Research Center of Advanced Robotics and Environmental Science

Cybertronica Research

Laboratory of Advanced Sensors

PRELIMINARY REPORT

EIS MEASUREMENTS OF NON-CHEMICAL WATER TREATMENT FOR THE 'GLOBAL EXPERIMENT...'

(THE PROJECT NO. 230917-4542-BG)

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Preliminary REPORT
EIS measurements of non-chemical water treatment for the 'Global Experiment...' (the project No. 230917-4542-BG)

1. SUMMARY

The Laboratory of Advanced Sensors (Cybertronica Research, Stuttgart, Germany) performed tests with Electrochemical Impedance Spectroscopy (EIS) of non-chemical water treatment by IC medicals® technology. The tests are performed within the framework and methodology of the 'Global Experiment...' in context of the Conference on Physics, Chemistry and Biology of Water 2017[1]. The goal was to detect with well-known electrochemical measurements the anomalies in dynamics of samples in terms their non-chemical treatment. One significant aspect of these measurements was to demonstrate a fast approach for detecting similar treatments in the fields of so-called 'informational pharmacology' and 'high-dilute solutions'. Two series of independent experiments with 20 attempts have been performed with differential EIS spectrometers to demonstrate on the one hand a repeatability of the approach, on the other hand – an impact of external conditions on the high-resolution measurements. These tests did not intent to collect any statistically significant data and are considered as the feasibility study.

The results indicated a high impact of nearly located reflective objects (CD & DVD) on electrochemical parameters of water. Two independent experiments demonstrated similar data in this regard. The external conditions influence this impact. The maximal impact of a 'pre-processed' reflective object is recorded in the phase 3 (3.5-4 hours after the treatment), which significantly decreased in the phase 4 (24-26 hours after the treatment). Differential measurements between 'pre-processed' and 'clear' reflective objects demonstrated a measurable difference between them (~ 10%) at the phase 3, which however was not detectable in all other phases of tests. It is recommended to introduce safety and security protocols for the tested technology.

[1] www.watercof.org

2. TERMS OF THE TESTS

The Laboratory of Advanced Sensors (Cybertronica Research, Stuttgart, Germany), further the CYB, performed tests with water samples within the 'Global Experiment...' in connection with the Conference on Physics, Chemistry and Biology of Water 2017, further the technology under test (TUT). The goal is to detect with well-known electrochemical measurements the anomalies in water samples in terms of their non-chemical treatment. Analysis of samples (distilled water, conductivity at 3kHz about $3\mu S/cm$) has been performed between 23.09.17 and 24.09.17 with two EIS spectrometers (firmware 1188). These tests are 'curiosity driven' and have been initiated in cooperation between CYB and TUT's manufacturer. CYB did not ask and did not receive any payment from any sides for performing these tests. These attempts do not intent to collect any statistically significant data due to occasional nature of experiments. One significant aspect of these measurements is to demonstrate a fast approach for detecting the impact from TUT, which can be used by customers of the TUT in field conditions.

3. THE TECHNOLOGY UNDER TEST

The details of TUT are unknown to CYB. As stated, TUT is able to transmit 'informational copies of chemical substances', in particular, via reflective objects (CD & DVD). CYB received from manufacturer of TUT a detailed instructions how to use the TUT, this instruction is publicly available[2].

Generally, the **non-chemical water treatment** means such processes as e.g. the controlled hydrodynamic cavitation, the high frequency electric/DC electric field pulsing, UV lighting, pre-processing by acoustic waves or magnetic fields [1] in corrosion/microbiological/viscosity control in cooling/heating/osmosis applications or for control of calcium carbonate crystallization process [2], among others. Weak non-chemical treatment is difficult to detect by common methods of physicochemical analysis of water.

4. EXPERIMENTAL METHODOLOGY AND USED INSTRUMENTS

These tests underlie the common conditions for performing tests on ultra-weak impact factors, as described in [3], [4]. In particular, it means an isolation from thermal, EM[3], mechanical, and acoustic environmental influences. The measurements have been performed by two differential impedance spectrometer with MU-EIS system [5]. These devices are produced by CYB and are specifically adapted to high-resolution measurements with internal and external thermostats. Similar methodology was utilized also in other experiments known in the literature [6], [7], [8].

The experimental methodology is described in [9], it was closely followed. Specific requirement of the TUT is related to open non-chemical treatment of samples, where thermal stabilization of samples is impossible. Thus, the differential measurement scheme with open samples has been selected [10]. As shown by measurements, this approach can be improved

[2] https://science.gict.world/

[3] See e.g. the EMC Directive 2014/30/EU (former 2004/108/EG).

when to measure samples after their treatment (also without opening the water containers). In this case a standard scheme with thermostabilization of samples and better EM-protection can be utilized (measurement of samples inside the thermostats). Additional requirement was imposed for finding two environments (rooms) with slightly different conditions. By performing two independent experiments, the influence of these conditions on results can be observed. The used reflective objects are shown in Figure 4.1(a). These are new (previously not 'pre-processed') CDs. The 'pre-processing' of reflective objects is shown in Figure 4.1(b) with a portable computer. Two CDs are 'pre-precessed' simultaneously for further tests. The measurement setup is shown in Figure 4.1(c), the distance between channels is about 35-40 cm. The second setup is exactly the same. **All tests are performed in darkened rooms**, no human personal was present in the laboratories.

The differential methodology underlies the performed experiments. Always the comparison between 'with CD' vs 'without CD', 'pre-processed CD' vs 'clear CD' has been performed.

5. STRUCTURE OF ATTEMPTS

CYB performed two independent series of experiments, each experiments is divided into 5 phases, Table 5.1 provides an overview over these attempts. Dynamics of the channel 2 (channels with 'pre-processed' CD, the device ID 322006) in phases 0,2,3,4 is shown in Figure 5.1. Differential dynamics (comparison between 'pre-processed' CD and 'clear' CD, the device ID 322006) in phases 1,2,3,4 is shown in Figure 5.2. Examples of dynamics for all phases and both devices (the device ID 322005 and 322006) are shown in appendix in Figures A.1-A.10. **All water samples are closed in measurement containers at the begin of experiments, the containers are kept closed during all attempts, thus a chemical contamination of sample is excluded.** A non-chemical treatment has been performed for about 60 minutes, after this the reflective objects are removed from samples.

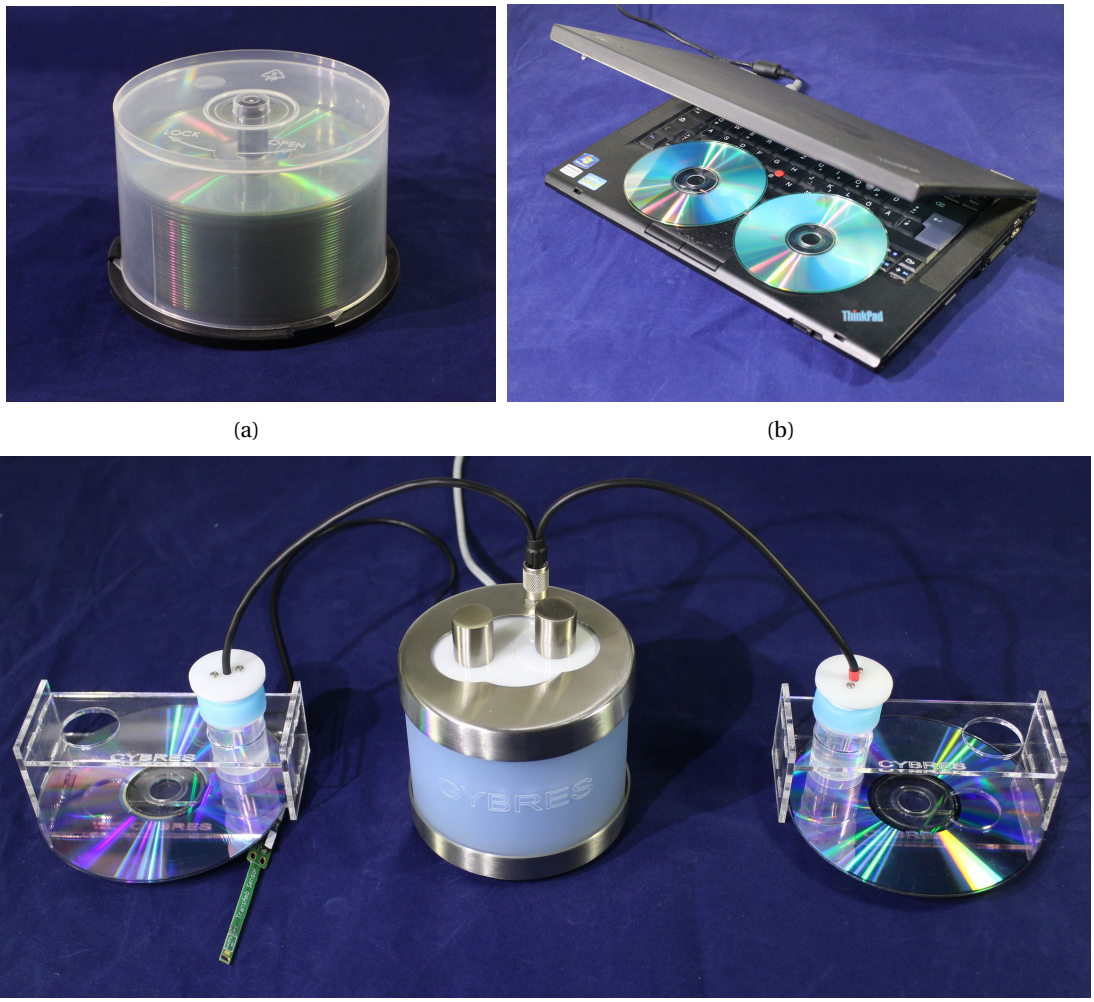
Table 5.1: Overview of performed experiments.

Phase	Data	Description	Comments
0	23.09.17	measurement without CD	about 60 min in both devices
1	23.09.17	two 'clear' CDs are inserted under samples	
2	23.09.17	one 'clear' CD is replaced by a 'pre-processed' CD	channel 2 in device ID 322006, channel 1 in device ID 322005
3	23.09.17	3.5-4 hours after non-chemical treatment	
4	24.09.17	24-26 hours after non-chemical treatment	

6. EIS MEASUREMENT METHODOLOGY

CYBRES EIS devices are high-resolution spectrometers that require understanding of corresponding electrochemical processes for proper setting of parameters. This represents an important condition for the replication of these measurements in different laboratories.

1. The water samples can have different initial dynamics depending on storage conditions, contamination of non-H_3O^+/OH^- ions, and several other factors. When the samples



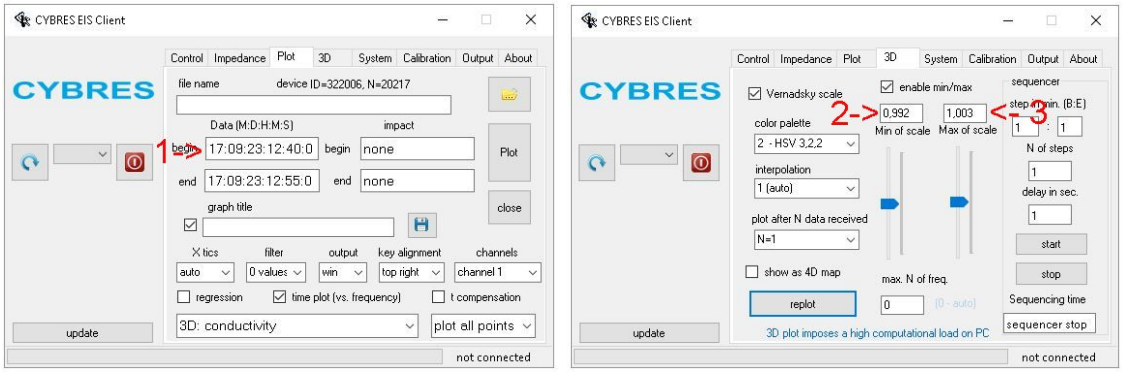
(a) (b)

(c)

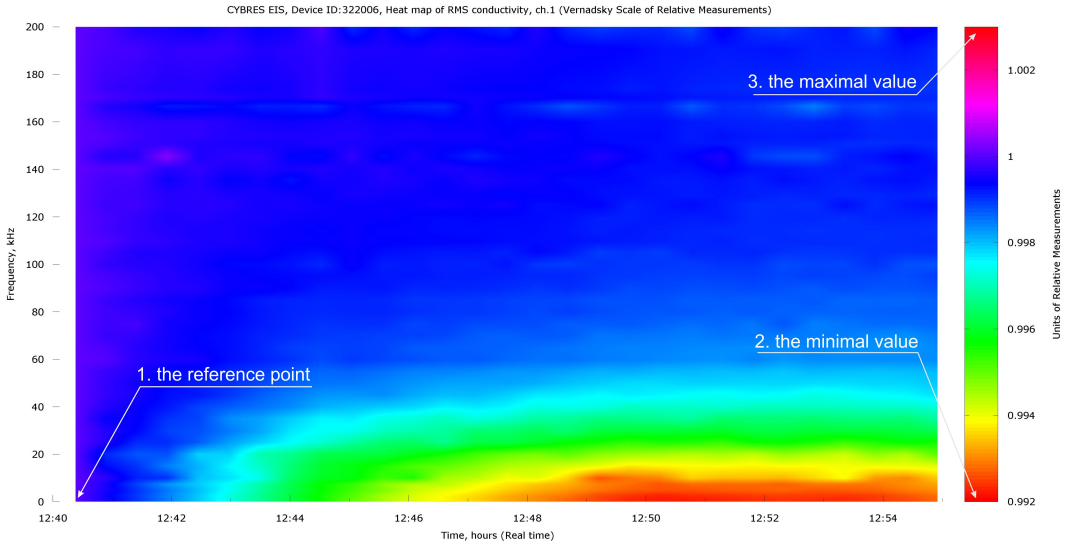
Figure 4.1: The used setup of the experiments: **(a)** Used reflective objects; **(b)** The used scheme of pre-processing of reflective objects; **(c)** The measurement setup with EIS spectrometers (the device ID 322005 and 322006) with open measurement approach, the environmental measurement sensors are placed under one of channels.

demonstrate an essential deviation from a typical dynamics (see typical pattern in Figure 4.2(c)), these samples need to be replaced.

2. All measurements are performed in the relative Vernadsky scale – the initial point (the left boundary of graphs, see Figure 4.2(a)) is set as D_1, all other data D_i are related to this point as $\frac{D_1}{D_i}$. Thus, the left boundary of graphs are always equal to '1' and the selection of this reference point is important for a proper indication of further dynamics. The reference point should be selected in 'steady-state' regions of dynamics (taking into account a general non-stationarity of measurements).



(a) (b)

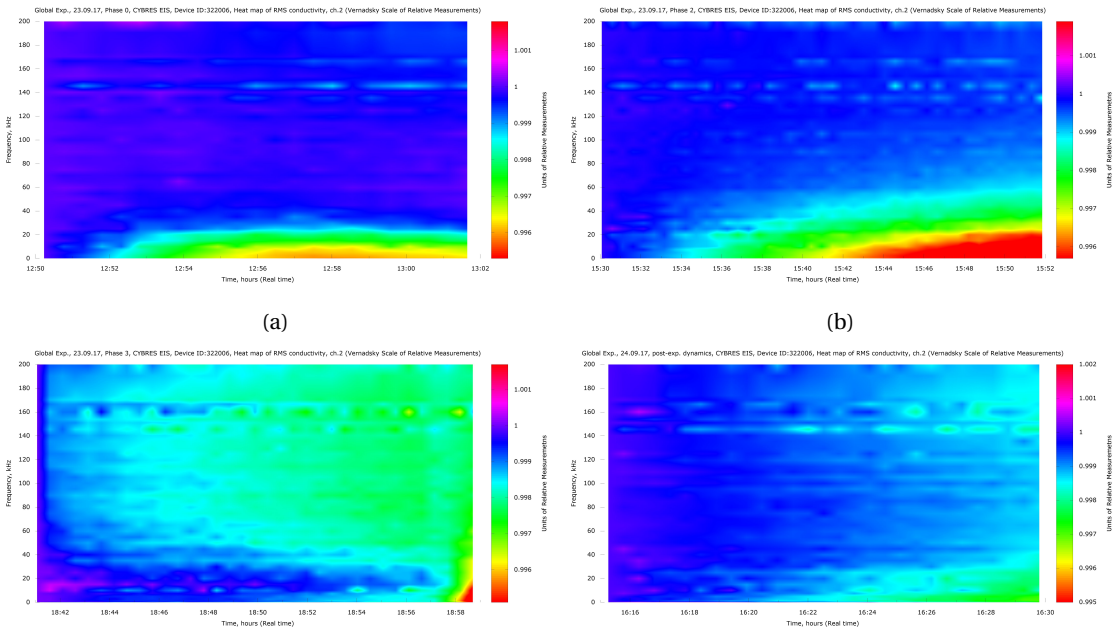


(c)

Figure 4.2: The used setting of the EIS spectrometers: **(a)** the section 'Plot'; **(b)** The section '3D'; **(c)** Explanation of settings in the EIS spectrogram (typical low-frequency degradation pattern of distilled water).

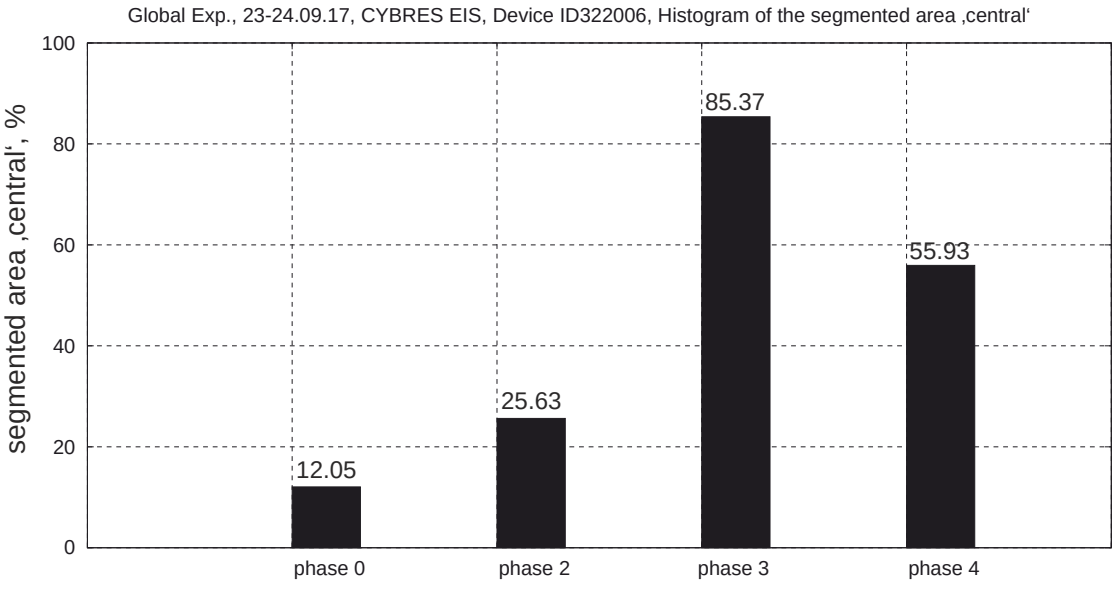
3. The water samples electrochemically degrade all the time – the conductivity is increasing due to absorbtion of CO_2 from the atmosphere, changing of self-ionization during measurement, and number of other factors. This appears as decreasing the values of Vernadsky scale towards the right boundary of a graph. The distilled water has a specific low-frequency degradation pattern, shown in Figure 4.2(c). The duration of a measurement frame should be selected as short as possible (typically 10-15 minutes).

4. The resolution of measurements is set as boundaries of the color scale (see Figure 4.2(b)); it defines among others the signal/noise level. It needs to remember that at initial conductivity of $2\mu S/cm$, the value of 0.999 URM in Vernadsky scale represent



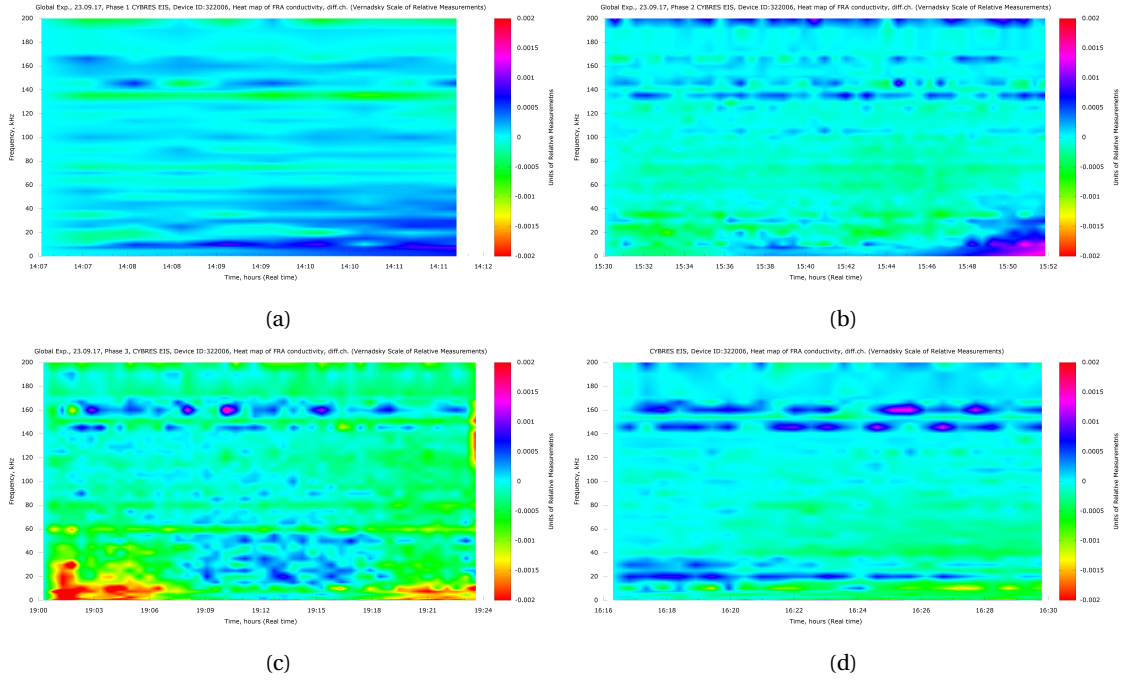
(a) (b)

(c) (d)



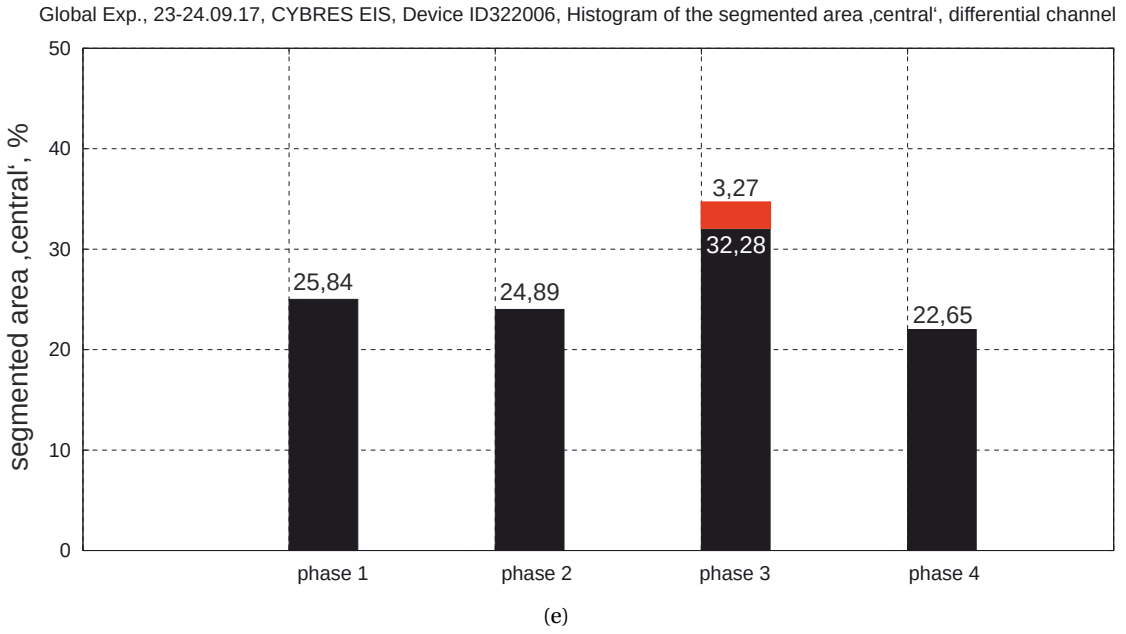
(e)

Figure 5.1: Spectrograms of the channel 2 (the channel with 'pre-processed' CD, the device ID 322006) in phases 0,2,3,4 **(a)**-**(d)**; **(e)** Analysis of all spectrograms by the segmentation approach, shown is the %-content of the 'central areas' (green and turquoise colours).



(a) (b)

(c) (d)



(e)

Figure 5.2: Spectrograms of the differential channels (the channel with 'pre-processed' CD vs the channel with a 'clear' CD, the device ID 322006) in phases 1,2,3,4 **(a)**-**(d)**; **(e)** Analysis of all spectrograms by the segmentation approach, shown is the %-content of the 'central areas' (green and blue colours, the red colour is segmented separately and is shown by red colour in the phase 3).

2/2.002 $\mu S/cm$, i.e. the resolution is on the level of $10^{-9} S/cm$. Setting of boundaries for color scale has to be kept the same (or very similar) for all measurements in one series, otherwise the patterns will be non-comparable with each other.

5. The water samples after a non-chemical treatment (and generally under environmental influences) become non-stationary, they can loose electrochemical stability and the measured values are time-dependent. The high-resolution measurement and non-stationarity introduce a certain level of stochasticity in experimental results, which in turn require multiple measurement attempts to accumulate a statistical significance of obtained experimental data.

7. Environmental conditions during measurements

Recording of environmental conditions is continuously performed by internal sensors of EIS devices (3D acceleromeret/magnetometers, temperature in several points, light intensity, air humidity, air pressure, RF power). An example of temperature recording is shown in Figures A.1-A.10 in appendix. No anomalous environmental conditions were detected during all measurements.

8. Control measurements

There are two types of control measurements: time-wise and channel-wise. First, the time-wise measurements compare dynamics with and without CDs, with 'clear' and 'pre-processed' CDs. The channel-wise control measurements utilize the same principle, but between channels. Thus, each measurement with electrochemical impedance spectroscopy includes in fact a control measurement as well.

9. Main conclusions

The used measurement approaches are an experimental technology of measuring non-chemical water treatment with time-frequency EIS [11]. Beside this experimental character, many properties of the TUT are unknown (no measurement model is available) – thus, all results should be considered as preliminary.

1. Two independent experiments each with 10 measurements = in total 20 measurements have been performed, they originate from two setups. Due to a low number of iterations these measurements cannot be considered as statistically significant, and thus no statistical analysis is performed. These results have an explorative character (so-called feasibility study) before further larger tests and experiments.

2. The shown in Figure 5.1 spectrograms and their analysis by the segmentation approach demonstrated the impact from reflective objects on electrochemical properties of water. The maximal impact of 85.37% appeared in the phase 3 (3.5-4 hours after non-chemical

treatment of water) and decreased to 55.93% in the phase 4 (24-26 hours after non-chemical treatment of water). Immediately after treatment the impact is about 25.63% (the background level is 12.05%). This evidently demonstrated that a maximum of impact is produced several hour after removing the reflective objects, however within the 24 hours time frame.

3. The shown in Figure 5.2 spectrograms of the differential channel demonstrated the difference between impacts produced by 'clear' and 'pre-processed' reflective objects, which is about 10% in the phase 3. The difference in other phases is not evident.

4. Variation of data in Figures A.1-A.10 demonstrated that environmental conditions, in particular light and EM emissions, have a clear influence on results of measurements. However, the qualitative electrochemical dynamics indicated the same behaviour of both EIS devices in corresponding phases.

5. Tests demonstrated that a 'clear' reflective object (CD without any pre-processing) is also able to produce a non-chemical impact on water properties. The questions arise whether any reflective object can produce a similar impact, whether the reflective object after initial pre-processing can be accidentally 're-processed' (considering a relative simple pre-processing procedure)? CYB recommends to the manufacturer of TUT to consider the safety and security aspects of the technology and to introduce corresponding protocols (especially taking into account the stated 30-days usage of 'pre-processed' reflective objects).

6. The performed experiments indicated that it is possible to measure the impact from TUT and reflective objects by the shown methodology in a reliable way. However, due to nature of these experiments, we cannot say whether the impact can be accounted directly to TUT, to collective effects between TUT and environment, or even represents an impact of any other factors. Further investigations with a larger statistics, blind attempts and with biological tests are necessary. Therefore CYB suggests to perform larger experiments for detection of non-chemical water treatment with TUT by time-frequency EIS approach and biological tests (e.g. the fermentation or MFC tests with microorganisms).

7. Since these positive results repeat qualitatively and quantitatively results of other measurements of non-chemical treatments (by other TUT and DUT – Device Under Test), and thus they are of a large interest for scientific auditory, CYB suggests to publish all obtained results of these and other attempts in scientific journals.

8. The total run time of the EIS spectrometers was about 7 hours each, the used operator time – about 20 minutes including generation of images. Moreover, these tests can be simplified and improved when to skip the phase 0 and 1 and to measure only the phase 2 (after the CDs are removed), 3, and 4 inside of the thermostats. This will further reduce the required operator time and increase the accuracy level of measurements.

10. General Conditions and Explanations

1. Measurements intend to confirm presence/absence of responses/effects from physical/biological test systems impacted by the customer's experimental technology (TUT) or device (DUT). Any other purpose is not intended.

2. General explanations of the mentioned effects can be found in [3], [4].

3. Both, the customer and the laboratory, are agreed for non-disclosure of any information, related to the measurements, their results, experimental technology, etc. All data are treated as confidential. The customer is agreed with long-term storage of received data by the laboratory. In case the customer approaches an open-science, or open-access, or any other public dissemination strategy for the obtained results, a separate agreement is required. Generally, copyrights on the materials, such as graphics, images of experimental equipment, tables, belong to the laboratory.

4. The laboratory guarantees performing all tests according to specific conditions by high-qualified personal. The customer's experimental technology is responsible for positive/negative outcomes of the tests.

5. Generally, the laboratory communicates any positive or negative results to the customers as soon as they are obtained. The customer can suggest other experimental conditions, other measurement strategies, etc. to test different aspects the experimental technology.

6. The certificate based on the performed measurements can be issued, however it requires to meet specific conditions related to statistical significance of data, enough iterative measurements in different environments as well as a fulfilment of several other requirements. In this case a separate agreement between the laboratory and the customer is required.

7. The laboratory is in general not responsible for any ethical or legal aspects of customer's experimental technology. The customer should take care of satisfying all legal requirements imposed by the customer's original country on the experimental technology.

8. The performed tests/measurements have in general no issues related to the Amsterdam protocol on animal protection and animal experiments. Tests/measurements do not involve any kinds of human behavioural observation, invasive and non-invasive experimentation, and personal data records; do not involve any kind of localization, tracking or position storing of individuals; do not have any issues on ICT implants; do not have any issues on the personal privacy implications of the intended use or potential use of the outcomes; do not involve any kind of human genetic material; do not use any biological or other samples/emission that can contaminate the environment; do not have any ICT-bio/nano-electronics issues; do not have any direct military applications or misuse potential for terrorist abuse.

References

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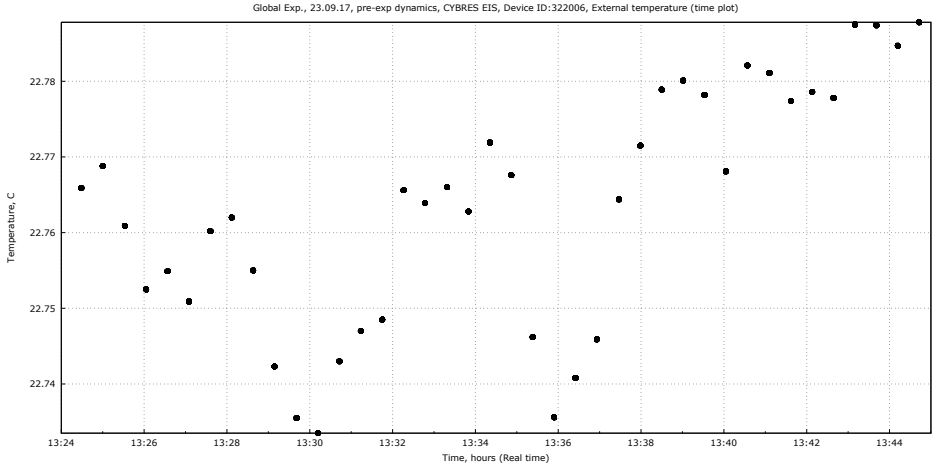
A. Examples of measurement data in all phases of both experiments

A.1. The EIS device ID 322006



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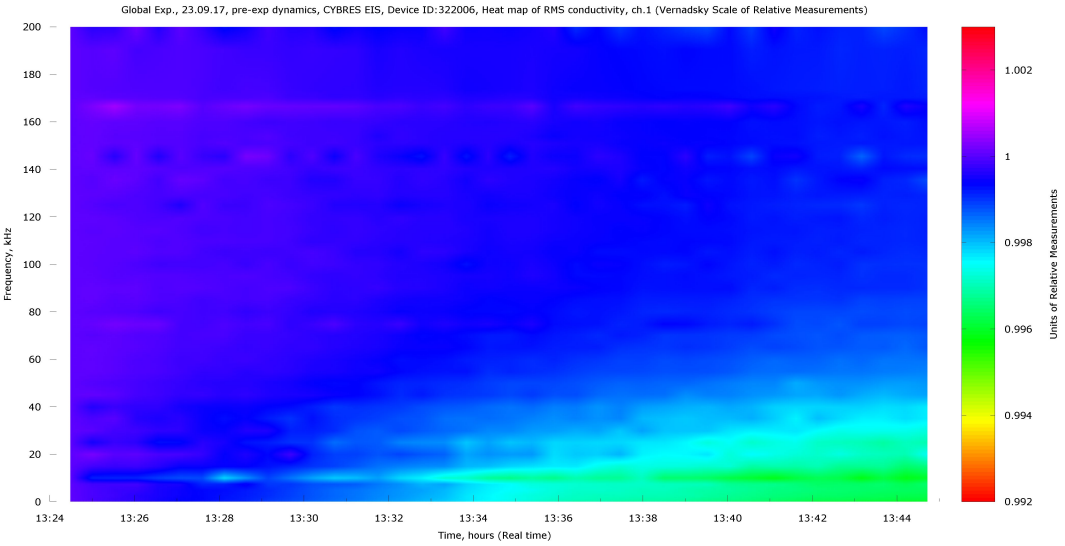

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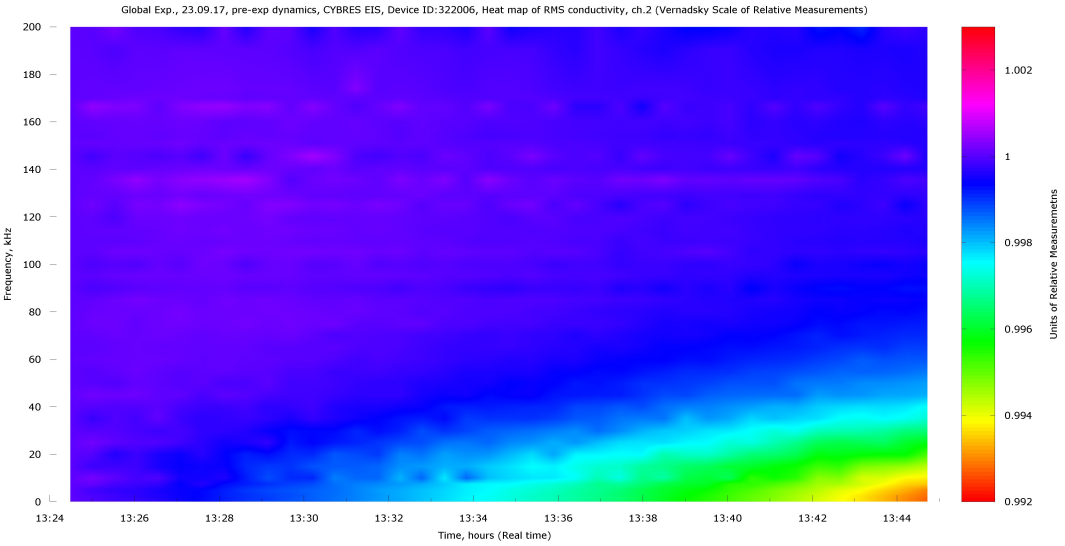
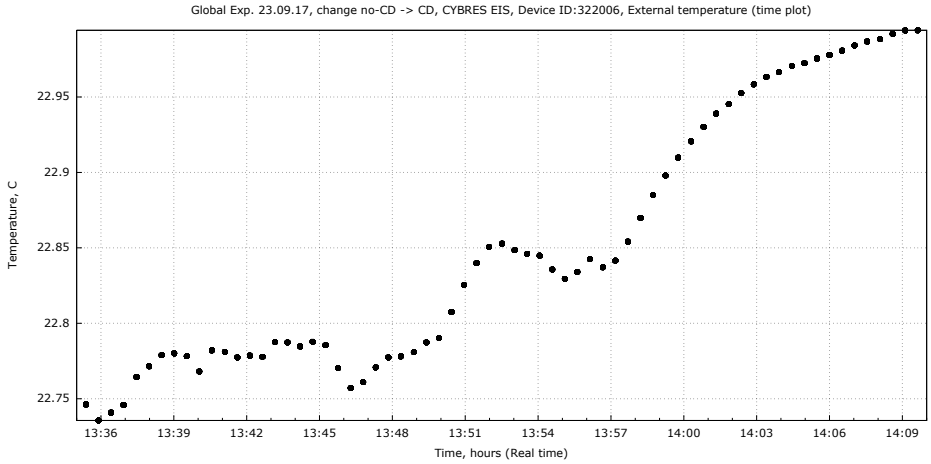


(c)

Figure A.1: **The phase 0:** pre-experimental dynamics of both water samples (device ID 322006). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



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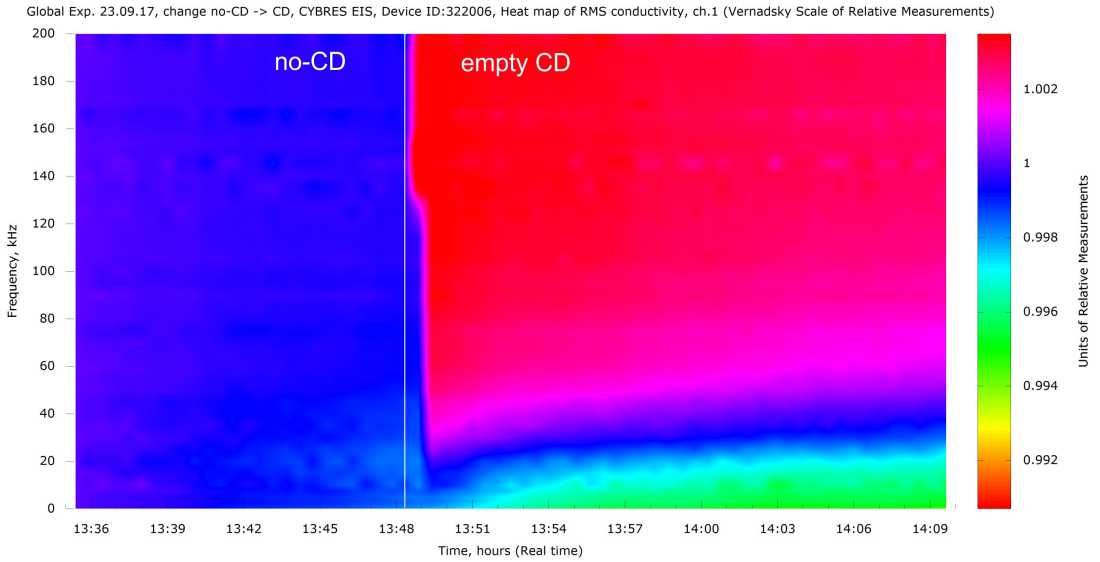

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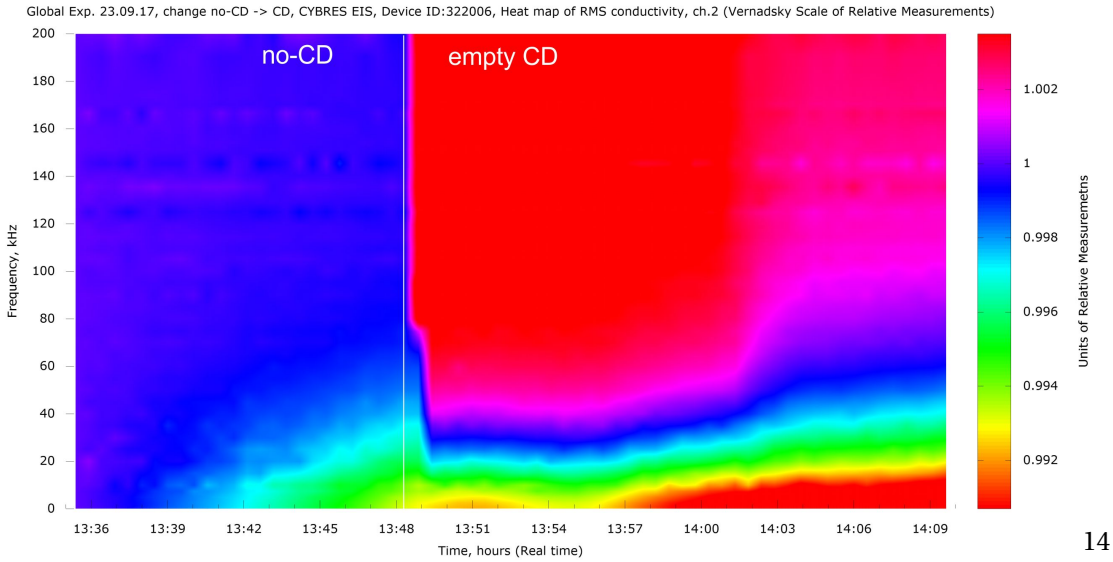
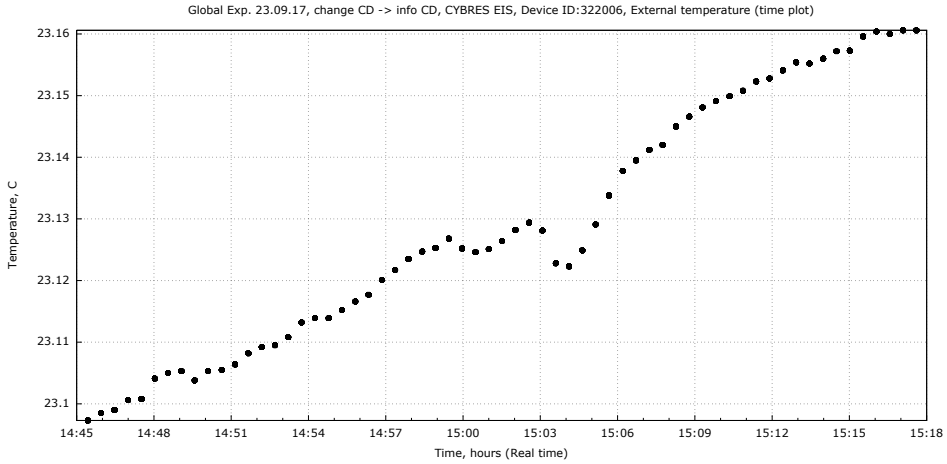


(c)

Figure A.2: **The phase 1:** insertion of empty CDs under both containers with water samples (device ID 322006). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



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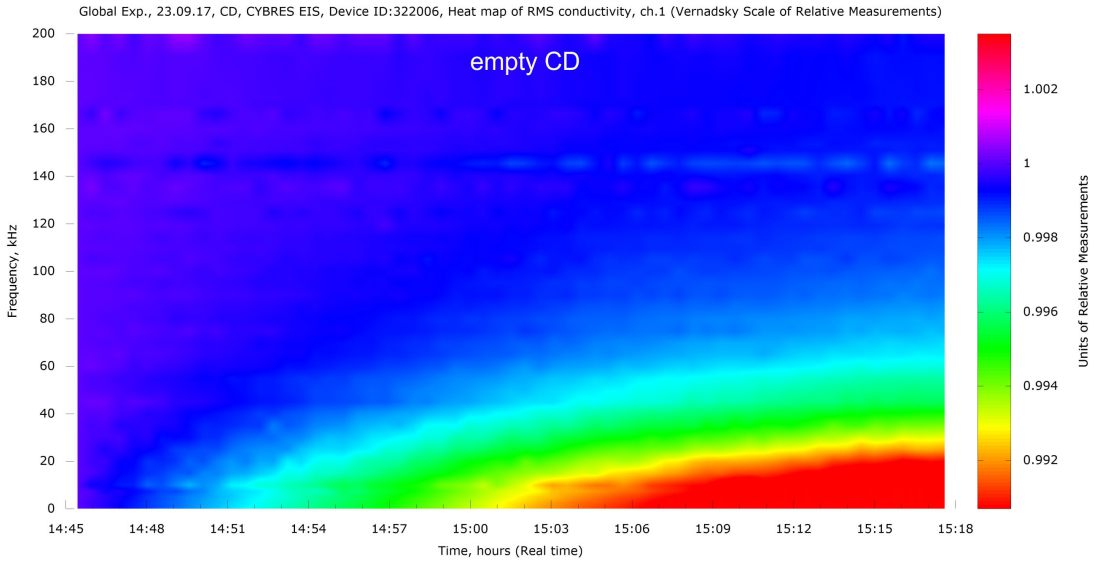

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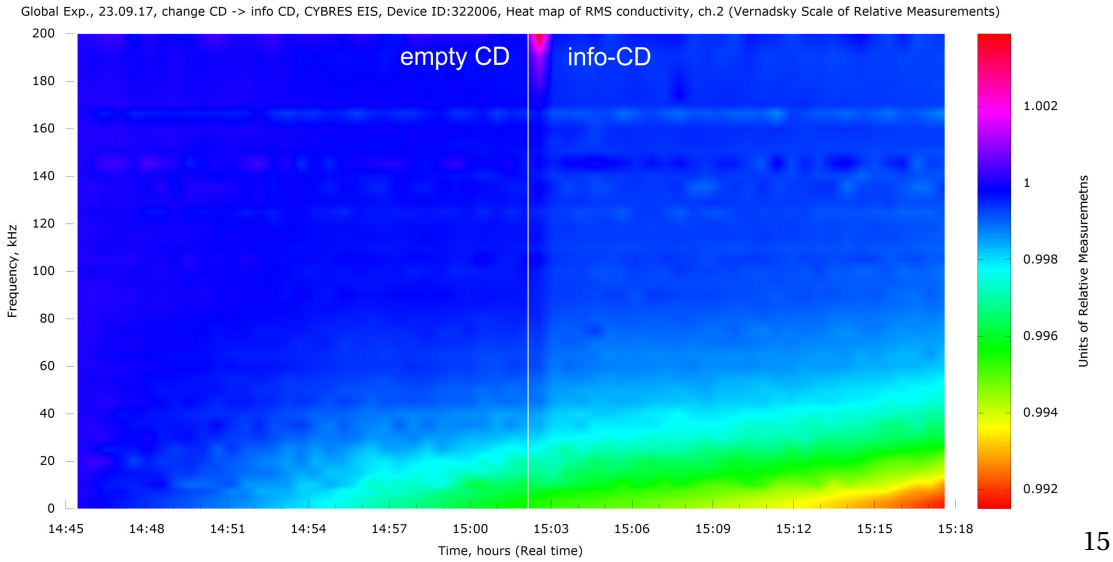
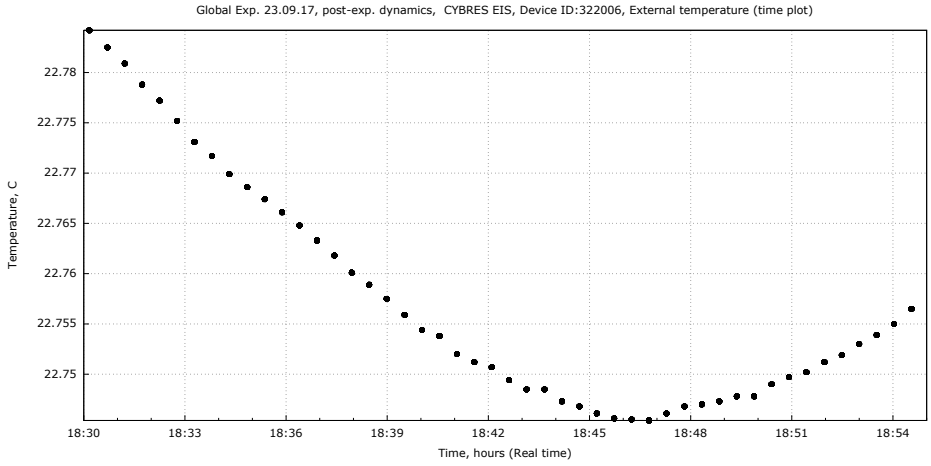


(c)

Figure A.3: **The phase 2:** insertion of info-CD under the channel 2, the channel 1 remains with an empty CD (device ID 322006). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



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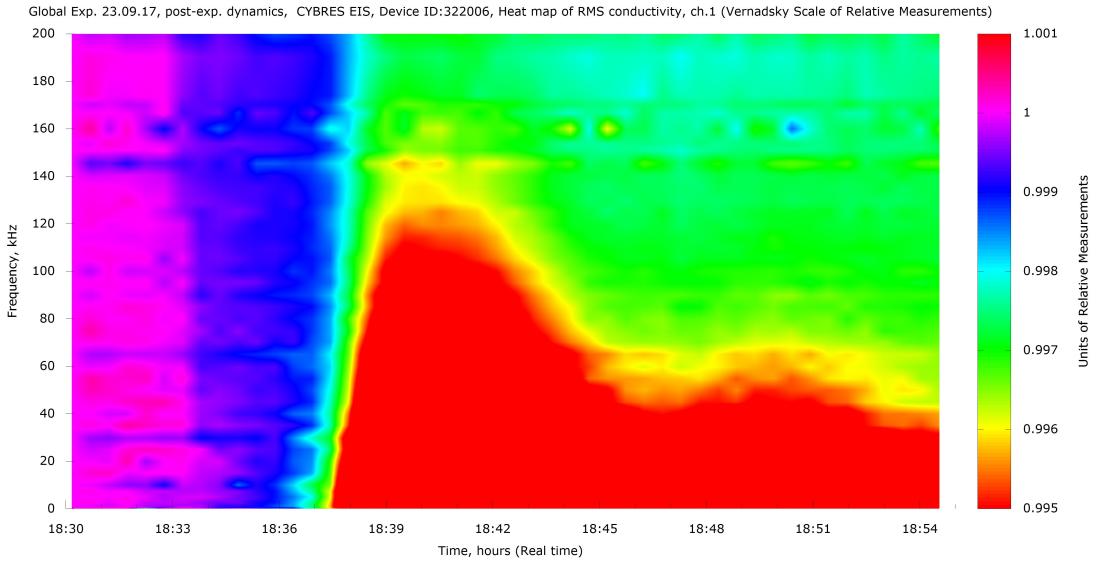

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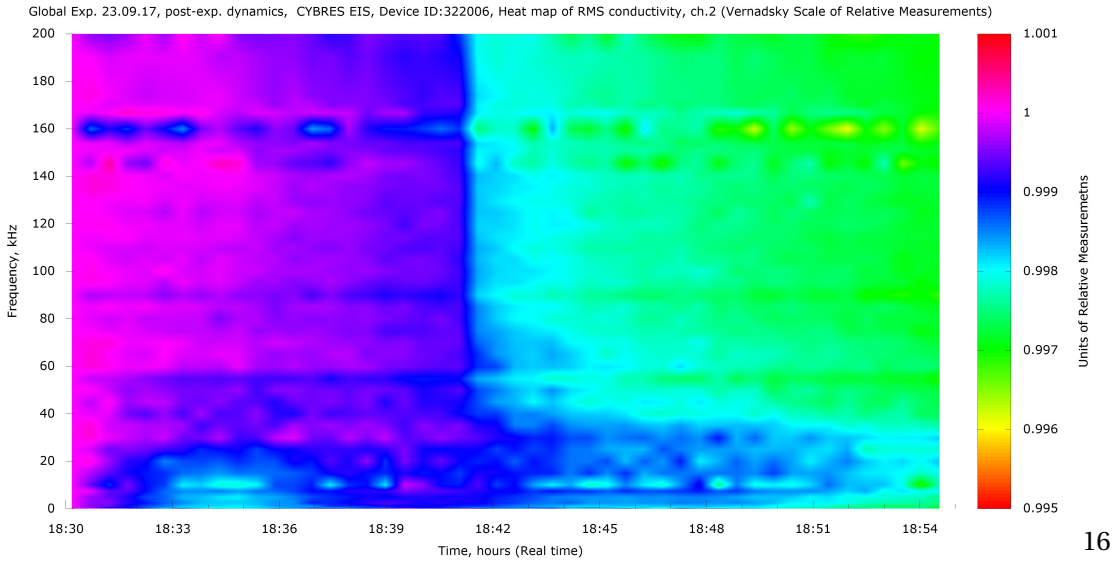
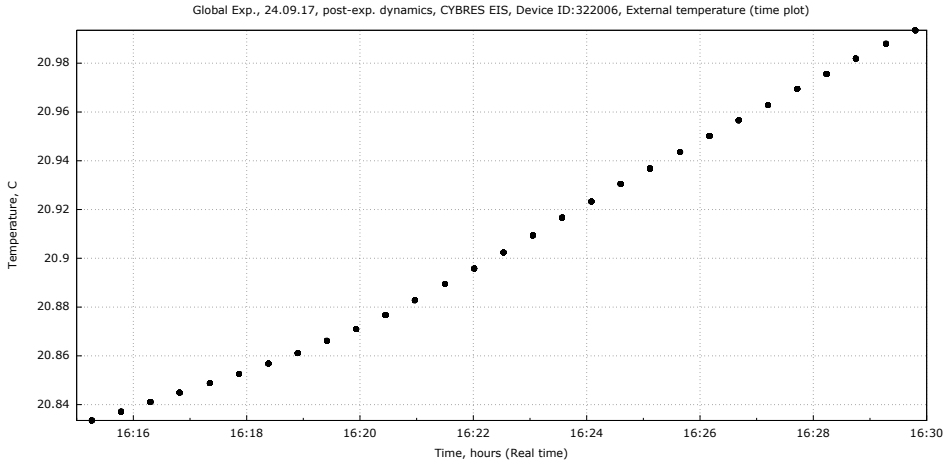
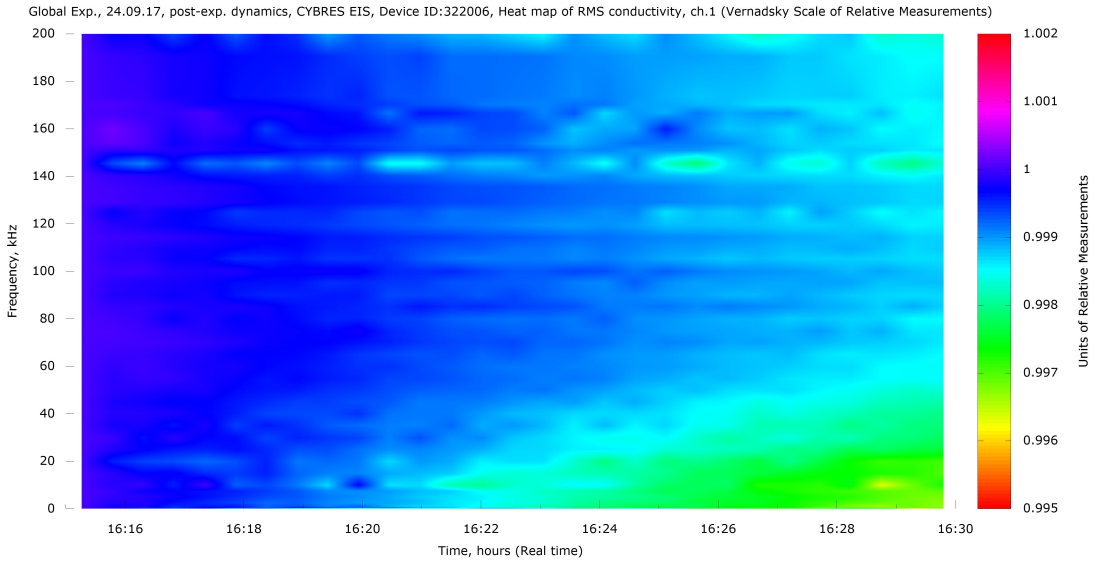


(c)

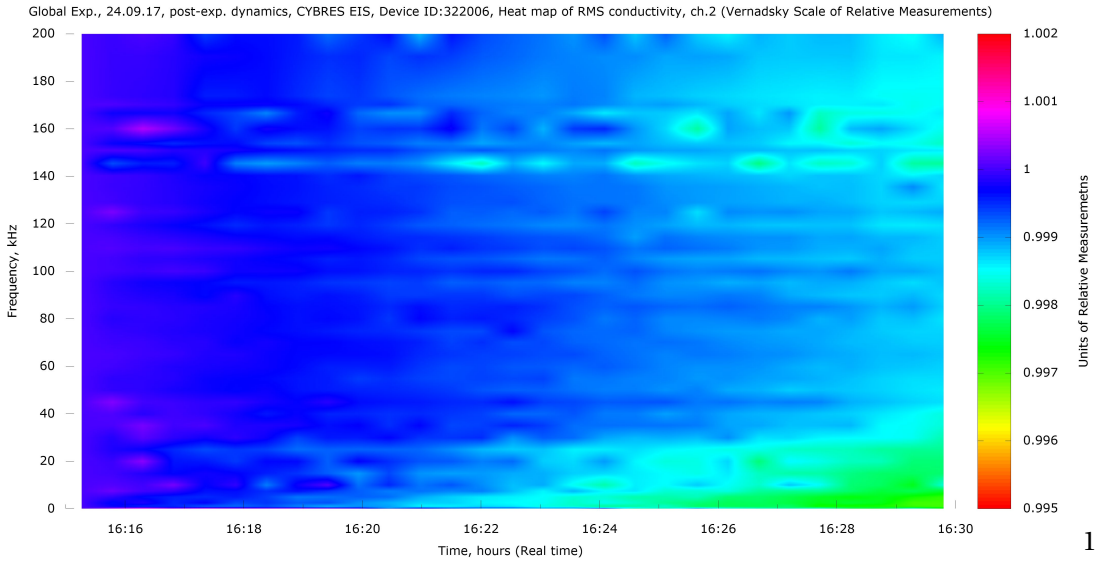
Figure A.4: **The phase 3:** post-experimental dynamics of both channels 180-240 min after exposition, CDs are removed (device ID 322006). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



(a)



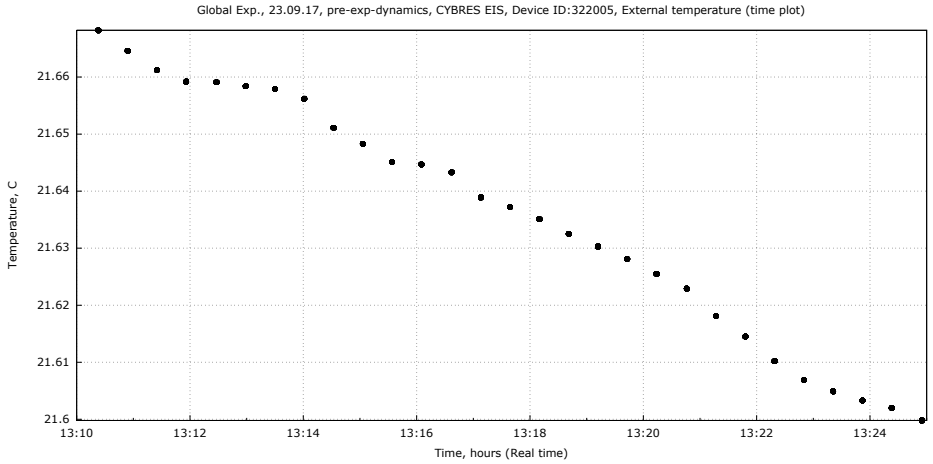
(b)



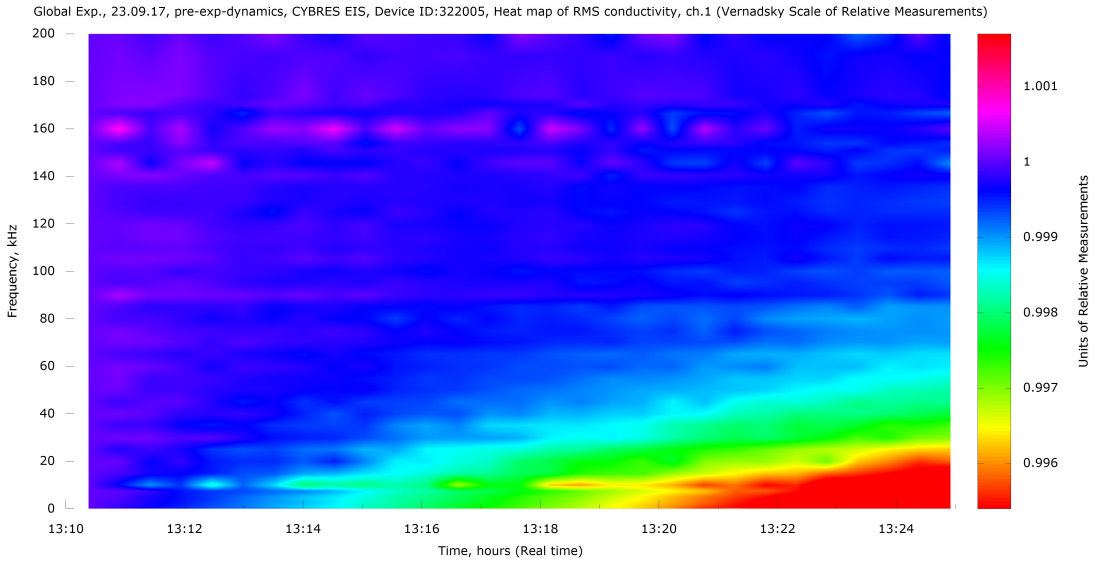
(c)

Figure A.5: **The phase 4:** post-experimental dynamics of both channels 22-24 hours after exposition, CDs are removed (device ID 322006). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.

A.2. THE EIS DEVICE ID 322005



(a)



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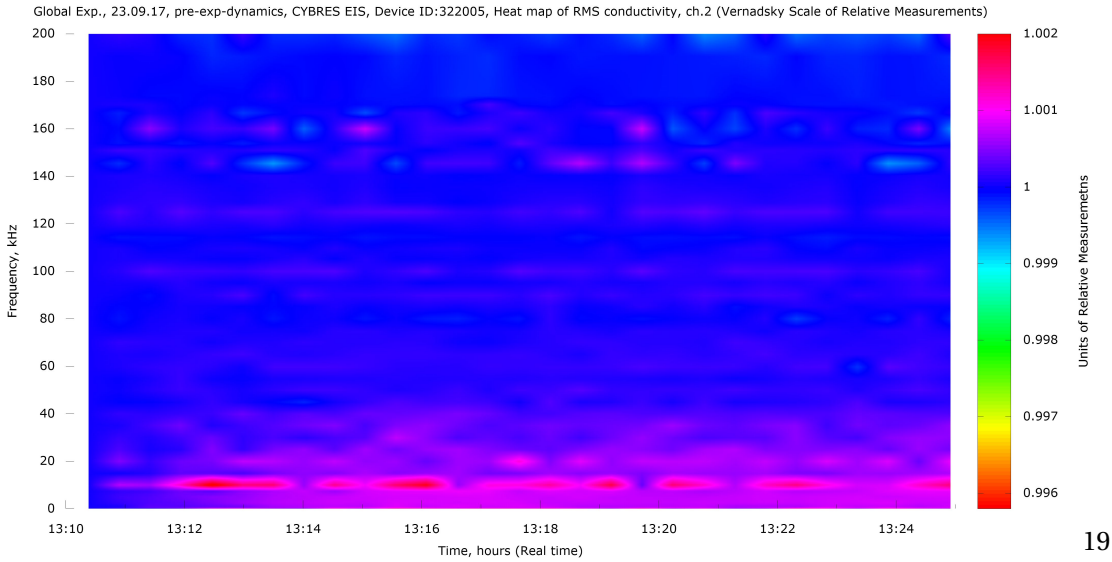
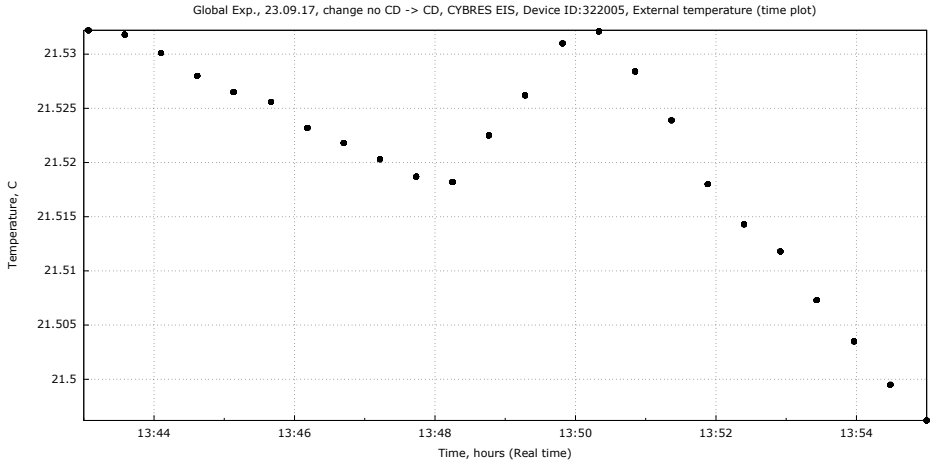
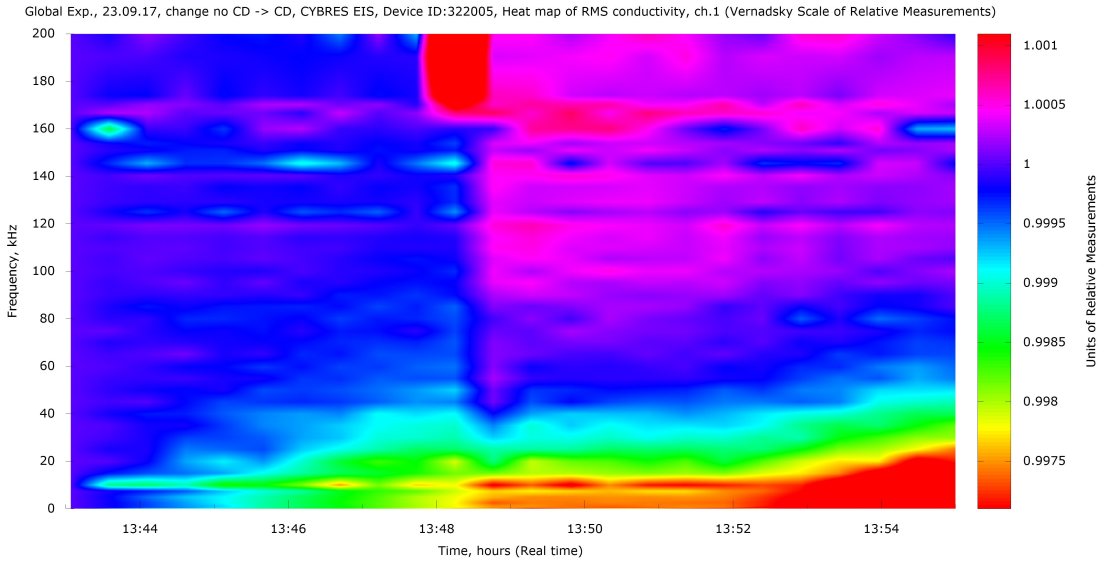


(c)

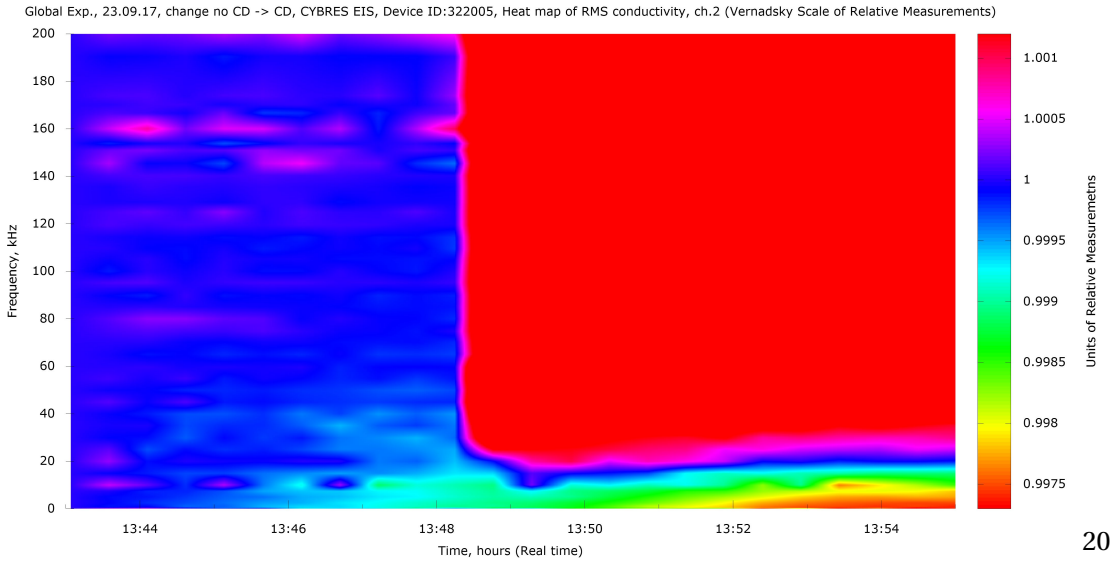
Figure A.6: **The phase 0:** pre-experimental dynamics of both water samples (device ID 322005). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



(a)

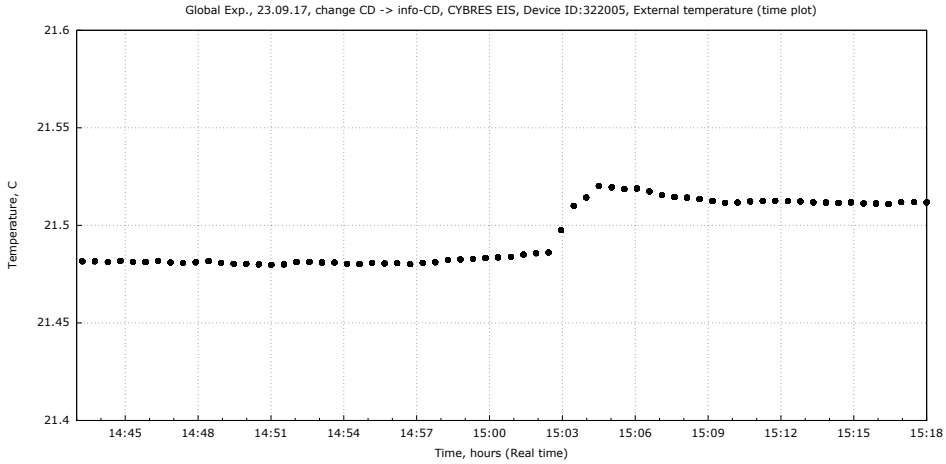


(b)

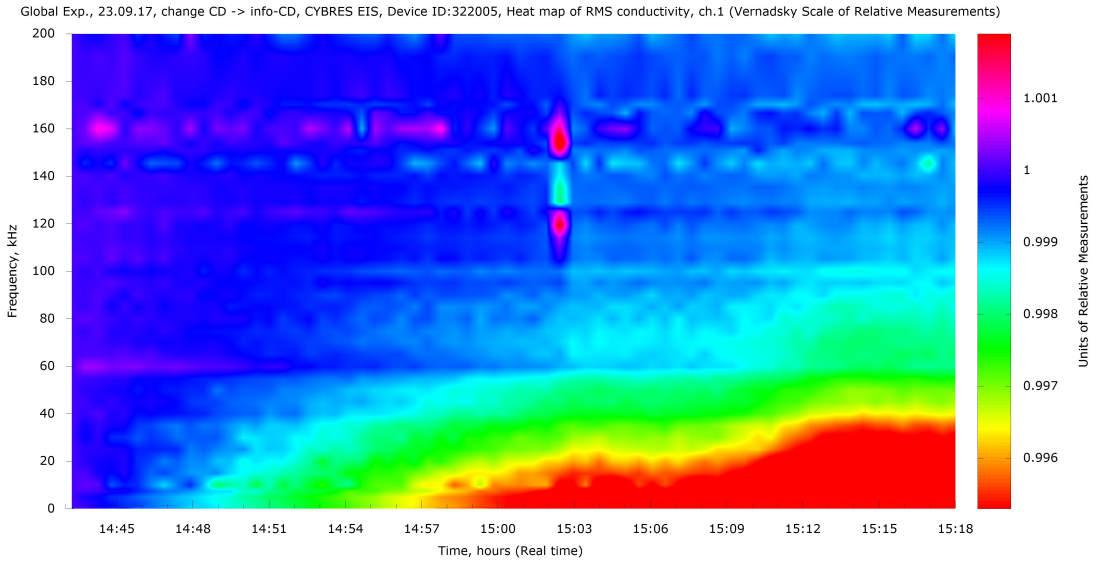


(c)

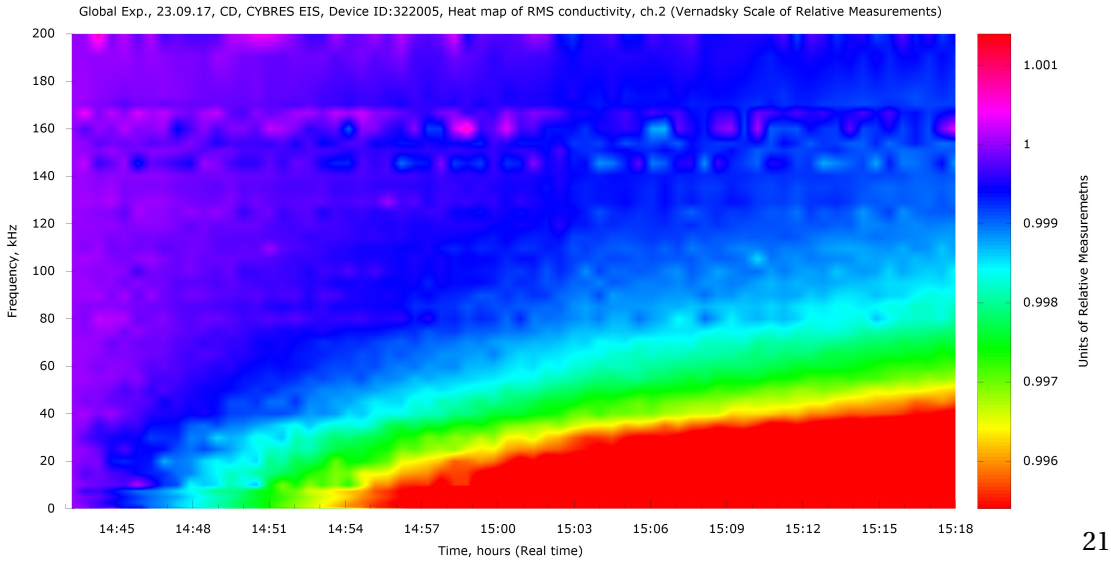
Figure A.7: **The phase 1** insertion of empty CDs under both containers with water samples (device ID 322005). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



(a)

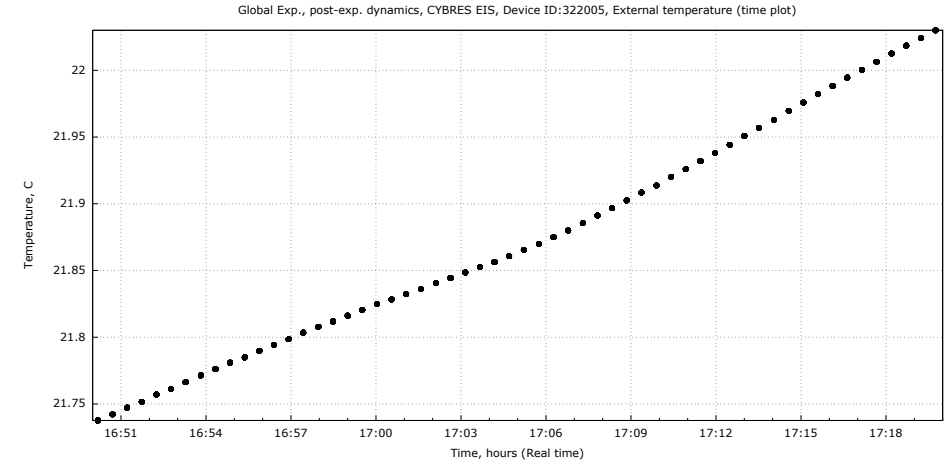


(b)

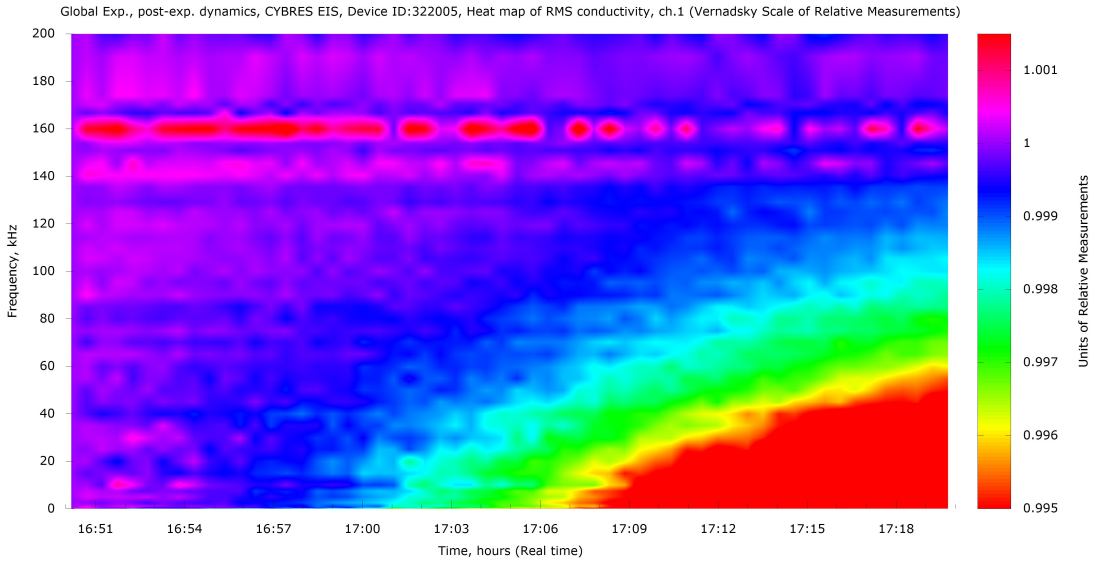


(c)

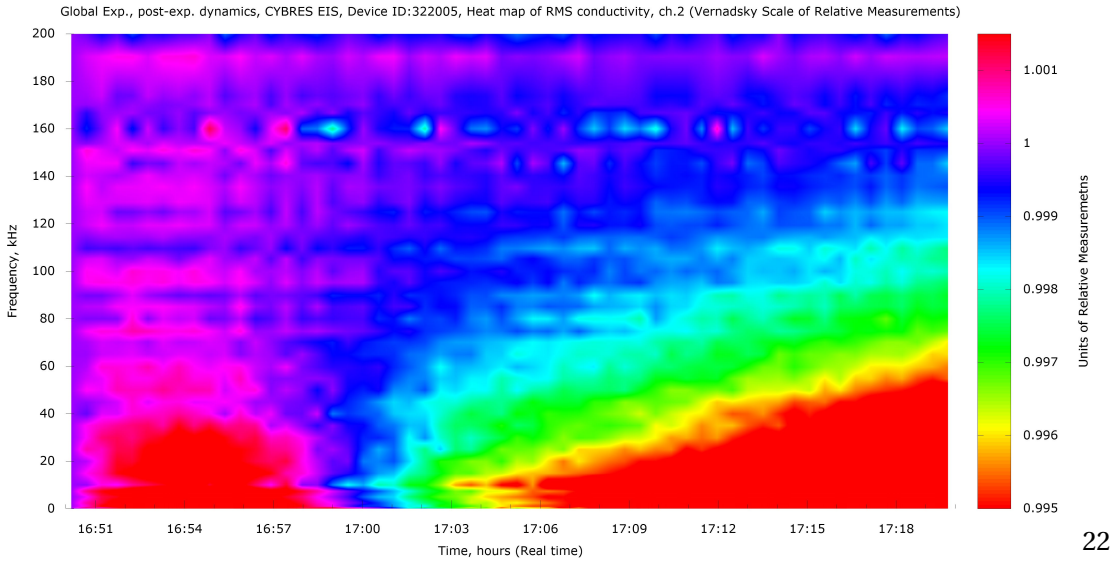
Figure A.8: **The phase 2:** insertion of info-CD under the channel 2, the channel 1 remains with an empty CD (device ID 322005). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



(a)

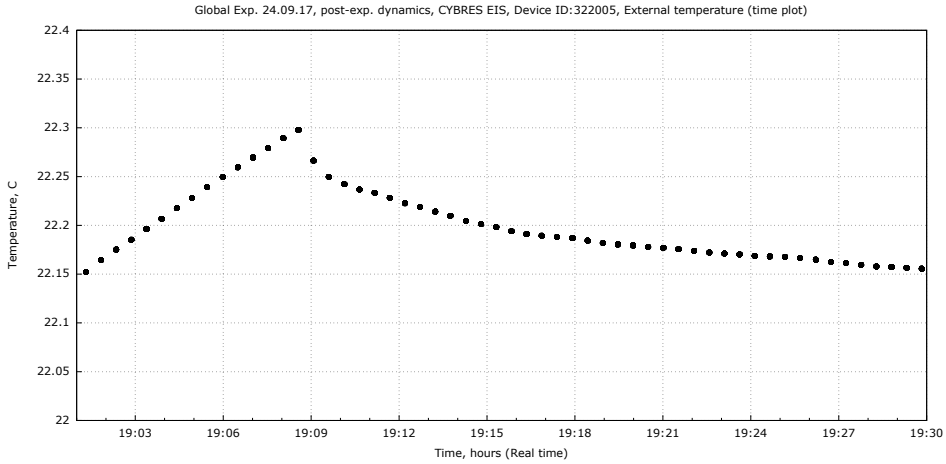


(b)

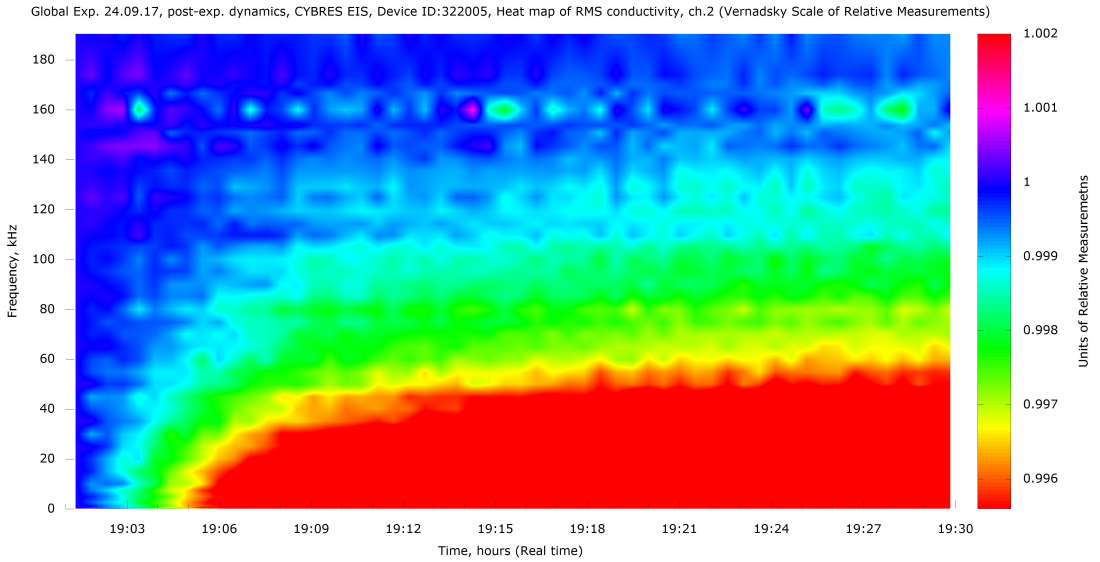


(c)

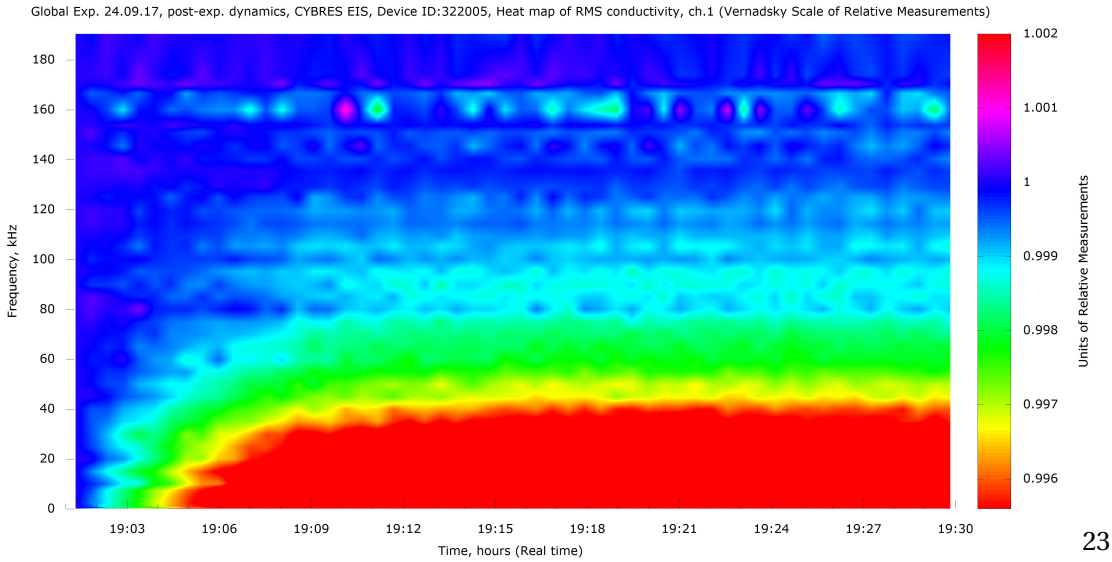
Figure A.9: **The phase 3:** post-experimental dynamics of both channels 180-240 min after exposition, CDs are removed (device ID 322005). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.



(a)



(b)



(c)

Figure A.10: **The phase 4:** post-experimental dynamics of both channels 22-24 hours after exposition, CDs are removed (device ID 322005). **(a)** Temperature data; **(b)** The time-frequency dynamics of the channel 1; **(c)** The time-frequency dynamics of the channel 2.