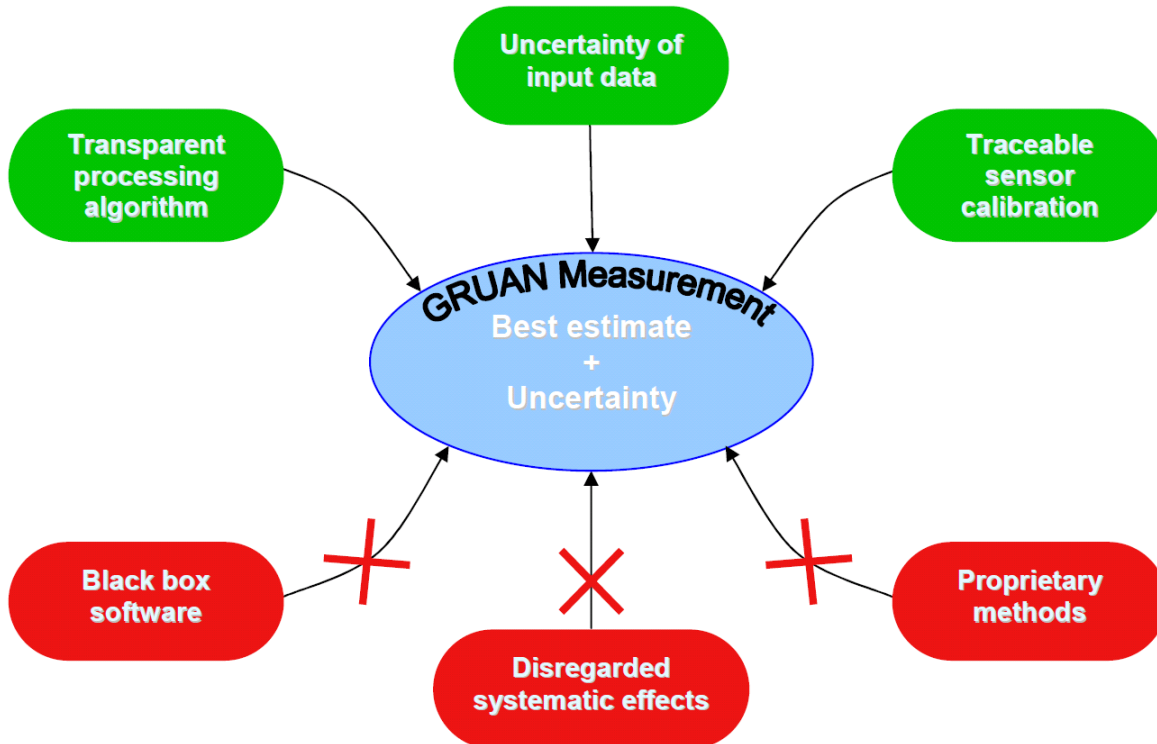


## How the Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) Contributes to Upper Air Climate Records

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Long-term changes of temperature, water vapor, and other essential climate variables within the free atmosphere are still questionable despite decades of observations. A key shortcoming of past observations is the lack of recognized references, against which to validate larger scale observing systems, leaving in doubt the quality of existing data. The GCOS Reference Upper Air Network (GRUAN) is now providing reference observations of temperature and humidity in the troposphere and stratosphere and is expanding to other essential climate variables, such as ozone, as the network continues to grow. To be called a reference, observations within GRUAN require traceable calibration, transparent processing and a detailed analysis of the uncertainty of all input parameters. Aspects of the observations such as proprietary methods, black box software or disregarded systematic effects are not acceptable in reference observations for GRUAN. Ongoing redundant measurements are essential to continuously test GRUAN observations for deficiencies, as is the storage of raw data and complete metadata, to allow reprocessing of the observations if necessitated by new knowledge. This approach may require new processing techniques and new observational procedures to assure the long-term stability of the observations, despite changes in instrumentation. These processing techniques are currently being developed within GRUAN in close cooperation with existing networks, utilizing capabilities found in other working groups and task teams. GRUAN is part of the World Meteorological Organization (WMO) Integrated Global Observing System, providing the essential support to continue to grow. Although not globally comprehensive, the network serves as reference to constrain and adjust data from more spatially comprehensive global observing systems, including the larger WMO radiosonde network, but also satellite systems.



**Figure 1.** Do's and don'ts in establishing reference quality observations for GRUAN.