This project is supported by the European Commission's FP7 Capacities Programme for the period April 2013 - March 2017 under the Grant Agreement number 312495.
www.solarnet-east.eu

DELIVERABLE D70.3

Results of Site-Testing Campaign at ORM and OT

WP70 Wavefront Control: Turbulence Characterization and Correction

1ST Reporting Period

November 2014

PROJECT GENERAL INFORMATION

Grant Agreement number: 312495

Project acronym: SOLARNET

Project title: High-Resolution Solar Physics Network

Funded under: FP7-INFRASTRUCTURES: INFRA-2012-1.1.26 - Research Infrastructures for High-Resolution Solar Physics

Funding scheme: Combination of Collaborative Project and Coordination and Support Action for Integrating Activities

From: 2013-04-01 to 2017-03-31

Date of latest version of Annex I against which the assessment will be made: **13/02/2013**

Periodic report: 1st **X** 2nd ☐ 3rd ☐ 4th ☐

Period covered: from **01/04/2013** to **30/09/2014**

Project's coordinator: Dr. Manuel Collados Vera, IAC.

Tel: (34) 922 60 52 00

Fax: (34) 922 60 52 10

E-mail: mcv@iac.es

Project website address: http://solarnet-east.eu/

IAC TECHNOLOGY DIVISION

DS/IP-SNT/021v.1

DSIPSNT_021V1

October 14, 2014

Project Ref.: 312495

PROJECT / DESTINATION:

SOLARNET

TITLE:

WP70.2 SITE TESTING CAMPAIGN AT ORM AND OT - LONG BASELINE SHABARS (D70.3)

INSTITUTO DE ASTROFISICA DE CANARIAS

38200 La Laguna (Tenerife) - ESPAÑA - Phone (922)605200 - Fax (922)605210

AUTHOR LIST

Name	Function
José Marco de la Rosa	Instrument engineer

APPROVAL CONTROL

Control	Name	Function
Revised by:	Christine Grivel	System Engineer
Approved by:	Manuel Collados Vera	WP70 Leader
Authorised by:	Manuel Collados Vera	Project Coordinador

DOCUMENT CHANGE RECORD

Issue	Date	Change Description
01	30/09/2014	First Issue

SUMMARY

Two long-baseline SHABAR instruments were deployed in the Canary Islands during 2011, one in *Observatorio del Teide* (OT), in Tenerife island, and another in *Observatorio del Roque de los Muchachos* (ORM), in La Palma island. The instruments acquire sunlight signal data that can be reduced to produce C_n^2 and r_0 profiles for the lower atmosphere layers up to some 10 Kms height. The mission of these instruments, together with other daytime turbulence measurement instruments, is the characterization of the daytime sky in both sites, OT and ORM, in order to select the best location for the European Solar Telescope.

This document describes the current status and the main tasks developed for work package *WP7.2. (Atmospheric Seeing)* of the SOLARNET project, including all work regarding instrument operation, acquisition and reduction software corrections and enhancements, and acquired data preliminary analysis.

Section 1 is a very brief introduction to the instrument.

Section 2 explains the standard instrument operation and the status and planned tasks are presented as divided in two main branches: operation and reduction software; and site testing data reduction and analysis.

Section 3 presents a detailed description and justification of the main tasks that had been developed in the near past. The tasks are classified into four categories: operation and reduction software; instrument operation, test and calibration; data reduction; and reduced data and comparison results publishing. The main performed tasks include: improvements in the data acquisition software, creation of an “observation replay” application, testing of the coherent functioning of both instruments at the same and different heights, calibration of instrument electronics, creation of scripts for batch reduction and comparison, and installation of a software architecture for supporting live data publishing.

Section 4 presents a preliminary site testing data overview. The preliminary character is due to the lack of some calibrations that need to be performed before a more supported analysis can be carried out. The data shown can work as an illustration of what the results can be expected to look like. This section shows graphs for some of the acquired data and explains why the data shown is preliminary, what error rates were estimated and how they were estimated.

Finally, ongoing and future work is detailed, presented in three categories: operation and data publishing software; instrument operation and calibration; and data reduction and comparative analysis.

TABLE OF CONTENTS

AUTHOR LIST **2**

APPROVAL CONTROL **2**

DOCUMENT CHANGE RECORD **2**

SUMMARY **3**

TABLE OF CONTENTS **4**

LIST OF ABBREVIATIONS **5**

1. THE LONG-BASELINE SHABAR INSTRUMENT **6**

2. INITIAL STATUS AND SCHEDULED TASKS **6**

2.1 STANDARD OPERATION 6
2.2 OPERATION AND REDUCTION SOFTWARE 7
2.3 SITE TESTING DATA REDUCTION AND ANALYSIS 7

3. DETAILED TASK DEVELOPMENT **8**

3.1 OPERATION AND REDUCTION SOFTWARE 8
3.1.1 Fake data feeding 8
3.1.2 Observation replay application 10
3.1.3 Integration of data reduction with data acquisition software 11
3.2 INSTRUMENT OPERATION, TESTS AND CALIBRATION 12
3.2.1 Long-baseline SHABAR field tests 12
3.2.2 Electronic signal conditioning box calibration 14
3.3 DATA REDUCTION 16
3.3.1 New scripts for automatic daily data reduction and basic analysis and comparison developed 16
3.3.2 Reduction algorithm tuned to allow per-channel gain correction 18
3.4 REDUCED DATA AND COMPARISON RESULTS PUBLISHING 19
3.4.1 http-php-mysql infrastructure installed and running 19
3.4.2 Communication between Labview and database server achieved 20

4. PRELIMINARY SITE TESTING DATA OVERVIEW **21**

4.1 ESTIMATED ERROR RATES 22
4.2 ILLUSTRATIVE PRELIMINARY REDUCED DATA 25

5. FUTURE WORK **33**

5.1 OPERATION AND DATA PUBLISHING SOFTWARE 33
5.2 INSTRUMENT OPERATION AND CALIBRATION 33
5.3 DATA REDUCTION AND COMPARATIVE ANALYSIS 33

ANNEXES **34**

A. LIST OF REFERENCE DOCUMENTS **34**

LIST OF ABBREVIATIONS

1. THE LONG-BASELINE SHABAR INSTRUMENT

The long-baseline SHABAR (SHadow BAnd Ranger) instrument [RD.1, RD.2, RD.3] is a daytime seeing monitor. SHABAR's objective is characterizing the daytime turbulence distribution in atmospheric layers at different heights above the site where it is deployed.

Long-baseline SHABARs consist of 16 photodiodes which measure the sun scintillation, mounted at different distances in a 3 meter bar which tracks the sun. Each SHABAR includes the required electro-mechanical automatism and data acquisition stages including analog signal processing, analog to digital signal conversion, digital processing and data storage.

There are two functional long-baseline SHABARs in operation in the Canary Islands at present. They are usually deployed in two different sites: one in *Observatorio del Teide* (OT), in Tenerife island, and one in *Observatorio del Roque de los Muchachos* (ORM), in La Palma island.

Figure 1. Images of the SHABAR instrument.

2. INITIAL STATUS AND SCHEDULED TASKS

2.1 Standard operation

The two available long-baseline SHABARs were deployed in their respective locations, one in OT and another in ORM, during 2011. Since then, they have been observing almost daily during the months when the instruments are not limited to operate. The instruments cannot operate during some of the dates in winter because of limitations in their mechanical design. The standard observation months comprise the year period between May and November. Besides this winter stop, the observations also stop when immediate instrument maintenance is needed (cables failure, broken sensors, mayor problems). Non immediate maintenance is normally planned to be performed during the winter stops.

Each instrument works independently and, each operation day, the instrument produces raw and preprocessed signal data files that are copied in a permanent storage in the internal servers of IAC. Those files work as inputs for the reduction software that is run manually by the people in charge of monitoring the site testing data.

The following subsections present an overview of the status and planned tasks regarding the two current main work branches for this work package.

2.2 Operation and reduction software

The situation in February 2014 is that the instrument software allows raw data acquisition from its photodiodes and generation of a mean and cross covariance preprocessed dataset derived from the acquired data. This preprocessed dataset generation is an intermediate step in the process of obtaining the seeing estimation, which is the final objective. The remaining computation is performed through the use of reduction routines external to the instrument software. These routines are applied offline to the files obtained for an observation after the observation has ended and not in an automatic way. This way of functioning does not allow real time seeing monitoring.

Taking all that information into account, the following main tasks and improvements were planned to be developed in the following months:

- Addition of data reduction to the instrument software in order to monitor r_0 in real time
- Analysis of the obtained and reduced data
- Enhancement of quality, publication and accessibility of the final r_0 data

Besides the data acquisition software, some improvements in the instrument electro-mechanical automatism and control are also under study for future observation campaigns.

2.3 Site testing data reduction and analysis

Currently, the acquired data is stored from dates ranging from May 2010 to present for OT and from November 2010 to present for ORM. In both cases there exist intermittent stops due to technical limitations of the instruments and typical technical problems requiring instrument maintenance. The technical limitations constrain standard campaigns to take place from May to November. The situation in February 2014 was that only a portion of the data had already been reduced to obtain r_0 estimations and thorough comparisons between data obtained in OT and ORM had not been performed yet. Besides, checking that both instruments produce the same reduced data by operating them in parallel was a desired test for validating the differences between r_0 observed in the different sites. This test had never been carried out before.

According to that, the following main tasks were planned:

- Prepare and carry out the test of both instruments operating in parallel at the same site and very close together in order to check that the reduced data obtained is the same. These tests should include operation with both instruments mounted at the same height and at different heights so the r_0 height profile can also be validated.
- Conduct the standard campaign as usual with one SHABAR at OR and the other at ORM
- Reduce all data from previously and newly performed observations.

- Prepare some software infrastructure that reduces the data daily in an automatic fashion.
- Supervise the instruments operation in order to detect possible problems.
- Analyze and compare the reduced data and get conclusions regarding the differences in r_0 quality for both observatories.

3. DETAILED TASK DEVELOPMENT

3.1 Operation and reduction software

Some needs were detected in the operation software. The main developments regarding this software are described in this section.

3.1.1 Fake data feeding

Detected need:

The initial SHABAR data acquisition software could not be fed with data not coming from the actual acquisition hardware. This limitation made the software behavior difficult to test. Adding this feature would allow the software to be fed with artificially created data, for which you know the expected output according to the physical model you are assuming. In this way validation tests for controlled data can be easily performed for the data acquisition software.

Task development:

The data acquisition software was modified in order to add the new testing features. The current data acquisition software now allows to be fed from a saved raw data file (which can be easily produced with any general purpose programming language) or from a couple of predefined signal generation patterns.

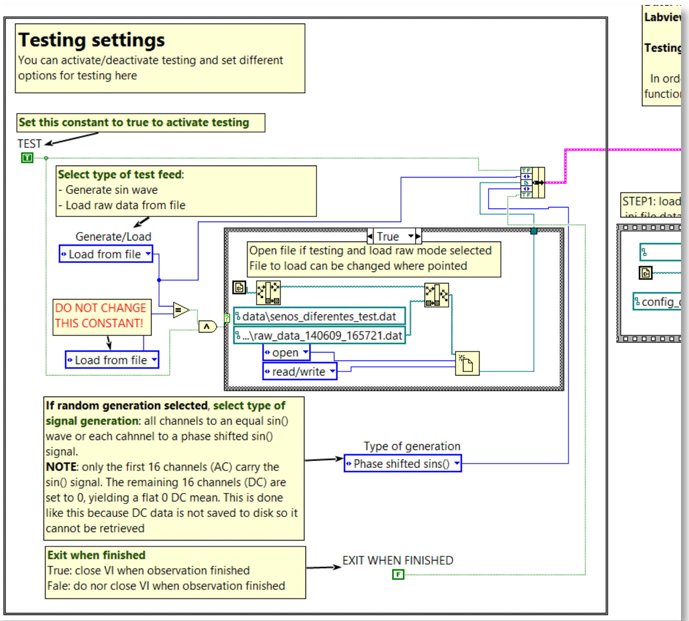


Figure 2. Block added for test mode configuration.

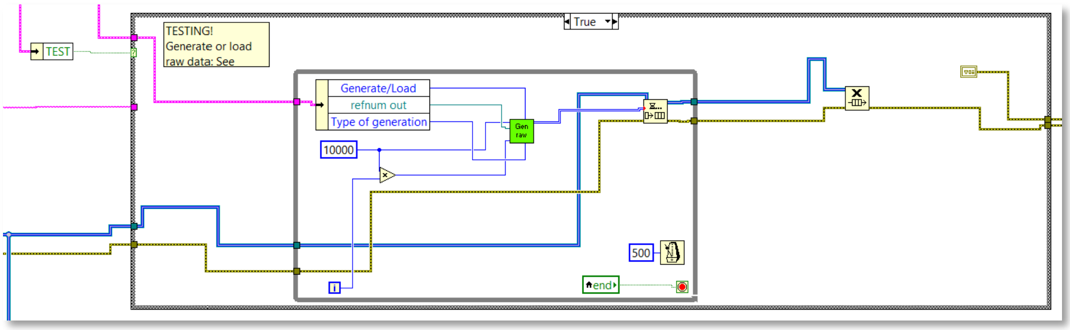


Figure 3. Block for substitution of hardware acquired data with test data.

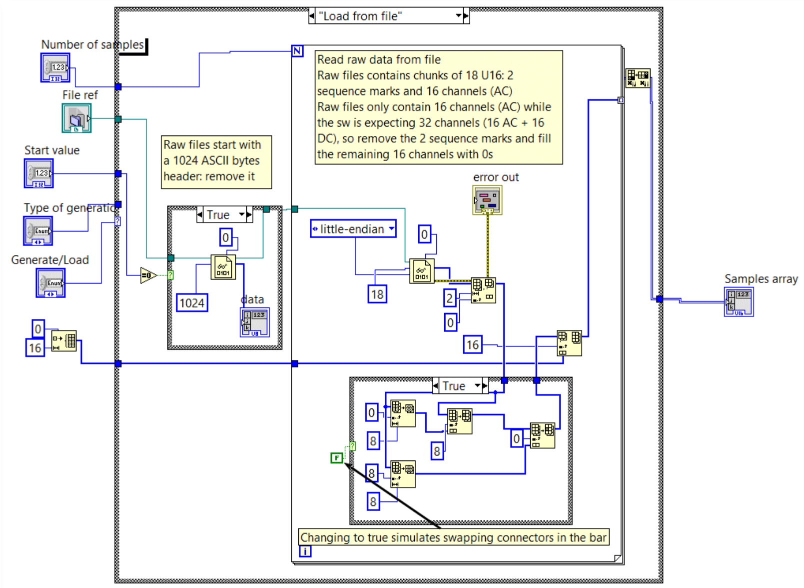


Figure 4. Virtual instrument (vi) for test data generation. Block generating data from a previously stored hardware acquired data file.

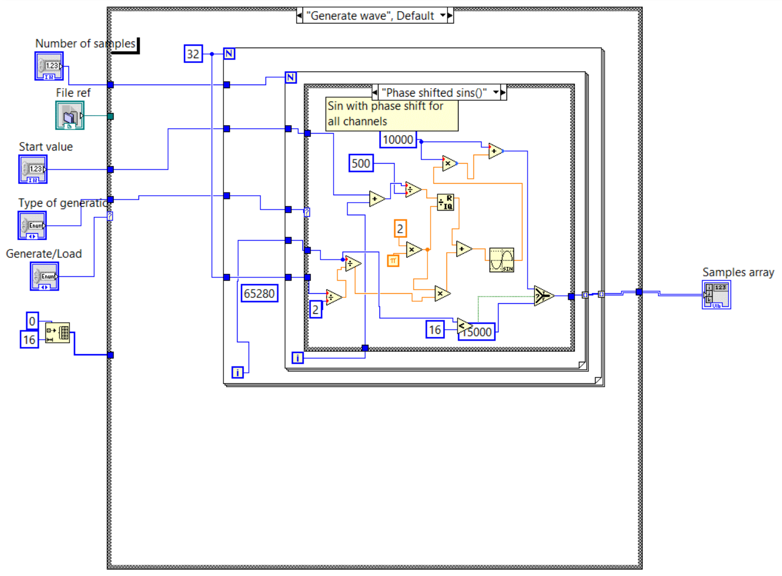


Figure 5. Virtual instrument (vi) for test data generation. Block generating 16 channels different phase sinusoidal signals.

3.1.2 Observation replay application

Detected need:

While performing standard daily observation checking, the need of an appropriate observation data exploration tool arose. Experience suggested that a data visualization application mimicking the behavior of the actual data acquisition application would allow data revision and would also allow learning how do some real effects (clouds, photodiode dirtiness or misbehavior, etc.) look in the acquisition application during the actual observation.

Task development:

An observation replay application was developed. It allows the user to open preprocessed data files saved as output for the observations by the data acquisition program and replay them. The software allows setting different replay speeds, stepping through the data and pausing. This software has proved very useful and is currently used very frequently (daily).

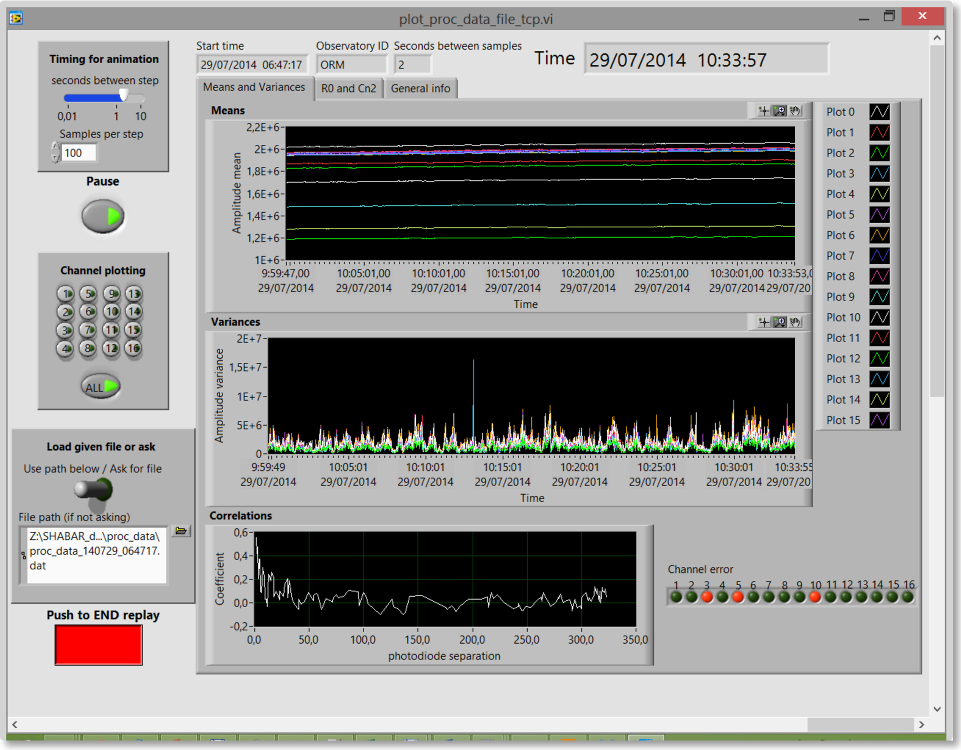


Figure 6. Observation replay application front panel.

3.1.3 Integration of data reduction with data acquisition software

Detected need:

In the initial situation, the data acquisition software only samples data from the instrument photodiodes and performs a basic covariance computation between the acquired signals. That data is saved when the observation finishes and, *after that*, the data is used as input to the reduction software that computes r_0 and C_n^2 estimations. This way of working does not allow real time monitoring of observed r_0 and C_n^2. Adding reduction capability to the data acquisition software enabling real time monitoring of r_0 and C_n^2 would be interesting. Besides the convenience and possibility of real time data publishing, r_0 and C_n^2 monitoring can also give early clue of problems in the instrument operation.

Task development:

The trickiest part of this task was integrating the data acquisition software which is programmed using Labview with the data reduction software which is programmed in IDL. Those are two very different software development platforms and porting the reduction algorithm to Labview was not easy. A compromise between architectural complexity and ease of development was adopted. Both Labview and IDL include TCP communication capabilities, so a TCP communication channel can be established between both software platforms. A small communication protocol and the needed communication interfaces were developed so Labview can send preprocessed data to IDL and receive the reduction performed by IDL on the fly. The reduced data returned by IDL is adequately plotted in the Labview data acquisition application so achieving real time r_0 and C_n^2 monitoring.

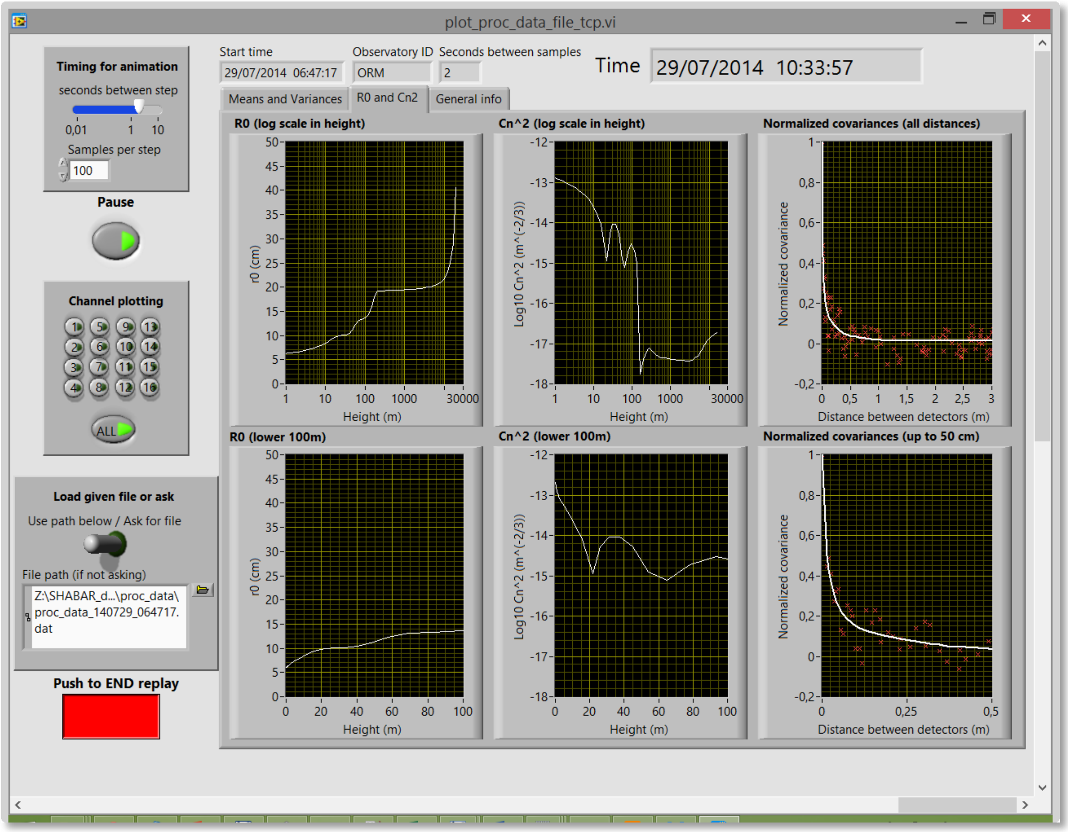


Figure 7. Reduced data view added to the operation software applications.

3.2 Instrument operation, tests and calibration

As mentioned before, some field tests needed to be carried out in order to validate the data generated by both SHABARs and in order to detect possible instrumental differences. The main related tasks are described in this section.

3.2.1 Long-baseline SHABAR field tests

Detected need:

The initial plan was installing both SHABARs, the one in OT and the one in ORM, at a similar height above the ground in order to avoid unwanted effects derived from ground wind and dust. Unfortunately, some technical issues obliged to install the SHABAR in ORM at ground level (although on the roof of a one-floor building) while the SHABAR in OT was installed on a 9 m high tower. Theoretically, the instruments allow the reconstruction of an r_0 profile for different heights, so just ignoring the lowest ones should be enough to eliminate the higher turbulence in lower layers. Anyway, a practical check was desirable. Besides, no previous tests to check that both instruments do produce the same data in the same observations conditions had been performed so you could not be sure that observed differences were completely result of differences in the sky or were result of physical differences between both instruments in some degree.

Task development:

Some tests were carried out during May and June months. The tests consisted in performing observations of both instruments in parallel installed very close together. Some observations were performed with both instruments installed at ground level and some were performed with one instrument at ground level and the other installed on the top of a 9 meter tower. The tests included multiple observations and checking of signal calibrations. They required an amount of logistical and field tasks for transportation and redeployment of the instruments, being those tasks time requiring. New cables and temporary installations needed to be created.

Figure 8. Some images of the instrument redeployment and temporary installations.

The tests showed that there existeda slight but constant difference in the r_0 estimated by the two instruments (Figure 9). One of the instruments generated slightly better r_0 for the synchronized observations at the same height.

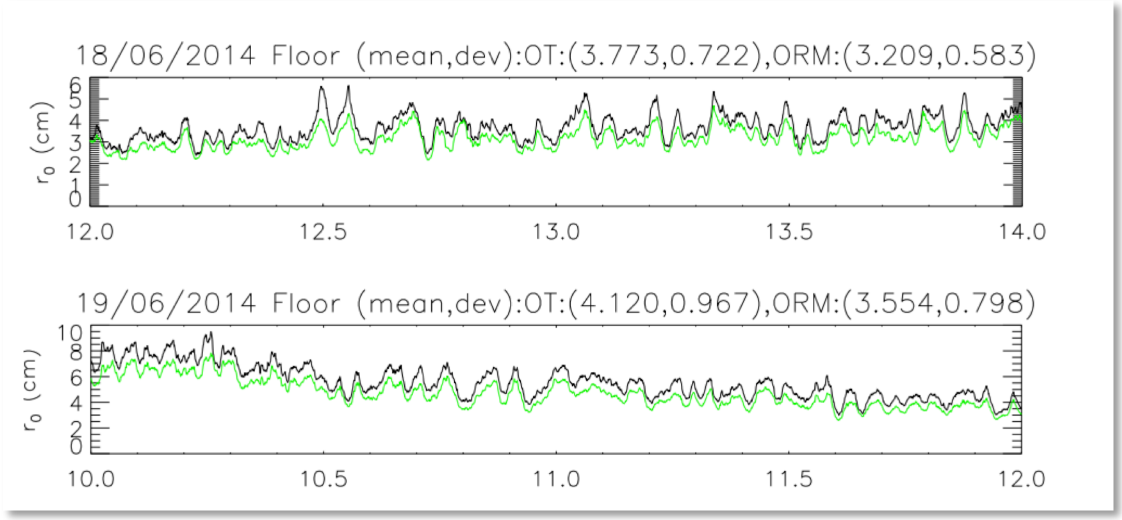


Figure 9. Reduced r_0 values for both instruments installed at ground level and very close together.

This circumstance led to further tests that pointed out that there were deficiencies in the calibration of the electronic signal conditioning boxes (each instrument has one). The tests showed that the boxes were being incorrectly assumed to work according to the theoretical electronic circuit description. The tests suggested that the different signal channels should be calibrated independently in order to quantify their real deviation from the theoretical specifications. This finding led to the next described task.

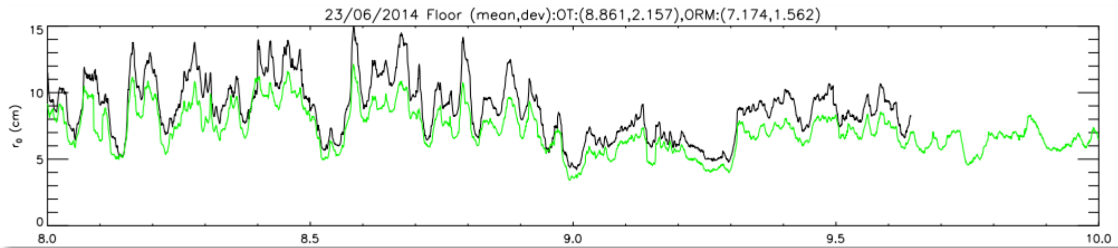


Figure 10. Initial results. Note black is constantly higher than green.

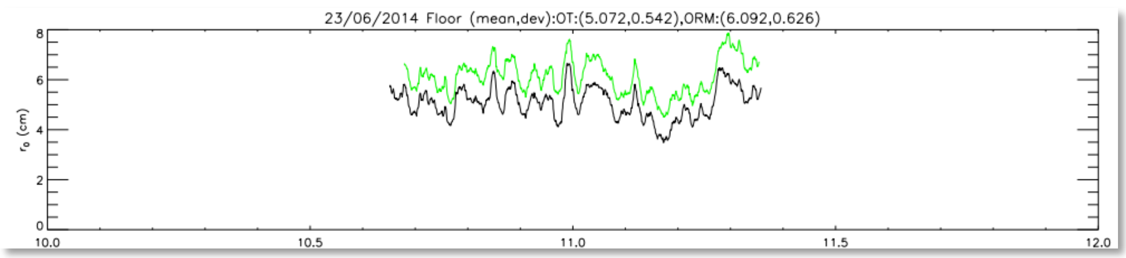


Figure 11. Results after swapping the electronic signal conditioning boxes between both instruments. Note green is now constantly higher than black.

3.2.2 Electronic signal conditioning box calibration

Detected need:

The previously described tests pointed out that there was some misassumption with the electronic signal conditioning boxes. Calibration of each channel in the box was needed in order to allow accurate reduction of the data. This calibration should be performed for all available electronic signal conditioning boxes (one for each SHABAR plus one spare).

Task development:

The electronic box corresponding to the SHABAR in OT was calibrated in the IAC laboratory. The box had to be disassembled and a testing setup was mounted in order to measure all channel gains. The values that had to be calibrated were the gain between AC and DC for each of the 16 channels. By appropriately plugging some testing points and injecting artificially generated signals, the actual gain values could be measured.

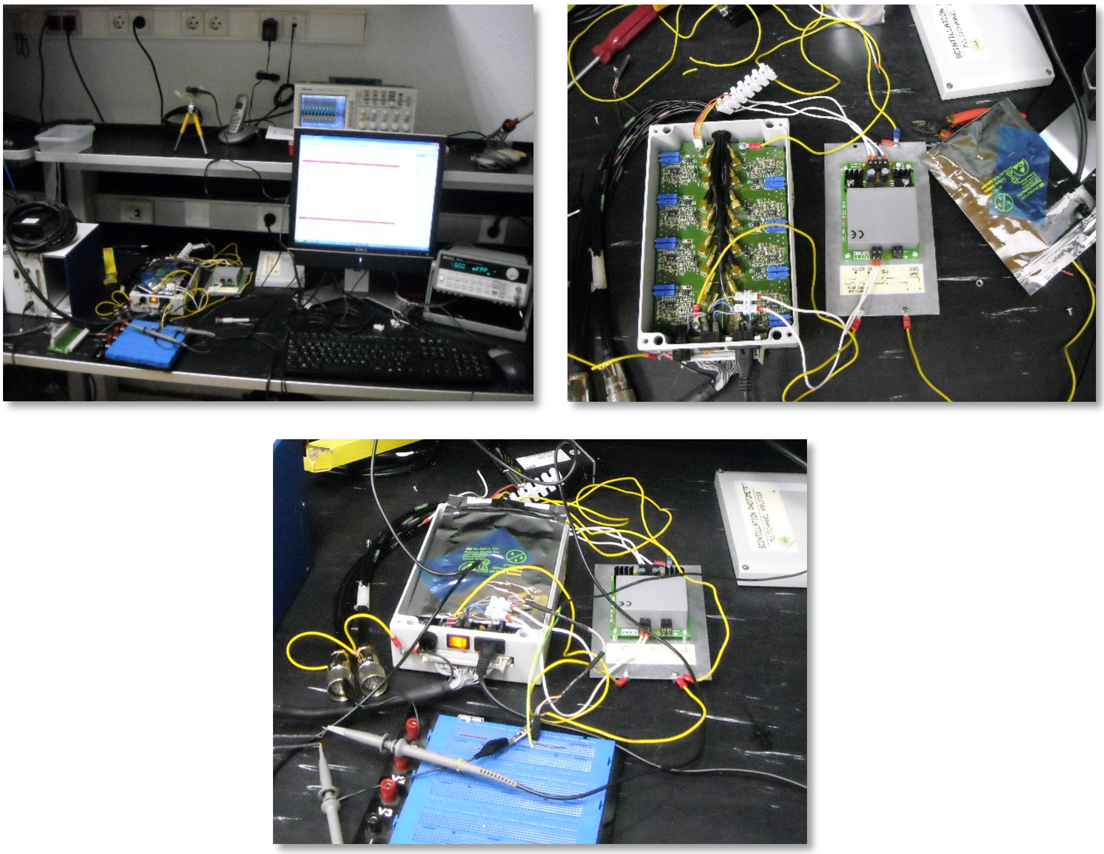


Figure 12. Images of the electronic testing setup.

The tests required the use of an oscilloscope and an electronic signal generator. Each channel output was measured for different signal inputs, varying in DC intensity, AC intensity and AC frequency. All values were tabulated and analyzed. Differences from the theoretical values for the gains were found. It was also found that, although slightly, the changes in the adjustable gain, which should not affect the reduced data magnitude, do actually affect it. Obtained gains ranged from 74 to 132, notably diverging from the theoretical 105.5 default value.

	A	B	C	D	E	F	G	H	I	J	K
1	Canal 1										
2	DC in	DC out	AC in	AC out	Var gain	Acout/Acin		AC in * Var g	AC out / <--		10Hz
3	203	232	236	23200	1,14285714	98,3050847		269,714286	86,0169492		110
4	203	232	216	21000	1,14285714	97,2222222		246,857143	85,0694444		100
5	203	232	196	19200	1,14285714	97,9591837		224	85,7142857		90
6	203	232	172	17000	1,14285714	98,8372093		196,571429	86,4825581		80
7	203	232	156	14600	1,14285714	93,5897436		178,285714	81,8910256		70
8	203	232	132	12600	1,14285714	95,4545455		150,857143	83,5227273		60
9	203	232	112	10900	1,14285714	97,3214286		128	85,15625		50
10								Media	84,8361772		
11											
12	DC in	DC out	AC in	AC out	Var gain	Acout/Acin		AC in * Var g	AC out / <--		30Hz
13	203	233	236	22600	1,14778325	95,7627119		270,876847	83,432749		110
14	203	233	216	20800	1,14778325	96,2962963		247,921182	83,8976315		100
15	203	233	196	18800	1,14778325	95,9183673		224,965517	83,568363		90
16	203	233	172	16800	1,14778325	97,6744186		197,418719	85,0983132		80
17	203	233	156	14700	1,14778325	94,2307692		179,054187	82,0980522		70
18	203	233	132	12600	1,14778325	95,4545455		151,507389	83,1642606		60
19	203	233	112	10500	1,14778325	93,75		128,551724	81,6791845		50
20								Media	83,2769363		
21											
22	DC in	DC out	AC in	AC out	Var gain	Acout/Acin		AC in * Var g	AC out / <--		100Hz
23	203	233	236	22400	1,14778325	94,9152542		270,876847	82,6944061		110
24	203	233	216	20400	1,14778325	94,4444444		247,921182	82,2842155		100
25	203	233	196	18600	1,14778325	94,8979592		224,965517	82,6793378		90
26	203	233	172	16600	1,14778325	96,5116279		197,418719	84,085238		80
27	203	233	156	14100	1,14778325	90,3846154		179,054187	78,7471113		70
28	203	233	132	12400	1,14778325	93,9393939		151,507389	81,844193		60
29	203	233	112	10300	1,14778325	91,9642857		128,551724	80,1233906		50
30								Media	81,7796989		

Figure 13. Measurements for one of the 16 AC/DC channel pairs.

Fortunately, data can be corrected easily to consider the newly measured gains, although reduction should be repeated for the corrected data. This means that the acquired data *can* be corrected *after* acquisition.

All available data will be corrected, reduced and analyzed again once the electronic signal conditioning box in ORM is calibrated. This task is planned to be performed after the standard 2014 campaign, during the winter stop.

3.3 Data reduction

The main tasks regarding improvements in data reduction are listed here.

3.3.1 New scripts for automatic daily data reduction and basic analysis and comparison developed

Detected need:

The main data reduction algorithm had already been programmed in IDL by February 2014. Anyway, the data was not being routinely reduced. It was clear that automatic reduction was a desirable feature.

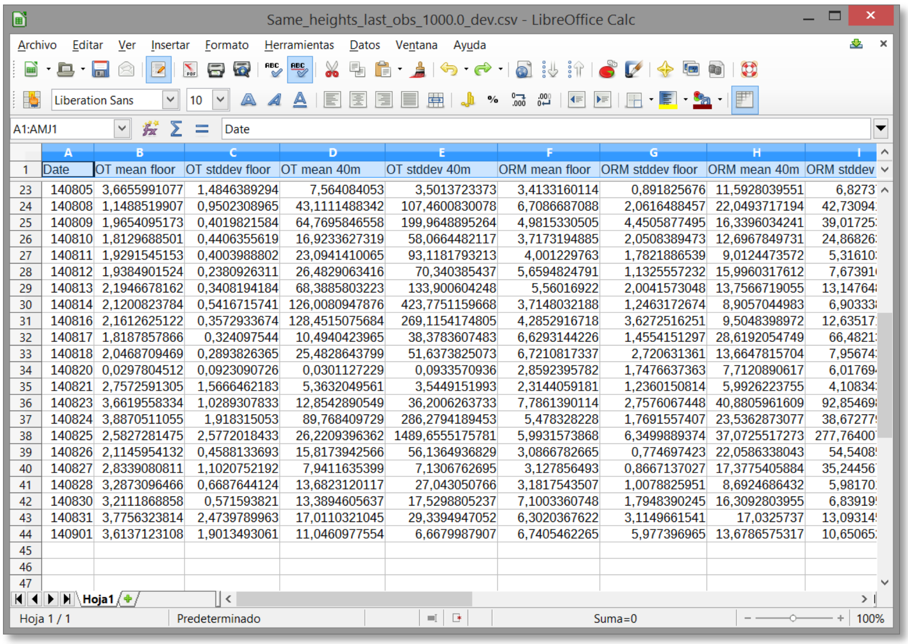
Task development:

The output of both SHABARs is currently being stored in two directories in a network storage inside IAC's network. A good and simple approach to automatic data reduction is the creation of scripts that scan those directories in search of new unreduced files and that reduce them. This script was created and a task in a server was set so the script automatically starts once a day to perform the reduction of the files generated the day before (actually all files not having being reduced so far). This script also adds some useful preliminary preprocess of the data like generating a comparative graph between OT and ORM observations and a csv table with a reduced data summary for all the dates available.

```
pro bulk_reduction

  start_reduction_date = '140722'

; Reduce OT data
  print, 'Reducing OT data'
  gains = [ $
    83.27693629, 103.3495171, 98.41538635, 79.77605354, $
    118.991975, 125.6931482, 104.6807133, 122.4109695, $
    92.92471291, 102.2927067, 95.44114573, 81.93536067, $
    116.6201249, 131.3037047, 75.60411812, 83.79325673 $
    ]
  in_dir = 'Z:\SHABAR_data\OT\proc_data'
  out_dir = 'E:\Datos\Shabar\Reduccion\OT_corrected'
  bulk_reduce, in_dir, out_dir, from_date=start_reduction_date, gains=gains

; Reduce ORM data
  print, 'Reducing ORM data'
  gains = dblarr(16)+105.5 ; Using default gains!
  in_dir = 'Z:\SHABAR_data\ORM\proc_data'
  out_dir = 'E:\Datos\Shabar\Reduccion\ORM_not_corrected'
  bulk_reduce, in_dir, out_dir, from_date=start_reduction_date, gains=gains

; Generate comparisons
  in_dir_ot = 'E:\Datos\Shabar\Reduccion\OT_corrected'
  in_dir_orm = 'E:\Datos\Shabar\Reduccion\ORM_not_corrected'
  out_dir = 'E:\Datos\Shabar\Reduccion\OT_ORM_OT_corrected'
  start_reduction_date = 140703
  args = command_line_args()
  dev_limit_set = (args ne "")?float(args[0]):1000.
  out_csv_filename                                                          =
'Same_heights_last_obs_'+string(dev_limit_set,FORMAT='(F0.1)')+'_dev.csv'
  ; Generate new comparisons
  bulk_compare,in_dir_ot,in_dir_orm,out_dir, $
    from_date=start_reduction_date,dev_limit=dev_limit_set
  ; Generate the stats file
  out_dir = 'E:\Datos\Shabar\Reduccion\stats'
  bulk_compare,in_dir_ot,in_dir_orm,out_dir, $
    from_date=start_reduction_date,csv_filename=out_csv_filename,$
    /only_stats,dev_limit=dev_limit_set

end
```

Figure 14. Main IDL bulk reduction script.

Although this script is currently working, its results are only illustrative as the reduction algorithm is using practically measured (real) gains for the electronic box in OT while it is assuming theoretical gains for the electronic box in ORM until it is measured in the future, during the winter observation stop. All available data must be checked, corrected and newly reduced when the real gains for the ORM box are measured. The designed script works in bulk fashion, so the task of a new bulk reduction can be carried out in an unsupervised fashion. The correction and reduction of all available data takes some 1-2 days computation and it statistics and graphs are generated in the same process once the new reduction finishes, some analyses and comparisons can be done very quickly.



	Date	OT mean floor	OT stddev floor	OT mean 40m	OT stddev 40m	ORM mean floor	ORM stddev floor	ORM mean 40m	ORM stddev
23	140805	3,6655991077	1,4846389294	7,564084053	3,5013723373	3,4133160114	0,891825676	11,5928039551	6,8273
24	140808	1,1488519907	0,9502308965	43,1111488342	107,4600830078	6,7086687088	2,0616488457	22,0493717194	42,73094
25	140809	1,9654095173	0,4019821584	64,7695846558	199,9648895264	4,9815330505	4,4505877495	16,3396034241	39,01725
26	140810	1,8129688501	0,4406355619	16,9233627319	58,0664482117	3,7173194885	2,0508389473	12,6967849731	24,86826
27	140811	1,9291545153	0,4003988802	23,0941410065	93,1181793213	4,001229763	1,7821886539	9,0124473572	5,31610
28	140812	1,9384901524	0,2380926311	26,4829063416	70,340385437	5,6594824791	1,1325557232	15,9960317612	7,67391
29	140813	2,1946678162	0,3408194184	68,3885803223	133,900604248	5,56016922	2,0041573048	13,7566719055	13,14764
30	140814	2,1200823784	0,5416715741	126,0080947876	423,7751159668	3,7148032188	1,2463172674	8,9057044983	6,90333
31	140816	2,1612625122	0,3572933674	128,4515075684	269,1154174805	4,2852916718	3,6272516251	9,5048398972	12,63517
32	140817	1,8187857866	0,324097544	10,4940423965	38,3783607483	6,6293144226	1,4554151297	28,6192054749	66,4821
33	140818	2,0468709469	0,2893826365	25,4828643799	51,6373825073	6,7210817337	2,720631361	13,6647815704	7,95674
34	140820	0,0297804512	0,0923090726	0,0301127229	0,0933570936	2,8592395782	1,7476637363	7,7120890617	6,01769
35	140821	2,7572591305	1,5666462183	5,3632049561	3,5449151993	2,3144059181	1,2360150814	5,9926223755	4,10834
36	140823	3,6619558334	1,0289307833	12,8542890549	36,2006263733	7,7861390114	2,7576067448	40,8805961609	92,85469
37	140824	3,8870511055	1,918315053	89,768409729	286,2794189453	5,478328228	1,7691557407	23,5362873077	38,67277
38	140825	2,5827281475	2,5772018433	26,2209396362	1489,6555175781	5,9931573868	6,3499889374	37,0725517273	277,76400
39	140826	2,1145954132	0,4588133693	15,8173942566	56,1364936829	3,0866782665	0,774697423	22,0586338043	54,5408
40	140827	2,8339080811	1,1020752192	7,9411635399	7,1306762695	3,127856493	0,8667137027	17,3775405884	35,24456
41	140828	3,2873096466	0,6687644124	13,6823120117	27,043050766	3,1817543507	1,0078825951	8,6924686432	5,98170
42	140830	3,2111868858	0,571593821	13,3894605637	17,5298805237	7,1003360748	1,7948390245	16,3092803955	6,83919
43	140831	3,7756323814	2,4739789963	17,0110321045	29,3394947052	6,3020367622	3,1149661541	17,0325737	13,09314
44	140901	3,6137123108	1,9013493061	11,0460977554	6,6679987907	6,7405462265	5,977396965	13,6786575317	10,65065

Figure 15. Automatically obtained statistics for some recent observations. No overview graph is provided because, as explained in the previous text, these statistics will be recalculated after further calibrations are performed during the incoming months.

3.3.2 Reduction algorithm tuned to allow per-channel gain correction

Detected need:

As explained in the previous sections, the acquisition software is treating all data channels coming from the photodiodes as having the same AC/DC gain. This gain is assumed to be the theoretical 105.5 derived from the circuitry schematics. Once the electronics boxes are experimentally measured, the actual gains should be used to correct the data before reduction.

Task development:

The needed correction can be performed in several places in the acquisition-reduction software chain. The most reasonable place to add it seems to be in the acquisition software, so the acquired data saved is faithful to the *real* data. This approach, though, is trickier than adding the correction to the reduction script just before starting the actual reduction. The former approach requires data headers to be changed and would need the stop of the standard observation campaign in order to appropriately deploy the newly developed software including correctness tests. So, as a temporary first approach, the gain correction has been added to the reduction script but intends to be translated to the acquisition software in time for the next observation campaign after the winter stop.

```
pro bulk_reduction

;############ Missing code

  gains = [ $
    83.27693629, 103.3495171, 98.41538635, 79.77605354, $
    118.991975, 125.6931482, 104.6807133, 122.4109695, $
    92.92471291, 102.2927067, 95.44114573, 81.93536067, $
    116.6201249, 131.3037047, 75.60411812, 83.79325673 $
    ]

;############ Missing code

  bulk_reduce, in_dir, out_dir, from_date=start_reduction_date, gains=gains

;############ Missing code

end

;############ Missing code


pro read_long_gains,filein,tt,time,sig,covar,dc,d,gains,err,bar
;############ Missing code

; Gain correction, just after load!

default_gain = 105.5
for j=0,ndata-1 do data(2:17,j)=(data(2:17,j)/default_gain)*gains

;############ Missing code
end
```

Figure 16. Key code lines performing gain correction in acquired data before reduction.

Adding the gain correction to the reduction algorithm was also useful in order to quantify the error that incorrectly calibrated gains induce in the reduced data. Several tests assuming high gains for all the channels and low gains for all the channels were carried out. Significant results of these tests are shown in the site testing data preliminary overview section later in this document.

3.4 Reduced data and comparison results publishing

First steps towards publishing the reduced data in real time have already been taken. This subsection summarizes them.

3.4.1 http-php-mysql infrastructure installed and running

Detected need:

A webpage is considered to be a proper way to publish results for reduction and data comparison from the site testing campaign. Some computation infrastructure is needed in order to provide support.

Task development:

A typical infrastructure consists in a scripting enabled http server and a database server. Typical scripting languages for the http server are php or python. The present application does not need to be very complex in its functionality. In principle, the generation of a webpage with some graphs for the latest observations (or even for some series of them) does not need very specific features from the scripting programming language. Given that, php has been chosen for convenience and prior experience working with it. An http-php-mysql infrastructure has already been installed for the development of the web page. The selected software package is called Wampserver and is available at http://www.wampserver.com/en/.

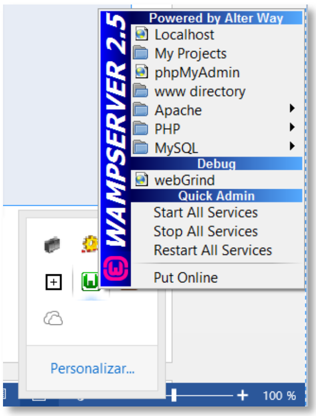


Figure 17. Wampserver configuration and operation menu.

3.4.2 Communication between Labview and database server achieved

Detected need:

In order to create a real time representation of the reduced data in the web server, the actual reduced data must be transferred to the server in some way.

Task development:

The typical way of doing that is by using the database server as a hub. Real time reduction data is generated by the acquisition software (Labview + IDL) so dumping the reduced data in the database should be performed by that software as an intermediate step. Currently, the database connection, writing and reading from Labview have already been achieved.

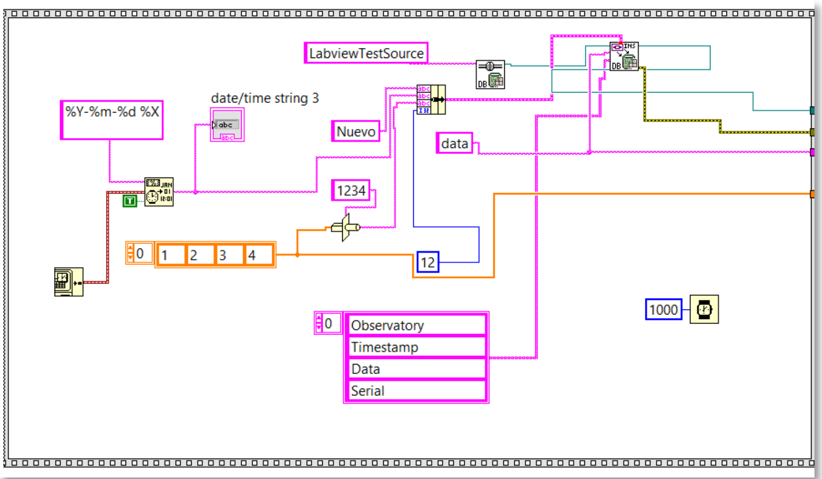


Figure 18. Database connection and data record insertion from Labview.

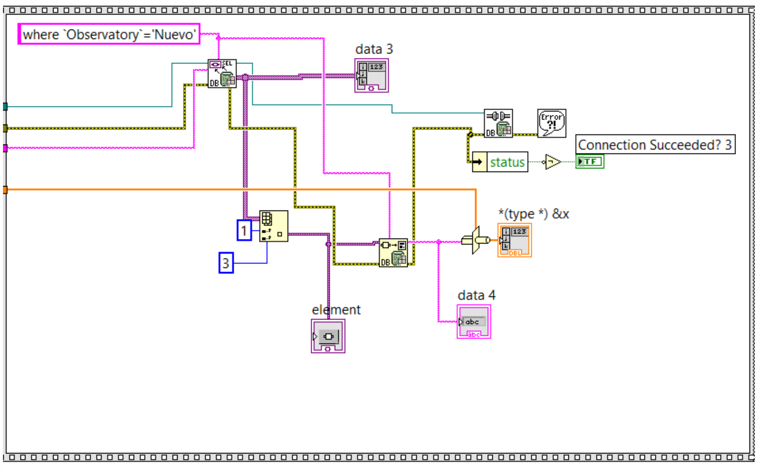


Figure 19. Database record selection query from Labview and deserialization from the received polymorphic type to Labview common types.

4. PRELIMINARY SITE TESTING DATA OVERVIEW

As explained in the previous sections, data reduction has been automated up to some degree but incorrect assumptions for the gains of the signal channels in the electronic signal conditioning boxes of the instruments were detected during operation and validation tests. These calibration problems can be easily fixed after observation, but the electronic signal conditioning boxes need to be calibrated in order to perform the corrections. The calibration process is time consuming, requiring several days of instrument stop. Given the fact that the instruments must stop during winter due to design limitations, the required calibration process has been scheduled to be carried out in that period for avoiding unnecessary loss of observation days.

At present, only illustrative measurements can be shown. During testing, a rough error rate estimation in the r_0 values for different gain values was calculated.

Some important findings were possible only because the observations were monitored. In fact, monitoring of the first observations of the 2014 campaign revealed that the signals measured by the SHABAR installed in OT had a significant noise consisting in 50 Hz pulse trains occurring in seemingly random periods in the order of some seconds. The observation replay application allowed the determination of the period when the noise was present. That period comprised from September 2013 up to the date of detection in May 2014. The noise was eliminated just by revising and correctly setting the electrical ground connections. All data in the cited period is unusable. Fortunately there were not many observation days between those dates.

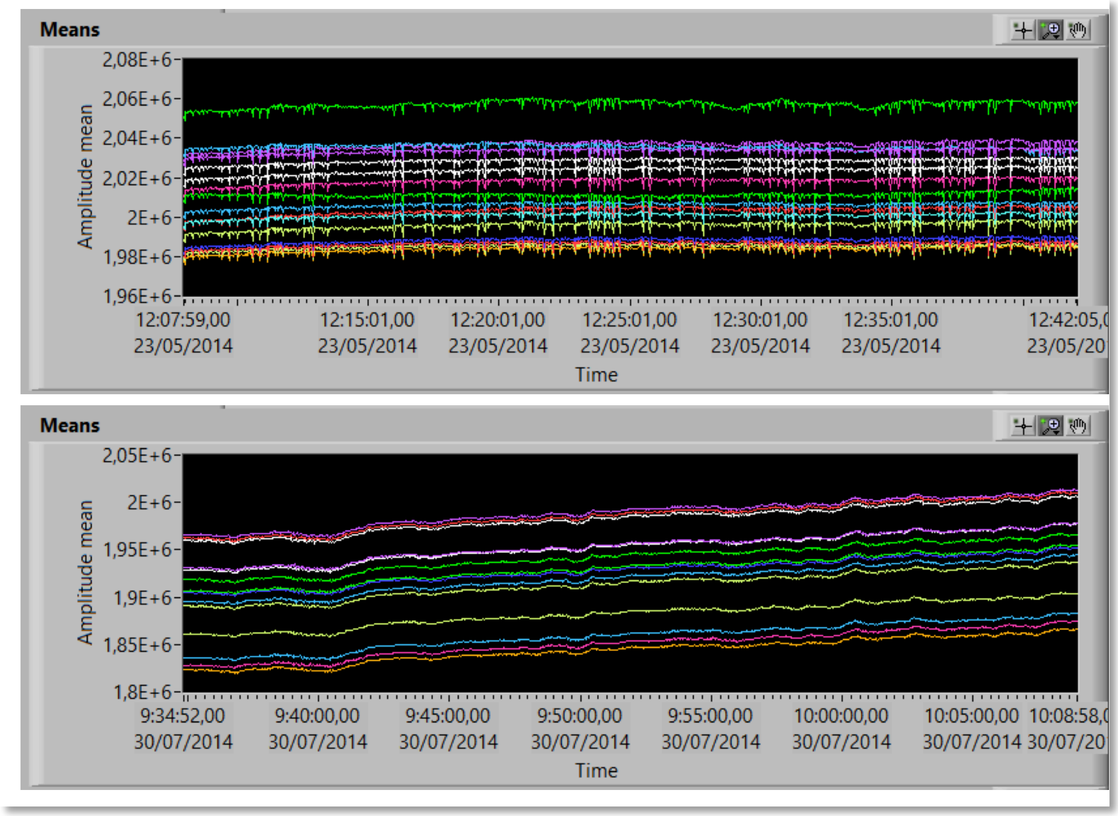


Figure 20. Effect of noisy pulses coming from the electric power grid. Up: Signals affected by floating ground connections. Down: correct signals once all ground connections were correctly set.

4.1 Estimated error rates

Once the gains for all channels were experimentally measured, some tests were carried out in order to estimate rough error rates. The gains assumed for the channels can be set before applying the reduction algorithm. For estimating errors, several reductions, using the experimentally measured (correct) gains and using artificially modified gains, were computed and compared. The idea was observing how much does the reduction change depending on the bias of the channel gains from the actual physical gains. The 16 experimentally measured gains range from 74 to 132 (see section 3.2.2 for further detail) and have an average value of 101. Reductions were produced with the newly measured gains, with all high gains (131) and with all low gains (75). Besides, a reduction using the default theoretical gain value (105.5) was also performed.

As a first estimation, a comparison between the reduction using the corrected gains and the assumed 105.5 gains results in an 11% – 15% difference in the reduced r_0 (Figure 21). This error could be assumed similar to the one expected for the electronic box at ORM. (TBC after ORM electronic box calibration in winter 2014)

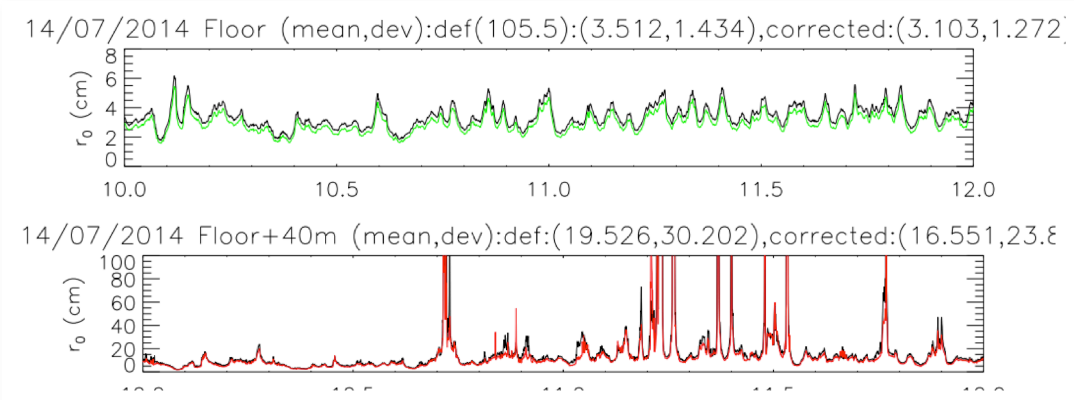


Figure 21. Data reduction results assuming theoretical 105.5 gains for all channels (black) and assuming the experimentally measured gains (green/red). Results are shown for r_0 estimations at ground level (up) and at 40 m above the ground (down).

From a more extreme and conservative point of view, for the cases shown in Figure 22 and Figure 23 a rise of 24% in gains produces 29% higher r_0 values, while a lowering of 29% in the gains produces 33% lower r_0 values. That means changes in 1.20% and 1.30% respectively for a 1% error in the gains. Given the experimental measures for the gains ranging between a lowest value of 74 and a highest of 132, and that the gain value currently assumed for the electronic signal conditioning box in ORM is 105.5 for all of them, an error in the gains around 27% could be possible (mean value of errors 74 (29%) and 132 (25%) compared to 105.5). Mean percentage of error for a 1% error in the gain is 1.25% ((1.20 + 1.30)/2), so a rough error in the reduction of up to 33.75% (27*1.25) positive or negative could be present in the values currently being reduced for the SHABAR installed in ORM.

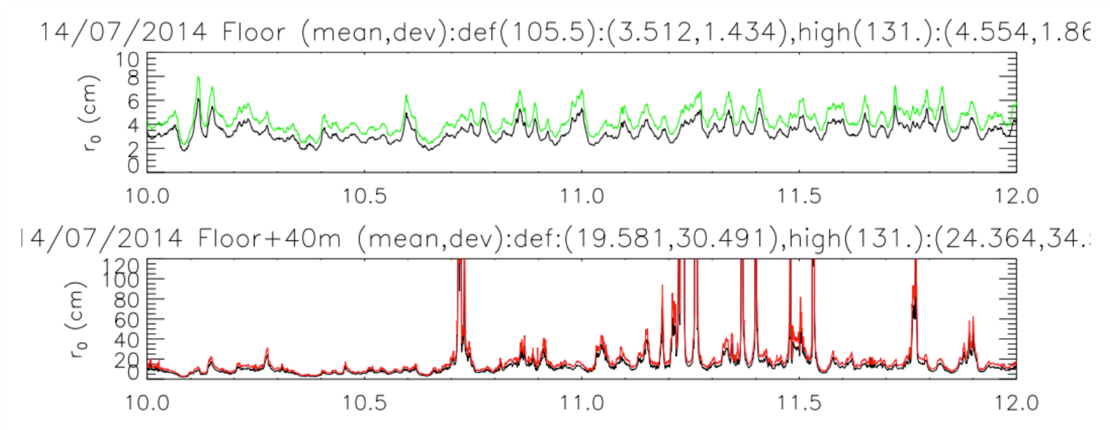


Figure 22. Data reduction results assuming theoretical 105.5 gains for all channels (black) and assuming very high gains (131) (green/red). Results are shown for r_0 estimations at ground level (up) and at 40 m above the ground (down).

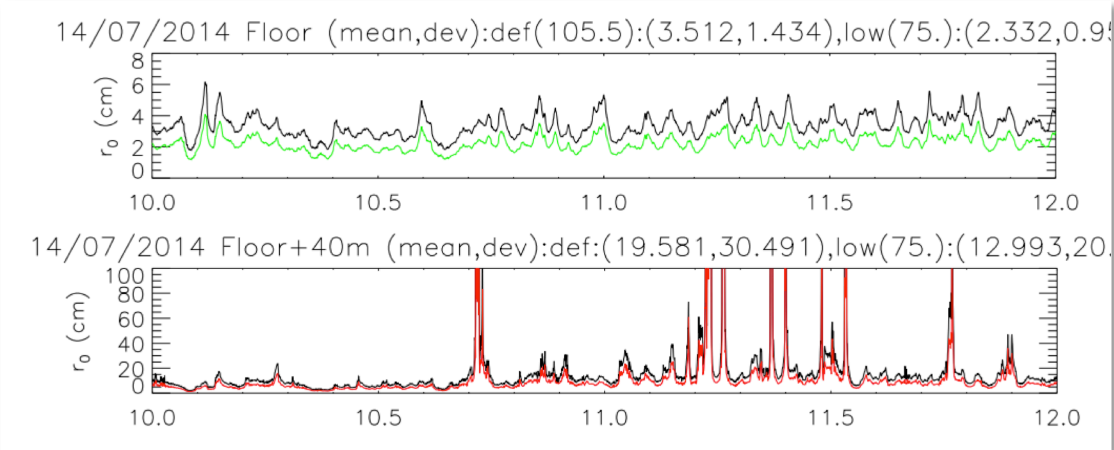


Figure 23. Data reduction results assuming theoretical 105.5 gains for all channels (black) and assuming very low gains (74) (green/red). Results are shown for r_0 estimations at ground level (up) and at 40 m above the ground (down).

Taking all this into account, the following graphs must be considered to be only illustrative as the r_0 reduction for the SHABAR in ORM will be corrected after the standard campaign. As explained, the r_0 error for the SHABAR in ORM for this campaign is expected to be some +/-10% but possibly as high as +/-30%.

4.2 Illustrative preliminary reduced data

The following pages show graphs for some of the preliminary reduced data. As explained in in the previous section, these data should be considered as affected by a possibly important error. More specifically, data for ORM (green/red) is the one probably affected by a higher error. This error is expected to be around 11-15% but possibly as high as 33% as explained in the previous paragraphs. Cleaner reduced data will be produced as soon as the pending electronic box calibration is carried out.

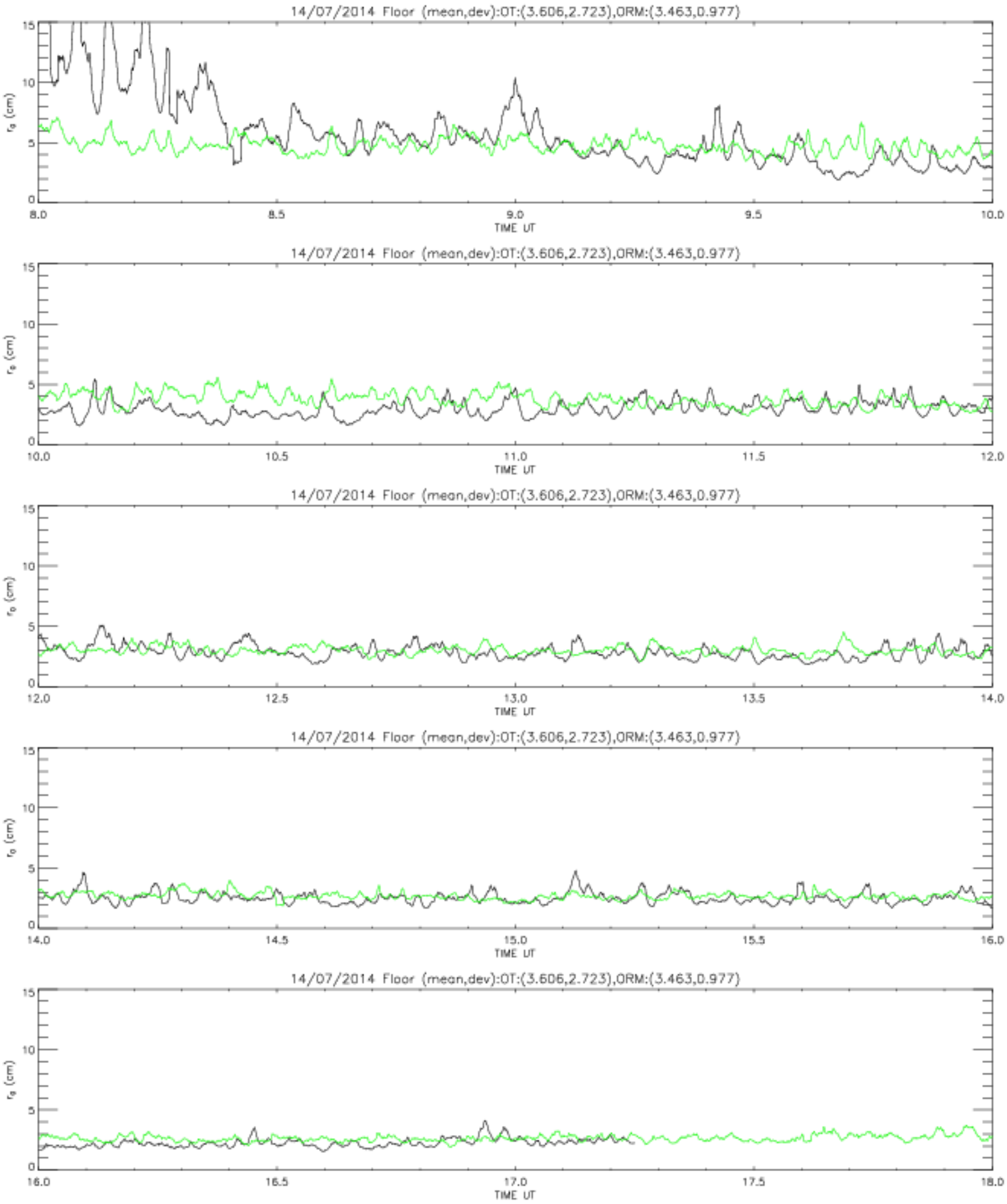


Figure 24. Reduced data for date 14/July/2014 at ground level. Black line represents data from OT and green line represents data from ORM.

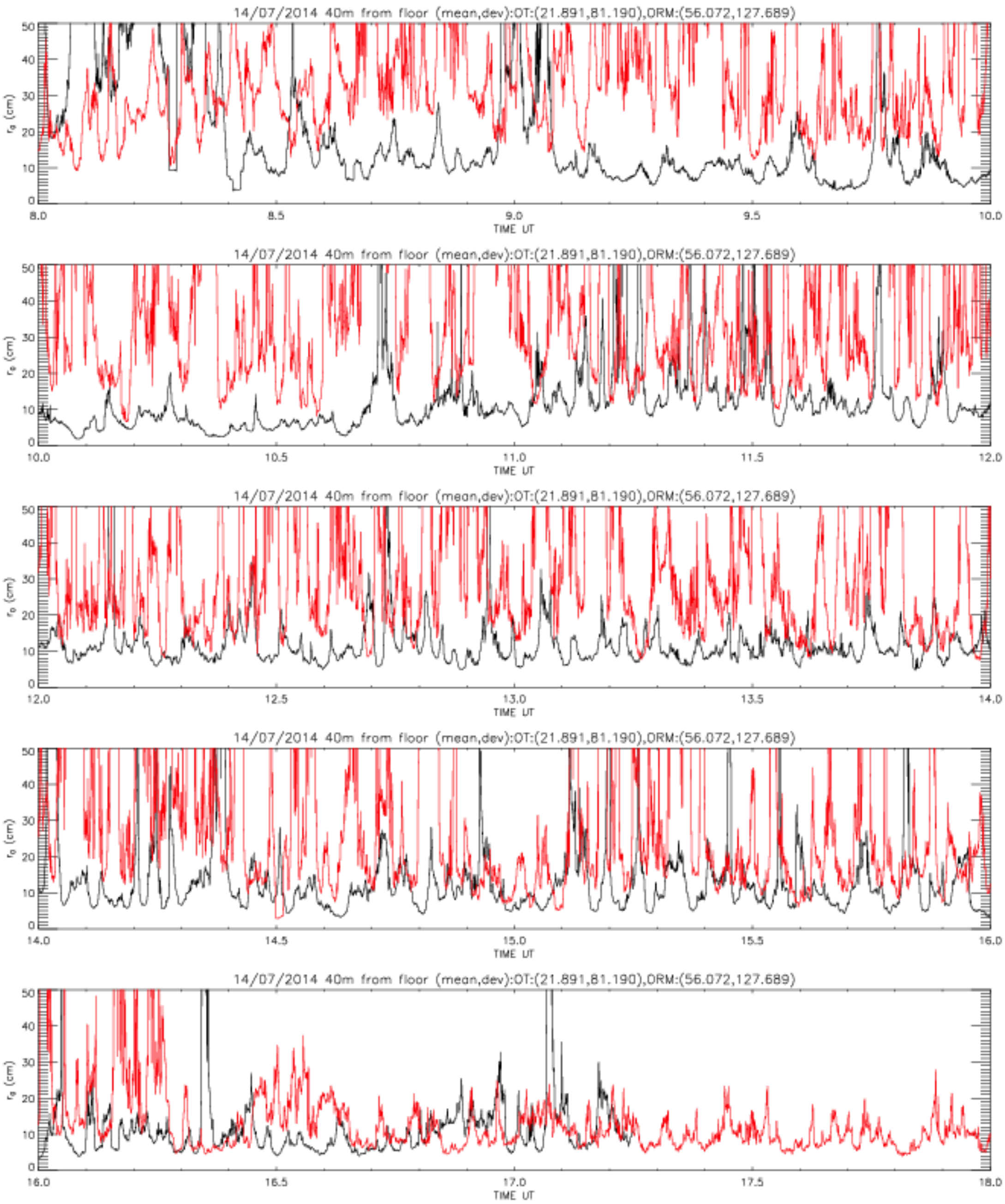


Figure 25. Reduced data for date 14/July/2014 at 40 meters above the ground. Black line represents data from OT and red line represents data from ORM.

Figure 24 and Figure 25 show data for date 14th July 2014. This is an example day with good sky for observation. In this case, even though a similar r_0 is estimated at ground level, r_0 at 40 m above the ground is much better in ORM than in OT (TBC after ORM electronics box calibration).

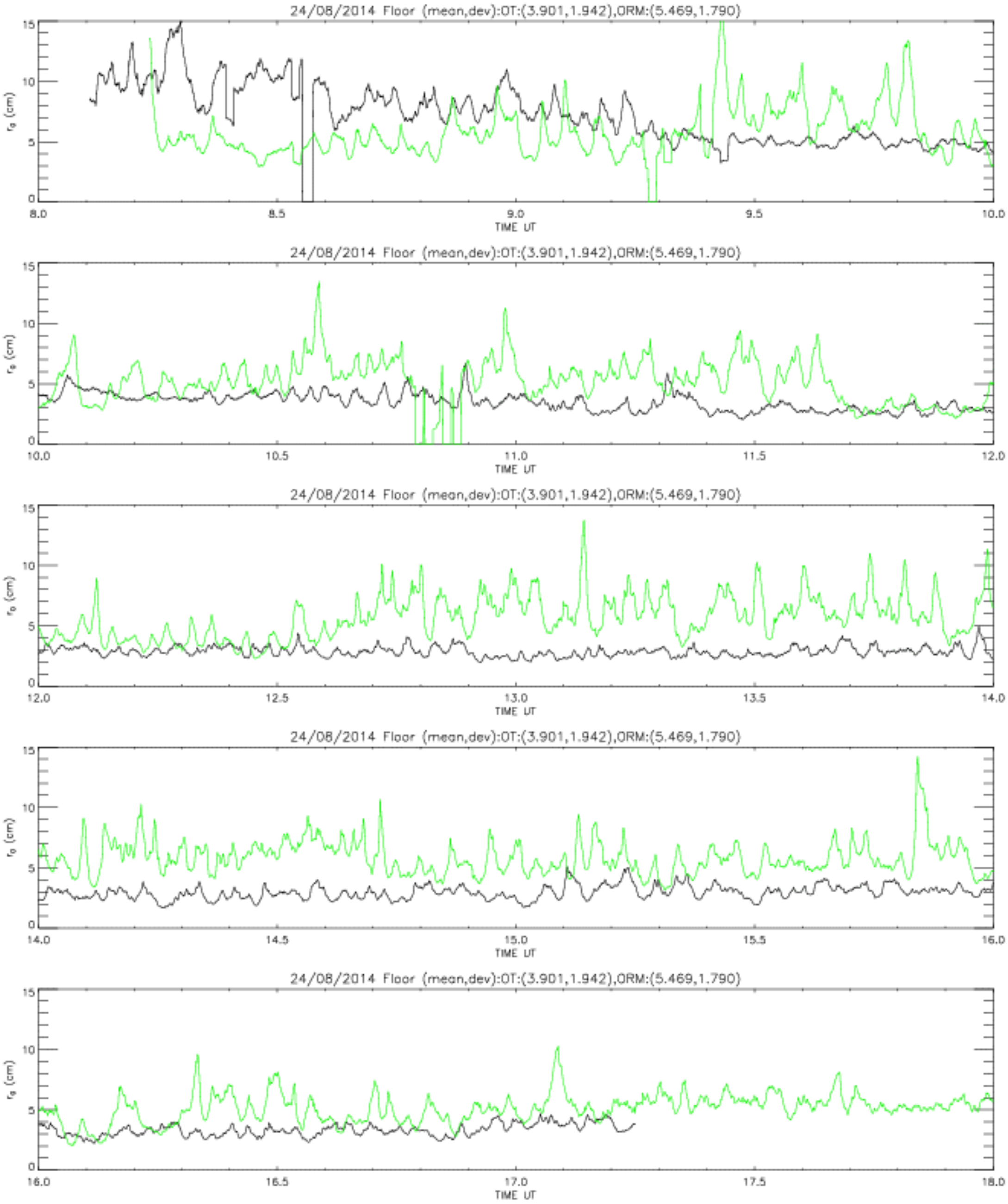


Figure 26. Reduced data for date 24/August/2014 at ground level. Black line represents data from OT and green line represents data from ORM.

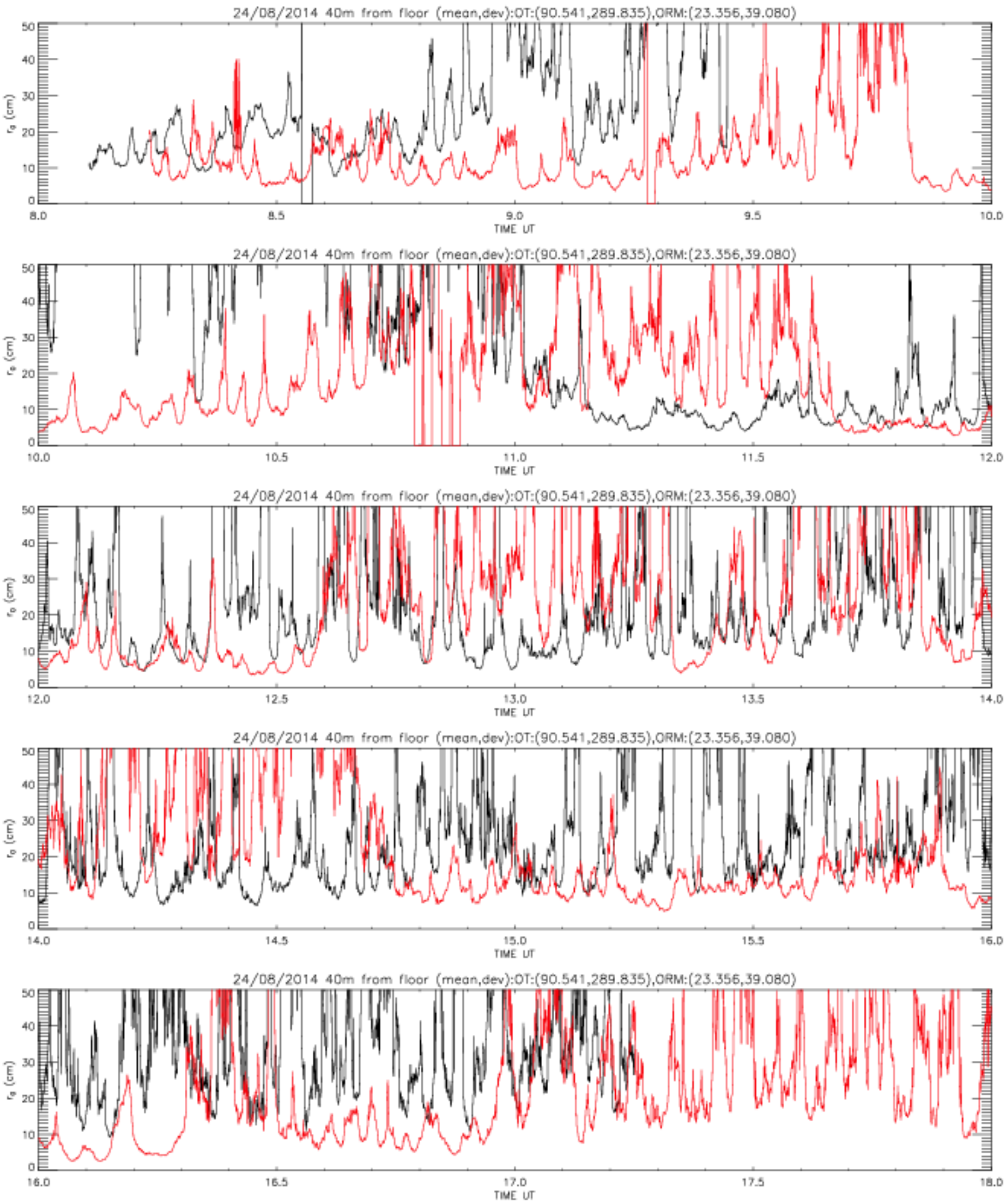


Figure 27. Reduced data for date 24/August/2014 at 40 meters above the ground. Black line represents data from OT and red line represents data from ORM.

Figure 26 and Figure 27 show data for date 24th August 2014. This is an example day with good sky for observation. In this case, even though better r_0 is estimated at ground level for ORM, r_0 at 40 m above the ground is much better in OT than in ORM (TBC after ORM electronics box calibration).

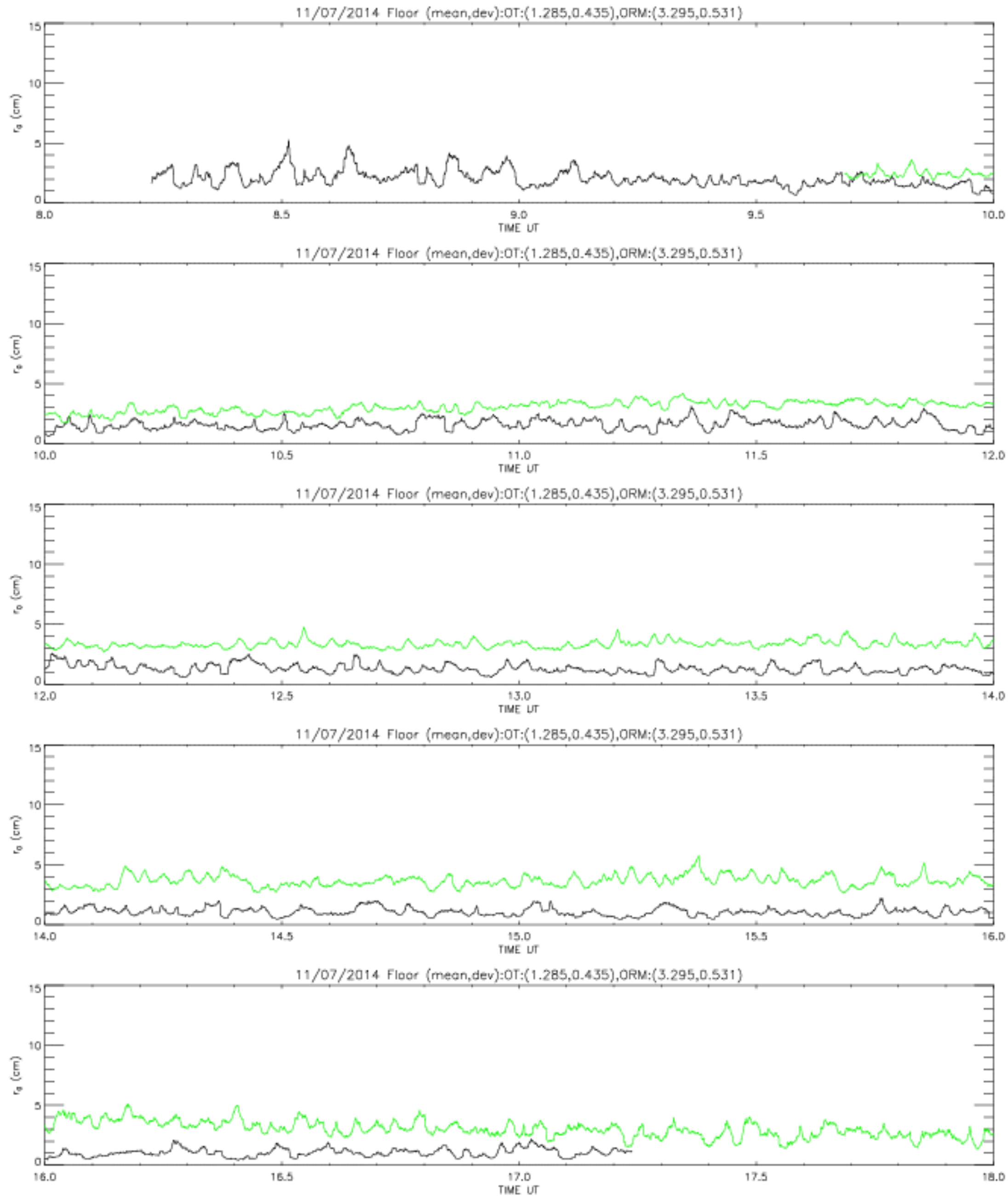


Figure 28. Reduced data for date 11/July/2014 at ground level. Black line represents data from OT and green line represents data from ORM.

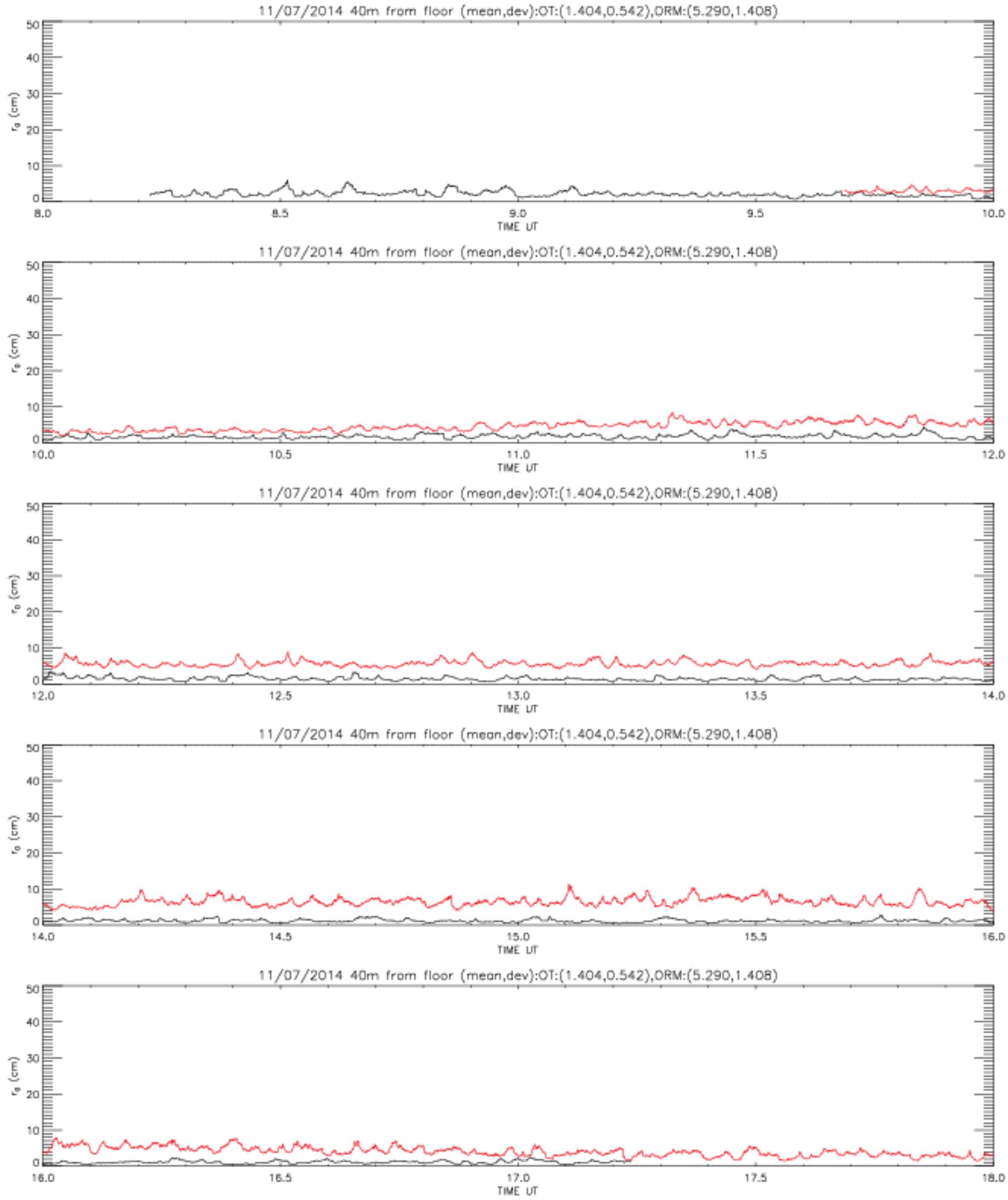


Figure 29. Reduced data for date 11/July/2014 at 40 meters above the ground. Black line represents data from OT and red line represents data from ORM.

Figure 28 and Figure 29 show data for date 11th July 2014. This is a day with bad sky for observation. Both observatories show very bad r_0 at ground level and at 40 m above the ground (TBC after ORM electronics box calibration).

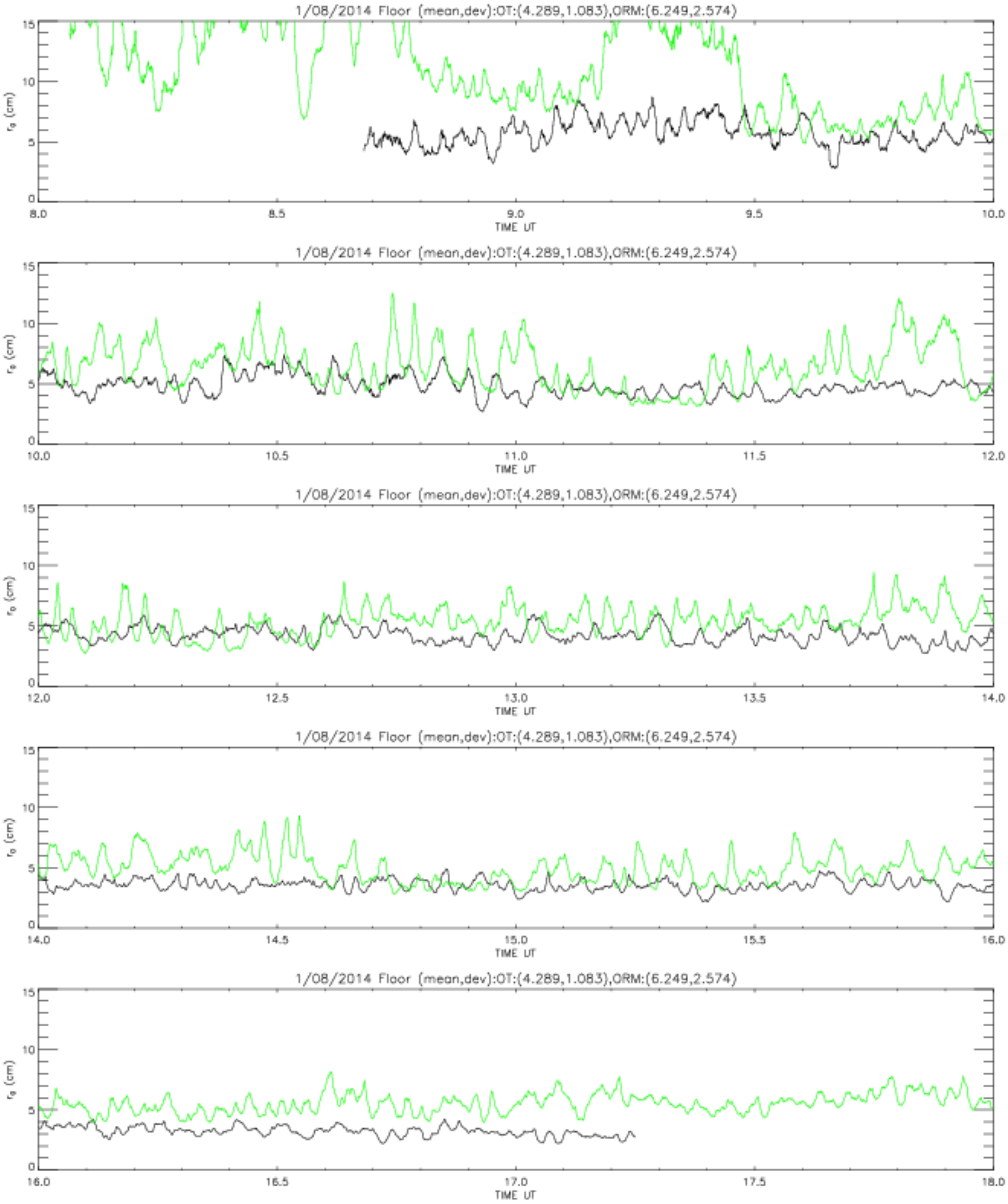


Figure 30. Reduced data for date 1/August/2014 at ground level. Black line represents data from OT and green line represents data from ORM.

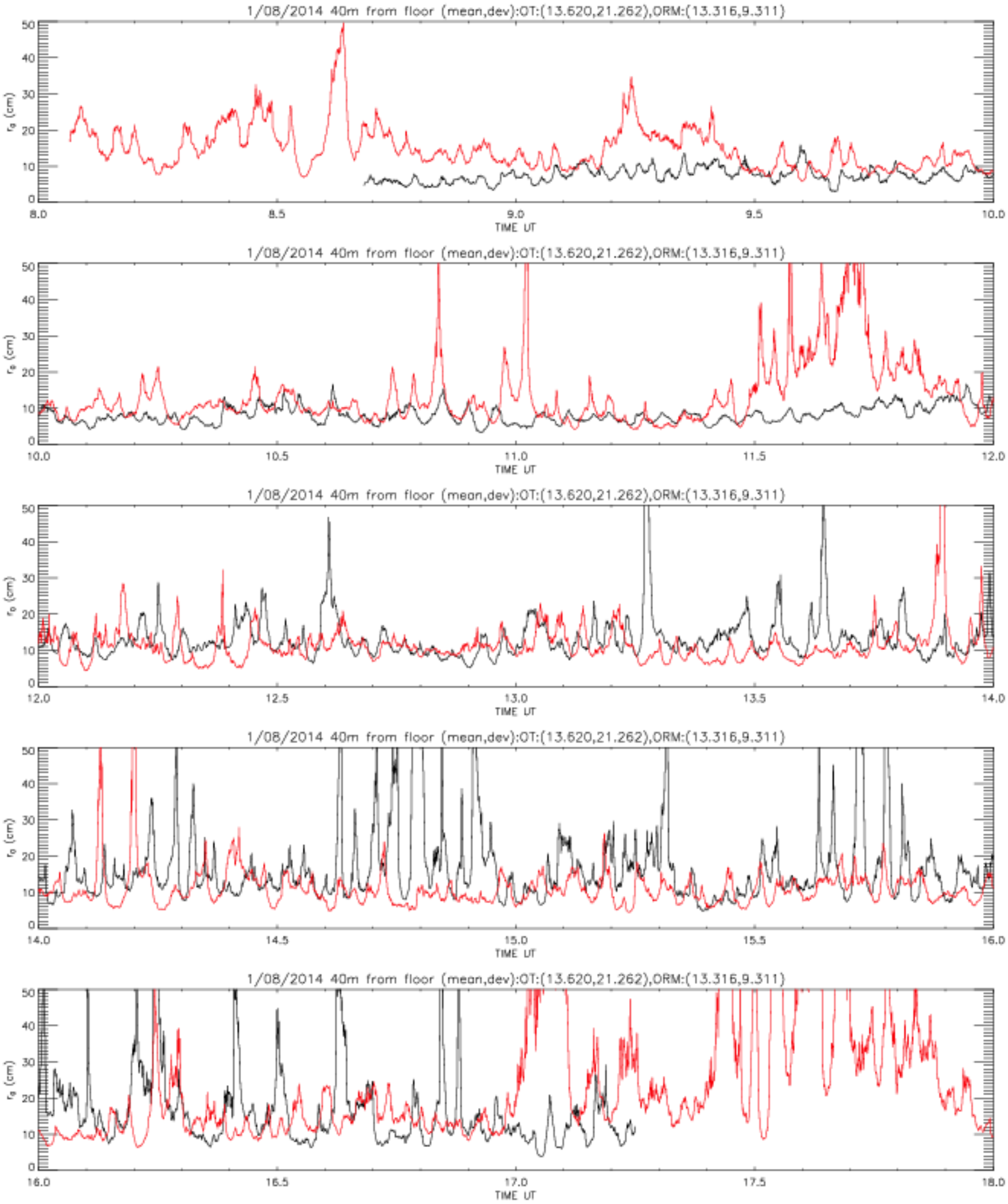


Figure 31. Reduced data for date 1/August/2014 at 40 meters above the ground. Black line represents data from OT and red line represents data from ORM.

Figure 30 and Figure 31 show data for date 1st August 2014. This is a day with not especially good or bad sky for observation. This is a day when average r_0 in both observatories was quite similar (TBC after ORM electronics box calibration).

As stated several times before in this document, further analysis after finer reduction using corrected electronic gains must be carried out before being able to get conclusions. Comparison with data from other instruments in the same spots (short SHABAR and WFWFS at SST, scintillometers in Gregor, etc.) is also needed for cross validation.

5. FUTURE WORK

The currently planned tasks for future work are listed here. This list is subject to new additions in case new issues are found during development of the planned tasks and instrument operation.

5.1 Operation and data publishing software

- Addition of the specific experimentally measured gain values for the particular electronic box performing the observation to the data acquisition software.
- Improvement of reduced data visualization in the operation software. In particular, addition of an averaged r_0 plot for better monitoring.
- Specification of the reduced data database schema for the site testing webpage and addition of data dumping from acquisition software to the database.
- Deployment of newly developed operation software to both instruments (during winter observation stop).
- Webpage requirement specification, development and deployment.
- Completion of documentation for all the newly developed software (user and installation manuals, technical reports, etc.).
- Further integration of the webpage with the project servers if considered interesting.

5.2 Instrument operation and calibration

- Operation, monitoring and maintenance of both instruments until the end of the current campaign (November 2014).
- Calibration of ORM and spare electronic signal conditioning boxes after this campaign
- Preparation of the next standard campaign (foreseen in May 2015).

5.3 Data reduction and comparative analysis

- Transfer of automatic daily data reduction to a permanent IAC server.
- Study and specification of automatically generated plots and statistics.
- Acquired data revision in order to classify the observations and add possibly relevant information regarding operational conditions (height where the instrument was installed (floor/tower), site of installation (to avoid confusion with test observations), photodiodes erroneous behavior, etc.)
- Comparison of long SHABAR in OT and in ORM reduced data with reduced data available from other instruments (short SHABAR and WFWFS at SST, scintillometers in Gregor, etc.).

ANNEXES

A. LIST OF REFERENCE DOCUMENTS

RD.1	RPT-0014 Deriving (h) from a Scintillometer Array, F. Hill, R. Radick and M. Collados- ATST project documentation.
RD.2	WP8100: LONG-BASE SHABAR . PRINCIPLES OF OPERATION AND INSTRUMENT (PRE-IAC-8001-1A)
RD.3	SHADOW BAND RANGING (SHABAR) - USE AND MAINTENANCE MANUAL (TEN-IAC-8101-3A)