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Boulder, Colorado

Water vapour inter-comparison effort in the frame of the Convective and Orographically-induced Precipitation Study

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Convective and Orographically-induced Precipitation Study (COPS)

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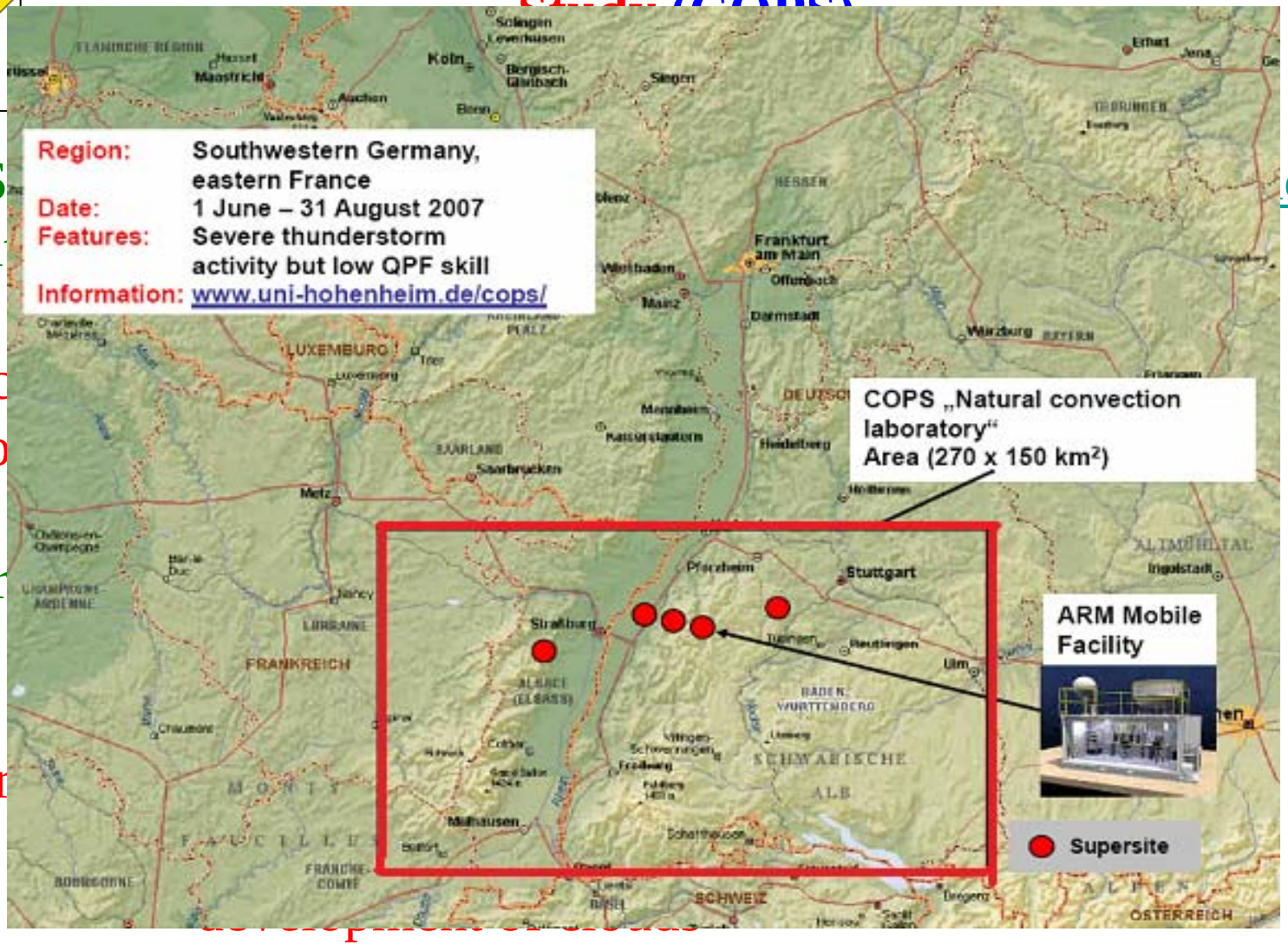


to the formation and development and decay of precipitation

Water vapour inter-comparison effort

main objective → error estimates for the different water vapour profiling/integrated column sensors based on an intensive inter-comparison effort.

Different Instruments →
- airborne and ground-based water vapour lidar systems
- Radiosondes
- GPS
- MW radiometers

Simultaneous and co-located data → to compute relative bias and root-mean square (RMS) deviations

Need → complete and comprehensive inter-comparison table

Sample from the intercomparison table for IOP-9c on 20 July 2007

IOP-9c	20 JULY																								
Hours	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SuSiH																									
DLR DIAL									08:20:49-08:22:03	09:08:54-09:09:53															
Leandre2							06:57-07:08																		
Radiosondes						05:08			08:08			11:11			14:05			17:06							
WV DIAL						05:12	06:53	07:15		09:33				13:52	14:56										
RRL						05:12	06:53	07:15		09:33				13:52	14:56										
Windtracer																									
CloudRadar																									
TARA																									
CNR MWR																									
SuSiR																									
DLR DIAL								07:43:46-07:44:40	08:42:18-08:42:23, 08:48:38-08:48:42																
Leandre2							06:57-07:08																		
Radiosondes						05:14			08:01	09:08		11:00			14:03		16:53								
BASIL					04:08																20:31				
Doppler Lidar																									
CloudRadar																									
MWR																									
SuSiM																									
DLR DIAL									08:13:12-08:14:04																
Leandre2								No overpass																	
Radiosondes						05:30						11:29						17:29						23:29	
BERTHA						No measurements for water vapor																			
WiLi					04:51															19:25					
MPL																									
CloudRadar																									
HATPRO																									
SuSiV																									
DLR DIAL								07:35:34-07:36:39																	
Radiosondes																									
Leandre2								07:12-07:24																	
TRESS																									
IGN RL	00:00								08:30												20:24			23:59	
SuSiS																									
DLR DIAL								07:48:07-07:49:16																	
Leandre2																									
Radiosondes																									
Ceilometer																									
WTR																									
MICCY																									

Possible lidar-to-lidar intercomparisons for H_2O

BASIL Raman Lidar (Site R) vs SAFIRE-FA20 DIAL → 25 comparisons

BASIL Raman Lidar (Site R) vs DLR DIAL → 10 comparisons(only 3)

UHOH DIAL (Site H) vs SAFIRE-FA20 DIAL → 16 Comparisons (only 12)

UHOH DIAL (Site H) vs DLR DIAL → 11 comparisons

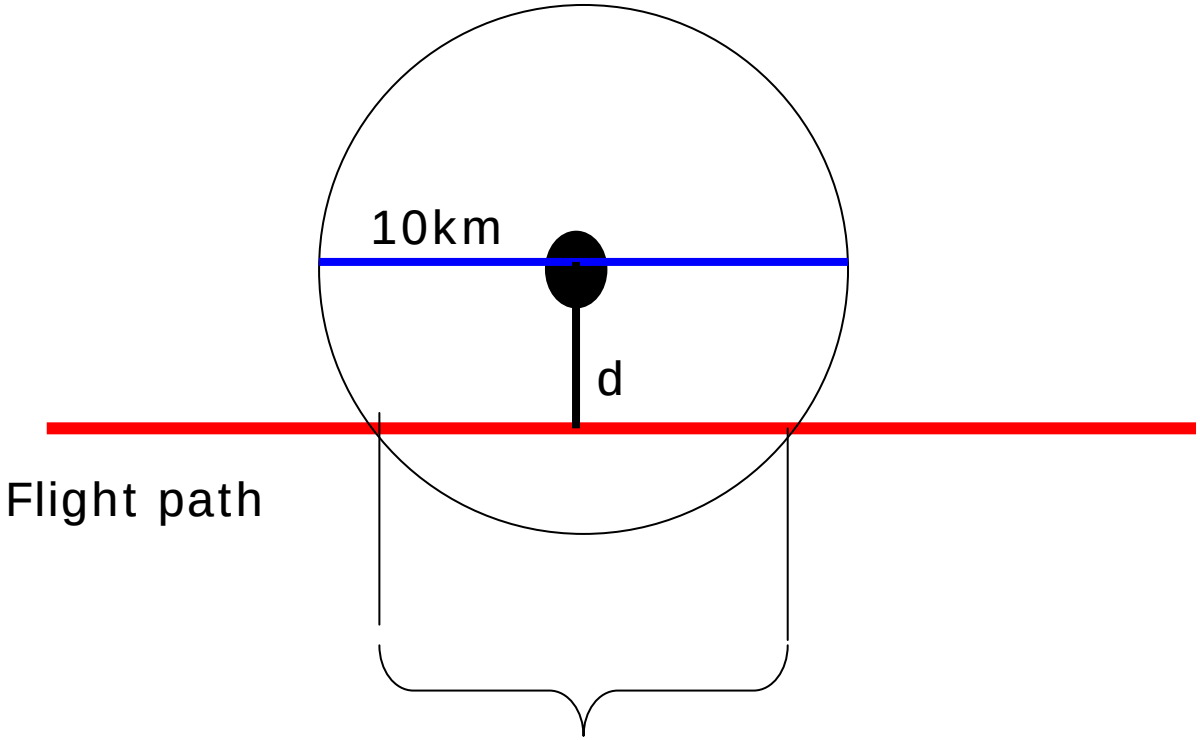
Bertha IFT (Site M) vs SAFIRE-FA20 DIAL → 6 comparisons

Bertha IFT (Site M) vs DLR DIAL → 9 comparisons

IGN Raman Lidar (Site V) vs SAFIRE-FA20 DIAL → 7 comparisons (only 6)

IGN Raman Lidar (Site V) vs DLR DIAL → 1 comparisons

SAFIRE-FA20 DIAL vs DLR DIAL → 14 comparisons (only 5)


10km
d
Flight path
Time corresponding to this flight path

SAFIRE-FA20 DIAL vs BASIL Raman Lidar – EUFAR Experiment

• SAFIRE-FA20 flights in the frame of the EUFAR Project H2OLidar were performed on 16 July, 25 July and 31 July.

• Each flight had a duration of 3 hours for a total of 9 hours.

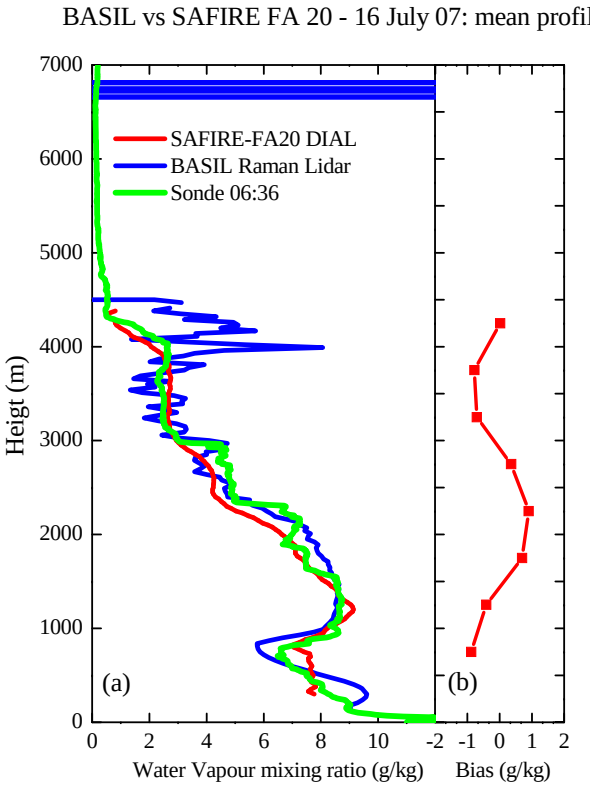
• In order to reduce statistical fluctuations, we considered for the SAFIRE-FA20 DIAL an integration time of 80 sec, corresponding to an horizontal integration length of 12-15 km. The integration time for BASIL was taken to be 1 min.

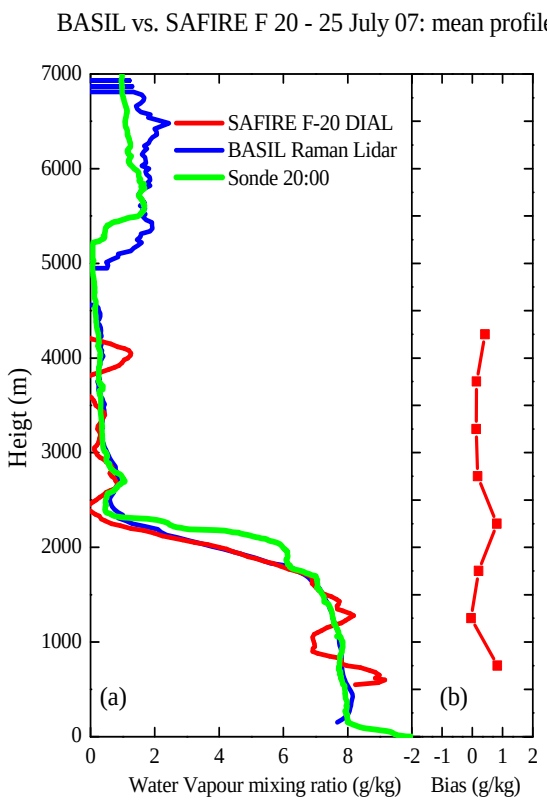
•The vertical step of the measurements is 25 m for the SAFIRE-FA20 DIAL, while it is 30 m for BASIL. Vertical resolution is 250 m and 150 m, respectively.

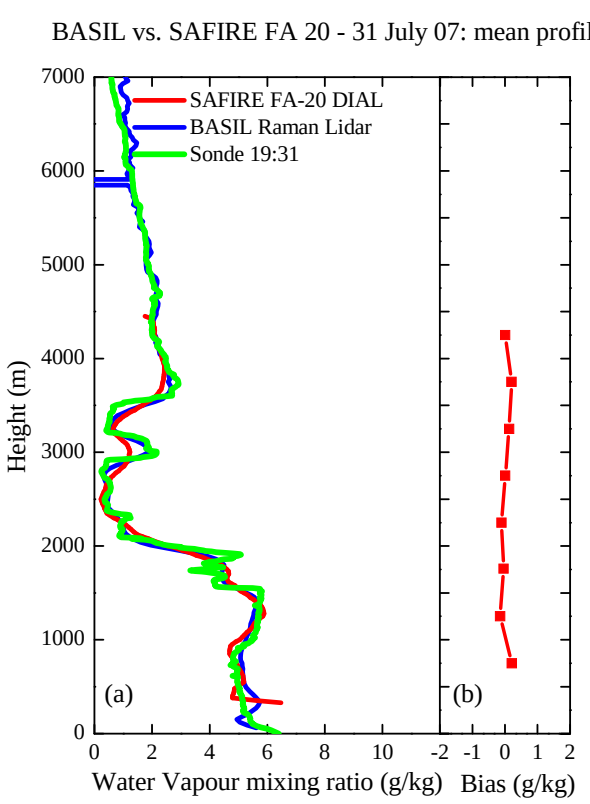
• Previous studies (Behrendt, 2007a,b) revealed that comparison of airborne and ground-based lidars are possible if distance between the aircraft footprint and the ground-based system is not exceeding 10 km. Thus, in our analysis we considered only DIAL profiles within 10 km from BASIL.

• The number of considered comparisons between SAFIRE-FA20 DIAL and BASIL is 18, 6 on each day.

Comparison between *BASIL* and *SAFIRE-FA20* DIAL on 16, 25 and 31 July 07 expressed in terms of mean daily profiles





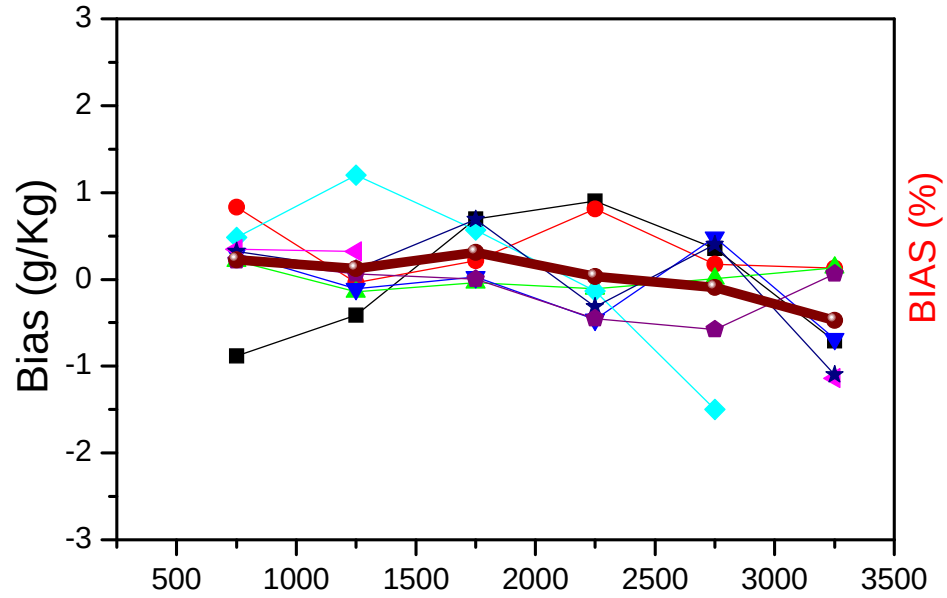


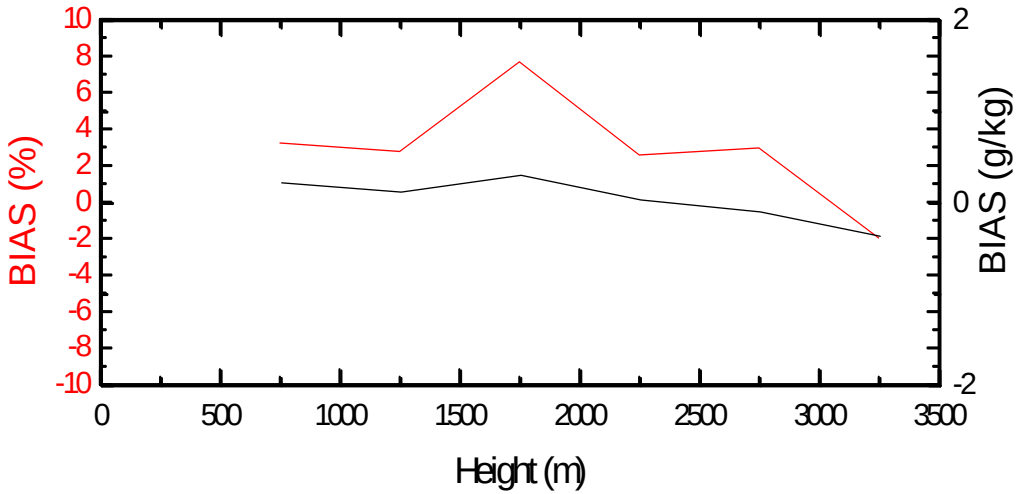
Larger deviations between the two instruments are found at the top of the boundary layer, where the effect of inhomogeneities may be larger.

Mean relative bias: 3.9 % (0.08 g/kg) in the altitude region 0–4.5 km a.g.l.

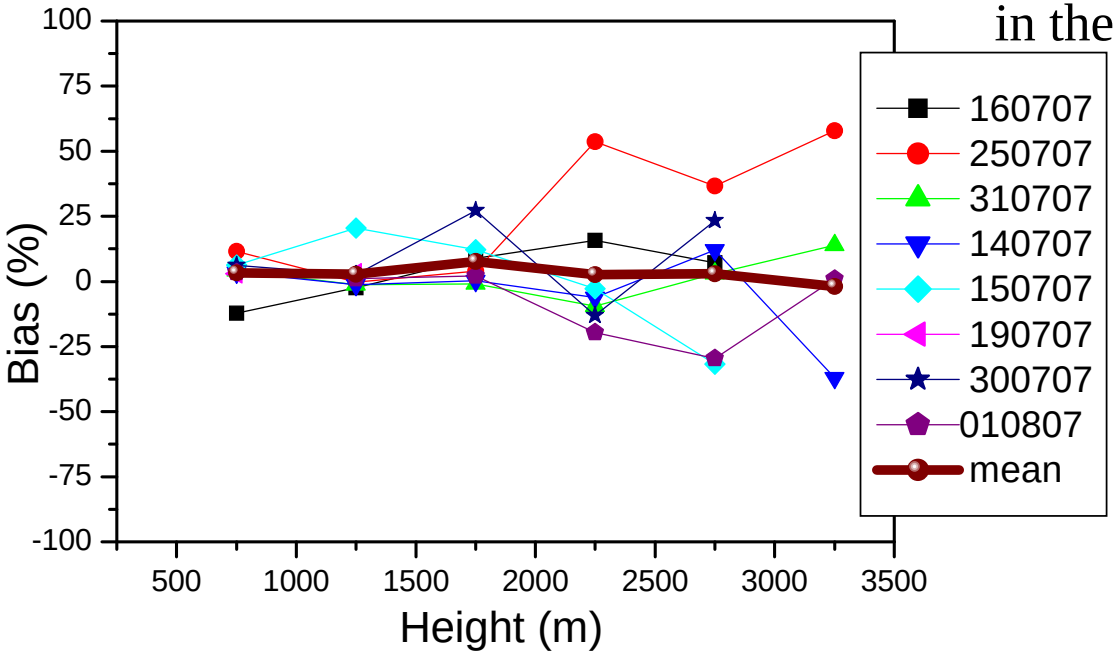
Mean RMS: 13.7 % (0.97 g/kg)

Bias intercomparison BASIL Raman Lidar vs. SAFIRE-FA20 DIAL including all possible flights (EUFAR+COPS)





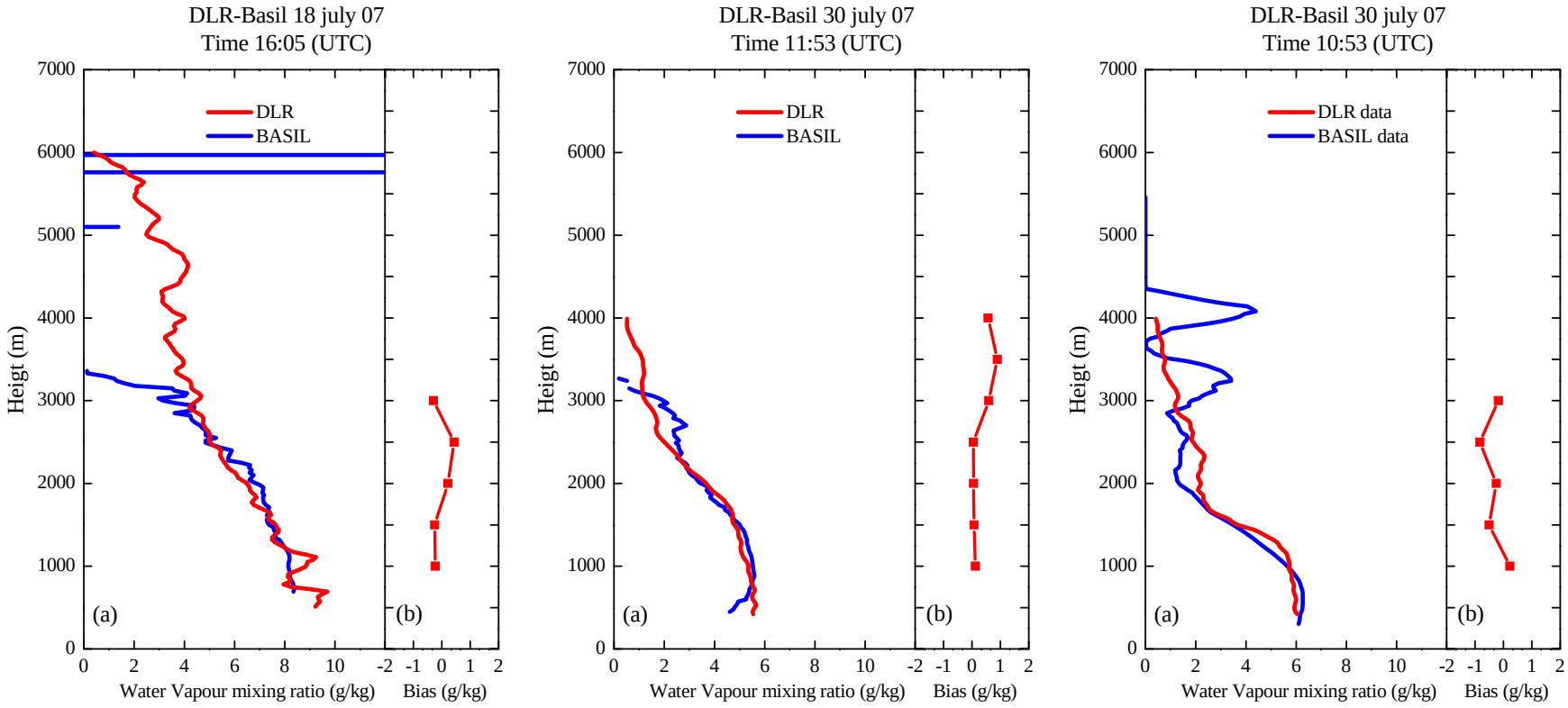
Mean relative bias: 2.1 % (0.12 g/kg) in the altitude region 0–3.5 km a.g.l.



$$\mathrm{Bias}_{t,\mathrm{absolute}}(z_1, z_2) = \frac{\sum_{z=z_1}^{z_2} [q_1(z) - q_2(z)]}{N_z}$$

$$\mathrm{Bias}_{t,\mathrm{relative}}(z_1, z_2) = \frac{2\sum_{z=z_1}^{z_2} [q_1(z) - q_2(z)]}{\sum_{z=z_1}^{z_2} [q_1(z) + q_2(z)]}$$

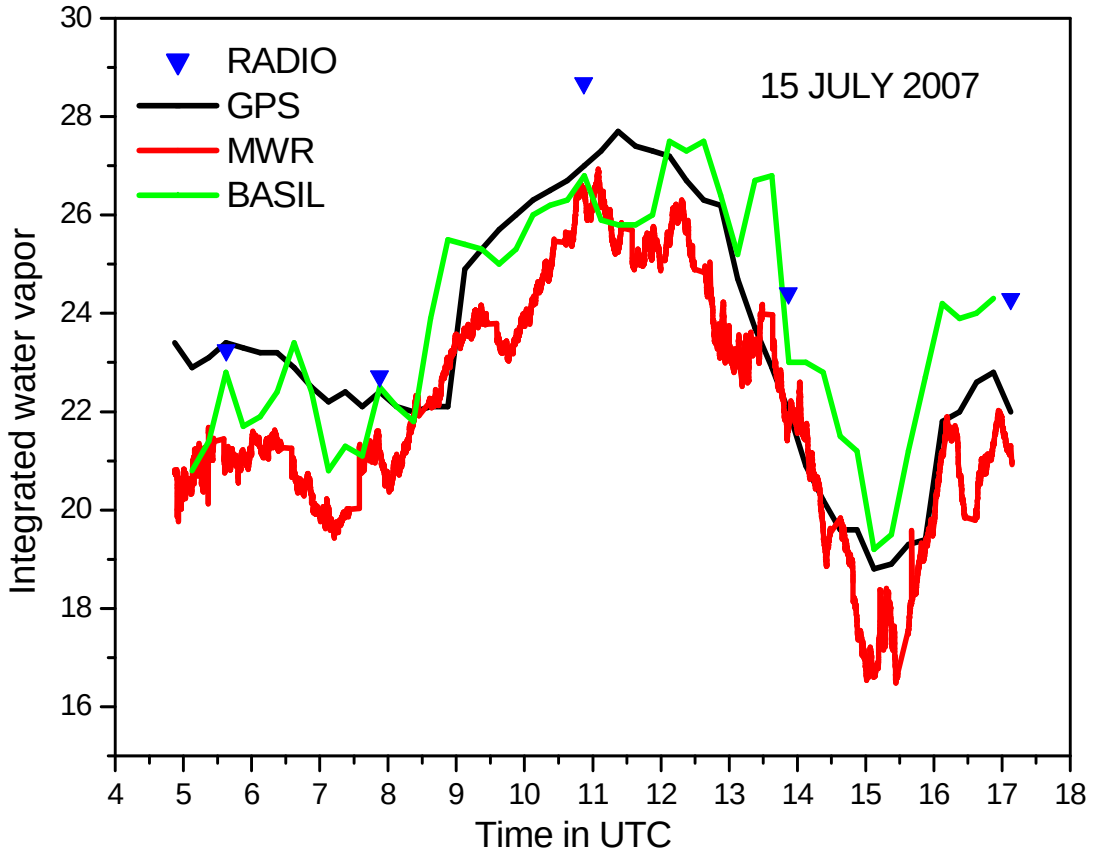
BASIL Raman Lidar vs DLR DIAL

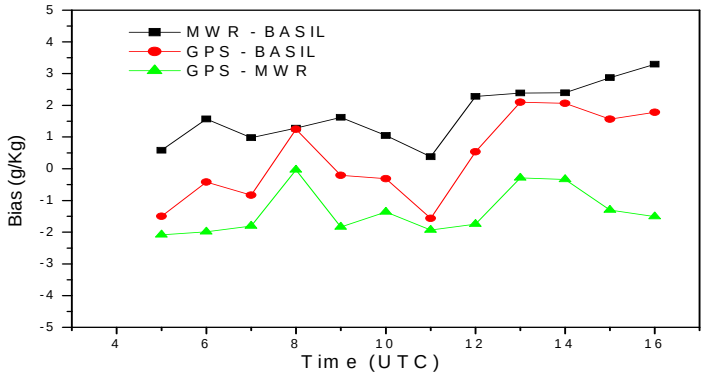


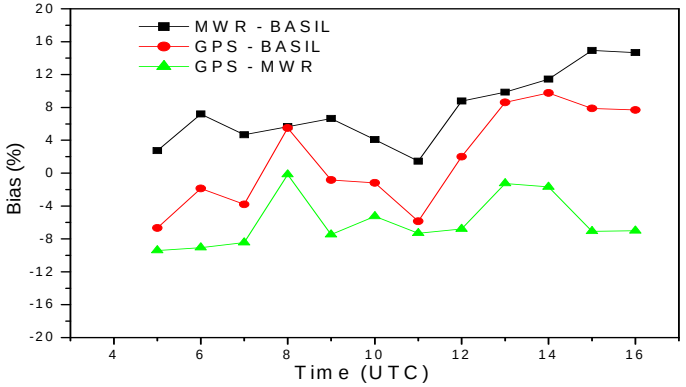
Mean relative bias: -3.5 % (-0.24 g/kg) in the altitude region 0–3 km a.g.l.

Mean RMS: 13 % (0.45 g/kg)

Integrated Water vapour inter-comparison
BASIL Raman Lidar vs. MWR, GPS and Radiosonde

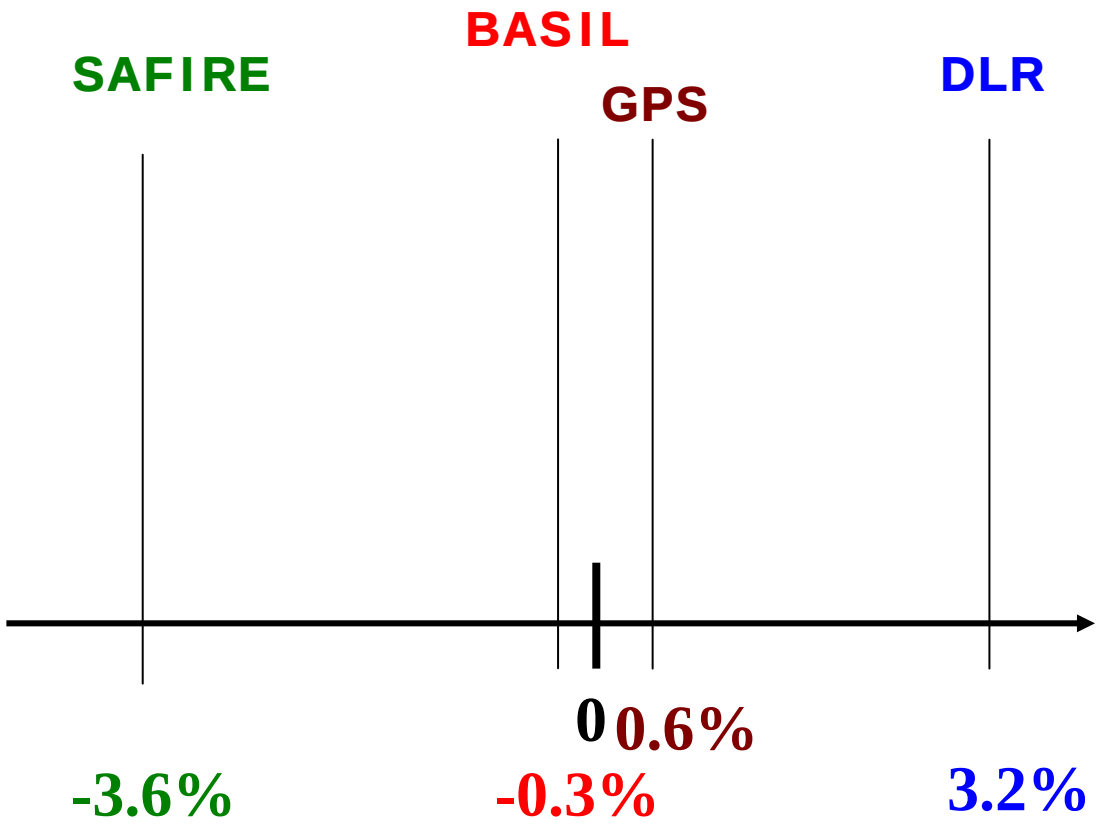






BASIL – MWR : 7.6% (1.7g/Kg) , BASIL – GPS : 1.7 % (0.3g/Kg)

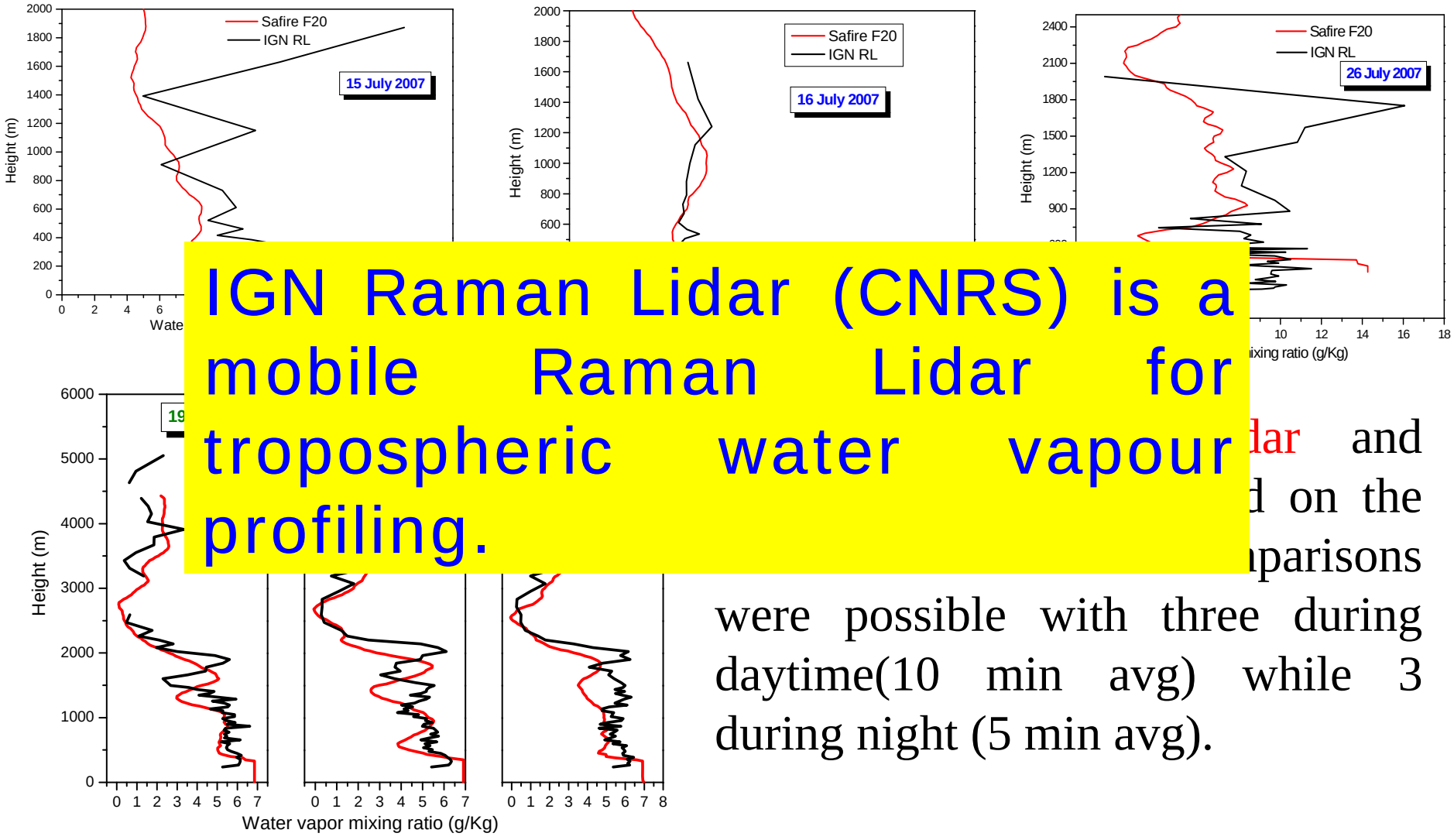
GPS – MWR: -5.9 % (-1.3g/Kg)



Putting equal weight on the data reliability of each instrument, results in bias values of

BASIL RL	-0.3 %
DLR DIAL	3.2 %
SAFIRE-FA20	-3.6 %
GPS	0.6 %

IGN Raman Lidar (Site V) vs SAFIRE-FA20 DIAL



IGN Raman Lidar (CNRS) is a mobile Raman Lidar for tropospheric water vapour profiling.

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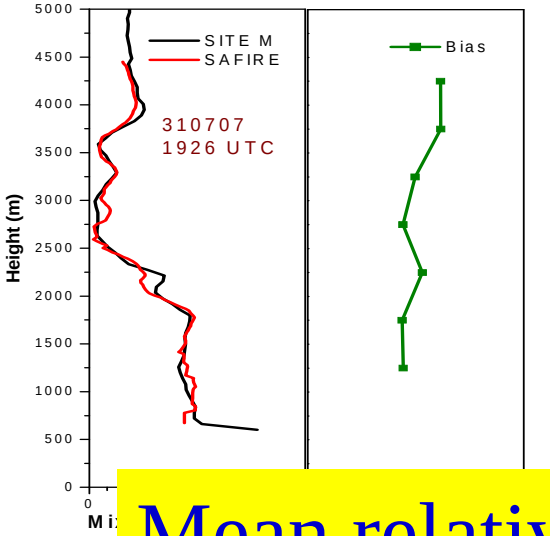
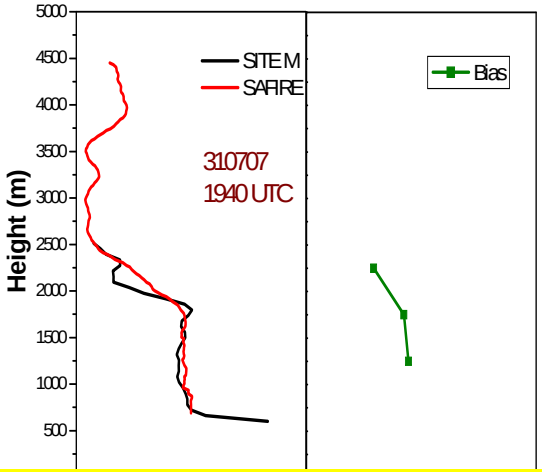
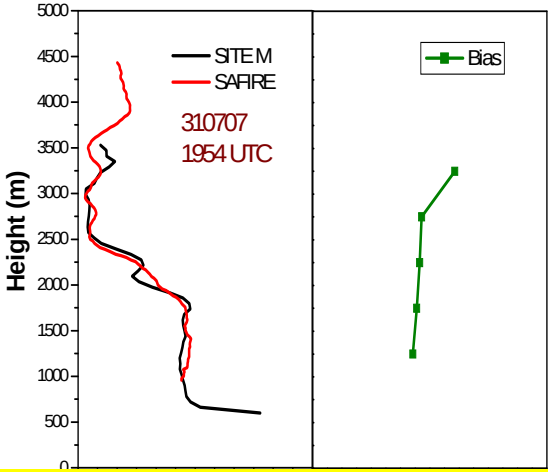
d on the
parisons
were possible with three during daytime(10 min avg) while 3 during night (5 min avg).

Mean relative bias: -8.7 % (0.17 g/Kg) in the altitude region 0–3 km a.g.l.

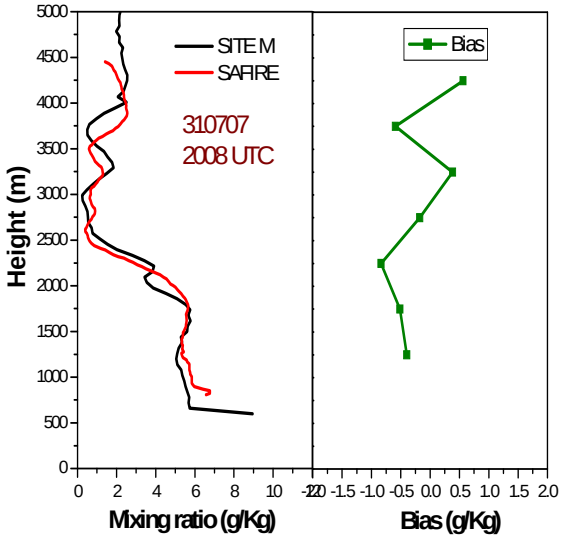
IFT Lidar (Site M) vs SAFIRE-FA20 DIAL

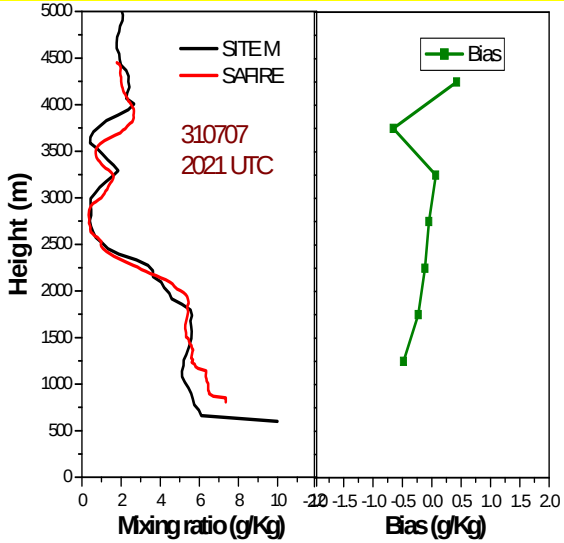


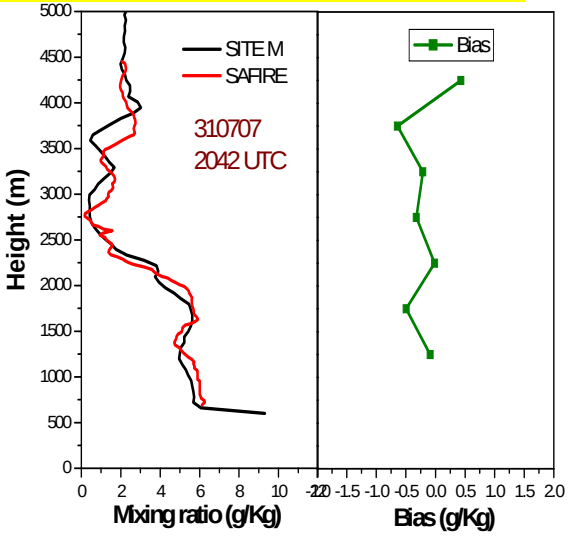




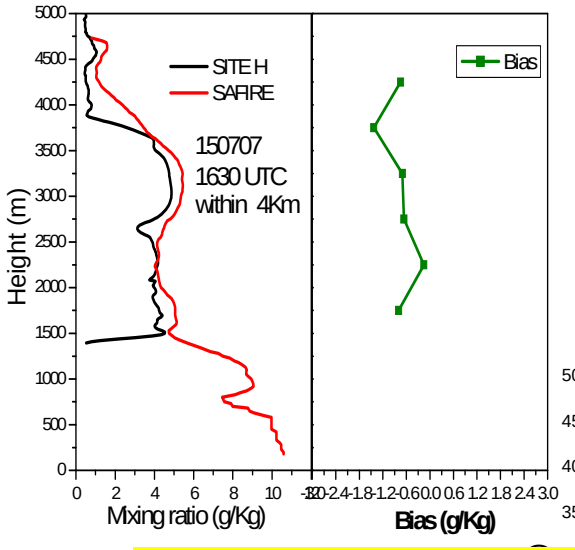
Mean relative bias is -5.6% (0.57 g/Kg)

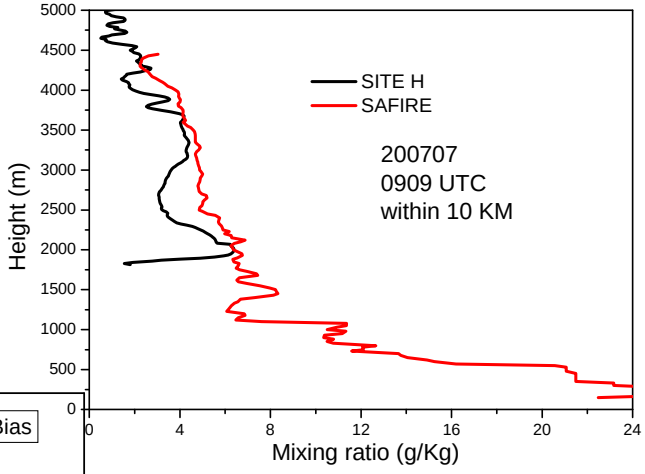


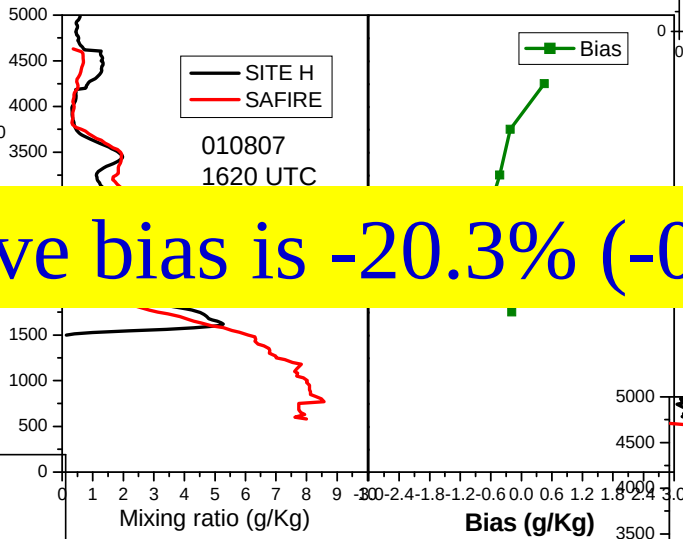




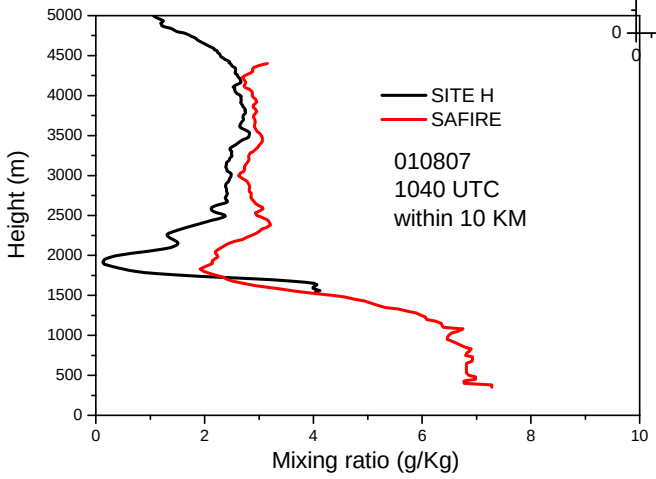
UHOH DIAL(Site H) vs SAFIRE-FA20 DIAL

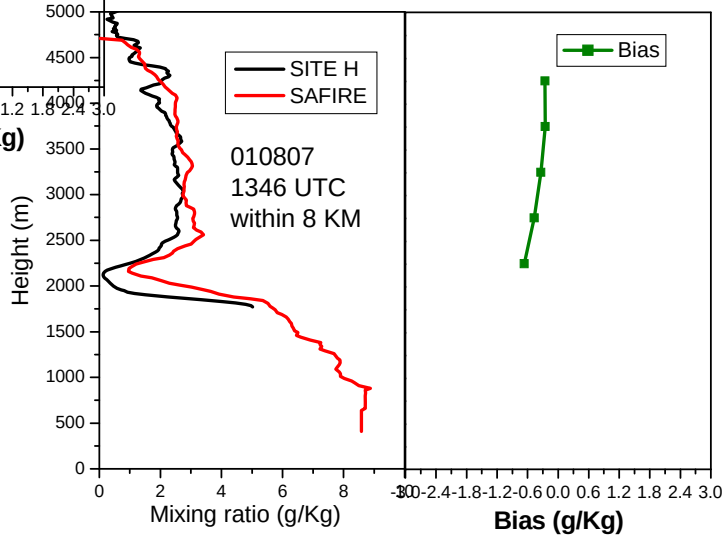




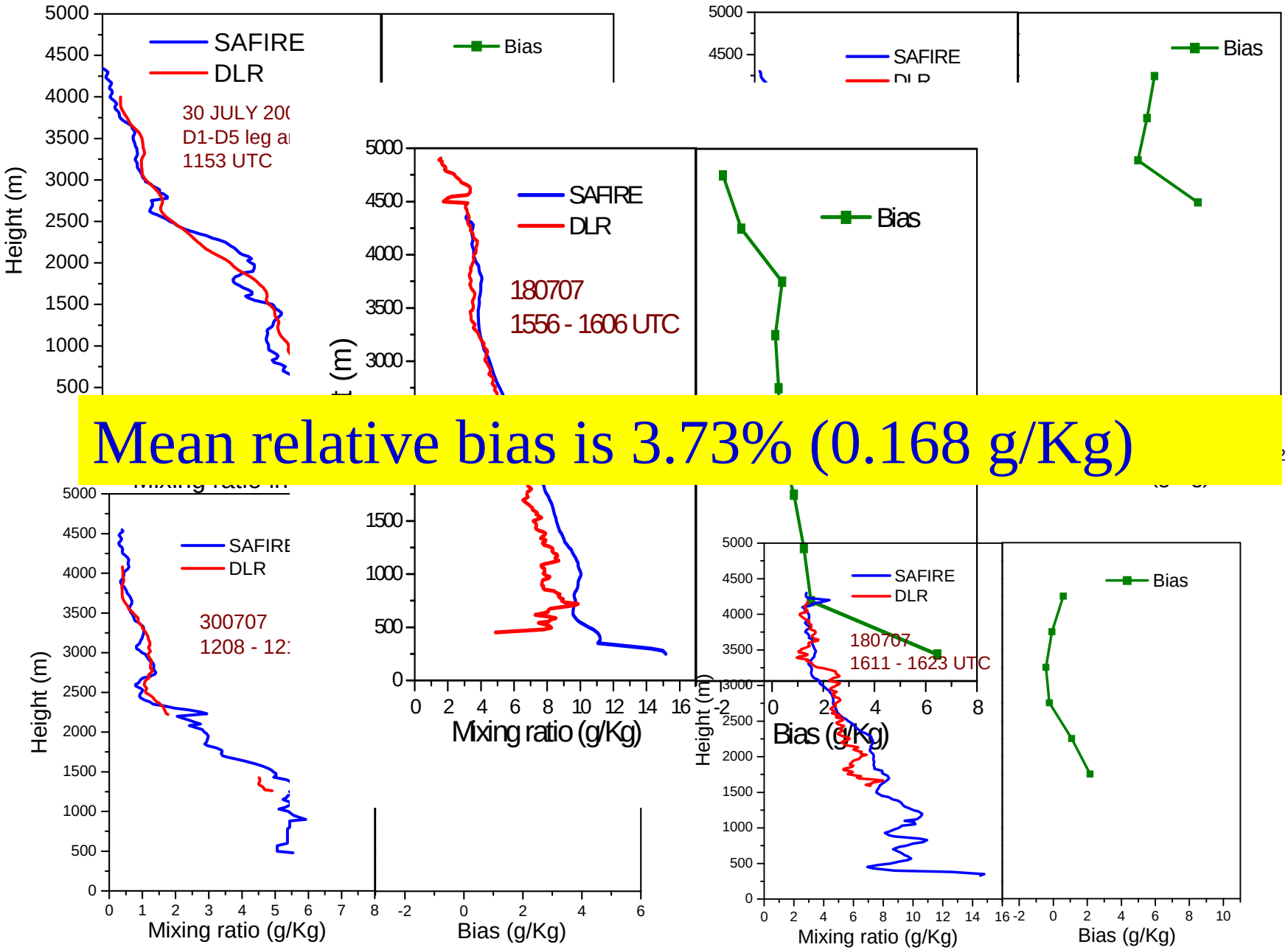


Mean relative bias is -20.3% (-0.48 g/Kg)





SAFIRE-FA20 DIAL vs DLR DIAL



Mean relative bias is 3.73% (0.168 g/Kg)

Radiosonde inter-comparison on July 13th

226 radiosondes launched in Supersite R during COPS
Sondes with different humidity sensors: Vaisala RS92, RS80-A and RS80-H
95 sondes RS92 – 13 July through 2 August, 21-30 August
RS 80 launched in all other periods (88 RS80-A and 43 RS80-H).

- Vaisala RS92, RS80-A and RS80-H were launched on July 13th for the Radiosonde inter-comparison effort.

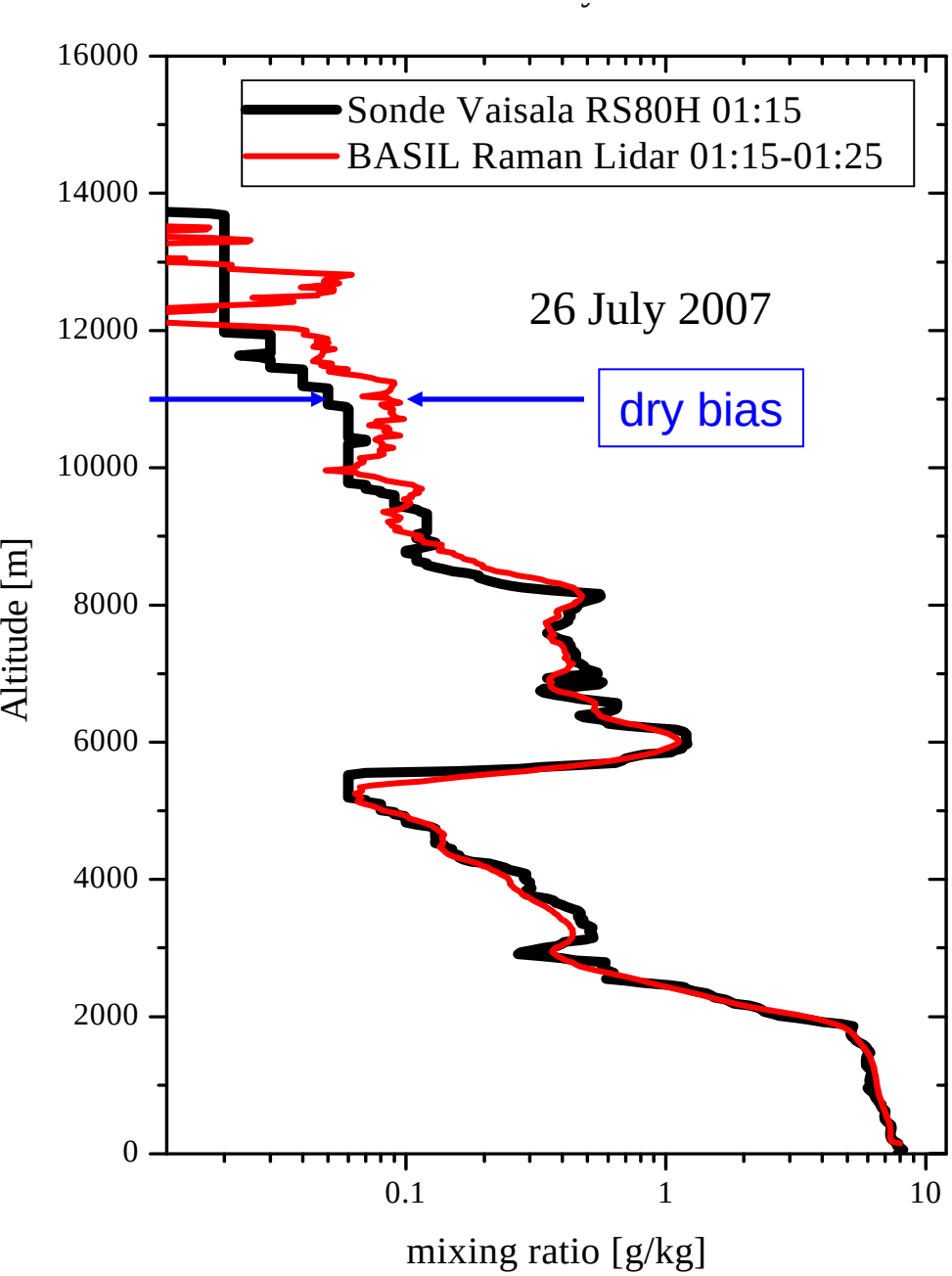
- The known different types of systematic errors for the RS80-A and H

1) Chemical Contamination error
2) Temperature dependence error
3) Basic calibration model error
4) Sensor-arm-heating error
5) Ground-check errors

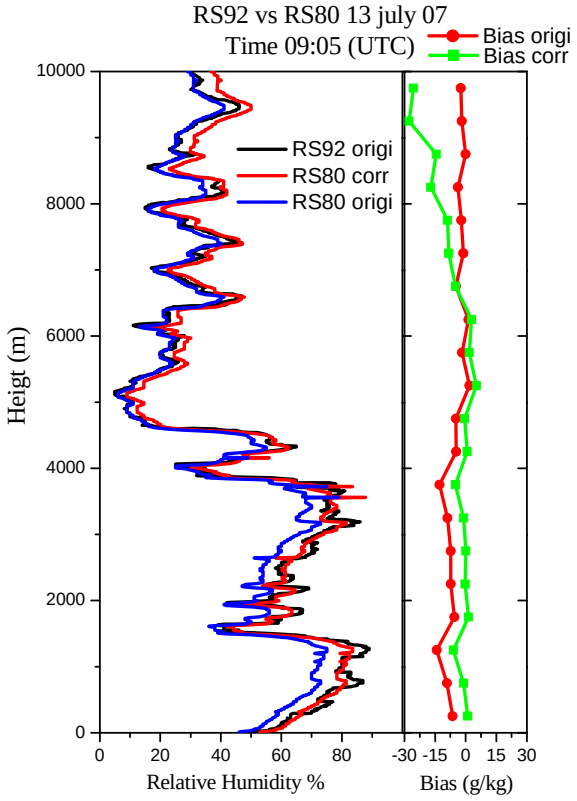
Wang et al., 2002,
Miloshevich et al., 2004,
Vomel et al., 2007,

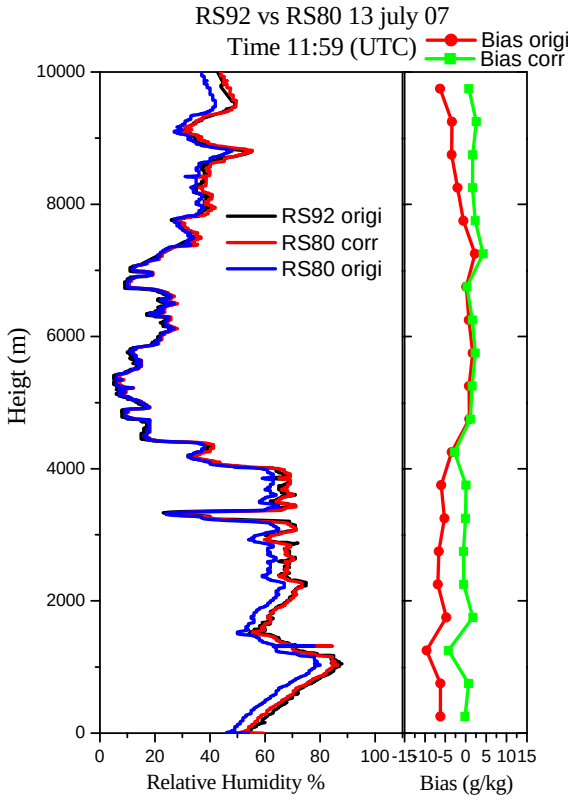
- The RS92 is also known to be affected by the solar radiation which induces a dry bias in the relative humidity measured by the sensor.

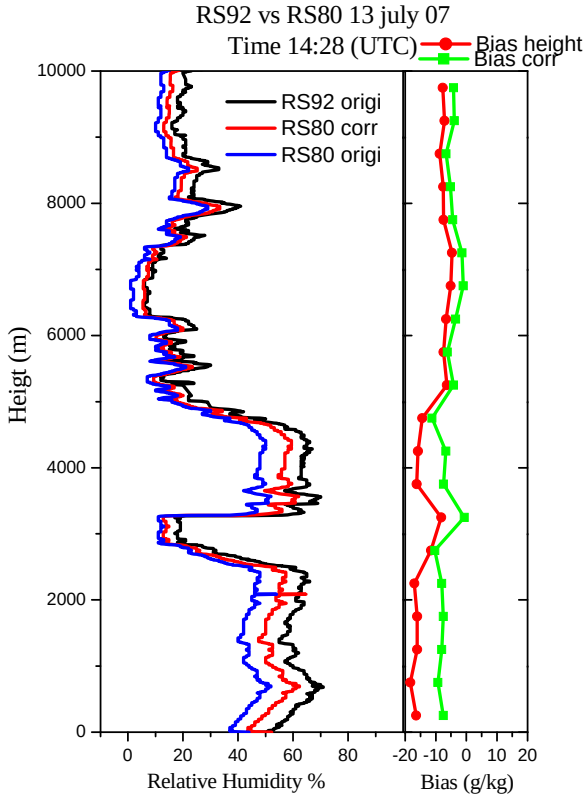
BASIL Raman Lidar vs RS80H (with advanced humicap sensor)

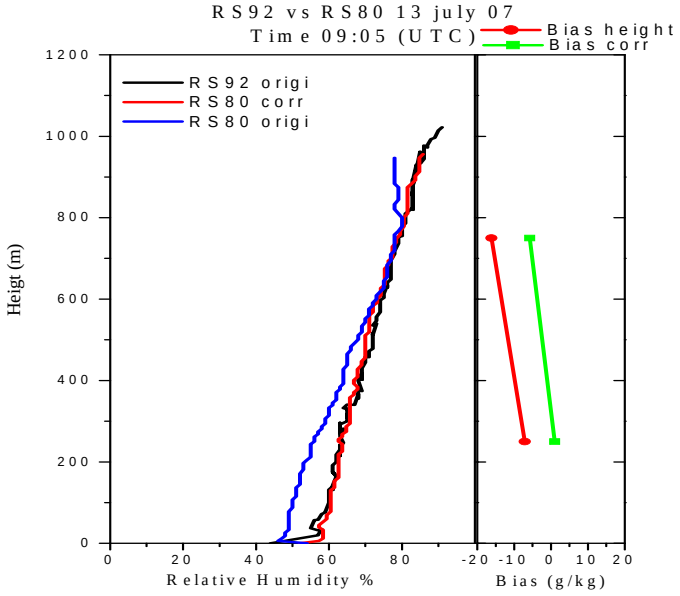


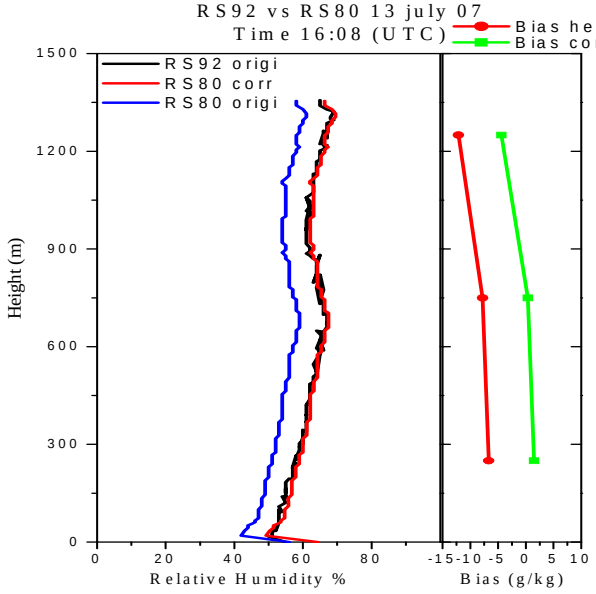
Example of temperature dependent error leading to a radiosonde dry bias in the upper troposphere











Mean relative bias between RS80 (A&H) and RS92 for all five inter-comparison launches on 13 July 07 - after correction of RS80 - is found to be approximately -4.5 % from -12 %

Future work

Extend the inter-comparison to **all possible couples of water vapour sensors** → to get an accurate error estimates for the different water vapour profiling/integrated column sensors

↓

We need to come to an **assessment** of **bias** between **different sensors** with **respect to a reference sensor**

The DIAL!!!!