



The ongoing collaboration between GRUAN and the radio occultation community

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The GCOS
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Ongoing
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²Global Space-based InterCalibration System



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 - ▶ Discuss how to better serve climate/meteorological application.

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 - ▶ Compare methods for uncertainty estimation.
 - ▶ Discuss how to better serve climate/meteorological application.
- ▶ Over the years, this led to an ongoing exchange between the communities. Some of you typically join the yearly GRUAN Implementation and Coordination Meeting and I am here for the third time.

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What is GRUAN?



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GRUAN - Global Climate Observing System (GCOS) Reference
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- ▶ International ground-based reference observing network,
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- ▶ Currently, two radiosonde data products are available, one for the Vaisala RS92 and one for **Meisei RS11-G**.



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- ▶ Currently, two radiosonde data products are available, one for the Vaisala RS92 and one for **Meisei RS11-G**.
- ▶ Data products for ground-based GNSS water vapour, microwave radiometer, lidar, frost point hygrometer etc. are under development → GRUAN is not only a radiosonde network.



Map of GRUAN sites



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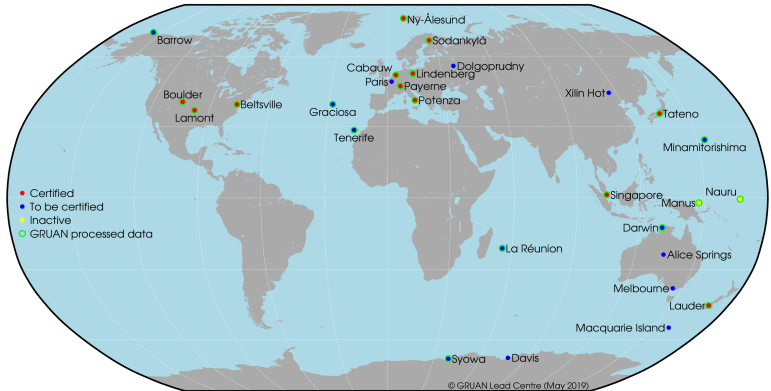
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We now also have candidate sites in Barbados and Suriname!



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Within a GRUAN data product, all known biases are corrected and an uncertainty estimate is given with every value.



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”Reference within GRUAN means that, at a minimum,

1. the observed profiles are tied to a **traceable standard** at one point (e.g., by an extended, manufacturer-independent ground check of a radiosonde),



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3. that the entire measurement procedure and set of processing algorithms are properly **documented and accessible.**”



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Why should we collaborate?

- ▶ RO and GRUAN data are of high-quality, but they rely on entirely independent measurement techniques.



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Why should we collaborate?

- ▶ RO and GRUAN data are of high-quality, but they rely on entirely independent measurement techniques.
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- ▶ Thus, the comparison between GRUAN and RO can help to:
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 - ▶ improve uncertainty estimates.



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- ▶ GRAS occultation prediction developed by Axel → allows GRUAN sites to time their measurements for better colocations. → Could this be offered by other RO providers as well?



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- ▶ Joe's work on estimating uncertainties based on comparison to GRUAN.



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- ▶ Comparison of GRUAN data for the Vaisala RS92 sonde and the ROM SAF Climate Data Record for GRAS.



Comparison of GRUAN and ROM SAF CDR



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- ▶ The comparison between GRUAN Vaisala RS92 and ROM SAF CDR for GRAS has been done for the years 2014-2016.



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- ▶ The comparison between GRUAN Vaisala RS92 and ROM SAF CDR for GRAS has been done for the years 2014-2016.
- ▶ A double differencing method using UK Met Office model background fields as transfer standard has been used to minimise effects caused by imperfect colocation.



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- ▶ A double differencing method using UK Met Office model background fields as transfer standard has been used to minimise effects caused by imperfect collocation.
- ▶ A tangent linear RO retrieval is used to propagate bending angle departures (with respect to model background fields) into dry temperature departures.



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- ▶ A tangent linear RO retrieval is used to propagate bending angle departures (with respect to model background fields) into dry temperature departures.
- ▶ A detailed description of the method can be found in Tradowsky et al. (2017).



Uncertainties in the GRUAN - RO comparison



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- ▶ The uncertainties given in the GRUAN data product are propagated into the mean GRUAN departures taking into account two distinct parts of the uncertainty budget, i.e.
 - ▶ Uncorrelated uncertainties, which decrease with sample size N by $1/\sqrt{(N)}$.
 - ▶ Correlated uncertainties, which don't decrease with sample size.
- ▶ These uncertainties are propagated individually and are then combined.
- ▶ For RO, only the sampling uncertainty is taken into account which means the RO uncertainty will be underestimated. A separate investigation into structural uncertainties builds part of ROM SAF VS37, see Tradowsky (2019).



Comparison of GRUAN and ROM SAF CDR



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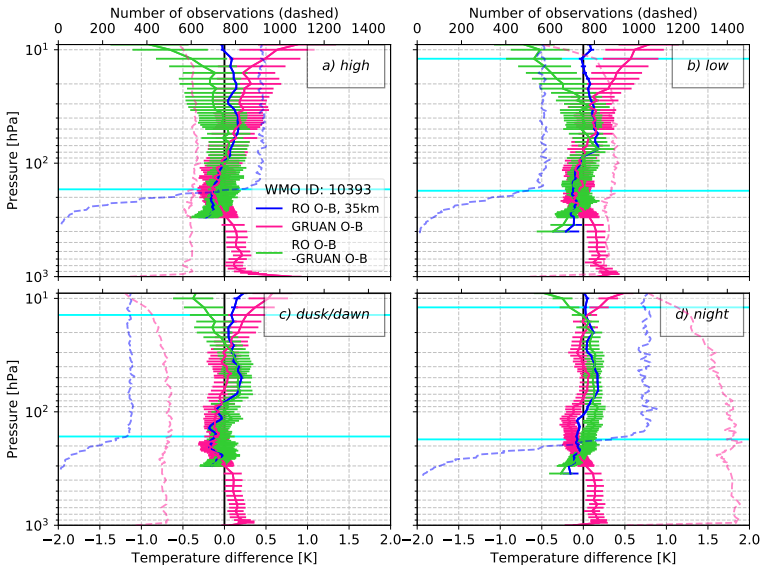
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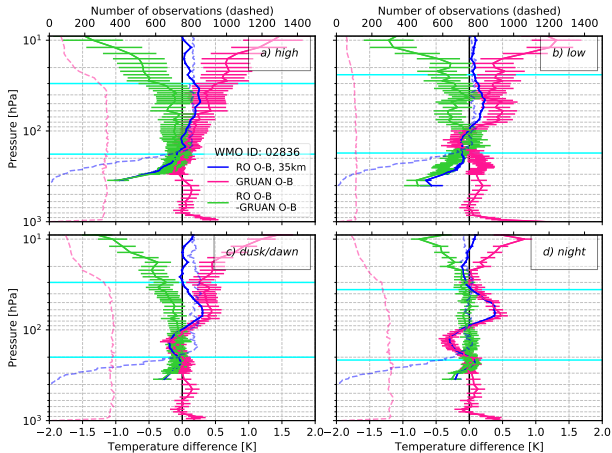
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The comparison can also reveal model biases as can be seen strongest at night time.



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- ▶ Data products for upper-air measurements from an increasing amount of instruments.



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- ▶ Uncertainty estimates on every value!!! → Please make use of them, much effort goes into producing them.



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- ▶ Data products for upper-air measurements from an increasing amount of instruments.
- ▶ Uncertainty estimates on every value!!! → Please make use of them, much effort goes into producing them.
- ▶ Reference-quality data including corrections of all known biases.



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- ▶ Strict evaluation of suitability of sites.



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And all of this is available for free!



A GRUAN video can be found here: <https://www.gruan.org/documentation/public-outreach/>

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