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GCOS Reference Upper Air Network: the Vaisala Reference Radiosonde Program

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The existing radiosonde networks have been designed to serve primarily the needs of short-term weather forecasting. Therefore, the historical upper-air records of important climate variables such as temperature and humidity fail to fulfill climate research requirements, and tropospheric water vapor trends, a key determinant of climate sensitivity to greenhouse gas forcing, are poorly known. The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) is being set up to fill this void. From day one, the GRUAN community has called upon the hydro-meteorological equipment industry to develop a new "reference grade radiosonde" to allow for more accurate records of temperature and humidity in the atmosphere. This is the challenge that Vaisala's Reference Radiosonde Program, launched in 2009, also aims to tackle. The program's first focus is to improve upper-air measurements of water vapor, the most important greenhouse gases in earth's atmosphere. However, it is also one of the most difficult parameters to measure with high precision and accuracy, especially in the upper troposphere and stratosphere where conditions are extremely cold and dry. The first prototype of the new instrument, the Vaisala Reference Radiosonde RR01, is built around the DRYCAPÆ humidity sensor, a new capacitive sensor capable of measuring extremely low humidity levels in upper troposphere and lower stratosphere. Vaisala Radiosonde RS92 technology is used for pressure, temperature and tropospheric humidity measurements and GPS wind finding. The goal is to make the Vaisala RR01 considerably easier to operate and less expensive than the current reference grade instruments, thus enabling more frequent operational climatological soundings. The Vaisala DRYCAPÆ technology was originally developed for measuring ultra-dry gases in industrial applications. As the highly sensitive sensor material can be applied for humidity measurement in the range from -30 to -90^{o}C frost point temperature, it supplements well the standard Vaisala HUMICAPÆ technology used in the RS92. The primary measurand of the Vaisala DRYCAPÆ sensor is water vapor pressure (Pw), which is then converted to frost point temperature. On-flight autocalibration procedure removes drift. The sensor is factory calibrated against a chilled mirror reference with traceability to NIST standards. As the development work progresses, two technical challenges remain to be solved. First, measurement errors tend to occur in very humid conditions. The suspected reason is "moisture contamination", a formation of ice on the sensor's shield or nearby surfaces in the lower atmosphere due to wetting or condensation. In addition, in the stratosphere the DRYCAPÆ sensor shows a systematically 1.5 ... 2^{o}C higher frost point temperatures compared to a cryogenic frost point hygrometer. Lately, new understanding has been gained related to this small but consistent bias. Systematic field testing and evaluation program continues together with research partners. In longer term, the Vaisala Climate Reference Radiosonde program, in close collaboration with the international research community, aims to develop more precise and well characterised measurements for other atmospheric parameters as well.