Retiring the RS92: Met Office Radiosonde Trials, Assessment and Operation

Author: David Edwards (Met Office), Reviewers: Adam Barber (Met Office), Stuart Goldstraw (Met Office)

Synopsis:

This extended abstract and associated oral presentation outline the process by which the Met Office in the UK is retiring the Vaisala RS92 radiosonde from operational use across manned and automated, civil and defence radiosonde stations across a number of locations nationally and internationally. Annex 1 contains a synopsis of the findings from the radiosonde intercomparison performed at Camborne, UK as part of the process.

Main article:

The Met Office operates an operational radiosonde network comprising 2 manned UK GCOS Upper Air Network (GUAN) sites, 4 UK automated 'Autosonde' sites, 3 manned defence sites and 1 overseas GCOS site. It also works with British Antarctic Survey (BAS) to support 2 Antarctic GUAN sites and the St Helena Government to operate a further GUAN site.

In 2014 the Met Office was notified that Vaisala would cease manufacture of the RS92 radiosonde in 2017, planning to replace it with the new RS41 model. At the time, the Met Office was using the RS92 radiosonde at all operational radiosonde stations.

The Met Office decided that the RS92 would not be considered as a potential radiosonde when tendering for the radiosonde contract at the end of the current period, ending in 2016. The Met Office decided that it was necessary to evaluate potential replacements before the supply of RS92 radiosondes came to an end, from both a service continuity and a climate monitoring point of view.

In order to minimise the risks to the operational network, the Met Office decided that the process of tendering and replacement of the network should be undertaken as a project, requiring a project manager, a specialist technical team to undertake the evaluation and transition tasks and a project board comprising customer representatives, technical specialist and headed by the Network Manager as project executive.

It had been approximately 15 years since the last major refurbishment of the radiosonde network, following the introduction of the RS92. It was decided that representatives of each of our key customers (Numerical Weather Prediction, civil and defence forecasting and climate science) should be interviewed to ensure that the project identified and met all of their key needs. A key goal was to replace the radiosonde systems without interruption to the operational observational data services they provided.

Following these interviews and subsequent discussions, the project board determined that the scope of the project should be limited to the refurbishment or replacement of the entire radiosonde network, including the Autosonde sites. However, it should not include the relocation of the sites or the establishment of additional sites.

The interviews with customers identified the key functionality the new radiosonde and its associated applications would need to provide. Additionally, the tender and subsequent implementation should enable the following:

- Improved efficiency by enabling automatic WMO and scientific message generation and transmission.

- Improved on-site and centralised recording of metadata to support automated long-term record keeping.
- Improved usability of scientific data through the generation of easily readable data format files.
- Standardised radiosonde hardware and software across all sites, enabling improved technical support and potentially reducing downtime.

Due to the volume of radiosondes used by the Met Office, it was necessary to undertake a competitive tender process, as defined by EU regulations, so our invitation to tender was issued on the Met Office public tendering portal. The tender was to comprise 2 parts: an initial desktop evaluation and an intercomparison to field-test the most viable candidates.

A number of manufacturers responded to the invitation to tender and following an examination of their responses against the tender criteria, Meteomodem (M10) and Vaisala (RS41-SG) radiosondes were selected to progress to the intercomparison exercise.

The main intercomparison was designed to provide data from 20 day time and 20 night time flights from the RS92, RS41 and M10 in an operational environment at our GCOS upper air test site Camborne [03808], UK, with aims as follows:

- To compare the performance of the Meteomodem M10 and Vaisala RS41 against the operational Vaisala RS92 across the following criteria:
    - Temperature
    - Humidity
    - Wind vectors
    - Pressure (derived from GPS height)
- To assess the software's suitability to produce operational radiosonde data files in WMO BUFR and TEMP format as well as additional formats for scientific research.
- To assess the software's suitability for use by our radiosonde operators in civil and defence environments, including the production of MET messages used at defence sites and suitable additional output files as used at 2 sites in acoustic propagation forecasting.
- To test the systems in a pseudo-operational environment, with all flights performed by current operational staff, producing WMO format messages which were submitted to the Met Office's central database via the same mechanisms as would be used if implemented operationally. The data was also compared against NWP forecast runs to identify any anomalies relative to the model background fields for investigation and provide overall O-B statistics.

In addition, further intercomparison tests were designed to test the following:

- Reproducibility of radiosonde pressure, temperature, humidity and wind data by comparing 2 M10 or RS41 radiosondes against 2 RS92 radiosondes in groups of 5 day and 5 night flights at Camborne.
- Ozone capability at our operational ozone radiosonde site in Lerwick, UK, including the production of the NASA format 'NILU' message and an intercomparison of the output ozone data and additional parameters.

The Met Office also organised visits to a working Vaisala Autosonde site and the Meteomodem Robotsonde at Meteomodem headquarters, to assess the suitability of the systems for use at Met Office radiosonde stations. The visit to the Autosonde site also helped to understand what was involved in refurbishing the current AS14 Autosonde current systems, to be able to use the RS41 in the new AS15 design.

Following the intercomparison, a technical report was presented to the project board detailing the performance of the radiosonde models including the main differences seen. Additional analysis was performed regarding the determination of cloud bases and tops, missing data and corrections applied to the data, as requested by our customers. Using the outcomes of the visits to suppliers; the technical report and the analysis of the financial, environmental and corporate assessments, the Vaisala RS41 was selected to replace the Vaisala RS92. Summary findings from the report are detailed in Annex 1 and further information may be made available upon request.

To satisfy our customers that the system was suitable for use by the Met Office and to provide a record for future climate analyses, as recommended by the WMO, the Met Office undertook a further intercomparison following the installation of the first Vaisala RS41 system (MW41, software version 2.5), comprising 30 day time and 30 night time RS92 vs RS41 twin-flights at Camborne, UK. The MW41 system was operationally accepted, with the RS41 will become the operational radiosonde at Camborne [03808], Lerwick [03005] and at Mount Pleasant Airport [88889] in the Falkland Islands in September 2016.

As the RS92 is the current operational radiosonde at a large number of radiosonde stations internationally, the Met Office climate and NWP customers felt that it would be necessary to better understand the transition from the RS92 to the RS41 in different climate zones. It was agreed that RS92 vs RS41 intercomparisons would be attempted at 3 sites for a period of 1 year: Camborne [03808] (UK), St Helena [61901](South Atlantic) and Halley [89022] (Antarctica), in cooperation with our partners in the St Helena Government and BAS. These flights will comprise 1 RS92 vs RS41 flight per week for approximately one year, giving data across 3 climate zones: temperate, tropical and polar.

Following the completion of this project, it is hoped that the Met Office's future radiosonde network will produce high quality, reliable data which can be easily utilised by both operational and scientific communities until at least 2021 and additionally support the international climate radiosonde records.

Annex 1: High level synopsis of RS92-SGP vs RS41-SG intercomparison findings

The comparisons against NWP and by direct comparison of RS92 and RS41 data showed that both radiosondes produced very similar temperature and wind data, but differences in the relative humidity data that would be of interest to forecasters, NWP and climate scientists:

- RS41 Flight-by-flight temperature systematic differences from RS92 approximately between -0.2 ^{o}C and +0.2 ^{o}C when measured in 1 km bands
- RS41 Flight-by-flight temperature standard deviations from RS92 were within ±0.3 ^{o}C during the day and ±0.3 ^{o}C during the night when measured in 1 km bands.
- RS41 Flight-by-flight relative humidity systematic differences from RS92 approximately between -1 % and +3 % when measured in 1 km bands.
- RS41 Flight-by-flight relative humidity standard deviations from RS92 were within ±3 % during the day and ±2 % during the night when measured in 1 km bands.
- RS41 Flight-by-flight systematic differences from RS92 approximately between -0.1 m/s and +0.1 m/s when measured in 1 km bands for either N/S, E/W or Velocity wind components.
- RS41 Flight-by-flight standard deviations from RS92 were within ±0.3 m/s for the N/S component, ±0.3 m/s for the E/W component and ±0.3 m/s for velocity when measured in 1 km bands.

Key improvements that the RS41 radiosonde and MW41 ground station, software version 2.5) is expected to provide, relative to the RS92 radiosonde and MW31 ground station, software version 3.64.1):

- Lighter radiosonde (280 g vs 109 g (+ approximately 20g for the unwinder/dereeler)) – reducing overall environmental impact of the device and the volume of lifting gas required.
- Greater reliability – missing data volumes were 0.1 % of total data expected for the RS41 compared to 0.4 % of total data expected for the RS92 during testing (38 flights).
- More robust sensors should reduce the risk of failures in flight or in pre-flight testing.
- Status light on the RS41 radiosonde could reduce the risk of an operator launching a radiosonde that has developed a fault.
- Wireless communication between the radiosonde and ground station during ground check removes the risk of potential problems caused by faulty cables or connectors.
- Consistent or improved data reproducibility:
    - The general temperature performance of RS92_1 vs. RS92_2 was within ±0.2°C during the day and within ±0.1°C during the night to 1 standard deviation when measured in 1 km bands.
    - The standard deviation of RS41_1 vs. RS41_2 temperatures were within ±0.1°C during the day and within ±0.1°C during the night to 1 standard deviation when measured in 1 km bands.
    - The standard deviation of RS92_1 vs. RS92_2 relative humidities were within ±0.8 % during the day and within ±0.5 % during the night to 1 standard deviation when measured in 10°C bands.
    - The standard deviation of RS41_1 vs. RS41_2 relative humidities were within ±0.5 % during the day and within ±0.6 % during the night to 1 standard deviation when measured in 10°C bands.
    - The general standard deviation of RS92_1 vs. RS92_2 and also for RS41_1 vs. RS41_2 wind vectors and speeds were within ±0.1 m/s for the velocity to 1 standard deviation when measured in 1 km bands
- Reduced correction of humidity data: The RS41 radiosonde data showed significantly reduced differences between raw and processed data for humidity, due to the direct measurement of the RS41 humidity sensor temperature, rather than relying upon solar radiation corrections during daytime ascents.
- Improved responsiveness to rapid changes in temperature following cloud exits and sensor contamination (wet-bulb effect), some evidence of which was seen in the comparisons between the RS92 and RS41.
- Reduced contamination of the humidity sensor by clouds. The continuous heating of the RS41 throughout the flight should reduce the risk of humidity sensor contamination following exits from clouds and also into the stratosphere, some evidence of which was seen in the comparisons between the RS92 and RS41.
- Improved software requiring reduced training and more straightforward technical support, including improved fault identification and reporting.
- Potential access to descent data for potential future use in BUFR dropsonde template 3 09 053.
- Real-time access to ongoing flight information for users and operational staff.
- Automatic generation of all data files, including metadata for each flight and scientific data formats.
- Removal of calibrations against an external reference for temperature and a ‘dry’ environment for humidity, as is used by the MW31’s GC25 ground check unit currently. This should reduce the risk of ground checks introducing a systematic bias or reduced reproducibility, as the RS41 performs an internal humidity ground check and utilises more stable platinum resistive temperature sensor.