The Lindenberg Upper-Air method intercomparison (LUAMI)

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LUAMI radiosonde intercomparison

- Comparison of ground based and airborne remote sensing with in-situ observations
- Parallel ascents of research type radiosonde with commercial ones
  - Goals:
    - Identifying systematic errors
    - Test suitability of Radiosondes for operational networks including GRUAN
Ground based remote sensing

- DWD
  - Raman water vapor LIDAR (RAMSES)
  - CHM 12 Ceilometer (Jenoptik)
  - RASS Windprofiler
  - 36 Ghz Cloud radar
  - Microwave radiometer (total column water vapor)
  - Microwave profiler
  - Tethered balloon
- External
  - Small scale GPS receiver network (run by GFZ)
  - Leosphere Aerosol and Doppler Lidar
  - HALO cloud radar
## Reference type radiosondes (BQRSS)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Type / Method</th>
<th>Organization / Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS-90 FN</td>
<td>FN Reference method</td>
<td>RAO/DWD, Lindenberg, Germany</td>
</tr>
<tr>
<td>RS-92 FN</td>
<td>FN Reference method</td>
<td>RAO/DWD, Lindenberg, Germany</td>
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<tr>
<td>SW</td>
<td>Frostpoint mirror</td>
<td>Meteolabor AG Wetzikon, Switzerland</td>
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<tr>
<td>FLASH</td>
<td>Lyman-Alpha-Hygrometer</td>
<td>CAO Moscow, Russia</td>
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<tr>
<td>CFH</td>
<td>Frost-point mirror</td>
<td>RAO/DWD, Lindenberg, Germany, University Colorado, Boulder/USA</td>
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<tr>
<td>APS</td>
<td>Advanced Polymere sensor</td>
<td>Vaisala, Finland</td>
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<tr>
<td>COBALD</td>
<td>Backscatter sonde</td>
<td>ETH Zurich</td>
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**Commercial radiosondes (HQOR)**

<table>
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<th>Organization / Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS-92</td>
<td>PTU - GPS</td>
<td>Vaisala Oyj, Finland</td>
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<tr>
<td>DFM-06</td>
<td>PTU - GPS</td>
<td>GRAW Radiosondes GmbH, Germany</td>
</tr>
<tr>
<td>BAT-4G</td>
<td>PTU - GPS</td>
<td>Int. Met. Systems, USA /SZA</td>
</tr>
<tr>
<td>SRS-C34</td>
<td>PTU - GPS</td>
<td>Meteolabor</td>
</tr>
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Temperature

L005 Start: 06.11.2008 22:46:00 time smooth 030 s

differences from mean
Temperature and radiation
Radiosonde intercomparison: Relative humidity
Dry bias of polymer sensors still
Radiation error on humidity measurements
How accurate is the GPS / MW?

Comparison of total water vapor from different instruments

rel. difference from RS-92 (%)
GPS, MW, and Radiosondes

Comparison with GPS total water vapor

rel. difference from GPS TPW (%)
Stratosphere: CFH and FLASH

Water vapor mixing ratio (ppm) FLASH-B and CFH

Franz Immler (DWD, RAO3, GRUAN lead centre)

ICM-1 Norman, OK, March 2009
Performance indicator: data within 2x errorbars of CFH

Sonde performance in stratosphere

2 Sig level

Fraction of good data

Routine  CFH  FLASH  APS  RS92FN  RS90FN  GRAW
Percentage of data RH within ±5% rH of mean
Percentage of data RH within $\pm 2^*\sigma$ of CFH

![Bar chart showing sonde performance in upper troposphere with CFH, FLASH, APS, RS92FN, RS90FN, and GRAW compared against the 2 Sig level.](chart.png)
Percentage of data RH within 5 % of mean

Sonde performance in lower troposphere

Fraction of good data

Routine  CFH  FLASH  APS  RS92FN  RS90FN  GRAW

2 Sig level
**Conclusion**

- Comprehensive data set for comparisons of Radiosonde and remote-sensing instruments on water vapor

- Temperature:
  - substantial radiation (0.2 K) error in both, troposphere and stratosphere
  - another error of same magnitude possibly related to calibration
  - issue with clouds

- Water vapor:
  - GCOS-121 target of 2% accuracy/precision is a tough one!
    - stratosphere: CFH and FLASH (descent) in excellent agreement
    - upper troposphere: All sondes of more or less similar quality
    - lower troposphere: generally good agreement,