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What final GRUAN observations may consist of and look like

(Submitted by GRUAN lead centre)

Summary and Purpose of Document

This documents contains what final GRUAN observations may consist of and look like.

GRUAN's list of parameters to be measured is extensive and separated in three groups of different priorities. The highest priority belongs to observations of water vapor, temperature, pressure, followed by wind, ozone and several other parameters. For practical purposes GRAUN will initially focus on reference observations of water vapor, temperature, and pressure. However, the problems, and suggested solutions related to reference measurements apply to most other parameters as well.

During the Seattle meeting in May of 2006, the working group defined a set of accuracy requirements needed to accomplish the goal of reference observations. For water vapor an accuracy of 2% (in mixing ratio) was required and for temperature an accuracy of 0.1K for tropospheric measurements and 0.2K for stratospheric measurements. These requirements form the basis for the quality assurance / quality control procedures that should be implemented for GRUAN. These accuracy requirements represent a serious challenge since no balloon borne sensors currently exists to meet these criteria. Thus QA/QC test of measurements using currently produced sensors would necessarily fail.

To face this challenge, the lead center proposes a quality quantification program that is designed to quantify the performance of current sensors and in particular to quantify the measurement uncertainty as a function of altitude.

The quality quantification program may require a detailed investigation of all sources of measurements uncertainty and a documentation of all known sources of uncertainty. These sources of uncertainty may be categorized in four different classes. The first class contains all sources related to sensor calibration, such as the accuracy of the calibration reference, the underlying calibration model and other procedural influences. The second class contains all sources related to the sensor integration, such as installation of a calibrated sensor on a radiosonde, telemetry limitations and telemetry or payload artifacts. The third class contains all sources of uncertainty related to the ability to characterize the sensor performance in flight, such as temperature dependent time lag variations, controller stability issues, or production variabilities. The last class contains all sources related to external influences such as radiation errors, balloon contaminations or sensor icing.

The quality quantification program has to distinguish between sources of uncertainty that can be corrected for such as sensor integration offset or radiation error, and those that cannot be corrected for, such as sensor icing or balloon contamination. Systematic errors that can be corrected must be corrected with appropriate documentation of the procedure used to achieve this. As part of quality quantification, the correction algorithm has be evaluated as well and the additional measurement uncertainty introduced by the correction algorithm needs to be quantified and accounted for as well. Systematic errors that can not be corrected need to be flagged as such with an appropriate documentation of the suspected error. Radiation errors on both temperature and humidity sensors are an example for external sources of uncertainty that can be accounted for, but their corrections introduce additional random errors that cannot be accounted for and need to be quantified. The 0% ground check of humidity sensors is an example for operator dependent systematic errors, that cannot be accounted for and need to be covered by proper preparation procedure. The 100% ground check of humidity sensors is an example for production variability that is not being considered and can be corrected. This is currently not done.

The data describing a GRUAN observation may finally consist of several components. First are the manufacturer output data, which is the information that is currently used in almost all operational networks. In addition GRUAN data should have all known corrections applied to the best of the current scientific understanding .These corrections need to be quantified and their uncertainty needs to be folded in with all other sources of random and systematic uncertainty to provide a vertically resolved profile of the measurement uncertainty. The next component to a GRUAN observation should be an appropriate ground check, which verifies that the sensor performance before launch is within the expected range of uncertainty. This ground check should be in addition to any manufacturer's ground check used to recalibrate a sensor.

This level of processing exceeds that of the instrument manufacturer and a clear documentation of all corrections and uncertainty analysis steps is key to the traceability of GRUAN data.

This information should be part of the meta-data belonging to an observation. Scientific understanding of sensor performance is continuously evolving and new information becomes available as studies and new developments progress. New corrections and new sensor developments need to be properly documented, preferably in the public peer-reviewed literature. To maintain a homogeneous and self consistent data set, reprocessing of older measurements may be required. This requires the storage of raw physical data and to some extent some raw engineering data. It may also require versioning of data processing levels to provide the user of these data with the information about the status of the data that is being provided.
It is expected that the quality quantification program and the related vertically resolved uncertainty profile may provide a metric for sensor comparison in future large scale sensor intercomparisons. This may quantify the agreement or disagreement of different sensors and indicate to what level a sensor performance is well understood and where gaps in our understanding of a sensors performance exist. The vertically resolved uncertainty will automatically provide the information about the vertical range over which a sensor output provides meaningful information about the state of the atmosphere. The vertical range that a sensor may be used may depend on the user's application. Providing this information may allow an optimal use of the data. The quality quantification program may also indicate where sensors can be improved or where other sensors may be more suitable.

Currently, no sensor exists to meet the GRUAN requirements and to form the basis of a reference sonde. Nevertheless, GRUAN forges ahead and will make use of the best technology currently available. The quality quantification program may describe sensor performance of existing sensors around the network and allow a quantification of their performance GRUAN data may provide vertically resolved uncertainty estimates as additional information as key contribution to the reference network. Documentation of all analyses and procedures may be key to traceability and lay the foundation for a true reference network.