Empirical estimation of random uncertainties and error covariance matrices from radiosondes, radio occultations and model forecast.

A possible application of high accuracy soundings

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ROM SAF

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EUMETSAT ROM SAF RADIO OCCULTATION METEOROLOGY

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Outline

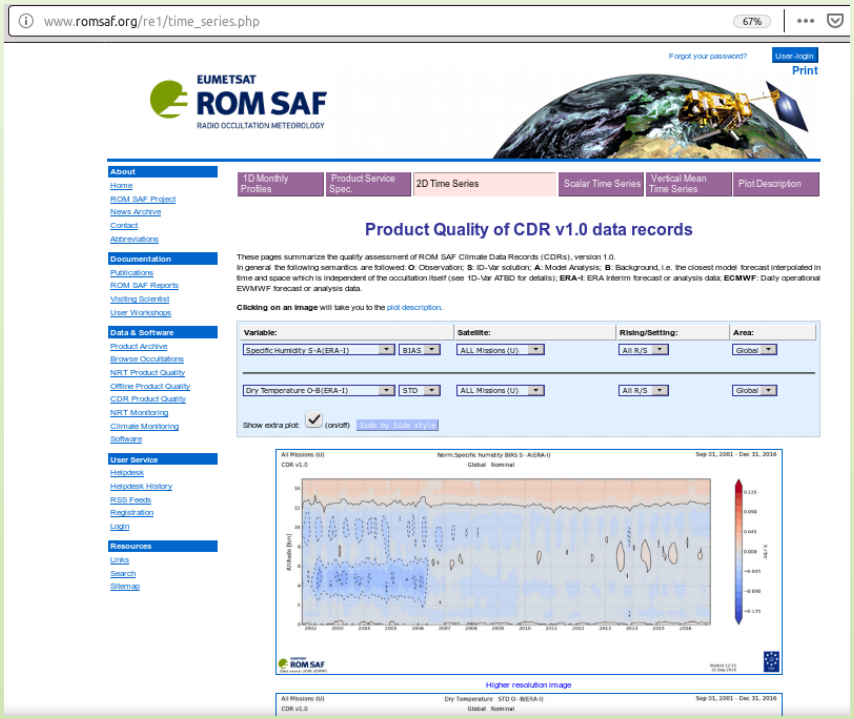
Context: Specific humidity retrieval from GNSS Radio Occultation

Triple collocation method.

Results

Conclusion

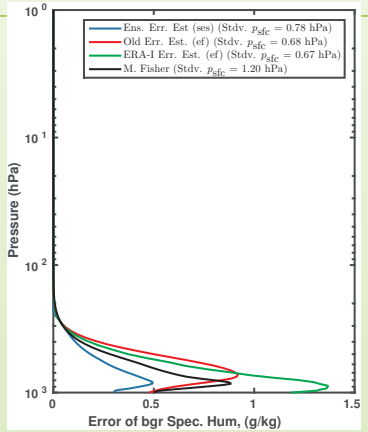
ROM SAF CDR v1 and ICDR v1

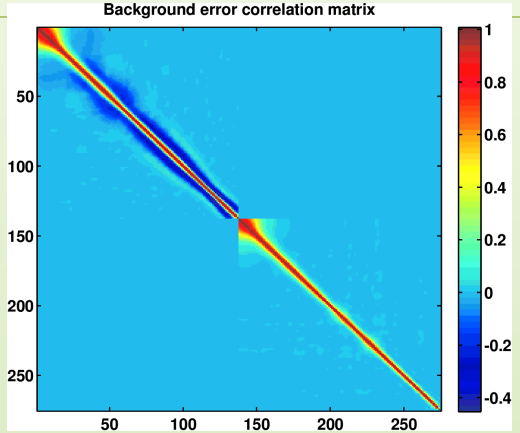


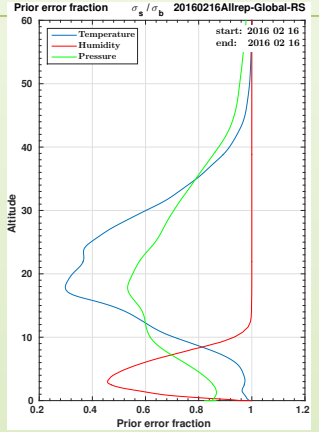
- $> 10^7$ profiles
- $> 10^6$ validation plots
- Bending angle
- Refractivity
- Dry temperature
- Temperature
- Spec. humidity
- Pressure
- Surface pressure
- + gridded data

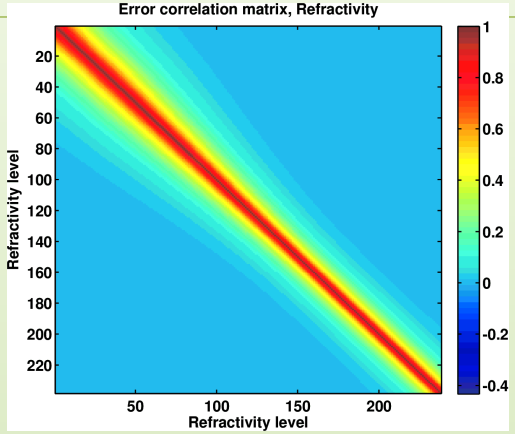
GRUAN radio sondes to be used formally in coming CDRs for temperature and specific humidity validation.

Specific humidity retrieval from GNSS RO









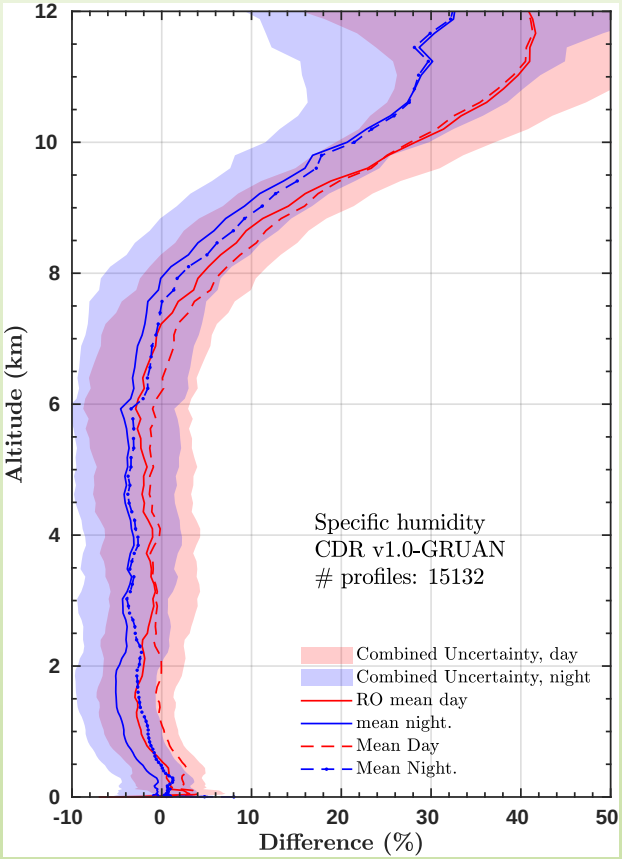
Sensitivity to tropospheric humidity.
Method: 1D-Var
(http://www.romsaf.org/product_documents/romsaf_atbd_1dvar.pdf)

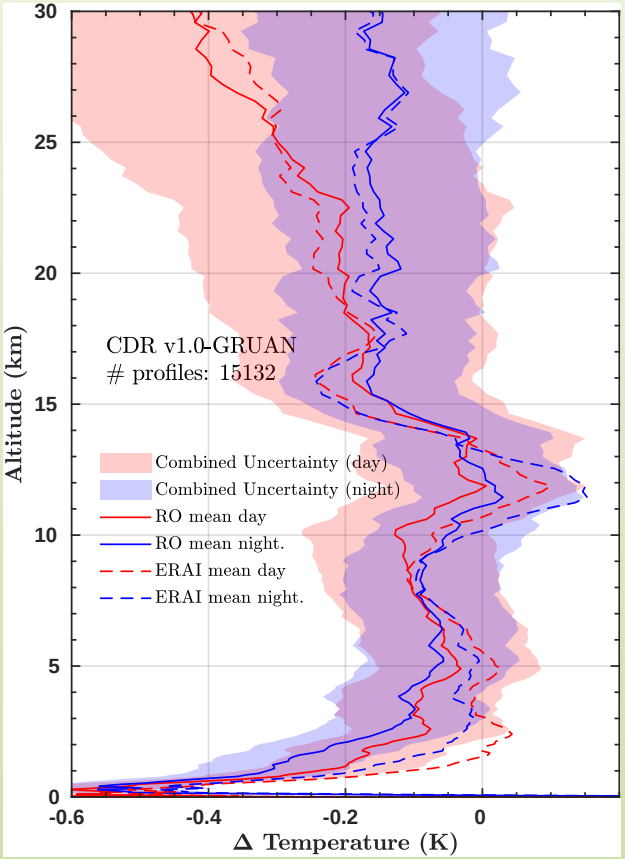
$$N = \kappa_1 \frac{P_d}{T} + \kappa_2 \frac{e}{T^2} + \kappa_3 \frac{e}{T}, \; \boldsymbol{x} = (\boldsymbol{T}, \boldsymbol{q}, \boldsymbol{p_s}) \qquad (1)$$

$$J(\boldsymbol{x}) = \frac{1}{2}(\boldsymbol{x} - \boldsymbol{x}^b)^T \boldsymbol{B}^{-1}(\boldsymbol{x} - \boldsymbol{x}^b) + \frac{1}{2}(\boldsymbol{N} - \boldsymbol{N}(\boldsymbol{x}))^T \boldsymbol{R}^{-1}(\boldsymbol{N} - \boldsymbol{N}(\boldsymbol{x})) \qquad (2)$$

Basic problem: ***R*** and ***B*** determines result!

RO-GRUAN systematic differences “global”





Estimated uncertainty dominated by systematic GRUAN uncertainty.
-The task is to improve this. The ***R*** matrix is one ingredient.

Refractivity uncertainty, triple point collocation method

- 17552 collocations 2006-2020. dist < 300km, t < 3 h
- Interpolation to 247 levels
- (ERA-I, GRUAN, GNSS RO) $\rightarrow$ Vertical filter, width: 0.2 - 3.2 km.
- Remove biases and do regularization
- Algebraic estimation of vertically correlated refractivity standard uncertainties at different collocation distances
  $\boldsymbol{R} = \frac{1}{2}\langle (r-b)(r-b)^T + (r-g)(r-g)^T - (g-b)(g-b)^T \rangle$
- Extrapolation of covariance matrices to zero distance.

Top-down uncertainty estimate

Could we call it an “error” estimate? Perhaps: Under certain conditions, it is an estimate of the measurements deviation from the idealized truth. But I do not want to mess things up.

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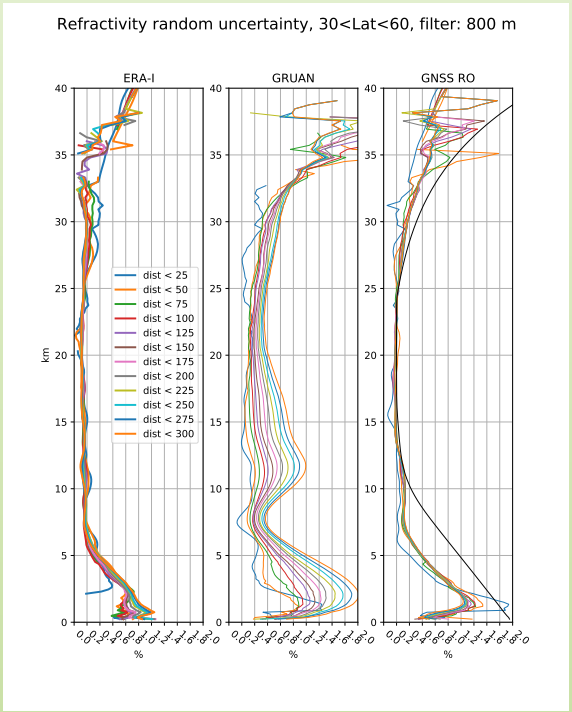
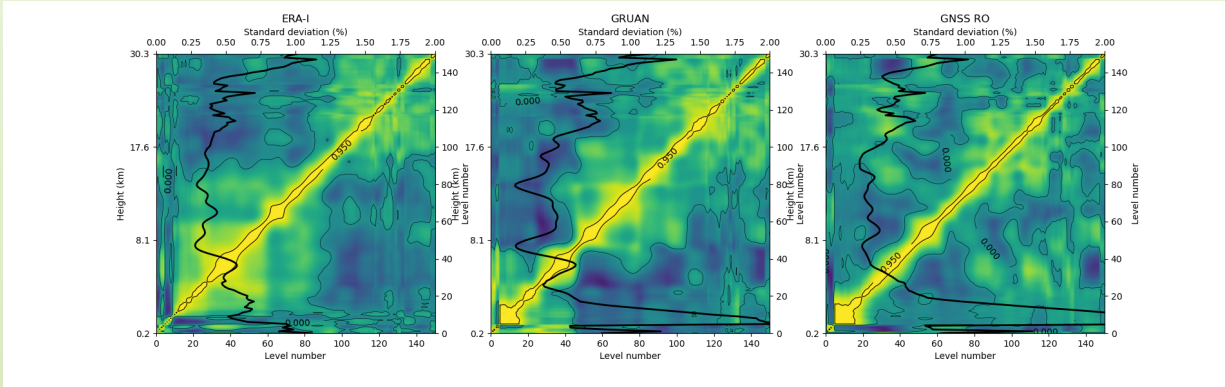
Results...

Uncertainty estimates, Mid Latitudes, filter = 800 m

Refractivity:

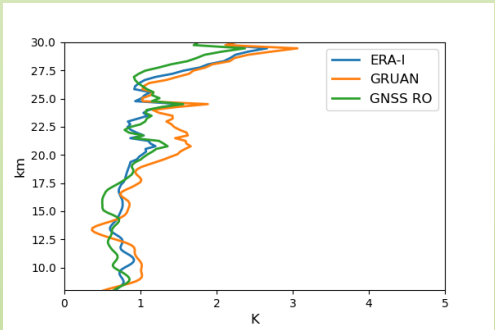


ERA-I, GRUAN and GNSS-RO correlations:



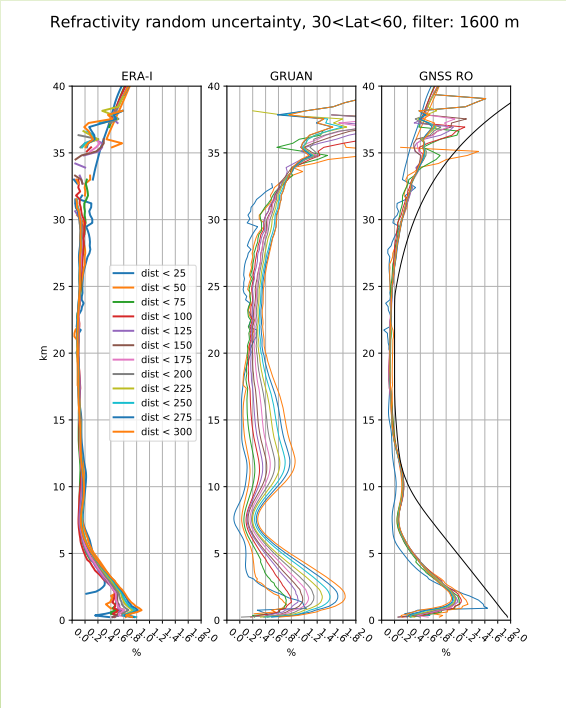
GRUAN is not treated fair in the collocation.
Best collocation in upper troposphere

(Temperature:)

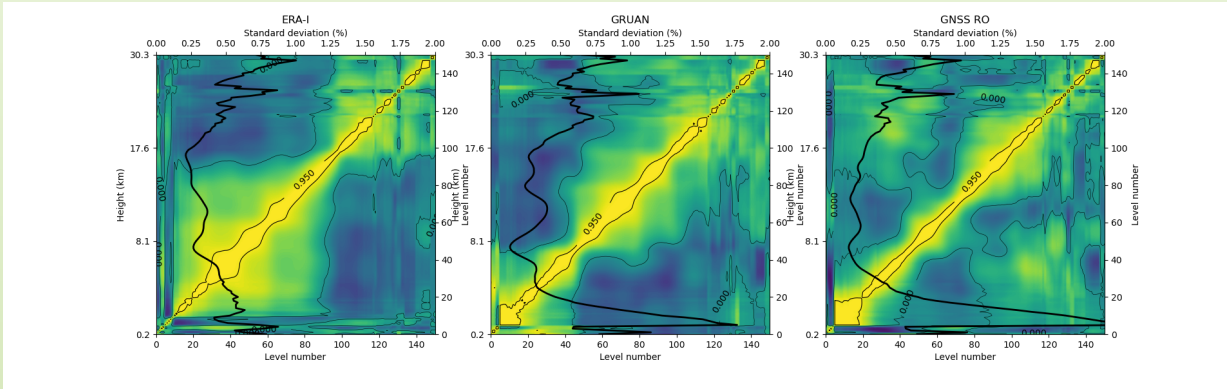


Uncertainty estimates, Mid Latitudes, filter = 1600 m

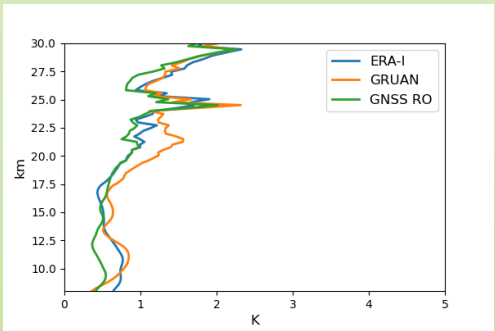
Refractivity:



ERA-I, GRUAN and GNSS-RO correlations:



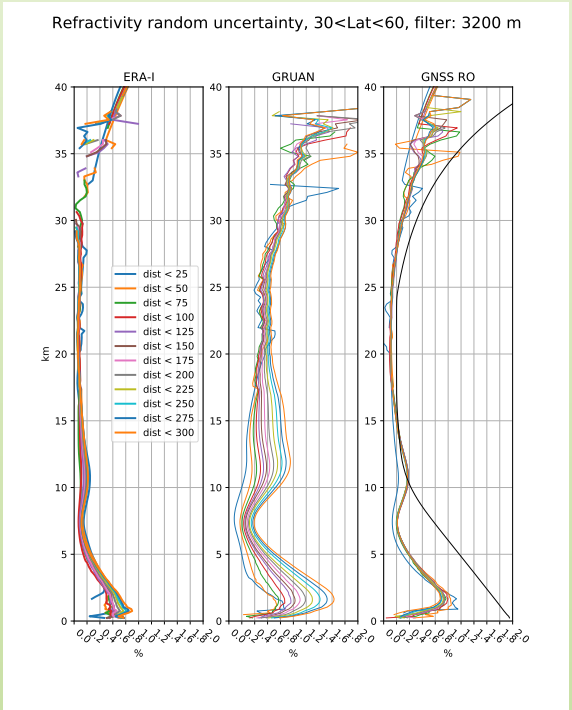
(Temperature:)



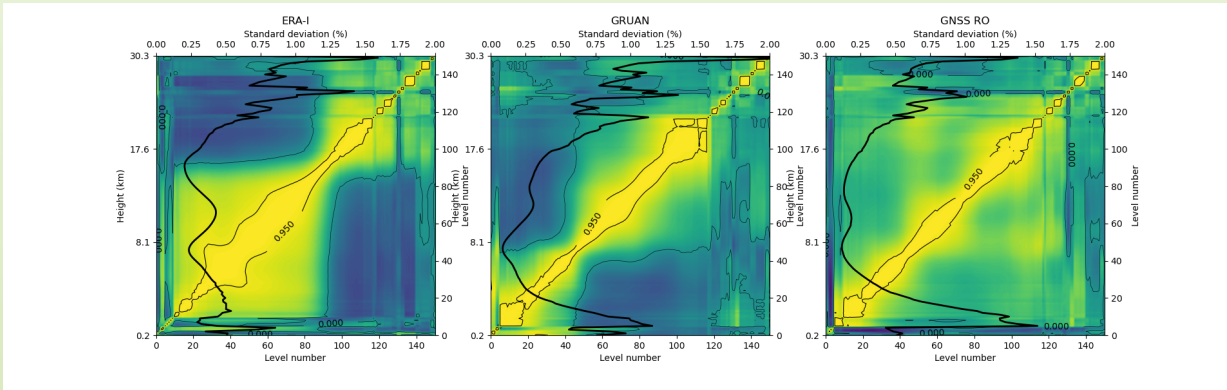
Note the black curve - the current refractivity uncertainty estimate.

Uncertainty estimates, Mid Latitudes, filter = 3200 m

Refractivity:

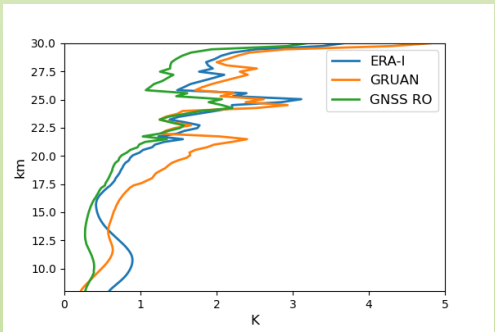


ERA-I, GRUAN and GNSS-RO correlations:



Filter reduces errors but increases correlations

(Temperature:)



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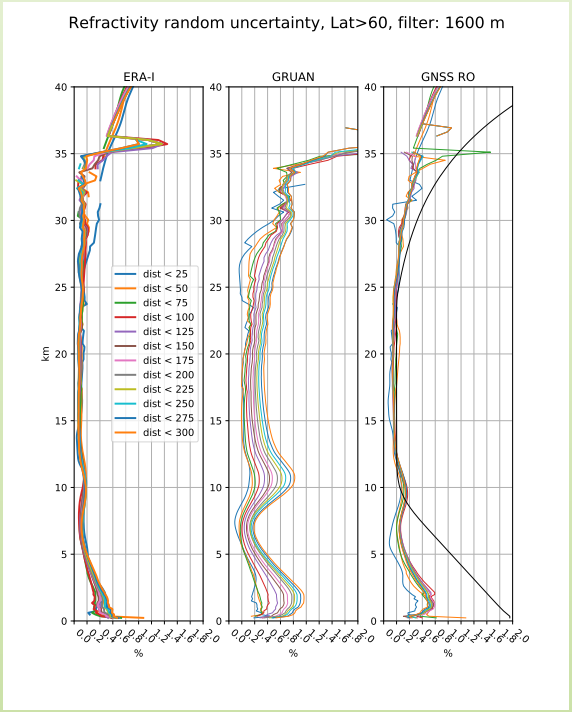
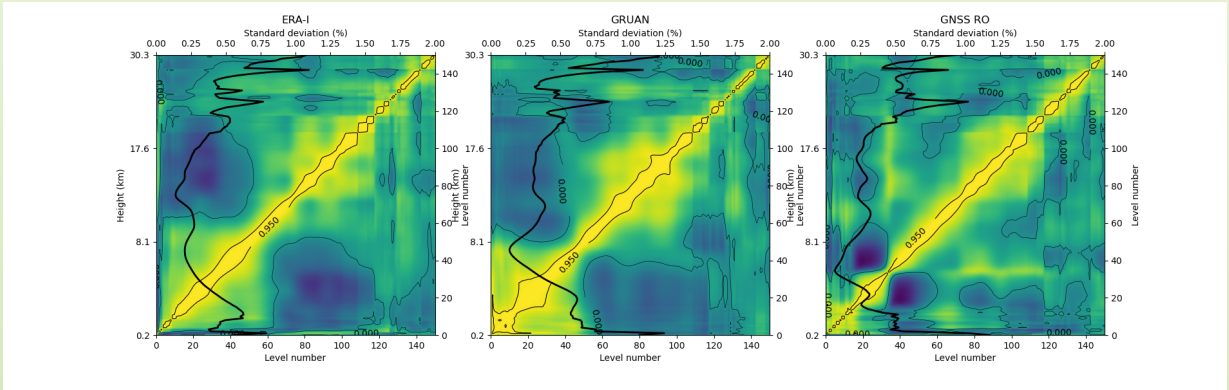
Uncertainty estimates, Polar Latitudes, filter = 1600 m

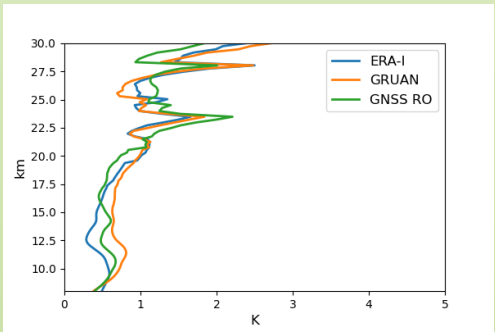
Refractivity:



ERA-I, GRUAN and GNSS-RO correlations:



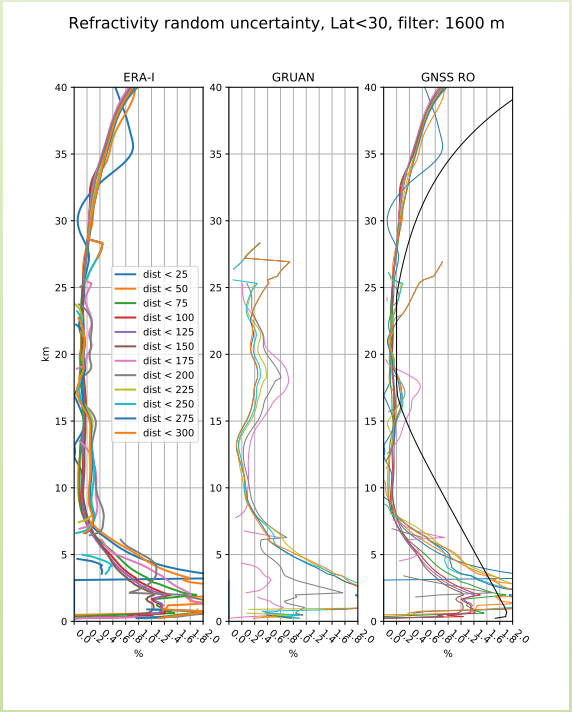
(Temperature:)



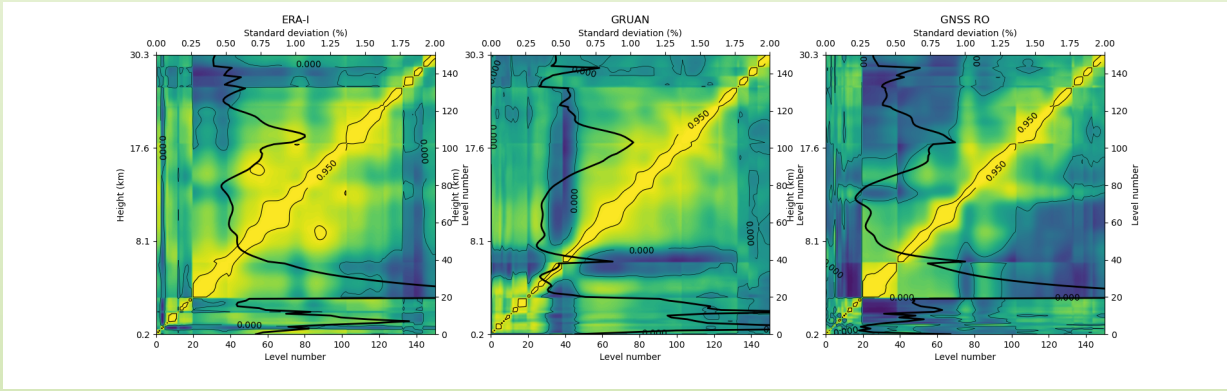
Latitude > 60

Uncertainty estimates, Tropical Latitudes, filter = 1600 m

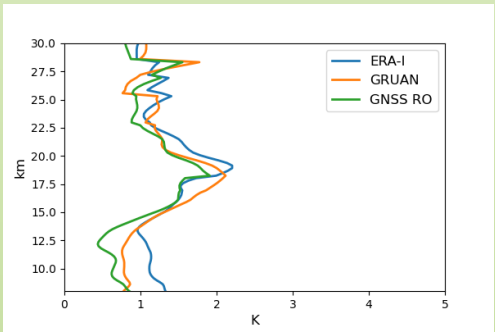
Refractivity:



ERA-I, GRUAN and GNSS-RO correlations:



(Temperature:)



Only 512 colloca-tions in tropics

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Conclusions

- Triple collocations can be used to estimate uncertainty and error correlations of three independent measurement techniques.
- GRUAN radiosondes can help to constrain RO refractivity uncertainty in the troposphere.
- Representation uncertainty is falsely attributed to the “best resolution” measurement.
- Some sensitivity to filtering still needs to be sorted out. Filtering decreases error estimates and increases correlations.
- The applied collocation method is too primitive. More information could be gained.