On the accuracy of Vaisala RS41 versus RS92 upper air observations: Implications for satellite data cal/val

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RS92 versus RS41 Data Comparison Methods

• Using NWP as the transfer medium (T, RH)
  – Compute OB-BG for RS92 and RS41
  – Compute OB-AN for RS92 and RS41

• Using GPSRO as the truth (T)

• Direct comparison using dual launches from 6 sites (T, RH)
Data (2015.01-2017.06)

- Conventional radiosonde data
  - Vaisala RS41 (~65,000) and RS92 (~311,500)

- Dual (twin/simultaneous) launch data
  - 6 sites

- NWP data (used for OB-BG and OB-AN)
  - NOAA Climate Forecast System Re-analysis (CFSR) forecast background and analysis
  - ECMWF analysis

- GPSRO Tdry (used as the truth)
  - UCAR COSMIC
  - ROM SAF GRAS

- RS92 vs RS41 in satellite data validation:
  - NOAA sounding retrievals from S-NPP CrIS/ATMS
  - EUMETSAT sounding retrievals from MetOp IASI/AMSU
Satellite single closest matchup with a given raob
RS92 to RS41 transition in the conventional network
Conventional RS92 during 2015.01 – 2017.6 (~311500 profiles)
Conventional RS41 during 2015.01 – 2017.6 (~65900 profiles)
RS92 RS41 Dual sites

NOAA Products Validation System (NPROVS)

<table>
<thead>
<tr>
<th>Coast</th>
<th>Land</th>
<th>Island (Coast)</th>
<th>Island (Inland)</th>
<th>Ship</th>
<th>Dropsonde</th>
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</thead>
</table>

Lindenberg
Payerne
Ny Alesund
Lamont
Lauder
Beltsville

Number of collocations: 8777 (6 unique locations)
T, RS92-minus-BG CFSR

Solar Elevation Categories
- NIGHT (< -7.5 deg)
- DAWN/DUSK (-7.5 - 7.5 deg)
- LOW (7.5 - 22.5 deg)
- HIGH (>22.5 deg)

Mean Diff.  SD  Sample

e.g., 12Z BG: 3-hr forecast made at 09Z
T, RS41-minus-BG CFSR

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- NIGHT (<−7.5 deg)
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T, RS92-minus-AN ECMWF

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[Graph showing mean difference, standard deviation, and sample data across different pressure levels]
T, RS41-minus-AN ECMWF

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- DAWN/DUSK (−7.5 − 7.5 deg)
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- HIGH (>22.5 deg)
(RS92-minus-RS41) obtained using NWP as transfer medium

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COSMIC-1 and GRAS RO
(April 8, 2017)

COSMIC RO profiles: 618
GRAS RO profiles: 1200
RS92-minus-Tdry COSMIC

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- NIGHT (<−7.5 deg)
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Similar to Sun et al. (2013, JGR) based on 2008-2011 data
RS92-minus-Tdry GRAS

Solar Elevation Categories

- **NIGHT** (<7.5 deg)
- **DAWN/DUSK** (7.5 – 7.5 deg)
- **LOW** (7.5 – 22.5 deg)
- **HIGH** (>22.5 deg)
RS41-minus-Tdry COSMIC

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RS41-minus-Tdry GRAS

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Mean Diff vs SD for different locations and times of day.

- **Lindenberg**
- **Payerne**
- **Ny Alesund**
- **Lamont**
- **Lauder**
- **Beltsville**

Legend:
- **NIGHT (<-7.5 deg)**
- **DAY (> 7.5 deg)**
- **ALL**
RS92(GDP)-minus-RS92(standard)


GDP RS92 is warmer than RO Tdry by < 0.2 K
T, RS92 vs RS41

- RS92 agrees with RS41 < 0.1-0.2 K in the lower stratosphere; RS41 appears to be less sensitive to solar elevation change than RS92.
RH (RS92-minus-RS41) obtained using NWP as transfer medium

Solar Elevation Categories
- NIGHT (<-7.5 deg)
- DAWN/DUSK (-7.5 – 7.5 deg)
- LOW (7.5 – 22.5 deg)
- HIGH (>22.5 deg)
RH RS92-minus-RS41 from duals

NIGHT (< -7.5 deg)  
DAY (> 7.5 deg)  
ALL

Lindenberg

Payerne

Ny Alesund

Lamont

Lauder

Beltsville
RH, RS92 vs RS41

- RS41 shows improvement over RS92 by ~2% in RH in the troposphere; still a challenge for measurements in the stratosphere.
Simplified flow diagram of the NOAA NUCAPS retrieval algorithm

Climatological First Guess

Microwave Physical for $T(p)$, $q(p)$, LIQ(p), $\varepsilon(f)$

$R_{\text{warm}}$ Regression for $T_s$, $T(p)$, $q(p)$

Initial Cloud Clearing, $\eta_j$, $R_{ccr}$

$R_{ccr}$ Regression for $T_s$, $\varepsilon(v)$, $T(p)$, $q(p)$

IR Physical $T_s$, $\varepsilon(v)$, $\rho(v)$

Improved Cloud Clearing, $\eta_j$, $R_{ccr}$

IR Physical $T(p)$

IR Physical $q(p)$

IR Physical $O_3(p)$

Final Cloud Clearing, $\eta_j$, $R_{ccr}$

IR Physical $T_s$, $\varepsilon(v)$, $\rho(v)$

IR Physical $T(p)$

IR Physical $CO(p)$

IR Physical $HNO_3(p)$

IR Physical $CH_4(p)$

IR Physical $CO_2(p)$

IR Physical $N_2O(p)$

Heritage of AIRS, adopted by NUCAPS (S-NPP, MetOp-A,B)

Courtesy of C. Barnet
EUMETSAT IASI L2 v6 High-level processor overview

L1

IASI
AMSU
MHS
AVHRR

PWLR3
All-sky

T, q, Ts, O3
land emiss.

Statistical retrieval

Cloud detection

Optimal estimation

Atm. comp.

T, q, Ts, O3

Cloud fraction, top height, phase
Dust index

O3
CO
CH4
SO2
HNO3
(CO2, N2O)

L2

Single footprint

Courtesy of Thomas August
RS92 vs RS41 assessment of EUMETSAT IASI sounding product

Conventional RAOBs data for Jan 2015 to Jun 2017; collocations (1hr&50km)
RS41 makes NOAA NUCAPS S-NPP “look” better than RS92

NUCAPS - minus - RAOB water vapor MR (%)

Sample:
RS92 (6641)
RS41 (1810)
Major Results

• Accuracy of RS92 versus RS41 global conventional radiosondes was assessed from Jan 2015 to Jun 2017 by
  – using NWP data as the transfer medium and
  – using GPSRO as the truth
  – The global assessment was then verified using data from dual launches

• RS92 agrees with RS41 < 0.1-0.2 K in the lower stratosphere; RS41 appears to be less sensitive to solar elevation change than RS92.

• RS41 shows improvement over RS92 by ~2% in RH in the troposphere; still a challenge for measurements in the stratosphere.

• RS41 makes the satellite retrievals “look” better than RS92.