Measurements and Intercomparisons at the Payerne GRUAN Site and the Meteolabor Sonde Product

R. Philipona¹, A. Kräuchi², G. Romanens¹, G. Levrat¹

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History:

- Studies in Sweden in 1942
- Comparisons of Vaisala and U.S. Radiosondes showed systematic and large differences
- At a P.I.C.A.O. meeting in London in 1946 the I.M.O. was charged to study the question
- First steps at I.M.O. meeting in Toronto 1947
- At the R.A. VI meeting in London 1949, the Swedish Institute suggested a new Committee
- Dr. Jean Lugeon, became president and in 1950 he invited all members to Payerne
- Six radiosondes were compared at Payerne: Finnish, French, Swiss, U.S., U.K., German
- Reports from: U.S., U.K, Switzerland, Belgium, Sweden, France
WMO Intercomparison of QRS in Yangjiang, China, 2010

Night

Day

Temperature difference [ K ]

Altitude [ km ]

J. Nash, T. Oakley, H. Vömel, LI Wei, WMO/TD-No. 1580, 2011
### Table 12.1: Summary of operational performance of QRS as measured in Yangjiang

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<th>Mark</th>
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<tbody>
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WMO Intercomparison of QRS in Yangjiang, China, 2010

Night

Day

J. Nash, T. Oakley, H. Vömel, LI Wei, WMO/TD-No. 1580, 2011

Reinvestigation of Meteolabor radiation correction
1 Measurements of the radiation error on unshaded and shaded temperature sensors in flight

2 Measurements of the radiation error on temperature sensors in a vacuum chamber in Lindenberg

3 Measurements of solar and thermal radiation flux profiles through the atmosphere
- Aluminium plate (brilliant / black) attached to Meteolabor sonde
- Temperature sensors on both sides (5cm distance)
- Alternately one sensor is exposed to the sun

Shaded / Unshaded Temperature Measurement

Reference sensor

front view

side view

T sensor

SRS C34
50 micron thermocouple temperature sensors unshaded and shaded
Radiation Error on Temperature Measurement

\[ \Delta T_{\text{year}} = 0.2 + (0.8 \times \frac{\text{Alt}_{\text{geo}}}{32'000}) \]
\[ \Delta T_{\text{year}} = 0.2 + (0.8 \times \frac{\text{Alt}_{\text{geo}}}{32'000}) \]

Uncertainty on radiation error: \( u = \pm [0.1 + (0.2 \times \text{Alt geo}/32'000)] \)
Experiment with one Meteolabor sonde having three thermocouple sensors with wires of 20µ, 50µ, 100µ

Observatory of Lindenberg Vacuum Chamber
Xenon Arc Lamp, Intensity: \(~ 1650 \text{ Wm}^{-2}\)
Radiation Error: Atmosphere / Laboratory

Old radiation error  New radiation error and uncertainty

\[ \Delta T_{year} = 0.2 + (0.8 \frac{Alt_{geo}}{32'000}) \]

Uncertainty on radiation error: \( u = \pm [0.1 + (0.2 \times \text{Alt geo}/32'000)] \)
Radiation Measurements through the Atmosphere

SRS-C34 Radiosondes from Metelabor and CNR 4 Net Radiometer from Kipp and Zonen

Longwave Radiation Error during the Night

Night flight: 23 Sep 2011, UT21:20

Longwave Radiation Budget on Temperature Sensor

Glenn E. Daniels, JAM, 1968:
- Reduce sensor Size
- Reduce sensor Emissivity
- Increase sensor Speed

\[
\frac{\varepsilon \sigma T^4}{
\text{Cooling}
}
\]

\[
\frac{\varepsilon \sigma T^4}{
\text{Heating}
}
\]
Longwave Radiation Error during the Night

WMO China, Night results

Cooling

Heating

Cooling

Altitude [km]

Temperature difference [K]

Meteolabor

50μ T sensor

smallest Size

uncertain Emissivity

same Speed
WMO China, Night results

- Cooling
- Heating

Sensors are too warm
Sensors are too cold
LW and SW Radiation Error during the Day

Day flight: 23 Sep 2011, UT10:13

Longwave Radiation Budget on Temperature Sensor

Longwave Emission \( \varepsilon \): (0.05 - 0.3)
Shortwave Absorption \( \alpha \): (0.01 - 0.2)
\[ \Delta T_{year} = 0.2 + (0.8 \times \frac{Alt_{geo}}{32'000}) \]

Uncertainty on radiation error: \( u = \pm [0.1 + (0.2 \times \text{Alt geo}/32'000)] \)
Radiation Error Correction during Day

WMO China, Day results

Altitude [km]

Temperature difference [K]
Radiation Error Night and Day

Night

Day

Philipona et al., JTECH, 2013 doi:10.1175/JTECH-D-13-00047.1
Vaisala versus Meteolabor 2010 and 2013

Night

Day

Temperature difference [ K ]

Temperature difference [ K ]

Altitude [ km ]

Altitude [ km ]

T - Difference RS92 - SRSC34 / 15 Night Flights 2013

T - Difference RS92 - SRSC34 / 22 Day Flights 2013

Altitude [ km ]

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## Summary of operational performance of QRS as measured in Yangjiang

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Differences versus RS92 on relative Humidity

RH - differences versus RS92 / 8 Day and Night Flights 2014

Altitude [m]

Relative Humidity Difference [%]
Double-Sounding to evaluate Reproducibility

CIMO-Testbed Intercomparisons:
Fall 2013
Spring 2014
Uncertainty on Reproducibility in Temperature

Stdev of Dualflights / 4 Day and Night Flights 2014

Altitude [m]

TEMPERATURE - Stdev of Differences [K]
Uncertainty on Reproducibility in Relative Humidity

Stdev of Dualflights / 4 Day and Night Flights 2014

Altitude [m]

RELATIVE HUMIDITY - Stdev of Differences [%]

- C34_new
- MOD
- RS92
- RS41
Uncertainty on Reproducibility in Altitude

Stdev of Dualflights / 4 Day and Night Flights 2014

Altitude [m]

ALTITUDE - Stdev of Differences [m]

C34
MOD
RS92
RS41
Uncertainty on Reproducibility in Pressure

Stdev of Dualflights / 4 Day and Night Flights 2014

Altitude [m]

PRESSURE - Stdev of Differences [hPa]
Uncertainty on Reproducibility in Direction

Stdev of Dualflights / 4 Day and Night Flights 2014

Altitude [m]

DIRECTION - Stdev of Differences [°]
Uncertainty on Reproducibility in Velocity

Stdev of Dualflights / 4 Day and Night Flights 2014

Altitude [m]

VELOCITY - Stdev on Differences [m/s]
### Summary of Stdev on Reproducibility

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<tr>
<th>Parameter</th>
<th>Troposphere</th>
<th>Stratosphere</th>
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<td>Wind Vel.</td>
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Summary Radiosonde Intercomparisons

• The radiation error on temperature was determined by simultaneous measurements of shaded and unshaded temperature sensors.

• Laboratory experiments in a vacuum chamber and artificial light confirm the radiation error as measured in the atmosphere.

• Radiation profiles measured through the atmosphere explain thermal nighttime radiation errors measured on different sensor diameters.

• Temperature differences between SRS-C34 and RS92 radiosondes observed during the China intercomparison are confirmed at Payerne.

• Double soundings allow reproducibility tests of radiosondes which provide important information on instrument uncertainty.
Steps towards GRUAN certification:

• Weekly GRUAN multi-soundings with RS92 + RS41 + SRS-C34

• GRUAN certification on Vaisala RS92 soundings during 2015

• Develop a GRUAN product data file for the SRS Radiosonde in collaboration with Lead Center

• New Meteolabor SRS-NEW radiosonde in operation early 2016

• GRUAN certification on Meteolabor sonde product end of 2016
**Biweekly Daytime**  UT 12:00 (Tuesday or Thursday)

**Multi-sounding:**
- Meteolabor SRS-C34 (operational) submitted to GRUAN
- Vaisala RS92 (DigiCORA MW31) submitted to GRUAN
- Vaisala RS41

**Biweekly Nighttime**  UT 00:00 (Tuesday or Wednesday or Thursday)

**Multi-sounding:**
- Meteolabor SRS-C34 (operational) submitted to GRUAN
- Vaisala RS92 (DigiCORA MW31) submitted to GRUAN
- Vaisala RS41
- Meteolabor SnowWhite dew/frost point hygrometer

**Daily Operational SRS-C34 at UTC 00:00 and 12:00**
**PAY_GRUAN_001_20150213.12.csv**

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The GRUAN Product Data File for SRS-C34 was developed with the help of the GRUAN Lead Center (Michael Sommer).

All GRUAN product data values and all uncertainties are calculated by MeteoSwiss.

GRUAN Data files and all metadata are submitted with the GRUAN RsLaunchClient to the Lead Center since Sep 2014.

Future corrections that need to be made to the Payerne GRUAN product data values will be made by MeteoSwiss.
Swiss Radiosonde

Meteolabor SRS-C34

Temperature: Thermocouple
Humidity: Rotronic HC2 capacitive
Altitude/Pressure: GPS (Hypsometer)
Wind Speed/Dir.: GPS

Rotronic HC2 capacitive sensor
GPS
Water Hypsometer
Electronique Interface
Telemetry
Transmitter 400 Mhz

Thermocouple (Copper - Constantan) (wire Ø 0.05 mm)
Main goals:

- The new Meteolabor radiosonde SRS-NEW will be smaller and lighter
- SRS-NEW will be compatible with the SRS-C34 ground station
- SRS-NEW will use the present Meteolabor software
- SRS-NEW will use the same sensors except for the humidity sensor
- SRS-NEW will be compatible with ECC-Ozone, SnowWhite, COBALD
Conclusions

Payerne GRUAN Data Product

• Daily operational SRS-C34 soundings at UTC 00:00 and 12:00 are submitted in NRT to the GTS and weekly as GRUAN products.

• Weekly multi-soundings with RS92, RS41 and SRS-C34 sondes are made during 2015 and submitted to the Lead Center.

• The Payerne GRUAN station will be certified during 2015 on the basis of the weekly Vaisala RS92 soundings.

• A new Meteolabor SRS radiosonde will be operational in 2016 and submitted in NRT and weekly as improved GRUAN product.

• Change management between the old and the new Meteolabor sonde will be made during the weekly multi-soundings.

• In 2016 Payerne should become GRUAN certified for their new Meteolabor GRUAN sonde data product.

Thank you for your attention!