Interpolation Uncertainty for RS/41 (review) and GNSS-RO (preliminary results)

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Interpolation uncertainty for RS41 missing data

Recently the interpolation uncertainty for missing data imputation has been considered for RS41 providing both a method an assessment for small to medium gaps.

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https://doi.org/10.5194/amt-13-6445-2020

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Interpolation uncertainty of atmospheric temperature profiles

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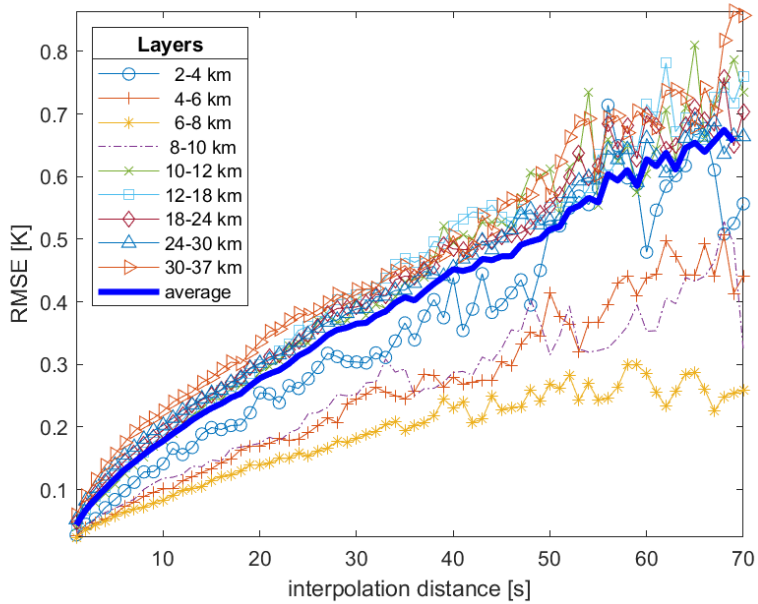

Interpolation uncertainty for RS41 missing data

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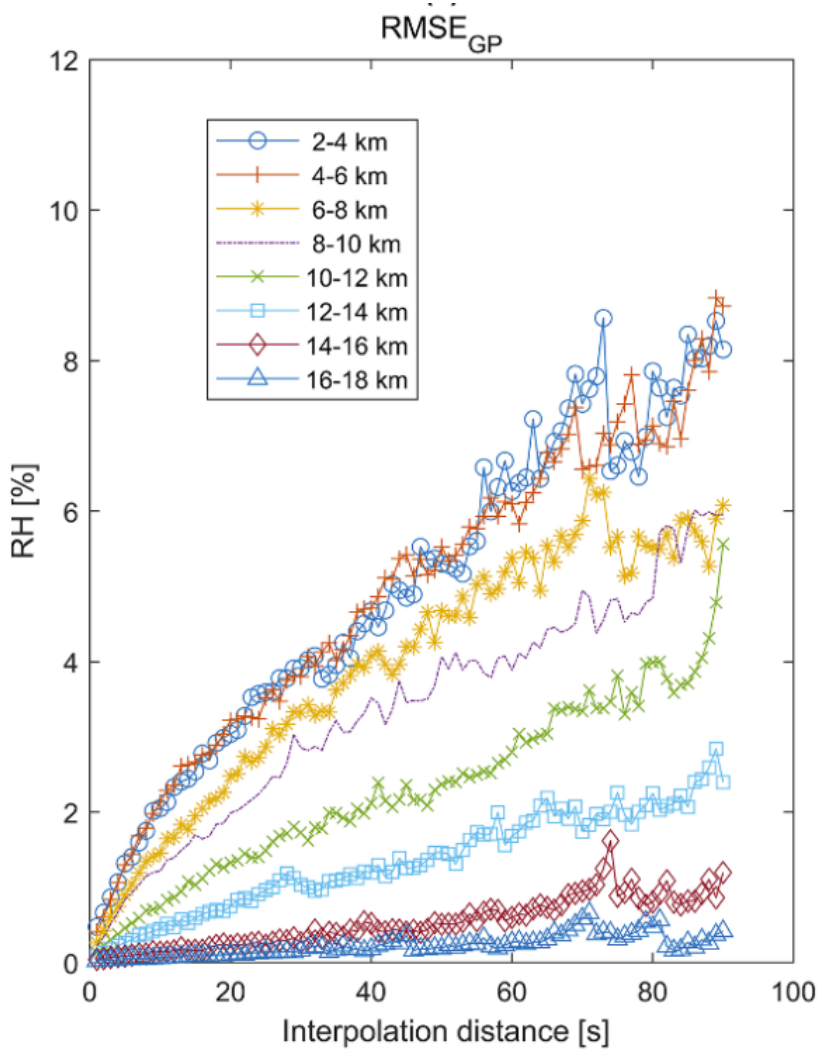
Measurement Science and Technology
Meas. Sci. Technol. **33** (2022) 074001 (12pp)
https://doi.org/10.1088/1361-6501/ac5bff

Quantifying the interpolation uncertainty of radiosonde humidity profiles

Pietro Colombo* and **Alessandro Fassò**



Considerations and further developments

- Implementable in a future GDP version.
- Extendable to other (all) RS41 variables
- Updatable on the more recent and extended RS41 dataset
- Easily adaptable to RS92

GNSS-RO interpolation uncertainty

In collaboration with Kalev Rannat and Hannes Keernik

Underlying motivation:

The comparison of GNSS-RO and RS has been considered in a correction problem recently[1].

Here, I consider the more general problem of the collocation uncertainty budget.

- Difference in smoothing
- Spatial displacement
- Temporal delay
- ...

[1] Tradoswky et al, 2017, https://www.jstor.org/stable/26179972

Data

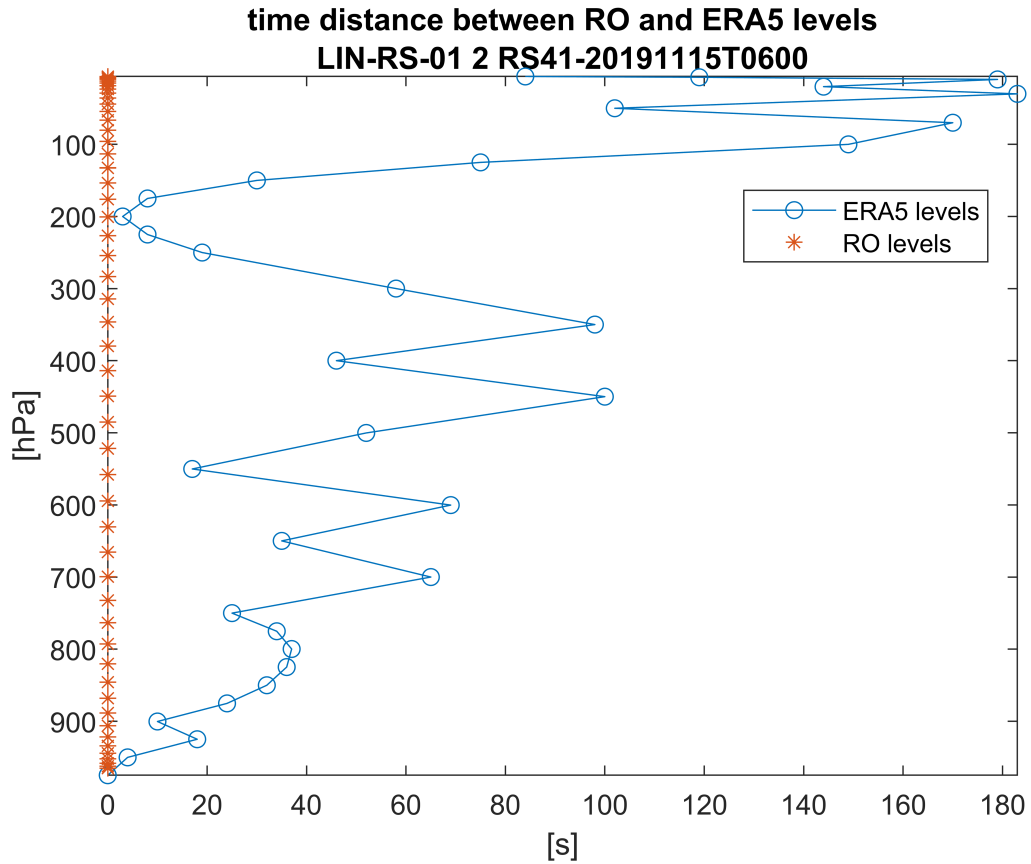
This preliminary study considers T and RH from 215 GNSS-RO retrievals[2] collocated to Lindenberg in year 2016.

Each GNSS-RO profile has 60 pressure levels which are not constant over different profiles.

Another 215 high-resolution GRUAN RS41 profiles with raw data for T and RH are used as "truth" and filtered at the same 60+37 RO and ERA levels to mimic the GNSS-RO dataset from the interpolation point of view.

[2]Source: ROM SAF - Product Archive, https://www.romsaf.org

RO-ERA5 time distance



(Based on RS41 flying time)

Talk aim

Assessing the uncertainty due to interpolation of RO levels to ERA5 levels

Main points

- to consider T and RH
- to use high resolution GRUAN RS41 as "truth"
- to embed measurement uncertainty of RO in the interpolation algorithm
- to propagate it into the interpolated values

Interpolation with meausurement errors

$$y_i = x_i + \varepsilon_i$$
$$x_i = x_{i-1} + \alpha_i \times \Delta p_i + \eta_{1,i}$$
$$\alpha_i = \alpha_{i-1} + \eta_{2,t}$$

Where

- y_i is the measured T or RH at level i
- ε_i is the (unobserved) measurement error
- $u_i = \sigma(\varepsilon_t)$ is the measurement uncertainty (known for GNSS-RO)
- x_i is the unobserved true value
- α_i is the unobserved true value
- p_i is the pressure at level i.
- $\eta_{1,i}$ and $\eta_{2,i}$ are two white noise innovations
- $i = 1, ..., n = 60 + 37$ is the pressure level index.

The Kalman smoother

The Kalman smoother provides the estimate for the ERA5 levels:

$$\hat{y}_i = E(x_i|y_1, ..., y_n)$$

and the uncertainty at interpolated levels:

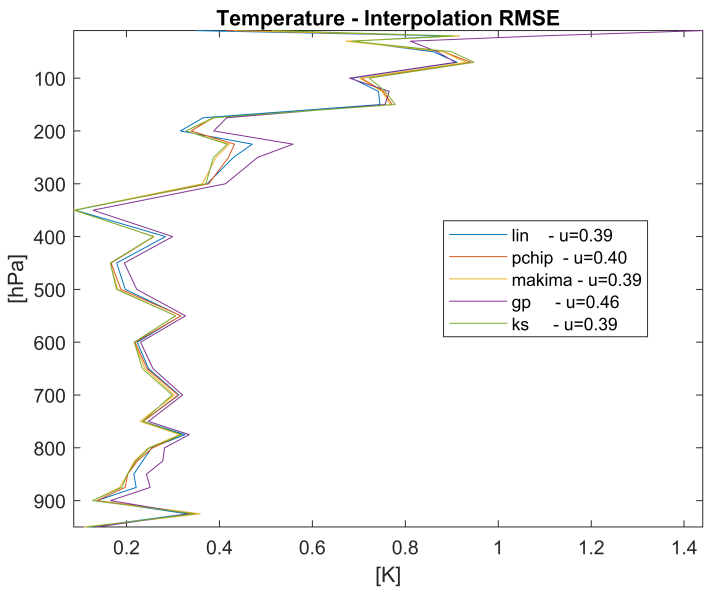
$$u(\hat{y}_i) = \sqrt{Var(x_i|y_1, ..., y_n)}$$

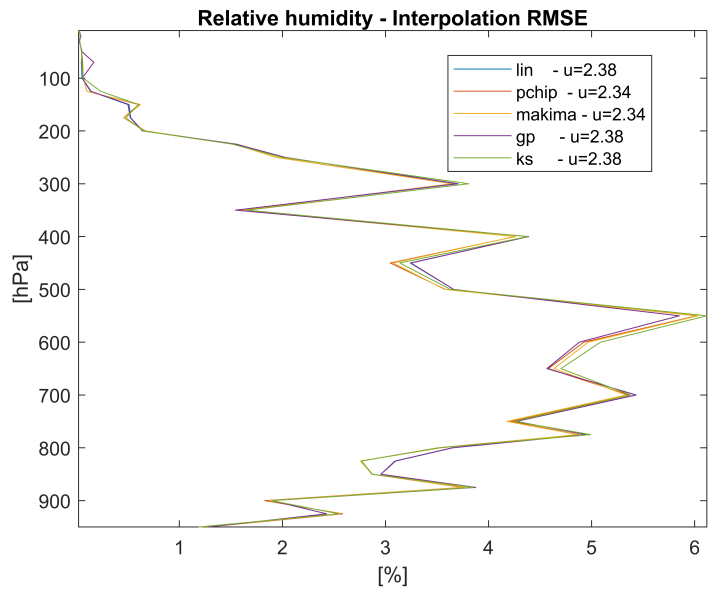
Experiment plan

I consider two phases

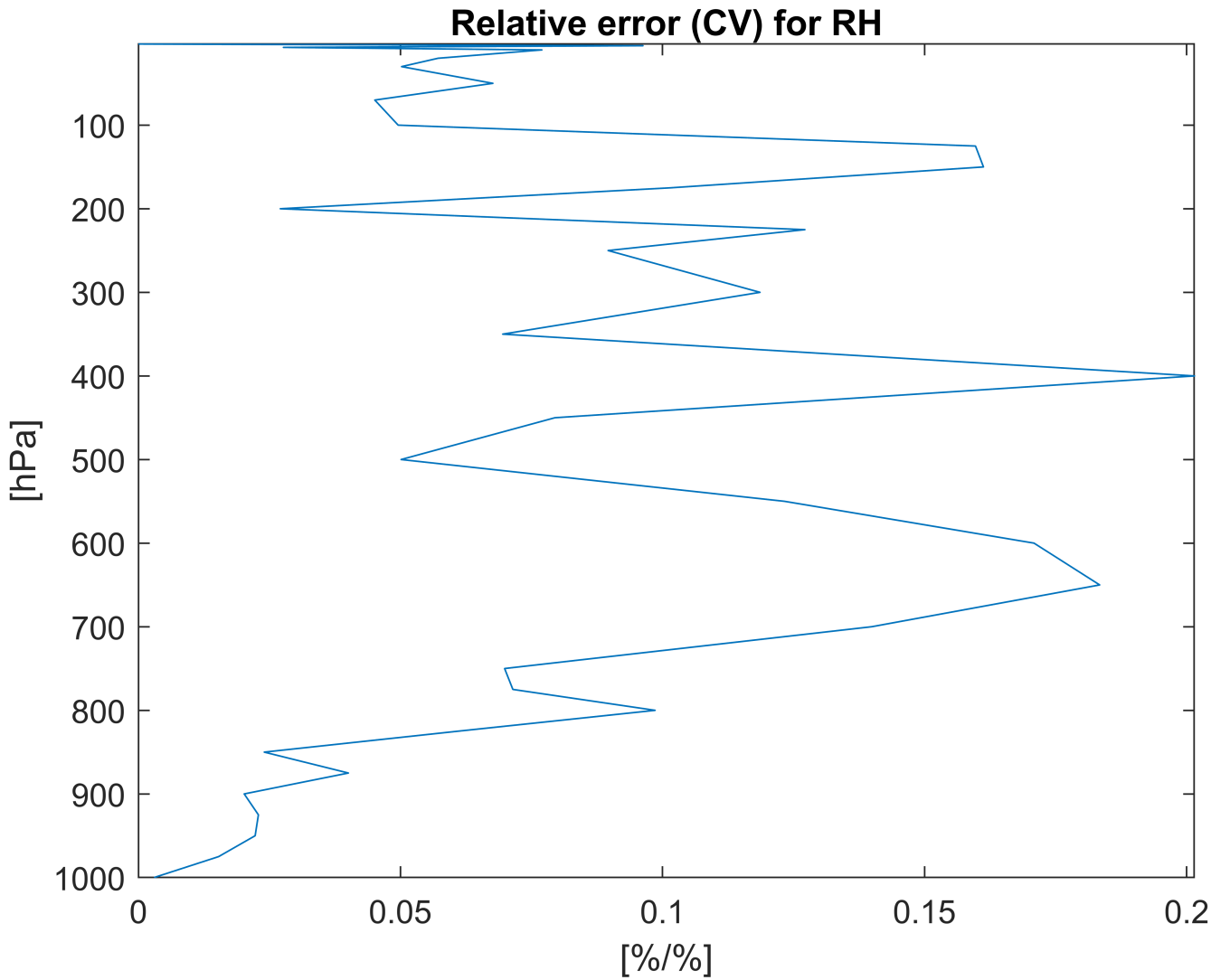
1. using GRUAN dataset to assess empirically the performance of interpolation
   - linear interpolation
   - pchip
   - makima
   - GP
   - Kalman smoother
2. using the KS model to propagate the measurement uncertainty and assess its impact on interpolation uncertainty

GRUAN evidence

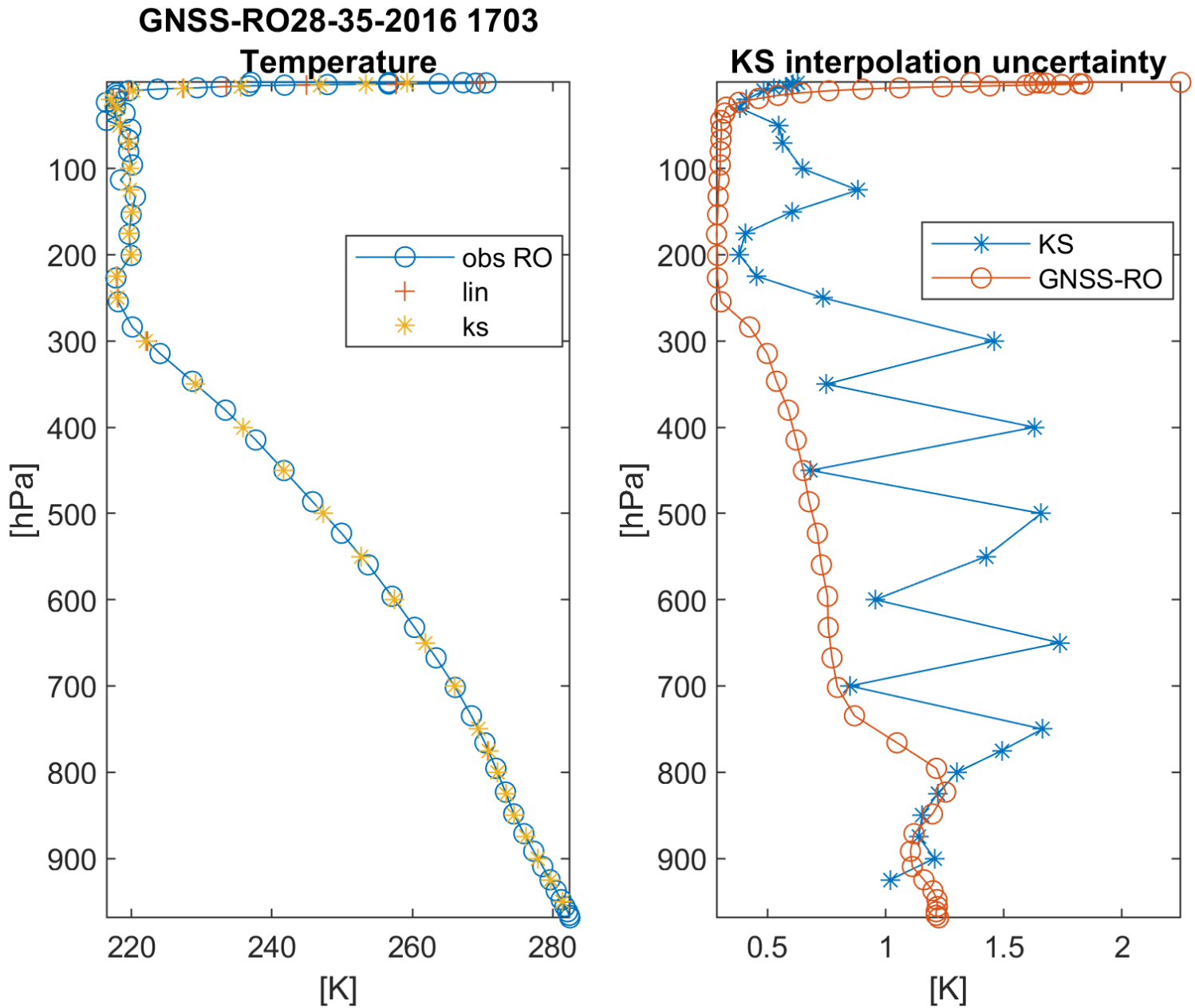




relative RH error



GNSS-RO


GNSS-RO28-35-2016 1703
Temperature
obs RO
lin
ks
[hPa]
100
200
300
400
500
600
700
800
900
220
240
260
280
[K]
KS interpolation uncertainty
KS
GNSS-RO
[hPa]
100
200
300
400
500
600
700
800
900
0.5
1
1.5
2
[K]

Further developments in GNSS-RO

To do:

- Phase 1:
  - to apply this approach to RS41 GDP data and their uncertainty
- Phase 2:
  - to analyse RH - to compare KS and GP formula for uncertainty
- Phase 1 and 2:
  - to extend to other GRUAN stations
  - to extended to other ECVs
  - to consider pressure uncertainty

Thanks for your questions!