Suggestions for potential ground based observing systems to be used in GRUAN operations.

John Nash, T. Oakley, C. Gaffard and J. Jones
Upper Air Development, Met Office

GRUAN Workshop, Lindenberg, 27 February 2008

Next Generation Upper-Air Network

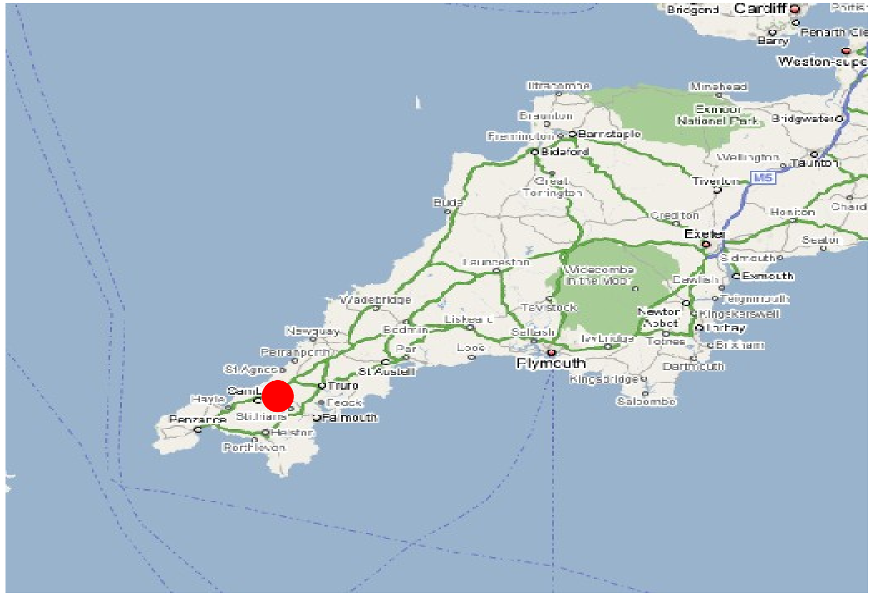
- **‘Large-scale’ project to produce costed options for the future (2010 – 2020)**

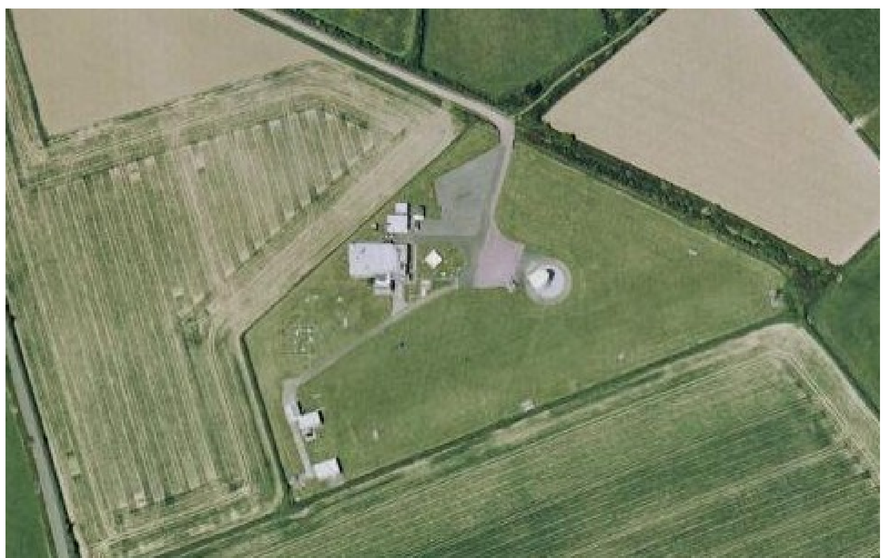
- **<u>Benefits</u>**
- **Optimize current network with surface and weather radar**

- **Meet User Requirements. (i.e. Higher spatial and temporal resolution)**
- **Reduce costs or deliver more for similar cost**

FUND – Future Upper-air Network Development + COST Action ES0702: European Ground-Based Observations of Essential Variables for Climate and Operational Meteorology (EG-CLIMET)

Camborne – Demonstration ‘Test’ Site.





Ground based remote sensing

- Provides higher temporal resolution than is feasible with radiosondes, but height coverage , stability and vertical resolution may be much lower than ideally required. However can indicate nature of errors /changes in radiosonde performance. Can provide evidence on representativeness errors of radiosondes .

- Wind profilers come closest to similar accuracy to radiosondes, but vertical resolution in stated GCOS user requirements seems extremely high compared to any operational use, although can be delivered by GPS radiosondes. Why???

- Satisfactory cloud measurements require use of laser ceilometers and cloud radars in addition to radiometers

- Useful surface based remote sensing of the upper troposphere and tropopause is only possible through VHF wind profilers and higher powered lidars, which may not be suitable for widespread use at the moment.

Basic variables in the troposphere

1 in operational use,
2 long term scientific deployments
3 Short term deployments

Temperature profile	Height range	Vertical resolution	Accuracy	Stability	Limitations
Microwave Radiometer[2]	0-5 Km?	At 1 km About 500m	0.5 K?	1 K?	Not in moderate or heavy rain
Infrared Spectrometer[2]	0-5 Km?	At 1 km probably similar to microwave	0.3 K ?	0.3K?	Cannot see through cloud.

Will have different day-night characteristics to radiosondes.

Basic variables in the troposphere

1 in operational use,
2 long term scientific deployments
3 Short term deployments

Water vapour profile	Height range	Vertical resolution	Accuracy	Stability	Limitations
Microwave Radiometer[2]	0-5 Km?	At 1 km About 750m	About 6 per cent	?	Not in moderate or heavy rain
Infrared Spectrometer[2]	0-5 Km?	At 1 km probably slightly better than microwave	?	?	Cannot see through cloud.

Will have different day-night characteristics to radiosondes.
GPS Integrated water vapour can be used to verify absolute accuracy.

Basic variables in the troposphere

1 in operational use,
2 long term scientific deployments
3 Short term deployments

Wind profile	Height range	Vertical resolution	Accuracy	Stability	Limitations
Wind profiler[1]	0-5 Km [UHF] 1-16 km [VHF]	100 in PBL To 500 m at upper levels	Better than 1 ms^{-1} in each component	?	Operational Monitoring Needs improving Birds, ground clutter, interference
Optical doppler lidar[2]	0-3 Km?	50 m	?	?	Cannot see through cloud.

Basic variables in the troposphere

1 in operational use,
2 long term scientific deployments
3 Short term deployments

Cloud profile	Height range	Vertical resolution	Accuracy	Stability	Limitations
Laser ceilometer[1]	0-12?? Km depends on specification]	10 to??m	Cloud base Heights similar to vertical resolution	?	Good for cloud base, but limited when low cloud present
Cloud radar[2]	0-12 Km?	15 m to 100m	Cloud top will be poorer than vertical resolution	?	Can see through cloud, but in sensitive to small cloud drops

Met Office

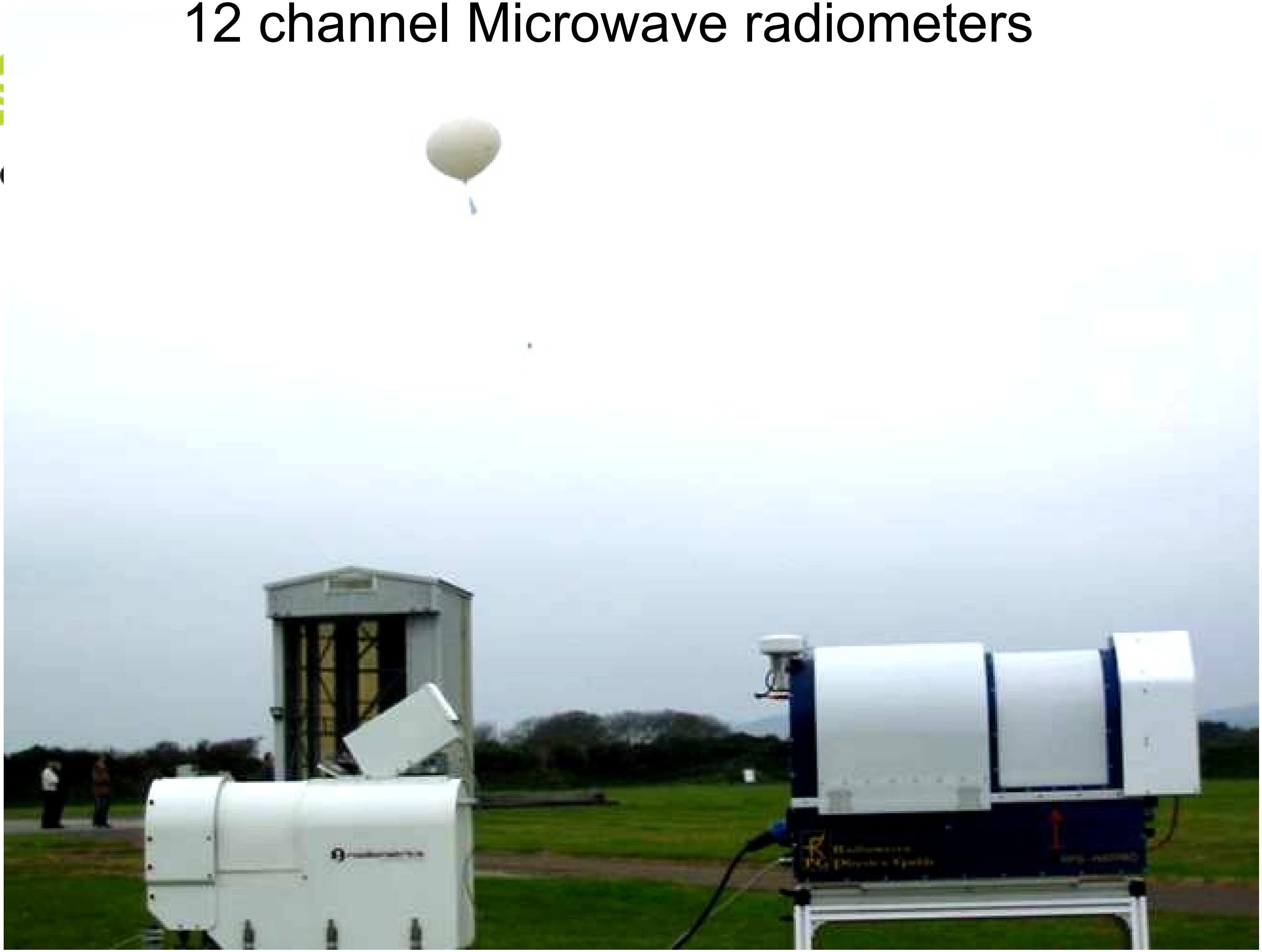
Variables not discussed here

- Radiation… see BSRN presentation
- Ozone, carbon dioxide, Methane… see GAW
- Lower stratosphere water vapour needs specialised instrumentation not yet available in near operational state
- Aerosol - sun photometers, etc

Instrumentation considered
[can be purchased through commercial tender]

- Microwave radiometer
- Infrared spectrometer
- GPS water vapour
- Wind profiler, UHF
- Optical doppler lidar
- Laser ceilometer
- Cloud radar

12 channel Microwave radiometers

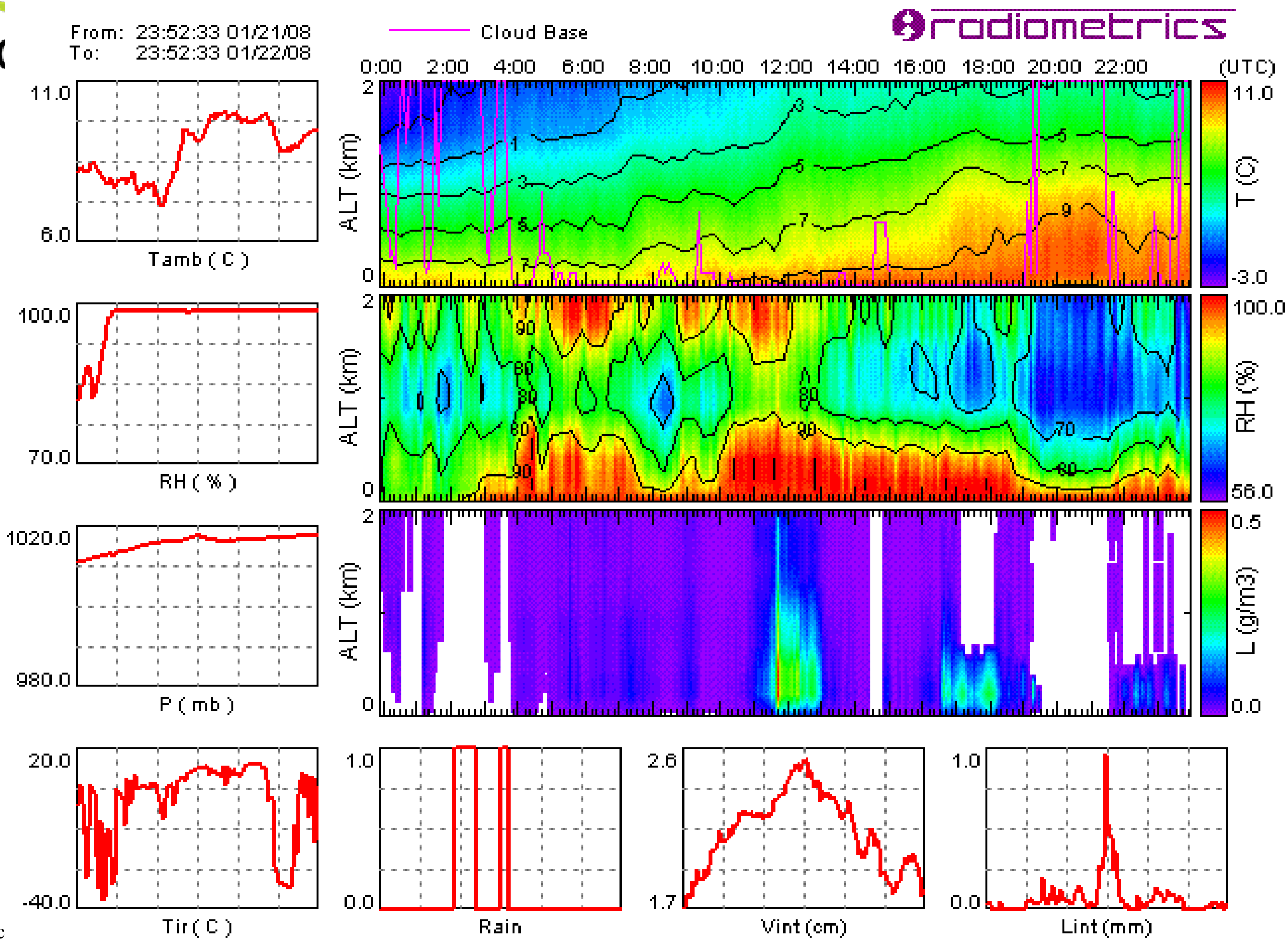


Radiometer Physics HATPRO

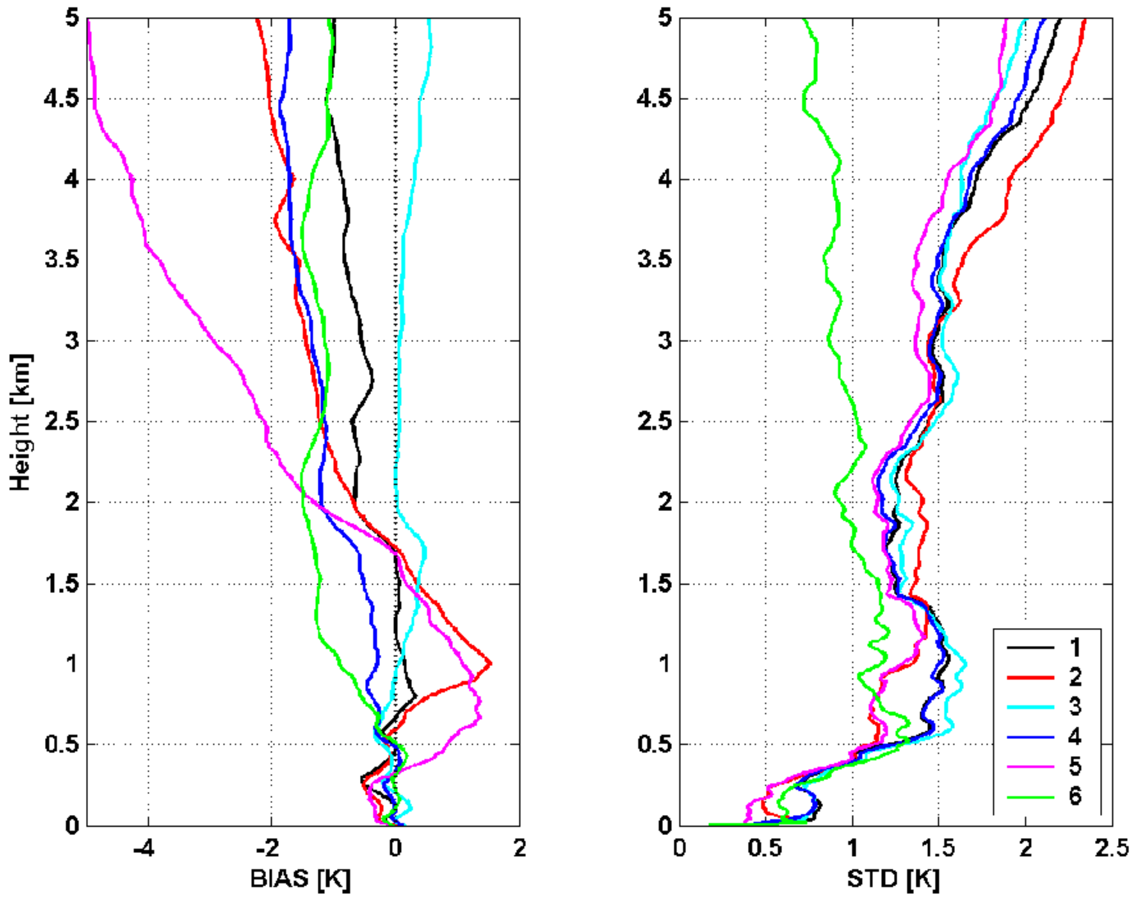
Humidity And Temperature PROfiler

- Filter bank Design – Fast!
- 22-29 GHz – humidity/cloud
- 51-58 GHz – temperature
- Beamwidth: 3.5° at 22 GHz
- Noise: 0.3-0.4 K for τ=1.0 s
- Absolute system stability: 1.0K
- Thermal stability: < 0.02 K
- Rain sensor and shutter (including a dew-blower)
- Pressure, humidity, temperature sensors
- IR-radiometer

Microwave radiometer output received at Exeter



Statistics of Temperature Profiles

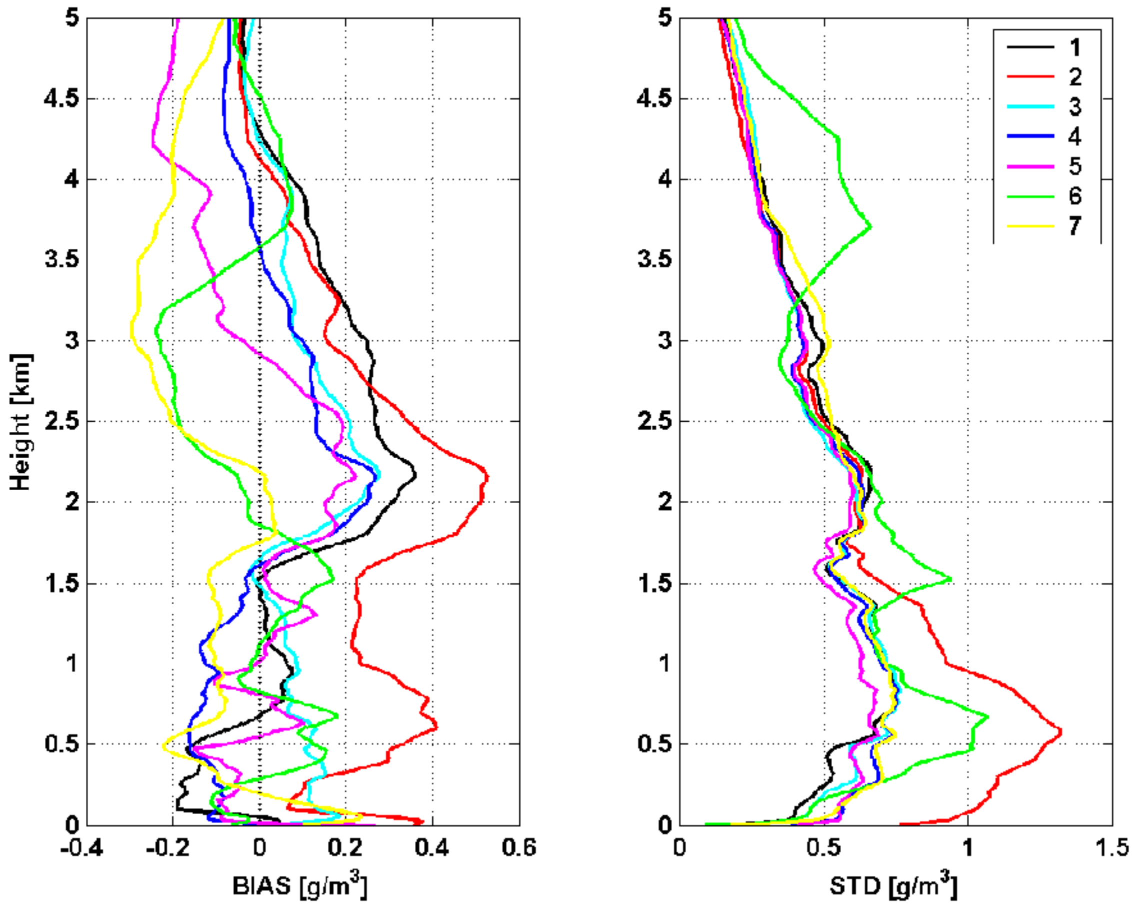


Retrieval accuracy for:

1) NN
2) NNelev
3) M-REG
4) S-REG
5) S-REGelev
6) 1D-VAR

Left: Temperature Bias
Right: Temperature StDev

Statistics of Humidity Profiles



Retrieval accuracy for:

1) NN
2) NNelev
3) M-REG
4) S-REG
5) S-REGelev
6) 1D-VAR
7) OEM

Left: Vapour Density Bias
Right: Vap. Den. StDev

Compare 2 Radiometrics Profilers during LAUNCH

Met Office

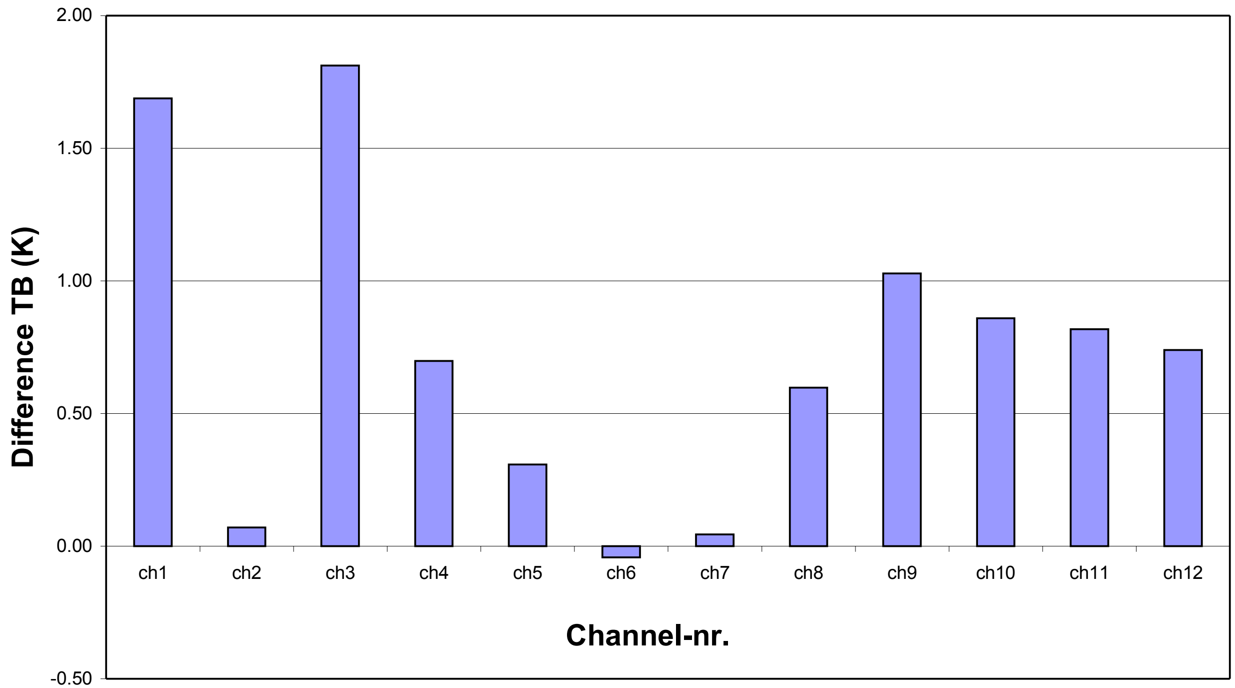
Mean value of TB difference MWP(DWD) - MWP(IMAA) (31.08.-07.09.2005)

IMAA TB prepared by F.Madonna, IMAA Potenza

Mean TB difference ~1.6 - 1.8 K at 22.23 GHz and 23.83 GHz

Mean TB difference < 1 K for other channels

Mean TB difference < 0.1 K at 23.03, 51.25 and 52.28 GHz



Compare Radiometrics and HATPRO during LAUNCH

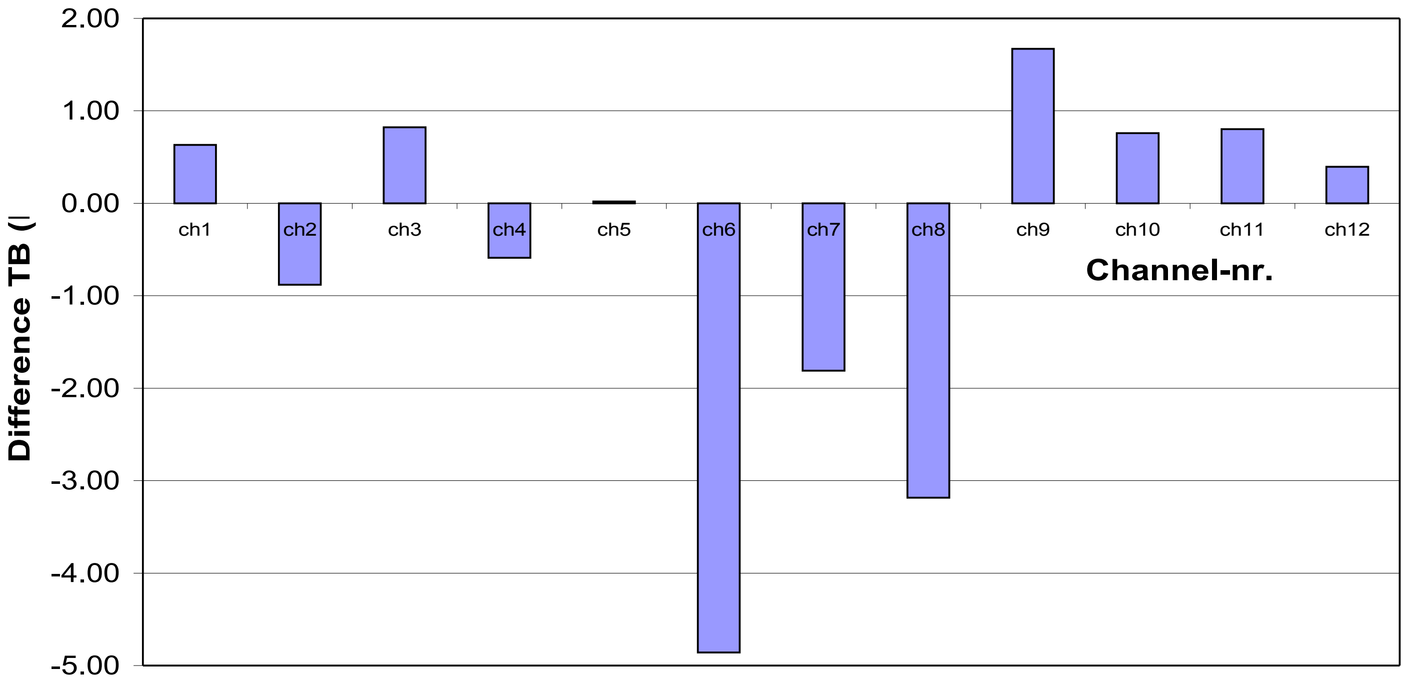
Met Office

Mean value of TB difference MWP(DWD) - HATPRO (18.10.-31.10.2005)

HATPRO TB provided by U.Löhnert, University Munich

Abs Mean TB difference ~1.8 - 5 K for V band channels between 51 and 55 GHz

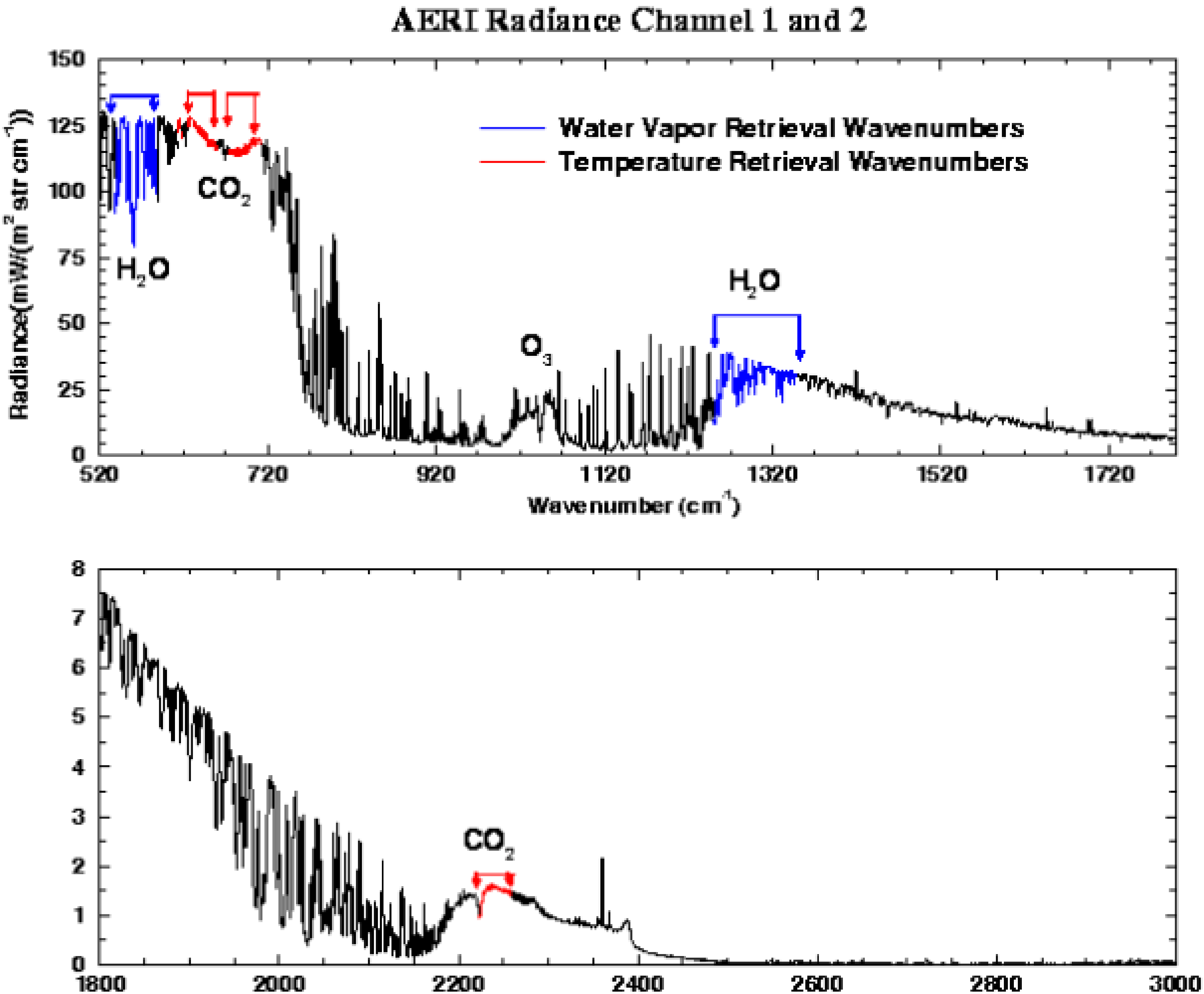
Abs Mean TB difference < 0.8 K for other channels



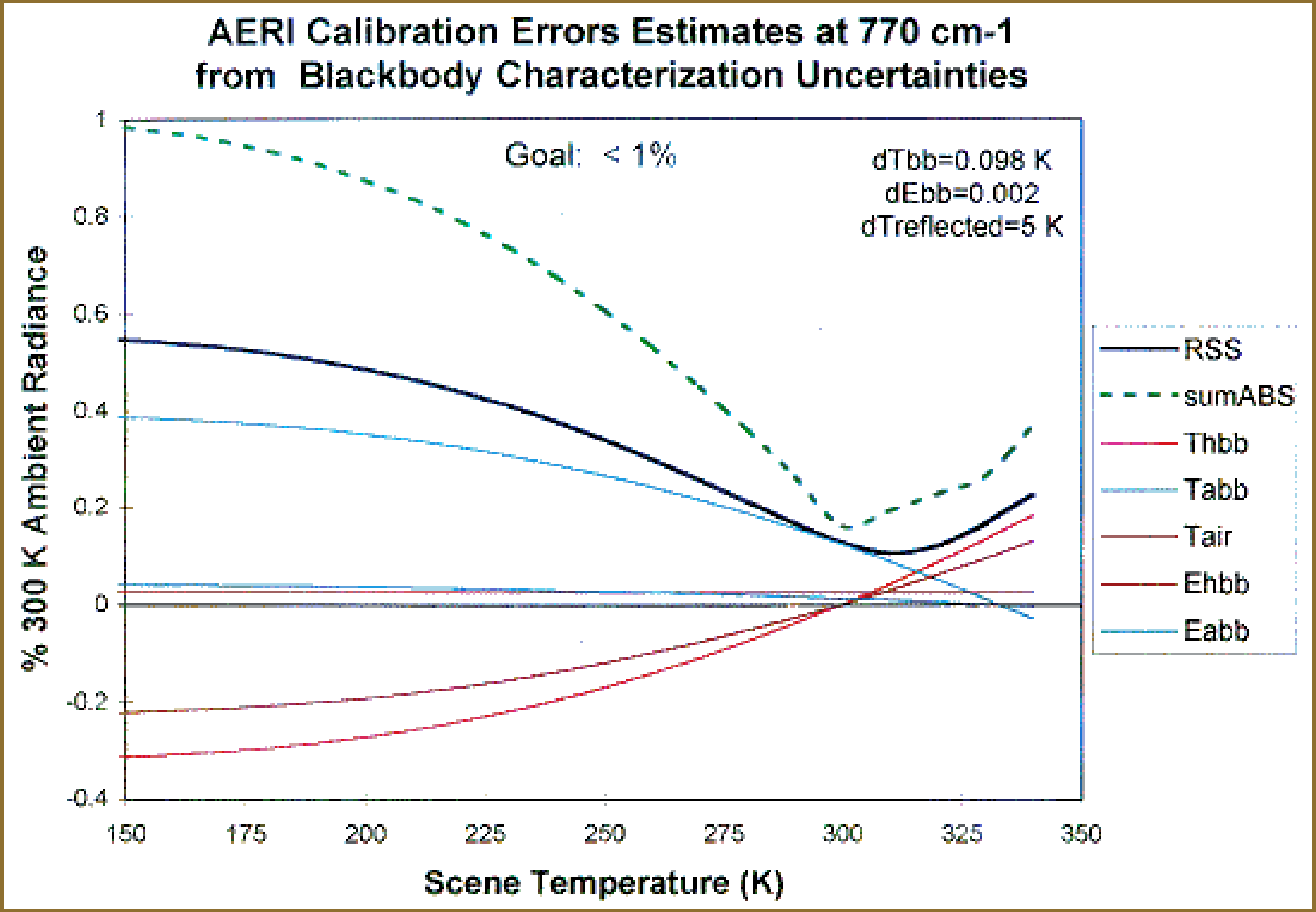
HATPRO TB closer to newer Radiometrics Profiler at ν>55GHz

Atmospherically Emitted Radiance Interferometer (AERI)

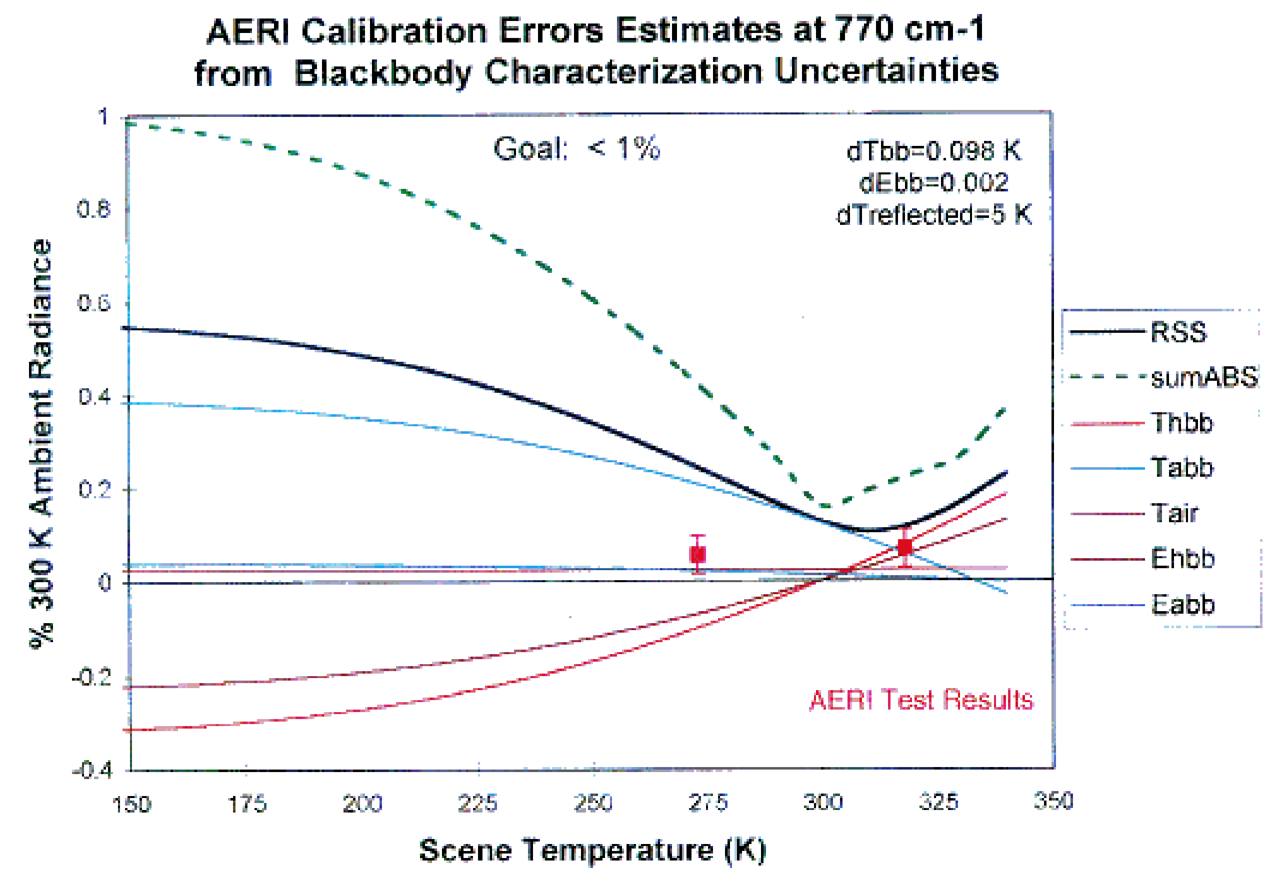
Atmospherically Emitted Radiance Interferometer (AERI)


AERI Radiance Channel 1 and 2
Water Vapor Retrieval Wavenumbers
Temperature Retrieval Wavenumbers
H2O
CO2
O3
H2O
Radiance(mW/(m2 str cm-1))
Wavenumber (cm-1)
CO2

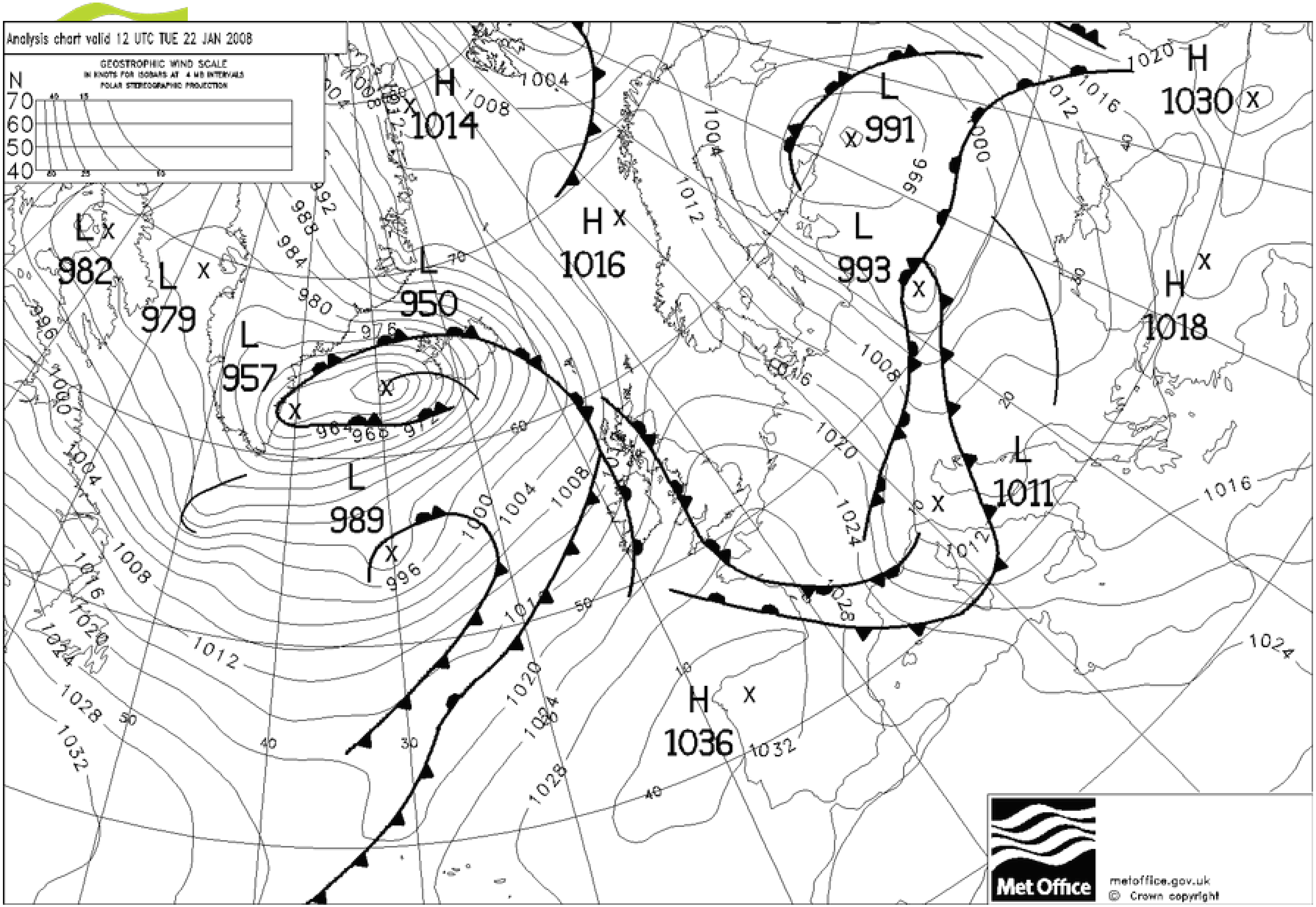
AERI Calibration Error Estimates



Calibration Results Compared to Goals



GPS water vapor



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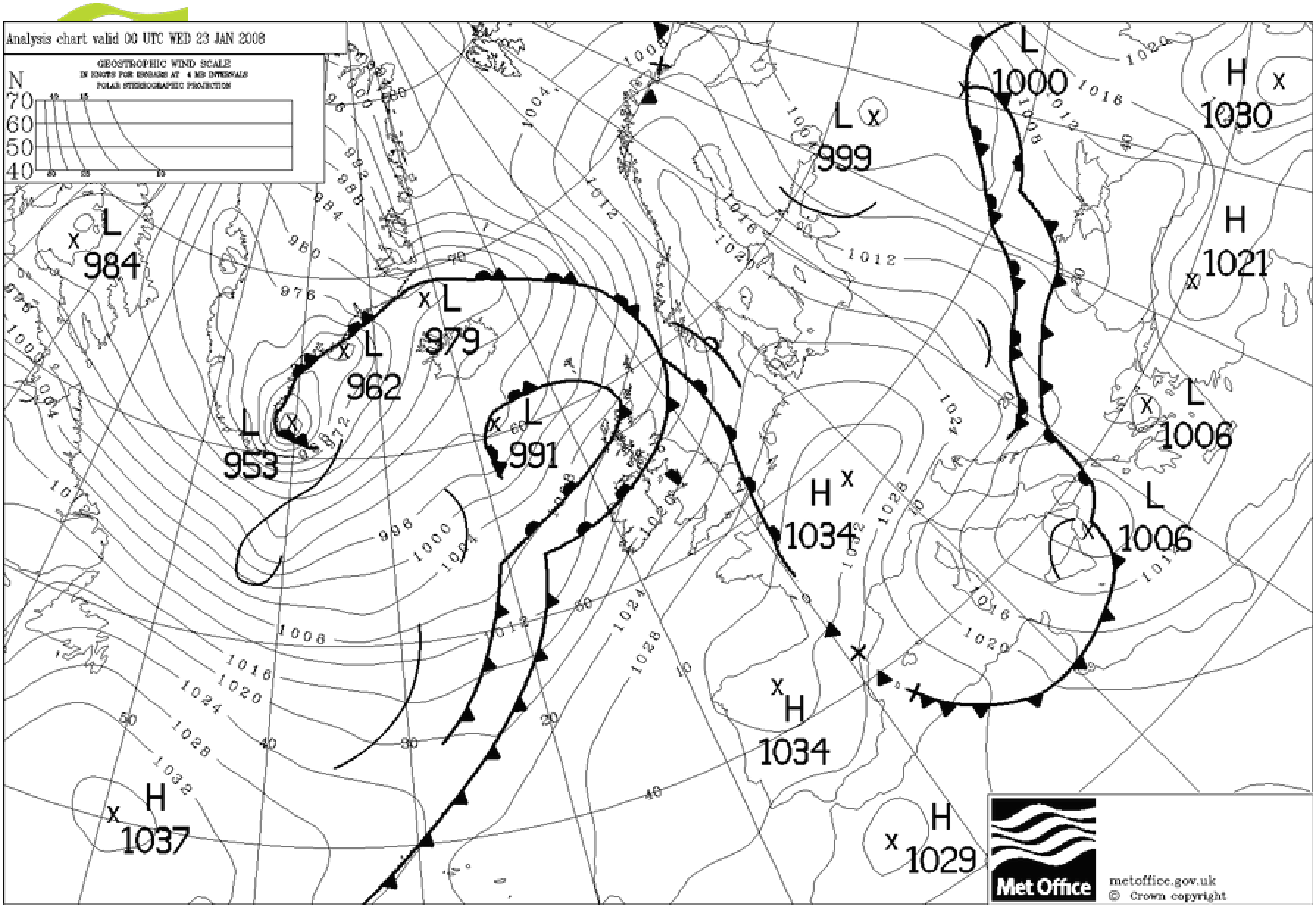
Analysis chart valid 00 UTC WED 23 JAN 2008
GEOSTROPHIC WIND SCALE
IN KNOTS FOR ISOBARS AT 4 MB INTERVALS
POLAR STEREOGRAPHIC PROJECTION
N
70
60
50
40
L 984
L 953
L 962
L 979
L 991
L 1000
L 999
H 1030
H 1021
L 1006
L 1006
H 1034
H 1034
H 1037
H 1029
Met Office
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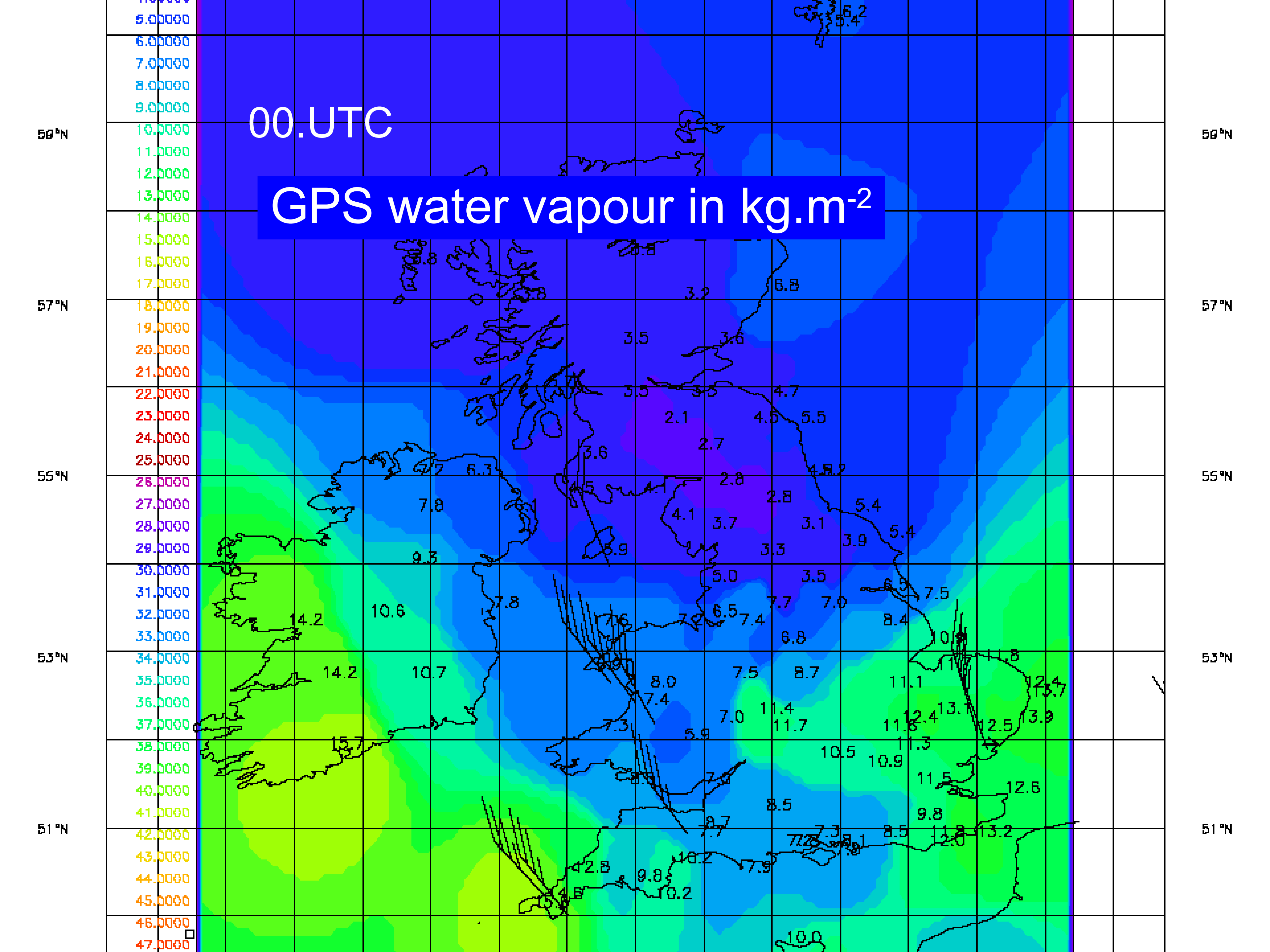
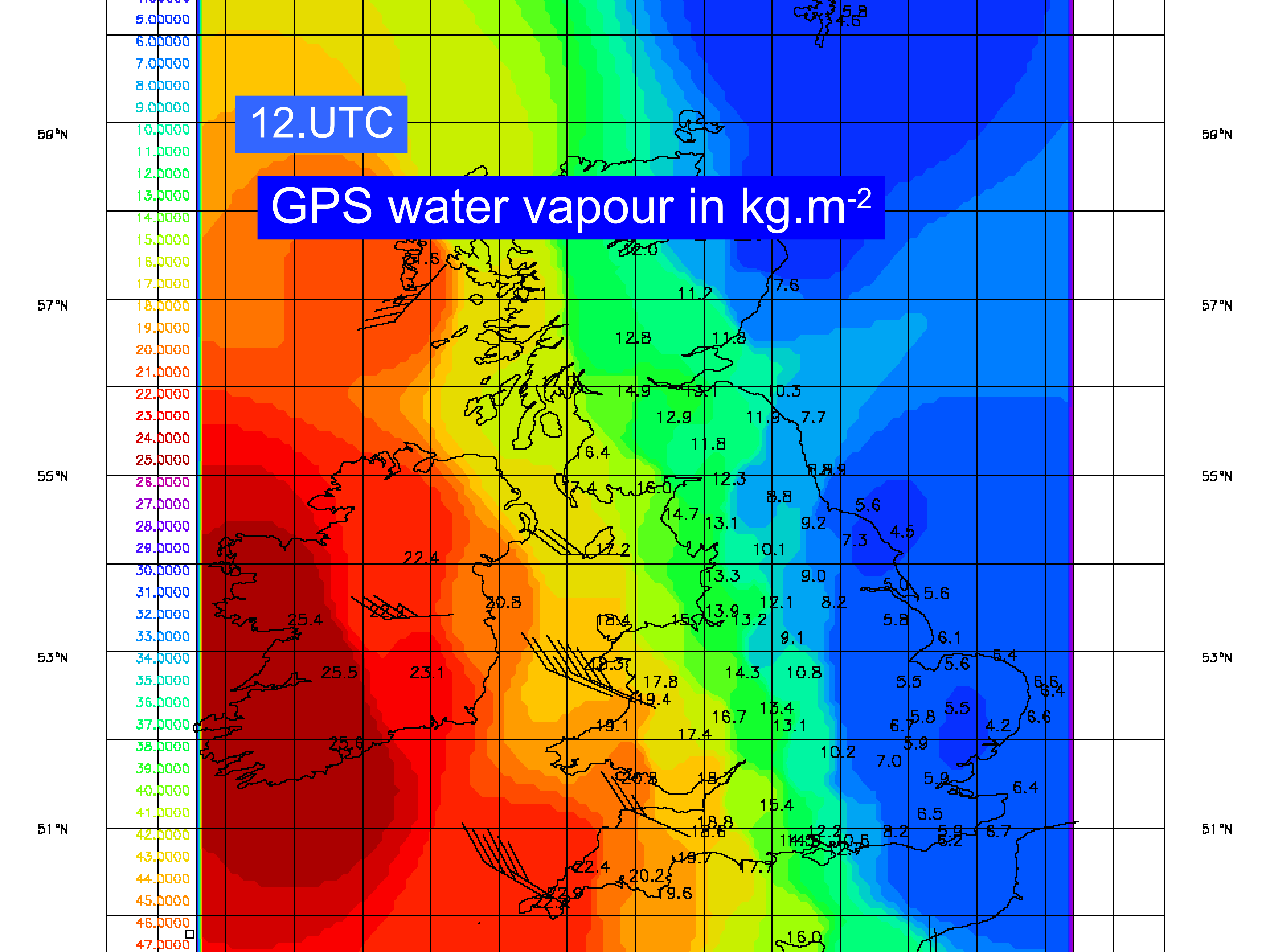
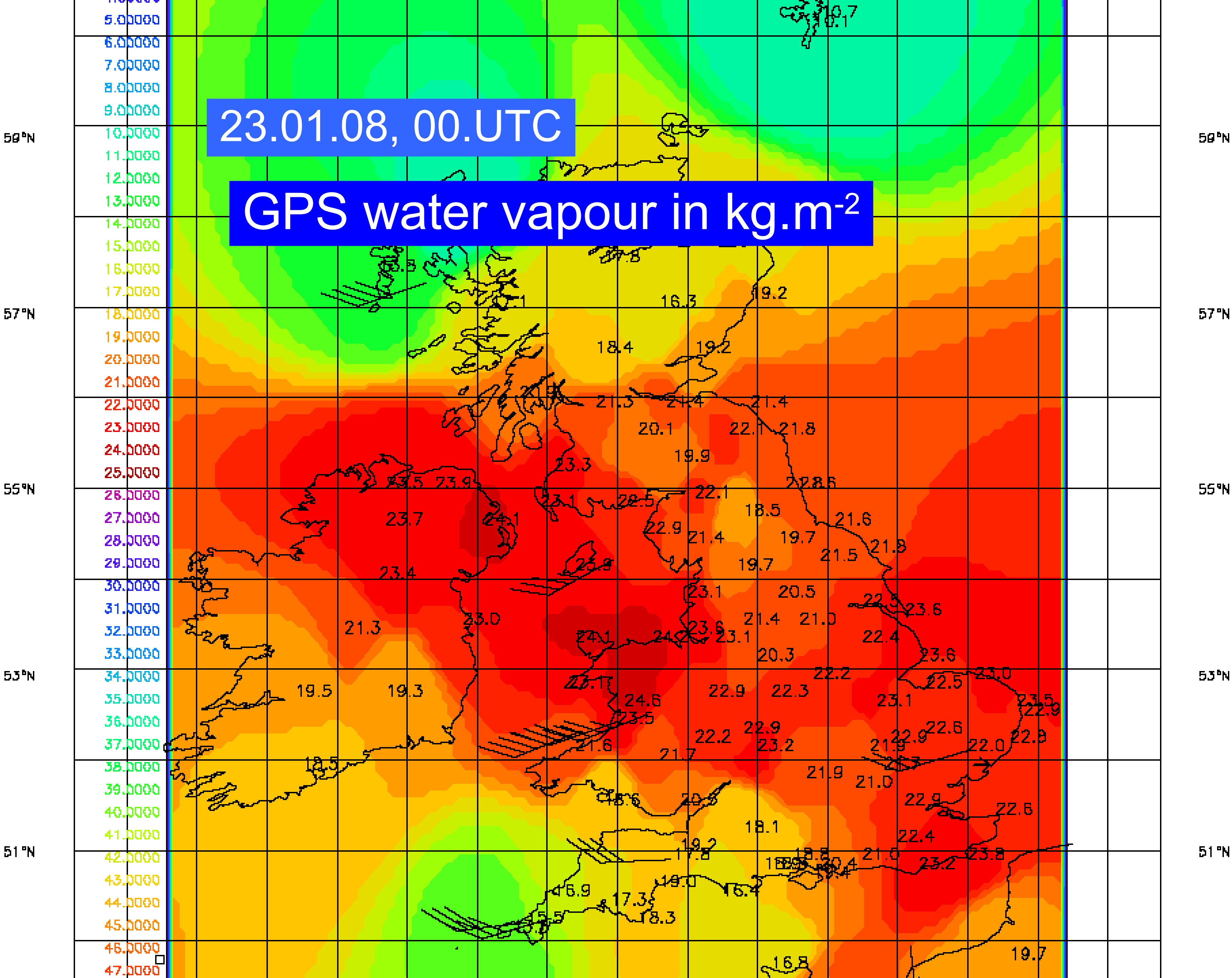
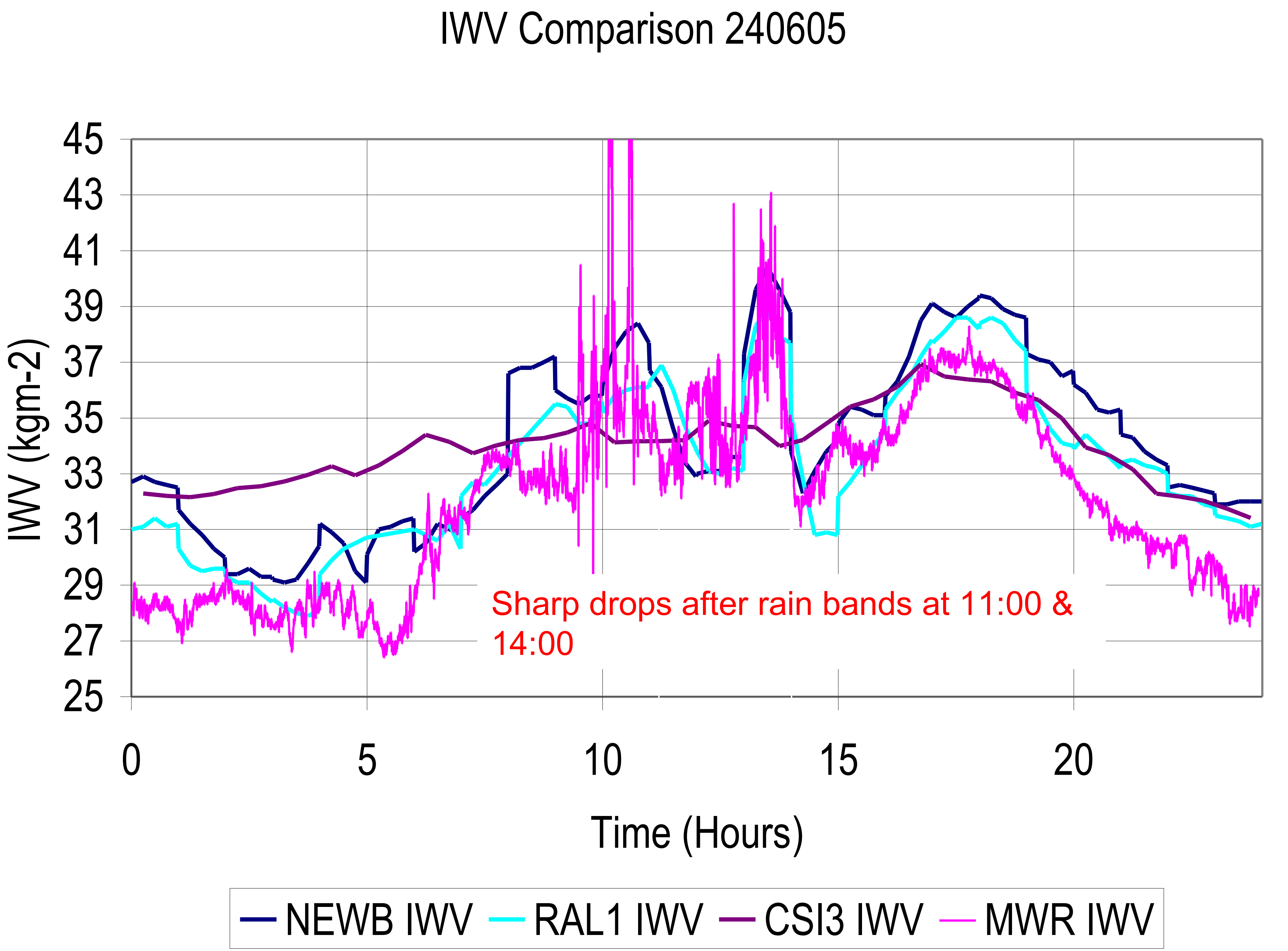


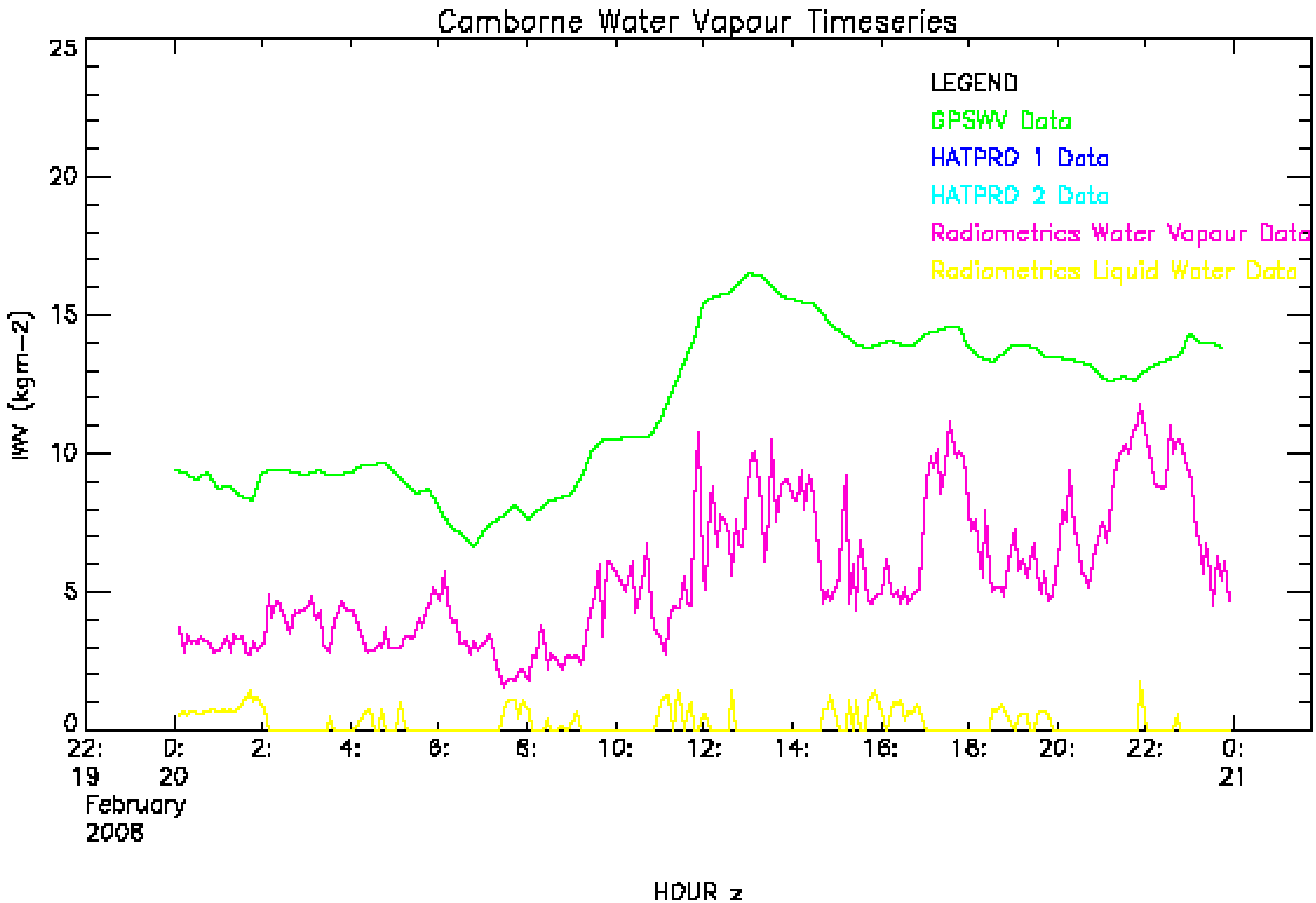
00.UTC
GPS water vapour in kg.m-2
59°N
57°N
55°N
53°N
51°N


12.UTC
GPS water vapour in kg.m^{-2}
59°N
57°N
55°N
53°N
51°N
5.00000
6.00000
7.00000
8.00000
9.00000
10.0000
11.0000
12.0000
13.0000
14.0000
15.0000
16.0000
17.0000
18.0000
19.0000
20.0000
21.0000
22.0000
23.0000
24.0000
25.0000
26.0000
27.0000
28.0000
29.0000
30.0000
31.0000
32.0000
33.0000
34.0000
35.0000
36.0000
37.0000
38.0000
39.0000
40.0000
41.0000
42.0000
43.0000
44.0000
45.0000
46.0000
47.0000

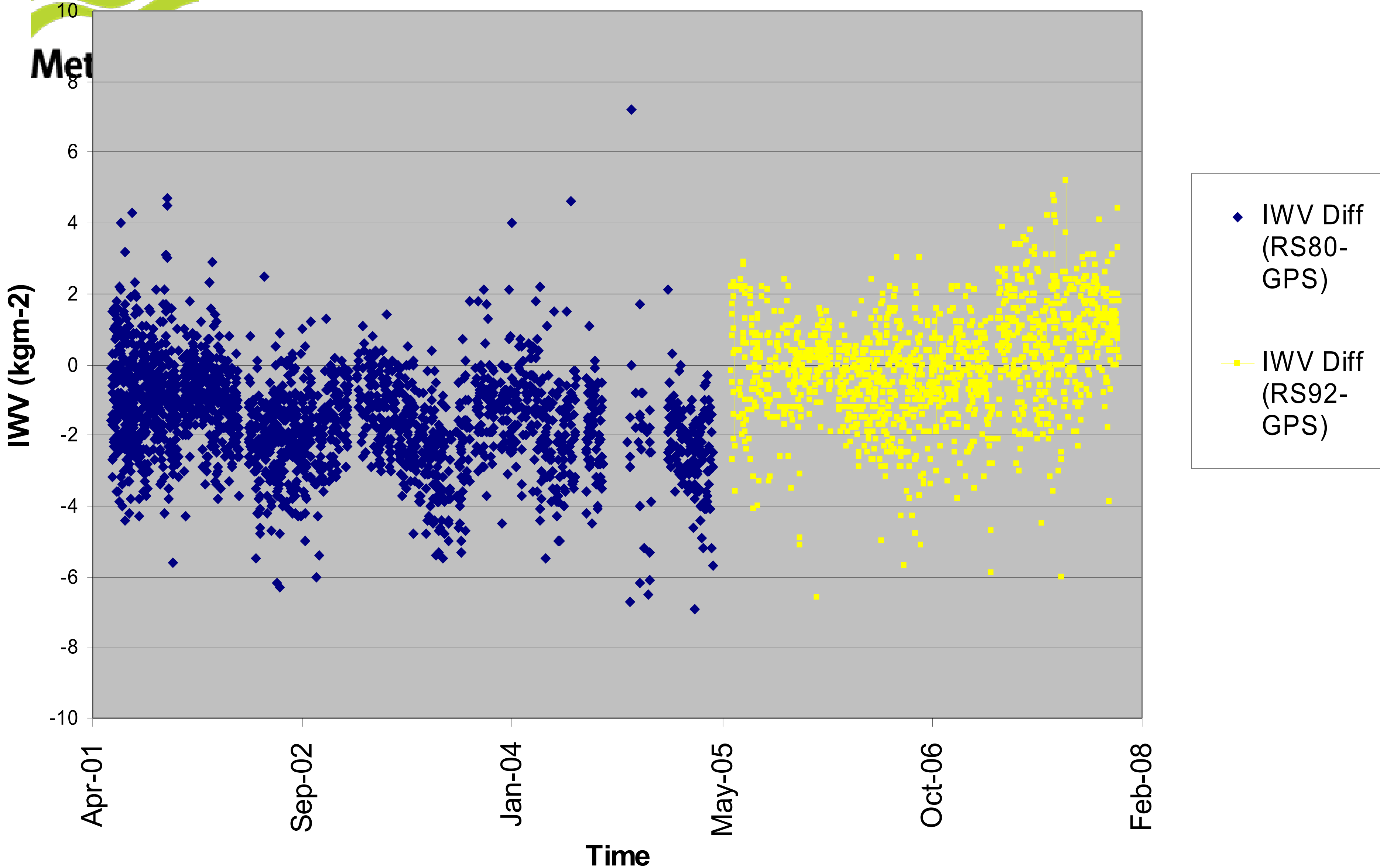

23.01.08, 00.UTC
GPS water vapour in kg.m^{-2}
5.00000
6.00000
7.00000
8.00000
9.00000
10.0000
11.0000
12.0000
13.0000
14.0000
15.0000
16.0000
17.0000
18.0000
19.0000
20.0000
21.0000
22.0000
23.0000
24.0000
25.0000
26.0000
27.0000
28.0000
29.0000
30.0000
31.0000
32.0000
33.0000
34.0000
35.0000
36.0000
37.0000
38.0000
39.0000
40.0000
41.0000
42.0000
43.0000
44.0000
45.0000
46.0000
47.0000
59°N
57°N
55°N
53°N
51°N

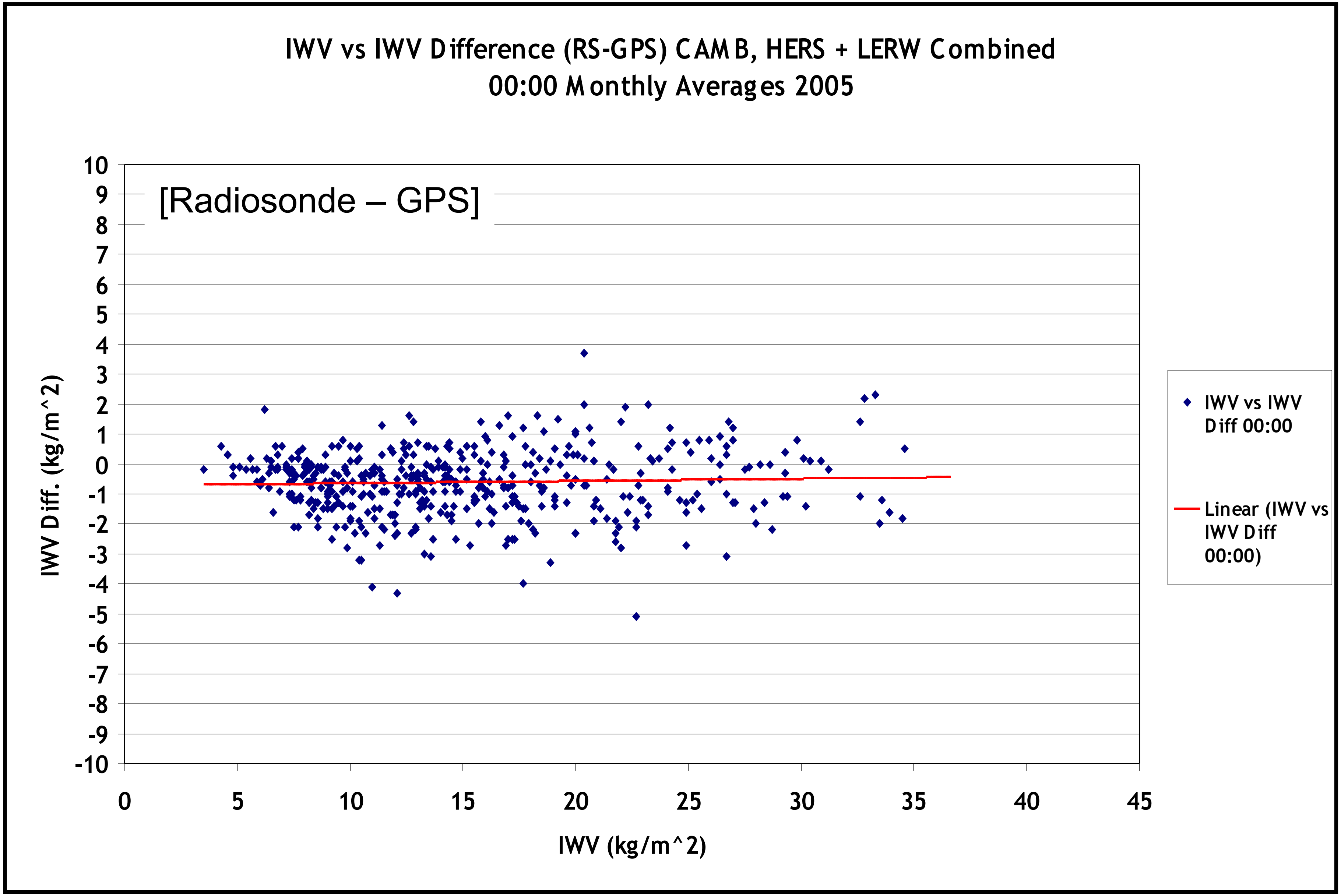

IWV Comparison 240605
IWV (kgm-2)
45
43
41
39
37
35
33
31
29
27
25
0
5
10
15
20
Time (Hours)
Sharp drops after rain bands at 11:00 & 14:00
NEWB IWV
RAL1 IWV
CSI3 IWV
MWR IWV

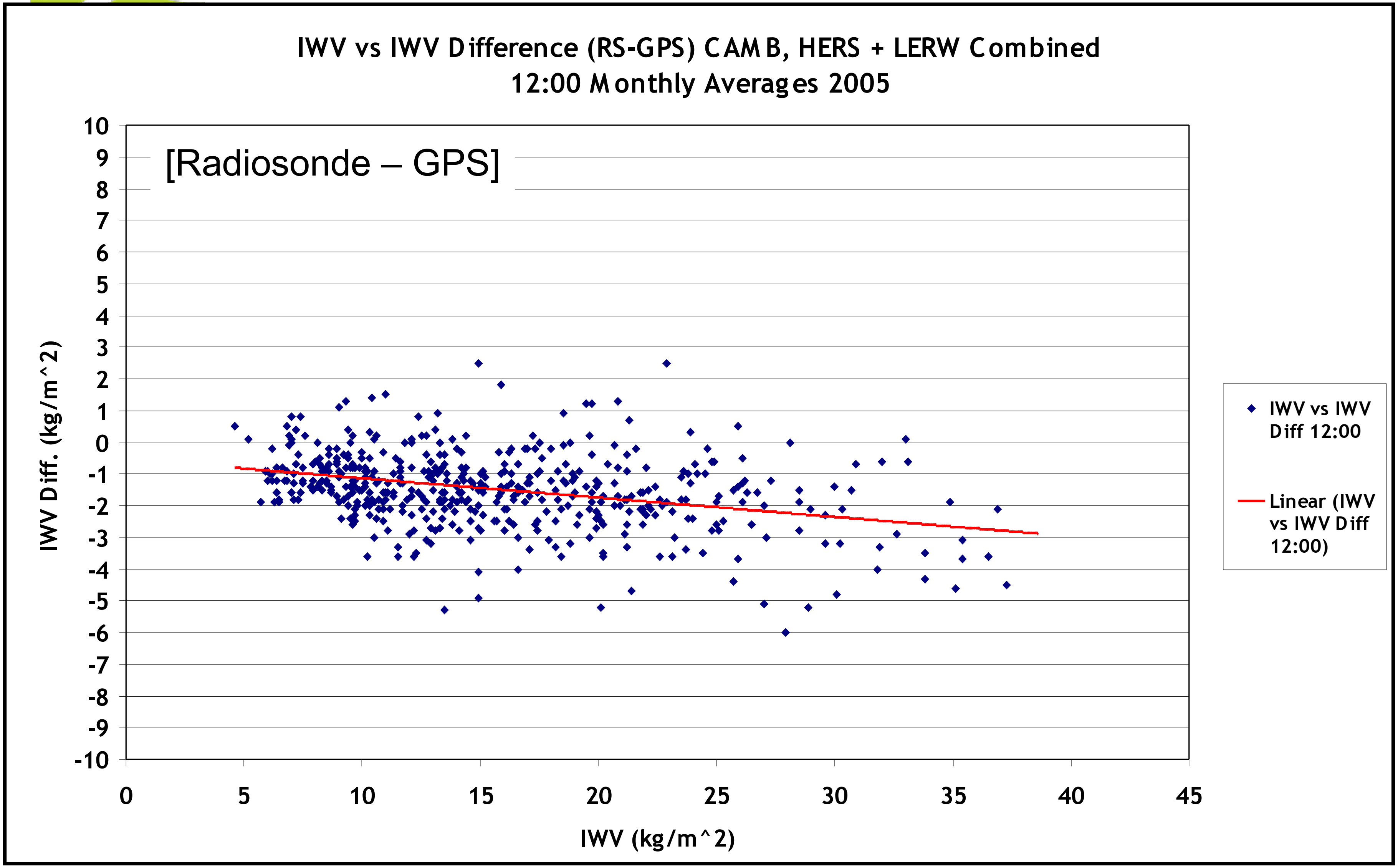
Recent FUND Plot GPS vs. MP3008 MWR

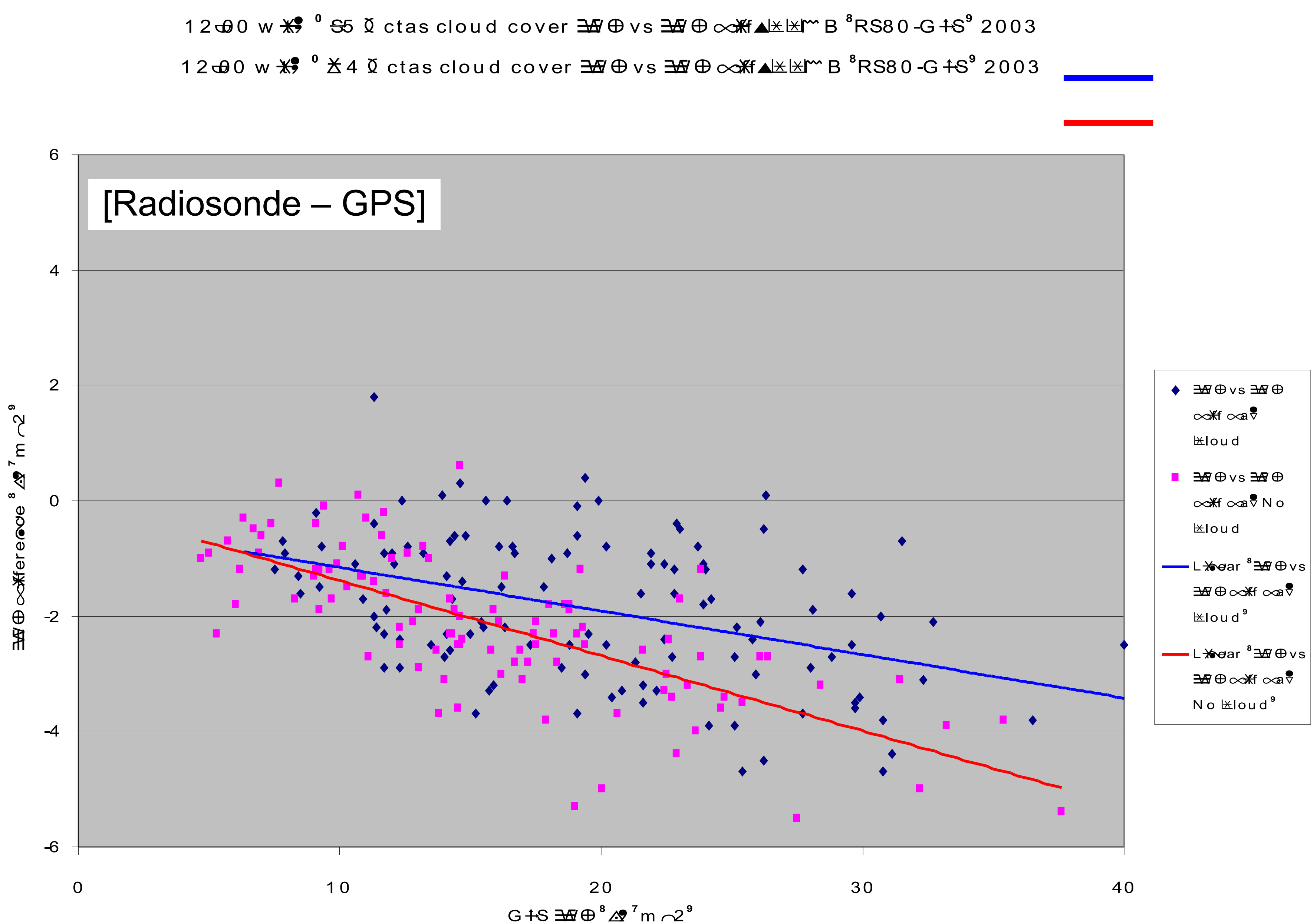


Long Term Trend of IWV Difference (RS-GPS) Trend of IWV at Camborne June 2001 - Dec 2007

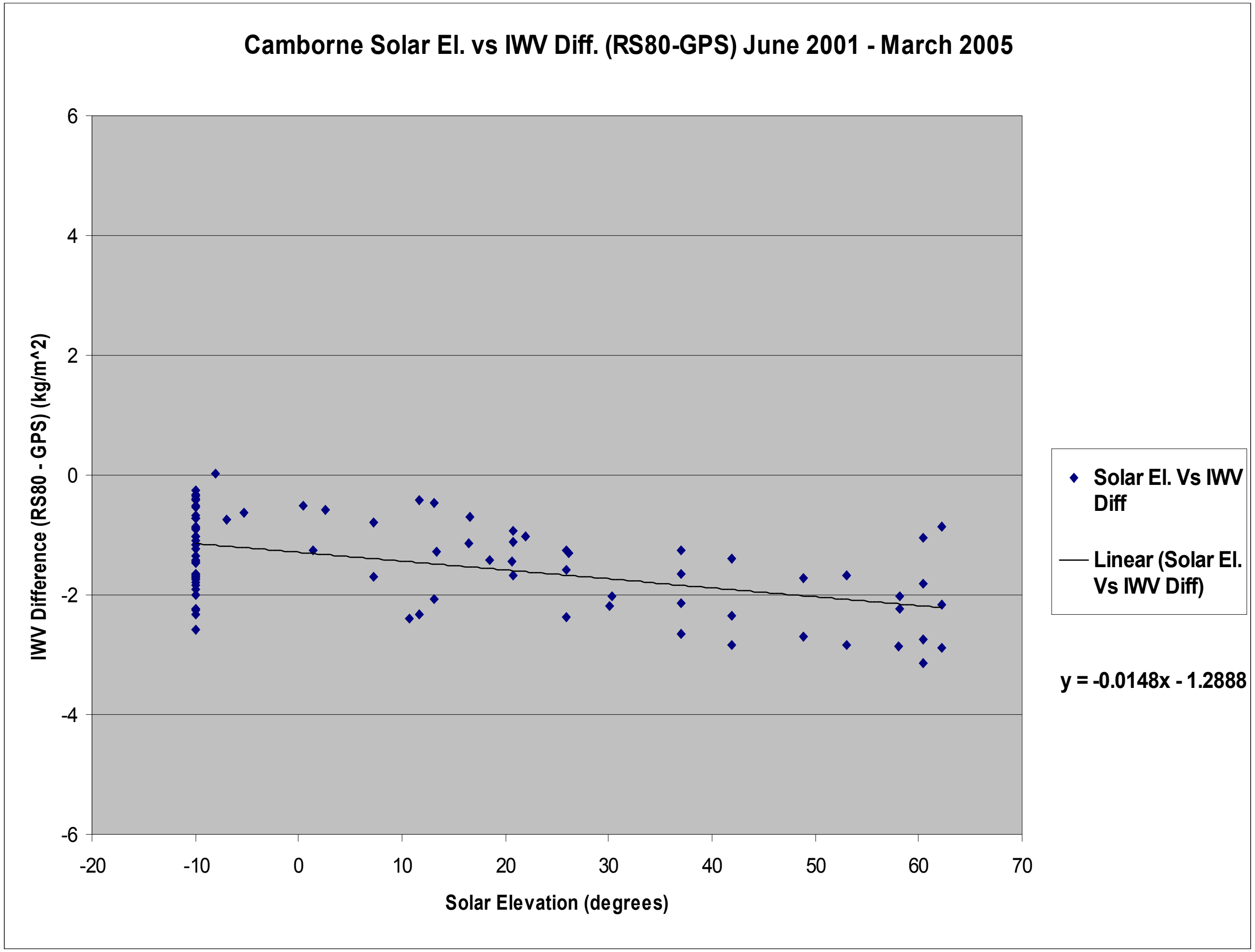



IWV vs IWV Difference (RS-GPS) CAMB, HERS + LERW Combined
00:00 Monthly Averages 2005
[Radiosonde – GPS]
IWV Diff. (kg/m^2)
IWV (kg/m^2)
IWV vs IWV Diff 00:00
Linear (IWV vs IWV Diff 00:00)
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
5
10
15
20
25
30
35
40
45

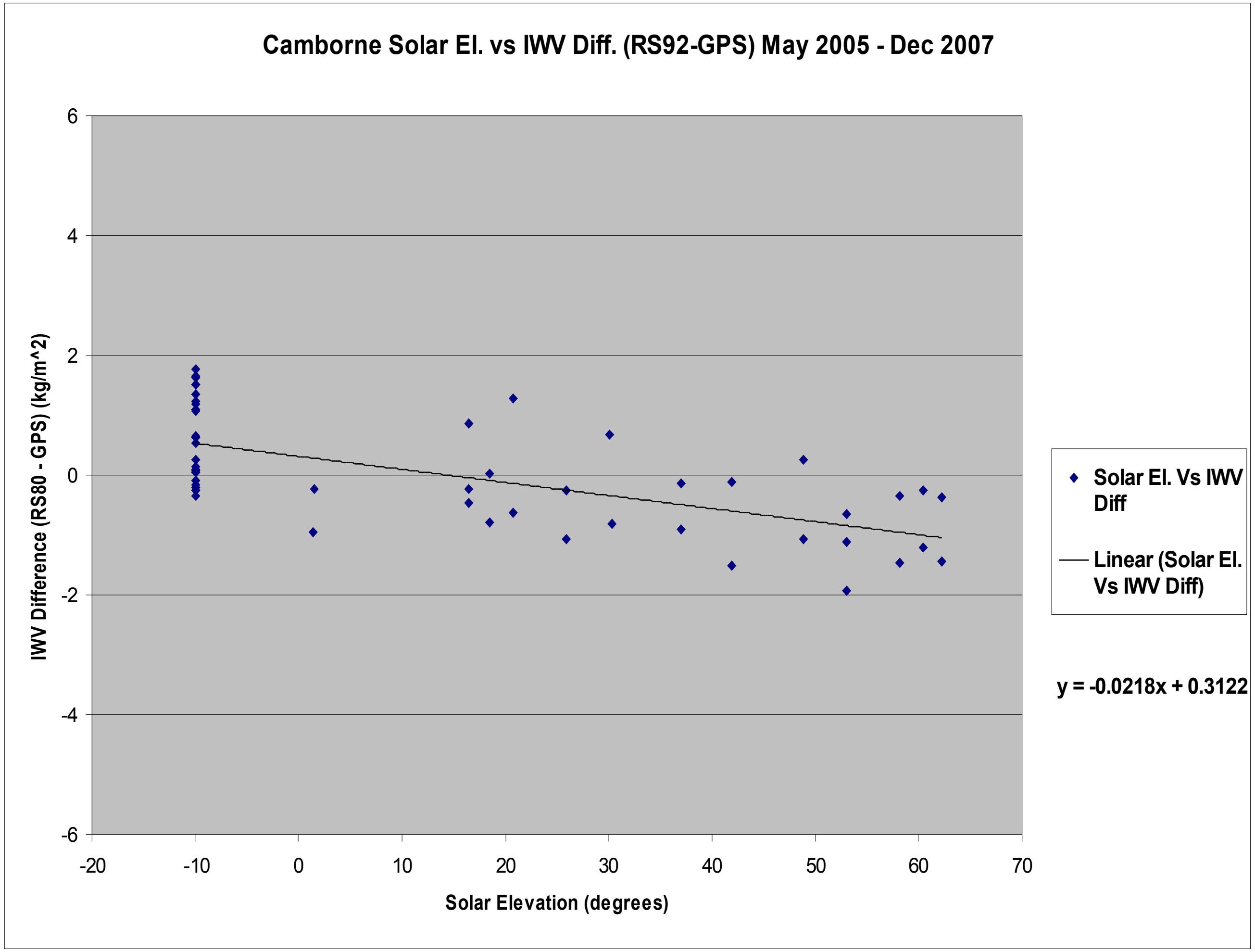

IWV vs IWV Difference (RS-GPS) CAMB, HERS + LERW Combined
12:00 Monthly Averages 2005
[Radiosonde – GPS]
IWV Diff. (kg/m^2)
IWV (kg/m^2)
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
5
10
15
20
25
30
35
40
45
IWV vs IWV Diff 12:00
Linear (IWV vs IWV Diff 12:00)


[Radiosonde – GPS]
6
4
2
0
-2
-4
-6
0
10
20
30
40

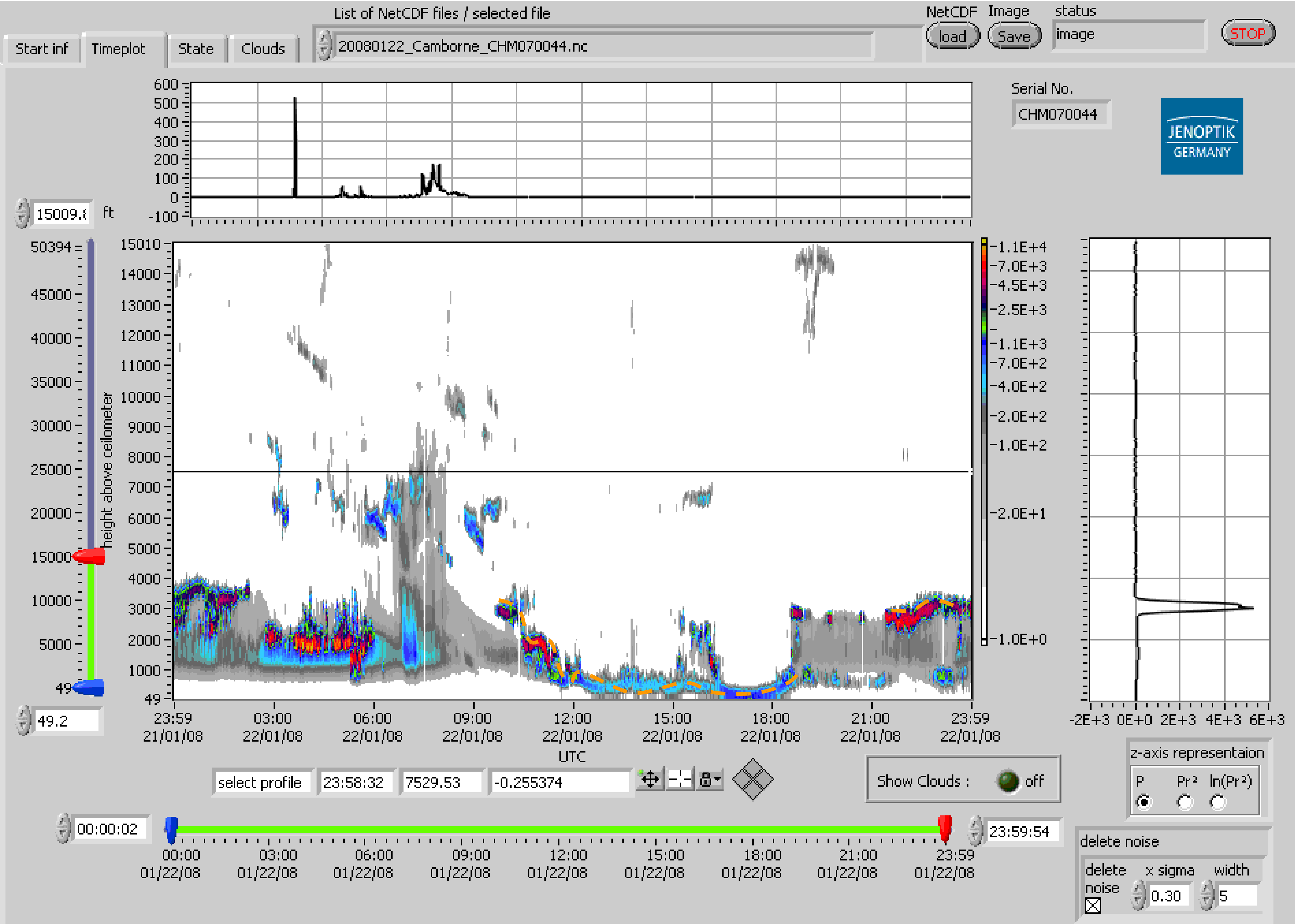
Vaisala RS80 –GPS at Camborne

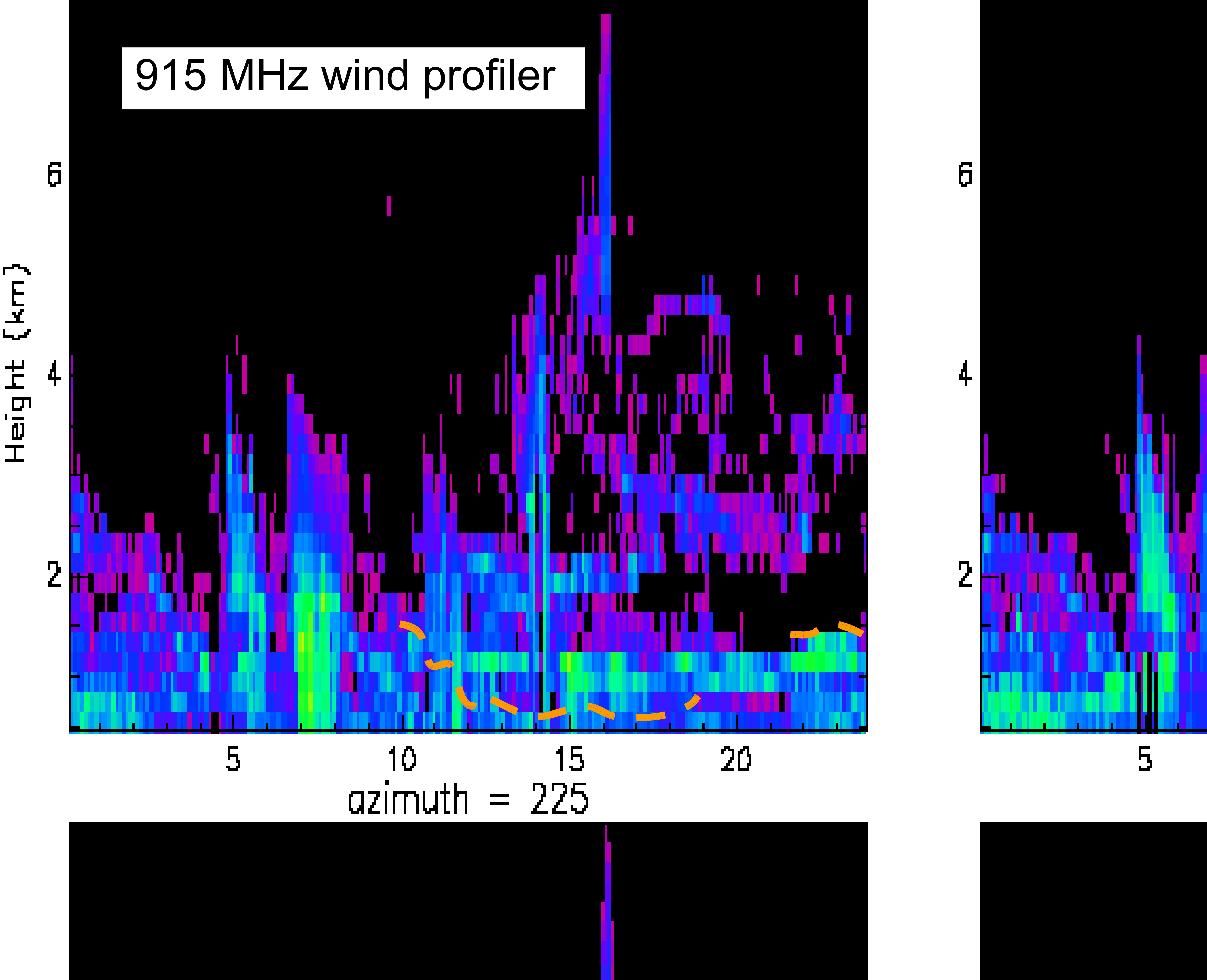


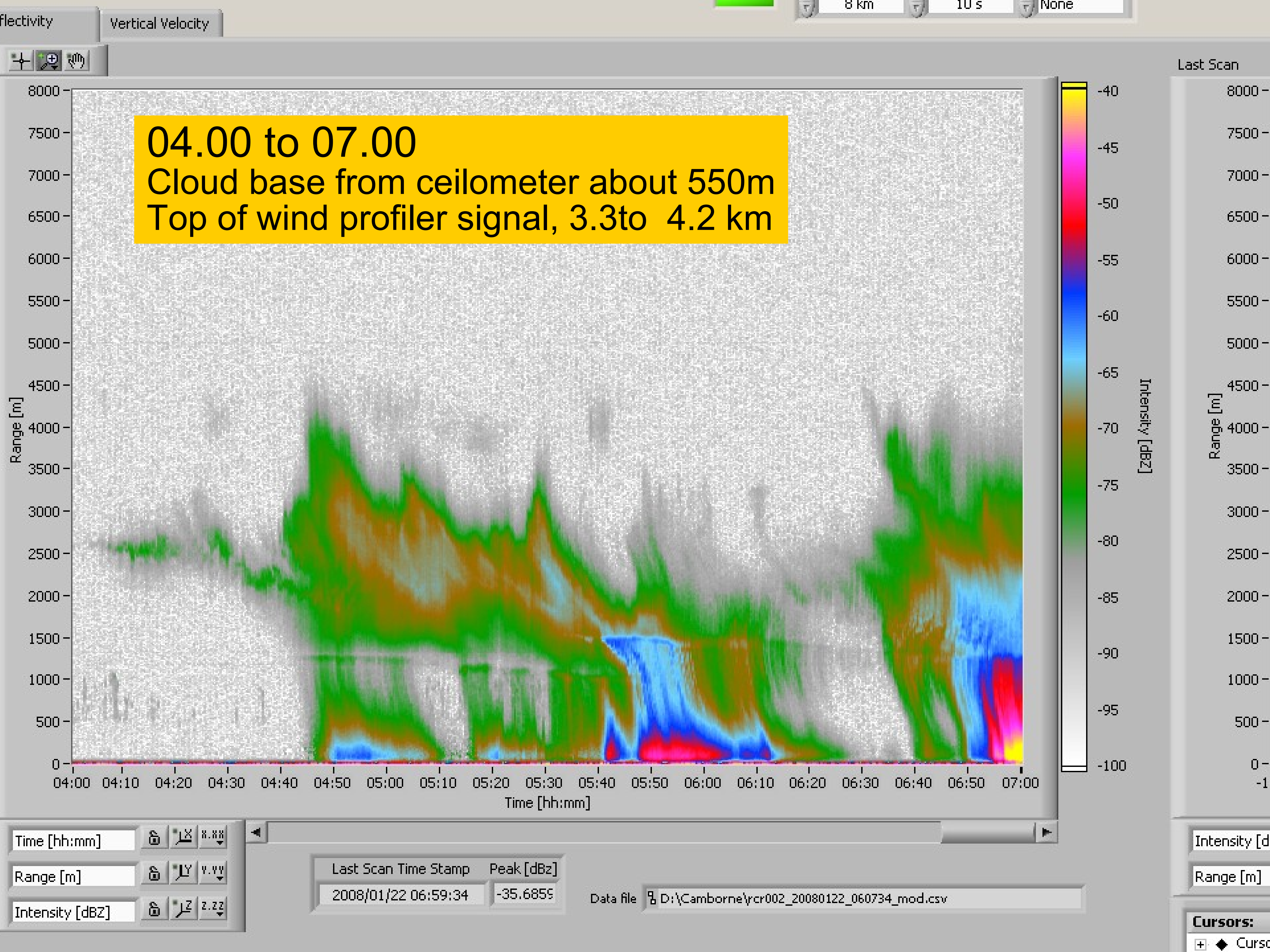
Vaisala RS92 –GPS at Camborne




Jenoptik Laser ceilometer

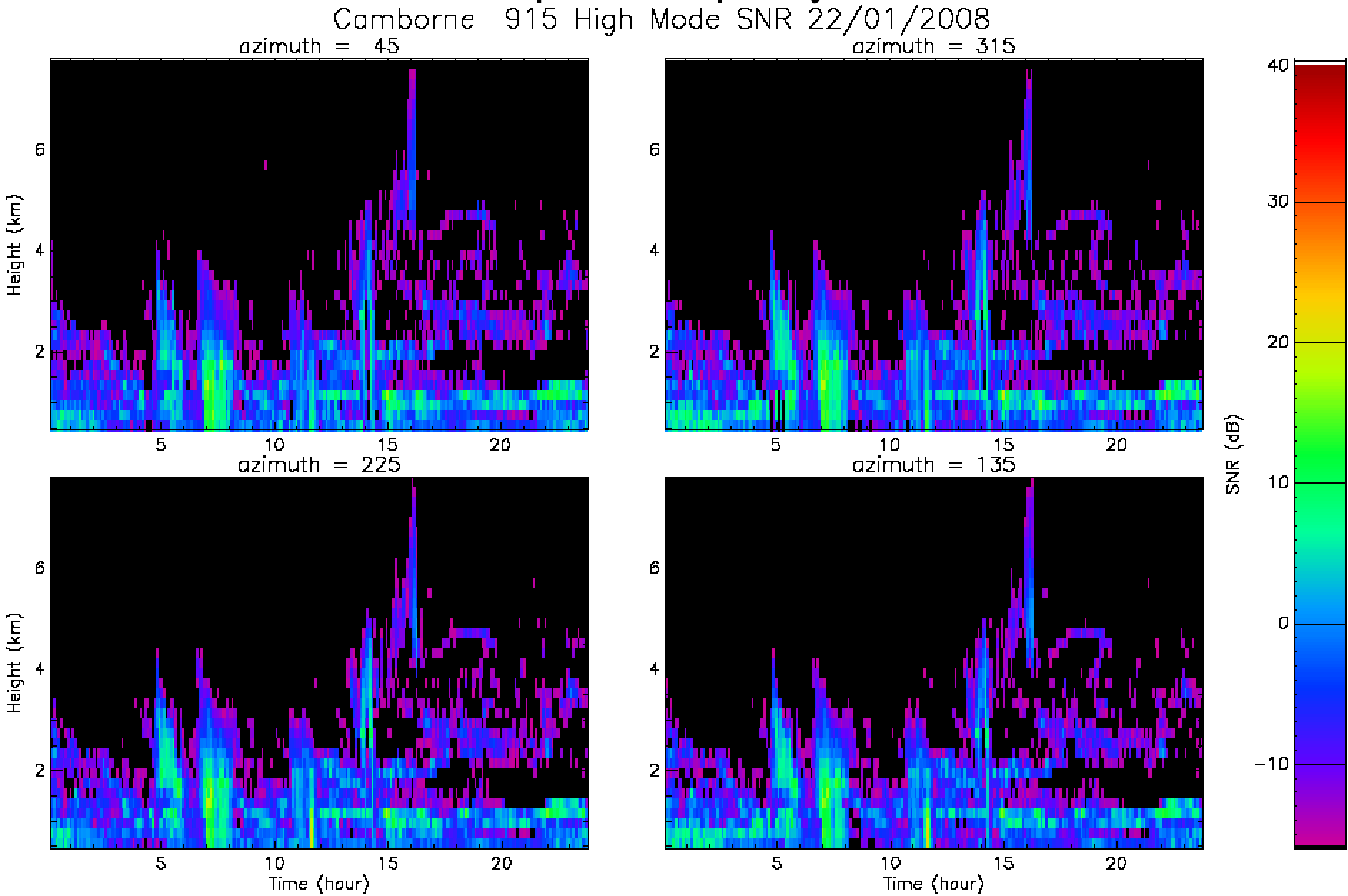

List of NetCDF files / selected file
NetCDF
Image
status
Start inf
Timeplot
State
Clouds
20080122_Camborne_CHM070044.nc
load
Save
image
STOP
Serial No.
CHM070044
JENOPTIK
GERMANY
15009.8
ft
height above ceilometer
49.2
UTC
select profile
23:58:32
7529.53
-0.255374
Show Clouds :
off
z-axis representaion
P
Pr²
ln(Pr²)
00:00:02
23:59:54
delete noise
delete
noise
x sigma
width
0.30
5


915 MHz wind profiler
Height (km)
6
4
2
5
10
15
20
azimuth = 225
6
4
2
5

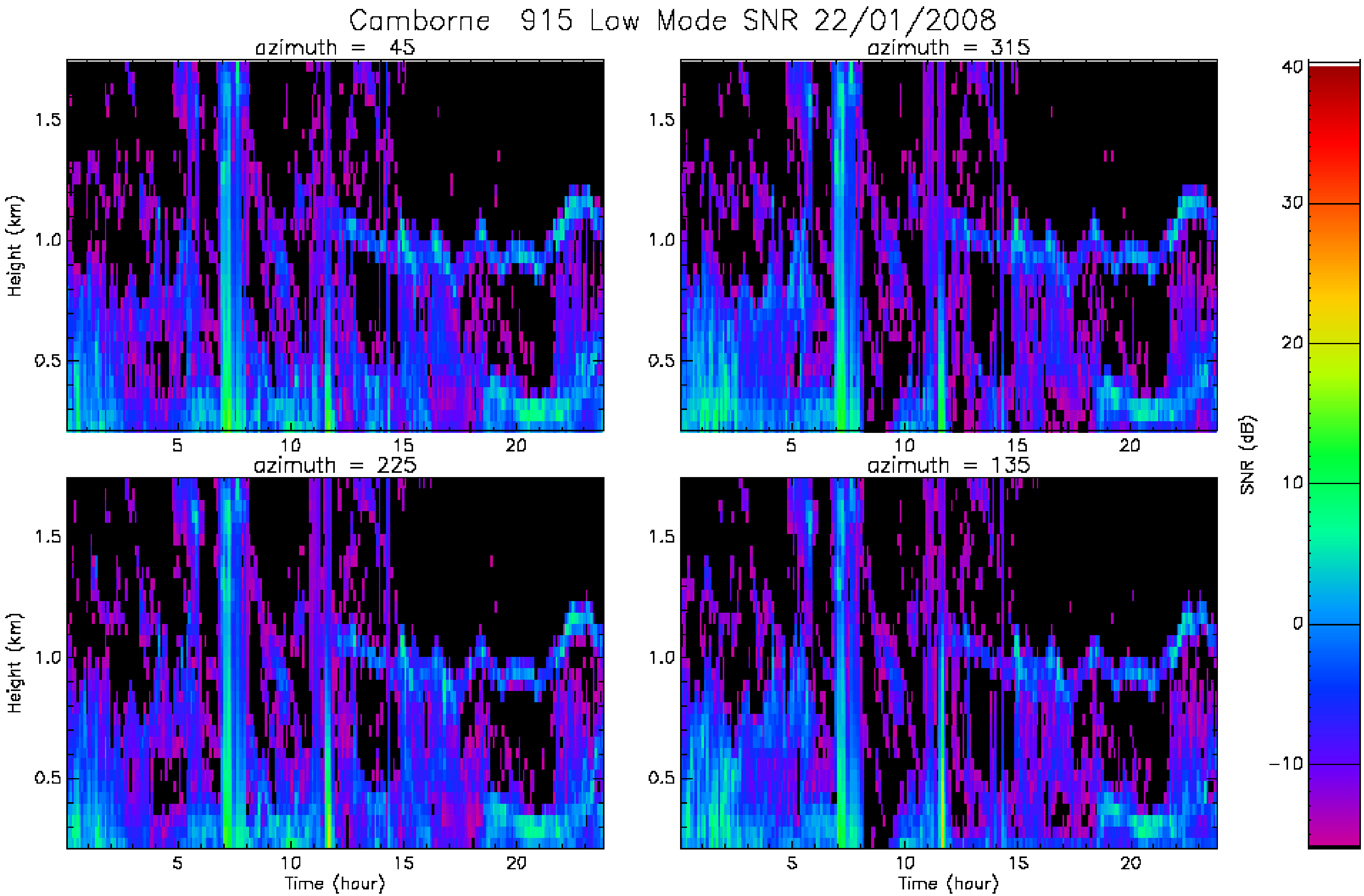

04.00 to 07.00
Cloud base from ceilometer about 550m
Top of wind profiler signal, 3.3to 4.2 km
flectivity
Vertical Velocity
8 km
10 s
None
Last Scan
Range [m]
Time [hh:mm]
Intensity [dBZ]
Last Scan Time Stamp
Peak [dBz]
2008/01/22 06:59:34
-35.6859
Data file
D:\Camborne\ycr002_20080122_060734_mod.csv
Cursors:

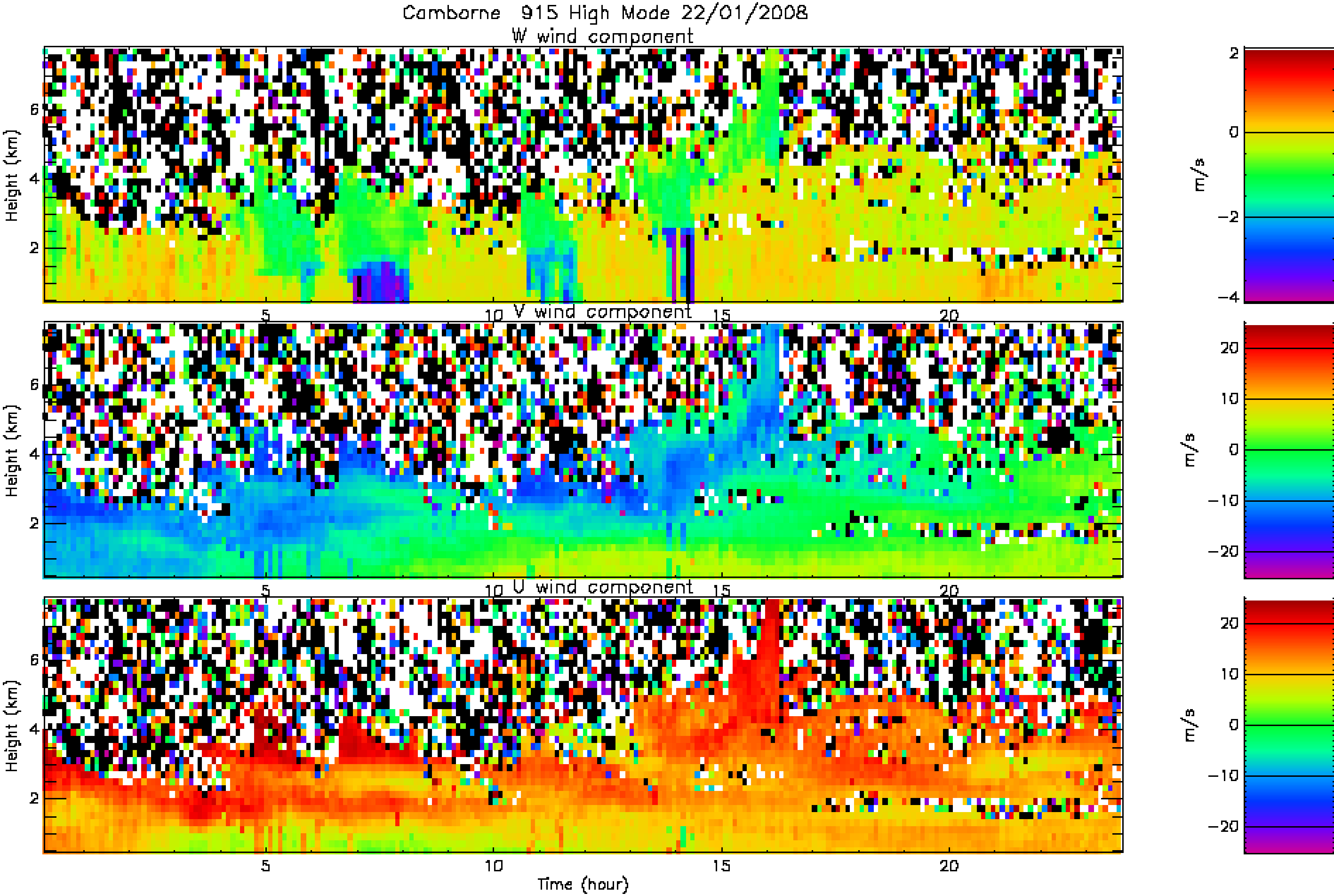

915 MHz wind profiler

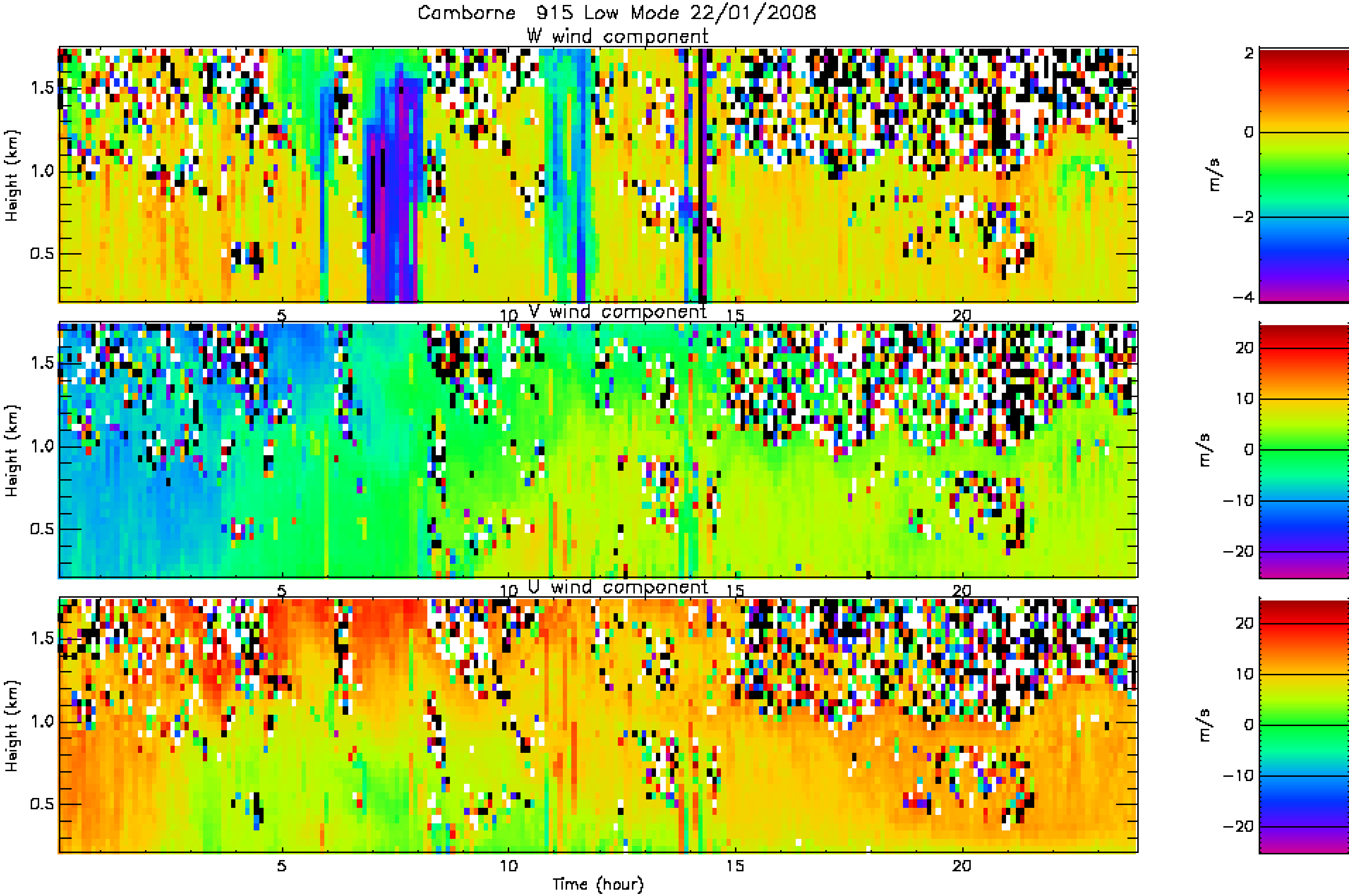
915 MHz wind profiler, quality evaluation tool



915 MHz wind profiler, quality evaluation tool




Camborne 915 High Mode 22/01/2008
W wind component
V wind component
U wind component
Height (km)
Time (hour)
m/s
2
0
−2
−4
20
10
0
−10
−20
5
10
15
20
2
4
6

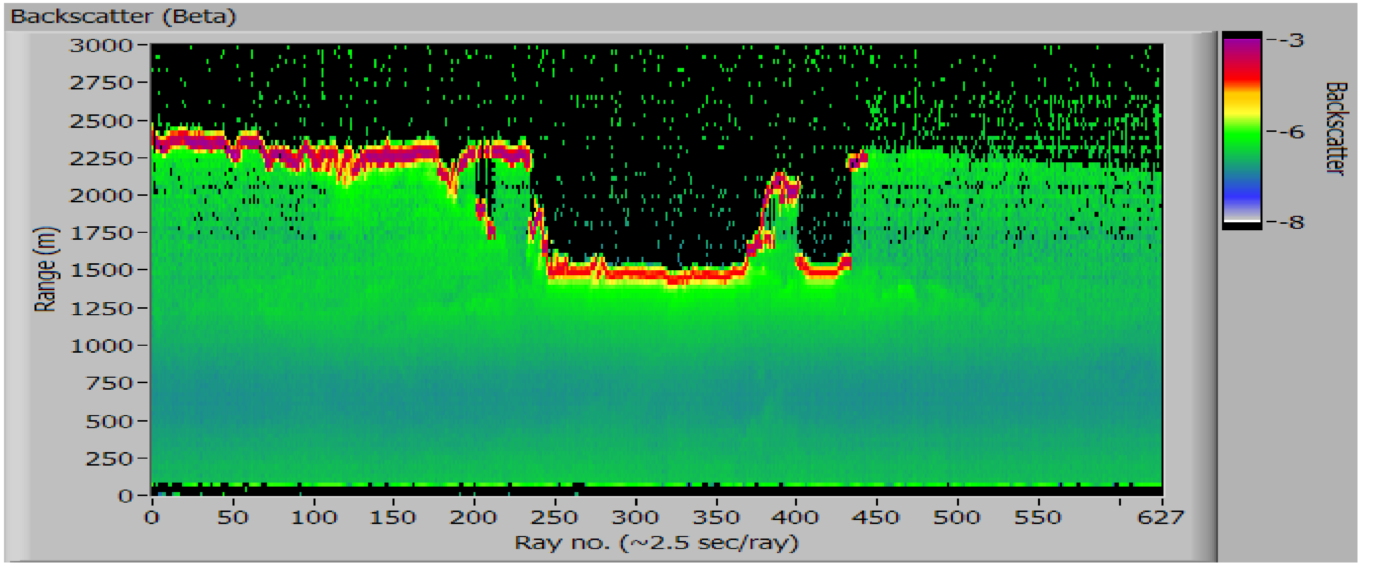


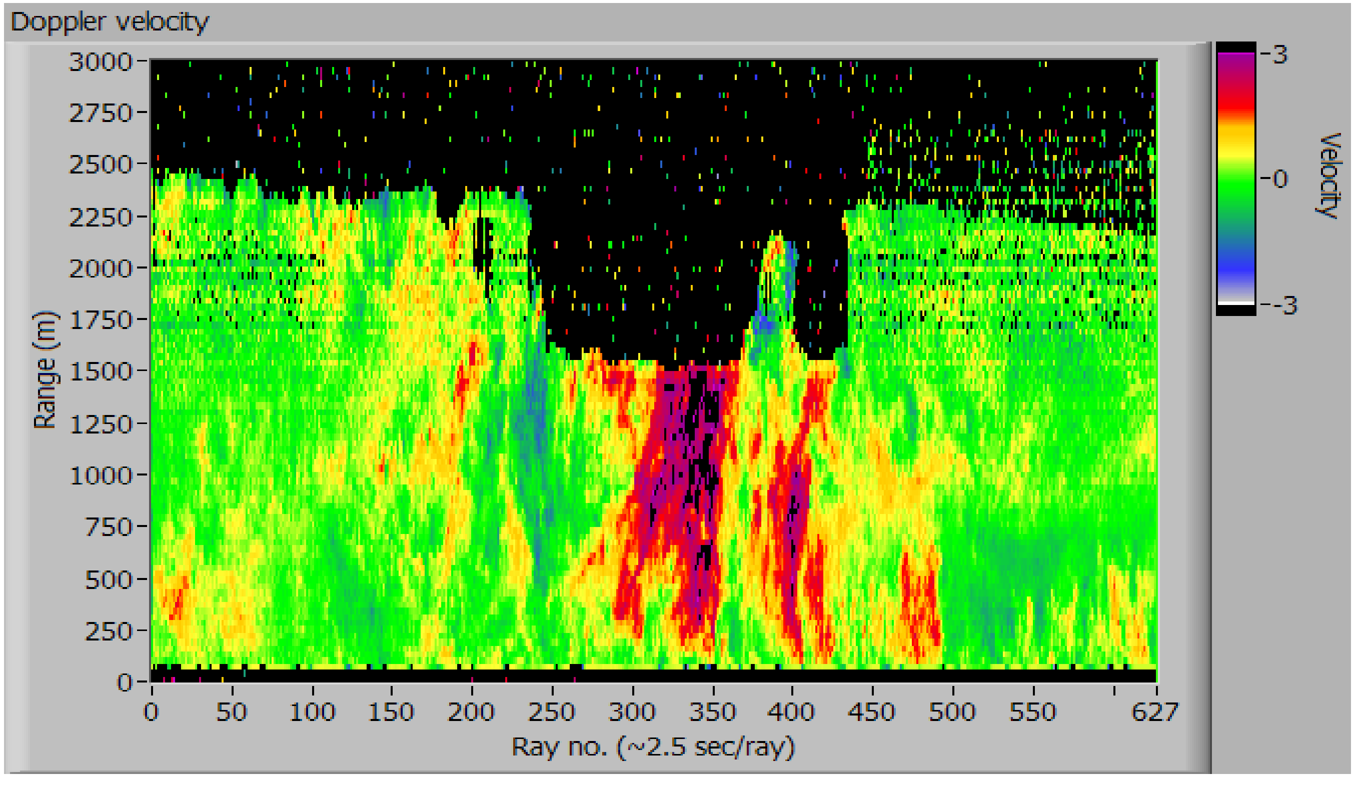
Camborne 915 Low Mode 22/01/2008
W wind component
V wind component
U wind component
Height (km)
Time (hour)
m/s

Optical Doppler lidar

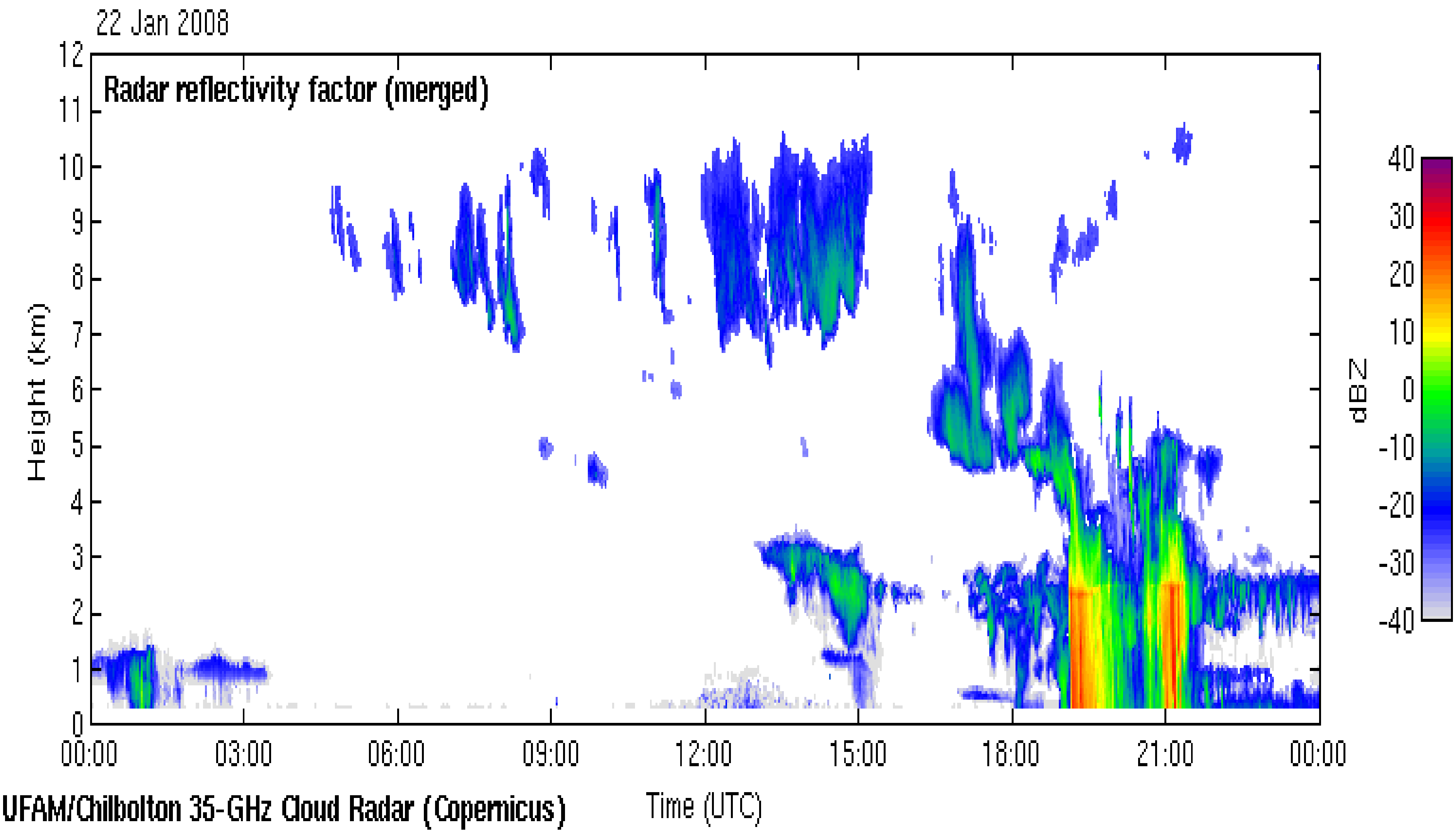
Halo Photonics
Vertical velocity

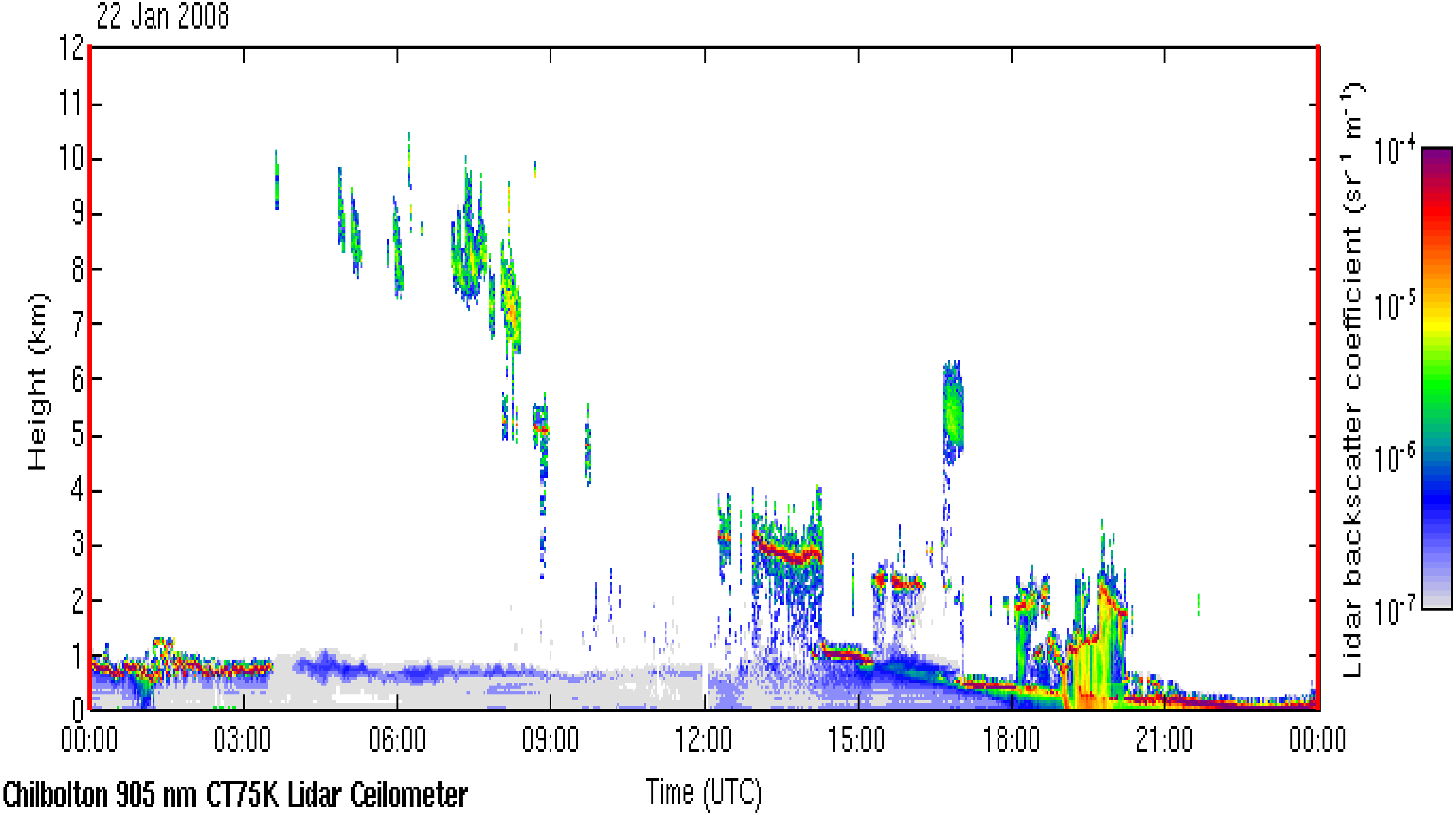
Cardington
13.09.07
Starting at 16.00



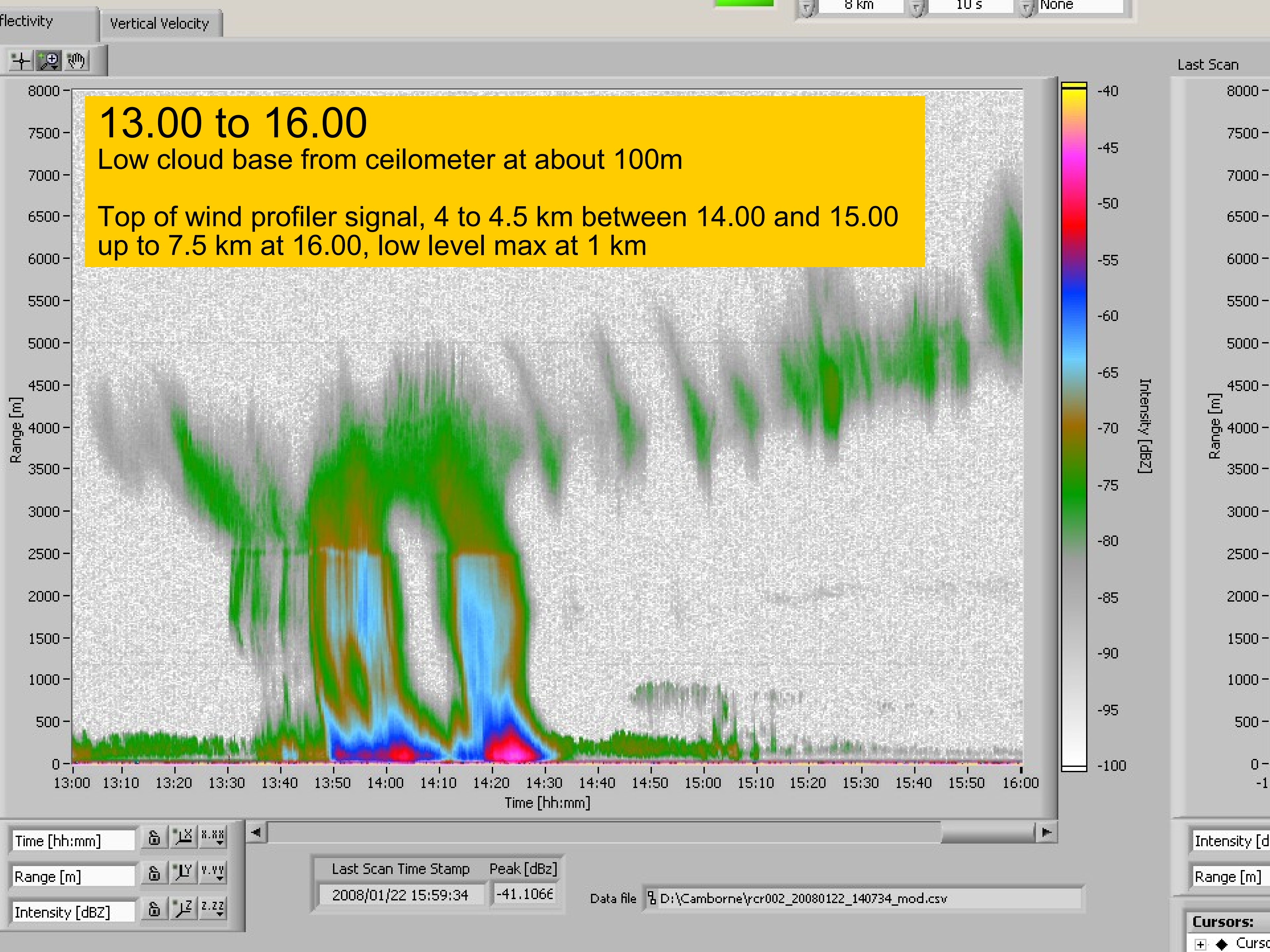


94 GHz and 35 GHz pulsed cloud radars at Chibolton, UK.

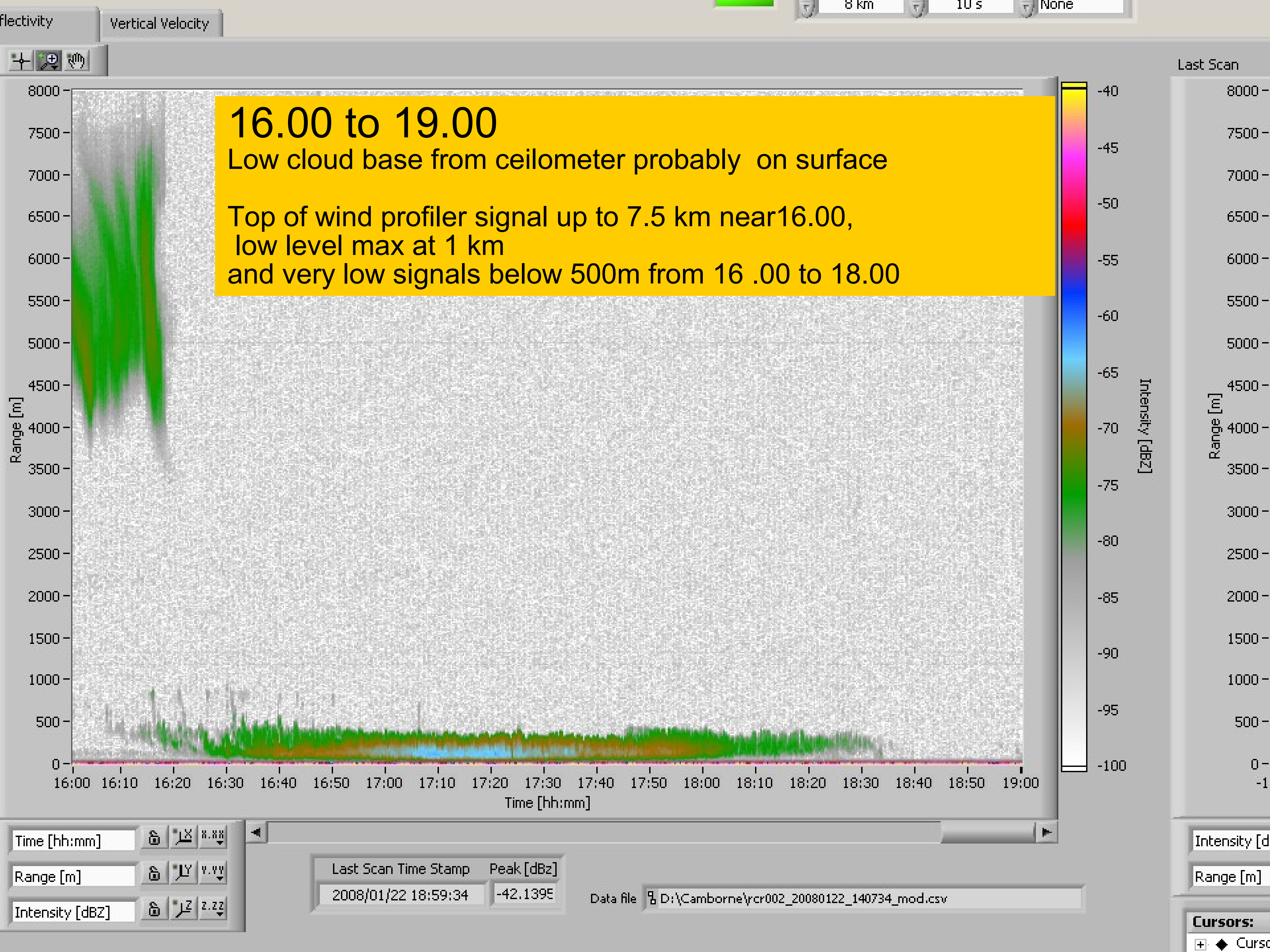

22 Jan 2008
Radar reflectivity factor (merged)
Height (km)
0
1
2
3
4
5
6
7
8
9
10
11
12
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time (UTC)
UFAM/Chilbolton 35-GHz Cloud Radar (Copernicus)
dBZ
40
30
20
10
0
-10
-20
-30
-40


22 Jan 2008
Height (km)
12
11
10
9
8
7
6
5
4
3
2
1
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time (UTC)
Lidar backscatter coefficient (sr⁻¹ m⁻¹)
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
Chilbolton 905 nm CT75K Lidar Ceilometer


94 GHz fmcw cloud radar



13.00 to 16.00
Low cloud base from ceilometer at about 100m
Top of wind profiler signal, 4 to 4.5 km between 14.00 and 15.00
up to 7.5 km at 16.00, low level max at 1 km
flectivity
Vertical Velocity
8 km
10 s
None
Last Scan
Range [m]
Time [hh:mm]
Intensity [dBZ]
13:00
13:10
13:20
13:30
13:40
13:50
14:00
14:10
14:20
14:30
14:40
14:50
15:00
15:10
15:20
15:30
15:40
15:50
16:00
Last Scan Time Stamp
2008/01/22 15:59:34
Peak [dBz]
-41.1066
Data file
D:\Camborne\rcr002_20080122_140734_mod.csv
Cursors:



flectivity
Vertical Velocity
8 km
10 s
None
Last Scan
16.00 to 19.00
Low cloud base from ceilometer probably on surface
Top of wind profiler signal up to 7.5 km near16.00,
low level max at 1 km
and very low signals below 500m from 16 .00 to 18.00
Range [m]
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
16:00 16:10 16:20 16:30 16:40 16:50 17:00 17:10 17:20 17:30 17:40 17:50 18:00 18:10 18:20 18:30 18:40 18:50 19:00
Time [hh:mm]
-40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100
Intensity [dBZ]
Time [hh:mm]
Range [m]
Intensity [dBZ]
Last Scan Time Stamp
2008/01/22 18:59:34
Peak [dBz]
-42.1395
Data file
D:\Camborne\ycr002_20080122_140734_mod.csv
Intensity [d
Range [m]
Cursors:
Curso

Integration Project

- Aims to develop new products from basic measurements ofbasic intsruments,

- E.g. more detailed estimates of clouds
- Identification of top of the convective boundary layer
- Identifiy significant capping inversions
- Estimates of cloud top
- Estimates of fog depth

Summary

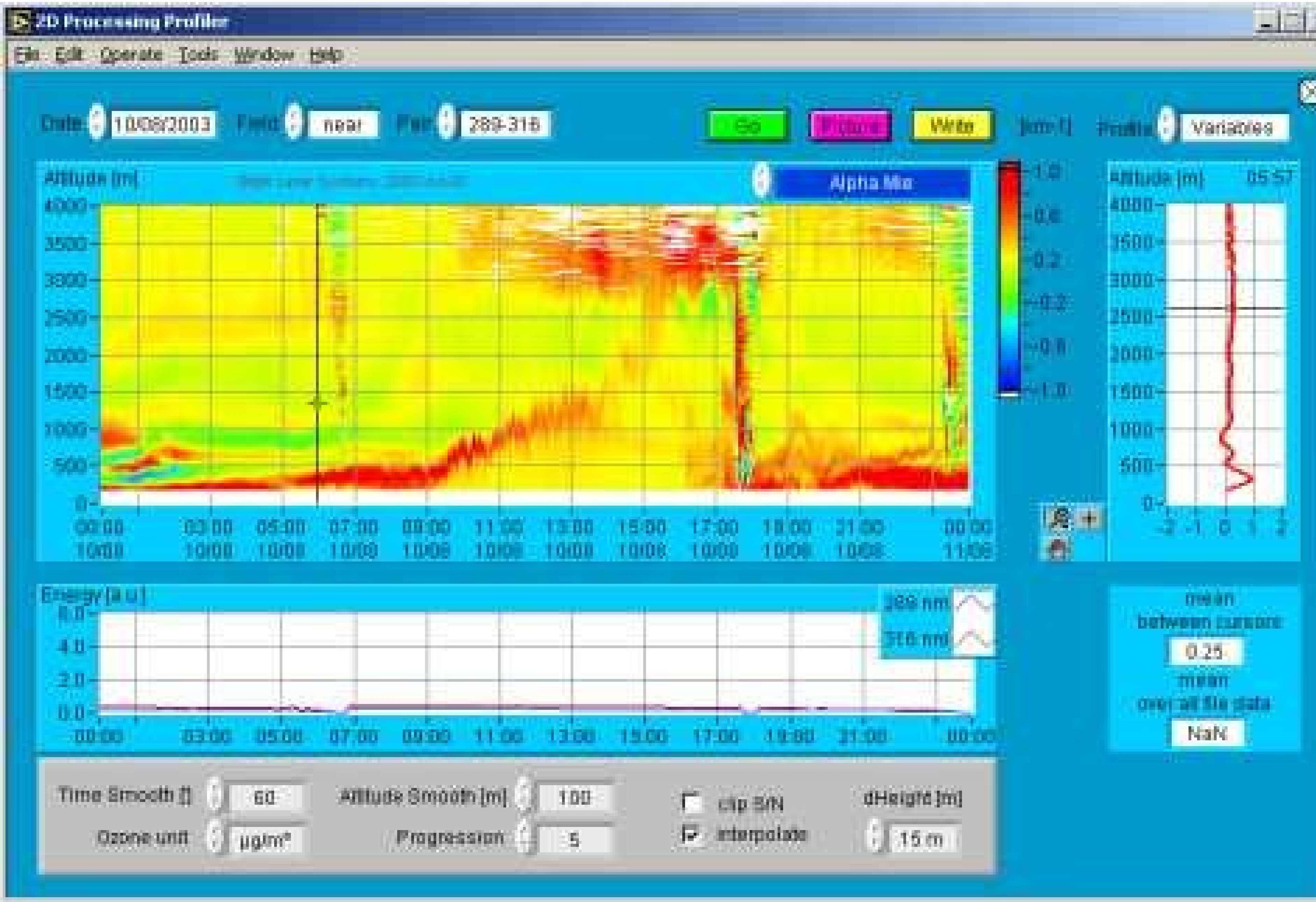
- Ground based remote sensing is required in future upper air networks
- Design of networks needs to be based on a knowledge of mesoscale structure and the associated atmospheric structures
- Error characteristics of the remote sensing observations must be established for data assimilation techniques
- Improved operational practices need to be developed and are not yet readily available
- It is recommended that testbed experiments be used to develop the necessary knowledge
- CIMO/WMO will sponsor experiments

UFAM Ozone and Aerosol Lidar

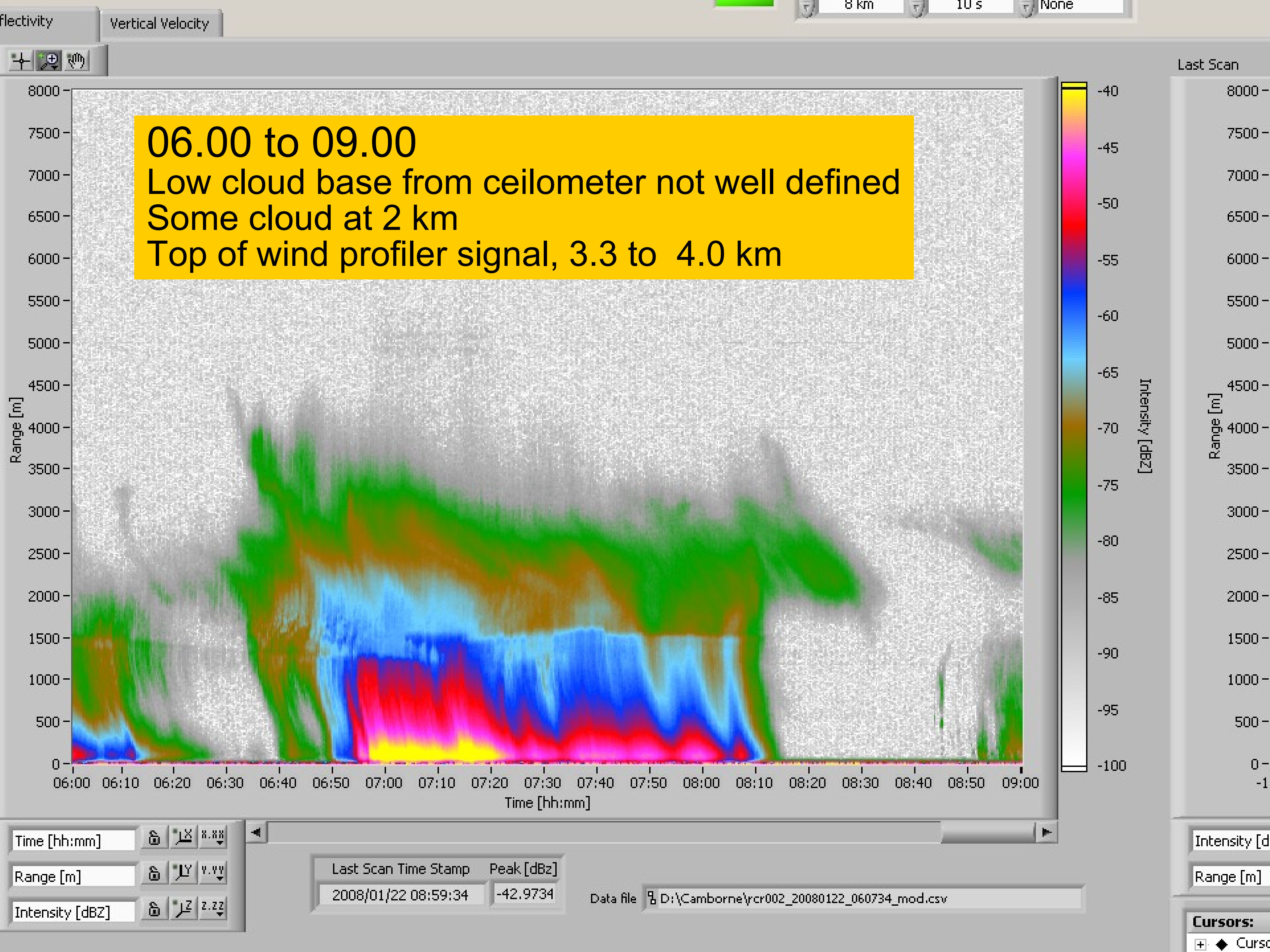
Geraint Vaughan, Emily Norton, Dave Wareing, Hugo Ricketts

- The five wavelength ozone profiler is a compact stand alone differential absorption lidar (DIAL) system designed by Elight uses a Continuum PL8020 Nd:YAG laser in conjunction with a multiplexer to pump Raman shifting cells to produce wavelengths of 266, 289, 299, 316 and 315 nm. The wavelengths 289 nm, 299 nm and 316 nm are generated by stimulated Raman scattering in three respective Raman cells. The 266 nm light beam of the laser pumps the Raman gas cells sequentially by means of a continuously triggering multiplexer. These beams are expanded and emitted into the atmosphere. Backscattered light is collected in a double-coaxial 40 cm diameter telescope allowing measurements in both the near and far field and detected using analogue photo-multiplier tubes.

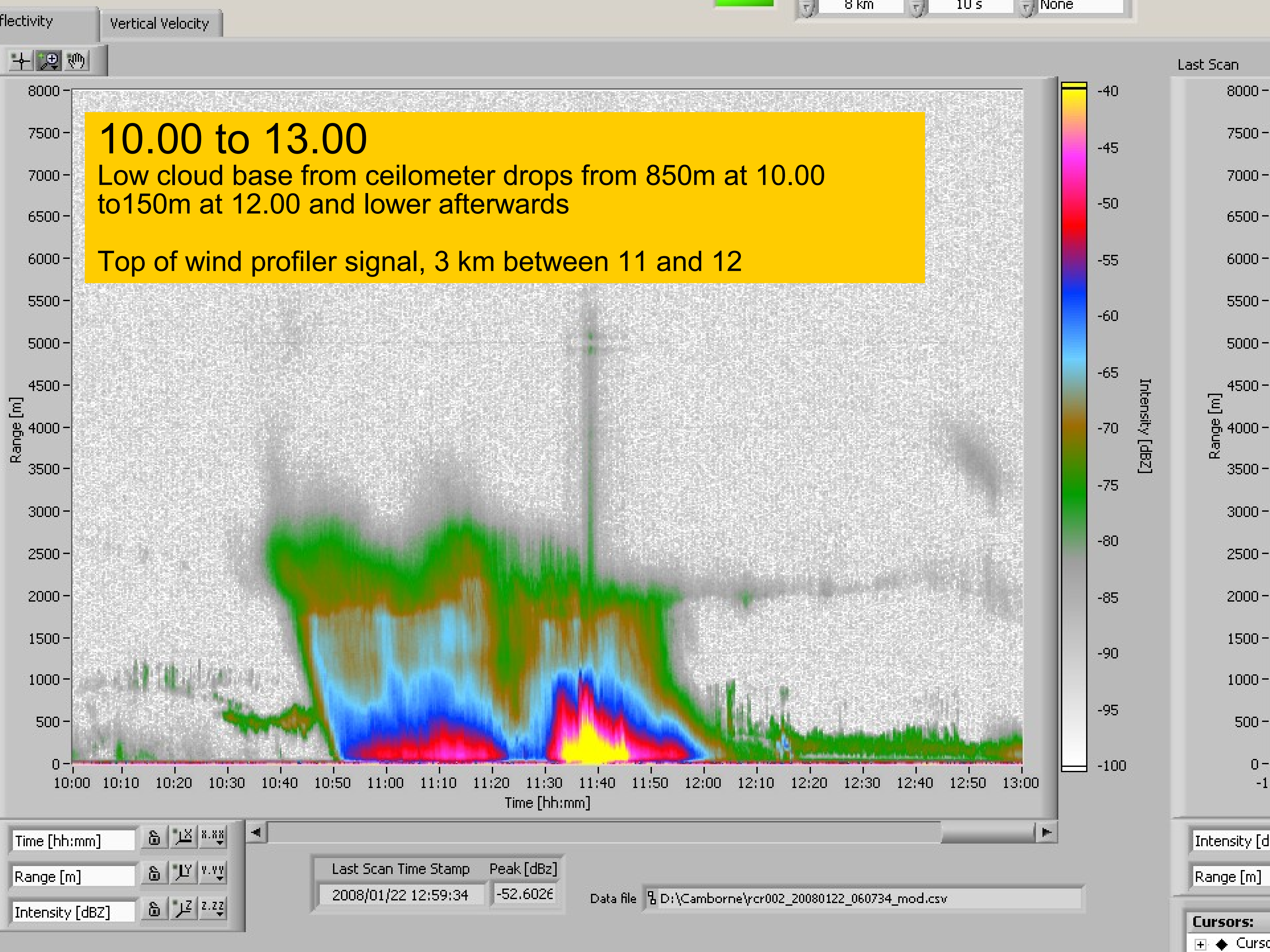
- The system uses five wavelength beams in the UV region two 'on' and three 'off' the absorption cross-section of ozone . The attenuation at these wavelengths is measured and used to calculate the vertical distribution of ozone and aerosols up to altitudes of ~5 km.


2D Processing Profiler
File Edit Operate Tools Window Help
Date 10/08/2003
Field near
Pair 289-316
Go
Picture
Write
[km-1]
Profile Variables
Altitude [m]
Alpha Mie
Energy [a.u.]
289 nm
316 nm
mean between cursors
0.25
mean over all file data
NaN
Time Smooth [] 60
Altitude Smooth [m] 100
clip S/N
interpolate
dHeight [m]
Ozone unit µg/m³
Progression 5
15 m

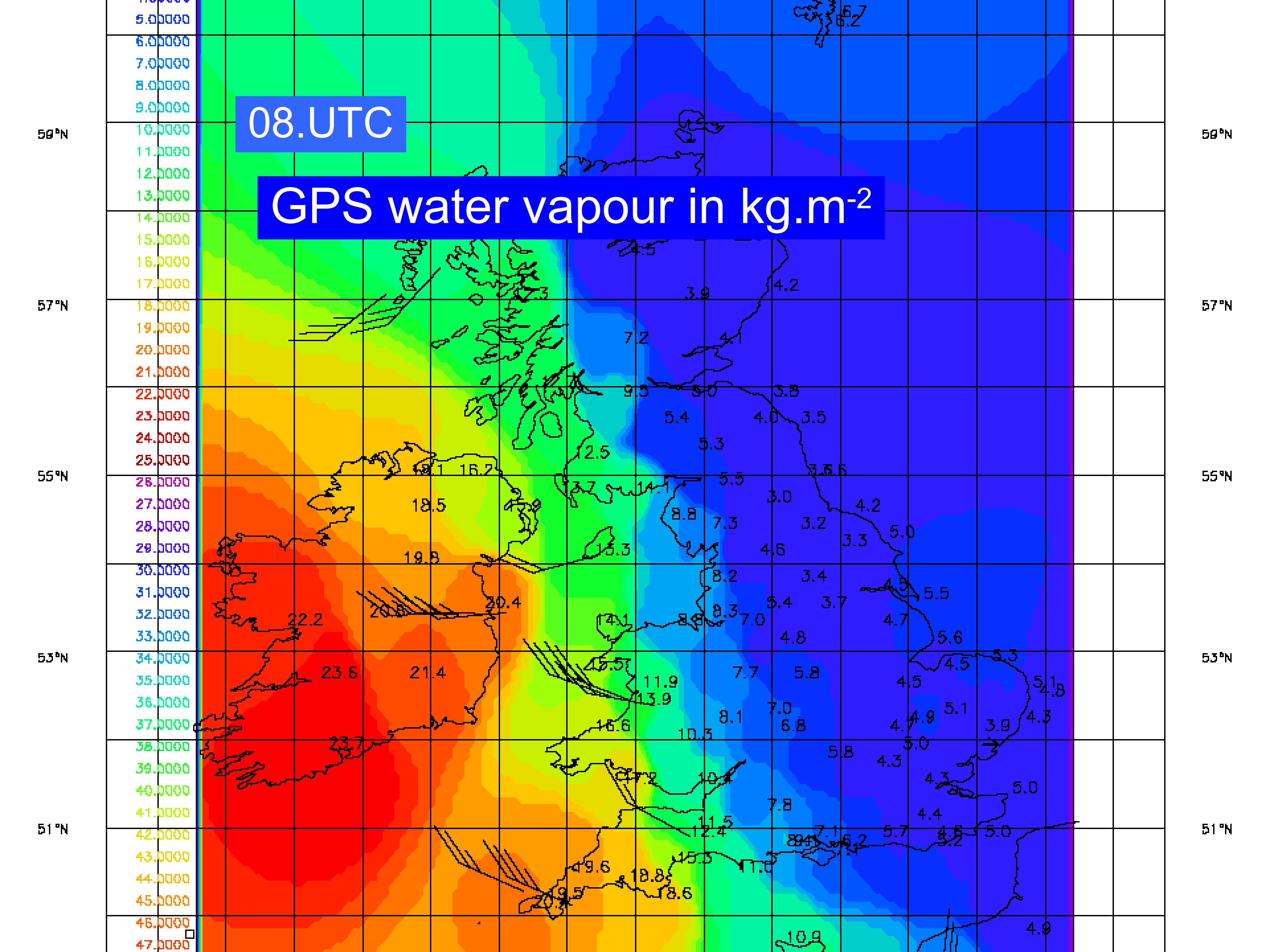
Questions & answers

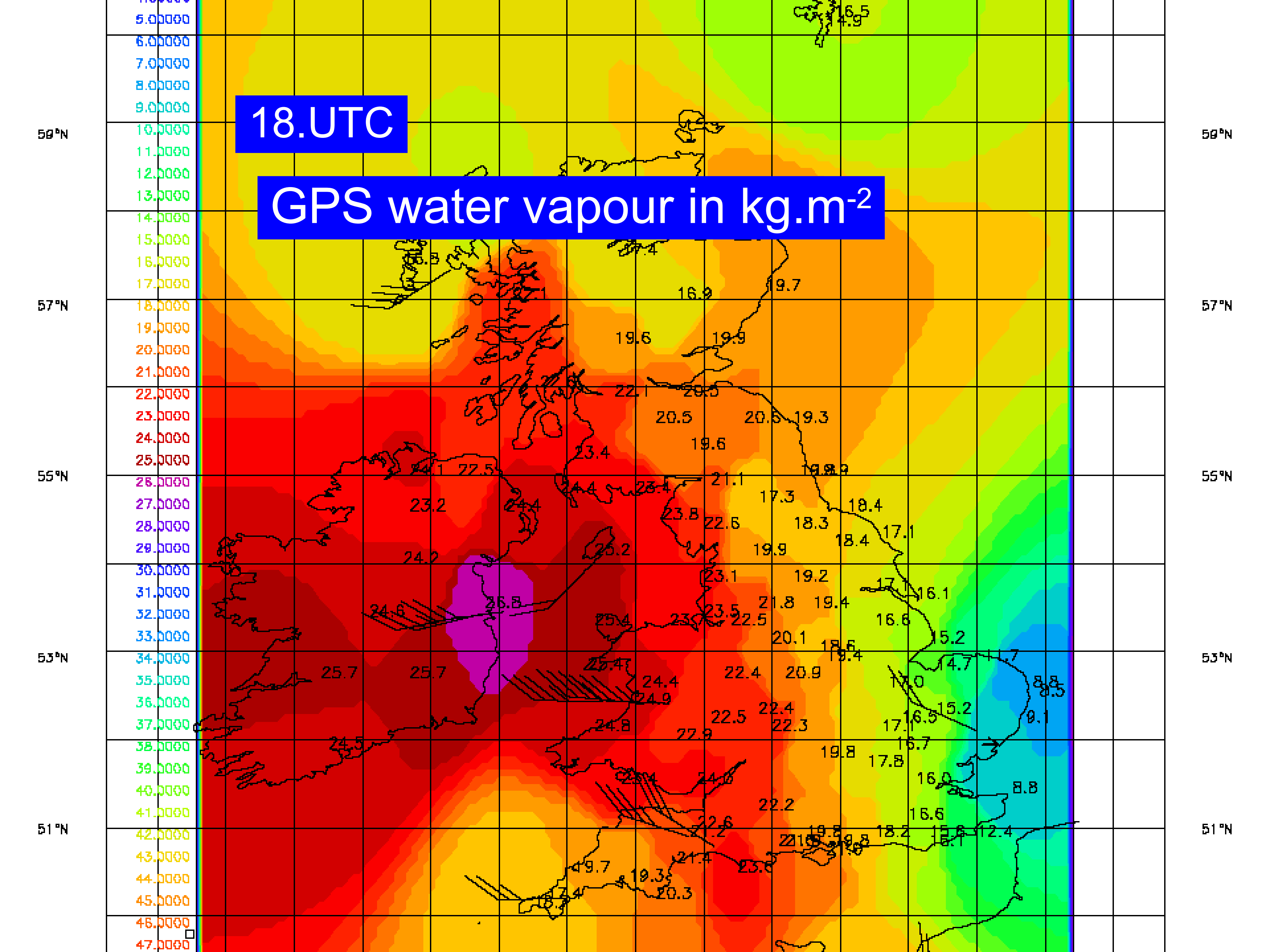


06.00 to 09.00
Low cloud base from ceilometer not well defined
Some cloud at 2 km
Top of wind profiler signal, 3.3 to 4.0 km
flectivity
Vertical Velocity
8 km
10 s
None
Last Scan
Range [m]
Time [hh:mm]
Intensity [dBZ]
06:00
06:10
06:20
06:30
06:40
06:50
07:00
07:10
07:20
07:30
07:40
07:50
08:00
08:10
08:20
08:30
08:40
08:50
09:00
Last Scan Time Stamp
Peak [dBz]
2008/01/22 08:59:34
-42.9734
Data file
D:\Camborne\ycr002_20080122_060734_mod.csv
Cursors:



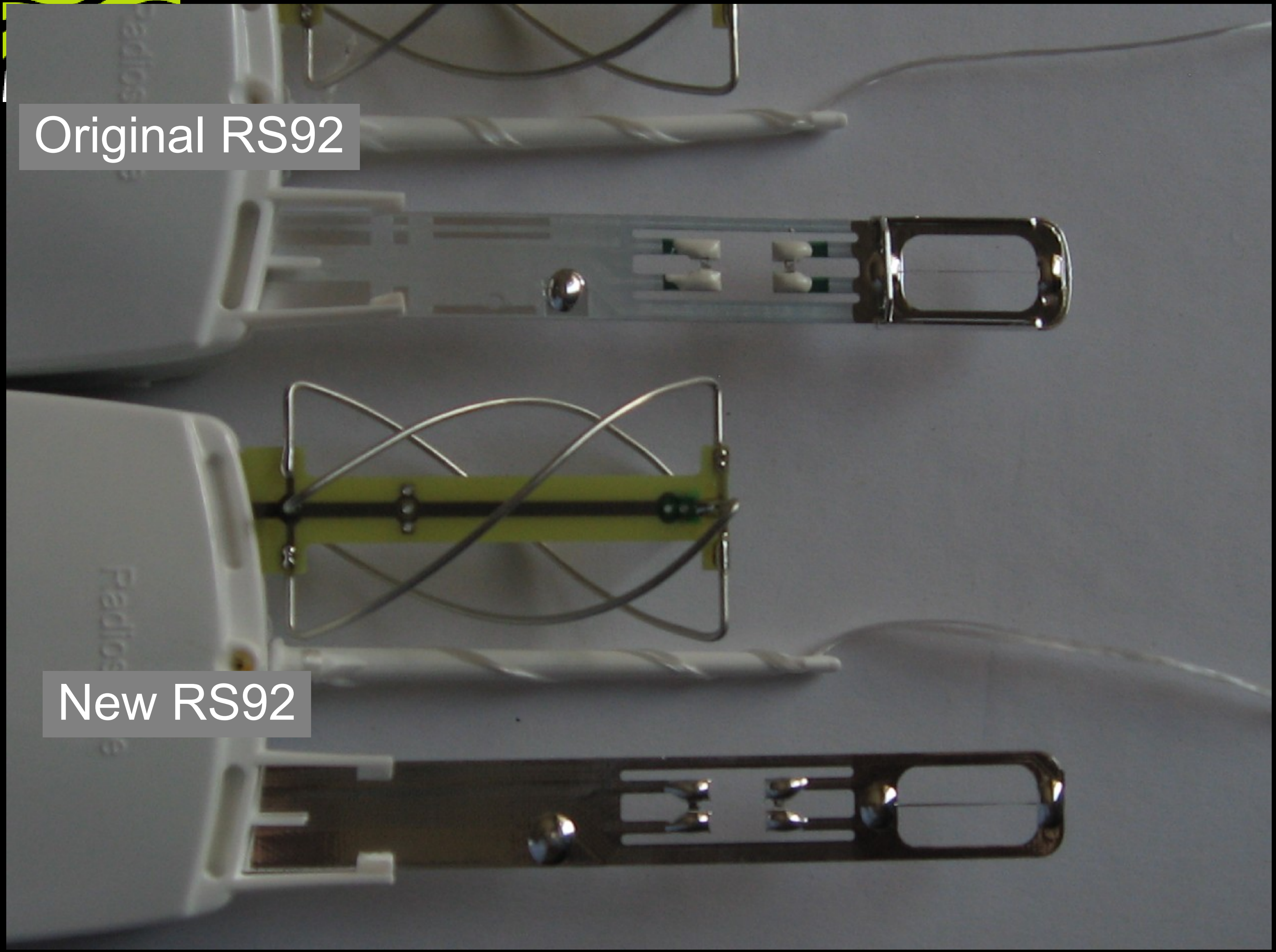
flectivity
Vertical Velocity
8 km
10 s
None
Last Scan
10.00 to 13.00
Low cloud base from ceilometer drops from 850m at 10.00 to150m at 12.00 and lower afterwards
Top of wind profiler signal, 3 km between 11 and 12
Range [m]
Intensity [dBZ]
Time [hh:mm]
10:00 10:10 10:20 10:30 10:40 10:50 11:00 11:10 11:20 11:30 11:40 11:50 12:00 12:10 12:20 12:30 12:40 12:50 13:00
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000
-40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100
Time [hh:mm]
Range [m]
Intensity [dBZ]
Last Scan Time Stamp
2008/01/22 12:59:34
Peak [dBz]
-52.6026
Data file
D:\Camborne\ycr002_20080122_060734_mod.csv
Cursors:


08.UTC
GPS water vapour in kg.m-2
59°N
57°N
55°N
53°N
51°N
5.00000
6.00000
7.00000
8.00000
9.00000
10.0000
11.0000
12.0000
13.0000
14.0000
15.0000
16.0000
17.0000
18.0000
19.0000
20.0000
21.0000
22.0000
23.0000
24.0000
25.0000
26.0000
27.0000
28.0000
29.0000
30.0000
31.0000
32.0000
33.0000
34.0000
35.0000
36.0000
37.0000
38.0000
39.0000
40.0000
41.0000
42.0000
43.0000
44.0000
45.0000
46.0000
47.0000

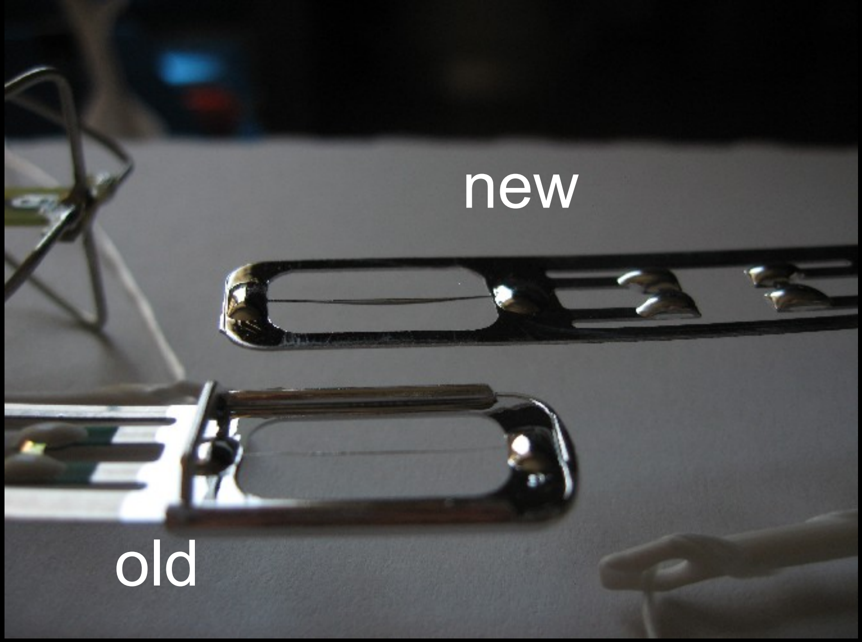

18.UTC
GPS water vapour in kg.m-2
59°N
57°N
55°N
53°N
51°N
5.00000
6.00000
7.00000
8.00000
9.00000
10.0000
11.0000
12.0000
13.0000
14.0000
15.0000
16.0000
17.0000
18.0000
19.0000
20.0000
21.0000
22.0000
23.0000
24.0000
25.0000
26.0000
27.0000
28.0000
29.0000
30.0000
31.0000
32.0000
33.0000
34.0000
35.0000
36.0000
37.0000
38.0000
39.0000
40.0000
41.0000
42.0000
43.0000
44.0000
45.0000
46.0000
47.0000

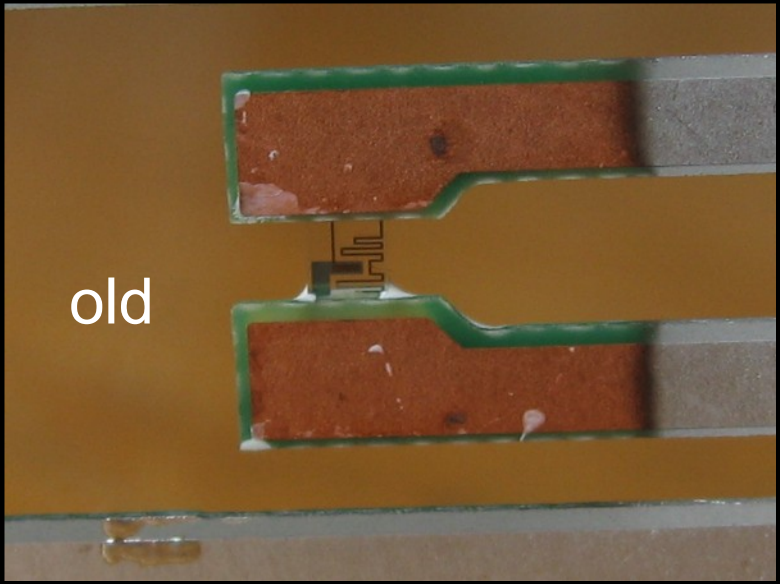
Latest developments in radiosondes

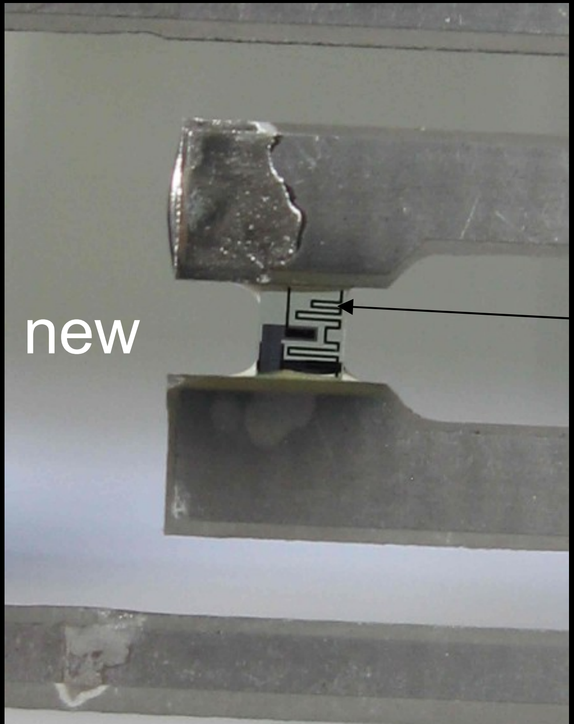
- New Sensors on Vaisala RS92
- New LMS Sippican design
- New Modem sensor designs
- New Intermet (SA) GPS radiosonde


Original RS92
New RS92

Met Office







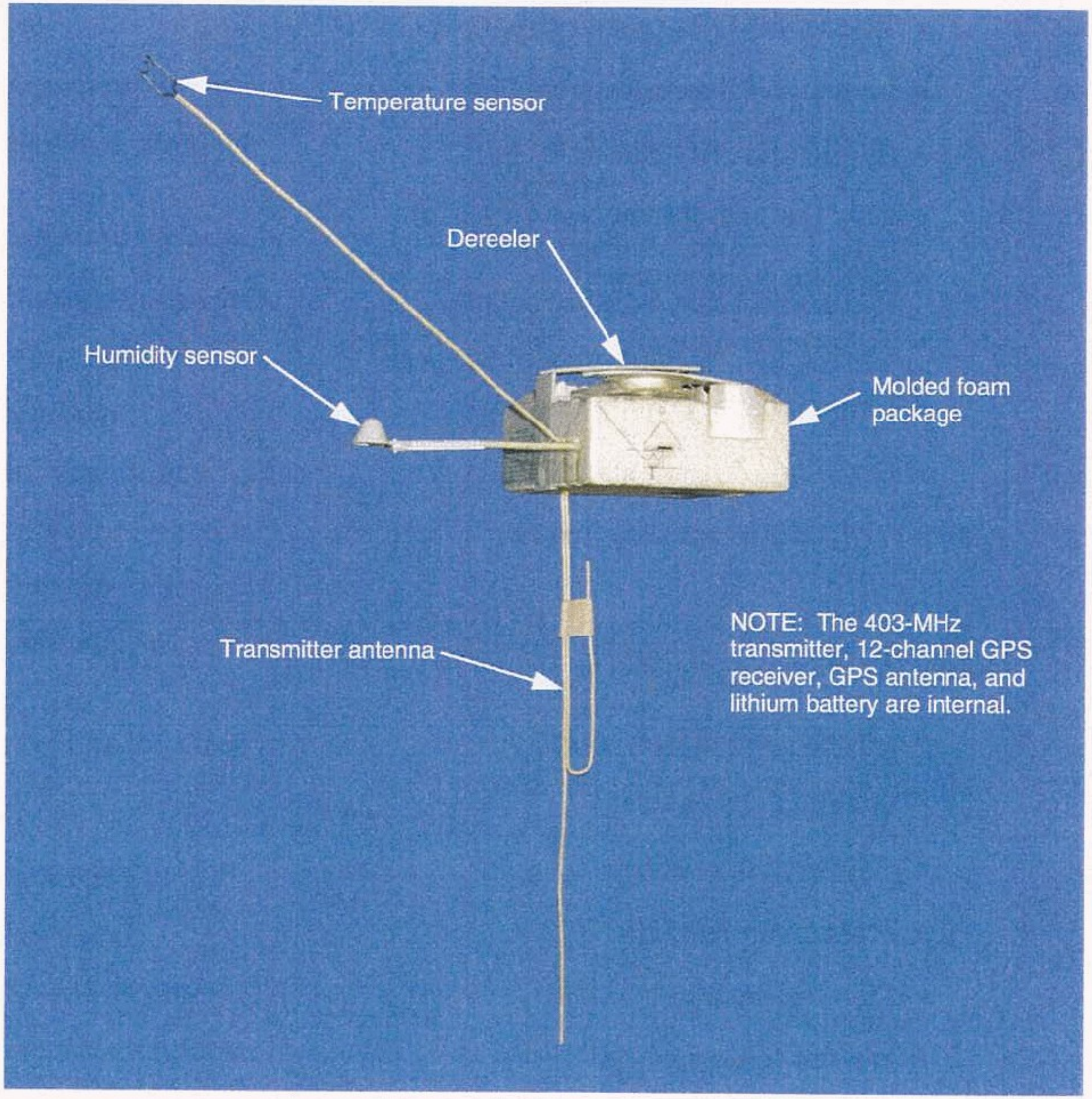
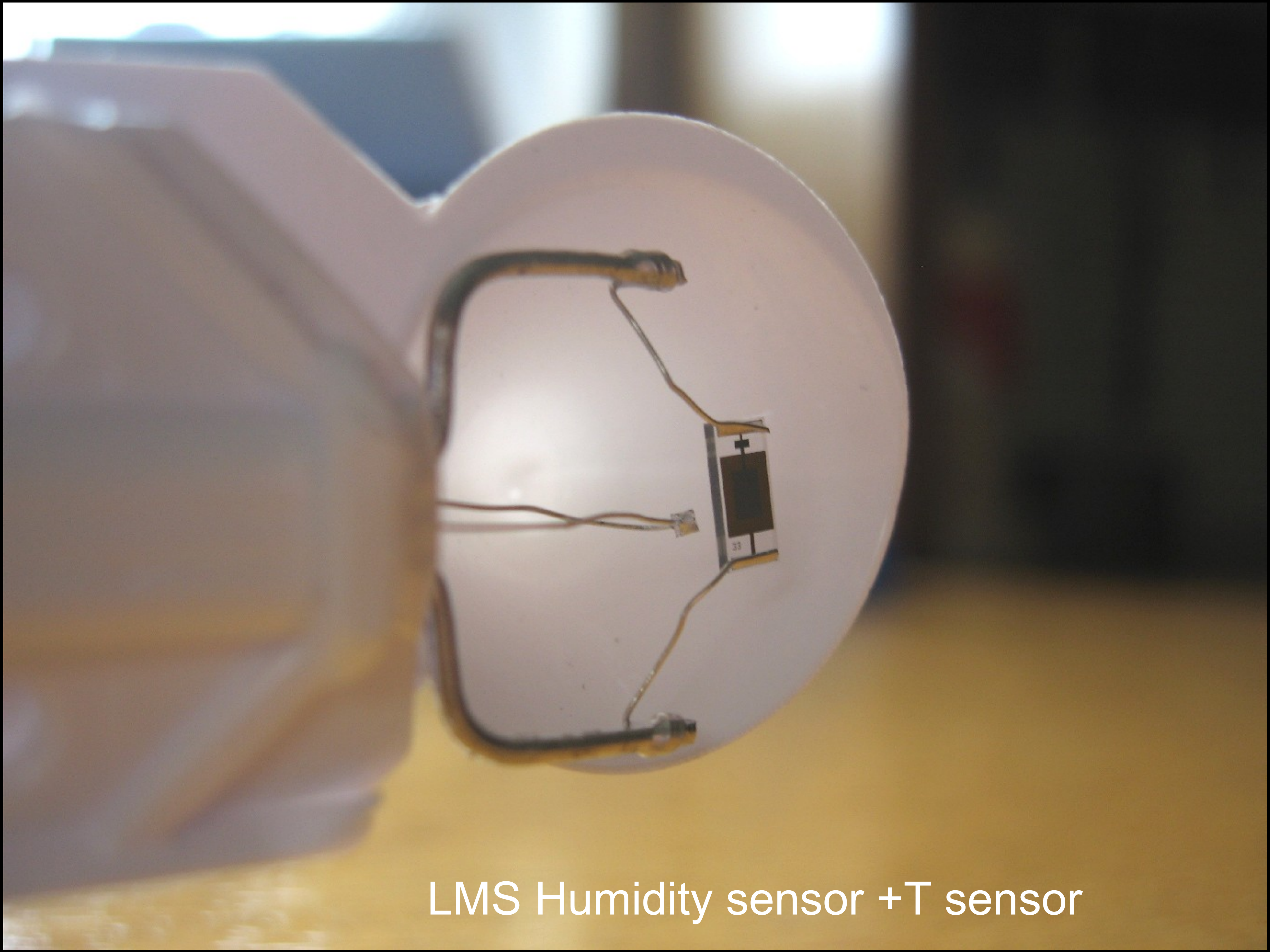


FIGURE 1-1: ***The LMS6 Radiosonde***

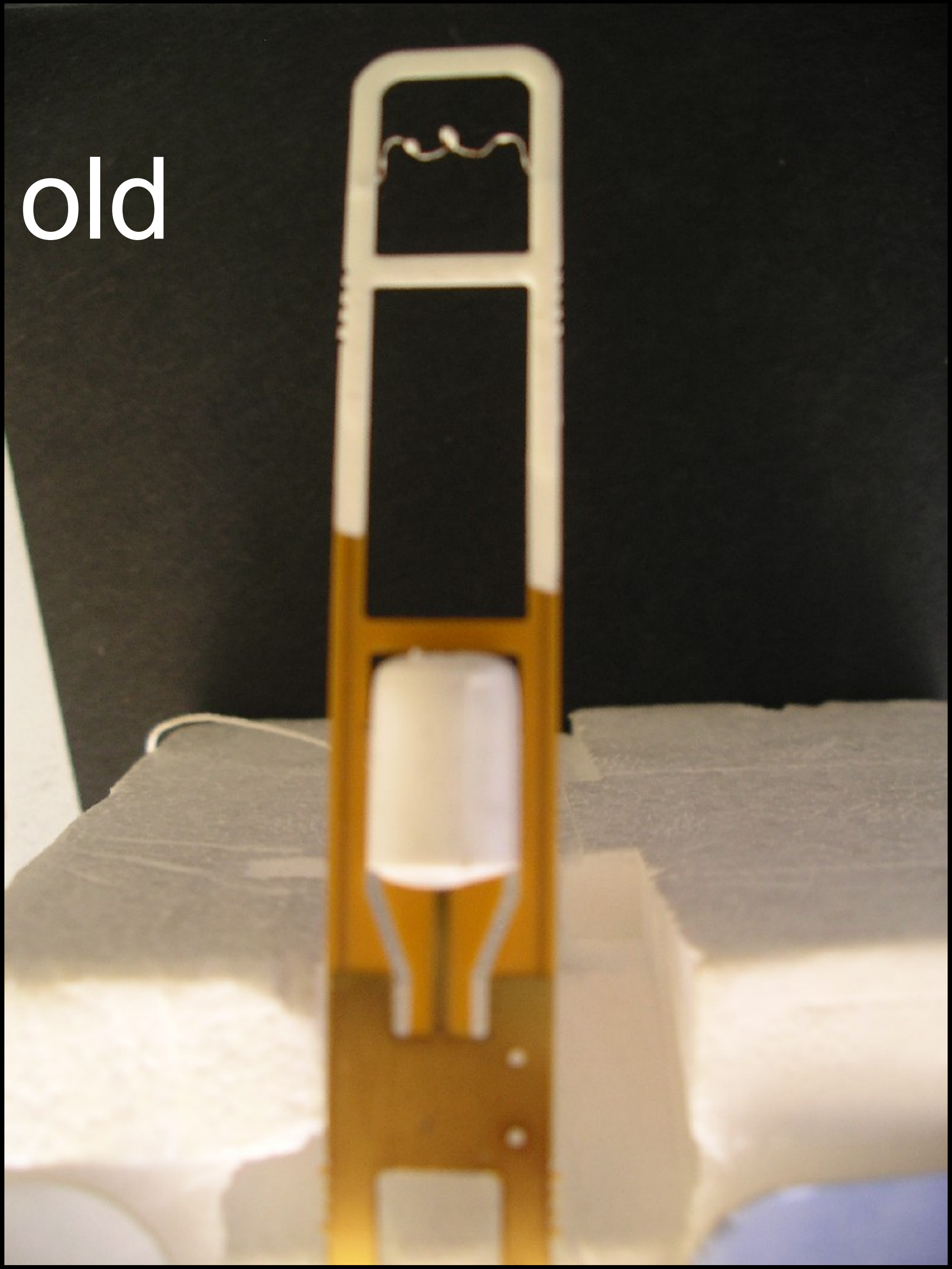


LMS Humidity sensor +T sensor

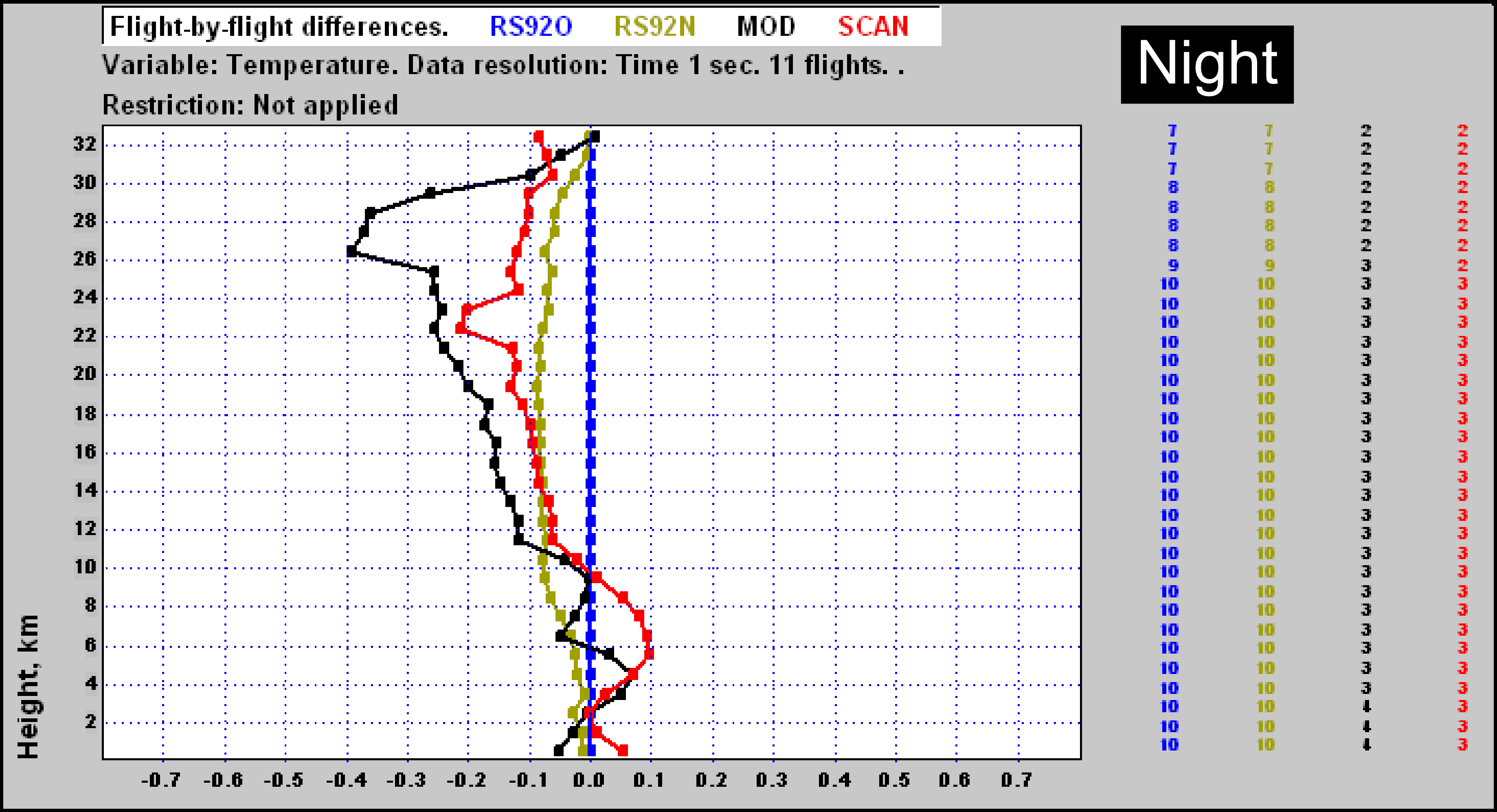
new

Return process
Si vous trouvez cette
participez à la
protection de votr
environnement en
renvoyant la boite
polystyrène et son
contenu par la poste à
dresse indiquée sur le
boîtier. Le parachute e
ballon sont à déposer
dans un container ada
Merci d'avance
If you find a radiosond
please contribute to
your environment
otection in returning
the polystyrene box
nd its contents by
postmail to the addre
printed on the box.
Parachute and balloo
should be put in an
adapted garbage can.

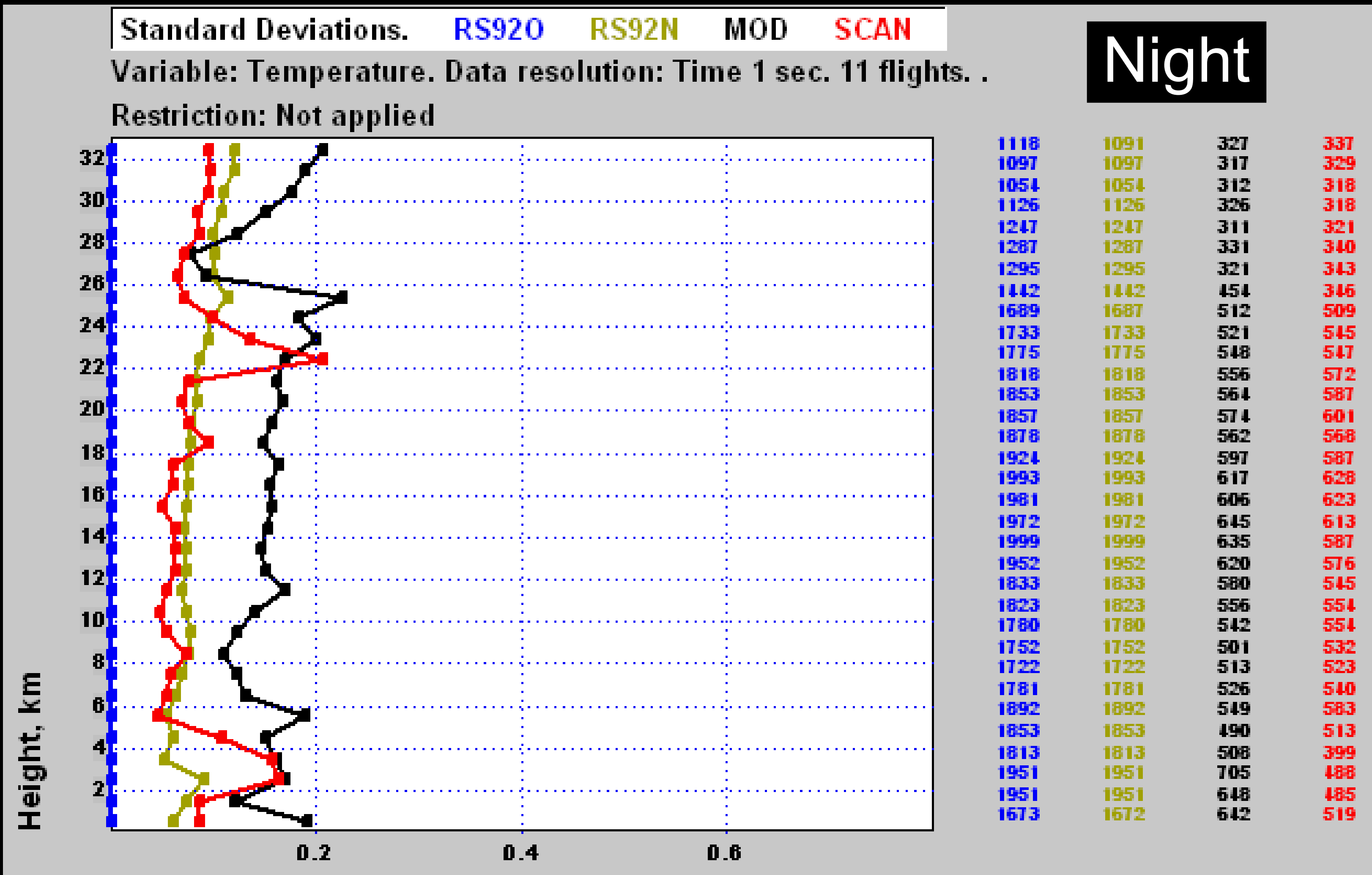
Met Office



Met Office


Flight-by-flight differences. RS92O RS92N MOD SCAN
Variable: Temperature. Data resolution: Time 1 sec. 11 flights. .
Restriction: Not applied
Night
Height, km
32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

Met Office



Standard Deviations. RS92O RS92N MOD SCAN
Variable: Temperature. Data resolution: Time 1 sec. 11 flights. .
Restriction: Not applied
Night
Height, km
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0.2
0.4
0.6
1118 1091 327 337
1097 1097 317 329
1054 1054 312 318
1126 1126 326 318
1247 1247 311 321
1287 1287 331 340
1295 1295 321 343
1442 1442 454 346
1689 1687 512 509
1733 1733 521 545
1775 1775 548 547
1818 1818 556 572
1853 1853 564 587
1857 1857 574 601
1878 1878 562 568
1924 1924 597 587
1993 1993 617 628
1981 1981 606 623
1972 1972 645 613
1999 1999 635 587
1952 1952 620 576
1833 1833 580 545
1823 1823 556 554
1780 1780 542 554
1752 1752 501 532
1722 1722 513 523
1781 1781 526 540
1892 1892 549 583
1853 1853 490 513
1813 1813 508 399
1951 1951 705 488
1951 1951 648 485
1673 1672 642 519

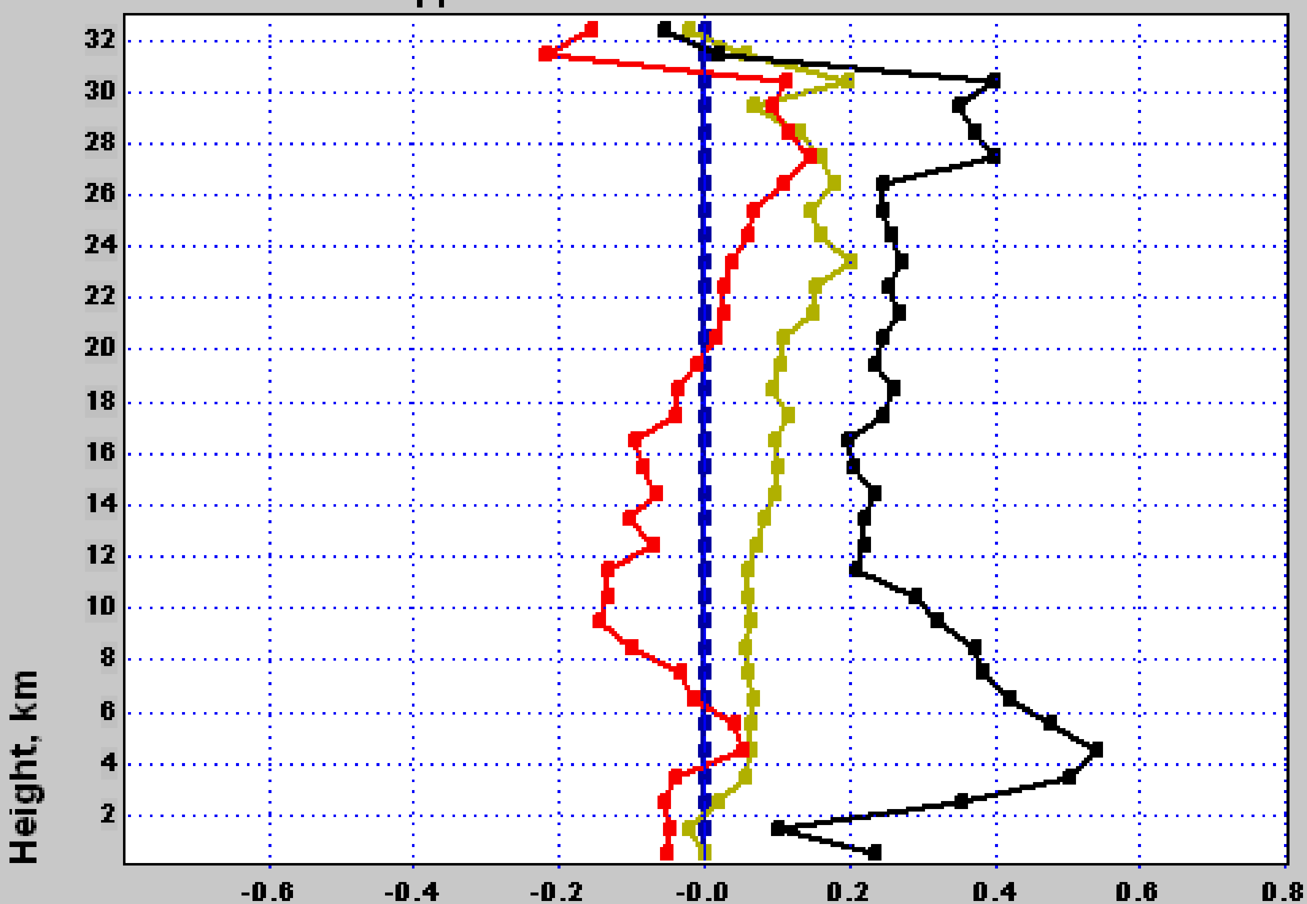
Met Office

Flight-by-flight differences. RS92O RS92N MOD SCAN

Variable: Temperature. Data resolution: Time 1 sec. 21 flights. .

Restriction: Not applied

Day



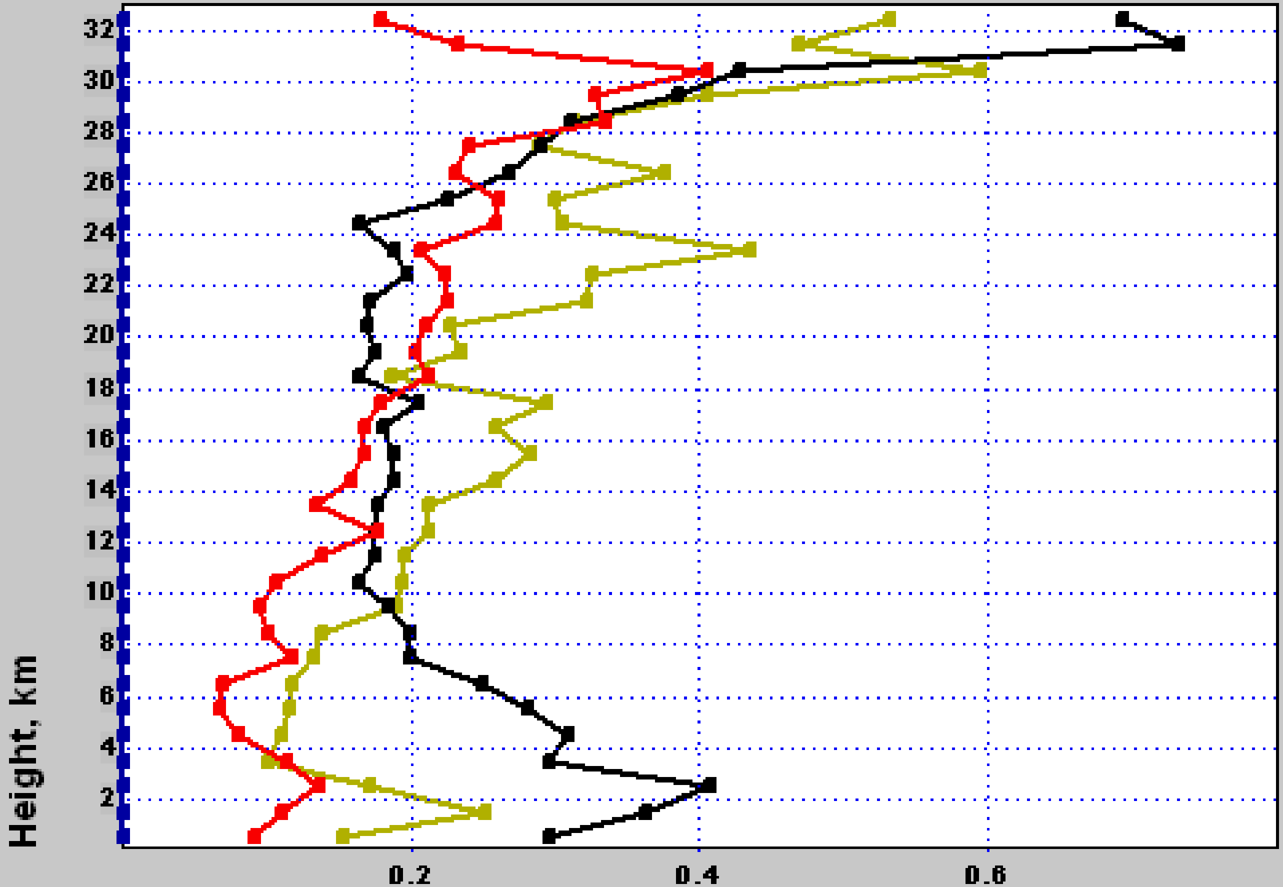
RS92O	RS92N	MOD	SCAN
14	13	3	1
16	15	4	1
19	18	6	3
19	18	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	2
20	19	5	2
20	19	6	3
20	19	6	3

Standard Deviations. RS92O RS92N MOD SCAN

Variable: Temperature. Data resolution: Time 1 sec. 21 flights. .

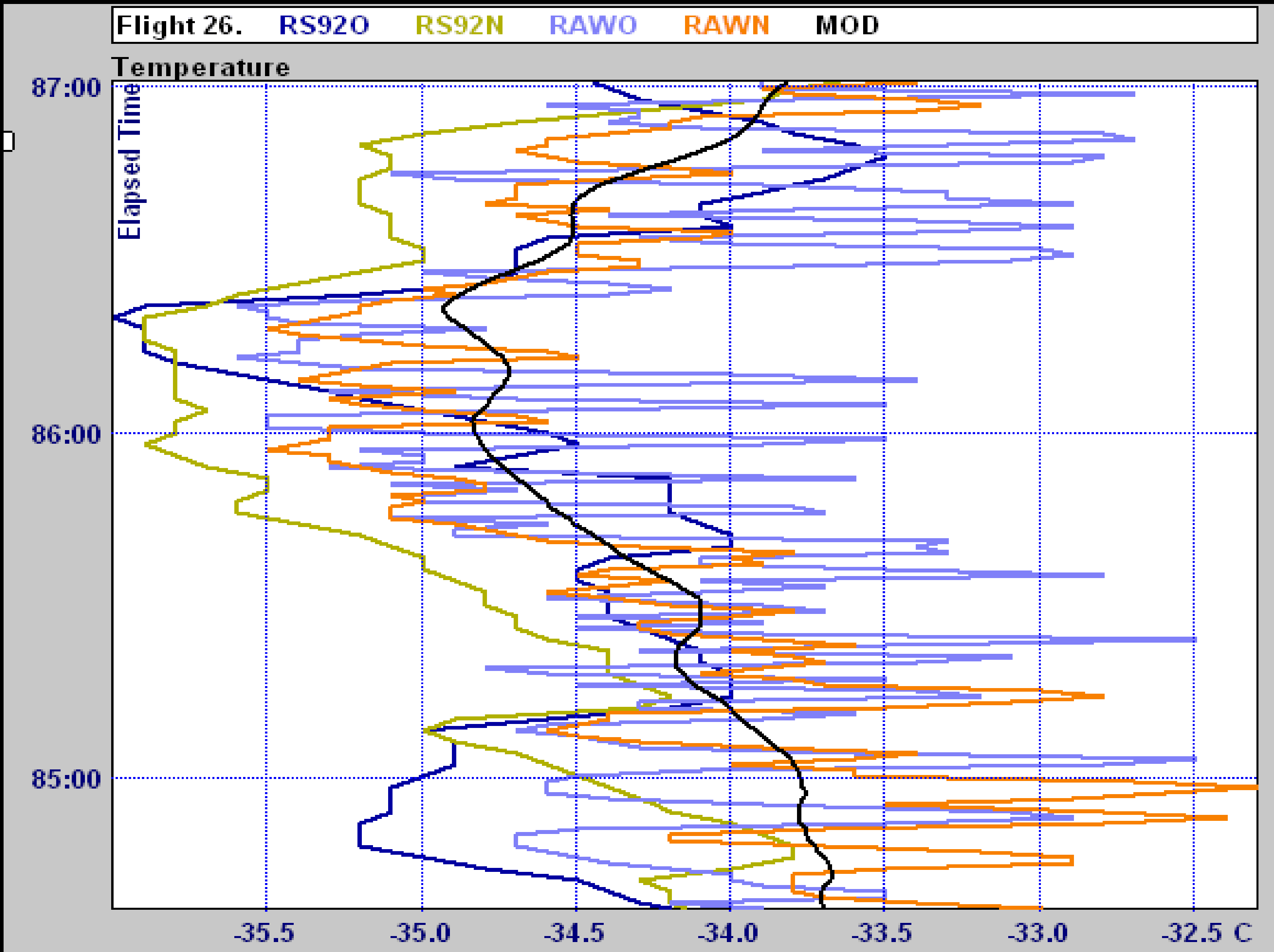
Restriction: Not applied

Day

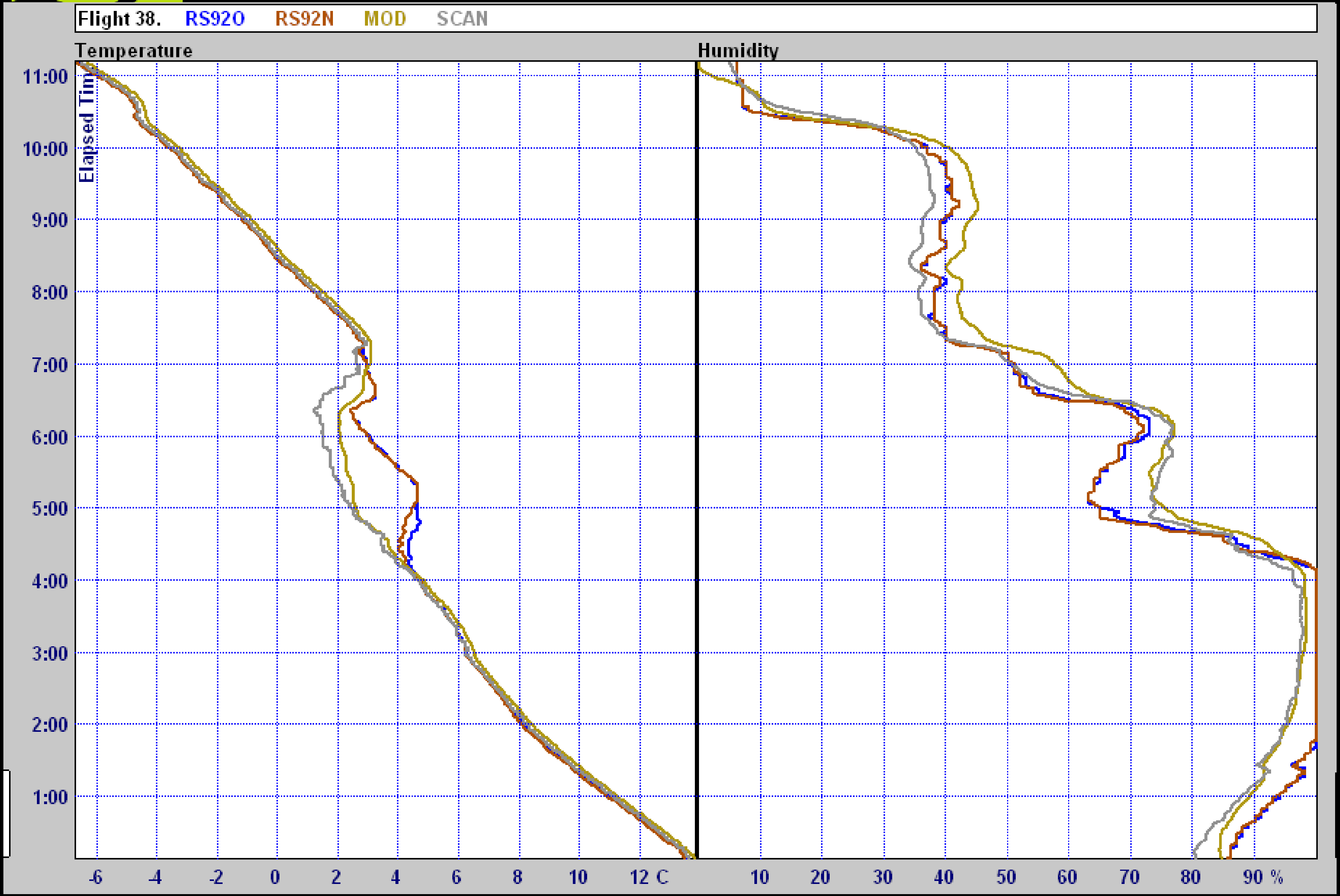


1868	1676	337	140
2351	2202	592	142
2647	2498	854	396
2845	2692	906	458
2935	2782	921	484
3067	2918	921	457
3124	2965	933	476
3180	3020	939	478
3236	3075	958	494
3311	3143	984	497
3419	3246	1006	512
3449	3278	1016	507
3552	3370	1046	550
3628	3446	1078	537
3692	3506	1099	563
3734	3543	1121	574
3813	3622	1137	581
3825	3641	1133	599
3885	3713	1162	614
3851	3674	1148	596
3697	3535	1093	583
3499	3328	1034	539
3452	3280	997	556
3392	3215	965	524
3442	3264	1007	517
3454	3275	1005	522
3564	3379	1041	575
3624	3441	1048	569
3590	3392	1029	410
3552	3372	916	387
3777	3590	948	459
3791	3599	877	434
3361	3200	1014	476

Comparison of raw and processed temperatures at about 15 hPa in day



Evidence of humidity contamination in emerging from cloud

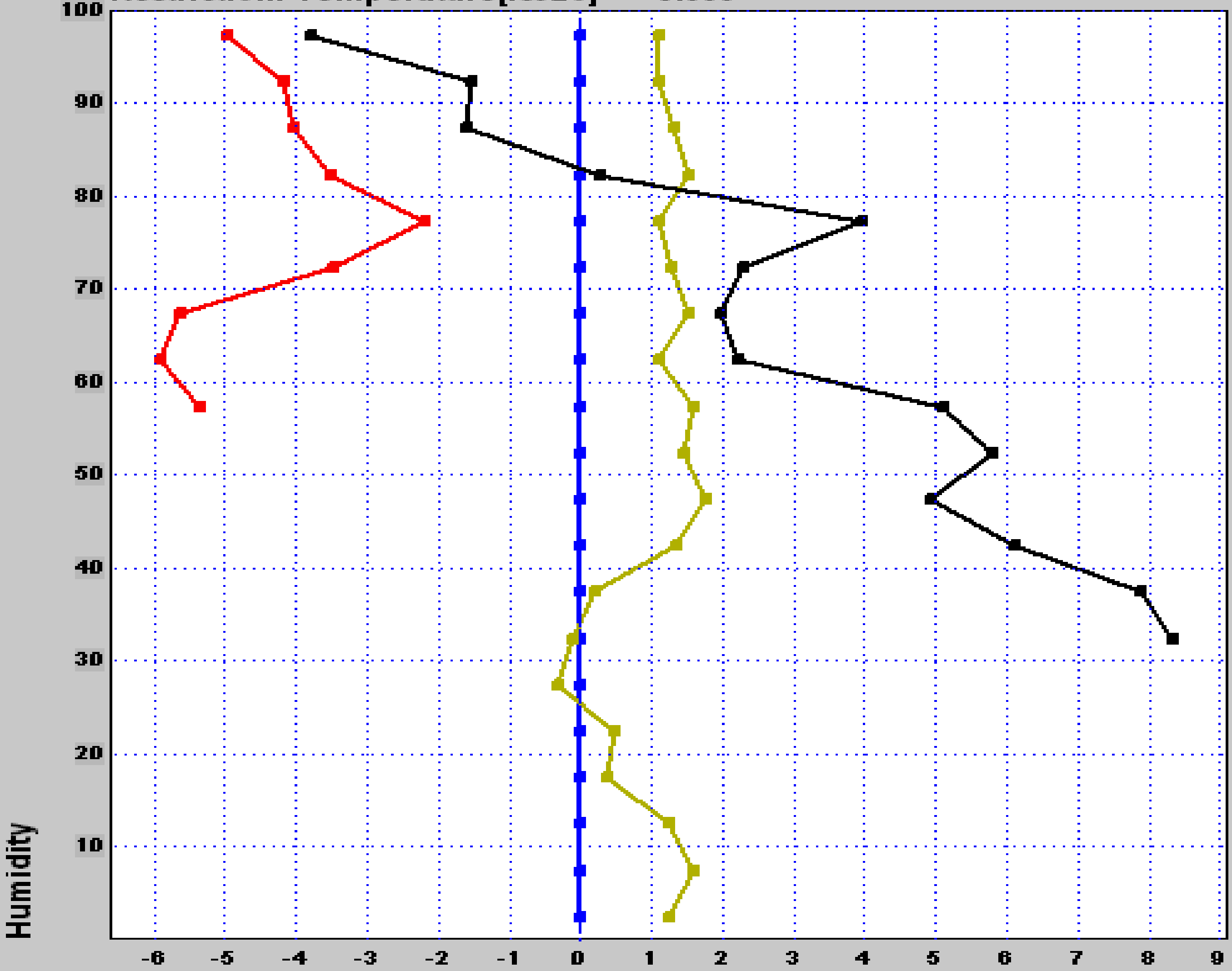


Direct Differences. RS92O RS92N MOD SCAN

Variable: Humidity. Data resolution: Time 1 sec. 26 flights. .

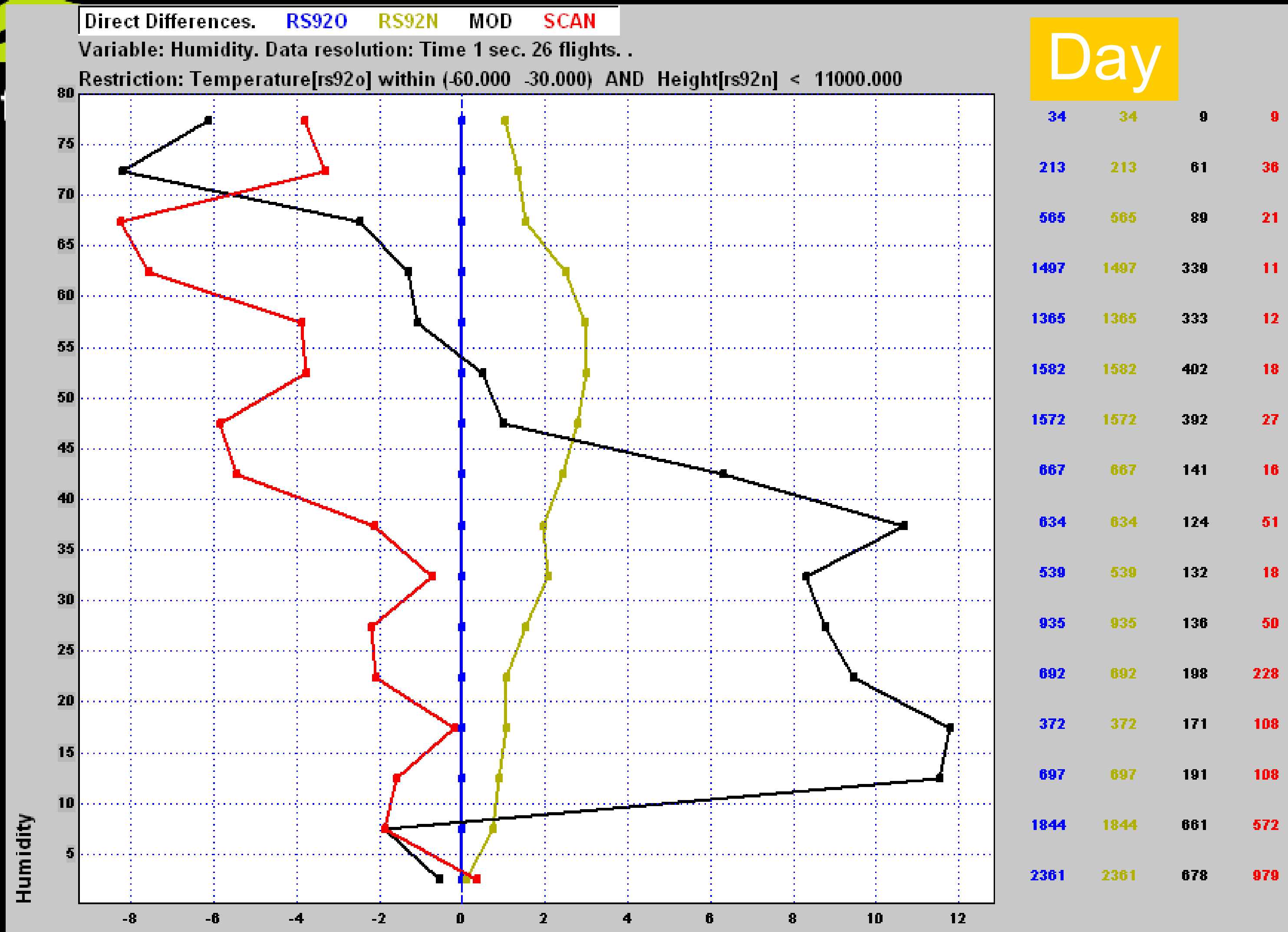
Restriction: Temperature[rs92o] > 0.000

Day

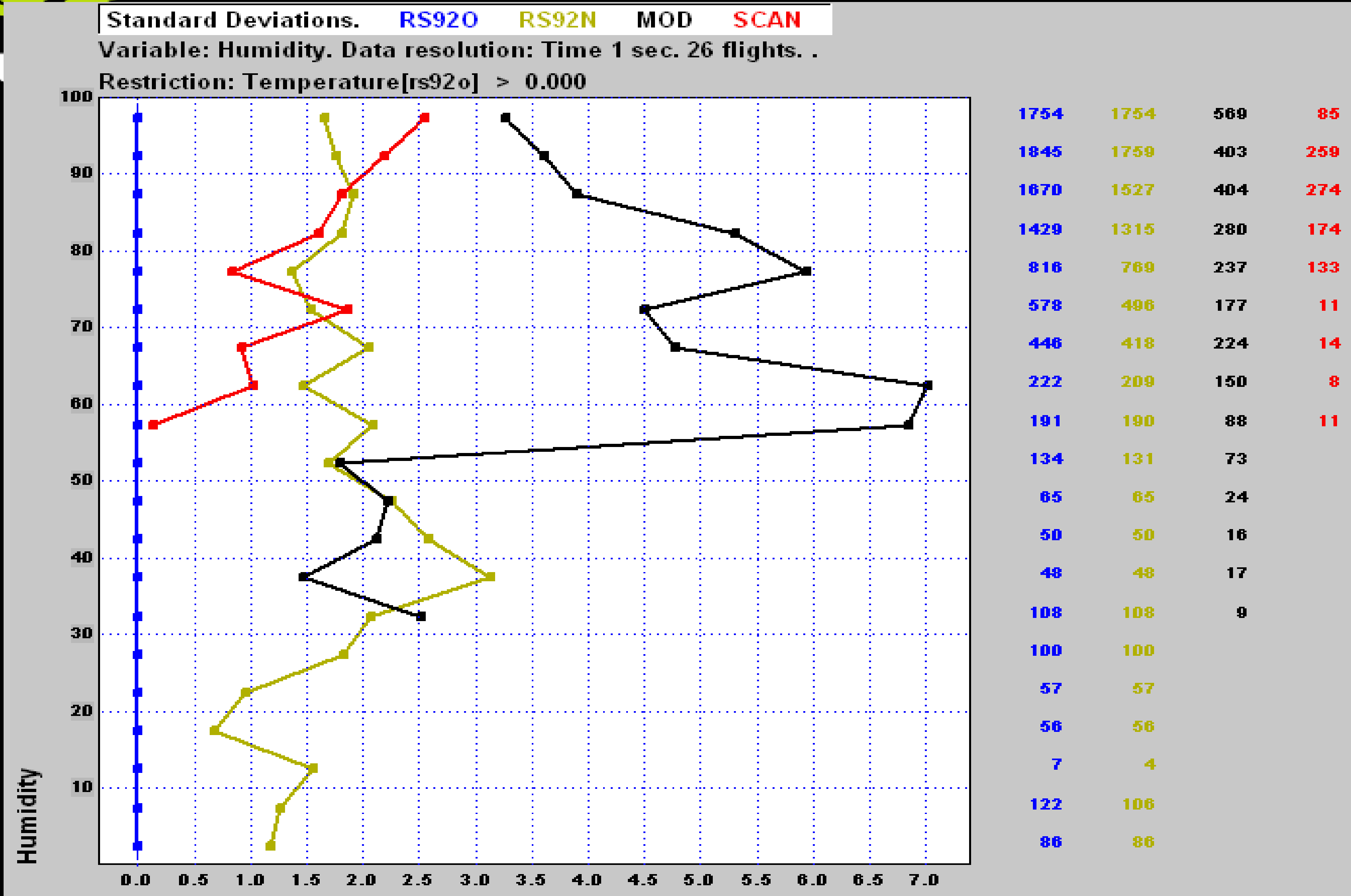


RS92O	RS92N	MOD	SCAN
1754	1754	569	85
1845	1759	403	259
1670	1527	404	274
1429	1315	280	174
816	769	237	133
578	496	177	11
446	418	224	14
222	209	150	8
191	190	88	11
134	131	73	
65	65	24	
50	50	16	
48	48	17	
108	108	9	
100	100		
57	57		
56	56		
7	4		
122	106		
86	86		

Met Of

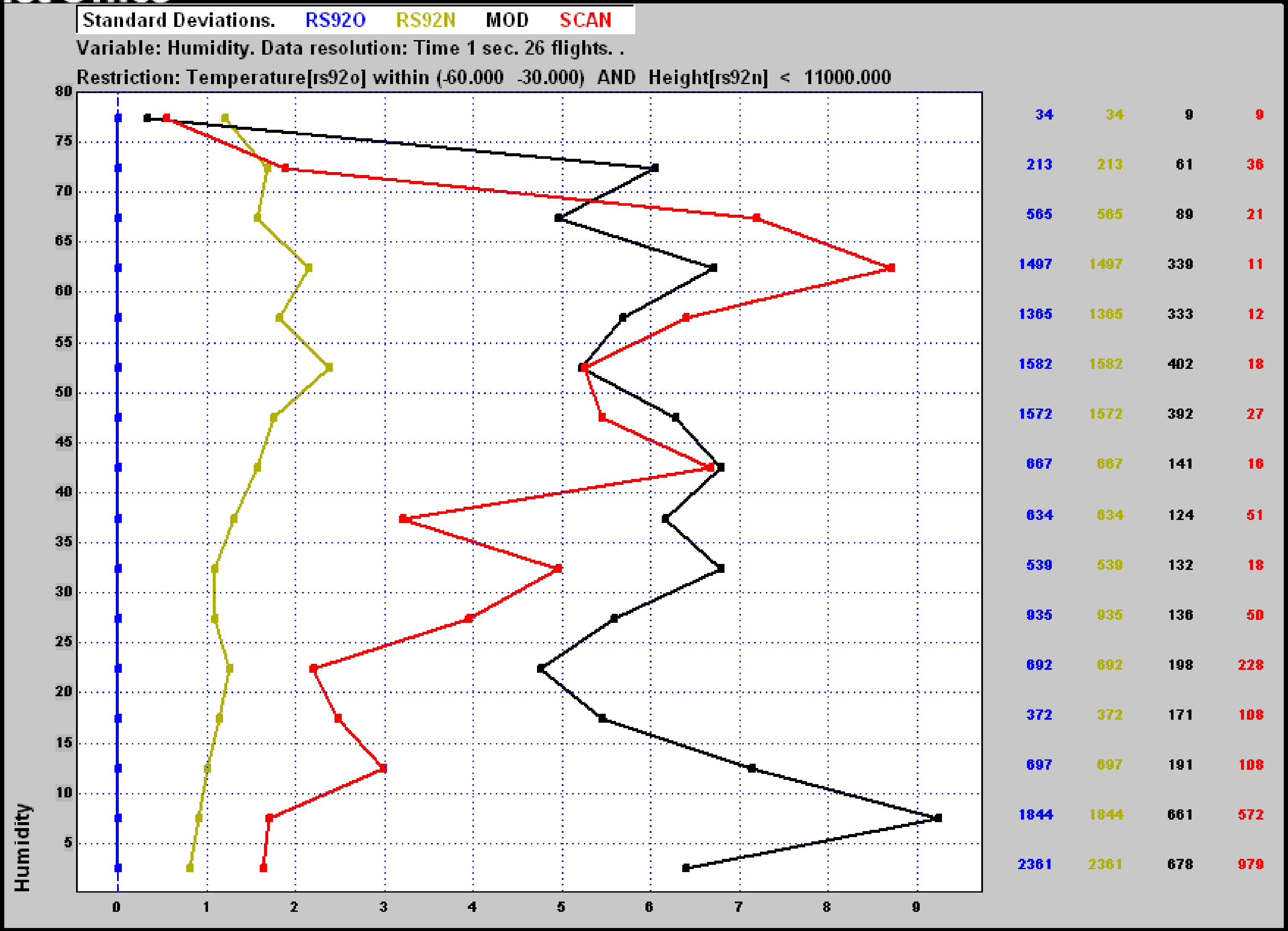


Direct Differences. RS92O RS92N MOD SCAN
Variable: Humidity. Data resolution: Time 1 sec. 26 flights. .
Restriction: Temperature[rs92o] within (-60.000 -30.000) AND Height[rs92n] < 11000.000
Day
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Humidity
-8
-6
-4
-2
0
2
4
6
8
10
12
34 34 9 9
213 213 61 36
565 565 89 21
1497 1497 339 11
1365 1365 333 12
1582 1582 402 18
1572 1572 392 27
667 667 141 16
634 634 124 51
539 539 132 18
935 935 136 50
692 692 198 228
372 372 171 108
697 697 191 108
1844 1844 661 572
2361 2361 678 979



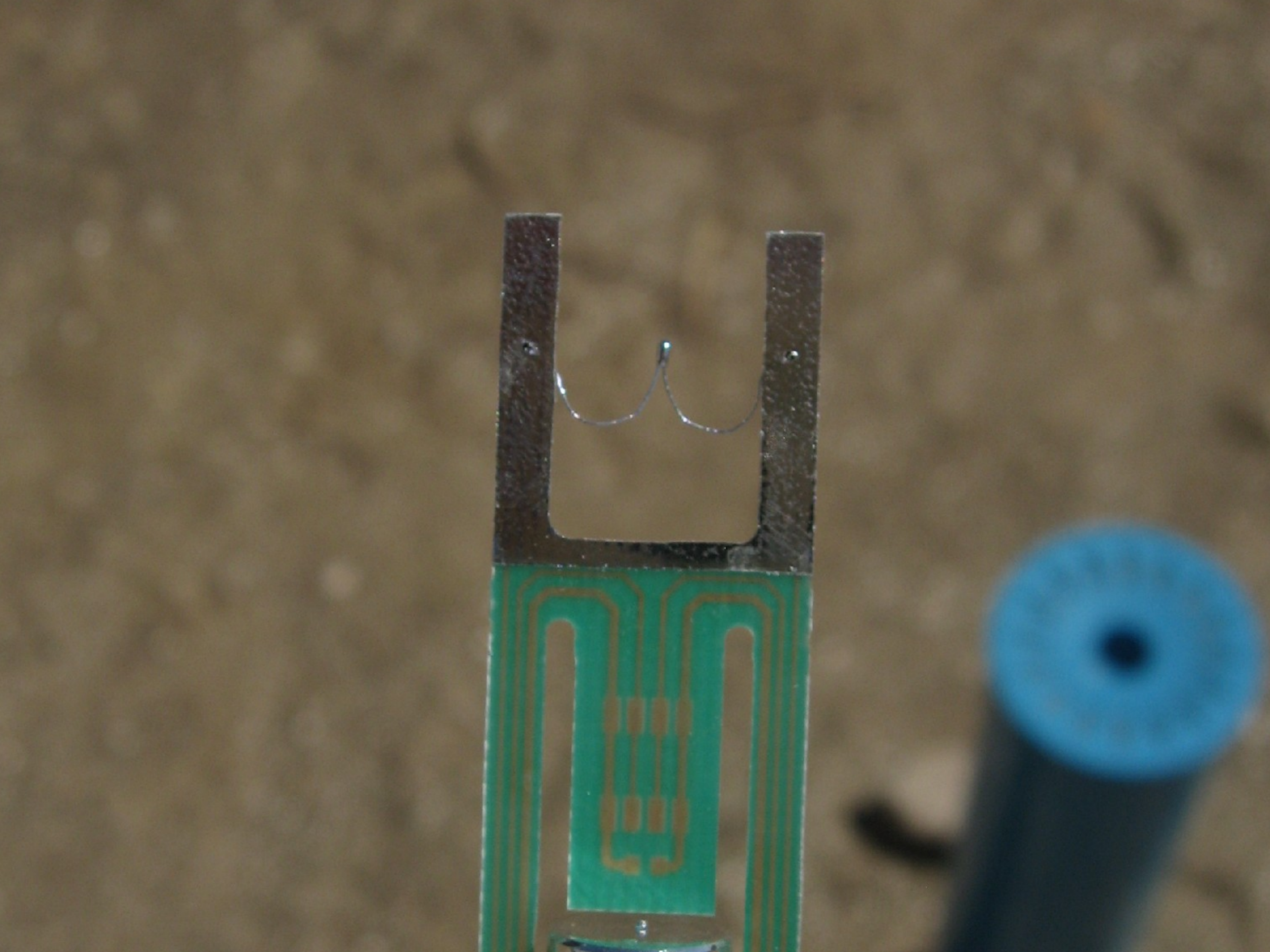
Standard Deviations. RS92O RS92N MOD SCAN
Variable: Humidity. Data resolution: Time 1 sec. 26 flights. .
Restriction: Temperature[rs92o] > 0.000
Humidity
100
90
80
70
60
50
40
30
20
10
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
1754 1754 569 85
1845 1759 403 259
1670 1527 404 274
1429 1315 280 174
816 769 237 133
578 496 177 11
446 418 224 14
222 209 150 8
191 190 88 11
134 131 73
65 65 24
50 50 16
48 48 17
108 108 9
100 100
57 57
56 56
7 4
122 106
86 86

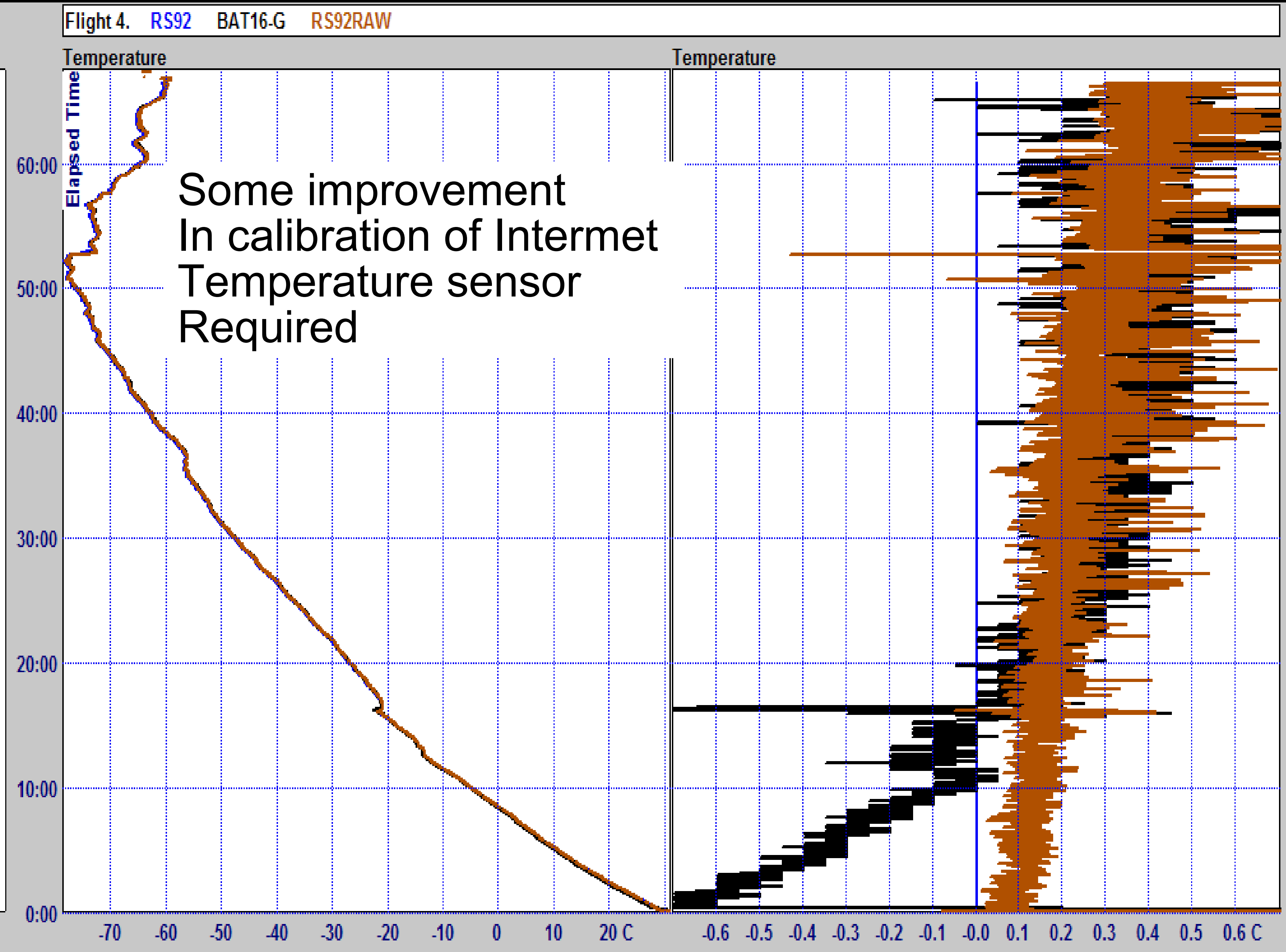
Met Office



Standard Deviations. RS92O RS92N MOD SCAN
Variable: Humidity. Data resolution: Time 1 sec. 26 flights. .
Restriction: Temperature[rs92o] within (-60.000 -30.000) AND Height[rs92n] < 11000.000
Humidity
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
34 34 9 9
213 213 61 36
565 565 89 21
1497 1497 339 11
1365 1365 333 12
1582 1582 402 18
1572 1572 392 27
667 667 141 16
634 634 124 51
539 539 132 18
935 935 136 50
692 692 198 228
372 372 171 108
697 697 191 108
1844 1844 661 572
2361 2361 678 979

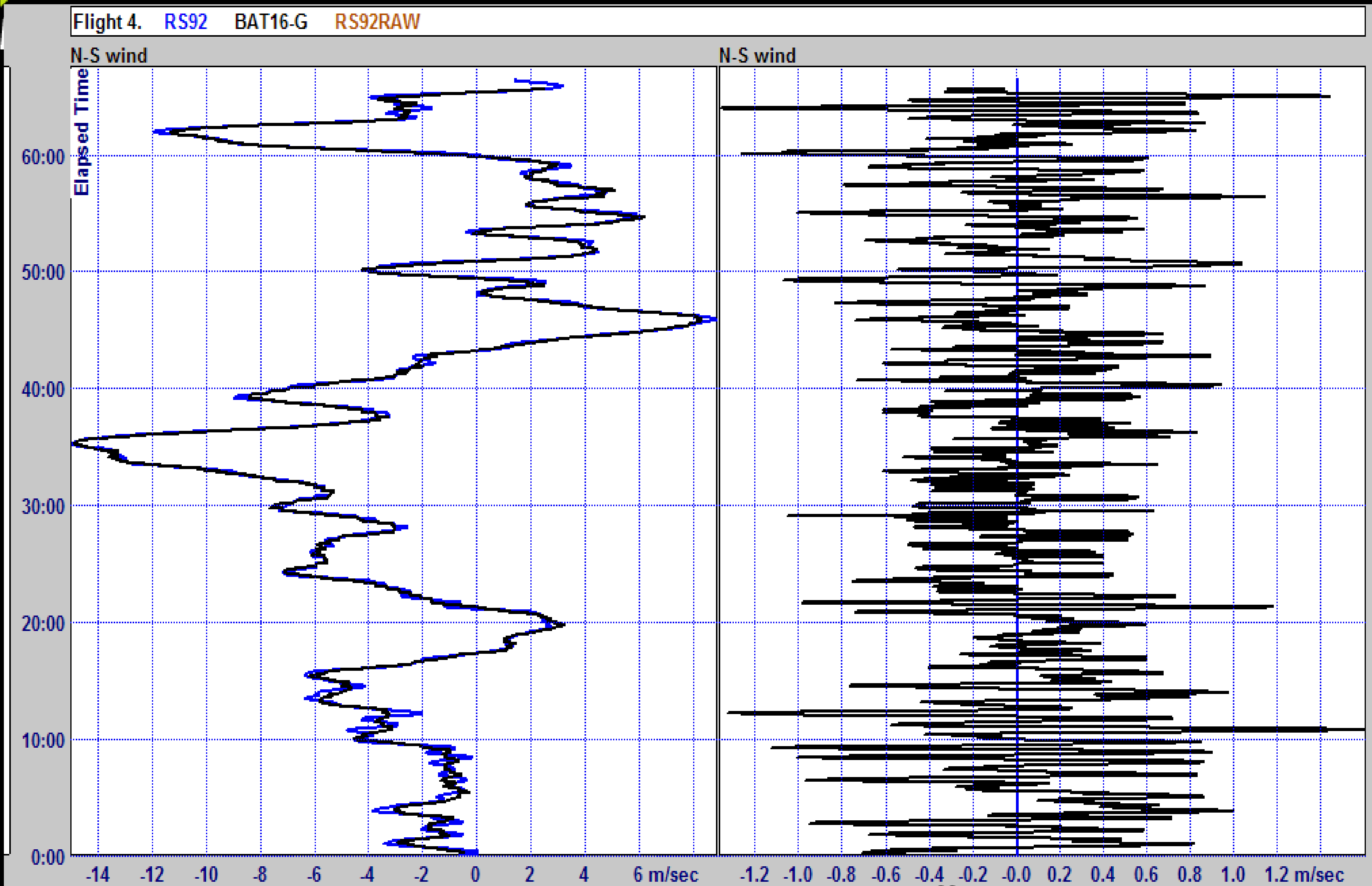

InterMet
International Met Systems
BATTERY BOX
MODEL
BAT-16G 1680MHz
NSN
Mass
P/N 4507000600
220g
S/N 45079663
Manufactured 10/2007
Batt. Expiry 2013



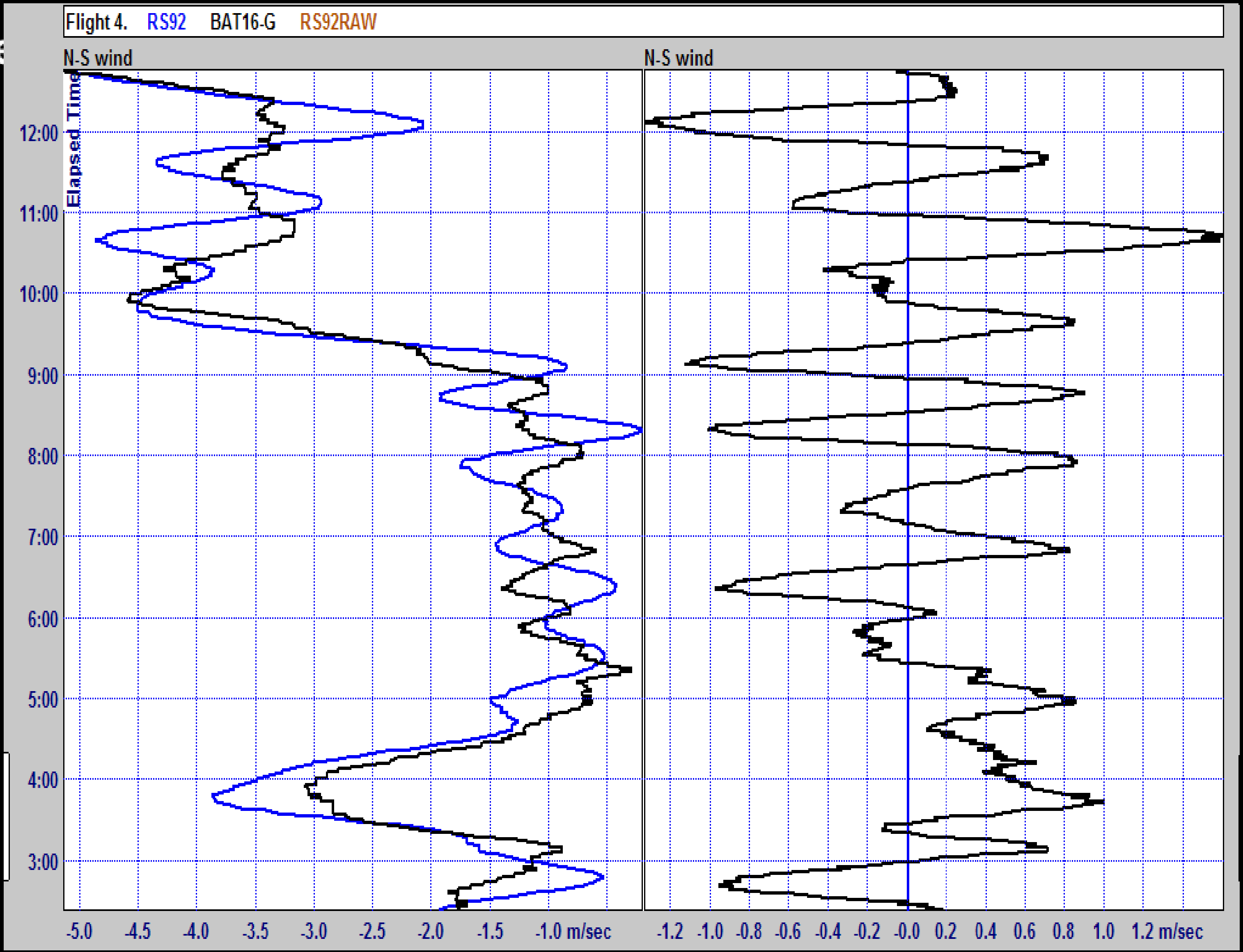


Some improvement
In calibration of Intermet
Temperature sensor
Required

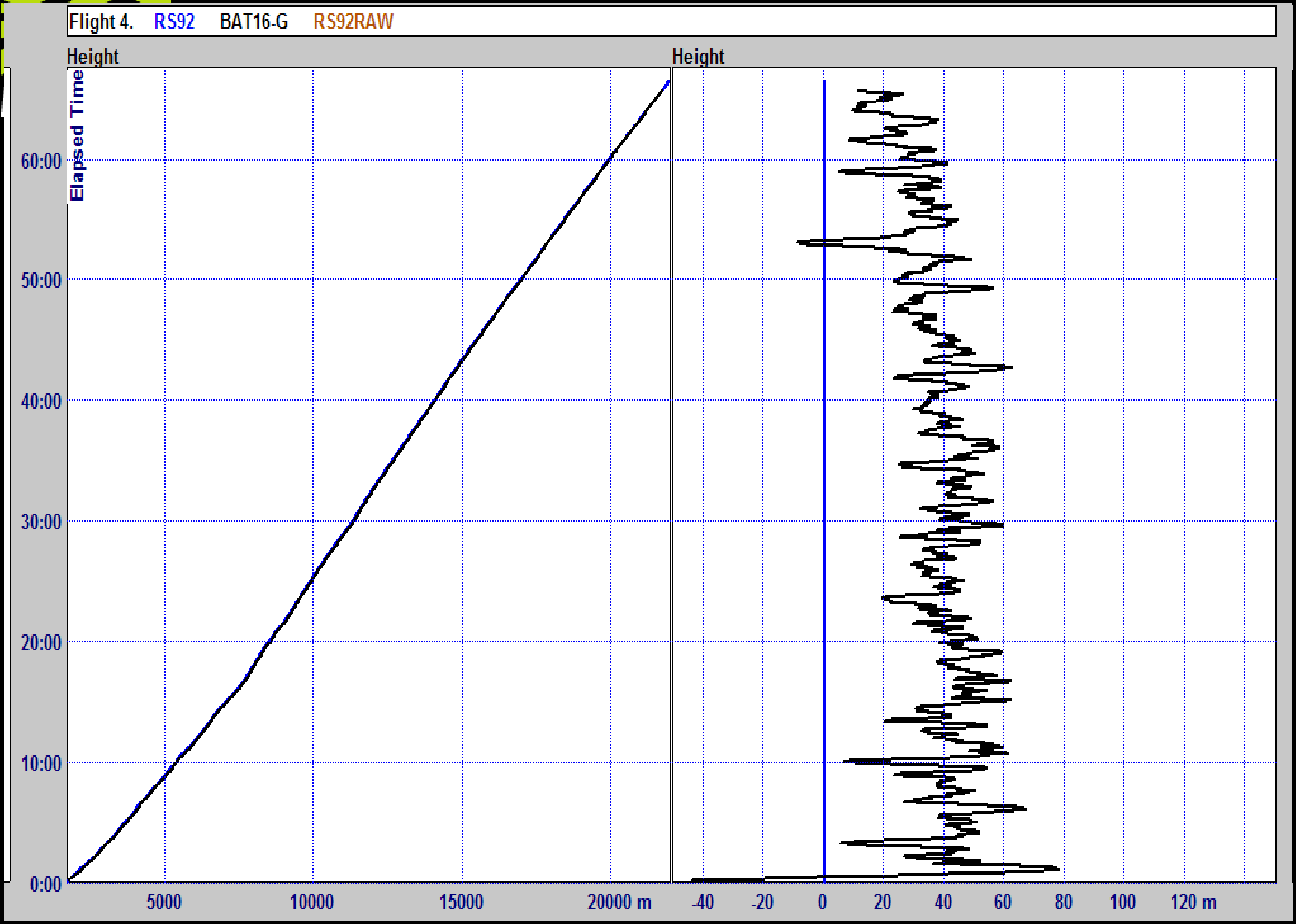
GPS winds usually reliable



Differences in wind often caused by differences in filtering of GPS winds to get rid of pendulum under balloon



GPS heights should be very reproducible, 5 to 10 m



Summary

- Examples of testing newly developed radiosonde systems are shown
- Measurement quality achievable now is much higher than even 5 years ago.
- Can India benefit from bilateral or regional collaboration in developing new radiosondes?