Integrating Uncertainty in Atmospheric Profile Validation

Xavier Calbet  AEMET
Tony Reale NOAA

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OUTLINE

• GRUAN and Uncertainty

• NPROVS+

• Estimating uncertainty components (σ, u1 and u2)
  ➢ GSICS Article (COSMIC/GRUAN)

• Estimating uncertainty components (σ, u1 and u2)
  ➢ NPROVS+ (NUCAPS, AIRS, ECMWF: GRUAN)

• Summary
GCOS Reference Upper-Air Network

GRUAN processed RAOB include traceable uncertainty estimates for T, RH

*(see Poster 12p.01)*
Given two measurement \((m_1, m_2)\), their uncertainty \((u_1, u_2)\) and their systematic variability \((\sigma)\), then two observations are consistent if

\[ |m_1 - m_2| < k \sqrt{\sigma^2 + u_1^2 + u_2^2} \]

1) \(u_2\) is GRUAN uncertainty … given

\(u_1\) is SAT (or NWP) profile uncertainty … needed

\(\sigma\) is systematic variability between platform pair… needed
Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

JPSS Funded Dedicated RAOB

- DOE ARM (SGP, NSA, ENA)
  - CIMSS
  - (2) per week
  - GRUAN processed
  - dual vs single, etc

- AEROSE
- CALWATER
- PMRF
- Sterling Test Site ...

... need better coordination with “other” intensive field experiments particularly if synchronized with S-NPP
Integrated GRUAN and JPSS Funded (* ) Dedicated (S-NPP) RAOB Sites
Over 12,000 RAOBS (2000 Dedicated) since July 2013 … and counting
Quantifying uncertainty when comparing Space-based and Ground Observations

By Tony Reale, NOAA and Xavier Calbet, AEMET

A problem in satellite product cal/val is that uncertainty budgets are typically overlooked. Uncertainty originates in the native measurement space, for example the radiances from satellites or temperature from radiosonde observations (RAOB). Uncertainty is not solely an “intrinsic” property of the observations, but also has “secondary” components that are introduced when comparing measurements with different spatial and/or temporal characteristics including mismatch. Quantifying these components is needed for robust inter-comparison, validation and integration, for example, in WMO Integrated Global Observing System (WIGOS). Addressing such issues through strict comparison of reference RAOB, satellite IR/MW sounding...

Figure 1: Collocated temperature profiles from GRUAN RAOB, COSMIC (Tdry), MetOp-B IASI sondings from NOAA and EUMETSAT and European Center for Medium-Range Weather Forecasts (ECMWF) analysis within 30 minutes and 30 km of RAOB except for COSMIC at 183 km.
for \( k=2 \), sum under square root (1) is 9 \((u_1^{**2})\)
assuming \( u_1 \sim u_2 (0.15) \), then \( \sigma \sim 0.4K \) thru layer
Integrating
1) uncertainty based “k” profiles analysis
and
2) traditional specification based satellite products cal/val
provides
more robust cal/val approach:

NOAA NUCAPS

ECMWF

NASA AIRS v.6 (contain error estimates)
Unlike COSMIC Tdry, projection of the uncertainty of SAT Temp (or H20) as some multiple of GRUAN uncertainty is not justified, thus we can only address the sum under the square root (1).

However, for NWP Temp, projection that uncertainty is on order of the GRUAN uncertainty somewhat justified …
“Spec” RMS (K)

Based on GRUAN Uncertainty

Temp

Baseline: GRUAN Radiosonde

AIRS AQUA

ECMWF

NUCAPS NPP

for “k”=2, sum uncertainty under square root (1) in vicinity 500 hPa:

for SAT is 18(u1**2) … for ECMWF is 3(u1**2)

2)For ECMWF, assuming u1 ~ u2 (0.13K), then σ ~ 0.1K thru layer
Baseline: GRUAN Radiosonde

AIRS AQUA  ECMWF  NUCAPS NPP

for “k”=2, sum uncertainty under square root (1) in vicinity 600 hPa
for SAT is 12(u1**2) ... for ECMWF is 4(u1**2)
Baseline: NASA AIRS v.6

GRUAN Radiosonde  ECMWF  NUCAPS NPP

All platforms have “k” less than 2 suggesting that reported AIRS v.6 “errors” much larger than actual AIRS v.6 “uncertainty”
SUMMARY

• GRUAN reference RAOB provide traceable uncertainty

• NPROVS+ analytic interface (PDISP) includes preliminary capability to integrate GRUAN uncertainty in “k” profile analysis

• Need uncertainty for all profiles \(u_1\) and “\(\sigma\)” for respective profile pairs

• Analytic directions (GSICS article) and order magnitude estimate of 0.4K for “\(\sigma\)” in stratosphere for COSMIC Tdry vs GRUAN \((u_1 \sim u_2)\)

• Analytic directions for more robust satellite products cal/val integrating RMS and “k” profile statistics

• Preliminary estimate of 0.1K for “\(\sigma\)” in vicinity 500 hPa for ECMWF Analysis vs GRUAN \((u_1 \sim u_2)\)

• Evolving GRUAN / NOAA satellite synergy … 3G, GAIA-CLIM, etc