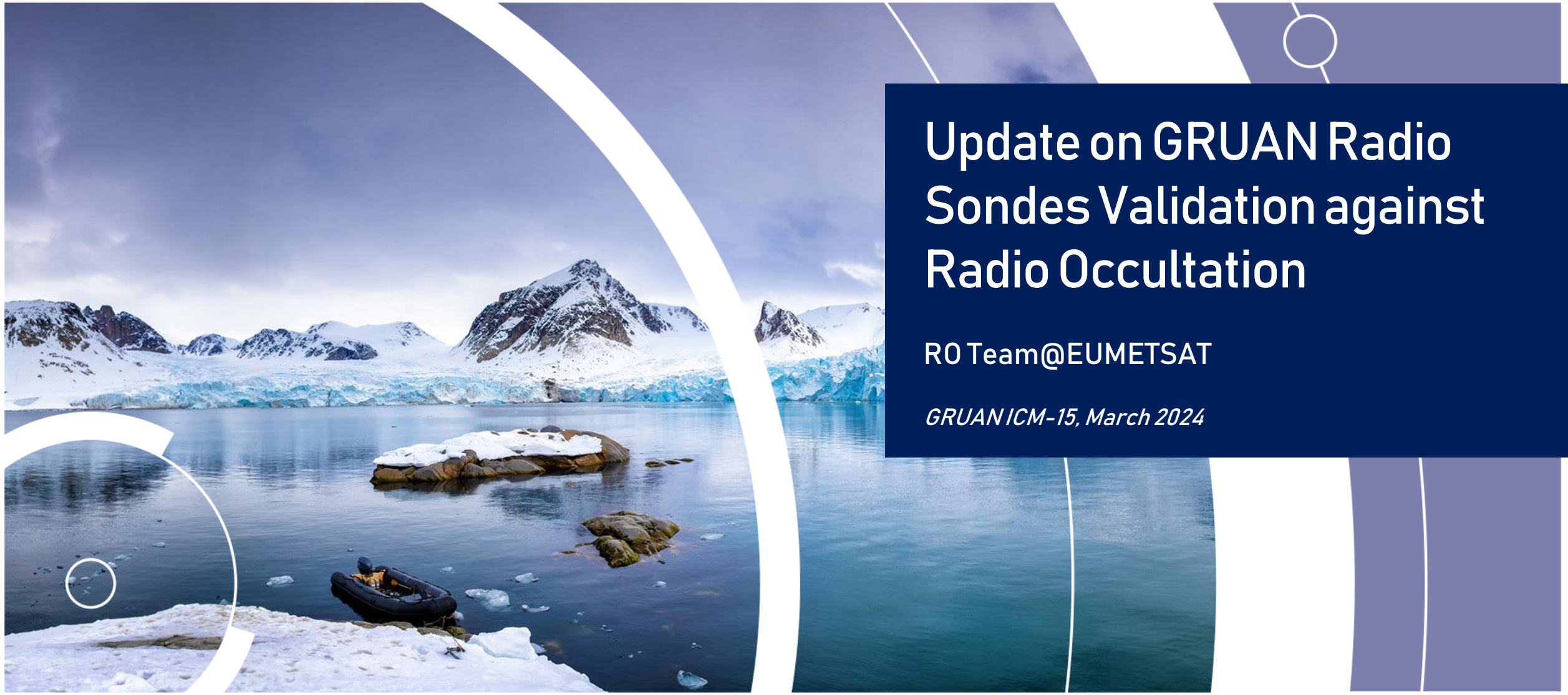
EUMETSAT



Update on GRUAN Radio Sondes Validation against Radio Occultation

RO Team@EUMETSAT

GRUAN ICM-15, March 2024

Agenda

Introduction

Data Sets / Pre-Processing

GRUAN vs. ERA5

GRUAN vs. Metop-A/-B

Summary / Open Points

Introduction

- Comparing radio sondes against radio occultation (RO) has mutual benefits, e.g. for sondes, to assess the radiative bias; for occultation, to assess data processing in the lower troposphere where SNR is low, multi-path, super refraction impacts data quality, temperature and water vapour cannot be separated without a-priori data
- Validation of these measurements generally done by processing RO data to temperature and water vapour, involving several processing steps and use of a priori information (or, use refractivity which smoothes the data)
- Generating bending angles from radio sonde data would not necessarily involve a priori data, and allows to validate directly on the RO FCDR, with the original high resolution
- Caution: bending angles are integrated over all altitudes above the tangent point, thus processing sondes requires extrapolation, which might lead to erroneous biases higher up. Refractivity validation should not have that issue.

Data Sets / Pre-Processing

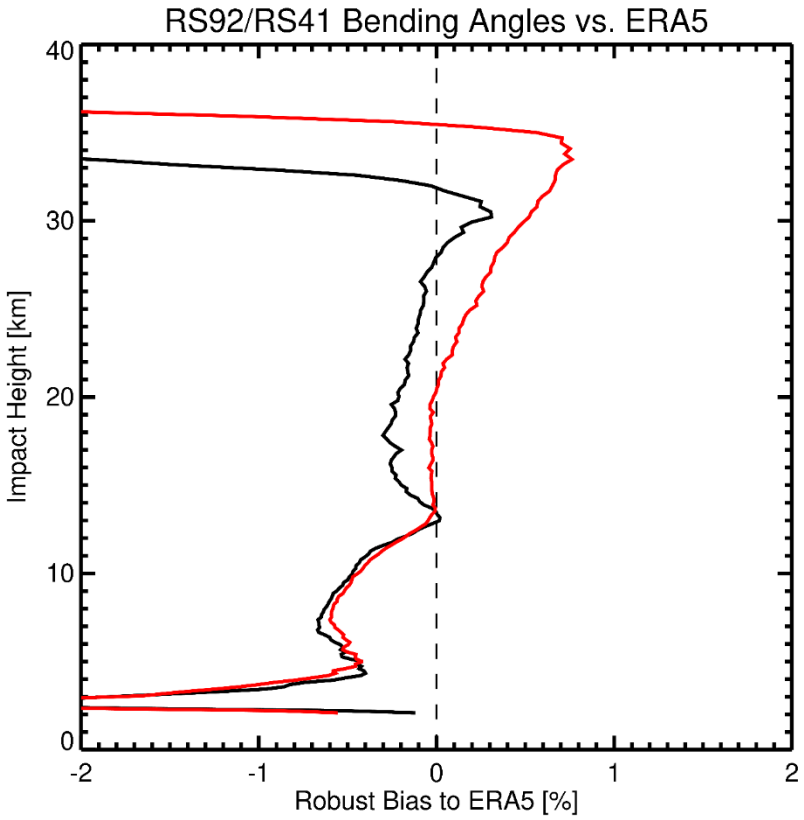
- Radio Sondes:
  - Data Sets: RS92 GDP.2, RS41 GDP.1 (up to 31/12/2023)
  - Pre-Processing: removal of data with larger gaps (~2%), “ordering” altitudes, up-sampling to uniform 1m resolution, box average over 150m
- Radio Occultation:
  - Metop-A, -B reprocessed data (v2.0, few years old, covering up to 06/2020)
  - Collocations: 300km/3h
- ECMWF:
  - ERA5, 6h resolution, 137 vertical levels, 0.5 Degree resolution, time and space interpolation
- Bending Angle Calculation:
  - ROPP-like implementation (v11), allowing to ignore multi-path / super refraction filter

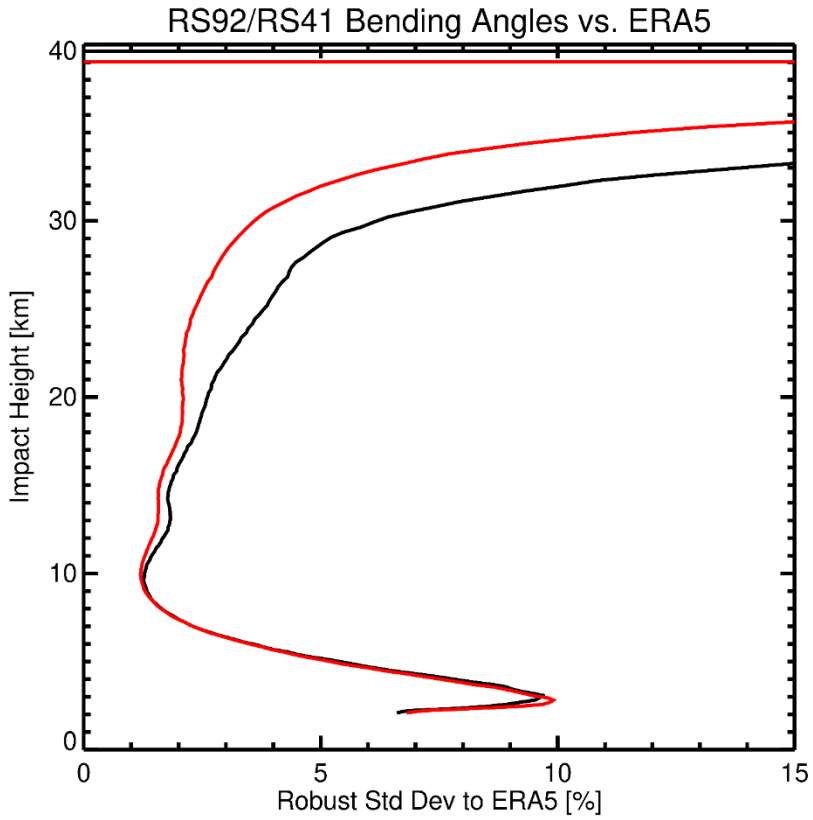
Data Sets / Pre-Processing

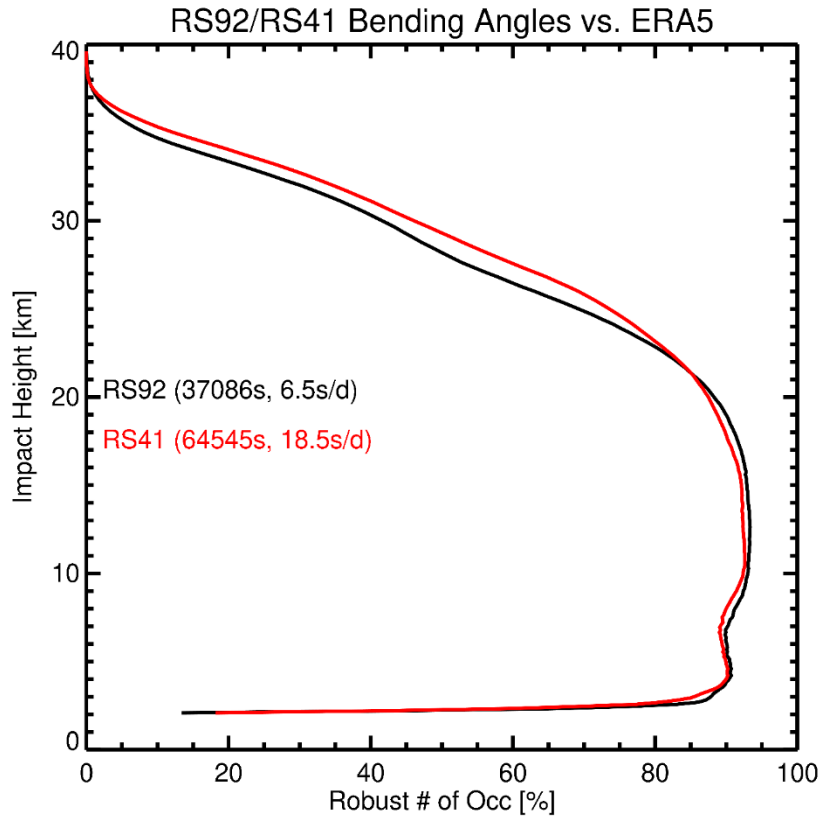
- Corrections tested:
  - Use ERA5 at sonde location to correct for missing upper atmosphere in sonde data – use 2 ERA5 bending angle runs per sonde with full ERA5 vertical levels, and one with reduced vertical levels, and use the delta for correction
  - Use ERA5 to correct for temporal and geographic collocation, assuming that ERA5 captures this variability to sufficient accuracy

Collocating radiosonde bending angles with ERA5 ones

Results: RS vs ECMWF

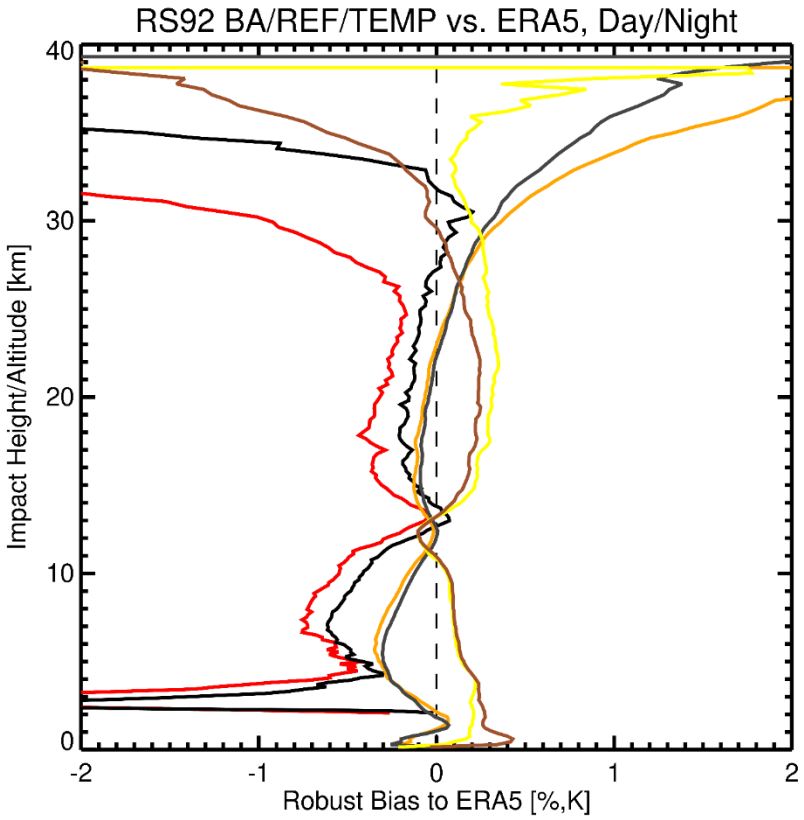


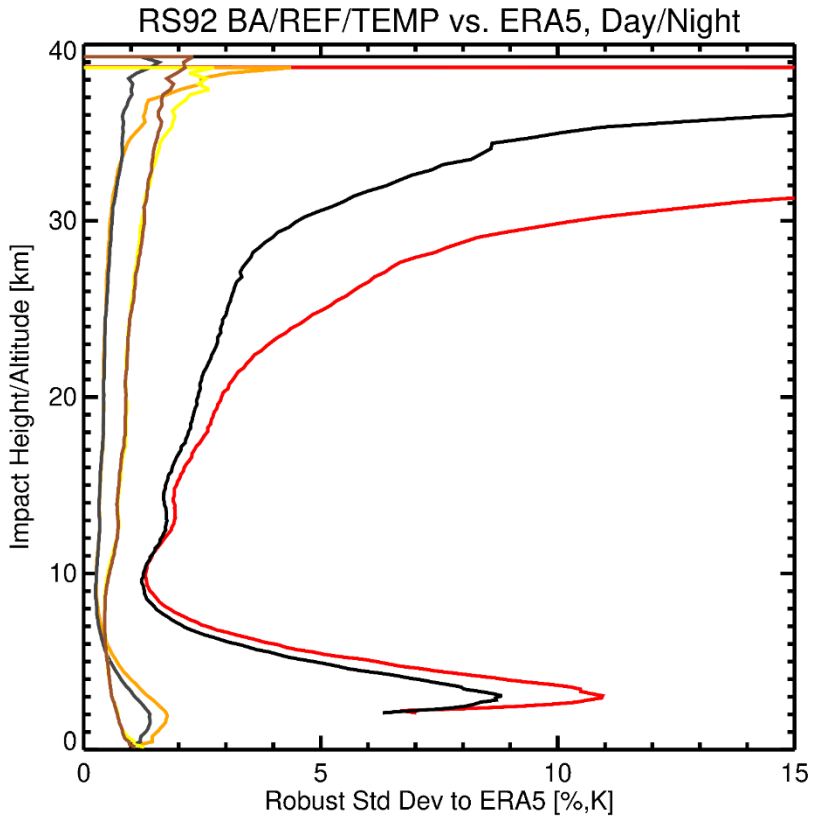


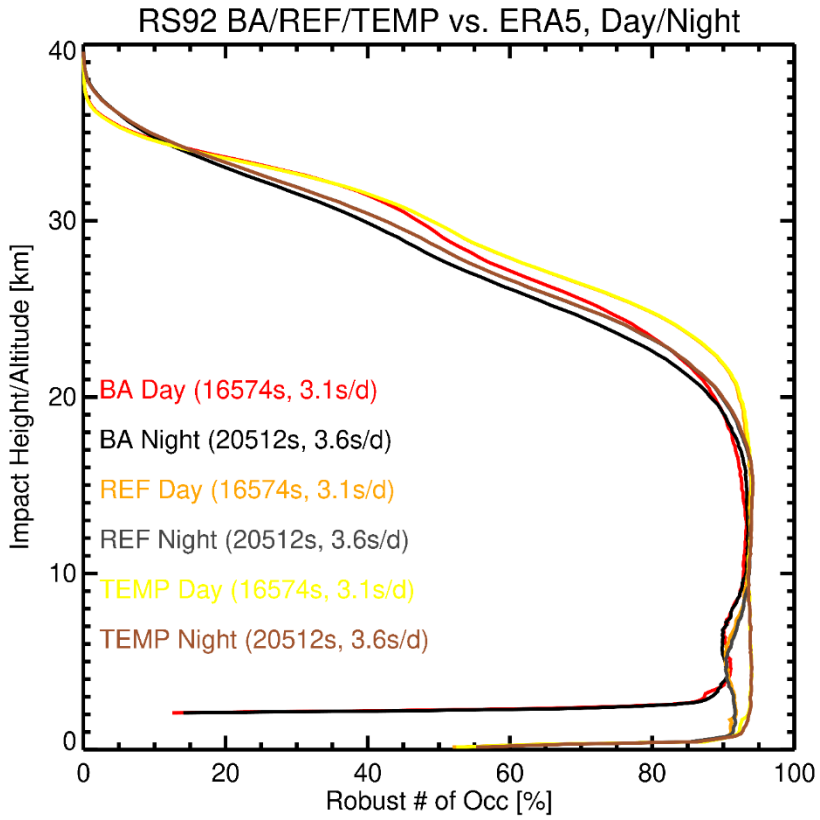


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92, RS41 sondes against ECMWF ERA5 forward propagated bending angles. Legend provides total sondes, average sondes/day.

Results: RS92 vs ECMWF

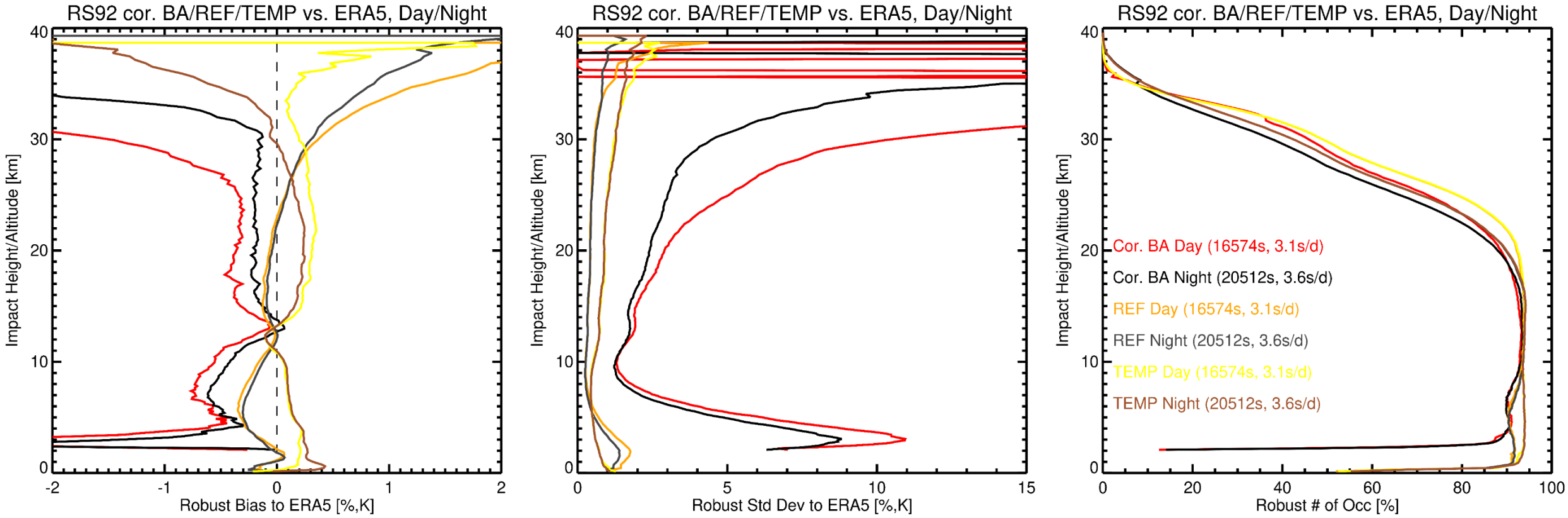






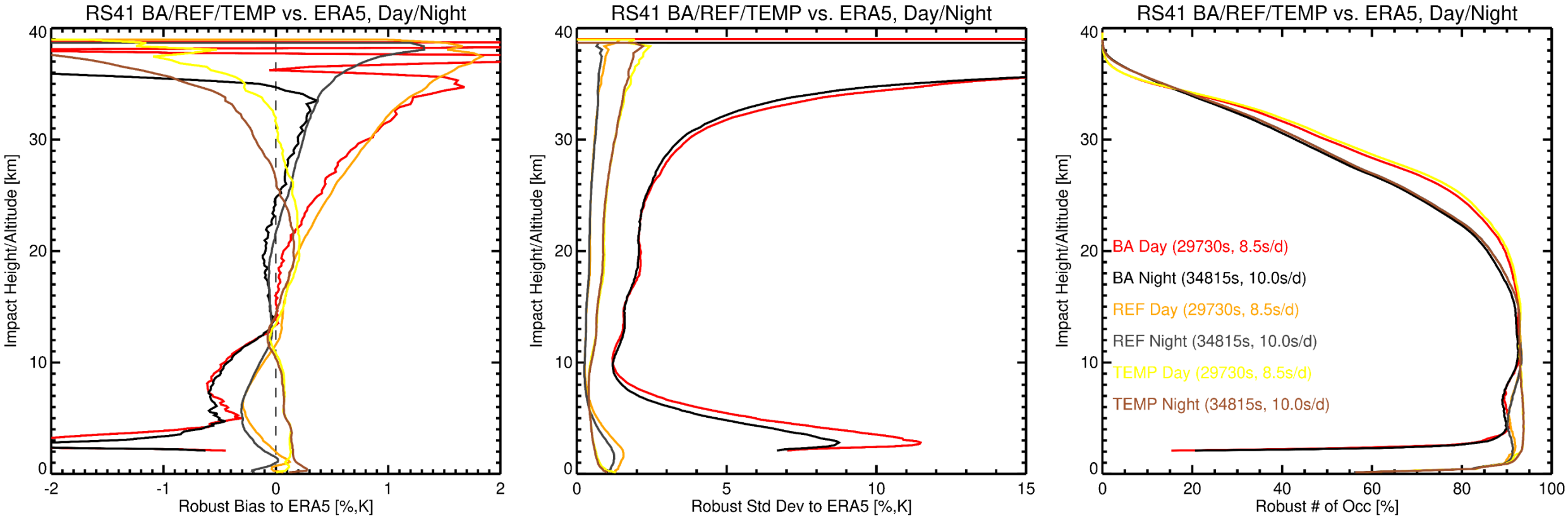
Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92 sondes against ECMWF ERA5 forward propagated bending angles, refractivity, temperature. Legend provides total sondes, average sondes/day.

Results: Corrected RS92 vs ECMWF



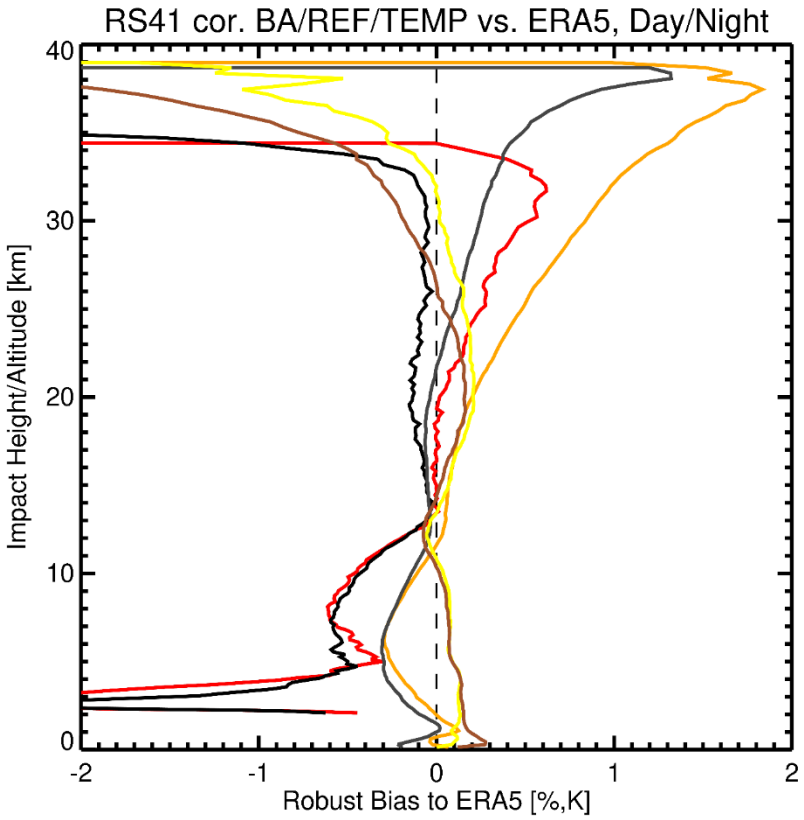
Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92 sondes against ECMWF ERA5 forward propagated corrected bending angles, refractivity, temperature. Legend provides total sondes, average sondes/day.

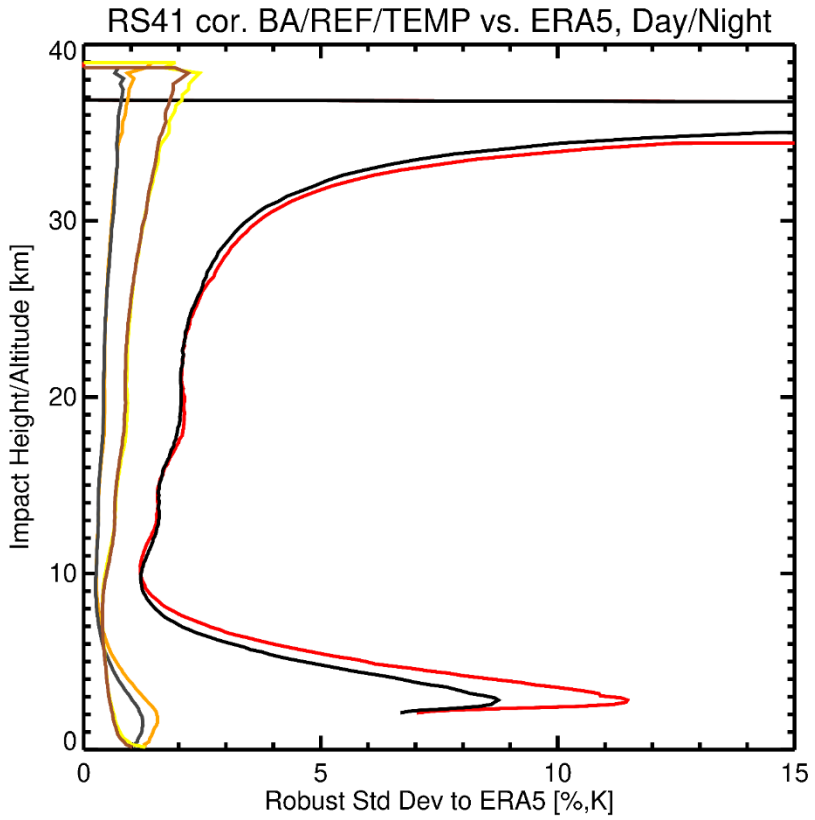
Results: RS41 vs ECMWF

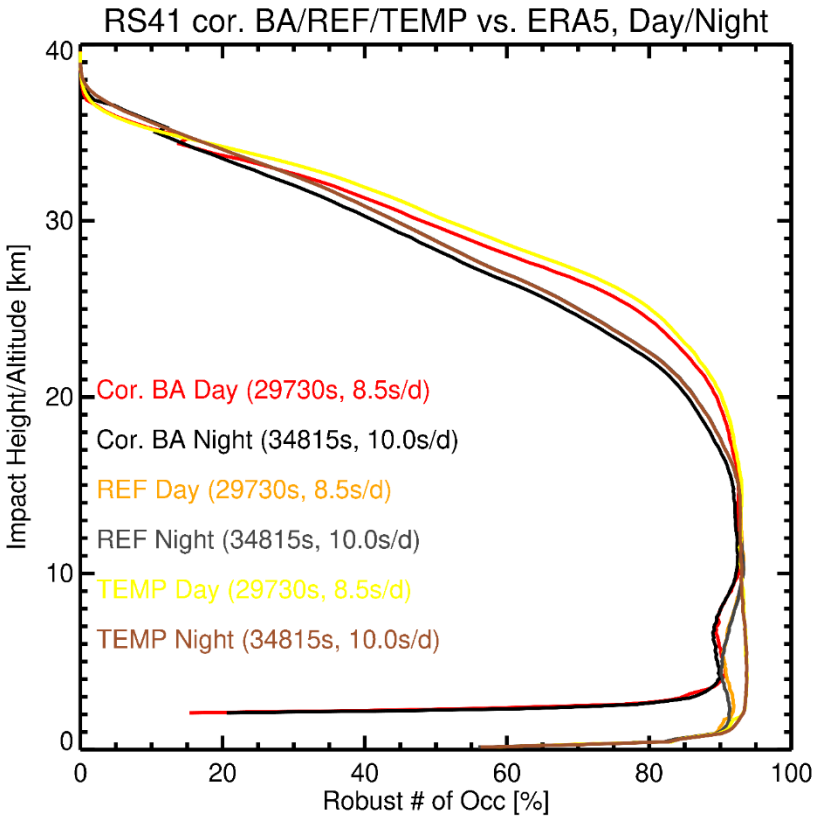


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS41 sondes against ECMWF ERA5 forward propagated bending angles, refractivity, temperature. Legend provides total sondes, average sondes/day.

Results: Corrected RS41 vs ECMWF



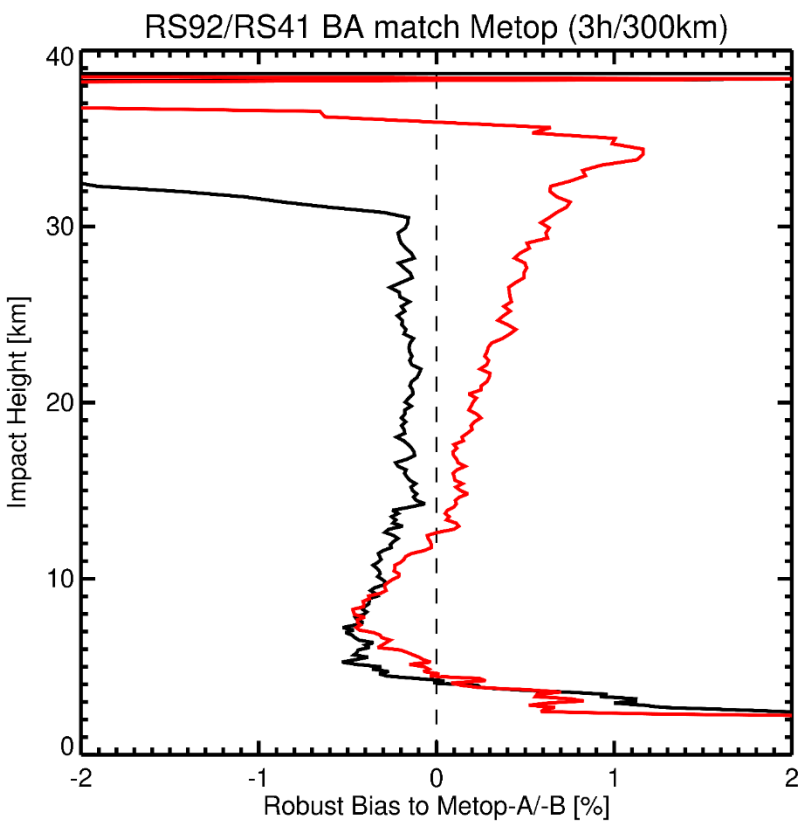


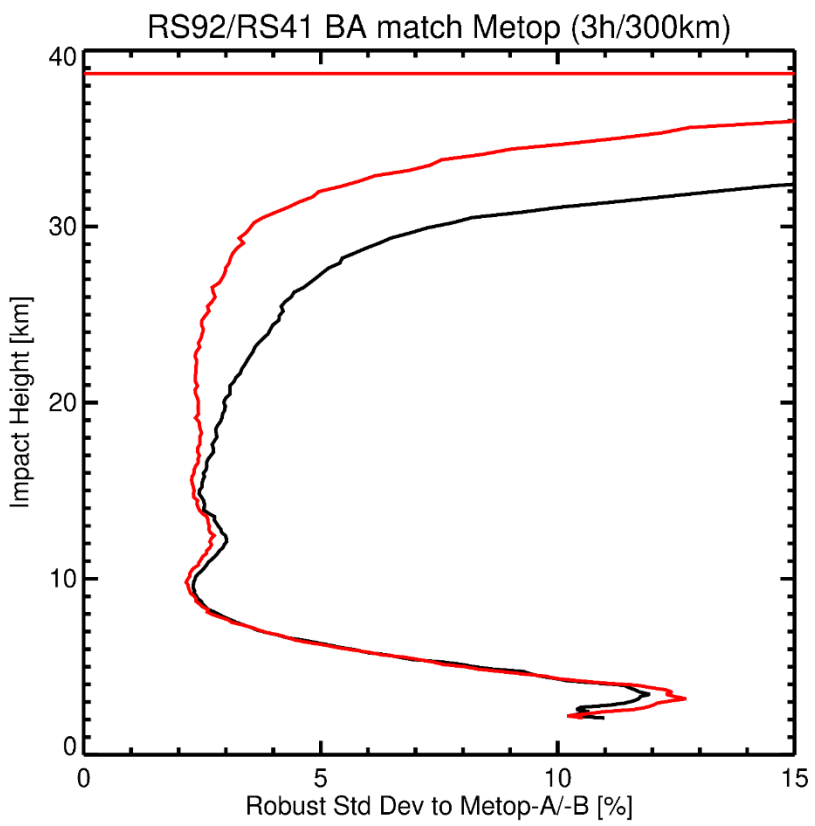


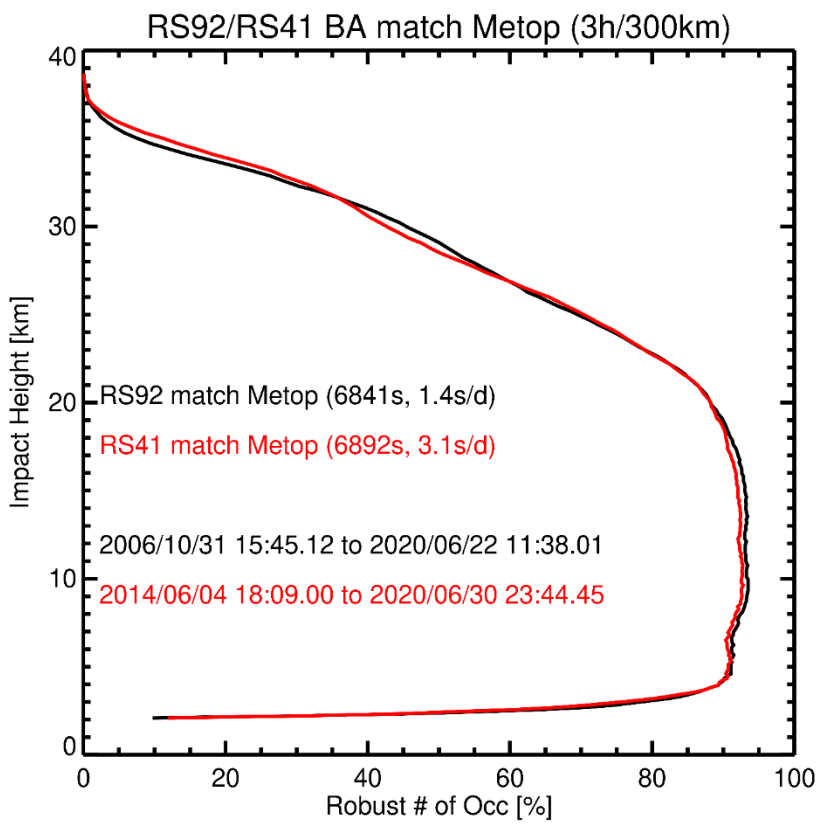
Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS41 sondes against ECMWF ERA5 forward propagated corrected bending angles, refractivity, temperature. Legend provides total sondes, average sondes/day.

Collocating radiosonde bending angles with Metop GRAS ones

Results: RS vs Metop/GRAS

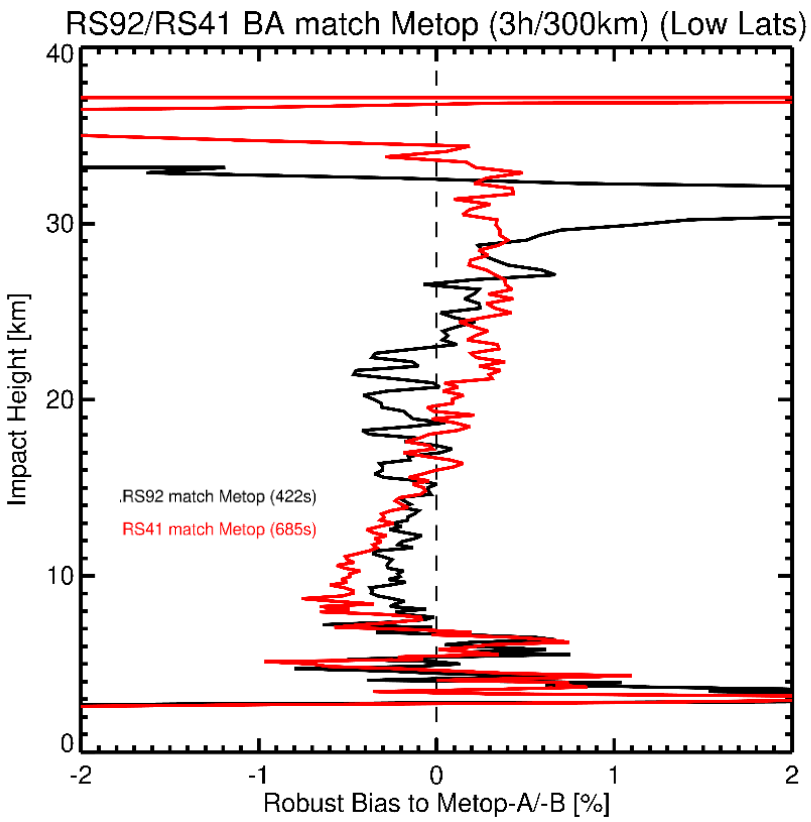


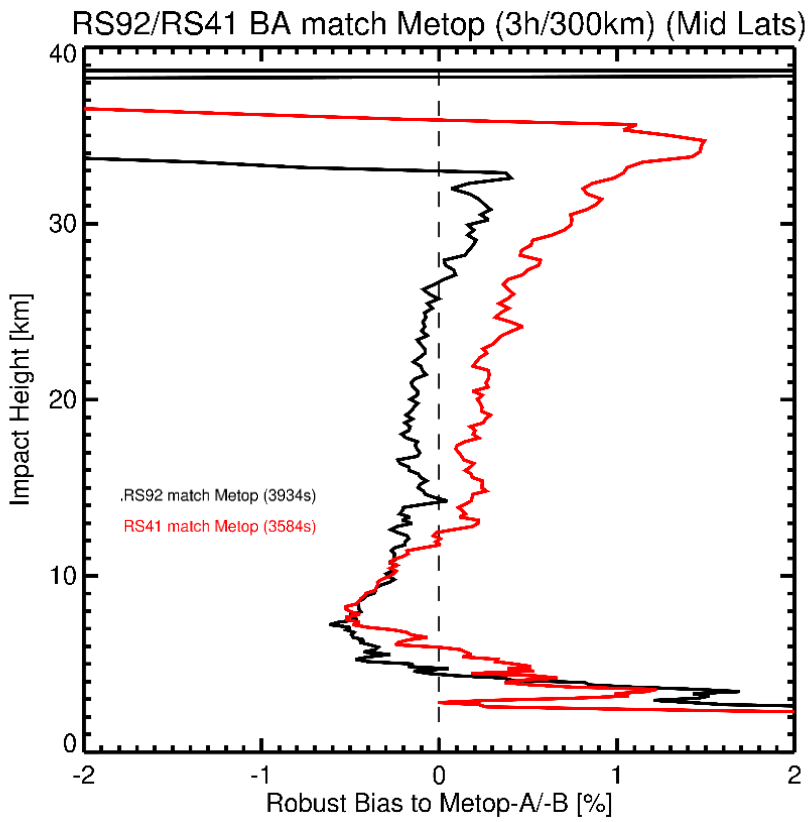


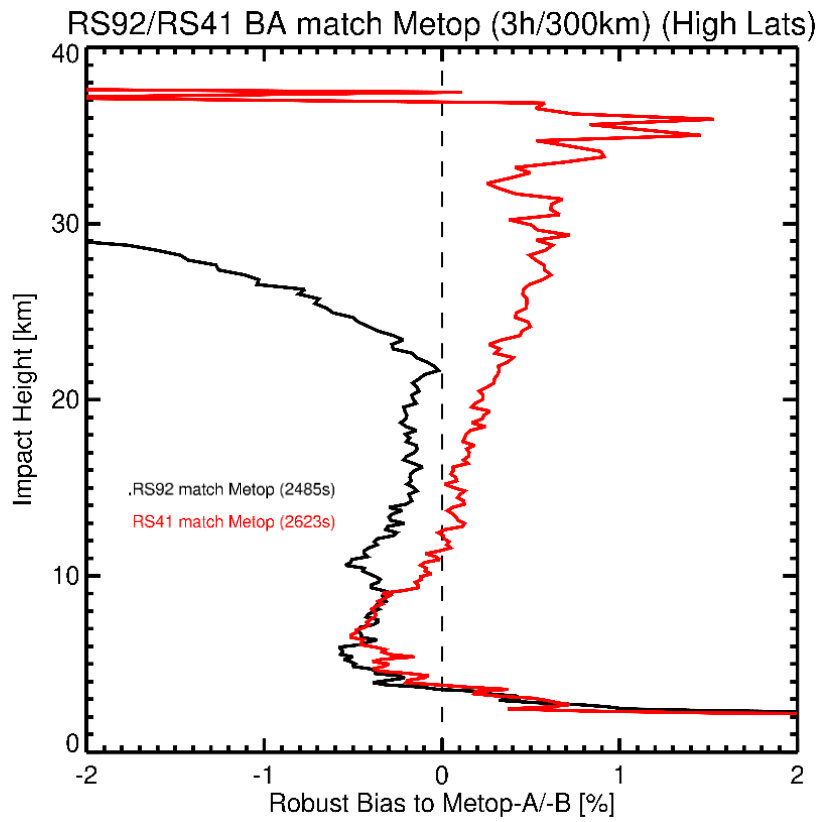


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92 and RS41 sondes forward propagated bending angles matched against Metop/GRAS bending angles. Legend provides total sondes, average sondes/day, and data coverage.

Results: RS vs Metop/GRAS by Latitude Band

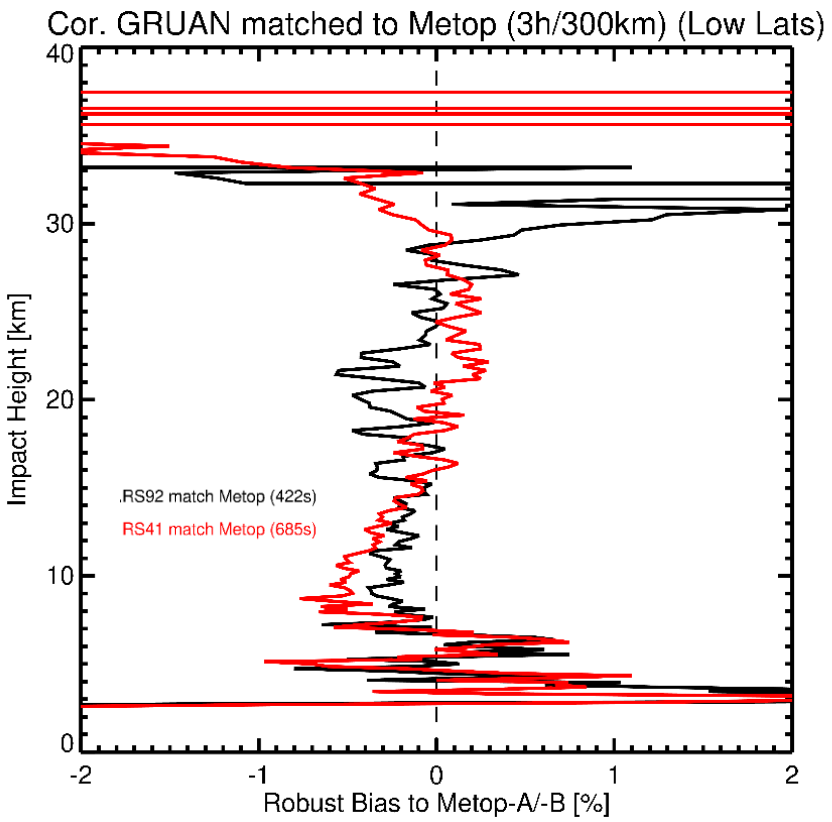


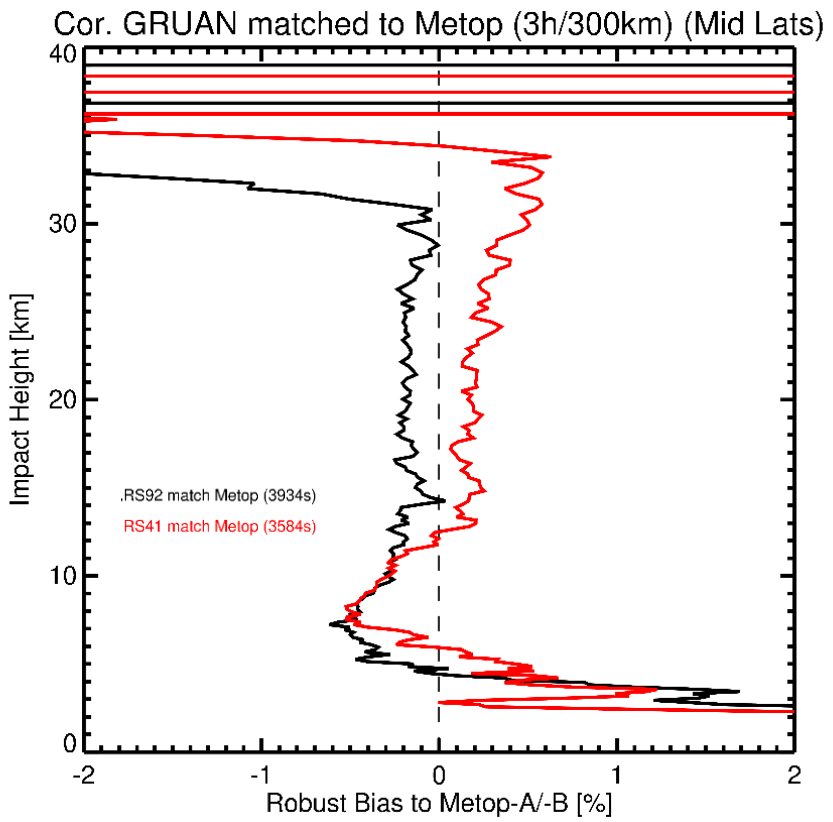


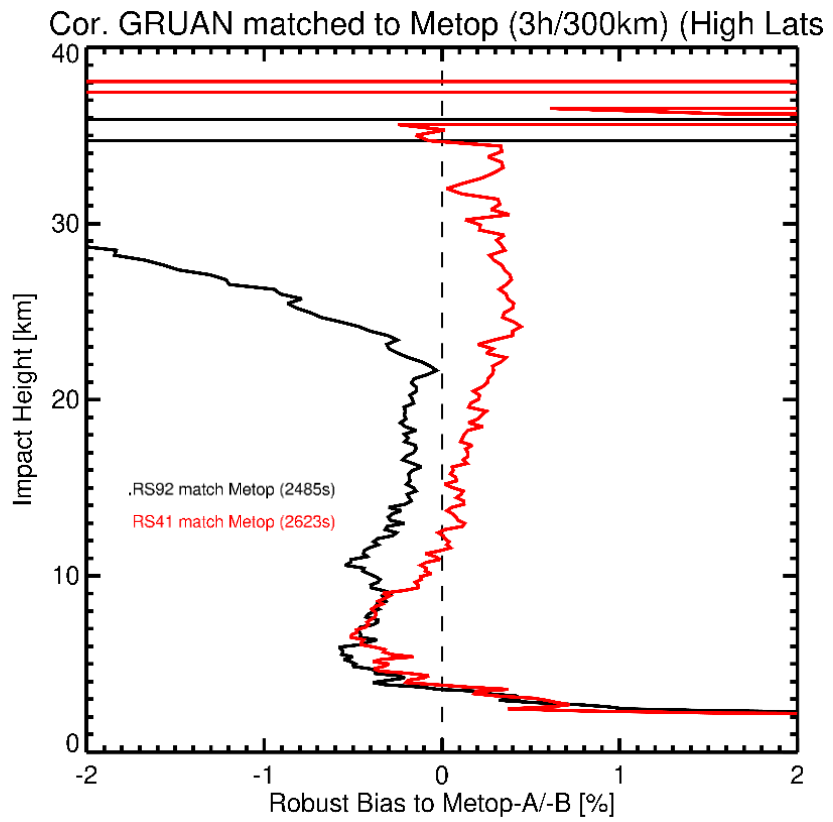


Bias for low latitudes (left), mid (middle), and high (right) of GRUAN RS92 and RS41 sondes forward propagated bending angles matched against Metop/GRAS bending angles. Legend provides total sondes.

Results: Corrected RS vs Metop/GRAS by Latitude Band

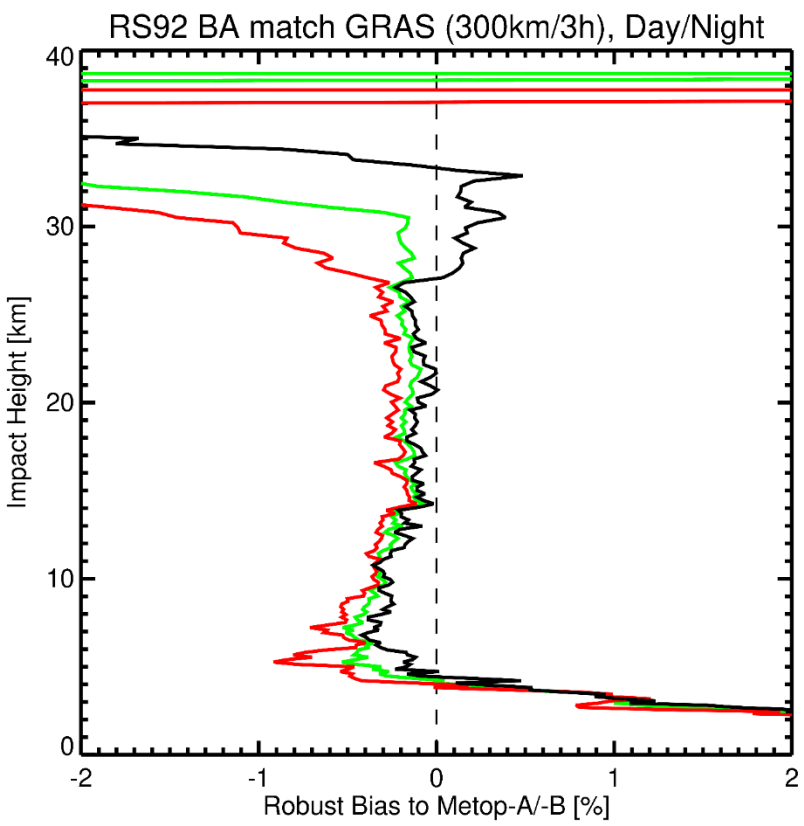


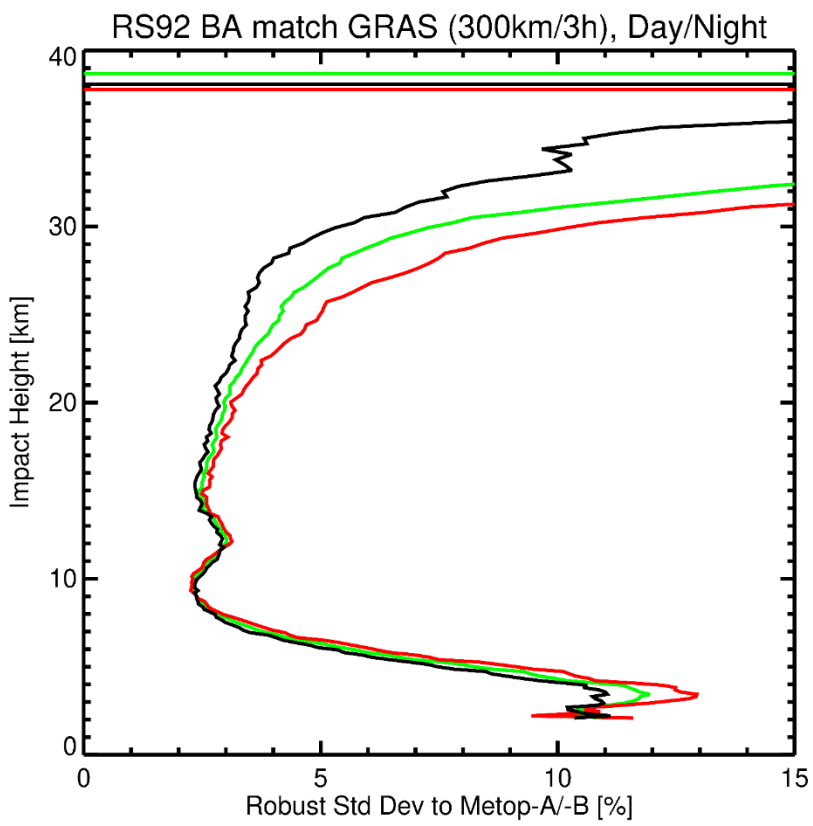


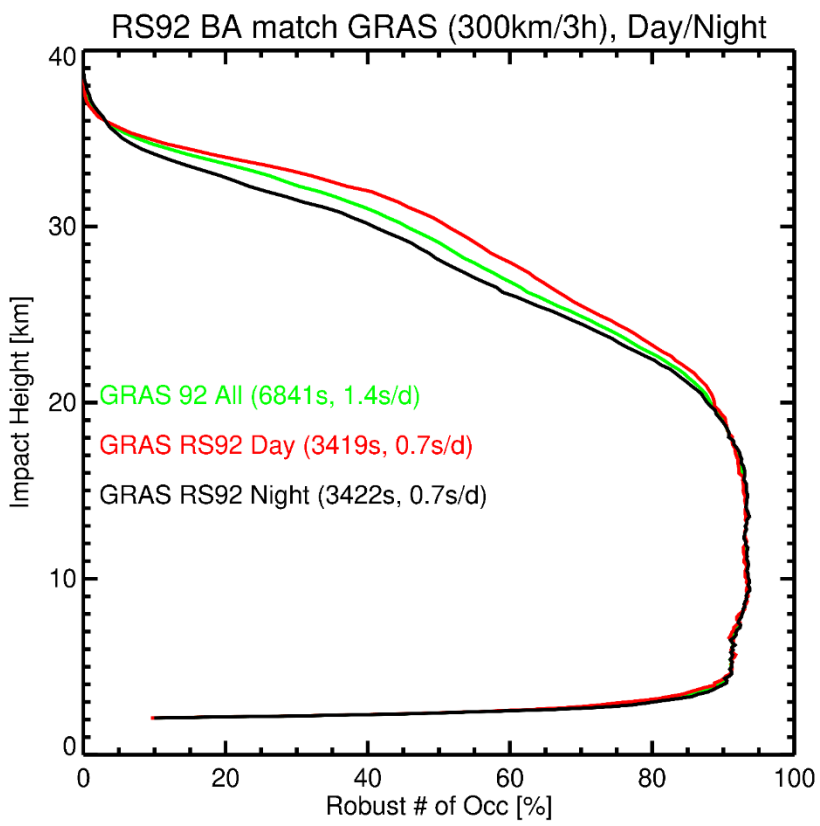


Bias for low latitudes (left), mid (middle), and high (right) of GRUAN RS92 and RS41 sondes forward propagated corrected bending angles matched against Metop/GRAS bending angles. Legend provides total sondes.

Results: RS92 vs Metop/GRAS

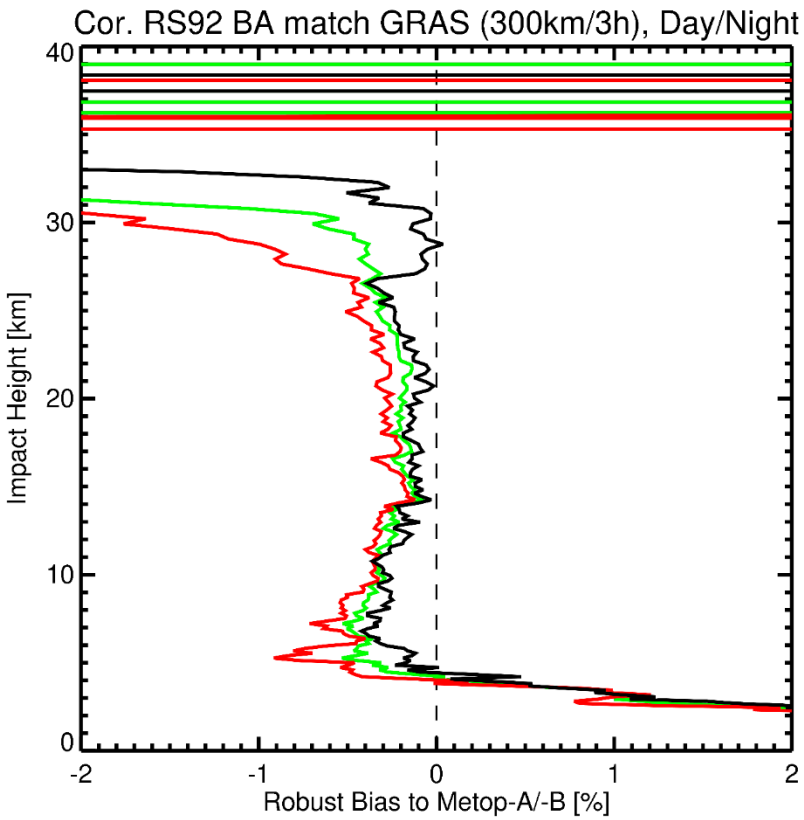


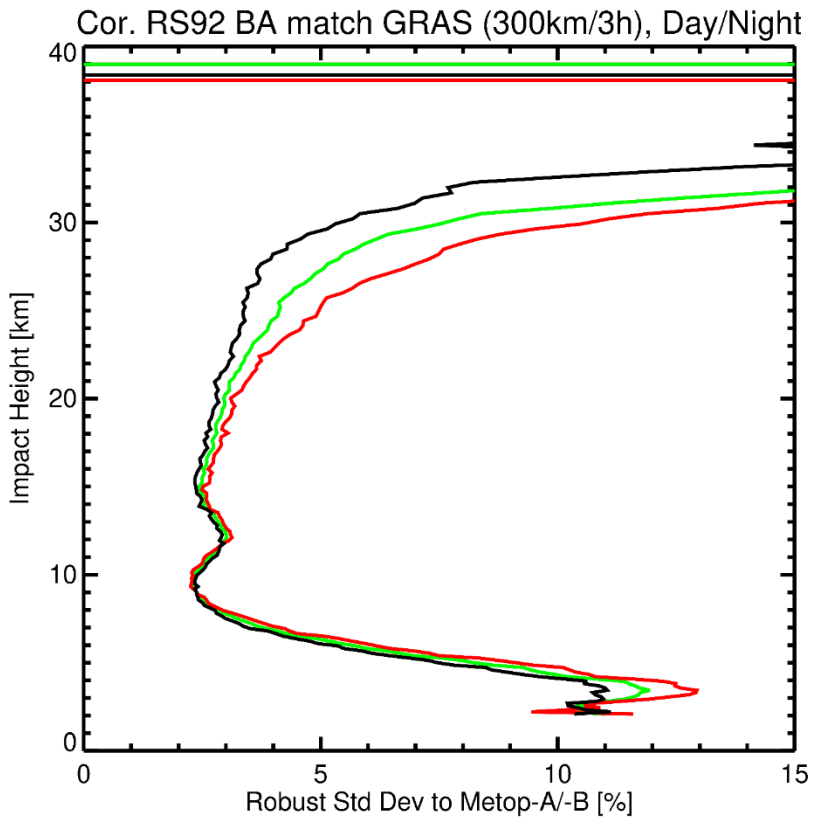


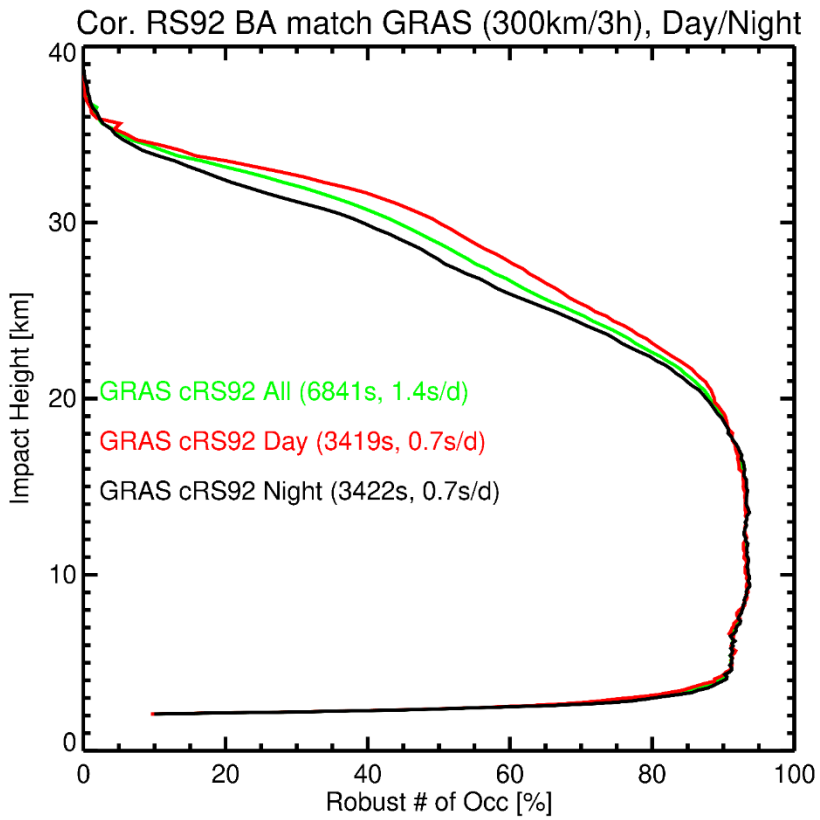


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92 sondes forward propagated bending angles matched against Metop/GRAS bending angles. Legend provides total sondes, average sondes/day.

Results: Corrected RS92 vs Metop/GRAS

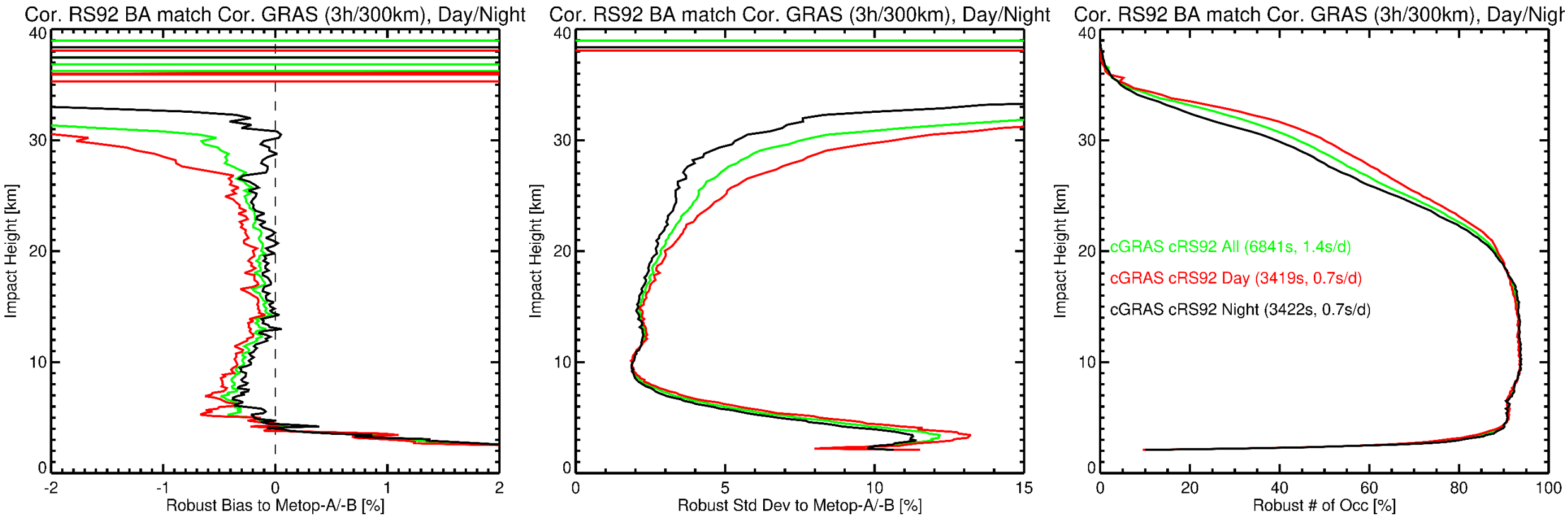






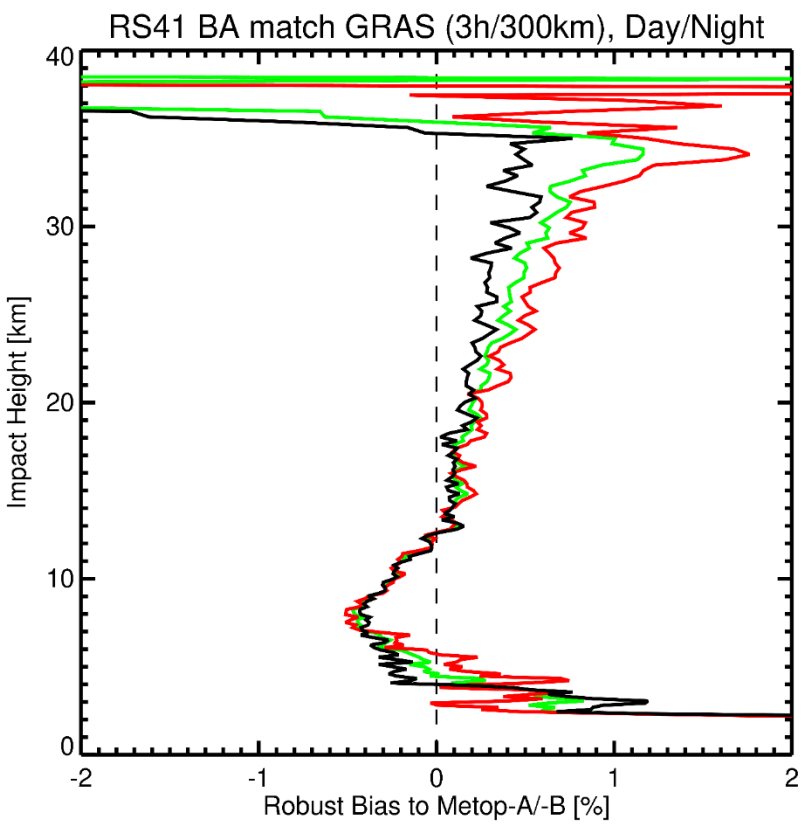
Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92 sondes forward propagated corrected bending angles matched against Metop/GRAS bending angles. Legend provides total sondes, average sondes/day.

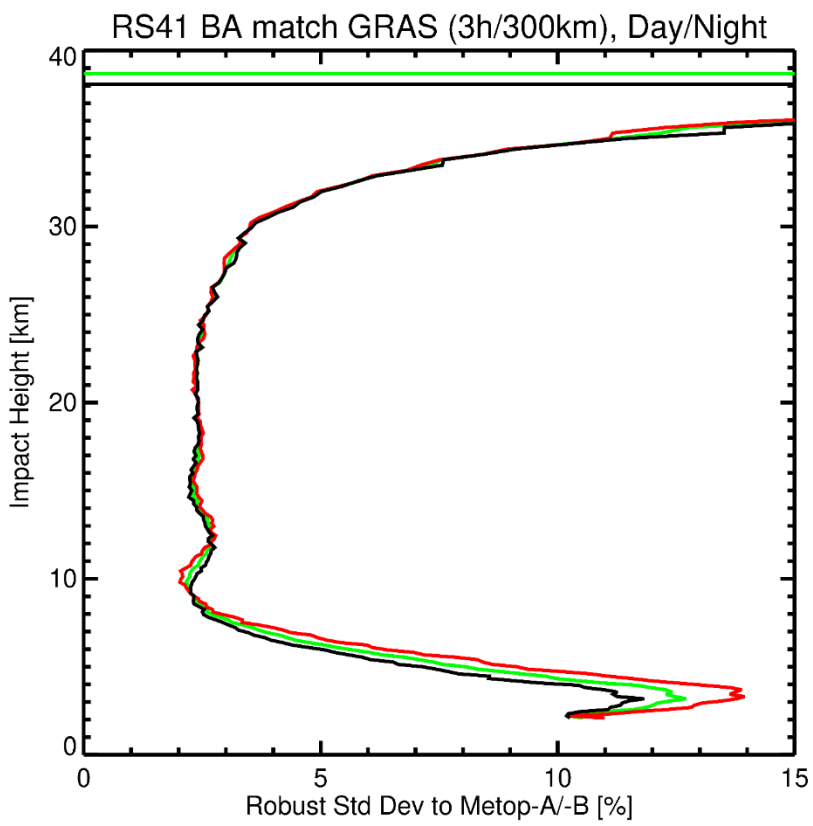
Results: Corrected RS92 vs Metop/GRAS / Collocation Correction

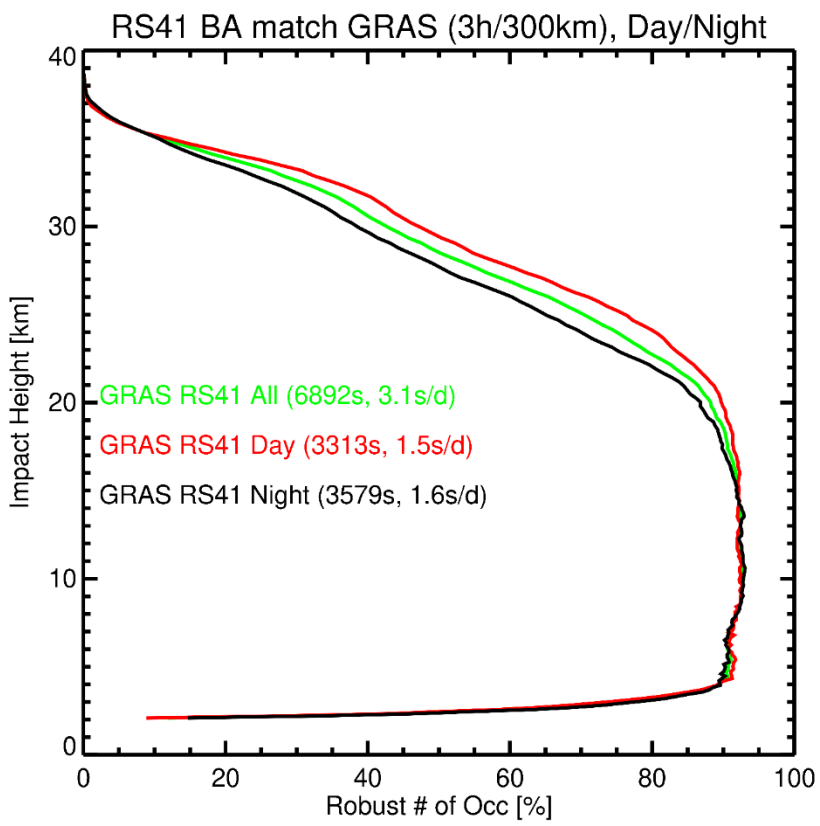


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92 sondes forward propagated corrected bending angles matched against Metop/GRAS bending angles, correcting collocation time/distance using ERA5. Legend provides total sondes, average sondes/day.

Results: RS41 vs Metop/GRAS

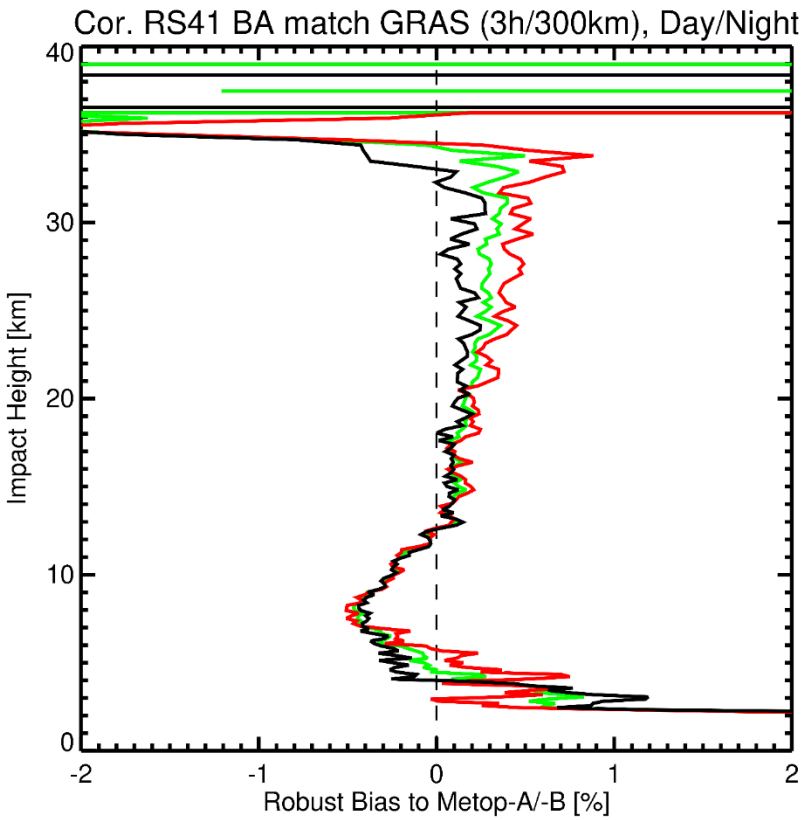


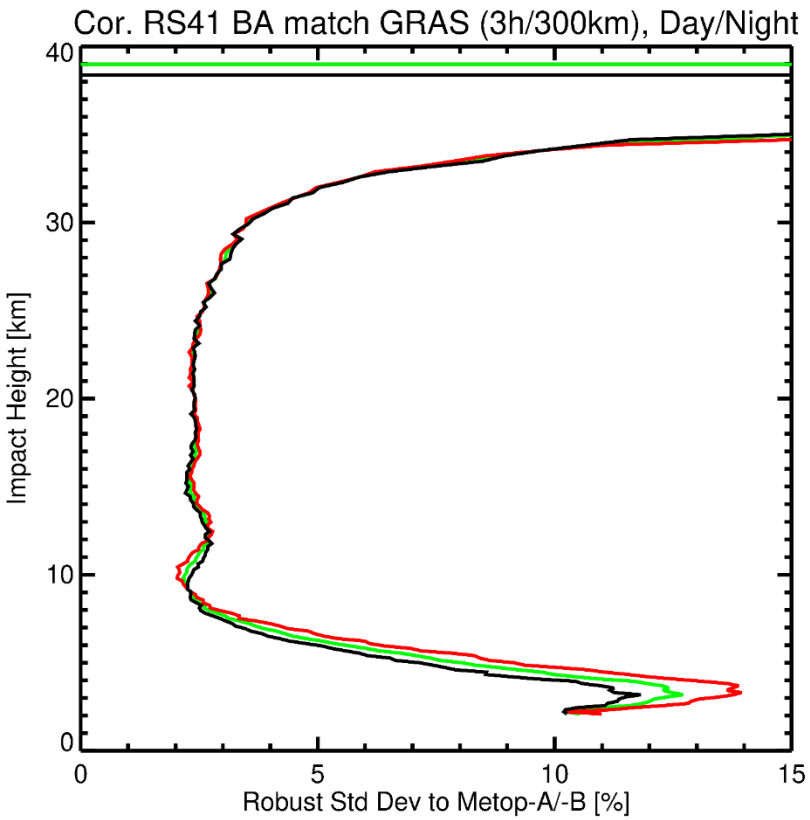


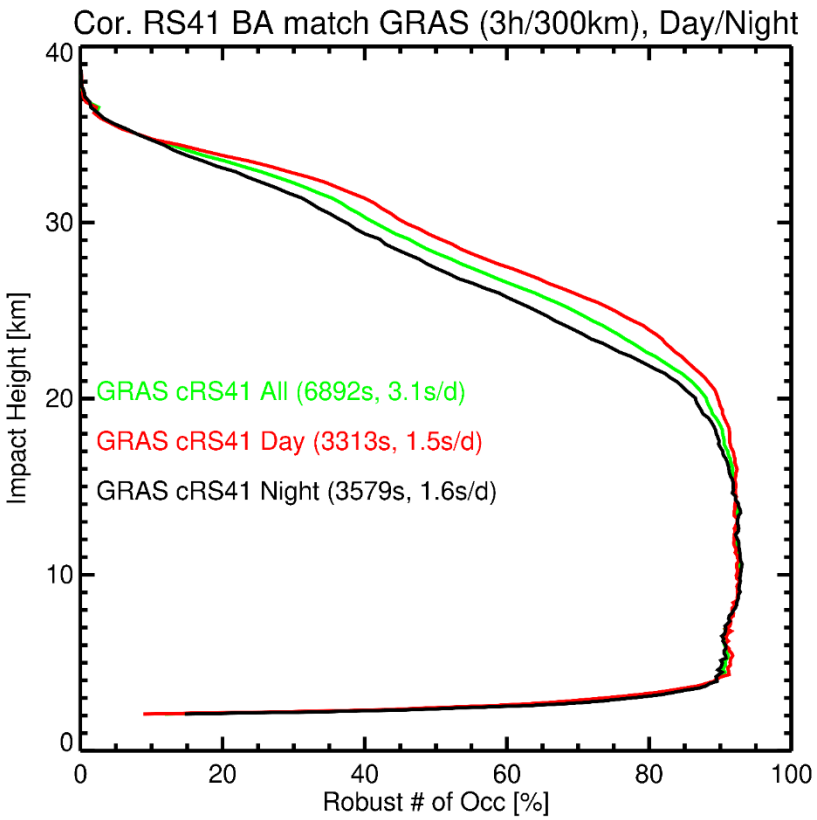


Bias (left), standard deviation (middle), data availability/Gaussian-ness (right) of GRUAN RS41 sondes forward propagated bending angles matched against Metop/GRAS bending angles. Legend provides total sondes, average sondes/day.

Results: Corrected RS41 vs Metop/GRAS

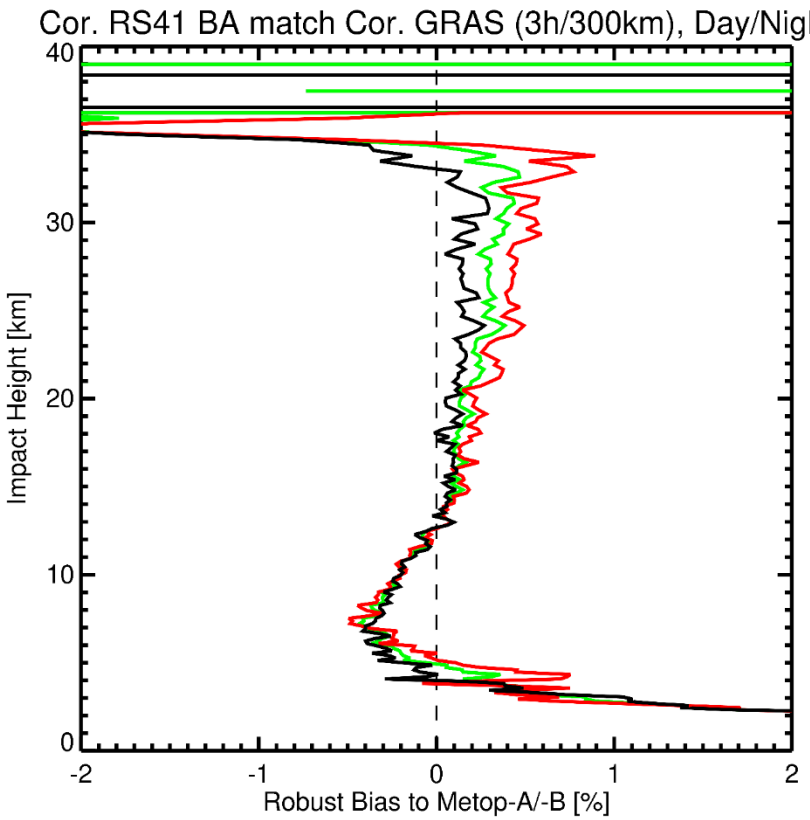


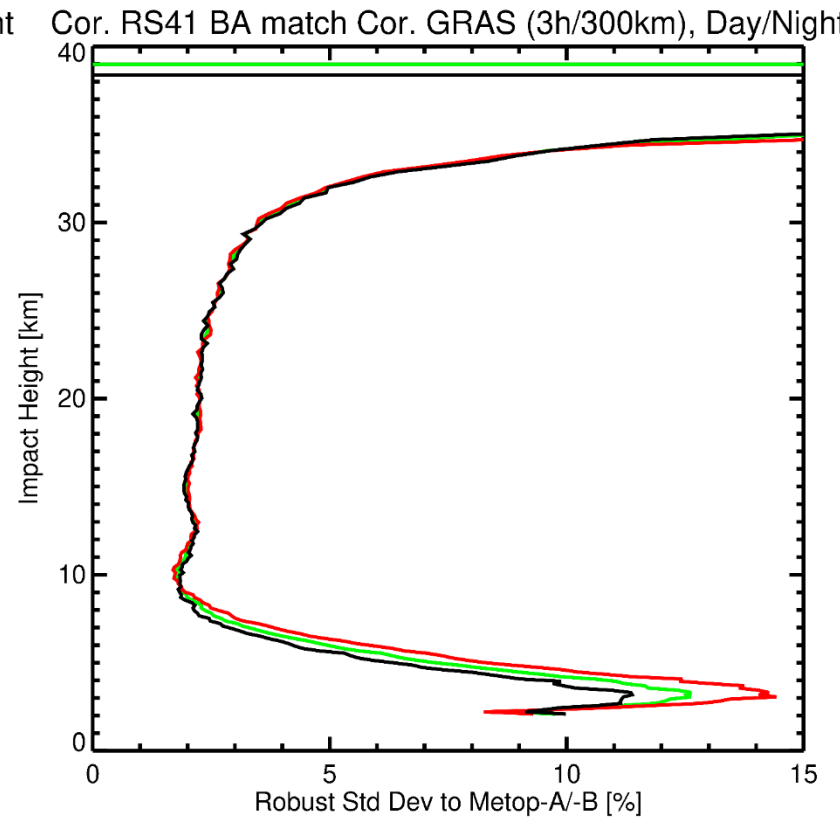


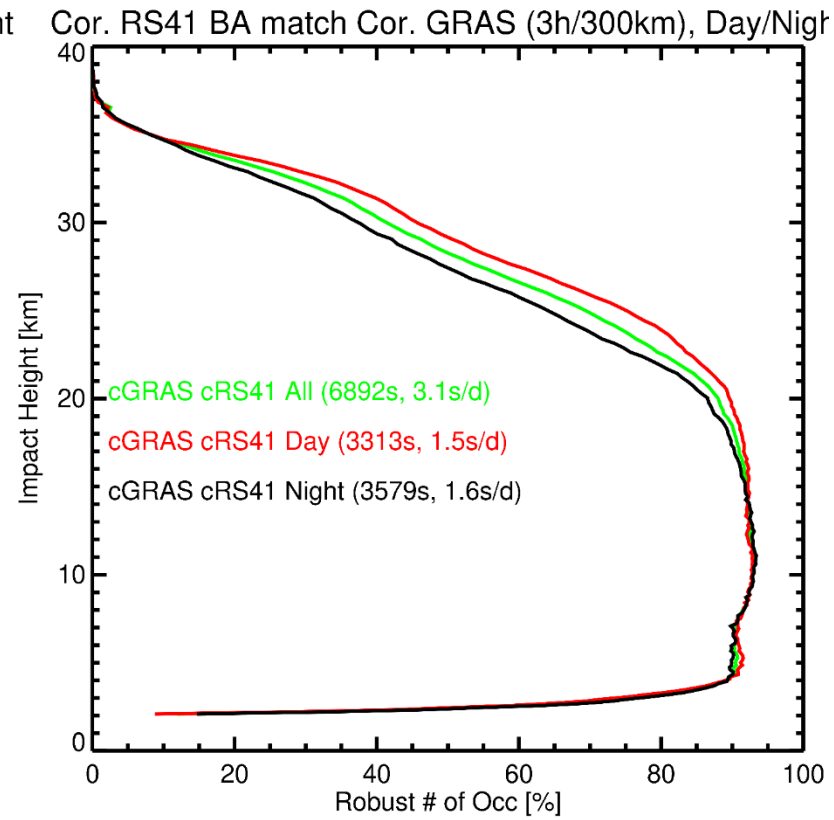


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS41 sondes forward propagated corrected bending angles matched against Metop/GRAS bending angles. Legend provides total sondes, average sondes/day.

Results: Corrected RS41 vs Metop/GRAS / Collocation Correction

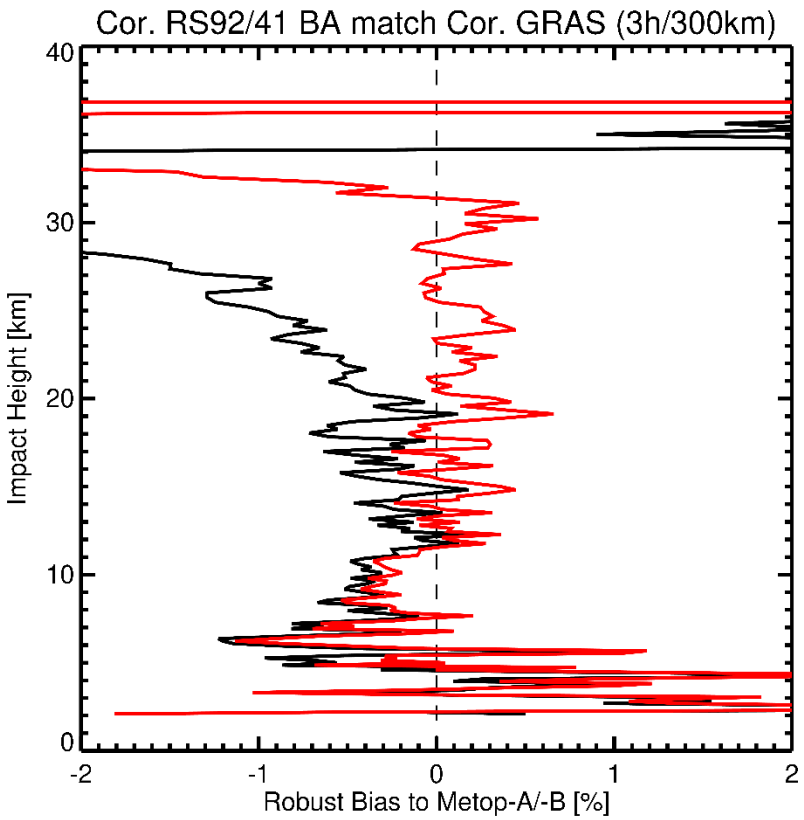


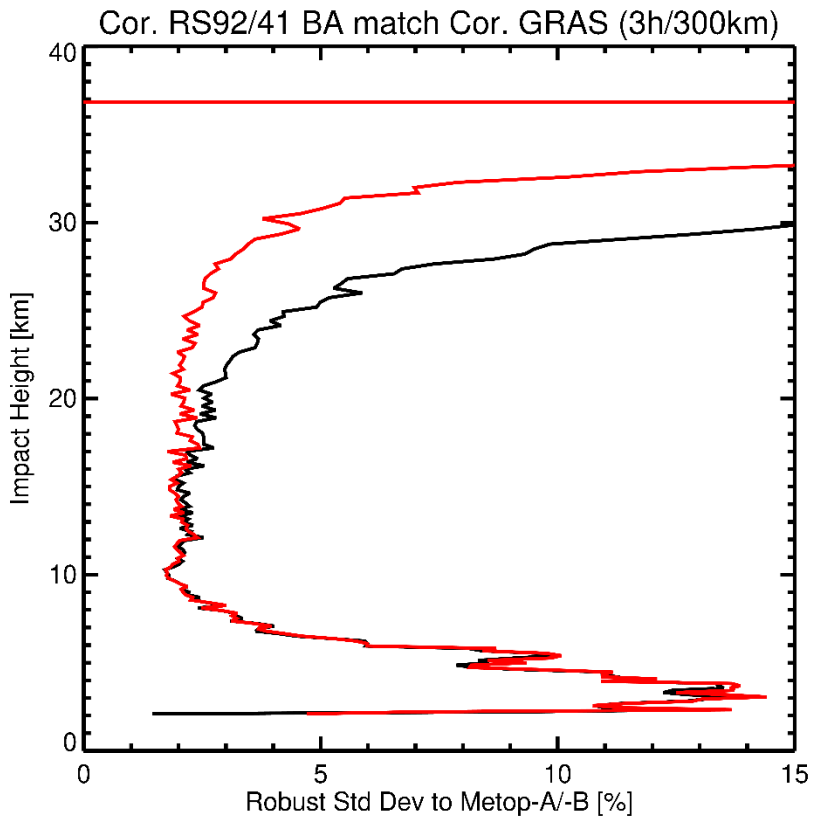


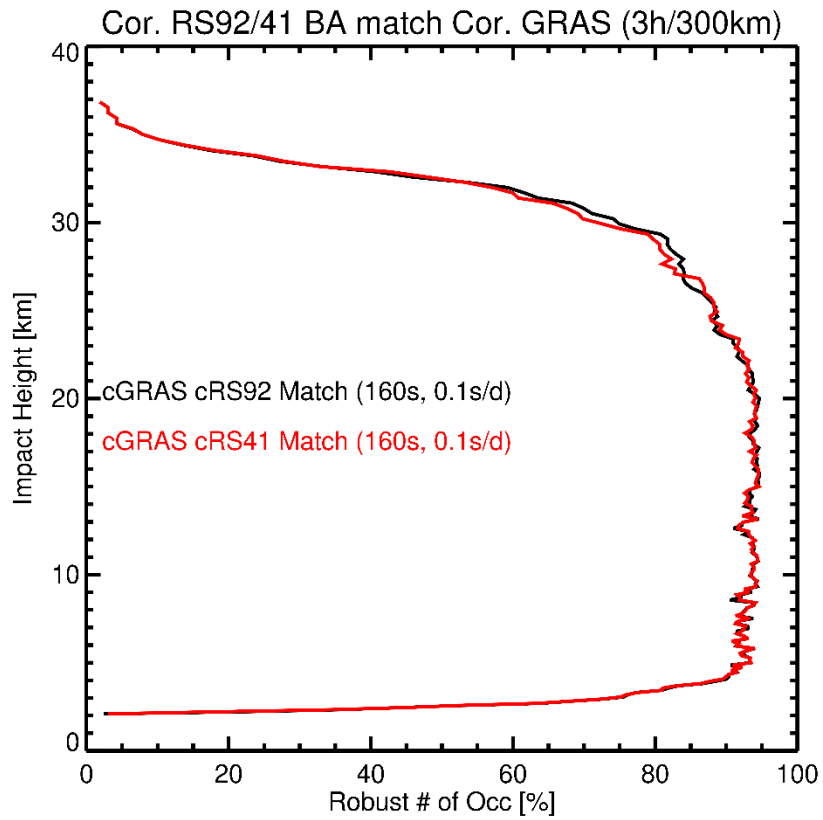


Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS41 sondes forward propagated corrected bending angles matched against Metop/GRAS bending angles, correcting collocation time/distance using ERA5. Legend provides total sondes, average sondes/day.

Results: Corrected and Matched RS41/92 vs Metop/GRAS / Collocation Correction







Bias (left), standard deviation(middle), data availability/Gaussian-ness (right) of GRUAN RS92/RS41 sondes forward propagated corrected bending angles matched against Metop/GRAS bending angles, correcting collocation time/distance using ERA5, using only radio sonde pairs that are close in time and space (dual launch). Legend provides total sondes, average sondes/day.

Next Steps

- Re-do validation with upcoming Metop reprocessing (Q3/4 2024)
- Assess whether the found differences are in line with other GRUAN data validations
  - True: Assess how the found UT/LS differences could help correct temperature biases of day/night and between RS92 vs. RS41
  - True: Assess how the found differences in the lower troposphere can help to correct RO data, improving Planetary Boundary Layer retrievals
  - True: Assess how RO level 2 temperature compares to these results
  - False: Wonder, and go back to the beginning
- ???

Thank you!

Questions are welcome.